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OIL SANDS REGIONAL AQUATICS MONITORING PROGRAM (RAMP) 2002

Submitted to:

RAMP Steering Committee

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The binder cover page and spine artwork was designed and drawn by artist Robert F. McDonald.

EXECUTIVE SUMMARY

Purpose and Scope

The Oil Sands Regional Monitoring Program (RAMP) began in 1997. It is an industry funded, long-term, multi-stakeholder initiative that assesses the aquatic environment in the Oil Sands Region of northeastern Alberta near Fort McMurray. The program has been designed to identify and address potential impacts of oil sands developments and is frequently adjusted to reflect monitoring results, technological advances and community concerns. RAMP is currently funded by Albian Sands Energy Inc., Canadian Natural Resources Limited, ExxonMobil Canada Ltd., Devon Canada Corporation, OPTI Canada Inc., Nexen Canada Ltd., Petro-Canada Oil and Gas, Shell Canada Limited, Suncor Energy Inc., Oil Sands, Syncrude Canada Ltd. and TrueNorth Energy L.P.

The RAMP Steering Committee, formed in 1998 as the decision making body of RAMP, held four meetings in Fort McMurray in 2002. Highlights of 2002 include the following:

- establishing the scope of the 2003 monitoring program;
- expanding the communication of the Fish Abnormality Program to the community and equipping additional local environmental liaison workers with sampling equipment;
- representing RAMP at the annual Winter Carnival and Dog Sled Races in Fort Chipewyan and at Fort McMurray Environmental Days in Fort McMurray;
- issuing two RAMP newsletters;
- producing and distributing the RAMP 2001 Summary Report;
- amending the RAMP Program Design and Rationale document;
- implementing and communicating the River Response Network and the Fish Tag Return programs to the community;
- evaluating the Index of Biotic Integrity method of monitoring fish community health in the Oil Sands Region; and
- completing planned monitoring activities.

Over the last five years, RAMP has adapted to results from previous monitoring activities and on-going developments in the Oil Sands Region. It is designed as a long-term monitoring program with sampling frequencies ranging from continuous or seasonal to once every few years. RAMP has been in place since 1997; hence, six years of the program have been completed.

RAMP component appendices are reported in Volume II. The 2002 monitoring program included in this volume consists of the following main components:

- water levels and discharges on the Athabasca River and some tributaries to the Athabasca River;
- water levels at three wetlands;
- snow survey in the Birch Mountains east slope basins;
- climate monitoring at six stations in the Oil Sands Region;
- water and sediment quality in the Athabasca River, the Athabasca River Delta and some tributaries to the Athabasca River;
- water quality in three wetlands;
- sediment quality in two wetlands;
- continuous temperature monitoring in some tributaries to the Athabasca River;
- benthic invertebrate communities in six tributaries to the Athabasca River, the Christina River, two small streams and three wetlands;
- fish populations, fish inventory survey on the Athabasca River and the Muskeg River basin, fish tissue collections in the Muskeg and Athabasca rivers and Gregoire Lake, fish fence site reconnaissance in the Muskeg River, sentinel species monitoring at various locations in the Athabasca River; fyke net monitoring in Muskeg River tributaries and Index of Biotic Integrity testing in the Athabasca River;
- water quality in 49 acid sensitive lakes;
- aerial photograph interpretation at three wetlands; and
- a quality assurance/quality control program.

The RAMP regional study area covers a large portion of northeastern Alberta and includes the Regional Municipality of Wood Buffalo. The focus study area within the regional study boundaries includes watersheds where oil sands development is occurring or planned. In 2002, RAMP focused on these main aquatic systems:

- the Athabasca River and Peace Athabasca Delta;
- the tributaries to the Athabasca River including the Steepbank, Muskeg, Calumet, Clearwater, Christina, Ells, Firebag, MacKay and Tar rivers and McLean, Poplar, Jackpine, Muskeg, Wapasu and Fort creeks;
- wetlands occurring in the vicinity of current and proposed oil sands developments; and
- acid-sensitive lakes in northeastern Alberta.

Climate and Hydrology

The 2002 RAMP Climate and Hydrology monitoring component has resulted in an expansion of the climatic and hydrologic database for the Oil Sands Region, particularly for the Muskeg River basin, Birch Mountains east slope basins and Fort Hills basins. The specific contributions of the 2002 monitoring program are summarized below.

- Continuing operation of the Aurora Climate Station contributed to expansion of the regional climatic database and provided required climatic information for interpreting the hydrologic monitoring results. Continuing operation of the precipitation and temperature sensors at the Calumet River site initiated collection of climatic data to extend the regional coverage to the north and west. Installation of rain gauges at the Christina River, Tar River Lowland and McClelland Lake sites and continued operation of the rain gauge at the Iyinimin Creek site resulted in a denser rain gauge network in the Oil Sands Region than in the past.
- A second year of snow course survey for various terrain types in the Birch Mountains east slope basins expanded the snowpack database necessary for determining the snowfall undercatch correction factor and providing required input to calibrate and verify a snowmelt runoff model.
- New water level monitoring stations were installed on the Susan Lake Outlet, MacKay River, Firebag River and Christina River. Operation of the Petro-Canada stations on the Hangingstone River, Hangingstone Creek and Surmont Creek were incorporated by RAMP in 2002.
- The 2002 streamflow measurements and monitoring were conducted to meet regulatory requirements and to expand the existing streamflow database that is required to develop reliable stage-discharge rating curves and discharge hydrographs at the monitoring stations.
- The 2002 water level monitoring at McClelland Lake was conducted to meet regulatory requirements and to expand the hydrologic database for assessing the effects of the regional oil sands developments on this lake.
- The 2002 total suspended solids (TSS) measurements contributed to an expansion of the existing TSS database required to monitor watershed and channel erosion and streamflow water quality, and to develop more reliable predictive tools to correlate TSS concentrations with streamflows. Sufficient data have been acquired for long-term stations such that TSS measurements need only be undertaken during high discharges, supplemented with a limited number of low discharge measurements.

- Ongoing operations of the monitoring stations provided a basis for identifying the maintenance needs and developing recommendations for the upcoming 2003 monitoring program.
- The 2002 program has resulted in development of a regional climatic and hydrologic database updated to the end of 2002. This database is stored on a compact disc for easy access by users.

It is recommended that the collection of climatic and hydrologic data at the existing monitoring stations be continued and that the monitoring should cover the entire year including snowmelt flows, summer flows and winter low flows, where possible. Continuation of the monitoring program is required for development of an improved hydrologic database, which will allow updating of previous hydrologic analyses and modelling based on site-specific data. The continuation will also provide the hydrologic data necessary for monitoring any potential effects of the oil sands projects, as required by regulatory agencies.

Water Quality

The RAMP Five Year Report discussed both spatial and temporal water quality trends in the lower Athabasca River watershed. To avoid duplication, the examination of water quality data within this report was limited to temporal trend analysis involving waterbodies that were not previously examined, where oil sands development is occurring within their watersheds and sufficient data are available for statistical testing. Waterbodies meeting these criteria included the Steepbank, Firebag and MacKay rivers, McLean, Fort, Jackpine and Poplar creeks, and Shipyard Lake.

For each waterbody, the magnitude and potential significance of apparent temporal trends were evaluated using statistical tests. In rivers and streams, the analysis was completed using fall data collected from the mouth. For Shipyard Lake, the analysis focused on temporal trends in summer, as this was the only season for which more than five samples were available. The parameters considered in this investigation were limited to 11 indicator parameters summarizing acidity/alkalinity, organic carbon, salinity, suspended solids, nutrients and trace metals.

Significant temporal trends were detected in sulphate and boron concentrations in Shipyard Lake, suggesting that water quality may have been affected by human activities within its watershed.

No significant temporal trends were detected in other waterbodies included in the analysis. These results suggest that oil sands activities occurring within their watersheds are having no detectable impact on receiving water quality.

Sediment Quality

A spatial analysis of sediment quality in the lower Athabasca River watershed (Athabasca and Muskeg rivers) was recently completed as part of the RAMP Five Year Report. Sample sizes in other waterbodies were insufficient for statistical testing of long-term trends, or for "before - after development" testing. Therefore, analysis of sediment quality was confined to an investigation of how sediment physical composition, metal content and/or polycyclic aromatic hydrocarbon (PAH) content correlate to observed sediment toxicity within the lower Athabasca River watershed, using principal components analysis (PCA).

The following conclusions can be drawn from the results of this analysis:

- toxic responses exhibited by midges (C. tentans), amphipods (H. azteca) and bristle worms (L. variegatus) have been observed in 21, 23 and 35% of the sediment samples tested to date, respectively;
- the spatial distribution of sediments eliciting toxic responses includes both areas downstream of active oil sands development (e.g., Athabasca Delta) and areas without active development (e.g., the Ells River, Fort Creek and Isadore's Lake);
- the variability observed in the response of C. tentans and H. azteca to sediments from the lower Athabasca River watershed does not appear to be related to sediment composition, metal content or PAH concentrations; and
- the survival and growth of *L. variegatus* is strongly influenced by physical sediment properties, with significant negative correlations to sand content.

A significant, positive correlation was observed between *L. variegatus* growth and the principal component representing certain PAH compounds. This relationship may have resulted from the relative nature of the *L. variegatus* test results, which are expressed as a percentage of the observed performance of the test organisms in control sediments.

Given the importance of the sediment used for the control samples, it is recommended that RAMP consider comparing the chemical and physical composition of control sediments with sediments collected from the lower Athabasca River watershed, and collecting control sediments from a reference location in the Athabasca River watershed.

Benthic Invertebrate Community

Benthic invertebrate data collected in 2002 was summarized for the Athabasca River Delta, the MacKay, Muskeg and Steepbank rivers, Fort Creek, and Kearl and Shipyard lakes. Other waterbodies sampled in 2002 are in the baseline phase and available data at this time are insufficient to illustrate baseline variability or temporal trends.

The Fletcher Channel of the Athabasca River Delta supported a community of lower total abundance and richness compared to the Goose Island Channel, which was characterized by a more diverse community. There was no indication of effects related to sediment toxicity at either location, despite previous findings of sediment toxicity to *L. variegatus* in the Fletcher Channel.

Within erosional reaches, total benthic invertebrate abundance was lowest in the Steepbank River, intermediate in the Muskeg River and highest in the MacKay River, and varied without a trend over time. As in previous years, the Muskeg River supported the most diverse benthic fauna. Apparent increasing trends in richness over time in these rivers were artifacts of changes in sampling design. Declining trends in total abundance were apparent with increasing flow in all three rivers, suggesting the build-up of algae and lack of scouring during low flow years may allow the development of communities with greater abundances.

Total benthic invertebrate abundance was relatively high in the lower depositional reach of the Muskeg River in all years of monitoring. The upper depositional reach, first sampled in 2002, supported a community with a considerably lower total abundance and richness. In the lower depositional reach of Fort Creek, total benthic invertebrate abundance was considerably higher in 2002 than in 2001, but richness was similar in both years. Benthic communities of depositional reaches were dominated by chironomid midges.

Benthic communities in Kearl and Shipyard lakes were characterized by variable total abundance. Richness was slightly higher in Shipyard Lake. Kearl Lake was dominated by amphipods and midges. Midges amphipods, ostracods, fingernail clams, snails and mayflies were abundant in Shipyard Lake. Long term trends in community composition were not apparent.

Fish Populations

In general, concentrations of trace metals and tainting compounds in fish tissue samples from the Athabasca River, Muskeg River and Gregoire Lake were below levels that would affect fish health, suitability for human consumption, or fish flavour. Exceptions included mercury in fish tissues from the Athabasca River and Gregoire Lake, in relation to consumption guidelines for the protection of human health. Mercury concentrations in fish tissues from the Muskeg River were difficult to evaluate due to the small sample size collected in 2002. Although mercury concentrations in tissue from some fish were above consumption guidelines, mercury levels do not appear to be increasing and are representative of naturally high concentrations documented historically from the Athabasca River.

In the Athabasca and Muskeg rivers, there were no trends in tissue concentrations for any of the inorganic chemicals that have been measured in more than one year, with the possible exception of strontium in Athabasca River fish, which appears to have declined from higher levels recorded in 1998.

With respect to analysis of fish tissues for organic tainting compounds, development of an appropriate methodology is warranted, including an appropriate list of parameters to be examined. At present, CONRAD has undertaken a process to address this concern and provide to RAMP a recommended methodology.

Inventory sampling in the Athabasca River determined that walleye, goldeye, white sucker, longnose sucker and northern pike were the most abundant large-bodied species in the Oil Sands Region in the spring of 2002. Comparisons of relative abundance to previous inventory data indicated that, other than northern pike, the main large-bodied species appear to have declined in abundance in recent years (1997 to 2002). For walleye, goldeye and white sucker, catch-per-unit-effort (CPUE) in 2002 was comparable to 1995 estimates. For longnose sucker, the 2002 CPUE was the lowest yet recorded.

Potential trends in Athabasca River fish abundance (identified in the RAMP Five Year Report) included possible declines for walleye and lake whitefish. The 2002 results showed an increase in walleye CPUE in 2002 relative to 2001. The spring inventory data were not able to provide an assessment of lake whitefish abundance in 2002. The Athabasca River inventory data showed that length frequency distribution, condition factor and pathology index for the main large-bodied species were variable among years. However, there were no systematic changes in any of these variables that would indicate a change over time.

The inventory data from the Muskeg River basin indicated that the summer fish community in both the lower Muskeg River and lower Jackpine Creek were dominated by suckers and small-bodied species. A small number of sport fish were present, most of which were juveniles. The most significant difference relative to previous years was the lack of Arctic grayling in both watercourses in

2002, suggesting that this species may not have used the Muskeg River watershed for spawning, rearing or feeding activities in 2002.

The results for Athabasca River sentinel species sampling identified some differences for the five trout-perch populations examined. In comparing Site 1 (upstream of the Fort McMurray STP) to Site 2 (between the STP and the oil sands area), significant differences were found only for condition factor and relative liver size (LSI) in male fish, indicating that males may be responding to increased productivity below the STP. Compared to Site 2 (reference site for oil sands reach), adult trout-perch at some of the three downstream oil sands exposure sites had significantly lower age, weight, condition factor, LSI and fecundity, and significantly higher relative gonad size (GSI). However, in most cases, these differences did not occur at all three exposure sites and were not consistent for both sexes. The only consistent differences were lower condition factor and LSI for males and females at Site 4, providing some evidence of reduced levels of energy storage, a result consistent with 1999 data.

The responses of adult trout-perch at the exposure sites relative to the reference site were generally inconsistent between 1999 and 2002. The among-year differences may illustrate natural, year-to-year variability. It is also possible that the populations at the different sampling sites are not isolated. This suggests there may be a need to evaluate the mobility of trout-perch in the Oil Sands Region to verify the assumption that trout-perch do not move among sites.

In the examination of the lower 1.5 km of the Muskeg River, five sites were found that had depth and velocity profiles suitable for fish fence deployment. However, all sites have a soft, mobile substrate, poor access and poor working/staging areas. Of the candidate sites, Site 3 was recommended based on its velocity profile and proximity to the historical AOSERP fence site.

Spring and fall fyke net monitoring and inventory sampling in upper tributaries of the Muskeg River (Muskeg and Wapasu creeks) indicated that the fish communities in these watercourses were dominated by small-bodied species, along with small numbers of young-of-the-year or juvenile suckers. One adult northern pike was captured in Muskeg Creek. Small upstream (spring) and downstream (fall) fish movements were recorded in both of these watercourses, suggesting that either the fyke net monitoring periods did not coincide with the main migrations, or that migrations within these watercourses are small in scale. Groups of dead forage fish observed in Wapasu Creek after ice-out indicated that some fish attempted to overwinter in this watercourse, but conditions were not suitable.

Acid Sensitive Lakes

The objectives of the acidification monitoring network in 2002 were to continue collecting water chemistry data from lakes sampled in the past and to enhance the network by adding new lakes near the area of heaviest oil sands development. As a result, 49 lakes were monitored in 2002, including 17 new lakes.

For previously sampled lakes, acidity-related variables (pH, alkalinity) and ionic ratios showed no indication of changes signaling acidification in 2002 compared to previous years. At this time, the available data are insufficient to evaluate trends over time using statistical means. Of the 17 new lakes added in 2002, eight were found to have relatively high alkalinities and critical loads (i.e., low acid sensitivity). These results may warrant a re-evaluation of new lakes added to the monitoring network to ensure a sensitive and cost-efficient program.

Aquatic Vegetation

In Kearl Lake, no changes were apparent in lake boundary or the size of wetlands polygons surrounding the lake. Any differences to the lake boundary or wetlands polygons were attributable to the difference in quality of the 1997 photograph compared to the 2001 photograph and to the different individuals who interpreted the polygon boundaries.

Shipyard Lake appears to have increased in size based on a visual examination of the 1997 and 2002 photographs. The greatest amount of change was noted on the western and northern shores. Additionally, there has been recession and in-filling of the channel that flows from the open shrubby swamp (SONS) wetland into the open, non-patterned graminoid marsh (MONG) wetland in the centre of the photograph.

The northern channel of Isadore’s Lake appears to have receded from 1997 to 2001. Additionally, there appears to have been a reduction in the shallow open water (WONN) polygon to the north of the lake. This decrease has resulted in an increase to the area of the adjacent open, non-patterned graminoid fen (FONG) wetlands type. With the use of false colour infra-red photograph, vegetation within the lake is now visible for future analysis.

The northern shore of McClelland Lake is composed of a combination of wetlands and uplands ecosite phases while the southern shore is primarily uplands. The eastern and western shores of the lake are made up of a series of wetlands types, primarily MONG, SONS, open treed swamp (STNN) and open, non-patterned shrubby fens (FONS).

Quality Assurance/Quality Control

The results of the RAMP QA/QC assessment indicate that the water and sediment quality, benthic invertebrate communities, fish populations and acid sensitive lakes data are valid. Results of each component of the assessment are presented in Section 4.

ACKNOWLEDGEMENTS

This report documents the results of the sixth year of the Oil Sands Regional Aquatics Monitoring Program (RAMP). Funding was provided by Albian Sands Energy Inc. (Albian), Canadian Natural Resources Limited (CNRL), ExxonMobil Canada Ltd. (ExxonMobil), Devon Canada Corporation (Devon), OPTI Canada Inc./Nexen Canada Ltd. (OPTI/Nexen), Petro-Canada Oil and Gas (Petro-Canada), Shell Canada Limited (Shell), Suncor Energy Inc. (Suncor), Syncrude Canada Ltd. (Syncrude) and TrueNorth Energy L.P (TrueNorth).

Terry Van Meer was the RAMP Chairperson and Michael Burt was the Vice-Chairperson. John Gulley was the Secretary and the Project Director. The Golder Associates Ltd. (Golder) Project Manager was Kym Fawcett.

RAMP is a multi-stakeholder program composed of representatives from industry, provincial and federal governments, local aboriginal groups and environmental organizations. RAMP benefits from the active participation of its member organizations. In kind support was provided by Syncrude, Alberta Pacific Forest Products Industry Inc. (AlPac), Alberta Sustainable Resource Development (ASRD) and Alberta Environment (AENV). Syncrude and AlPac provided a boat, along with personnel for the fish tissue collection and Index of Biotic Integrity (IBI) test program in the fall on the Athabasca River. ASRD provided personnel and equipment for the fish tissue collection in the fall on the Athabasca River and Gregoire Lake. AENV collected samples for the Acid Sensitive Lake project.

RAMP continued involving the local community through a number of programs including the Fish Tag Return Program, the Fish Abnormalities Program and the River Response Network. RAMP also participated in Environment Days in Fort McMurray, May 2002.

Field work for most components was conducted primarily by Golder with assistance and/or in-kind support from various stakeholders. Participants in the RAMP field work conducted in 2002 are described below.

Climate and hydrology field work was conducted by Golder Associates Ltd. (Golder), specifically Nathan Schmidt, Lawrence Low, Tony Calverley, Jane Elser and Pat Marlowe. Water and sediment quality samples were taken by Ken Allen (Golder), Chris Stoesz (Golder), Glen Isaac (Golder), Gary Cooper (Fort McKay), Shane Cheecham (Anzac) and Pat Marlowe (Golder). Water and sediment sampling QA/QC was conducted by Lynda Gummer (Golder), Jane Elser (Golder), Pat Marlowe (Golder) and Julia Tarnowski (Golder).

The fisheries monitoring program was conducted by Ken Allen (Golder), Gary Cooper (Fort McKay), Louis Bouchier (Fort McKay), Barry Cooper (Fort McKay), Chris Bjornson (Golder), Lynda Gummer (Golder), Chris Stoesz (Golder), Cam Davis (Golder), Kris Driscoll (Golder), Glenn Isaac (Golder), Jeff Kearley (Golder), Nathan Schmidt (Golder) and Robert Grandjambe (Fort Chipewyan). In-kind support was provided by Terry Van Meer (Syncrude), Joanne Hogg (Syncrude), Neil Rutley (Syncrude), Larry Rhude (ASRD), Paul MacMahon (ASRD), Dwayne Latty (ASRD), Roger Ramcharita (AENV), Pat Rhude (volunteer) and Mark Spafford (AlPac). Fish ageing samples were analyzed by ageing specialist Jon Tost of North Shore Environmental Services, Ontario.

Tony Calverley (Golder) and Jane Elser (Golder) conducted benthic invertebrate sampling during the fall in the Athabasca River tributaries and wetlands. Fall sampling of sediment and benthic invertebrates in the Athabasca Delta channels and sediment in the lower Athabasca River at Embarras was completed by Kym Fawcett (Golder) and Tanis Dirks (Golder), with assistance from Harold Wiley (Fort Chipewyan). Benthic invertebrate samples were analyzed for abundance and taxonomic composition by J. Zloty, Ph.D., Calgary, Alberta.

The RAMP acid sensitive lake monitoring program field survey was undertaken by Alberta Environment (AENV). Ryan Wilkinson (Golder), Bob McDonald (Golder) and Deborah Maier (Golder) interpreted aerial photographs of RAMP wetlands.

The following Golder team members prepared sections of this report:

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1 INTRODUCTION

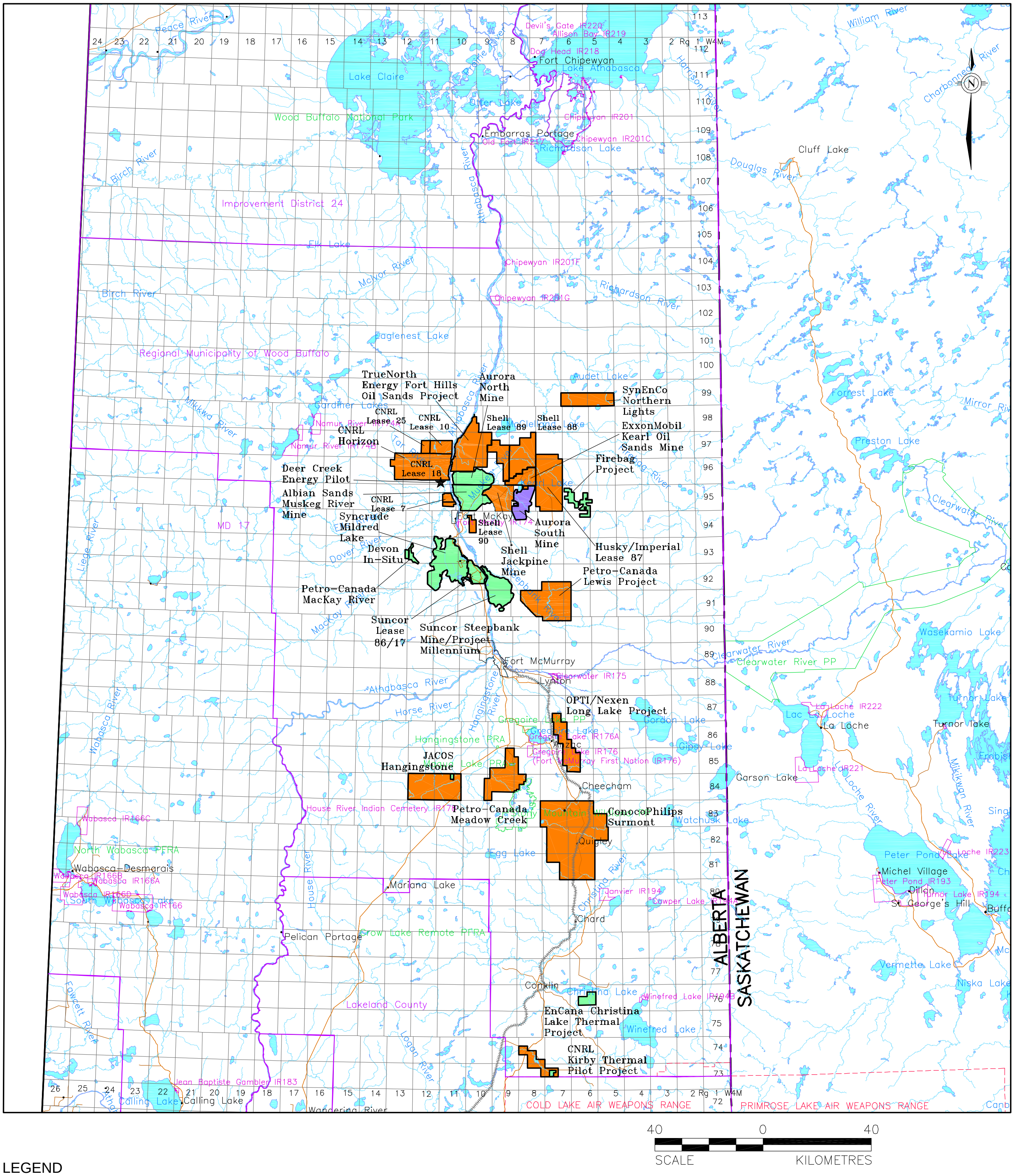
1.1 BACKGROUND

The Oil Sands Regional Aquatic Monitoring Program (RAMP) was developed in 1997 in response to the substantial growth in northeastern Alberta resulting from oil sands development. The intent of RAMP is to integrate aquatic monitoring activities so that long-term trends and potential cumulative effects can be identified and addressed. This coordination of data collection results in the development of a more complete, cost-effective database that may be used by oil sands operators for their environmental management programs and by project proponents and reviewers for assessments of proposed oil sands developments.

The existing, approved and planned oil sands developments as of December 31, 2002 are shown in Figure 1.1. Table 1.1 highlights the production capacity, development area and type of operation of the existing, approved and planned oil sands developments in the region.

RAMP is a multi-stakeholder initiative, currently funded by Albian Sands Energy Inc. (Albian), Canadian Natural Resources Limited (CNRL), ExxonMobil Canada Ltd. (Exxon), Devon Canada Corporation (Devon), OPTI Canada Inc. (OPTI), Nexen Canada Ltd. (Nexen), Petro-Canada Oil and Gas (Petro-Canada), Shell Canada Limited (Shell), Suncor Energy Inc., Oil Sands (Suncor), Syncrude Canada Ltd. (Syncrude) and TrueNorth Energy L.P. (TrueNorth).

The RAMP organizational structure is shown in Figure 1.2. The mandate of RAMP, as defined by its multi-stakeholder Steering Committee, is to monitor, evaluate, compare, review and communicate the state of the aquatic environment in the Athabasca Oil Sands Region. The Technical Subcommittee is responsible for the development and review of the RAMP technical program including the annual monitoring program. The Technical Subcommittee is divided into Subgroups that develop and review their specialty areas of the overall program. Investigators (e.g., Golder Associate Ltd.; Alberta-Pacific Forest Industries Inc.) primarily carry out the field work, analysis and reporting, as defined by the program.



LEGEND

- EXISTING and APPROVED DEVELOPMENTS
- PLANNED DEVELOPMENTS
- EUB APPROVED DEVELOPMENT

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12.
SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13.
ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.
OIL & GAS AND ENVIRONMENTAL DATA PROVIDED BY VERITAS GeoSERVICES LTD., CURRENT AS OF MAY 2001.

PROJECT

RAMP 2002

TITLE

EXISTING, APPROVED AND PLANNED DEVELOPMENTS IN THE OIL SANDS REGION

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Existing-Planned	
DESIGN	LG	11/03/03	SCALE AS SHOWN	REV. 1
CADD	GB	20/01/03	FIGURE: 1.1	
CHECK				
REVIEW				

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Table 1.1 Athabasca Oil Sands Production for Existing, Approved and Planned Developments

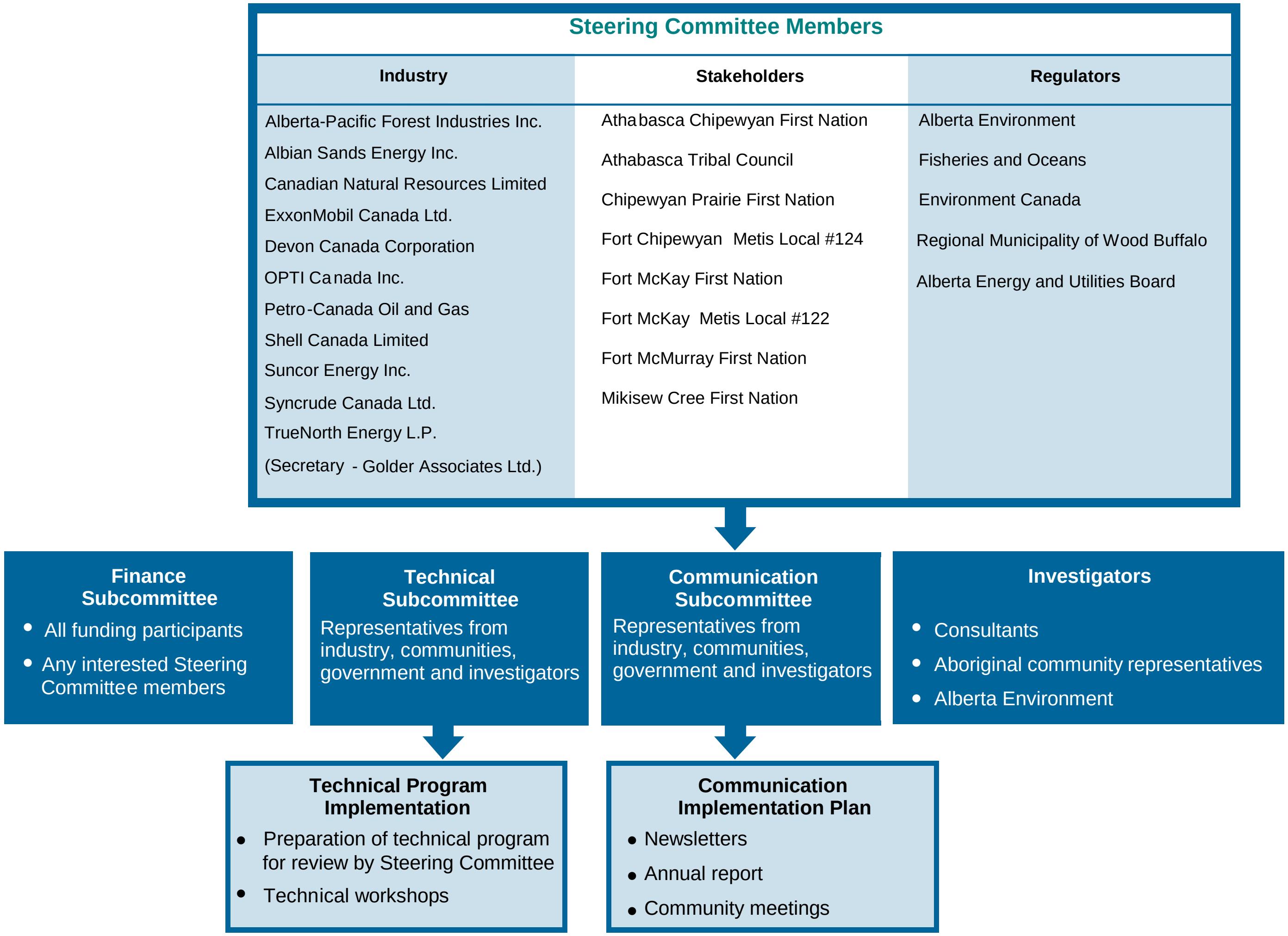
Oil Sands Development	Location	Capacity (bpd)[(a)]	Development Area (ha)[(b)]	Type of Operation	Status
Suncor Energy Inc.					
Upgrader Complex	30 km north of Fort McMurray	220,000 S	14,899	processing	approved
Lease 86/17, Steepbank and Millennium Mines	30 km north of Fort McMurray	280,000 B	3,399	open pit	approved
Firebag Project	40 km northeast of oil plant	140,000 B	1,105	in situ	approved
Firebag Pilot Project	40 km northeast of oil plant	1,200 B	369	in situ	approved
Voyageur	25 km north of Fort McMurray	550,000 B	nyd	processing	planned
Syncrude Canada Ltd.					
Mildred Lake Upgrader	45 km north of Fort McMurray	480,000 S	21,000	processing	approved
North Mine	60 km north of Fort McMurray	160,000 B	100	open pit	approved
Aurora North	east side of Athabasca River	200,000 B	7,700	open pit	approved
Aurora South	east side of Athabasca River	200,000 B	nyd	open pit	EUB approved
Albian Sands Energy Inc.					
Muskeg River Mine	75 km north of Fort McMurray	155,000 B	4,343	open pit	approved
Shell Canada Limited					
Jackpine Mine (Phase 1)	east portion of lease 13	200,000 B	8,474	open pit	planned
Muskeg River Mine Expansion (Phase 2)	north of Jackpine Mine	70,000 B	7,105	open pit	planned
ConocoPhillips (formerly Gulf)					
Surmont Pilot	60 km SE of Fort McMurray	2,000 B	7	in situ	approved pilot
Surmont		100,000 B	567	in situ	planned
Devon Canada Corporation (formerly Northstar Dover)					
Old UTF	90 km north of Fort McMurray	2,000 B	22	in situ	approved
Jackfish	15 km southeast of Conklin	35,000 B	nyd	in situ	planned
Japan Canada Oil Sands Limited (JACOS)					
Hangingstone Pilot	25 km west of Anzac, 50 km	10,000 B	420	in situ	approved pilot
Hangingstone	southwest Fort McMurray	50,000B B	631	in situ	planned
Petro-Canada Oil and Gas					
MacKay River	60 km northwest of Fort McMurray	30,000 B	170	in situ	approved
Meadow Creek	45 km south of Fort McMurray	80,000 B	1,181	in situ	planned
Lewis Project	30 km northeast of Fort McMurray in Steepbank area	50,000 B	1,000	in situ	planned
OPTI Canada Inc./Nexen Canada Ltd.					
Long Lake Pilot Project	40 km southeast of Fort McMurray	3,800 B	10	in situ	approved
Long Lake Project	40 km southeast of Fort McMurray	140,000 S 70,000 B	884	in situ	planned
ExxonMobil Canada Ltd.					
Kearl Mine	70 km north of Fort McMurray	165,000 S	5,336	open pit	planned
Upgrader	70 km north of Fort McMurray	185,000 B	nyd	processing	planned

Table 1.1 Athabasca Oil Sands Production for Existing, Approved and Planned Developments (continued)

Oil Sands Development	Location	Capacity (bpd)[a]	Development Area (ha)[b]	Type of Operation	Status
TrueNorth Energy L.P.					
Fort Hills	90 km north of Fort McMurray	190,000 B	12,000	open pit	approved
Canadian Natural Resources Limited (CNRL)[c]					
Horizon Project	80 km north of Fort McMurray	270,000 B 233,000 S	15,000[c]	open pit in situ	planned planned
Horizon In situ	west side of lease 18	270,000 B	26,881	open pit	planned
Kirby Project	85 km northeast of Lac la Biche	30,000 B	190	in situ	planned
Kirby Pilot	85 km northeast of Lac la Biche	1,600 B	3	in situ	approved
SynEnCo[c]					
Northern Lights Project	100 km northeast of Fort McMurray on Firebag River	80,000 S	7,138[c]	open pit	planned
Husky Oil					
Tucker	40 km west of Cold Lake	30,000 B	nyd	in situ	planned
Deer Creek Energy					
Joslyn SAGD Pilot	60 km southeast of Fort McMurray	30,000 B	20,234 [d]	in situ	approved
Joslyn Creek SAGD	60 km southeast of Fort McMurray	60, 000 B		in situ	planned
Encana					
Foster Creek Phase I		25,000 B		in situ	approved
Foster Creek Phase 2 and 3		B		in situ	filled
Christina Lake	170 km south of Fort McMurray	85,000 B	527	in situ	approved

(a) Barrels per day (bpd) of B = Bitumen; S = Synthetic Crude or pipelineable crude; bpd values are rounded off.
(b) Development areas are those that will result from the existing approved and planned operations. Areas represent the maximum disturbance footprint for terrestrial resources.
(c) Number based on preliminary estimates.
(d) Total hectares for SAGD and mining.
nyd = Not yet determined.
n/a = Not applicable.

Figure 1.2 RAMP Organizational Chart



The objectives of RAMP are as follows:

- to monitor aquatic environments in the oil sands area to detect and assess cumulative effects and regional trends;
- to collect scientifically defensible baseline and historical data to characterize variability in the oil sands area;
- to collect data against which predictions contained in environmental impact assessments (EIAs) can be verified;
- to collect data that may be used to satisfy the monitoring required by regulatory approvals of developments in the oil sands area;
- to recognize and incorporate traditional knowledge (including Traditional Ecological Knowledge and Traditional Land Use Studies) into the monitoring and assessment activities;
- to communicate monitoring and assessment activities, results and recommendations to communities in the Regional Municipality of Wood Buffalo, regulatory agencies, environmental committees/organizations and other interested parties;
- to design and conduct various RAMP activities such that they have the flexibility to be adjusted, on review, to reflect monitoring results, technological advances and community concerns; and
- to seek cooperation with other relevant research and monitoring programs where practical, and generate interpretable results which can build on their findings and on those of historical programs.

The RAMP regional study area covers a large portion of northeastern Alberta and includes the Regional Municipality of Wood Buffalo. The focus study area within the regional study boundaries includes watersheds where oil sands development is occurring or planned. In 2002, RAMP focused on these main aquatic systems:

- the Athabasca River Delta;
- the tributaries to the Athabasca River including the Steepbank, Muskeg, Clearwater, Christina, Ells, Tar, Calumet and MacKay rivers and McLean, Poplar, Jackpine, Stanley, Muskeg, Wapasu and Fort creeks;
- wetlands occurring in the vicinity of current and proposed oil sands developments; and
- acid sensitive lakes in northeastern Alberta.

The RAMP program design and rationale is described in the following document: “Oil Sands Regional Aquatic Monitoring Program (RAMP) Program Design and

Rationale" (Golder 2002d). This document was updated in 2002 to reflect changes to the program by the RAMP Technical Subcommittee.

The following publications were also produced by RAMP in the past year:

- RAMP Summary 2001 (Golder 2002a); and
- Oil Sands RAMP Newsletter: September 2002 (Volume 4, Issue 1).

1.2 SCOPE OF REPORT

As RAMP began monitoring in 1997, six years of sampling have been completed. This report describes the results of the 2002 field program for climate and hydrology, water and sediment quality, benthic invertebrate communities, fish populations, acid sensitive lakes and aquatic vegetation. The results include data collected for RAMP but do not generally include data from other sampling programs in the region. Exceptions include information from Albian and Syncrude's joint monitoring program for the Muskeg River, continuous monitoring data from Alberta Environment (AENV) for the Muskeg River and AENV's water quality data for selected sites; these results are included.

In 2003, RAMP produced its Five Year Report (Golder 2003a) that includes data from 1997 to 2001, as well as historical and other (e.g., EIA baseline) data that are appropriate. Where possible, these data were analyzed to characterize the variability of waterbodies monitored by RAMP and detect regional trends in the Oil Sands Region. Statistical or qualitative analyses were used to assess both spatial and temporal trends.

The 2002 Annual Report includes data for the first year after this comprehensive analysis of the 1997 to 2001 data. The annual report has a limited scope since it describes the detailed monitoring activities, methods and results for 2002. The summaries in the main body of the report are augmented by twenty appendices (I to XX) containing the new data and detailed results. To be efficient and limit the repetition of work done in the Five Year Report, statistical and other analyses provided in the main body of this annual report have been limited to areas where the 2002 data make an important new contribution. In areas where developments are proposed but not approved (south of Fort McMurray), baseline data are being gathered but analysis of the data is premature until a larger data set has been compiled. In general, statistical analyses have been done when the following conditions have been met:

- sufficient data are available to meet the conditions of the statistical test;
- oil sands development is actively occurring in the watershed; and
- the data set has not been analyzed for trends or variability in the Five Year Report.

The scope of each component of the 2002 Annual Report is described in more detail in the following sections.

1.2.1 Climate and Hydrology

Long-term regional climatic and hydrologic data were used in the Five Year Report to characterize existing variability and to detect regional trends. These analyses required long-term data because smaller data sets are unlikely to reflect the range and distribution of conditions necessary to characterize long-term natural variation. Since the range of natural variation is large compared to mean values, a long period of record is necessary to identify cumulative effects or regional trends. Short-term climatic and hydrologic data collected by RAMP were used in the Five Year Report to characterize the hydrologic responses of the smaller local areas monitored by RAMP, assess their likely long-term regimes and place data collected during the monitoring period in the context of natural variability.

The 2002 Annual Report focuses on climatic and hydrologic monitoring in the Muskeg River basin, the east slopes of the Birch Mountains and the upland watersheds south of Gregoire Lake. However, the 2002 Annual Report also includes hydrologic monitoring of the Athabasca River downstream of the proposed oil sands developments, and monitoring of Mills, Fort and Poplar creeks, Susan Lake outlet, and McClelland and Isadore's lakes. The 2002 program design was based on the current regulatory monitoring requirements and the long-term need to expand the regional climatic and hydrologic database analyzed in the Five Year Report.

The scope of work for the 2002 monitoring program was designed to include collection and compilation of climatic data recorded at the Aurora Climate Station and snow course data in the Birch Mountains east slope basins. Streamflow monitoring stations were installed on the Susan Lake Outlet, and MacKay, Firebag and Christina rivers. Existing streamflow monitoring stations on the Hangingstone River, Hangingstone Creek and Surmont Creek were incorporated into RAMP. Streamflow data from 14 streamflow monitoring stations in the Muskeg River basin, six streamflow monitoring stations on the east slopes of the Birch Mountains, four streamflow monitoring stations on Athabasca River tributaries, one station on the Athabasca River and four stations in the upland watersheds south of Gregoire Lake were collected and compiled. Similarly, water level data at three lake level monitoring stations (McClelland, Kearl and Isadore's lakes) were collected, processed and compiled.

The 2002 daily climate data, the updated climatic and hydrologic database, snow course survey data, station fact sheets, discharge measurements, stage – discharge rating curves and mean daily discharges and water levels are available in Appendices I, II, III, IV, V, VI and VII, respectively. Station locations are described in detail in Chapter 3.

1.2.2 Water Quality

The RAMP Five Year Report (Golder 2003a) discussed both spatial and temporal water quality trends in the lower Athabasca River watershed. The investigation of spatial trends included comparisons among the waterbodies sampled by RAMP, as well as specific "upstream - downstream" comparisons in the Athabasca and Muskeg rivers. Temporal trend analyses were focused on two long-term (i.e., 1976 to 2001) monitoring sites in the Athabasca River located upstream of Fort McMurray and near Old Fort, and two shorter-term (i.e., 1997 to 2001) reaches positioned in the Muskeg River upstream of Muskeg Creek and in the lower section of the Muskeg River between Jackpine Creek and the river mouth. In both cases, selected sites were situated upstream and downstream, respectively, of current oil sands development in their respective watersheds.

To be efficient and avoid repetition, the examination of water quality data within this report will be limited to temporal trend analysis involving waterbodies that were not examined in Golder (2003a), where oil sands development by member companies is actively occurring within their respective watersheds and sufficient data are available to meet the minimum requirements of the relevant statistical test. Waterbodies meeting these three criteria included the following:

- the Steepbank, Firebag and MacKay rivers;
- McLean, Fort, Jackpine and Poplar creeks; and
- Shipyard Lake.

For each waterbody, the Mann-Kendall test for trend in combination with Sen's slope estimation procedure (Gilbert 1987) was used to determine both the magnitude and potential significance of apparent temporal trends. In rivers and creeks, the analysis was completed using fall data collected from the mouth of each waterbody. Fall was selected, because, for many of these streams, sufficient data (i.e., sample size > 5) were only available for this season. Similarly, the analysis considered only the mouth of each river or creek, because upstream sites on a given stream are not currently included in RAMP or insufficient data were available from these areas to perform the Mann-Kendall test for trend.

With respect to Shipyard Lake, the analysis was focused on temporal trends in summer, as this was the only season for which more than five samples were available. The parameters considered in this investigation were limited to the following 11 indicators discussed in the RAMP Five Year Report (Golder 2003a):

- dissolved organic carbon (DOC)
- pH
- total alkalinity
- total dissolved solids (TDS)
- total suspended solids (TSS)
- sulphate
- total Kjeldahl nitrogen (TKN)
- total phosphorus
- total aluminum
- total boron
- total chromium

Total phosphorus, DOC and TKN were selected to provide a general indication of nutrient status. Total alkalinity and pH were selected as key variables for monitoring potential acidification. Sulphate, TDS, total aluminum, total boron and total chromium were chosen, because recent EIAs (e.g., Shell 1997; Golder and Cantox 2002) indicated that concentrations of these substances may increase as a result of development. Finally, TSS was included, due to its likely influence on total metal levels.

Although the analyses presented in the main body of the report are limited to the scope described above, all of the water quality data collected in 2002 are presented in Appendices VIII, IX and X.

1.2.3 Sediment Quality

A spatial analysis of sediment quality in the lower Athabasca River watershed was recently completed as part of the RAMP Five Year Report (Golder 2003a). Temporal trends in the Athabasca River and Muskeg River sediment quality were also discussed therein. Although temporal trend analysis in other waterbodies sampled by RAMP was considered for the 2002 annual RAMP report, sample sizes for these areas did not yet meet the minimum input requirements for the Mann-Kendall test procedure. Sufficient data were also not yet available from these locations to complete “before and after development” type of testing.

The analysis of sediment quality discussed herein was, therefore, confined to an investigation of how sediment composition (i.e., sand, silt and clay content), metal content and/or polycyclic aromatic hydrocarbon (PAH) content correlate to observed sediment toxicity within the lower Athabasca River watershed. As was done in Golder (2003a), Principal Component Analysis (PCA) was used to reduce the number of parameters included in this investigation. Input data were included for available historical information described in Golder (2003a), as well as all of the 2002 sample data available as of January 20, 2003.

Unforeseen difficulties occurred in the laboratory analysis of 13 out of 40 of the sediment PAH samples collected in 2002, resulting in the delayed production of those results. Polycyclic aromatic hydrocarbon results received after January 20, 2003 are included in Appendix XI, along with summaries of all of the 2002 sediment sampling results. They did not, however, form part of the input dataset used to investigate potential correlations between sediment toxicity and sediment quality.

1.2.4 Benthic Invertebrate Community

The scope of the 2002 annual report for benthic invertebrates included summarizing benthic community data in the same format as that used in previous annual RAMP reports. The number of waterbodies included in the data summary was limited by excluding those with a single year of RAMP data (Calumet, Christina, Ells and Tar rivers, Jackpine Creek and McClelland Lake), and the Clearwater River, where effects are not expected at this time due to the low level of oil sands activity. These waterbodies are in the baseline phase and available data at this time are insufficient to illustrate baseline variability or time trends. For these, and all other, waterbodies sampled in 2002, the detailed taxonomic data and supporting data are presented in Appendix XII. Waterbodies for which summaries are presented in the main body of this report include the Athabasca River delta, the MacKay, Muskeg and Steepbank rivers, Fort Creek, Kearl Lake and Shipyard Lake.

In light of the detailed analysis carried out for the Five Year Report (Golder 2003a), no statistical analysis was done, but the benthic invertebrate data were examined for temporal trends and potential changes related to oil sands activity in waterbodies close to developments (Muskeg River, Shipyard Lake).

1.2.5 Fish Populations

Fish population data collected in 2002 will be presented in this report in two ways. First, the examination of specific components that were addressed in the

RAMP Five Year Report will continue in 2002 (Golder 2003a). This includes programs that have been monitored for a sufficient period of time to identify trends (i.e., fish tissue collection from the Athabasca River and fish inventory of the Athabasca and Muskeg rivers). Analysis and recommendations for these components in 2002 will be made based on what was identified in the RAMP Five Year Report.

Second, 2002 data from fish populations programs that were not evaluated for trends in the Five Year Report will be analyzed and compared to previous RAMP data. This includes the fish tissue collection program in the Muskeg River and Gregoire Lake, fish inventory survey of Jackpine Creek and fyke net monitoring in the upper Muskeg River Basin.

In summary, the 2002 program consisted of the following:

- collection of tissue samples from fish in the Athabasca River, Muskeg River and Gregoire Lake for analysis of contaminants;
- a general fish inventory of the Athabasca River, Muskeg River and Jackpine Creek;
- sentinel species monitoring to assess the health of trout-perch populations in the Athabasca River;
- fyke net monitoring to evaluate species composition, abundance and movements of small-bodied species in selected Muskeg River tributaries;
- reconnaissance of the lower Muskeg River to select a site in preparation for future counting fence deployment; and
- a pilot program to test the potential of applying the ‘Index of Biotic Integrity’ (IBI method in the Athabasca River.

Appendix XIII contains the names of fish species, while Appendix XIV includes codes and definitions for fish pathology examinations. Data collected in 2002 for fish tissue collection, Athabasca and Muskeg rivers inventories, Athabasca River sentinel species monitoring, and Muskeg and Wapasu creeks fyke net data are presented in Appendices XV, XVI, XVII and XVIII, respectively.

1.2.6 Acid Sensitive Lakes

The acid sensitive lakes 2002 data will be presented in this report and compared with results from previous years. This will include the identification of indicators of acidification to evaluate whether changes have occurred since previous monitoring. Water chemistry data for acid sensitive lakes are provided in Appendix XIX.

1.2.7 Aquatic Vegetation

This report will present results of the third year of aerial photography interpretation for the four RAMP wetlands ecosystems (Kearl, Shipyard, Isadore's and McClelland lakes).

1.2.8 QA/QC

The QA/QC program has a broad scope related to field staff training and operations, laboratory requirements and office operations. In 2002, a formal quality assurance plan specific to RAMP was applied. Quality control procedures were implemented by each component. Quality control data collected by RAMP in 2002 is provided in Section 4.0 and Appendix XX.

2 2002 MONITORING PROGRAM

2.1 APPROACH

Monitoring water quality is a key component of aquatic monitoring programs; however, it does not detect effects on aquatic life caused by unmeasured chemicals, mixtures of chemicals or physical habitat alteration. Therefore, monitoring biological communities that integrate the effects of these complex and varied stressors on a variety of receptors (e.g., fish, benthic invertebrates, wetlands vegetation) may yield a more complete understanding of potential effects.

The Oil Sands Regional Aquatics Monitoring Program (RAMP) stresses the collection of biological data that is relevant to the assessment of effects on the aquatic ecosystem. Sensitive biological indicators were chosen in addition to traditional, chemistry-based monitoring to allow early detection of potential effects related to oil sands developments. Additionally, RAMP has integrated climatic and hydrologic monitoring to determine hydrologic changes and to support the water quality and biological survey data.

The 2002 monitoring program was a continuation of long-term monitoring that began in 1997. It consisted of six main components:

- climate and hydrology, which indicates changes in the quantity of water flowing through rivers and creeks in the Oil Sands Region;
- water and sediment quality in rivers and some wetlands, which indicates habitat quality and potential exposure of fish and invertebrates to organic and inorganic chemicals (water and sediment quality is assessed by chemical analyses and toxicity bioassays);
- benthic invertebrate communities in tributaries and wetlands, which are bioindicators of cumulative effects;
- fish populations in rivers and one lake, which are bioindicators of ecosystem integrity (the emphasis is on regional fish resources and sentinel species);
- water quality in acid sensitive lakes, which is an early warning indicator of potential effects from acid deposition; and
- wetlands aquatic vegetation monitoring, which assesses the ecological health of the wetlands ecosystems.

RAMP has focused on four main aquatic systems within the Oil Sands Region that may be affected by development activities: 1) the Athabasca River; 2) tributaries of the Athabasca River; 3) lakes and wetlands adjacent to developments; and 4) acid sensitive lakes.

The following sections discuss the approach followed by each monitoring component. Details on study design, sampling locations and methods are described in Section 3.

2.1.1 Climate and Hydrology

The RAMP climate and hydrology component measures key elements of the hydrologic cycle directly, in the case of streamflow, lake water level, rainfall and snowfall, or indirectly, in the case of evaporation and evapotransporation, which can be derived from measurements of temperature and solar radiation. The quantity of water in a system affects its capacity to support aquatic and terrestrial biota. Changes in the amount of water in a system may be due to natural fluctuations or due to human activities such as discharges, withdrawals or diversions.

Climatic and hydrologic data are collected for three purposes:

- to place water quality and biological survey data in its proper context, by allowing conditions during water quality, fisheries or aquatic vegetation sampling to be compared to historic mean or extreme conditions;
- to create a record of stream-specific baseline climatic and hydrologic data to support regulatory applications and to meet requirements of regulatory approvals; and
- to calibrate and verify regional hydrologic models that form a basis for environmental impact assessments, operational water management plans and closure reclamation drainage designs.

Long-term monitoring records, or hydrologic models supported by short-term monitoring records, can be used to quantify the response of a lake or stream to measured climatic conditions and thus indicate whether observed hydrologic changes are natural or due to human activity.

Streams in the same region may have differing hydrologic characteristics, primarily depending on topography, vegetation, surficial geology, lake storage, groundwater-surface water interaction and geographic effects on precipitation. For this reason, the RAMP monitoring network has gradually expanded geographically to cover announced oil sands projects. As baseline studies and environmental impact assessments have been completed, monitoring stations have remained to provide data for regulatory reporting and mine operations. In addition, a limited number of stations outside of active areas have been operated to provide data for undisturbed areas. Data from long-term Environment Canada climatic and hydrologic monitoring stations in the region are also integrated into the RAMP database to provide a comprehensive body of data for use by RAMP members.

Automated equipment is used to collect data at RAMP climate and hydrology stations during intervals ranging from 15 minutes to one hour, essentially providing a continuous record during monitoring. Streams that flow year-round are monitored year-round. Smaller streams that tend to freeze to the bottom in winter are monitored during the open-water season only. RAMP also undertakes winter (November to February) monitoring on some streams that are monitored by Environment Canada during the open-water season only.

Field visits are used to check and maintain automated sensors and data loggers at RAMP stations and to undertake manual measurements of water level, streamflow and climatic parameters. The frequency of field visits depends on the length of the period of record for the station, telemetry access conditions and physical access conditions. In general, sites are visited more frequently (up to 12 times per year) if they are new stations with a limited period of record and if they are not equipped with telemetry. Sites that require helicopter access, that can be downloaded from the office, or that have a stable and well-behaved set of field measurements are visited less frequently (as few as five times per year). This is discussed in more detail in subsequent sections.

2.1.2 Water and Sediment Quality

Analysis of water and sediment chemistry provides a direct measure of the suitability of a waterbody to support aquatic life. Changes in water and sediment quality may indicate chemical inputs from point and non-point sources. Monitoring of sediment quality also enables the assessment of the rate of chemical accumulation over time and identification of potential pathways by which aquatic biota may be exposed to hydrophobic chemicals (e.g., polycyclic aromatic hydrocarbons [PAHs]). Therefore, water and sediment quality surveys also provide valuable supporting data to interpret the results of biological surveys.

In order to determine if and how a development may be affecting water and sediment quality, an upstream site is selected (where possible) to act as a reference for comparison with downstream results. Sampling over time clarifies baseline conditions at new sites as well as temporal trends at existing sites, thus determining if there are changes over time.

Existing RAMP water quality sites are monitored annually in the fall and periodically in winter, because water levels and the assimilative capacity of the receiving waterbodies are generally at their lowest in fall and winter. One year of seasonal sampling is conducted at new locations in waterbodies already monitored by RAMP and three years of seasonal baseline information is collected at sites in new waterbodies added to RAMP.

Existing RAMP sediment quality sites in the Athabasca River are monitored annually in the fall. In this river, bottom sediments are very transient (i.e., almost completely flushed during the spring freshet) with accumulation of fine sediment occurring from late spring to late fall. In most other waterbodies, sampling is conducted every three years in the fall. These waterbodies are sampled less frequently, because they are generally exposed to less cumulative development and sedimentation rates are likely lower than in the Athabasca River. New sediment quality sites added to RAMP are monitored every fall for the first three years, with toxicity testing being conducted for the first two years to compile baseline data.

2.1.3 Benthic Invertebrate Community

Benthic invertebrate (benthos) monitoring complements water and sediment quality monitoring by providing an indication of the biological effects of disturbances. Benthic invertebrates are ubiquitous in freshwaters and form communities that reflect the physical and chemical characteristics of their habitat (Rosenberg and Resh 1993). They are sedentary, which render them useful for monitoring at the local or regional scale. Because of their relatively long life cycles, they reflect environmental quality over a period representing the length of their aquatic life stage (months to years), rather than serving as snapshot-type indicators. Benthic invertebrates also represent a food source for many fish species, making them an important feature of fish habitat.

The benthic invertebrate component of RAMP consists of annual baseline sampling of selected tributaries and lakes over a five-year period, followed by continued monitoring at a frequency that will be adjusted to the development schedules of nearby oil sands operations. The fall 2002 field program included sampling of the Calumet, Christina, Clearwater, Ells, MacKay, Muskeg, Steepbank and Tar rivers, Fort and Jackpine creeks, and Kearl, McClelland and Shipyard lakes. Three sites were also sampled in the Athabasca River Delta. The approach to be adopted for monitoring the Athabasca River mainstem will be developed during 2003.

The tributary monitoring approach adopted by RAMP has focused on the lower reach of each river to allow detection of the cumulative effects of all developments within each basin, or followed the control-impact (upstream-downstream) approach. To increase the amount of reference site data in the RAMP database and allow upstream-downstream comparisons, tributary monitoring is gradually being expanded by also sampling the upper river reaches where feasible. To monitor lakes, sampling effort is distributed over the entire open-water area of a lake, but is restricted by depth to reduce variation in the data. Both river and lake sampling includes the collection of a full suite of supporting data to allow separation of the effects of natural variation on benthic community structure from the effects of oil sands developments.

The objective of the 2002 benthic program was to further characterize natural variation in the rivers and lakes monitored, before the commencement of intensive oil sands development within their drainage basins. Some new development has already occurred in the Muskeg River and Shipyard Lake basins, including forest clearing, muskeg and overburden dewatering, and construction of roads and camps. However, because the likely impacts of these activities on benthic invertebrate habitat are low at this time, the 2002 monitoring results are tentatively considered part of the baseline data. Trends over time in benthic community structure and potential changes related to oil sands development in the waterbodies monitored by RAMP were examined in the Five Year Report (Golder 2003a), based on data collected by RAMP and previous monitoring. Hence, this report provides a summary of the collected data, with only brief evaluations of potential effects.

2.1.4 Fish Populations

RAMP monitors fish populations for a variety of reasons. Fish are important ecological indicators as they integrate the effects of natural and anthropogenic factors. More significantly, fish are a highly valued component of the aquatic ecosystem. Therefore, there is a public and regulatory expectation that fish will be monitored.

Within the Oil Sands Region there are two distinct yet related issues that need to be addressed by the fisheries component of RAMP. Firstly, it is necessary to ensure that fish populations are not adversely affected by increased oil sands development. The continued use of available fisheries resources for human consumption is of specific interest. Secondly, it is important to maintain the ecological integrity of aquatic ecosystems. With regards to fish, it is important to ensure that there are no adverse effects on ecological attributes such as growth, reproduction and survival.

Fish tissue assessments are conducted by RAMP to monitor contaminant levels in relation to the suitability of the fish resource for human consumption and potential direct or indirect toxicity effects on fish. As part of ongoing monitoring activities, muscle tissue samples were collected from lake whitefish and walleye in the Athabasca River and northern pike in the Muskeg River. Previous tissue collections were conducted in 1998 and 2001 in the Athabasca River and in 2001 in the Muskeg River. As in the past, the tissue samples were analyzed for concentrations of inorganic contaminants (i.e., trace metals, including mercury). Based on finding high mercury concentrations in some species relative to fish consumption guidelines, mercury analysis was expanded in 2002 to include a larger number of fish per species. Analysis of organic contaminants (i.e., target and alkylated PAHs) was conducted in the past but was excluded from the 2002 program because these compounds can be metabolized by fish and have not shown any accumulation in tissue samples. Due to general concerns related to possible tainting of fish flesh, organic compounds identified as potential tainting agents were added to the list of parameters analyzed in 2002.

A program to sample fish tissues in regionally important lakes was initiated in 2002, with sampling to occur opportunistically in conjunction with fisheries investigations conducted by other agencies. Gregoire Lake was the first waterbody to be sampled because the Alberta Sustainable Resource Development (ASRD) conducted a test-netting program there in the fall of 2002. Tissue samples were collected from lake whitefish, northern pike and walleye for analysis of trace metals (including mercury).

The purpose of the general fish inventory was to monitor species presence, relative abundance and population parameters in the selected watercourses. In the Athabasca River, the inventory was conducted by boat electrofishing and was designed to assess populations of large-bodied fish species. The Athabasca River inventory is currently being conducted on a three-year cycle, following previous inventories completed in 1997, 1998 and 1999. In 2002, the inventory was reduced from multi-season sampling to sampling during the spring period only.

Fish inventories were also conducted in the Muskeg River basin, including the lower Muskeg River and lower Jackpine Creek. Fisheries inventories have been conducted previously for RAMP in these watercourses: in 1997 and 2001 for the Muskeg River and in 2001 for Jackpine Creek. The inventory was conducted in the summer using multi-gear sampling. Following the 1997 inventory, the rationale document (Golder 2000d) called for a population estimate study for these two watercourses, with the study specifically targeting young-of-the-year and juvenile Arctic grayling. However, recent fisheries information suggested that the number of Arctic grayling utilizing the Muskeg River basin had declined from previously recorded levels. In 2001, a general fish inventory program was initiated, rather than the Arctic grayling population estimate study originally planned. The 2002 study was used to assess fish populations in a year when the Muskeg River counting fence was not deployed and to check for the presence of Arctic grayling.

The Athabasca River sentinel species component involved monitoring population and health parameters for a small-bodied fish species (i.e., trout-perch) as an indicator of ecosystem health. The sentinel fish species is used to assess potential effects of stressors (e.g., industrial development) on fish populations. The performance (e.g., growth, condition, reproductive parameters) of the sentinel species inhabiting a particular site of interest (e.g., Oil Sands Region) is characterized relative to reference and/or historical performance data. Populations of trout-perch in the Athabasca River were evaluated in comparison to RAMP data and to populations sampled in reference areas upstream of the Oil Sands Region. A reference site upstream of the Fort McMurray Sewage Treatment Plant (STP) was added to the program in 2002 in an attempt to separate potential influences of the STP and oil sands activity.

The fyke net monitoring program was established as a one-year (i.e., non-core) study designed to assess movements of small-bodied forage species and patterns of use in small tributary streams in the Muskeg River watershed relative to potential watercourse disruptions. Fyke net monitoring involved using trap nets in selected tributaries to the Muskeg River to monitor fish movements; upstream movements were assessed in the spring and downstream movements in the fall for Wapasu and Muskeg creeks. General inventory sampling was also conducted in these two watercourses to help assess the fish populations present.

Due to failure of the Muskeg River fish counting fence in 2001, additional preparatory work was recommended prior to deploying the fence in 2003. This included identifying a better location(s) for the counting fence. The lower Muskeg River was examined in the summer and fall in 2002 to locate and assess candidate fence sites relative to channel profile, substrate conditions, hydraulic characteristics and access.

The IBI is a community-based approach for monitoring potential changes in aquatic ecosystems. It has been suggested as an alternative to RAMP inventory and/or sentinel species monitoring. In 2002, a test program was conducted in the Athabasca River using the IBI sampling approach to assess the suitability of this technique in the Oil Sands Region. This program was conducted jointly by Alberta-Pacific Forest Industries Inc. (AlPac), ASRD and Syncrude Canada Ltd. (Syncrude).

2.1.5 Acid Sensitive Lakes

The RAMP long-term acidification monitoring network was established in 1999. The main objective of the network is to monitor the water chemistry of acid sensitive lakes in northeastern Alberta, with changes in water chemistry serving as early warning indicators of potential effects caused by acidic deposition. Lakes in the network are monitored annually for field parameters, acidity-related parameters, carbon parameters, major ions, nutrients and productivity indicators.

The objective of the monitoring network in 2002 was to continue collecting water chemistry data from lakes sampled in the past as well as enhance the network by adding new lakes near the area of heaviest oil sands development. As a result, 17 lakes were added to the network, increasing the total number of lakes sampled to 49 in 2002 compared to 32 lakes sampled in 2001. The lakes sampled in 2002 included 39 lakes in the Oil Sands Region, five lakes in the Caribou Mountains and five lakes on the Canadian Shield. The lakes in the Caribou Mountains and on the Canadian Shield are included for comparison purposes, since they are distant from sources of acidifying emissions relative to the lakes in the Oil Sands Region.

Acid sensitive lake monitoring is a partnership between RAMP and Alberta Environment (AENV). This RAMP component routinely interacts with the NO_X and SO_X Management Working Group (NSMWG) to ensure that acid sensitive lake monitoring reflects the latest scientific developments and to ensure consistency with analytical techniques (both chemistry and data analyses) employed in the Oil Sands Region.

2.1.6 Aquatic Vegetation

Aquatic vegetation communities in Isadore's, Kearl and Shipyard lakes are monitored on a regular basis as part of the RAMP core sampling program. The current RAMP sampling program includes airphoto interpretation and field sampling every three years. Field sampling was done in 1997, 1998 and again in 2001. In years when field sampling is not scheduled, aerial photographs are assessed and compared to the previous years' photos if they are available.

In 1997, the objective of the RAMP wetlands vegetation survey as stated in the Approach (Golder 1998) was to document baseline conditions as a reference point for future monitoring.

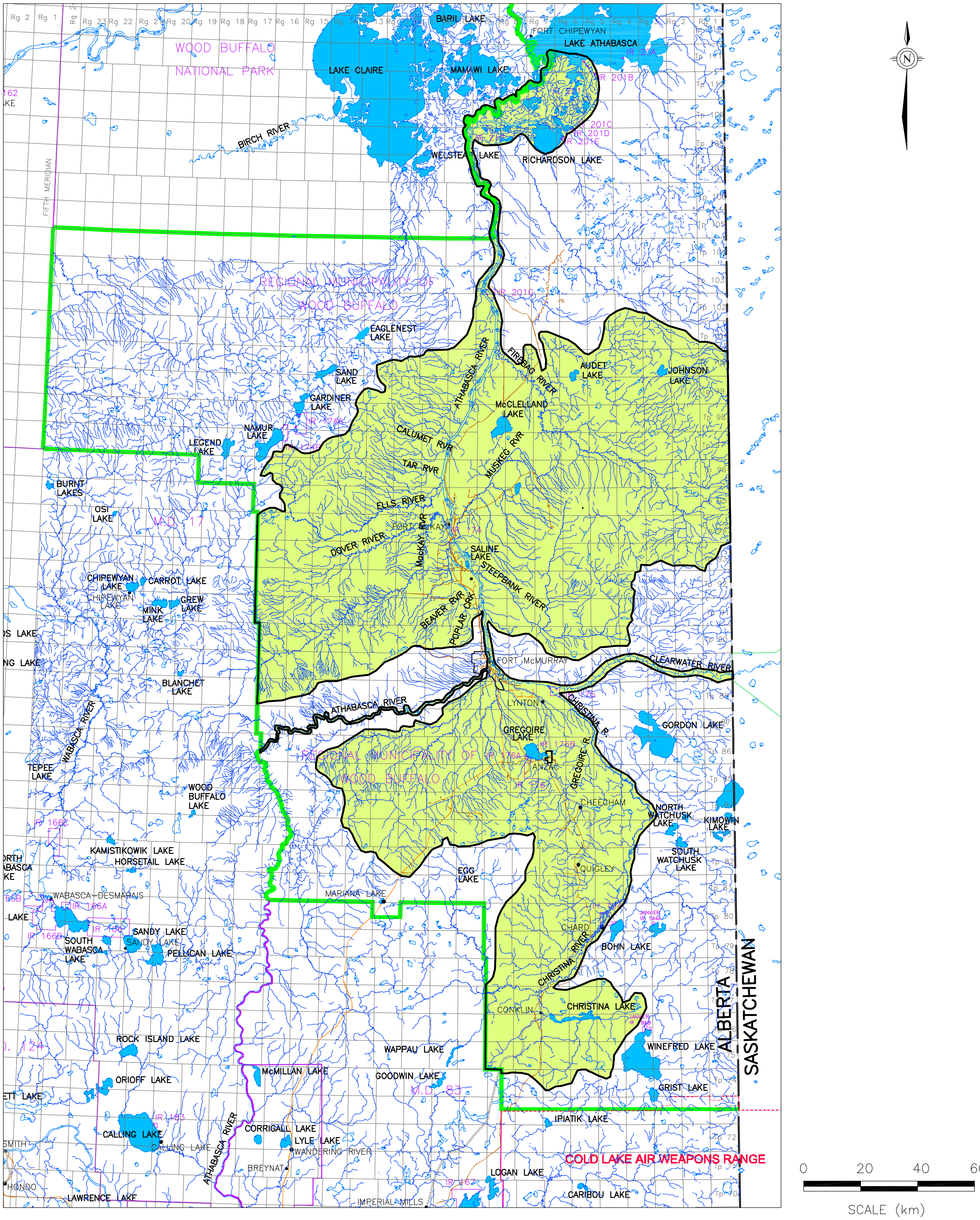
During the first three years of data collection and reporting for the RAMP wetlands vegetation program, the baseline conditions were assessed using a combination of qualitative description and analysis. At the 2002 RAMP

Technical Subcommittee meeting, the Aquatic Vegetation Component Subgroup decided to move the study towards a more quantitative and analytic focus in future years. The 2001 report represented the transition in that direction. The 2002 report uses aerial photography interpretation to compare parameters across the three core lakes. Additionally, McClelland Lake has been added for future assessment.

2.2 RAMP STUDY AREA

The study area for RAMP includes the Regional Municipality of Wood Buffalo (Figure 2.1). The RAMP study area is consistent with the Cumulative Environmental Management Association, Water Working Group (CEMA WWG) study area.

A focus study area is located within the RAMP study area (Figure 2.1). The focus area includes watersheds where oil sands development is occurring or planned. As well, areas downstream of the proposed developments, such as the lower Athabasca River and the Athabasca River Delta are also included. The Clearwater River and the Athabasca River upstream of Fort McMurray are included as reference areas.



LEGEND

RAMP REGIONAL STUDY AREA

RAMP FOCUS STUDY AREA

REFERENCE

ORIGINAL BASE MAP OF ALBERTA WAS PRODUCED IN 10TM FORMAT. THE MAP WAS CONVERTED FROM DGN FORMAT TO DWG FORMAT IN NAD 83 ZONE 12 UTM PROJECTION.

PROJECT

RAMP 2002

TITLE

RAMP STUDY AREA AND FOCUS AREA

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. STUDY AREA	
DESIGN	LG	11/03/03	SCALE AS SHOWN	REV. 0
CADD	GB	20/01/03		
CHECK				
REVIEW				

FIGURE: 2.1

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: STUDY AREA.dwg Mar 15, 2003 - 4:41pm

3 METHODS

3.1 CLIMATE AND HYDROLOGY

3.1.1 Overview

The activities of the Climate and Hydrology Monitoring Program for 2002 consisted of the following:

- monitoring climate parameters at six stations and conducting one snow course survey in the Birch Mountains east slope basins;
- monitoring stream flows and water levels at 12 stations on the Athabasca River tributaries;
- monitoring stream flows and water levels at one station on the Athabasca River mainstem;
- monitoring stream flows and water levels at 14 stations in the Muskeg River basin, as well as monitoring climate parameters at one station;
- monitoring stream flows and water levels at four stations in the watersheds south of Gregoire Lake;
- monitoring water levels at three wetland stations, as well as monitoring lake discharges at one station; and
- integrating regional Environment Canada climatic and hydrologic monitoring data into the RAMP database.

Specific management tasks for the climate and hydrology program included:

- updating the RAMP Program Design and Rationale document as required;
- preparing specific work instructions (SWIs) for each climate and hydrology field-trip;
- reviewing health and safety plans for climate and hydrology field trips;
- chairing pre-field meetings to discuss SWIs and logistics and to review relevant technical procedures with field crew(s);
- liaising with field crews to obtain updates on work completed while the crews were in the field;
- chairing post-field meetings with field staff to discuss monitoring results, problems encountered or areas of concern or improvement

- reviewing and authorizing purchase of new or replacement station sensors for continuous data measurement at the climate and hydrology stations;
- applying for permits for new station installation and major maintenance work;
- performing internal checks of logged and manually measured raw data once they were received to ensure data quality;
- overseeing QA/QC of data and reviewing QA/QC issues with field staff;
- acquiring and integrating data from other agencies for inclusion in the RAMP database;
- processing requests for historic and unpublished data for RAMP members; and
- managing data analysis and preparation of monthly and annual reports.

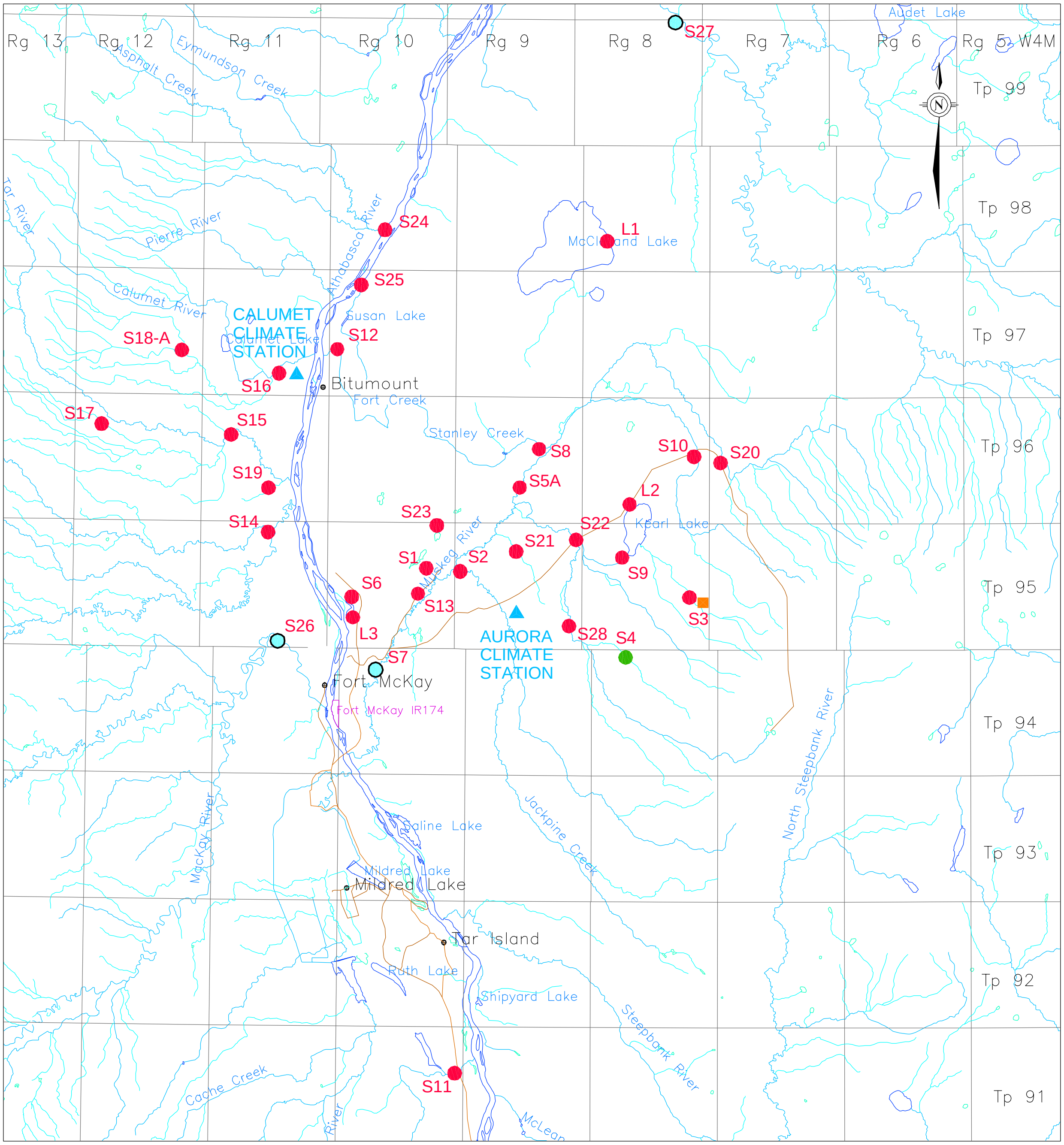
3.1.2 Station Locations

The climatic and hydrologic data documented in this report were collected from January to December 2002. The 2002 program included Aurora Climate Station (RAMP Station C1) and the following hydrologic stations:

- Alsands Drain (S1);
- Jackpine Creek (S2);
- Iyinimin Creek (S3) including rainfall gauge;
- Blackfly Creek (S4) (inactive in 2001);
- Muskeg River Aurora (S5A) including barometric pressure sensor;
- Mills Creek (S6);
- Muskeg River WSC (S7);
- Stanley Creek (S8);
- Kearl Lake Outlet Creek (S9);
- Wapasu Creek (S10);
- Poplar Creek (S11);
- Fort Creek (S12);
- Albian Sands Pond #3 (S13);
- Ells River (S14);
- Tar River (S15);

- Calumet River (S16) including rainfall and snowfall gauges and air temperature sensor;
- Upland Tar River (S17);
- Upland Calumet River (S18A);
- Lowland Tar River (S19) including rainfall gauge;
- Upland Muskeg River (S20);
- Shelley Creek (S21);
- Muskeg Creek (S22);
- Aurora Boundary Weir (S23);
- Athabasca River (S24);
- Susan Lake Outlet Creek (S25);
- MacKay River WSC (S26);
- Firebag River WSC (S27);
- Khahago Creek (S28);
- Christina River (S29) including rainfall gauge;
- Hangingstone River (S30);
- Hangingstone Creek (S31);
- Surmont Creek (S32);
- McClelland Lake (L1) including rainfall gauge;
- Kearl Lake (L2); and
- Isadore's Lake (L3).

Locations of RAMP climatic and hydrologic stations north of Fort McMurray are shown on Figure 3.1 and those south of Fort McMurray are shown on Figure 3.2. Locations of the 2001 and 2002 Birch Mountains east slope basins snow course survey sites are shown on Figure 3.3.



LEGEND

- ACTIVE HYDROLOGIC STATION (SUMMER OR YEAR-ROUND MONITORING BY RAMP)
- ACTIVE HYDROLOGIC STATION (WINTER MONITORING BY RAMP; SUMMER MONITORING BY ENVIRONMENT CANADA)
- INACTIVE HYDROLOGIC STATION
- RAMP CLIMATE STATION
- RAMP RAIN GAUGE

10 0 10
SCALE KILOMETRES

NOTE

STATION S4 WAS NOT OPERATIONAL IN 2001

REFERENCE

DIGITAL DATA 74D, 74E, 74I, 84A, AND 84H FROM RESOURCE DATA DIVISION ALBERTA ENVIRONMENT PROTECTION, 1997.

PROJECT

RAMP 2002

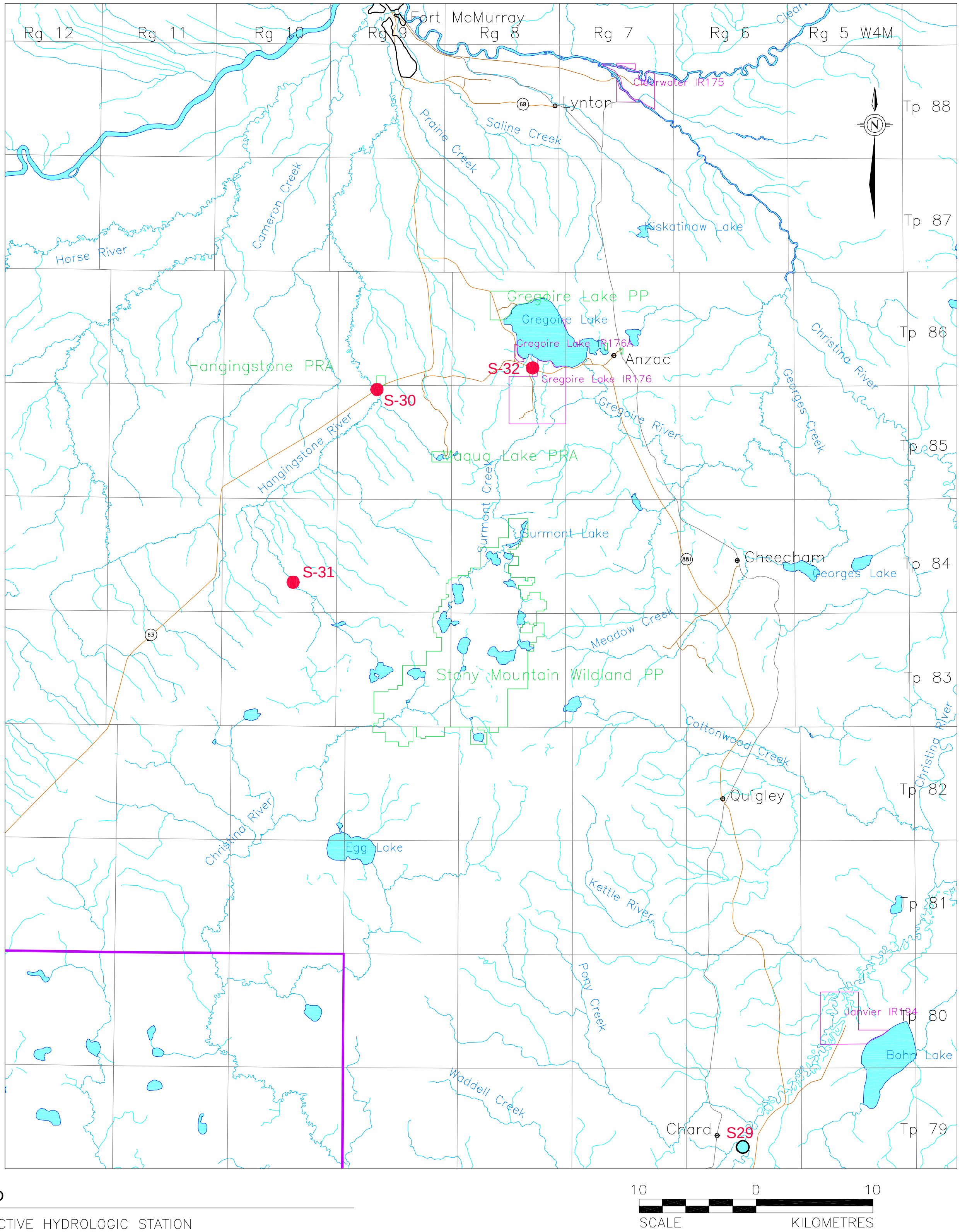
TITLE

LOCATIONS OF RAMP CLIMATIC AND HYDROLOGIC MONITORING STATIONS NORTH OF FORT McMURRAY

Golder Associates
Calgary, Alberta

PROJECT	No. 022-2301.5300		FILE No.	climatic and hydro
DESIGN	CS	19/02/03	SCALE AS SHOWN	REV. 0
CADD	AS	06/03/03		
CHECK			**FIGURE: 3.1**	
REVIEW				

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Climatic and Hydrologic monitoring stations.dwg Mar 15, 2003 - 4:43pm



LEGEND

- ACTIVE HYDROLOGIC STATION (SUMMER OR YEAR–ROUND MONITORING BY RAMP)
- ACTIVE HYDROLOGIC STATION (WINTER MONITORING BY RAMP; SUMMER MONITORING BY ENVIRONMENT CANADA)

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUG. 2001. NAD 83 ZONE 12. SHEETS 74D, E AND L IN NAD 27, ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG, 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83, UTM ZONE 12.

PROJECT

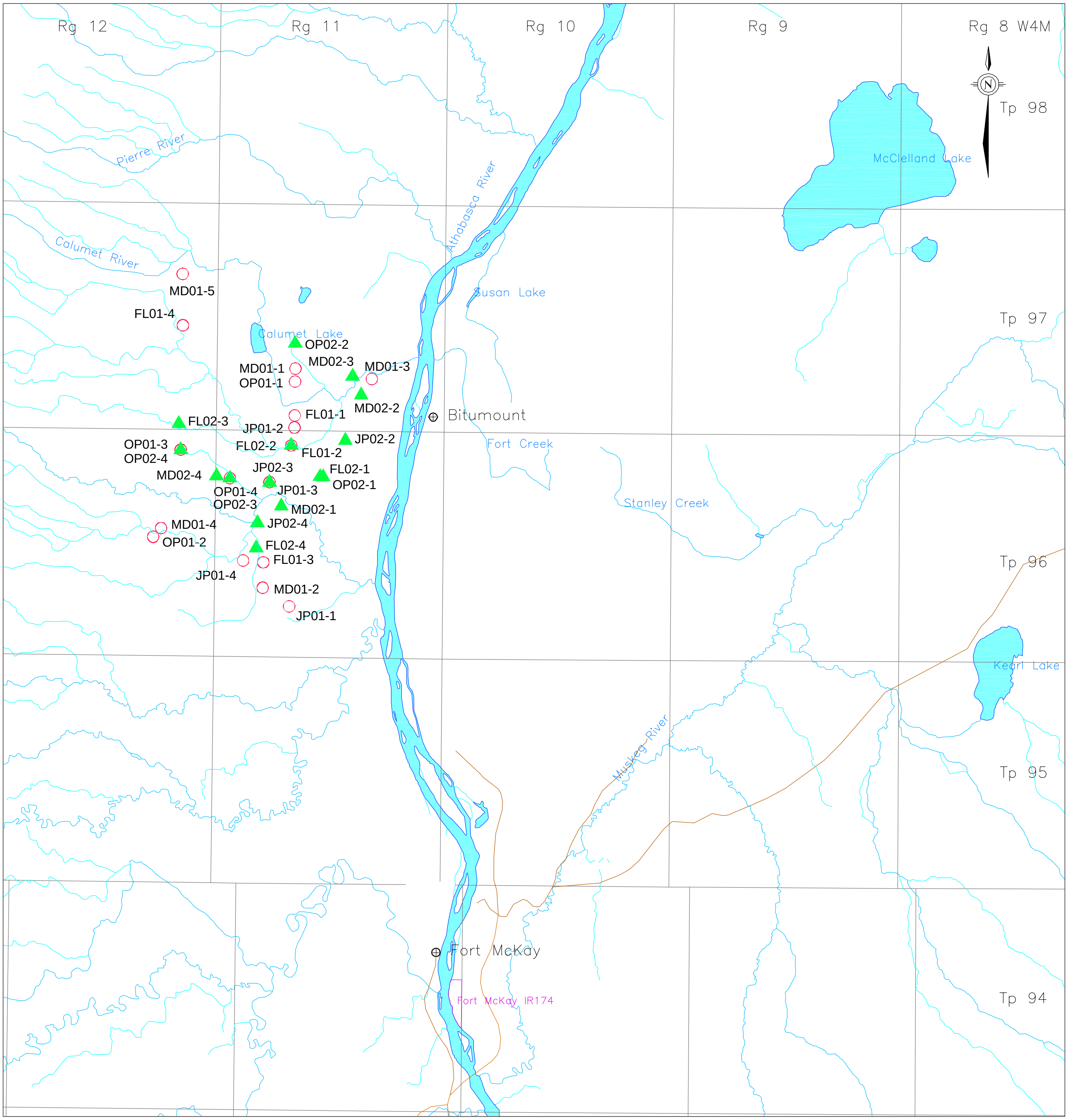
RAMP 2002

TITLE

LOCATIONS OF RAMP CLIMATIC AND HYDROLOGIC MONITORING STATIONS SOUTH OF FORT McMURRAY

Golder Associates
Calgary, Alberta

PROJECT	No. 022–2301.5300		FILE No. climat hydro south	
DESIGN	CS	19/02/03	SCALE AS SHOWN	REV. 0
CADD	AS	06/03/03		
CHECK			FIGURE: 3.2	
REVIEW				



LEGEND

FL	FLAT LOW LYING
OP	OPEN LAND OR LAKE
MD	MIXED DECIDUOUS
JP	JACK PINE
○ 01	2001 SNOW COURSE SURVEY
▲ 02	2002 SNOW COURSE SURVEY

5 0 5
SCALE KILOMETRES

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUG. 2001. NAD 83 ZONE 12. SHEETS 74D, E AND L IN NAD 27, ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG, 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83, UTM ZONE 12.

PROJECT

RAMP 2002

TITLE

LOCATIONS OF 2001 AND 2002 BIRCH MOUNTAIN EAST SLOPE BASINS SNOW COURSE SURVEY SITES

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. snow course survey	
DESIGN	CS	19/02/03	SCALE AS SHOWN	REV. 0
CADD	AS	06/03/03	**FIGURE: 3.3**	
CHECK				
REVIEW				

3.1.3 Field Methods

Field crews undertaking climatic and hydrologic monitoring tasks require two persons, at least one of whom has experience in the installation and maintenance of instrumentation, including data loggers, telemetry equipment and environmental sensors, and in the operation of levelling and streamflow measurement equipment.

During each field trip, the field crew performed the following tasks:

- measured stream flows at specified stations;
- measured water levels at specified stations;
- measured climatic parameters at specified stations;
- collected water samples at specified stations for analysis of Total Suspended Solids;
- downloaded data loggers at non-telemetry stations;
- recorded data logger readings at telemetry and non-telemetry stations; and
- performed routine maintenance and any required repairs at all climate and hydrology stations.

Measurement of stream discharges and water levels was performed according to Golder Technical Procedure 8-24-0 (Golder 1997a).

Snow course surveys were performed according to established protocols used in previous years. At each snow course survey plot, snow depths and snow densities were measured as follows:

- **Snow Depth Measurements**

  At each plot, 30 depth measurements were made at randomly selected locations on a large circle. These depth measurements were taken by inserting a sharp rebar into the snowpack, reading the snowline mark and then measuring it with a tape.

- **Snow Density Measurement**

  Three density measurements were taken at each plot, using an Atmospheric Environment Services (AES) density sampler. The AES sampler was inserted carefully into the snowpack. Snow depth was read on the tube, when the corer reached the soil surface. The corer was then inserted/twisted more deeply into the ground to get a plug of soil to prevent the granular snow falling out of the bottom of the snow profile. The tube weight was measured (with and without snow) using the spring scale. The units of the spring scale directly provided the snow water equivalent (SWE) of the snowpack in centimetres.

Additional notes were taken on vegetation cover type, colour of snow surface, and snow consistency.

3.1.4 Continuous Monitoring

Automated equipment was used to collect data at RAMP climate and hydrology stations on intervals ranging from 15 minutes to one hour, essentially providing a continuous record during the monitoring period. Streams that flow year-round were monitored year-round. Smaller streams that tend to freeze to the bottom in winter were monitored during open-water season only. RAMP also performed winter (November to February) monitoring on selected streams that are monitored by Environment Canada during the open-water season only, including the Firebag, Muskeg, McKay, Firebag and Christina Rivers.

Monitoring stations with telemetry were downloaded on a weekly basis and stations without telemetry were downloaded during site visits. Data were checked during the download to identify possible sensor failures.

Field visits were used to check and maintain automated sensors and data loggers at RAMP stations and to undertake manual measurements of water level, stream flow and climatic parameters. The frequency of field visits depended on the length of the period of record for the station, telemetry access conditions and physical access conditions. In general, sites were visited more frequently (up to 12 times per year) if they were new stations with a limited period of record and if they were not equipped with telemetry. Sites that required helicopter access, that were downloaded from the office, or that had a stable and well-behaved set of field measurements, were visited less frequently (as few as four times per year).

3.1.5 Data Analysis

For all stations, raw field data, including discharge and water level measurements, were processed during or shortly after each field visit. Continuously monitored data from selected operational stations, including S1 – Alsands Drain, S5A – Muskeg River Aurora, S13 – Albian Pond #3 and S23 – Aurora Boundary Weir, were processed on a monthly basis. This was necessary to satisfy regulatory requirements for the Syncrude Aurora North and Albian Sands Muskeg River Mine Projects.

For other stations, continuously monitored data were processed when the field season was complete and a full set of discharge and water level measurements were available to update the station's stage-discharge rating curve. Data were processed earlier if preliminary monitoring results were requested by a RAMP member, or if possible problems with the station were identified.

3.2 WATER QUALITY

3.2.1 Overview

In 2002, water quality data were collected from the lower Athabasca River watershed by RAMP, Alberta Environment (AENV), Albian Sands Energy Inc. (Albian) and Syncrude Canada Ltd. (Syncrude). The scope of the 2002 water quality survey comprises the following elements:

- continued monitoring of the same set of water quality parameters analyzed in 2001;
- re-sampling the mouths of Jackpine, Muskeg, McLean, Poplar, Fort and Stanley creeks, and the MacKay and Steepbank rivers;
- re-sampling the Muskeg River at five locations (i.e., the river mouth, upstream of the Canterra Road crossing, and upstream of Jackpine, Muskeg and Wapasu creeks);
- re-sampling Kearl, Shipyard and McClelland lakes;
- re-sampling the east and west portions of the Athabasca River upstream of Donald Creek, the Steepbank River, the Muskeg River and Fort Creek;
- re-sampling the Athabasca River upstream of Fort McMurray and near Old Fort;
- continued monitoring of seasonal water temperatures in the Muskeg River, McLean Creek, Fort Creek and the Clearwater River;
- re-sampling the Clearwater River upstream of Fort McMurray and upstream of the Christina River;
- continued monitoring of selected lakes in and around the OPTI Long Lake project area;
- sampling the east portion of the Athabasca River upstream of the Firebag River, and collecting cross channel composite samples from the

Athabasca River upstream of Donald Creek and downstream of existing oil sands development;

- sampling the mouths of the Tar, Ells and Calumet rivers; and
- expanding the program to include two locations on the Firebag and Christina rivers, as well as upstream sites on the Steepbank, North Steepbank and MacKay rivers.

This work included discrete water sampling in the following waterbodies:

- the Athabasca River (completed by RAMP and AENV);
- the Clearwater and Christina rivers (completed by RAMP);
- McLean Creek, Poplar Creek, the Steepbank, North Steepbank, MacKay, Ells, Tar, Calumet and Firebag rivers, and Fort Creek (completed by RAMP);
- the Muskeg River (completed by RAMP, Albian and Syncrude);
- Jackpine, Muskeg and Stanley creeks (completed by RAMP); and
- Kearl, Shipyard and McClelland lakes (complete by RAMP).

As well, water temperature, pH, dissolved oxygen (DO) and/or conductivity levels were monitored continuously at the following locations:

- the Clearwater River (completed by RAMP);
- McLean Creek (completed by RAMP);
- Fort Creek (completed by RAMP);
- the Muskeg River (completed by RAMP and Alberta Environment [AENV]); and
- the Alsands Drain (completed by RAMP).

Water quality sample locations are shown in Figures 3.4 and 3.5. The specific methods used to collect this information are discussed in Sections 3.2.2 and 3.2.3.

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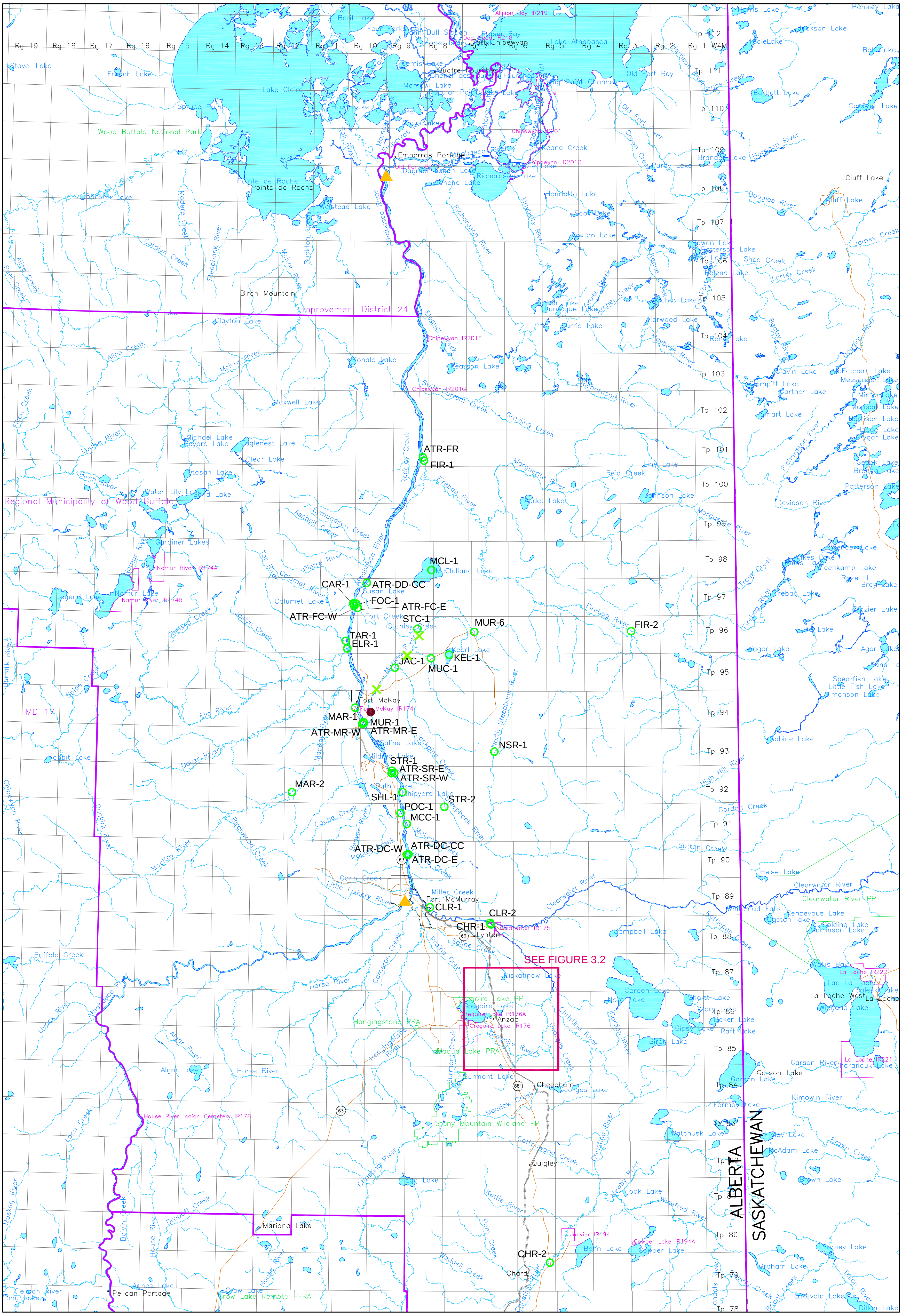


LEGEND

- WATER QUALITY SAMPLING SITE
- CONTINUOUS MONITORING SITE (DISSOLVED OXYGEN, pH, TEMPERATURE AND CONDUCTIVITY) MAINTAINED BY AENV
- AENV WATER QUALITY SAMPLING SITE
- INDUSTRY WATER QUALITY SAMPLING SITE

20 0 20
SCALE KILOMETRES

REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001. SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001. DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

RAMP 2002

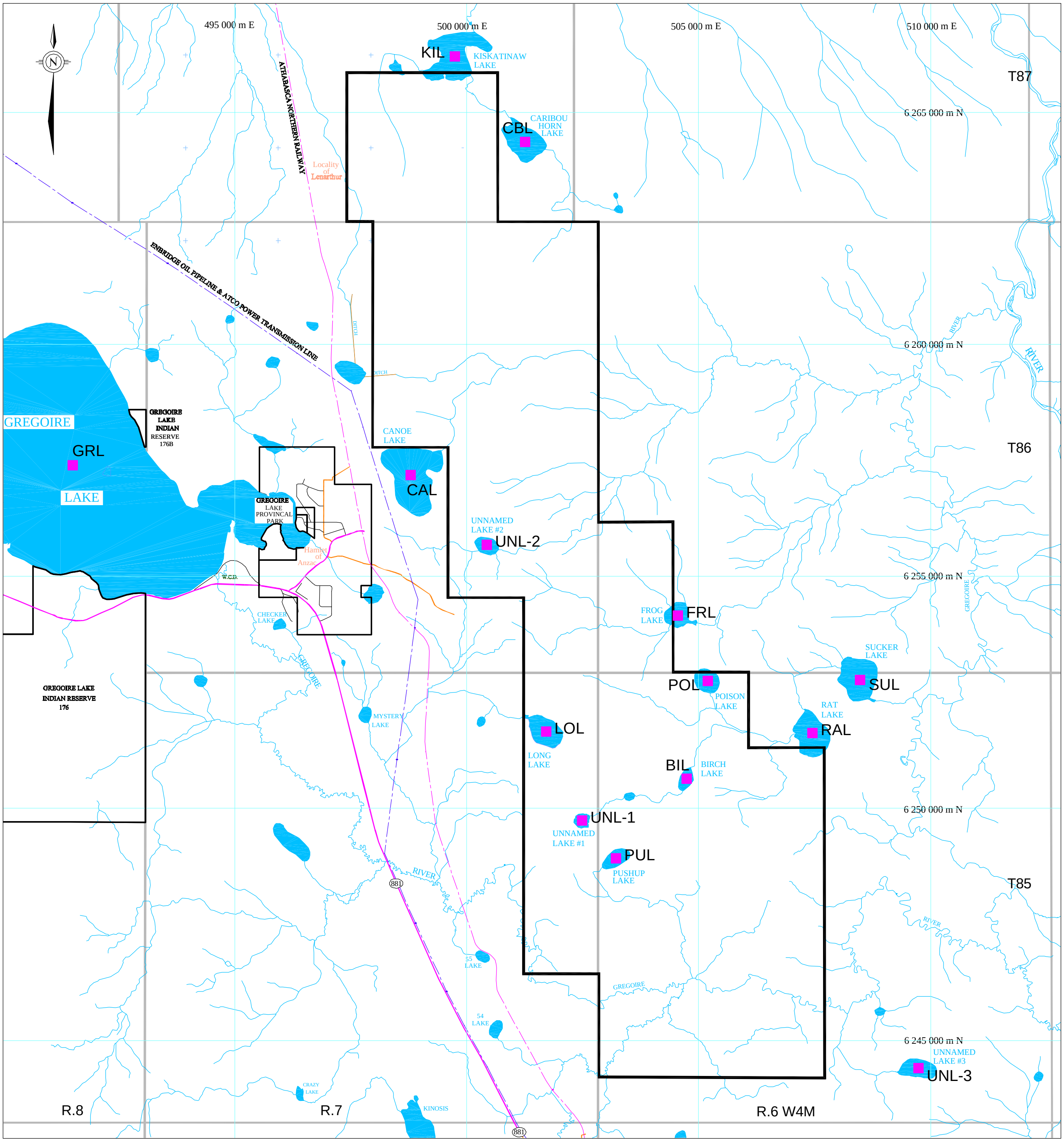
TITLE

WATER QUALITY SAMPLING SITES, 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Ramp-Water Sites	
DESIGN	TD	18/12/02	SCALE AS SHOWN	REV. 0
CADD	JMA	12/02/03		
CHECK				
REVIEW				

FIGURE: 3.4



LEGEND

- OPTI PROJECT BOUNDARY
- ROAD, HARD SURFACE, ALL WEATHER, 2 OR MORE LANES
- ROAD, LOOSE OR STABILIZED SURFACE, ALL WEATHER
- RAILWAY
- PIPELINE
- WATER QUALITY SAMPLING SITE

2.5 0 2.5
SCALE KILOMETRES

NOTES

TOPOGRAPHY/CULTURE SUPPLIED UNDER LICENSE FROM AltaLIS LTD.
KEY MOOSE/CARIBOU ZONES FROM WATERWAYS FOREST AREA – NEB1 November 1998
CULTURE UPDATED FROM AERIAL PHOTOGRAPHY FLOWN IN 1992
DATA FROM OPTI CANADA INC. (CH11x17A.DWG) NAD83

PROJECT

RAMP 2002

TITLE

WATER QUALITY SAMPLING SITES INCLUDED IN THE OPTI LAKES SURVEY, 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022–2301.5300			FILE No. 2002Wtr–Qual_OPTI	
DESIGN	TH	12/02/03	SCALE AS SHOWN	REV. 0
CADD	TVS	12/03/03	**FIGURE: 3.5**	
CHECK				
REVIEW				

R:\CAD\2300\022–2301\5300\Final 2002 Annual Report\ Drawing file: 2002Wtr–Qual_OPTI.dwg Mar 15, 2003 – 4:56pm

3.2.2 Discrete Sample Collection and Analysis

3.2.2.1 General Methods Specific to RAMP

All discrete water quality samples collected by RAMP were collected, preserved, stored and shipped in accordance with Golder Associates Technical Procedure 8.3-1 (Golder 1997b). Sample locations were determined by Global Positioning System (GPS), and all samples were collected from a depth of approximately 30 cm, using clean sample equipment. Field measurements, including pH, conductivity, temperature and DO levels, were recorded at each sample site, except where noted below.

Following sample collection, all samples were split. In winter, spring and summer, one portion was shipped to Enviro-Test Laboratories (ETL) in Edmonton, Alberta, for analysis of the standard RAMP water quality parameter list (Table 3.1), which includes conventional parameters, major ions, nutrients, recoverable hydrocarbons, naphthenic acids, and total and dissolved metals. Another portion was sent to the Alberta Research Council (ARC-Vegreville) in Vegreville, Alberta, for ultra-low level analysis of total mercury and total silver.

In the fall, a similar test procedure was used. However, due to data quality concerns, all total and dissolved metal analyses were completed by ARC-Vegreville, rather than by ETL. Waters from three sample sites (i.e., mouth of the Steepbank River and Muskeg River upstream of Wapasu Creek) were also submitted in the fall of 2002 to Syncrude's research facilities in Edmonton, Alberta, for detailed Naphthenic Acid analysis. The results of these analyses were not yet available at the time this report was prepared. Descriptions of the analytical methods used by each laboratory are provided in Appendix VIII.

During the winter sampling survey, dissolved metal samples were field filtered. This practice was abandoned for the rest of the sampling program, because of concerns that the filtering equipment was resulting in sample contamination. As a result, spring, summer and fall dissolved metal samples were shipped unpreserved to the relevant laboratory for filtering and preservation. As all samples arrived at the relevant laboratory within 48 hours of collection, it is unlikely that this deviation from standard collection and preservation protocols affected the sample results (A. Wharmby, ARC-Vegreville, pers. com.).

Table 3.1 Standard RAMP Water Quality Parameter List

Group Name	Individual Parameters
conventional parameters	colour
	dissolved organic carbon
	pH
	specific conductance
	total alkalinity
	total dissolved solids
	total hardness
	total organic carbon
	total suspended solids
major ions	bicarbonate
	calcium
	carbonate
	chloride
	magnesium
	potassium
	sodium
	sulphate
	sulphide
nutrients	nitrate + nitrite
	nitrogen - ammonia
	nitrogen - kjeldahl
	phosphorus - dissolved
	phosphorus - total
	chlorophyll *a*
biological oxygen demand	biological oxygen demand
organics	naphthenic acids
	total phenolics
	total recoverable hydrocarbons
metals (total and dissolved)	aluminum (Al)
	antimony (Sb)
	arsenic (As)
	barium (Ba)
	beryllium (Be)
	boron (B)
	cadmium (Cd)
	chromium (Cr)
	cobalt (Co)
	copper (Cu)
	iron (Fe)
	lead (Pb)
	lithium (Li)
	manganese (Mn)
	mercury (Hg)
	molybdenum (Mo)
	nickel (Ni)
	selenium (Se)
	silver (Ag)
	strontium (Sr)
	thallium (Tl)
	titanium (Ti)
	uranium (U)
	vanadium (V)
	zinc (Zn)

3.2.2.2 Athabasca River Mainstem

Conducted by RAMP

In the fall of 2002, east and west bank composite water samples were collected from the Athabasca River approximately 100 m upstream of each of the following tributaries: Donald Creek, the Steepbank River, the Muskeg River and Fort Creek. An east bank composite sample was also collected from upstream of the Firebag River in the fall of 2002. The sampling schedule is outlined in Table 3.2. Each 15 L composite sample was created by combining three 1 L grab samples collected from five, approximately equally-spaced, locations positioned between the respective river bank and 25% of the river width.

Five additional 15 L cross-channel composite water samples were collected from the Athabasca River downstream of existing development (i.e., several km downstream of Fort Creek near the outlet to Susan Lake - Figure 3.4). These samples were collected at a rate of one per season, with a second winter sample collected in January 2003. A cross-channel composite sample was also collected in the fall of 2003 from upstream of the Donald Creek site, according to the RAMP Program Design and Rationale described in Golder (2002d). Each of these samples was created by combining three 1 L grab samples taken from five locations equally-spaced across the entire width of the river. All grab samples were collected using a clean, triple-rinsed 1 L sample bottle and mixed together in clean, triple-rinsed 20 L pails.

The two cross-channel composite samples collected in the fall of 2002 were analyzed for polycyclic aromatic hydrocarbons (PAHs), in addition to the standard analyses listed in Table 3.1. The PAH analysis was completed by ETL. The individual PAH compounds included in this analysis are summarized in Table 3.3.

Table 3.2 2002 Water Sampling Schedule for the Athabasca River Mainstem

Sample Location		Short Title	GPS Location[a]		Sample Date
Sampling Site	Sampling Point		Easting	Northing	
upstream of Donald Creek	cross channel composite	ATR-DC-CC	474719	6297852	September 7 (fall)
	west bank composite	ATR-DC-W	474719	6297852	September 7 (fall)
	east bank composite	ATR-DC-E	475182	6297927	
upstream of the Steepbank River	west bank composite	ATR-SR-W	470826	6318981	September 6 (fall)
	east bank composite	ATR-SR-E	471029	6319299	
upstream of the Muskeg River	west bank composite	ATR-MR-W	463186	6331747	September 6 (fall)
	east bank composite	ATR-MR-E	463626	6331948	
upstream of Fort Creek	west bank composite	ATR-FC-W	461027	6362441	September 5 (fall)
	east bank composite	ATR-FC-E	461029	6362436	
downstream of development	cross channel composite	ATR-DD-CC	464384	6368261	March 15 (winter, 2002)
					May 30 (spring)
					July 15 (summer)
					September 5 (fall)
					January 7 (winter, 2003)[b]
upstream of the Firebag River	east bank	ATR-FR	478875	6400802	September 13 (fall)

(a) UTM coordinates recorded with reference to NAD 27.

(b) Although originally scheduled for collection in late November - early December 2002, the late onset of freeze-up only permitted safe collection of this water sample in January 2003.

Table 3.3 Individual Polycyclic Aromatic Hydrocarbon (PAH) and Alkylated PAH Compounds Included in the RAMP 2002 Water Sampling Program

Group Name	Individual Parameters
target PAHs	acenaphthene
	acenaphthylene
	anthracene
	benzo(a)anthracene/chrysene
	benzo(a)pyrene
	benzo(b&k)fluoranthene
	benzo(g,h,i)perylene
	biphenyl
	dibenzo(a,h)anthracene
	dibenzothiophene
	fluoranthene
	fluorene
	indeno(c,d-123)pyrene
	naphthalene
	phenanthrene
	pyrene

Table 3.3 Individual Polycyclic Aromatic Hydrocarbon (PAH) and Alkylated PAH Compounds Included in the RAMP 2002 Water Sampling Program (continued)

Group Name	Individual Parameters
alkylated PAHs	C1 substituted acenaphthene
	C1 substituted benzo(a)anthracene/chrysene
	C2 substituted benzo(a)anthracene/chrysene
	C1 substituted biphenyl
	C2 substituted biphenyl
	C1 substituted benzo(b or k)fluoranthene/methyl benzo(a)pyrene
	C2 substituted benzo(b or k)fluoranthene/benzo(a)pyrene
	C1 substituted dibenzothiophene
	C2 substituted dibenzothiophene
	C3 substituted dibenzothiophene
	C4 substituted dibenzothiophene
	C1 substituted fluoranthene/pyrene
	C1 substituted fluorene
	C2 substituted fluorene
	C1 substituted naphthalenes
	C2 substituted naphthalenes
	C3 substituted naphthalenes
	C4 substituted naphthalenes
	C1 substituted phenanthrene/anthracene
	C2 substituted phenanthrene/anthracene
	C3 substituted phenanthrene/anthracene
	C4 substituted phenanthrene/anthracene
	1-methyl-7-isopropyl-phenanthrene (retene)

Conducted by AENV

In 2002, AENV collected water samples from the Athabasca River upstream of Fort McMurray and near Old Fort (Figure 3.4). Results from this work were not available at the time this report was prepared.

3.2.2.3 Tributaries South of Fort McMurray

Water samples were collected from two sites on both the Clearwater and Christina rivers in 2002. Sample sites on the Clearwater River were located approximately 20 km downstream and 2 km upstream of the Christina River (Figure 3.5). Samples sites on the Christina River were located approximately 100 m upstream of the Clearwater River and upstream of Janvier near Pony

Creek. Water samples were collected seasonally from all four locations in accordance to the sampling schedule outlined in Table 3.4.

Each grab sample was taken from the middle of the river. In winter, ice and other debris were removed from the water surface prior to sample collection. Samples collected in the fall from both were analyzed for PAHs (Table 3.3), in addition to the parameters listed in Table 3.1.

Table 3.4 2002 Water Sampling Schedule for Tributaries South of Fort McMurray

Waterbody	Sample Location	Short Title	GPS Location [(a)]		Sample Date
			Easting	Northing	
Clearwater River	20 km downstream of the Christina River	CLR-1	480744	6284243	March 11 (winter)
					May 29 (spring)
					July 17 (summer)
					September 11 (fall)
	2 km upstream of the Christina River	CLR-2	496226	6280396	March 11 (winter)
					May 29 (spring)
					July 17 (summer)
					September 11 (fall)
Christina River	100 m upstream of the Clearwater River	CHR-1	496480	6280023	March 11 (winter)
					May 29 (spring)
					July 17 (summer)
					September 11 (fall)
	upstream of Janvier near Pony Creek	CHR-2	511785	6192140	March 14 (winter)
					June 12 (spring)
					July 17 (summer)
					September 12 (fall)

(a) UTM coordinates recorded with reference to NAD 27.

3.2.2.4 Tributaries North of Fort McMurray

Water samples were collected in the winter and fall of 2002 from the mouths of McLean, Poplar and Fort creeks. Additional samples were also collected from the mouths of the MacKay, Steepbank, Ells, Tar and Firebag rivers in accordance to the sampling schedule presented in Table 3.5. At each location, grab samples were collected approximately 100 m upstream of the confluence with the Athabasca River to avoid the influence of backflow from the Athabasca River.

In 2002, upstream sample sites were established on the Steepbank, Firebag and MacKay rivers, as shown in Figure 3.4. RAMP also initiated sampling in the North Steepbank River in 2002 at a site located approximately 40 km upstream of the Steepbank River (Figure 3.4). Fall and winter or seasonal grab samples were collected from each of these locations following the sampling schedule outlined in Table 3.5.

In addition to the routine analysis outlined in Section 3.2.2.1, a portion of the fall samples collected from the Tar, Ells and Calumet rivers were sent to HydroQual Laboratories (HydroQual) in Calgary, Alberta, for chronic toxicity testing using algae (*Selenastrum capricornutum*), the water flea (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*).

Table 3.5 Water Sampling Schedule for Tributaries North of Fort McMurray, 2002

Waterbody	Sample Location	Short Title	GPS Location[(a)]		Sample Date
			Easting	Northing	
McLean Creek	mouth	MCC-1	474710	6305840	March 12 (winter)[(b)]
					September 8 (fall)
Poplar Creek	mouth	POC-1	473111	6308612	March 12 (winter)[(b)]
					September 8 (fall)
Steepbank River	mouth	STR-1	470903	6319601	March 12 (winter)
					September 8 (fall)
	upstream of Project Millennium	STR-2	484461	6310287	March 15 (winter)
					September 9 (fall)
North Steepbank River	~40 km upstream of the Steepbank River	NSR-1	497419	6324558	March 15 (winter)[(b)]
					May 31 (spring)
					July 16 (summer)
					September 9 (fall)
MacKay River	mouth	MAR-1	461348	6335944	March 14 (winter)
					September 4 (fall)
	~70 km upstream of the Athabasca River	MAR-2	445001	6314055	March 13 (winter)
					September 10 (fall)
Ells River	mouth	ELR-1	459319	6351295	March 16 (winter)[(b)]
					May 30 (spring)
					July 15 (summer)
					September 4 (fall)
Tar River	mouth	TAR-1	458913	6353273	March 16 (winter)[(b)]
					May 30 (spring)
					July 15 (summer)
					September 5 (fall)
Calumet River	mouth	CAR-1	460898	6362978	March 16 (winter)[(b)]
					May 30 (spring)
					July 15 (summer)
					September 5 (fall)
Fort Creek	mouth	FOC-1	461652	6362889	March 16 (winter)[(b)]
					September 5 (fall)
Firebag River	mouth	FIR-1	479178	6399941	March 13 (winter)
					May 31 (spring)
					July 16 (summer)
					September 9 (fall)
	~140 km upstream or the Athabasca River	FIR-2	532798	6355788	March 15 (winter)
					May 31 (spring)
					July 16 (summer)
					September 9 (Fall)

(a) UTM coordinates recorded with reference to NAD 27.
(b) No flowing water was observed (i.e., frozen to bottom), so no sample was collected.

3.2.2.5 Muskeg River Watershed

Conducted by RAMP

In September 2002, grab samples were collected from two locations in the Muskeg River: near the river mouth 100 m upstream of the confluence with the Athabasca River and upstream of Wapasu Creek near the Canterra Road crossing (Figure 3.4). Water samples were also collected from the mouths of Jackpine, Muskeg and Stanley creeks, approximately 100 m upstream of the confluence with the Muskeg River (Table 3.6). In addition to the routine analysis outlined in Section 3.2.2.1, part of the grab sample taken from the Muskeg River upstream of Wapasu Creek was sent to HydroQual for chronic toxicity testing using the same three test species outlined in Section 3.2.2.4.

Table 3.6 2002 Water Sampling Schedule for the Muskeg River Watershed

Waterbody	Sample Location	Short Title	GPS Location[(a)]		Sample Date
			Easting	Northing	
Muskeg River	mouth	MUR-1	463531	6332188	September 4 (fall)
	upstream of Wapasu Creek	MUR-6	492209	6355587	September 10 (fall)
Jackpine Creek	mouth	JAC-1	471653	6346325	September 12 (fall)
Muskeg Creek	mouth	MUC-1	480960	6348759	September 4 (fall)
Stanley Creek	mouth	STC-1	477462	6356401	March 15 (winter)
					May 31 (spring)
					July 16 (summer)
					September 9 (fall)

(a) UTM coordinates recorded with reference to NAD 27.

Conducted by Albian Sands and Syncrude

In accordance to their respective *Environmental Protection and Enhancement Act* (EPEA) approvals, Albian Sands and Syncrude continued to monitor water quality in the Muskeg River upstream of Aurora North, between Aurora North and the Muskeg River Mine and downstream of the Muskeg River Mine (see Figure 3.4). The information collected by each operator in 2002 is summarized in Tables 3.7 and 3.8. A copy of these data was provided to RAMP and is provided in Appendix IX.

Table 3.7 Water Quality Data Collected from the Muskeg River by Albian Sands in 2002

Sampling Location	Parameter		Frequency
upstream of the Muskeg River Mine	total suspended solids		three samples per week
	dissolved oxygen		three samples per week (Oct. 1 to March 31 only)
	5 day biochemical oxygen demand		one sample per week
	nitrogen – ammonia		
	dissolved organic carbon		one sample per month
	dissolved iron		
	dissolved manganese		
upstream and downstream of the Muskeg River Mine	chronic toxicity using *Ceriodaphnia dubia* and fathead minnows		one sample per quarter
	temperature	total hardness	
	dissolved oxygen	pH	
	colour	total alkalinity	
	conductivity	total dissolved solids	
	dissolved organic carbon	total suspended solids	
	biochemical oxygen demand	nitrate and nitrite	
	bicarbonate	potassium	
	calcium	sodium	
	carbonate	sulphate	
	chloride	sulphide	
	magnesium	total phosphorus	
	aluminum (Al)	mercury (Hg)	
	antimony (Sb)	molybdenum (Mo)	
	arsenic (As)	nickel (Ni)	
	barium (Ba)	potassium (K)	
	beryllium (Be)	selenium (Se)	
	boron (B)	silicon (Si)	
	cadmium (Cd)	silver (Ag)	
	calcium (Ca)	sodium (Na)	
	chromium (Cr)	strontium (Sr)	
	cobalt (Co)	sulphur (S)	
	copper (Cu)	thallium (Tl)	
	iron (Fe)	titanium (Ti)	
	lead (Pb)	uranium (U)	
	lithium (Li)	vanadium (V)	
	magnesium (Mg)	zinc (Zn)	
	manganese (Mn)	phenols	
	naphthenic acids	m & p-xylene	
	oil & grease	o-xylene	
	benzene	toluene	
	ethylbenzene	dibenzo(a,h)pyrene	
	acenaphthene	dibenzo(a,i)pyrene	
	acenaphthylene	dibenzo(a,j)pyrene	
	acridine	dimethylbenz(a)anthracene (7,12)	
	anthracene	fluoranthene	
	benzo(a)anthracene	fluorene	
	benzo(a)pyrene	indeno(1,2,3-cd)pyrene	
	benzo(b&j)fluoranthene	3-methylcholanthrene	
	benzo(c)phenanthrene	naphthalene	
	benzo(g,h,i) perylene	phenanthrene	
	benzo(k)fluoranthene	pyrene	
	chrysene	quinoline	
	dibenz(a,h)anthracene		

Table 3.8 Water Quality Data Collected from the Muskeg River by Syncrude in 2002

Sampling Location	Parameter		Frequency
upstream of Aurora North	total suspended solids		three samples per week
	dissolved oxygen		three samples per week (Oct. 1 to March 31 only)
	5 day biochemical oxygen demand		one sample per week
	nitrogen – ammonia		
	chronic toxicity using *Ceriodaphnia dubia* and fathead minnows		one sample per quarter
	temperature	pH	
	dissolved oxygen	total dissolved solids	
	colour	sulphide	
	chloride	sulphate	
	nitrate and nitrite	total phosphorus	
	aluminum (Al)	lead (Pb)	
	antimony (Sb)	mercury (Hg)	
	arsenic (As)	nickel (Ni)	
	beryllium (Be)	selenium (Se)	
	cadmium (Cd)	silver (Ag)	
	chromium (Cr)	thallium (Tl)	
	copper (Cu)	zinc (Zn)	
	iron (Fe)	phenols	
	naphthenic acids	m & p-xylene	
	oil & grease	o-xylene	
	benzene	toluene	
	ethylbenzene	dibenzo(a,h)pyrene	
	acenaphthene	dibenzo(a,i)pyrene	
	acenaphthylene	dibenzo(a,j)pyrene	
	anthracene	dimethylbenz(a)anthracene (7,12)	
	benzo(a)anthracene	fluoranthene	
	benzo(a)pyrene	fluorene	
	benzo(b&j)fluoranthene	indeno(1,2,3-cd)pyrene	
	benzo(c)phenanthrene	3-methylcholanthrene	
	benzo(g,h,i)perylene	naphthalene	
	benzo(k)fluoranthene	phenanthrene	
	chrysene	pyrene	
	dibenz(a,h)anthracene		

3.2.2.6 Wetlands

Composite water samples were collected from Kearl and McClelland lakes in the fall of 2002. Summer and fall composite samples were also collected from Shipyard Lake in 2002, as outlined in Table 3.9. Sample locations are shown in Figure 3.4. During each sampling event, two or three 1-L grab samples were collected from six to ten randomly selected stations located within the open water areas in each lake. All grab samples collected from a given wetland in a given season were combined to create one composite sample for that lake, which was then submitted for the analysis of the standard parameters listed in Table 3.1.

Table 3.9 2002 Wetlands Water Sampling Schedule

Wetlands	Short Title	GPS Location[a]		Sample Date
		Easting	Northing	
Kearl Lake	KEL-1	485648	6349669	September 4 (fall)
Shipyard Lake	SHL-1	473599	6314053	July 18 (summer)
				September 12 (fall)
McClelland Lake	MCL-1	481100	6371607	September 6 (fall)

(a) UTM coordinates recorded with reference to NAD 27.

3.2.2.7 OPTI Lakes (Non-Core)

Water quality samples were collected from 14 lakes in and around the OPTI Long Lake Project in the summer and fall of 2002. Sampled lakes included Gregoire, Birch, Canoe, Caribou Horn, Frog, Kiskatinaw, Long, Poison, Pushup, Rat and Sucker lakes and Unnamed lakes 1, 2 and 3 (Figure 3.5). Sample coordinates and sampling dates are summarized in Table 3.10.

Table 3.10 2002 Water Sampling Schedule for the OPTI Lakes Survey

Sample Location	Short Title	GPS Location[a]		Sample Date
		Easting	Northing	
Unnamed Lake #1	UNL-1	502482	6249735	June 3 (summer)
				September 14 (fall)
Unnamed Lake #2	UNL-2	500436	6255677	June 2 (summer)
				September 15 (fall)
Unnamed Lake #3	UNL-3	509738	6244402	June 3 (summer)
				September 14 (fall)
Pushup Lake	PUL	503218	6248923	June 3 (summer)
				September 14 (fall)
Birch Lake	BIL	504740	6250642	June 3 (summer)
				September 14 (fall)
Sucker Lake	SUL	508482	6252763	June 2 (summer)
				September 14 (fall)
Rat Lake	RAL	507453	6251628	June 3 (summer)
				September 14 (fall)
Poison Lake	POL	505200	6252746	June 2 (summer)
				September 14 (fall)
Gregoire Lake	GRL	491509	6257394	June 3 (summer)
				September 15 (fall)
Long Lake	LOL	501709	6251651	June 2 (summer)
				September 15 (fall)
Canoe Lake	CAL	498795	6257182	June 2 (summer)
				September 15 (fall)
Caribou Horn Lake	CBL	501263	6264363	June 2 (summer)
				September 15 (fall)
Kiskatinaw Lake	KIL	499744	6266200	June 2 (summer)
				September 15 (fall)
Frog Lake	FRL	504553	6254158	June 2 (summer)
				September 15 (fall)

(a) UTM coordinates recorded with reference to NAD 27.

With the exception of Gregoire Lake, composite samples were prepared at each lake by combining ten 1-L grab samples collected from five randomly selected locations across the surface of each lake. Sampling depths were approximately 30 cm below the water surface. In Gregoire Lake, five sample sites were randomly positioned across the open-water portion of the lake. At each location, 1 L grab samples were collected from just below the water surface, at a depth equivalent to twice the Secchi depth and mid-way between the previous sample depth and the bottom of the lake. Samples from depth were collected using a Kemmerer sampler, and all grab samples were combined to form one composite sample.

3.2.3 Continuous Monitoring

3.2.3.1 General Methods Specific to RAMP

Continuous monitoring by RAMP in 2002 was limited to recording water temperature in the Clearwater and Muskeg rivers, McLean and Fort creeks and the Alsands Drain. Two types of probes were used: thermographs and thermostrings. Thermographs are stand-alone circular probes approximately 3 cm in diameter that must be programmed prior to deployment and store data internally until downloaded. Thermostrings are flexible, long, string-like probes that connect directly to the data loggers contained within RAMP's hydrometric stations. Data collected by the thermostrings are stored in the data logger and can be remotely downloaded over the Internet.

Both types of units were programmed to record water temperature every 30 minutes. When deployed, they were placed in deep pools or areas that would likely contain water year round. Thermostrings have shown to be more reliable than thermographs. Consequently, they were used where-ever possible.

3.2.3.2 Tributaries North and South of Fort McMurray

Thermostrings were installed at the mouths of McLean and Fort creeks, while thermographs were deployed in the Clearwater River upstream of Fort McMurray and upstream of the Christina River in the spring of 2002 (Table 3.11). The thermographs installed in the Clearwater River were downloaded in the summer, redeployed and then retrieved in the fall. The thermostrings installed in Fort and McLean creeks were retrieved in the fall to prevent frost damage.

Table 3.11 Installation and Retrieval Schedule for Thermographs and Thermostrings Placed in Tributaries North and South of Fort McMurray in 2002

Waterbody	Site	Short Title	Instrument	Installation Date	Retrieval Date
Clearwater River	upstream of Fort McMurray	CLR-1	thermograph	May 29	September 11[a]
	upstream of the Christina River	CLR-2	thermograph	May 29	September 11[a]
McLean Creek	mouth	MCC-1	thermograph	June 11	October 26
Fort Creek	mouth	FOC-1	thermostring	June 9	August 10

[a] Thermographs were downloaded and redeployed on July 17, 2002.

3.2.3.3 Muskeg River Watershed

Conducted by RAMP

One thermograph and one thermostring were installed in the Muskeg River in 2002 upstream of Jackpine and Muskeg creeks, respectively. Installation and retrieval dates for each unit are listed in Table 3.12. An additional thermostring was scheduled for deployment in the Muskeg River upstream of Wapasu Creek. However, the hydrometric station to which this unit connects was damaged as a result of forest fires in the area, preventing the installation of this unit. The thermostring previously installed in the Alsands Drain in 2001 continued to operate through 2002.

Table 3.12 Thermographs or Thermostrings Located Within the Muskeg River Watershed, 2002

Waterbody	Site	Short Title	Instrument	Installation Date	Retrieval Date
Muskeg River	upstream of Jackpine Creek	MUR-4	thermograph	June 4	September 12
	upstream of Muskeg Creek[a]	MUR-5	thermostring	January 12	January 7 (2003)
Alsands Drain	mouth	ALD-1	thermostring	remained from previous year	December 7

[a] Due to mechanical problems, no temperature data were collected between March 15 and May 14, 2002.

Conducted by AENV

RAMP purchased a HydroLab DataSonde 4™ continuous monitoring unit in 2000 that AENV services and maintains. Every spring for the past three years, AENV has installed this unit or another one like it in the Muskeg River downstream of the Canterra Road crossing near the Environment Canada gauge station and has retrieved it every fall before freeze-up. The unit was programmed to record in-stream pH, temperature, DO and conductivity levels every hour while deployed in the field. However, the resulting data were not yet available at the time this report was prepared.

3.2.4 Data Analysis

As outlined in Section 1.2.2, the analysis of the RAMP water quality data set consisted of an examination of temporal trends in the following waterbodies:

- the Steepbank, Firebag and MacKay rivers;
- McLean, Fort and Poplar creeks; and
- Shipyard Lake.

These seven waterbodies were selected based on the following rationale:

- they were not specifically discussed in the RAMP Five Year Report (Golder 2003a);
- oil sands development by member companies is actively occurring within their respective watersheds; and
- when used in conjunction with historical information from AENV (2001), RL&L (1989) and Golder (1996a), sufficient data are available to meet the minimum requirements of the relevant statistical test.

For each waterbody, the Mann-Kendall test for trend in combination with Sen's slope estimation procedure (Gilbert 1987) was used to determine both the magnitude and potential significance of apparent temporal trends. In rivers and creeks, the analysis was completed using fall data collected from the mouth of each waterbody. Fall was selected, because, for many of these streams, sufficient data (i.e., sample size >5) were only available for this season. Similarly, the analysis considered only the mouth of each river or creek, because upstream sites on a given stream are not currently included in RAMP or insufficient data were available from these areas to perform the Mann-Kendall test for trend. With respect to Shipyard Lake, the analysis was focused on temporal trends in summer, as this was the only season for which >5 samples were available.

When significant temporal trends were observed in the rivers and/or creeks, concentrations were adjusted to account for variations in flow over time following the methods outlined by IDT (1998). The analysis was then repeated to determine if changes in water flow were primarily responsible for the observed temporal trend. Flow adjustments were made using relevant average daily data collected by RAMP and reported in Golder (2002b). Both the flow adjustments and the Mann-Kendall analyses were completed using WQStat Plus (IDT 1998). Flow adjustments were not considered for Shipyard Lake, as this is a non-flowing, lentic system.

Parameters considered in this investigation consisted of the 11 indicators discussed in the RAMP Five Year Report (Golder 2003a):

- dissolved organic carbon (DOC)
- pH
- total alkalinity
- total dissolved solids (TDS)
- total suspended solids (TSS)
- sulphate
- total Kjeldahl nitrogen (TKN)
- total phosphorus
- total aluminum
- total boron
- total chromium

As previously discussed, DOC, total phosphorus and TKN were selected to provide a general indication of nutrient status. Total alkalinity and pH were selected as key variables for monitoring potential acidification. TDS, sulphate, total aluminum, total boron and total chromium were chosen, because recent EIAs (e.g., Shell 1997; Golder and Cantox 2002) indicate that concentrations of these substances may increase as a result of development. Finally, TSS was included, due to its likely influence on total metal levels.

Due to a lack of historical information, the analysis of potential trends in boron, aluminum and chromium concentrations in the Firebag River could not be completed.

3.3 SEDIMENT QUALITY

3.3.1 Overview

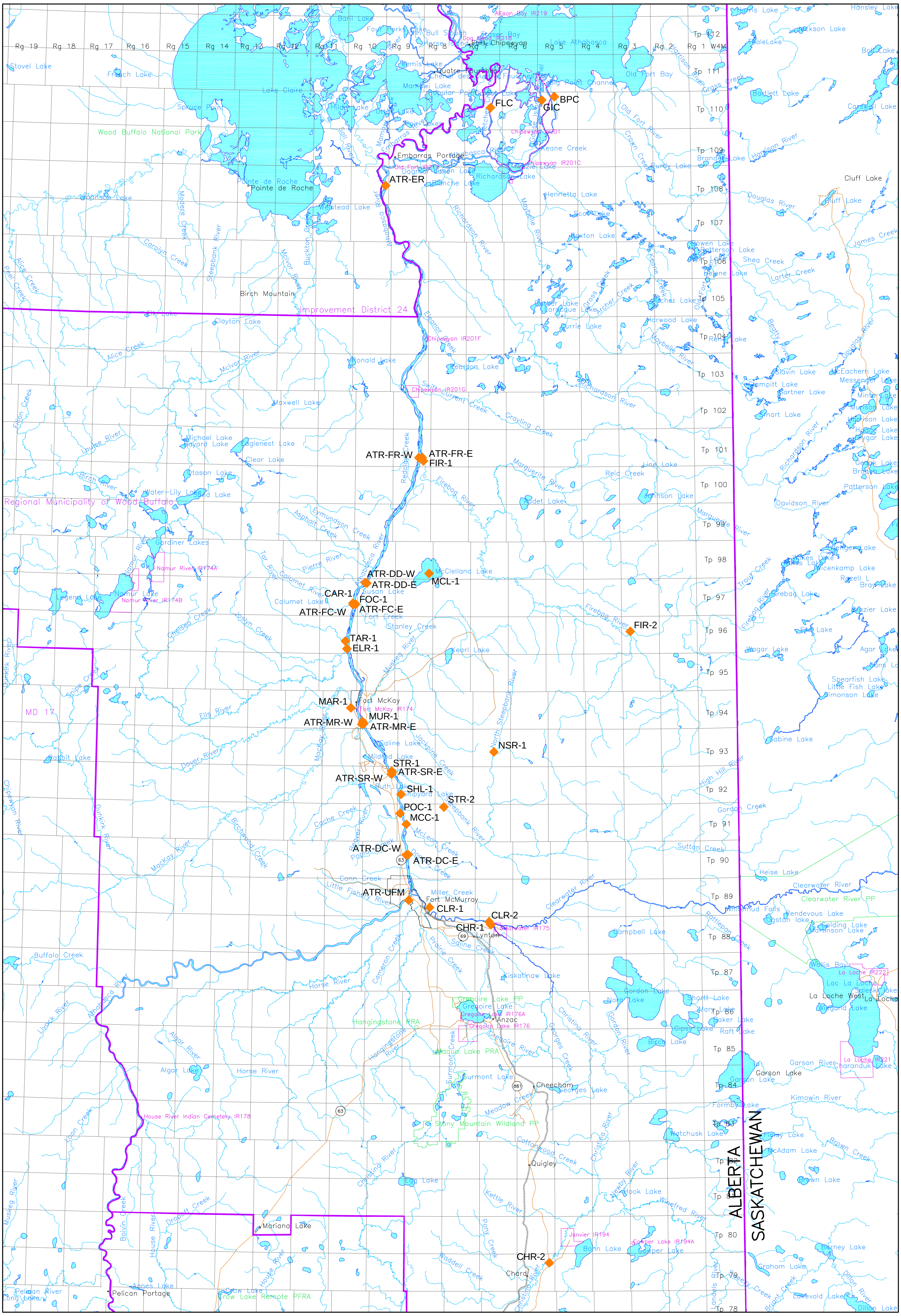
The scope of the 2002 sediment quality survey comprised the following elements:

- continued monitoring of the same set of sediment quality parameters analyzed in 2001;
- re-sampling the mouths of the MacKay and Muskeg rivers, and McLean and Fort creeks, as well as the upper reach of the MacKay River;

- re-sampling Shipyard Lake and the Clearwater River upstream of Fort McMurray and upstream of the Christina River,
- re-sampling the east and west portions of the Athabasca River upstream of Donald Creek, the Steepbank River, the Muskeg River and Fort Creek;
- re-sampling the Athabasca River upstream of the Embarras River and at three locations in the Delta (i.e., Big Point, Goose Island and Fletcher channels);
- sampling the east and west portion of the Athabasca River upstream of the Firebag River and downstream of existing oil sands development, as well as collecting a cross-channel composite sample upstream of Fort McMurray;
- sampling the mouths of Poplar Creek and the Tar, Ells and Steepbank rivers; and
- expanding the program to include McClelland Lake, two locations on the Firebag and Christina rivers, as well as upstream sites on the Steepbank and North Steepbank rivers;

Sample locations are shown in Figure 3.6, and the specific methods used to collect this information are discussed in Section 3.3.2.

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Ramp-Sediment Sites.dwg Mar 15, 2003 - 5:00pm



LEGEND

◆ SEDIMENT QUALITY SAMPLING SITE

20 0 20

SCALE KILOMETRES

REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001. SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001. DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

RAMP 2002

TITLE

SEDIMENT QUALITY SAMPLING SITES, 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Ramp-sites	
DESIGN	TD	18/12/02	SCALE AS SHOWN	REV. 0
CADD	JMA	12/02/03		
CHECK				
REVIEW				

FIGURE: 3.6

3.3.2 Sample Collection and Analysis

3.3.2.1 General Methods

All composite sediment samples were created by combining four to six grab samples collected from depositional areas located within each sample site. Grab samples were collected using an Ekman sediment sampler, and sample depths were approximately 3 to 5 cm. All samples were collected, preserved, stored and shipped in accordance with Golder Associates Technical Procedure 8.2-2 (Golder 1997c).

Following sample collection, all sediment samples were split. One portion was shipped to ETL for analysis of carbon content, particle size, total recoverable hydrocarbons, total volatile hydrocarbons, total extractable hydrocarbons and total metals (Table 3.13). Another part was sent to AXYS Analytical Services Ltd. (AXYS) in Sidney, B.C., and analyzed for the target and alkylated PAH compounds listed in Table 3.13. Descriptions of the analytical methods used by each laboratory are provided in Appendix VIII.

3.3.2.2 Athabasca River Mainstem and Delta

In the fall of 2002, east and west bank composite sediment samples were collected from the Athabasca River approximately 100 m upstream of each of the following locations: Donald Creek, the Steepbank River, the Muskeg River, Fort Creek and the Firebag River. Additional east and west bank samples were collected from the Athabasca River downstream of existing development (i.e., several km downstream of Fort Creek near the outlet to Susan Lake – Figure 3.6). The sediment sampling schedule is outlined in Table 3.14. Each composite sample was created by combining grab samples collected between the respective river bank and 25% of the river width.

Cross-channel composite sediment samples were collected from the Athabasca River approximately 100 m upstream of Fort McMurray, the Embarras River and from three locations within the Athabasca Delta (i.e., Goose Point Channel, Big Point Channel and Fletcher Channel). Each cross-channel composite sample was created by combining grab samples collected across the entire river or channel width. In addition to the analyses outlined in Section 3.3.2.1, a portion of the three sediment samples collected from the Athabasca Delta were sent to HydroQual for toxicity testing using midge larvae (*Chironomus tentans*), amphipods (*Hyalella azteca*) and oligochaete worms (*Lumbriculus variegatus*).

Table 3.13 Standard RAMP Sediment Quality Parameter List

Group Name	Individual Parameters
particle size	percent sand
	percent silt
	percent clay
	moisture content
carbon content	total inorganic carbon
	total organic carbon
	total carbon
organics	total recoverable hydrocarbons
	total volatile hydrocarbons (C5-C10)
	total extractable hydrocarbons (C11-C30)
total metals	aluminum (Al)
	arsenic (As)
	barium (Ba)
	beryllium (Be)
	boron (B)
	cadmium (Cd)
	calcium (Ca)
	chromium (Cr)
	cobalt (Co)
	copper (Cu)
	iron (Fe)
	lead (Pb)
	magnesium (Mg)
	manganese (Mn)
	mercury (Hg)
	molybdenum (Mo)
	nickel (Ni)
	potassium (K)
	selenium (Se)
	silver (Ag)
	sodium (Na)
	strontium (Sr)
	thallium (Tl)
	uranium (U)
	vanadium (V)
	zinc (Zn)
target PAHs	acenaphthene
	acenaphthylene
	anthracene
	benzo(a)anthracene/chrysene
	benzo(a)pyrene
	benzofluoranthenes
	benzo(g,h,i)perylene
	biphenyl

Table 3.13 Standard RAMP Sediment Quality Parameter List (continued)

Group Name	Individual Parameters
target PAHs (continued)	dibenzo(a,h)anthracene
	dibenzothiophene
	fluoranthene
	fluorene
	indeno(c,d-123)pyrene
	naphthalene
	phenanthrene
	pyrene
alkylated PAHs	C1 substituted acenaphthene
	C1 substituted benzo(a)anthracene/chrysene
	C2 substituted benzo(a)anthracene/chrysene
	C1 substituted biphenyl
	C2 substituted biphenyl
	C1 substituted benzofluoranthene/benzo(a)pyrene
	C2 substituted benzofluoranthene/benzo(a)pyrene
	C1 substituted dibenzothiophene
	C2 substituted dibenzothiophene
	C3 substituted dibenzothiophene
	C4 substituted dibenzothiophene
	C1 substituted fluoranthene/pyrene
	C2 substituted fluoranthene/pyrene
	C3 substituted fluoranthene/pyrene
	C1 substituted fluorene
	C2 substituted fluorene
	C3 substituted fluorene
	C1 substituted naphthalenes
	C2 substituted naphthalenes
	C3 substituted naphthalenes
	C4 substituted naphthalenes
	C1 substituted phenanthrene/anthracene
	C2 substituted phenanthrene/anthracene
	C3 substituted phenanthrene/anthracene
	C4 substituted phenanthrene/anthracene
	1-methyl-7-isopropyl-phenanthrene (retene)

Table 3.14 2002 Sediment Sampling Schedule for the Athabasca River Mainstem and Delta

Sample Location		Short Title	GPS Location[a]		Sample Date
Sampling Site	**Sampling Point**		**Easting**	**Northing**	
upstream of Fort McMurray	cross channel	ATR-UFM	475330	6286105	September 7 (fall)
upstream of Donald Creek	west bank	ATR-DC-W	474719	6297852	September 7 (fall)
	east bank	ATR-DC-E	475184	6297927	
upstream of the Steepbank River	west bank	ATR-SR-W	470826	6318981	September 6 (fall)
	east bank	ATR-SR-E	471029	6319299	
upstream of the Muskeg River	west bank	ATR-MR-W	463186	6331747	September 6 (fall)
	east bank	ATR-MR-E	463626	6331948	
upstream of Fort Creek	west bank	ATR-FC-W	461024	6362825	September 5 (fall)
	east bank	ATR-FC-E	461578	6362811	
downstream of development	west bank	ATR-DD-W	464160	6368491	September 5 (fall)
	east bank	ATR-DD-E	464384	6368261	
upstream of the Embarras River	cross channel	ATR-ER	469293	6471553	September 16 (fall)
Athabasca Delta	Big Point Channel	ATD-BPC	513049	6494580	September 16 (fall)
	Goose Island Channel	ATD-GIC	509851	6493463	September 16 (fall)
	Fletcher Channel	ATD-FLC	496563	6491511	September 16 (fall)

[a] UTM coordinates recorded with reference to NAD 27.

3.3.2.3 Other Waterbodies

Composite sediment samples were collected in the fall of 2002 from two sites on both the Clearwater and Christina rivers, as well as from Shipyard and McClelland lakes. Sample sites on the Clearwater River were located approximately 20 km downstream and 2 km upstream of the Christina River (Figure 3.6). Sample sites on the Christina River were located approximately 100 m upstream of the Clearwater River and upstream of Janvier near Pony Creek. Additional grab samples were collected from McLean, Poplar and Fort creeks and the Steepbank, North Steepbank, MacKay, Ells, Tar, Calumet, Firebag and Muskeg rivers in the fall of 2002. All composite and grab sediment samples were collected in accordance to the sampling schedule outlined in Table 3.15.

Table 3.15 2002 Sediment Sampling Schedule for Athabasca River Tributaries and Wetlands

Waterbody	Sample Location	Short Title	GPS Location [(a)]		Sample Date
			Easting	Northing	
Clearwater River	20 km downstream of the Christina River	CLR-1	480744	6284243	September 17 (fall)
	2 km upstream of the Christina River	CLR-2	496226	6280396	September 17 (fall)
Christina River	100 m upstream of Fort McMurray	CHR-1	496480	6280023	September 11 (fall)
	upstream of Janvier	CHR-2	511785	6192140	September 12 (fall)
McLean Creek	mouth	MCC-1	474710	6305840	September 8 (fall)
Poplar Creek	mouth	POC-1	473111	6308612	September 8 (fall)
Steepbank River	mouth	STR-1	470903	6319601	September 8 (fall)
	upstream of Project Millennium	STR-2	484461	6310287	September 9 (fall)
North Steepbank River	~20 km upstream of the Steepbank River	NSR-1	497419	6324558	September 9 (fall)
MacKay River	mouth	MAR-1	461348	6335944	September 4 (fall)
	~70 km upstream of the Athabasca River	MAR-2	-	-	September 10 (fall)[(b)]
Ells River	mouth	ELR-1	459319	6351295	September 4 (fall)
Tar River	mouth	TAR-1	458913	6353273	September 5 (fall)
Fort Creek	mouth	FOC-1	461652	6362889	September 5 (fall)
Firebag River	mouth	FIR-1	479178	6399941	September 9 (fall)
	~140 km upstream of the Athabasca River	FIR-2	532798	6355788	September 9 (fall)
Muskeg River	mouth	MUR-1	463531	6332188	September 4 (fall)
Calumet River	mouth	CAR-1	460898	6362978	September 5 (fall)
Shipyard Lake	composite	SHL-1	473304	6313563	September 12 (fall)
McClelland Lake	composite	MCL-1	480582	6370807	September 6 (fall)

(a) UTM coordinates recorded with reference to NAD 27.

(b) Sample site falls within an erosional zone, so no sample was collected.

3.3.3 Data Analysis

3.3.3.1 Scope and Initial Data Processing

As outlined in Section 1.2.3, the sediment data analysis consisted of an examination of the relationship between sediment toxicity and sediment composition, metal content and PAH content. The input data set included historical data from Albian (2000) and Golder (1996a), previous RAMP sediment data collected between 1997 and 2001 and all of the 2002 RAMP data available as of January 20, 2003.

Unforeseen difficulties occurred in the laboratory analysis of 13 out of 40 sediment PAH samples collected in 2002, resulting in the delayed production of those results. The deadline of January 20, 2003, was selected to ensure timely delivery of the annual report to the RAMP Technical Subcommittee. PAH results received after that date are included in Appendix XI, along with summaries of all of the 2002 sediment sampling results. They did not, however, form part of the input dataset used to investigate potential correlations between sediment toxicity and sediment composition, metal content and PAH content.

Within the input data set, split and duplicate sediment samples were reduced to single samples to guarantee data independence. This process was completed through either random selection or, in cases of unequal analysis, by choosing the sample that had been submitted for the more complete analysis. Values recorded as zeros were eliminated. Non-detectable results were replaced with half of the corresponding method detection limit, and metal and PAH data were then $\log_{10}$-transformed. Sediment composition (i.e., percent sand, silt and clay) and toxicity data were not transformed.

3.3.3.2 Principal Component Analysis

Principal Component Analysis (PCA) was used to limit the number of metal and PAH parameters included in the sediment toxicity - sediment chemistry comparisons. As discussed in Golder (2003a), PCA is a statistical procedure that can be used to transform a dataset containing multiple parameters that may be inter-correlated into one with completely independent variables, called Principal Components (PCs) (Tabachnick and Fidell 1996; Walder and Mayhood 1985; SPSS 2000). Each sample included in the input dataset is positioned in multi-dimensional space according to its “coordinates”, or the values associated with that sample for each of the parameters considered in the PCA. In combination, all of the samples form a cloud. The first PC runs along the main axis of the cloud. The second PC is positioned perpendicular to the first and runs along the next main axis of the cloud. Subsequent PCs are added in a similar fashion, with each one running perpendicular to the rest and stretching along the largest part of the yet unexamined portions of the data cloud.

A simplified version of a PCA would be to consider, for example, a three-dimensional scatter plot of iron, lead and aluminum. Each sample is positioned on the scatter plot according to the iron, lead and aluminum concentrations measured in that sample. After dozens of samples have been positioned on the plot, a three-dimensional cloud develops. For the purposes of this example, the cloud is assumed to be longer than it is wide, and wider than it is tall. Under these conditions, the first PC would run along the length of the cloud, with the second PC positioned along its width and third PC describing the height of the cloud.

Although the total number of PCs that can be developed in a PCA will equal the total number of variables included in the input dataset, the first few PCs will generally account for a large proportion of the total variance contained in the original dataset. These first few PCs can then be used in subsequent analyses with minimal loss of information. Interpretation of these results refers to which original parameter correlates to each PC. Parameters highly correlated to the same PC are also often highly correlated to one another (Walder and Mayhood 1985). Further detail concerning PCA can be found in Tabachnick and Fidell (1996).

In this study, two PCAs were performed. One PCA focused on the metal parameters listed in Table 3.13. The second PCA considered the individual PAHs included in the standard RAMP test suite (as listed in Table 3.13).

As outlined in Walder and Mayhood (1985), PCA requires a complete two-dimensional input table, wherein every sample included in the analysis has data for all of the corresponding parameters included in the PCA. This prerequisite resulted in a compromise between maximizing the number of parameters and the number of samples included in the metal and PAH PCAs. To achieve this requirement, the metal PCA was completed using 116 samples and the following 22 parameters:

- aluminum
- arsenic
- barium
- beryllium
- cadmium
- calcium
- chromium
- cobalt
- copper
- iron
- lead
- magnesium
- manganese
- mercury
- molybdenum
- nickel
- potassium
- selenium
- sodium
- strontium
- vanadium
- zinc

Of the remaining metals included in Table 3.13, boron, thallium and uranium were excluded from the metal PCA, because of insufficient data. Silver was excluded, because more than 70% of the available data were non-detectable results.

The PAH PCA was completed using 90 samples and the following 29 parameters:

- acenaphthene
- benzo(a)anthracene/chrysene
- benzo(a)pyrene
- benzo(g,h,i)perylene
- benzofluoranthenes
- dibenzothiophene
- fluorene
- fluoranthene
- naphthalene
- phenanthrene
- C1 and C2 substituted benzo(a)anthracene/chrysene
- C1 to C3 substituted dibenzothiophene
- C1 substituted fluoranthene/pyrene
- C1 and C3 substituted fluorene
- C1 to C4 substituted naphthalenes
- C1 to C4 substituted phenanthrene/anthracene
- pyrene
- indeno(c,d-123)pyrene
- TRH

Because of data gaps, 11 parameters were excluded from the PAH PCA, including C1 substituted acenaphthene, biphenyl, C2 substituted biphenyl, C1 and C2 substituted benzofluoranthene/benzo(a)pyrene, C4 substituted dibenzothiophene, 1-methyl-7-isopropyl-phenanthrene (retene), C2 and C3 substituted fluoranthene/pyrene, C2 substituted fluorene and TEH. Acenaphthylene, C1 substituted biphenyl, anthracene and dibenzo(a,h)anthracene were also excluded from the PAH PCA, because more than 70% of the available data were non-detectable results.

Both the metal PCA and the PAH PCA were performed without rotation in SYSTAT 10 (SPSS 2000), using pairwise correlations. Consistent with Golder (2003a), a loading of 0.4 was used to identify a significant correlation between an individual parameter and a PC. In cases where parameter loadings were greater than 0.4 on several PCs, the PC containing the highest loading was considered the most representative of that parameter.

The first three PCs produced from the metals PCA accounted for approximately 76% of the total variance contained within the two dimensional input table, with metal PC1, PC2 and PC3 accounting for 58.9, 10.5 and 6.8% of the total variance, respectively (Table 3.16). Successive metal PCs explained little of the total variance. As all of the individual metals included in the metal PCA were correlated to either metal PC1 or metal PC3, these two PCs were carried forward into the sediment toxicity comparisons.

Table 3.16 Correlation of Individual Metals to Each of the Three Key Principal Components Derived from the Metal Principal Components Analysis

Parameter	Metal PC1[(a)]	Metal PC2[(a)]	Metal PC3[(a)]
cobalt (Co)	**0.94**	-0.10	-0.01
iron (Fe)	**0.92**	0.14	0.10
magnesium (Mg)	**0.91**	0.06	0.07
potassium (K)	**0.91**	-0.18	0.14
barium (Ba)	**0.88**	**-0.42**	0.00
strontium (Sr)	**0.87**	-0.35	0.07
aluminum (Al)	**0.86**	**-0.43**	-0.02
chromium (Cr)	**0.86**	-0.13	-0.21
nickel (Ni)	**0.82**	0.34	-0.19
calcium (Ca)	**0.80**	0.10	0.04
zinc (Zn)	**0.78**	0.39	0.18
vanadium (V)	**0.76**	-0.17	0.07
arsenic (As)	**0.74**	0.22	0.26
copper (Cu)	**0.73**	**0.52**	0.15
selenium (Se)	**0.72**	0.08	0.17
manganese (Mn)	**0.71**	0.28	0.28
sodium (Na)	**0.71**	**-0.68**	0.03
beryllium (Be)	**0.70**	-0.13	**-0.45**
lead (Pb)	**0.62**	**0.59**	0.14
cadmium (Cd)	**0.58**	0.10	**-0.52**
molybdenum (Mo)	**0.53**	0.14	**-0.65**
mercury (Hg)	-0.08	0.43	**-0.47**
eigenvalue	13.0	2.3	1.5
percent of variance explained	58.9	10.5	6.8

(a) Correlation coefficients > | 0.4 | are bolded, and shading is used to identify the PC that best represents the parameter in question.

With respect to the PAHs, the first two PCs produced from the PAH PCA accounted for approximately 80% the total variance contained within the two-dimensional input table, with PAH PC1 and PAH PC2 accounting for 72.3 and 8.1% of the total variance, respectively (Table 3.17). Successive PAH PCs explained little of the total variance. Furthermore, all of the parameters included in the PAH PCA were correlated with either PAH PC1 or PC2. Therefore, only these first two PAH PCs were carried forward into the sediment toxicity analysis.

Table 3.17 Correlation of Individual PAHs and Total Recoverable Hydrocarbons to the Two Key Principal Components Derived from the PAH Principal Components Analysis

Parameter	PAH PC1[(a)]	PAH PC2[(a)]
C2 substituted phenanthren/anthracene	**0.97**	-0.05
pyrene	**0.95**	0.03
C1 substituted dibenzothiophene	**0.95**	0.06
C3 substituted phenanthrene/anthracene	**0.94**	-0.10
C1 substituted fluoranthene/pyrene	**0.94**	-0.10
benzo(a)anthracene/chrysene	**0.94**	-0.07
benzo(a)pyrene	**0.93**	0.00
benzo(g,h,i)perylene	**0.92**	0.04
fluoranthene	**0.92**	0.11
dibenzothiophene	**0.92**	0.05
C2 substituted dibenzothiophene	**0.92**	-0.16
benzofluoranthenes	**0.91**	-0.07
phenanthrene	**0.91**	0.27
C1 substituted phenanthrene / anthracene	**0.89**	0.11
indeno(1,2,3,cd)pyrene	**0.88**	0.04
C3 substituted naphthalenes		0.20
fluorene	**0.86**	0.28
C4 substituted phenanthrene/anthracene	**0.86**	0.01
total recoverable hydrocarbons	**0.84**	-0.21
C1 substituted fluorene	**0.84**	-0.11
C4 substituted naphthalenes	**0.83**	-0.28
C3 substituted dibenzothiophene	**0.81**	**-0.42**
acenaphthene	**0.80**	0.20
C2 substituted benzo(a)anthracene/chrysene	**0.72**	**-0.52**
C3 substituted fluorine	**0.70**	-0.35
C2 substituted naphthalenes	**0.65**	**0.44**
C1 substituted benzo(a)anthracene/chrysene	**0.62**	**-0.50**
naphthalene	**0.59**	**0.69**
C1 substituted naphthalenes	**0.56**	**0.65**
eigenvalue	21.0	2.4
percent of variance explained	72.3	8.1

(a) Correlation coefficients > | 0.4 | are bolded, and shading is used to identify the PC that best represents the parameter in question.

3.3.3.3 Correlation of Sediment Toxicity to Sediment Chemistry and Composition

The potential of sediment chemistry and composition to influence sediment toxicity was examined using explicit pairwise Pearson correlations with Bonferroni adjustments. This test procedure was used to compare growth and mortality data observed with midge larvae (*Chironomus tentans)*, amphipods (*Hyalella azteca*) and oligochaete worms (*Lumbriculus variegates*) to the corresponding physical and chemical characteristics of the tested sediment. The physical nature of the sediment was expressed as percent sand, silt and clay, while its chemical content was described using metal PC1, metal PC3, PAH PC1 and PAH PC2.

Initially, all of the available sediment toxicity information and associated chemical and physical data were used in the analysis. The process was then repeated using only those sediment samples where toxicity had been observed (i.e., growth and/or survival of the test species was <75% of that observed in the control sample; Golder 2002c). Although neither comparison yielded significant results, several of the correlation coefficients produced by the latter process were notably high (i.e., >0.8), so the latter analysis was repeated without Bonferroni adjustments. Significant results from this third test procedure were examined graphically to determine if a trend could be observed.

If significant correlations to metal PC1 or PAH PC2 were present and notable trends observed, the relevant analysis was repeated with individual metal PC1 or PAH PC2 scores normalized for silt content. This normalization was completed, because metal, naphthalene and C1 substituted naphthalene concentrations in sediments in the lower Athabasca River watershed tend to be significantly correlated to sediment composition (Golder 2003a). In particular, sediments with high silt content tend to contain higher metal, naphthalene and C1 substituted naphthalene levels than sediments with less silt and higher sand content.

Normalizing for silt content was completed using linear regression models with the form PC score = slope*(silt content) + intercept. For each individual measurement, the PC score predicted by the relevant regression equation was subtracted from the original observation to produce a series of residuals. The mean of the original data series was then added to each residual. Where required, a final correction factor was added to each sum to produce a series of silt-adjusted PC scores that had the same mean as the original data series produced by the relevant metal or PAH PCA. This normalization procedure was based on the flow-adjustment procedure described in IDT (1998), and all of the statistical analysis described above was completed using SYSTAT 10 (SPSS 2000).

3.4 BENTHIC INVERTEBRATE COMMUNITY

3.4.1 Overview

The fall 2002 benthic invertebrate sampling program consisted of sampling three sites in the Athabasca River delta, eight tributaries of the Athabasca River, two small streams and three lakes. Sampling site locations, habitat sampled and sampling dates are provided in Table 3.18.

Table 3.18 Summary of the Fall 2002 Benthic Invertebrate Sampling Program

Waterbody	Location Sampled	Sample Identifiers	Habitat	Sample Date
Calumet River	lower reach	CAL-D-1 to CAL-D-15	depositional	October 2
Christina River	lower reach	CHR-D-1 to CHR-D-15	depositional	September 11
	upstream of Janvier	CHR-D-16 to CHR-D-30	depositional	September 26
Clearwater River	downstream of Christina River	CLR-D-1 to CLR-D-15	depositional	September 7, 11 and 12
	upstream of Christina River	CLR-D-16 to CLR-D-30	depositional	September 10
Ells River	lower reach	ELR-D-1 to ELR-D-15[(a)]	depositional	September 25
Fort Creek	at mouth	FOC-D-1 to FOC-D-5	depositional	September 24
Jackpine Creek	lower reach	JAC-D-1 to JAC-D-15	depositional	September 27
MacKay River	lower reach	MAR-E-1 to MAR-E-15	erosional	September 13
	upper reach	MAR-E-16 to MAR-E-30	erosional	September 17
Muskeg River	lower reach	MUR-E-1 to MUR-E-15	erosional	September 19
	lower to mid-reach	MUR-D-1to MUR-D-15	depositional	September 23
	upper reach	MUR-D-16 to MUR-D-30	depositional	September 18 and 20
Steepbank River	lower reach	STR-E-1 to STR-E-15	erosional	September 16
Tar River	lower reach	TAR-D-1 to TAR-D-15	depositional	September 24 and 30, and October 2
Kearl Lake	10 samples throughout lake	KEL-1 to KEL-10	lake	September 4
McClelland Lake	10 samples throughout lake	MCL-1 to MCL-10	lake	September 6
Shipyard Lake	10 samples throughout lake	SHL-1 to SHL-10	lake	September 12

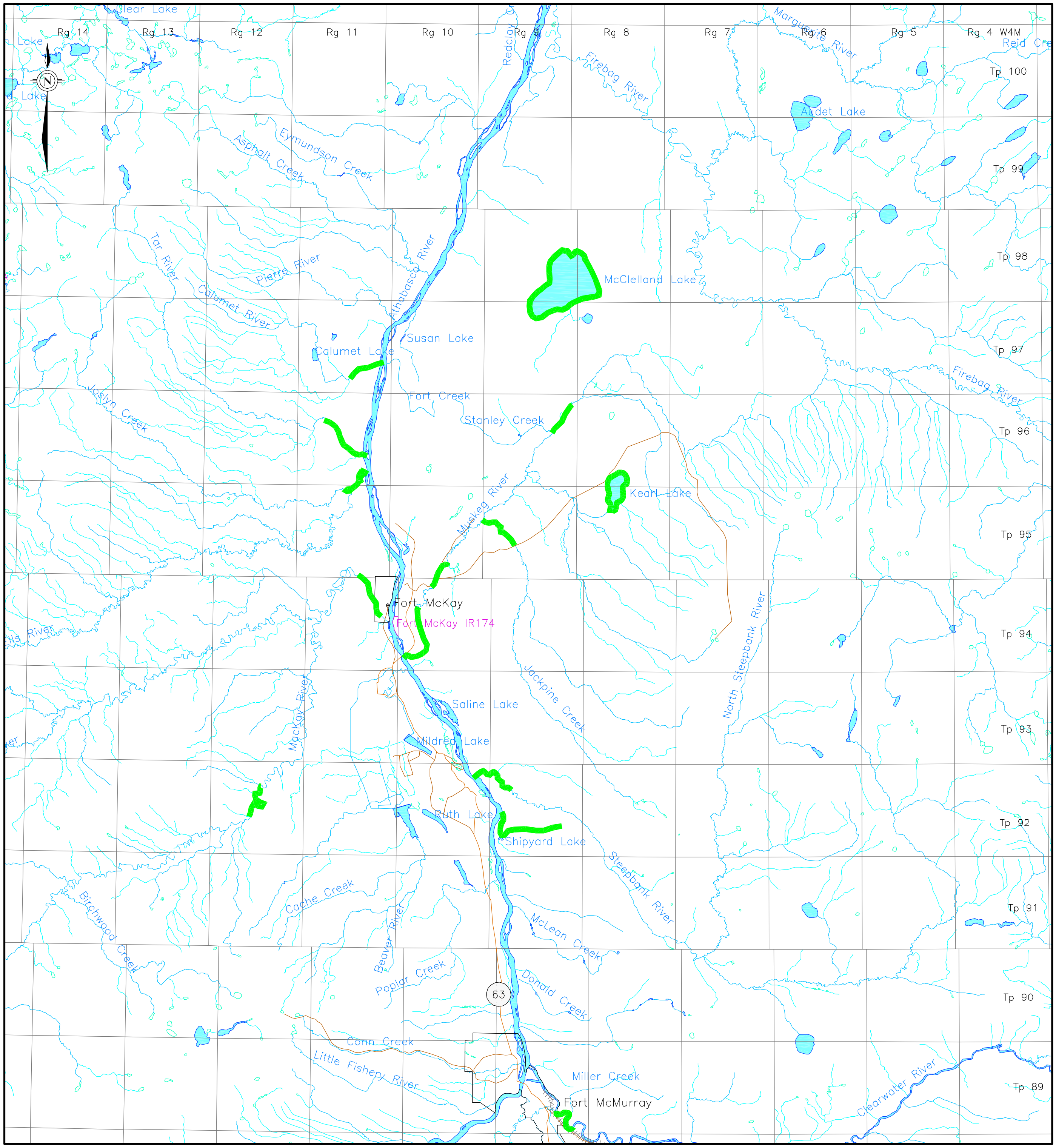
(a) Samples were lost during shipping from Fort McMurray to Calgary.

3.4.2 Sampling Site Locations

The dominant habitat was sampled in each river reach monitored (Table 3.18). Benthic invertebrate habitat is typically described as either erosional (i.e., riffles or runs with coarse substrates and moderate to fast currents) or depositional (i.e., runs or backwaters with fine sediments and slow currents or no currents). The MacKay and Steepbank rivers are largely erosional throughout their length, whereas the Muskeg River is mostly depositional with the exception of its lowest erosional reach from its mouth to about 10 km upstream. All other river reaches sampled were depositional.

The sampling design for rivers and streams other than Fort Creek consisted of collecting 15 samples within an approximately 5 km reach (Figures 3.7 to 3.8; exact site locations are provided in Figures XII.1 to XII.8 and as UTMs in Tables XII.9 and XII.10 in Appendix XII). Five samples were collected in Fort Creek (Figure 3.7), where the accessible lower reach (i.e., below beaver dams) was limited to about 100 m. Kearl, McClelland and Shipyard lakes were sampled at ten locations per lake (Appendix XII). In lakes, sample points were located outside of emergent vegetation, in 1.5 to 3 m deep water.

The objective of site selection in the field was to find sites in “representative” erosional, depositional or lake habitats, rather than to standardize the habitat sampled to within a narrow range. Although this approach may result in more variable data, it provides a better indication of the range of benthic communities inhabiting the waterbodies sampled. Spacing of the individual samples in rivers was dependent upon access (i.e., helicopter landing sites), availability of suitable habitat and time constraints. In areas where it was necessary to group samples within shorter reaches, spacing was about 50 to 100 m between samples to maximize spatial coverage.



10 0 10

SCALE KM

LEGEND

WATERBODIES MONITORED BY RAMP

PROJECT

RAMP 2002

TITLE

BENTHIC INVERTEBRATE SAMPLING SITES NORTH OF FORT McMURRAY, FALL 2002

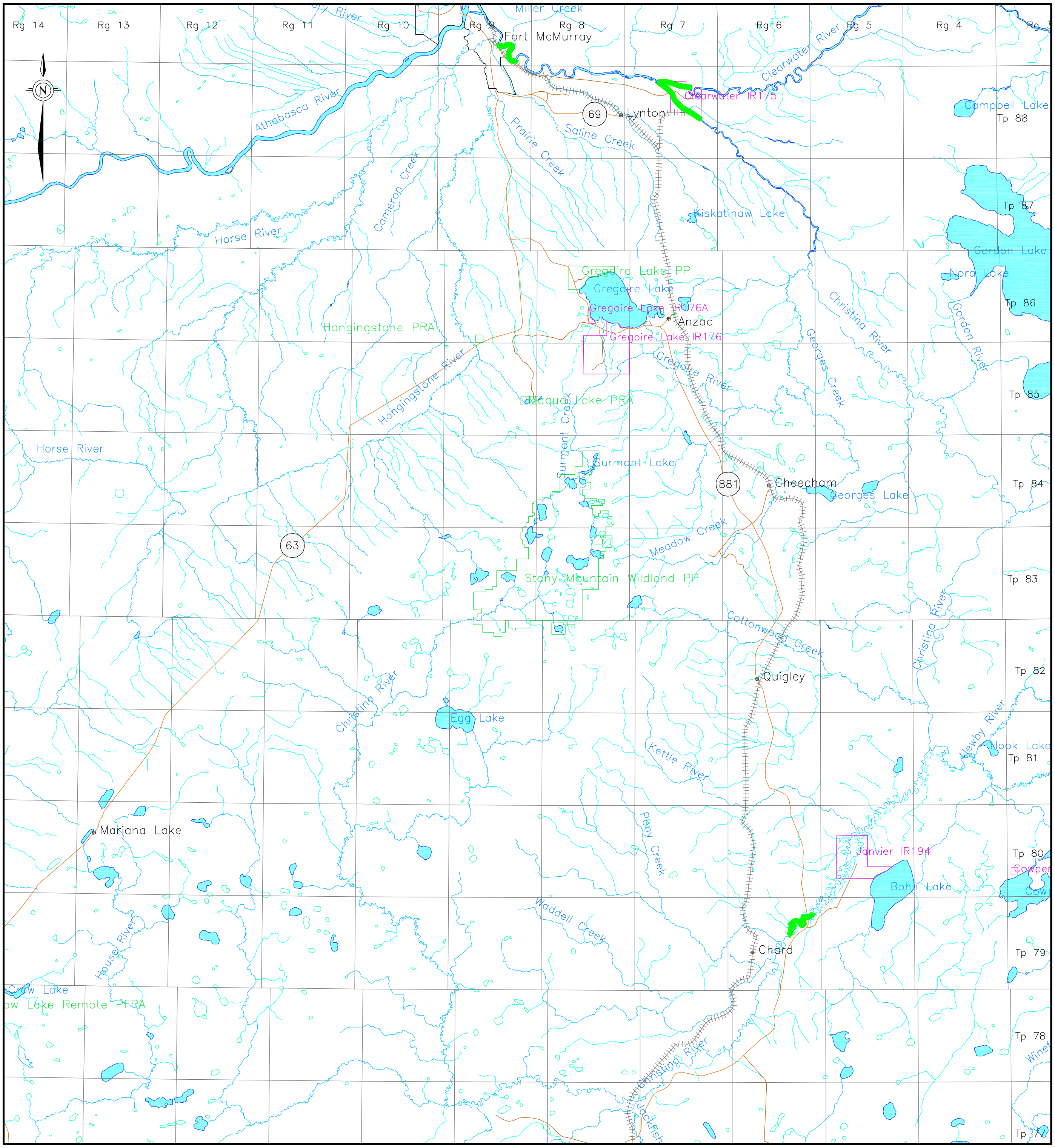
REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOSCIENCES CANADA, AUGUST 2001. SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 83 PROJECTION: UTM ZONE 13

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Sampling Sites Nort	
DESIGN	LG	11/03/03	SCALE 1:600,000	REV. 0
CADD	TVS	11/03/03	FIGURE: 3.7	
CHECK				
REVIEW				

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Sampling Sites North.dwg Mar 15, 2003 - 5:04pm



10 0 10

SCALE KM

LEGEND

WATERBODIES MONITORED BY RAMP

REFERENCE

ALBERTA NTDB DIGITAL DATA OBTAINED FROM GEOMATICS CANADA, AUGUST 2001. SASKATCHEWAN NTDB DATA OBTAINED FROM ISC, AUGUST 2001.
DATUM: NAD 83 PROJECTION: UTM ZONE 13

PROJECT

RAMP 2002

TITLE

BENTHIC INVERTEBRATE SAMPLING SITES SOUTH OF FORT McMURRAY, FALL 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300		
DESIGN	LG	11/03/03
CADD	TVS	11/03/03
CHECK		
REVIEW		

FILE No. Sampling Sites Sout	
SCALE 1:600,000	REV. 0

FIGURE: 3.8

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3.4.3 Field Methods

Benthic invertebrate samples were collected according to Golder Technical Procedure 8.6-1 (Golder 1997d). These procedures meet or exceed government guidelines for monitoring benthos in freshwaters (AENV 1990; Environment Canada 1993). A Neill cylinder of 0.093 m^2 bottom area with a 210 µm mesh collecting net was used to sample benthic invertebrates in erosional habitat. A pole-mounted Ekman grab of 0.0232 m^2 bottom area was used in depositional habitat and in lakes/wetlands. In rivers and streams, one sample was collected at each of the 15 locations selected within the sampling reach. In wetlands, ten grab samples were collected at randomly chosen locations in the wetland, within a depth range of 1.5 to 3 m. Ekman grab samples were sieved in the field prior to preserving, using a 250 µm mesh sieve. Benthic samples were preserved in 10% buffered formalin.

In depositional reaches and in wetlands, one additional Ekman grab was collected at each sampling location and was analyzed for particle size distribution (sand, silt and clay as dry weight percentages) and total organic carbon (TOC as a dry weight percentage) to aid in the interpretation of the benthic invertebrate data.

Physical characteristics of the sampling sites were recorded to allow an analysis of the influence of such variation on the invertebrate community. Supporting measurements are listed below and were measured at each sampling location using the following instruments:

- wetted and bankfull channel widths – visual estimate (rivers/streams only);
- field water quality: DO, conductivity, pH, water temperature – YSI™ water quality meter;
- current velocity – Marsh-McBirney™ current velocity meter (rivers/streams only);
- water depth – wading rod of current velocity meter or graduated pole on Ekman grab;
- amount of benthic algae at erosional sites – a quantitative benthic algae sample at each sampling location (2 × 2 cm scrapes from three cobbles, combined into one composite sample), analyzed for chlorophyll a;
- substrate particle size distribution at erosional sites – visual estimates of areal coverage by particles in standard size categories using the modified Wentworth classification system (Cummins 1962), expressed as percentages;
- exact position – Garmin™ Global Positioning System (GPS) unit; and

- general site appearance – photograph (rivers/streams only).

Benthic algal scrapes for chlorophyll *a* analysis were stored and transported frozen. Sediment samples for determination of particle size and TOC were stored on ice or in a refrigerator and were transported on ice. Both were submitted for analysis at ETL.

3.4.4 Laboratory Methods

The sample material was first passed through a 250 µm mesh sieve to remove the preservative and any remaining fine sediments. The material retained by this sieve was elutriated using a floatation technique to separate organic material from sand and gravel, and invertebrates from organic material. Samples containing bitumen were treated with paint thinner to remove hydrocarbons prior to sorting. Inorganic material was scanned under a magnifying lens and any remaining invertebrates were removed before discarding. The remaining organic material was separated into coarse and fine size fractions using a 1 mm sieve. The fine size fraction of large samples was subsampled using a method based on that described by Wrona et al. (1982). Invertebrates were removed from the detritus under a dissecting microscope. All sorted material was preserved for random checks of removal efficiency.

Invertebrates were identified using recognized taxonomic keys (Brinkhurst 1989; Brooks and Kelton 1967; Clifford 1991; Currie 1986; Edmunds et al. 1976; Epler 2001; McCafferty and Randolph 1988; Merritt and Cummins 1996; Oliver and Roussel 1983; Pennak 1989; Stewart and Stark 1988; Teskey 1969; Westfall and May 1996; Wiederholm 1986; Wiggins 1996; Zloty and Pritchard 1997). Animals were identified to the lowest practical level, typically genus with the exception of the Oligochaeta, which were identified to family. Small, early-instar or damaged specimens were identified to the lowest level possible, generally to family.

Quality assurance and quality control (QA/QC) procedures related to benthic invertebrate sample processing are discussed in Section 4.2.4. Five per cent (i.e., 13 samples) of the total number of samples collected during the field program were re-sorted to evaluate sorting efficiency.

3.4.5 Data Analysis

The 2002 benthic survey results were summarized to describe benthic community characteristics in selected waterbodies. Consistent with the scope described in Section 1.2.4, summaries were generated for the Athabasca River delta, the

MacKay, Muskeg and Steepbank rivers, Fort Creek and Shipyard Lake. Non-benthic and terrestrial taxa were deleted from the data set before analysis. Community variables such as total abundance (number/m^2), taxonomic richness (total taxa/sampling reach and the mean number of taxa/sample) and community composition by major invertebrate groups were examined as bar graphs of mean numbers per reach or lake and corresponding standard errors (SE; except for total taxa/reach). Historical data were also included in these graphs, where available, to allow a preliminary examination of temporal trends. Mean abundances of common taxa in 2002, defined as those constituting ≥1% of total abundance in a reach or lake, were tabulated to illustrate relative abundances, dominance and variability within sampling reaches or lakes.

The benthic invertebrate abundance data were also examined for relationships between key habitat variables and benthic community structure (summarized as total abundance, richness and abundances of common invertebrates). Spearman correlation coefficients were calculated to identify potential relationships, separately for each river and lake. Significant correlations were examined visually as scatter-plots. Habitat variables were included in this analysis if they varied over a sufficient range to account for some variation in community structure. Substrate composition in erosional reaches was expressed as the Weighted Average Index (WAI; Fernet and Walder 1986). The WAI summarizes particle size as a single variable, which is useful to represent average particle size, provided that the size distribution is continuous. In rivers with more than two years of data (i.e., Muskeg, Steepbank and MacKay rivers), the relationship between stream flow and benthic community variables was examined visually, because there are insufficient data at this time for a statistical analysis.

3.5 FISH POPULATIONS

3.5.1 Overview

In 2002, RAMP conducted the following monitoring of fish populations in the Oil Sands Region:

- tissue collection and analysis for target species in the Athabasca and Muskeg rivers and in one Regional Lake (Gregoire Lake);
- fish inventory in the Athabasca River and in the Muskeg River basin;
- sentinel species monitoring of trout-perch in the Athabasca River;
- fish fence site reconnaissance in the Muskeg River;
- fyke net monitoring (non-core) in Muskeg River tributaries; and

- Index of Biotic Integrity (IBI) testing in the Athabasca River.

Table 3.19 presents the watercourses where sampling occurred and the target fish species for each fisheries component of the 2002 program. Appendix XIII presents the common and scientific names of fish species mentioned in this report.

Table 3.19 Tasks, Sampling Sites and Target Species of the RAMP 2002 Fisheries Program

Task	Study Period	Watercourse or Waterbody				
		Athabasca River	Muskeg River	Muskeg and Wapasu Creeks	Jackpine Creek	Regional Lakes (Gregoire Lake)
fish tissue collection and analysis	fall 2002	walleye, lake whitefish	northern pike	-	-	walleye, lake whitefish, northern pike
fish inventory	spring 2002	general	-	-	-	-
	summer 2002	-	general	-	general	-
sentinel species monitoring	fall 2002	trout-perch	-	-	-	-
fish fence site reconnaissance	spring and fall 2002	-	general	-	-	-
fyke net monitoring	spring and fall 2002	-	-	forage fish	-	-
IBI test	fall 2002	general	-	-	-	-

Note: "-" = Not included in task.

Standardized field sampling and fish processing methods were employed for all aspects of RAMP fish population monitoring. The standard protocols are in Golder Technical Procedures TP-8.1-3 "Fish Inventory Methods" (Golder 1997e). Tissue collection, storage and shipping procedures were conducted following Golder Technical Procedures 8.15-0 "Fish Health Assessment - Organics" (Golder 1997f) and 8.16-0 "Fish Health Assessment - Metals" (Golder 1997g). Methods used for each task are described below.

3.5.2 Fish Tissue Collection and Analysis

The goal of the RAMP tissue program is to measure contaminants in tissues from fish populations in relation to their potential for effects on fish health and the suitability of fish for human consumption. In fall 2002, fish sampling for tissue collection was conducted in the Athabasca River, Muskeg River and Gregoire Lake. Athabasca and Muskeg rivers sampling was part of the ongoing RAMP fish tissue monitoring program. The inclusion of Gregoire Lake represents the initiation of the Regional Lakes portion of the RAMP tissue sampling program. The Regional Lakes program is designed to provide fish tissue information for species in the recreational, subsistence or commercial fisheries in important lakes connected to the Athabasca River, or in the zone of airborne oil sands emissions.

The program was developed to address community concerns regarding the suitability of local fish for human consumption. At present, fish sampling in the lakes is not part of RAMP. Tissue collection and analysis will occur on an opportunistic basis, when sampling is conducted by other agencies or programs. Gregoire Lake was included in the RAMP 2002 tissue component to coordinate with an ASRD test netting program.

Tissue samples (boneless/skinless fillets consisting of muscle tissue) were collected from the selected species for each watercourse or waterbody (Table 3.19) for analysis of inorganic chemicals and organic tainting compounds. This was the first year of analysis for tainting compounds. The analysis of PAHs in previous RAMP years was not included in the 2002 program because previous RAMP data (Golder 2003a) indicated PAHs were generally not detected in fish tissues, with lack of detection likely due to the metabolization of PAHs by fish.

3.5.2.1 Fish Capture and Handling

Fish capture methods, times and locations in the Athabasca and Muskeg rivers are in Table 3.20. Fish capture in the Athabasca River was conducted by boat electrofishing within the sections of river defined by RAMP as the Steepbank and Muskeg areas (Figure 3.9). These areas include reaches 4 to 6 (Steepbank Area) and reaches 10 to 12 (Muskeg Area), as per Syncrude sampling procedures. Fish capture in the Athabasca River was conducted jointly by Syncrude, ASRD and Al-Pac. Fish capture in the Muskeg River was conducted by Golder by boat electrofishing the lower 21 km of the river (Figure 3.10).

Fish capture in Gregoire Lake was conducted by ASRD during the fall test netting program (Table 3.20). Locations of gill net sets for Gregoire Lake are in Figure 3.9.

Captured fish of the species targeted for tissue analysis were brought to processing stations for tissue collection. Fish processing and tissue collections were conducted in an onshore tent, at an indoor facility in Fort McMurray or at the Gregoire Lake Provincial Park building.

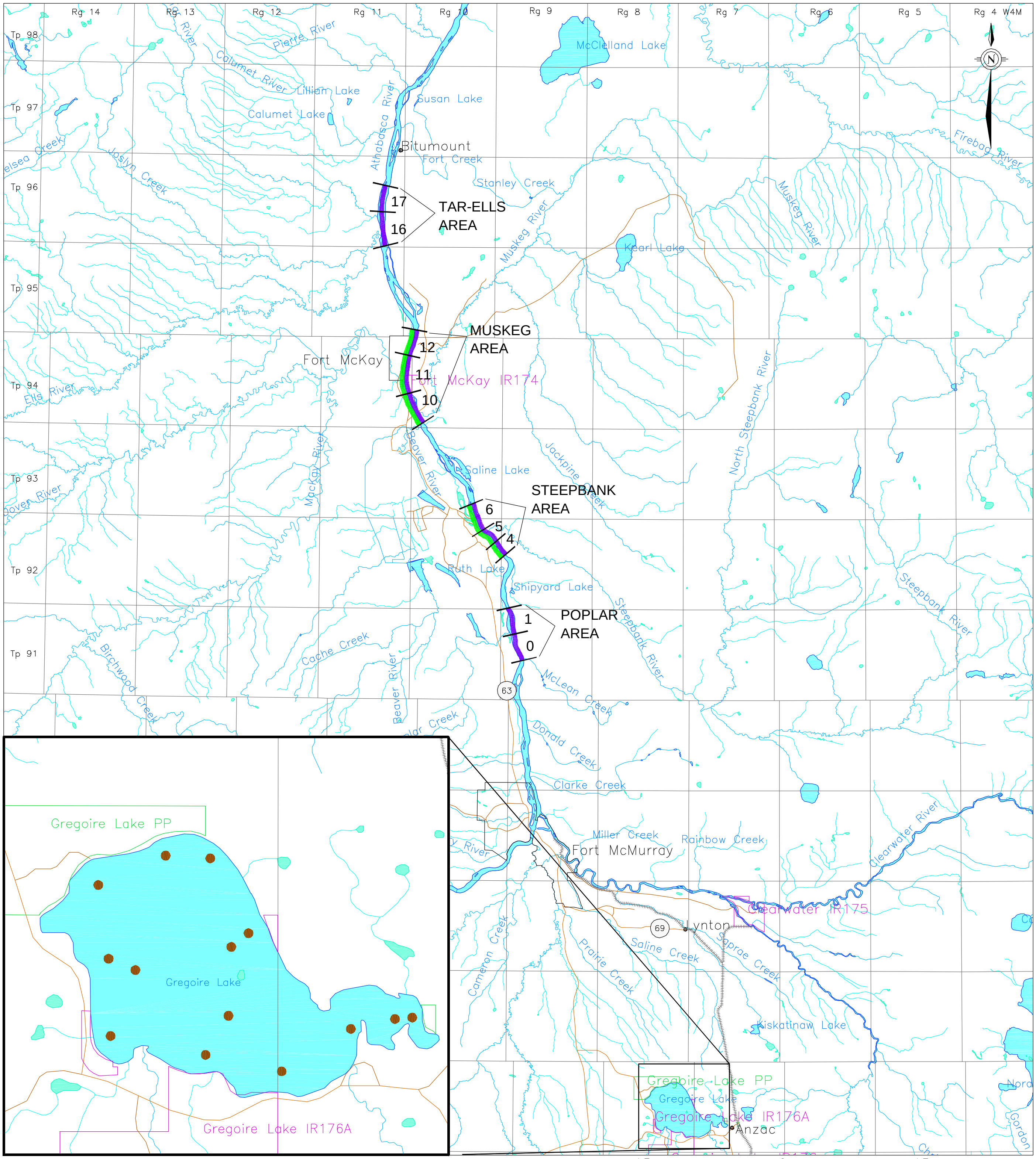
In the Athabasca and Muskeg rivers, individuals of the target species that were captured and not used for tissue collection were enumerated by species, measured for fork length and weight, examined externally for signs of sex and maturity, and released. In Gregoire Lake, all fish not used for tissue collection were processed by ASRD.

Table 3.20 Fish Collection Dates, Locations and Methods for the RAMP Fish Tissue Collection Program, Fall 2002

Watercourse or Waterbody	Sampling Dates	General Location	UTM Coordinates (NAD 83)		Sampling Crew	Sampling Equipment Details
			Start of Reach	End of Reach		
Athabasca River	Sept 4-21	Muskeg Area[(a)]	463967 E 6331391 N	463253 E 6341313 N	Syncrude ASRD Al-Pac	Smith-Root model SR-18 electrofishing boat with 5.0 GPP electrofishing unit, configured with two anode boom arrays with multiple dropper-cables and utilizing the boat hull as the cathode
		Steepbank Area[(a)]	472838 E 6317197 N	469314 E 6322688 N	Golder	Marathon jet boat with Smith-Root 5.0 GPP electrofishing unit, configured with two anode boom arrays with multiple dropper-cables and utilizing the boat hull as the cathode
Muskeg River	Sept 16-19	lower 21 km of the mainstem river[(b)]	467615 E 6341926 N	463563 E 6332213 N	Golder	Zodiac MK2C inflatable boat with Smith-Root model 5.0 GPP electrofishing unit, configured with two anode booms and two cathode booms with multiple dropper-cables
Gregoire Lake	Sept 16-19	throughout lake[(a)]	-	-	ASRD	Multi-mesh gill nets – 60 m long by 1.8 m deep with mesh sizes ranging from 38 to 152 mm

(a) See Figure 3.9 for sampling locations.

(b) See Figure 3.10 for sampling locations.



LEGEND

1 2 (purple line)	FISH INVENTORY REACHES (WITH REACH NUMBERS)
(green line)	FISH TISSUE COLLECTION SITES (ATHABASCA RIVER)
(brown dot)	FISH TISSUE COLLECTION SITES (GREGOIRE LAKE)

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12. OIL & GAS AND ENVIRONMENTAL DATA PROVIDED BY VERITAS GeoSERVICES LTD., CURRENT AS OF MAY 2001.

PROJECT

RAMP 2002

TITLE

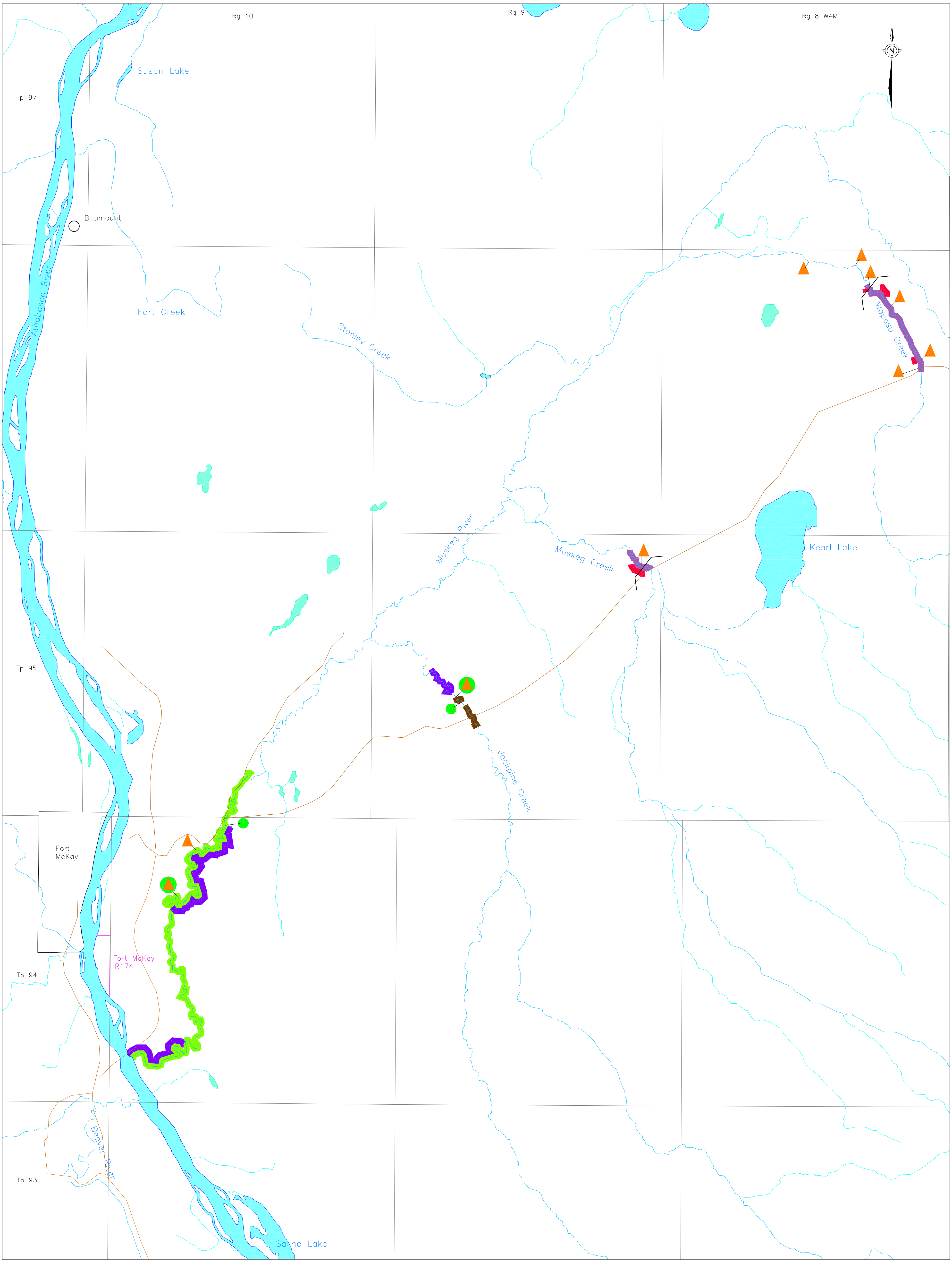
FISH TISSUE COLLECTION AND FISH INVENTORY SAMPLING SITES, ATHABASCA RIVER AND GREGOIRE LAKE, 2002

Golder Associates
Calgary, Alberta

PROJECT	No. 022-2301.5300		FILE No.	fish inventory	
DESIGN	LG	22/01/03	SCALE	AS SHOWN	REV. 0
CADD	AS	13/02/03			
CHECK			FIGURE: 3.9		
REVIEW					

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Fish inventory and tissue collection sampling sites.dwg Mar 15, 2003 - 5:13pm

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Sampling sites in the Muskeg River watershed.dwg Mar 15, 2003 - 5:19pm



LEGEND

- BAITED MINNOW TRAP
- GILL NET
- BOAT ELECTROFISHING
- BACKPACK ELECTROFISHING (SPRING)
- BACKPACK ELECTROFISHING (SUMMER)
- BACKPACK ELECTROFISHING (FALL)
- NORTHERN PIKE TISSUE COLLECTION
- FYKE NET (SRING AND FALL)

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83 UTM ZONE 12. OIL & GAS AND ENVIRONMENTAL DATA PROVIDED BY VERITAS GeoSERVICES LTD., CURRENT AS OF MAY 2001.

PROJECT

RAMP 2002

TITLE

FISH TISSUE COLLECTION, FISH INVENTORY AND FYKE NET MONITORING SITES, MUSKEG RIVER WATERSHED, 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. samp sites muskeg	
DESIGN	LG	29/01/03	SCALE AS SHOWN	REV. 0
CADD	AS	13/02/03	**FIGURE: 3.10**	
CHECK				
REVIEW				

3.5.2.2 Tissue Collection and Analysis

Tissue mercury concentration was analyzed for individual fish. The fish species and sizes targeted for tissue analysis for each watercourse/waterbody are in shown Table 3.21. From the captured fish of each target species, up to 25 individuals were selected for tissue analysis on the basis of their size (fork length). The objective was to collect tissues from five fish from each of five pre-determined size classes for each species (Table 3.21). Target size classes were used to obtain tissue samples for a wide range of fish sizes and ages to derive a better understanding of tissue concentrations in the populations being assessed. The size classes were selected following examination of the typical size ranges available in the fall, based on existing inventory data. Size classes for lake whitefish from the Athabasca River were relatively narrow compared to the other species because lake whitefish present in the fall are mainly adults.

The target size classes were used as a guide for selection of fish for tissue analysis; however, selection of fish was also dependent on the number and size of fish captured. The number of fish per size class was adjusted when smaller fish did not provide a sufficient weight of tissue for analysis (i.e., 10 grams) and when fish from specific size classes were not readily available.

In contrast to mercury analysis, trace metals and tainting compounds were analyzed for composite samples. For each watercourse/waterbody, composite samples were prepared for each target species by sex. Composite samples consisted of tissues from five fish per sex and included some of the fish for which mercury was analyzed. To minimize the variability within the composite, fish were to be from a narrow range in fork length (Table 3.21).

Table 3.21 Target Fork Length Classes for the Selection of Fish for the RAMP Fish Tissue Collection Program, Fall 2002

Watercourse or Waterbody	Species	Target Size Class for Mercury Analysis (mm)[a]					Target Size Class for Composite Samples (mm)[b]	
		1	2	3	4	5	Female	Male
Athabasca River	walleye	200-300	301-400	401-500	501-600	601-700	500-550	450-500
	lake whitefish	350-400	401-450	451-500	501-550	551-600	400-450	400-450
Muskeg River	northern pike	200-300	301-400	401-500	501-600	601-700	600-700	550-650
Gregoire Lake	walleye	200-300	301-400	401-500	501-600	601-700	500-550	450-500
	lake whitefish	200-300	301-400	401-500	501-600	601-700	400-450	400-450
	northern pike	200-300	301-400	401-500	501-600	601-700	600-700	550-650

(a) Target of five fish per size class.

(b) Target of five fish per sex.

Fish selected for analysis were measured for fork length (nearest 1.0 mm) and total body weight (nearest 1.0 g). For each fish, a sample of muscle tissue was removed for mercury analysis. Additional muscle tissue samples were collected from five males and five females of each species for composite analysis. From each of the fish making up the composite, a sample was removed from one side using the organics protocol (Golder 1997f) and from the other using the metals protocol (Golder 1997g). Muscle from each side was divided into two parts, one to be included in the composite sample for analysis, and the other for archiving. For each species and sex, the tissue samples for tainting compounds and metals analysis were separated, frozen to –78.5 °C and shipped to the laboratory on dry ice. The tissue samples for archiving were shipped to the Golder laboratory in Calgary for storage in a temperature alarmed sample freezer.

Archived tissues from fish were kept pending the analytical results of the composite samples. If the results for any composite sample showed a concentration above the recommended guideline for any parameter, the individual tissue samples for that composite were to be analyzed. Individual analysis was not required for any of the composite samples in 2002.

Tissue analysis was conducted by ETL, Edmonton. All individual fish tissue samples were analyzed for mercury concentration (detection limit 0.01 mg/kg). The composite samples were prepared in the laboratory using equal weights of tissue from each of the fish included in the composite. Composite samples for fish from the Athabasca and Muskeg rivers were analyzed for a suite of inorganic parameters and tainting compounds. The composite samples for fish from Gregoire Lake were analyzed for the suite of inorganic parameters only. The analytical methods used for the tissue analyses are shown in Table 3.22. The 30 individual parameters in the suite of inorganic chemicals, along with the associated analytical detection limits, are shown in Table 3.23. The organic parameters included fourteen compounds known to have the potential to taint fish flesh (Table 3.24). However, the laboratory was unable to analyze the full list of compounds; four of the parameters (naphthalene, m+p-xylenes, thiophene and toluene) were successfully analyzed. All tissue concentrations were expressed on the basis of wet tissue weight.

Table 3.22 Analytical Methods for Measuring Trace Metals and Tainting Compounds in Fish Tissue

Parameter	Method[a]
mercury	APHA 3114C
metals	U.S. EPA method 200.3 and 3050 (preparation), U.S. EPA method 200.7 and 6020 (analysis)
tainting compounds	U.S. EPA 5021/8240-Headspace GC/MS

[a] U.S. EPA 2000a, 2000b; Long and Martin 1991; McDaniel 1991.

Table 3.23 Parameter List and Detection Limits of Inorganic Chemicals for Composite Fish Tissue Analysis

Parameter	Detection Limit (mg/kg)	Parameter	Detection Limit (mg/kg)
aluminum	4	manganese	0.04
antimony	0.04	molybdenum	0.04
arsenic	0.2	nickel	0.08
barium	0.08	phosphorus	2
beryllium	0.2	potassium	2
boron	2	selenium	0.2
cadmium	0.08	silver	0.08
calcium	10	sodium	2
chromium	0.2	strontium	0.04
cobalt	0.08	thallium	0.04
copper	0.08	tin	0.08
iron	2	titanium	0.05
lead	0.04	uranium	0.04
lithium	0.5	vanadium	0.08
magnesium	2	zinc	0.2

Table 3.24 Parameter List and Detection Limits of Organic Tainting Compounds for Composite Fish Tissue Analysis

Parameter	Detection Limit (mg/kg)	Parameter	Detection Limit (mg/kg)
benzothiophene	-	2,6-dimethylnaphthalene	-
2,5-dimethylphenol	-	mesitylene	-
naphthalene	1	thiophene	1
1-methylnaphthalene	-	2-methylthiophene	-
dibenzothiophene	-	toluene	1
2,3,5-trimethylnaphthalene	-	total cresols	-
m+p-xylenes	1	phenol	-

Note: "-" = no detection limit, parameter could not be successfully analyzed.

3.5.2.3 Fish Health Assessment

In addition to tissue collection, a fish health assessment was conducting for each fish using an external/internal pathology examination to assess abnormalities such as disease and parasites, and to determine sex and state-of-maturity. The features evaluated in the pathological examination and abnormality assessment are in Appendix XIV. The results of the examination were used to calculate a pathology index (PI) for each fish (see Section 3.5.4 for a more detailed description of PI).

Following the pathology examination, the whole gonad and liver were removed and weighed to the nearest 0.1 g. All other internal organs were then removed and the weight of the remaining carcass was measured to the nearest 1.0 g. The gonad somatic index (GSI) and liver somatic index (LSI) were later calculated as the ratio of organ weight to carcass weight. Structures for ageing (as per MacKay et al. 1990) were removed, dried and placed in labeled envelopes. Ageing structures included sagittal otoliths and pelvic fin rays (lake whitefish), pelvic spine/fin rays and dorsal spine (walleye), and cleithrum and pelvic fin rays (northern pike). All tissues collected for ageing were assessed by ageing specialist Jon Tost of North Shore Environmental Services, Ontario.

3.5.3 Fish Inventory

3.5.3.1 Athabasca River

The RAMP Athabasca River fish inventory provides data on Key Indicator Resource (KIR) fish species and allows the examination of temporal variability in species composition, species relative abundance, size, age and condition factor. In 2002, a spring fish inventory was conducted in the Athabasca River as part of the ongoing program to document the presence and relative abundance of dominant large-bodied fish species in the Oil Sands Region. The inventory was conducted by Syncrude as an in-kind contribution to RAMP.

Fish Sampling and Handling

Fish sampling was conducted from May 29 to June 4, 2002. The portions of the Athabasca River sampled include the 10 reaches established for the inventory program (Figure 3.9). The 10 reaches are in four areas of the Athabasca River near major tributary confluences (Table 3.25). These areas include reaches 0 and 1 (Poplar Area), reaches 4 to 6 (Steepbank Area), reaches 10 to 12 (Muskeg Area), and reaches 16 and 17 (Tar-Ells Area). Sampling was conducted in near-shore areas within each of the reaches.

Table 3.25 Athabasca River Fish Inventory Sampling Sites, Spring 2002

Sampling Site[a]	Reach Numbers	UTM Coordinates (NAD 83)	
		Start of Area	End of Area
Poplar Area	0 and 1	474627 E / 6305817 N	473052 E / 6311432 N
Steepbank Area	4, 5 and 6	472838 E / 6317197 N	469314 E / 6322688 N
Muskeg Area	10, 11 and 12	463967 E / 6331391 N	463253 E / 6341314 N
Tar-Ells Area	16 and 17	459859 E / 6350353 N	459913 E / 6356845 N

[a] See Figure 3.9 for sampling sites.

Fish sampling was conducted using a Smith-Root model SR-18 electrofishing boat equipped with a 5.0 GPP electrofishing unit, configured with two anode boom arrays with multiple dropper-cables. The boat hull was the cathode. Fish stunned by the electrical discharge were dip-netted from the water and placed in a flow-through live well. Fish that were stunned but not dip-netted were enumerated by species and recorded as observed fish. Captured large-bodied fish were measured (fork length to the nearest mm) and weighed (nearest g). For small species (e.g., forage fish), only fork length was measured. Sex and state of maturity was determined when discernable by external examination. An external pathological examination was conducted for large-bodied fish to check for signs of abnormalities, disease and parasites, as per the features in Appendix XIV. An external pathology index (EPI) was calculated for each fish. KIR fish species of sufficient size were marked with RAMP Floy tags prior to release. Age analysis was not conducted in 2002.

Data Analysis

Analysis of previous RAMP inventory data for the Athabasca River (Golder 2003a) indicated that, because of biases associated with the sampling technique (boat electrofishing), the RAMP data was suitable for assessing large-bodied fish populations only. Analysis of the 2002 inventory data was conducted for large-bodied fish species of regional importance (i.e., KIR species or species that occur in high abundance). Fish species composition (% of total by species) and relative abundance (catch-per-unit-effort – CPUE), was estimated using fish captured and observed. Percent composition was calculated as the number of fish recorded as a percentage of the total for all species combined and CPUE was calculated as the number of fish recorded per 100 seconds of electrofishing.

For species where sample sizes were adequate (i.e., $n \geq 30$ for fish captured and measured), the following population parameters were compared to data from previous years:

- length frequency distribution;
- mean condition factor; and
- mean external pathology index.

Length frequency distributions in 2002 were based on fork length classes used in previous RAMP inventories (Golder 2003a). For comparisons to Athabasca River inventories from 1995 to 1999, length frequency distributions were transformed to percent frequency to standardize data and eliminate dependency on sample size. The length frequency distributions did not fit a 'normal distribution', therefore, the non-parametric multiple comparisons for non-parametric repeated-measures analysis of variance test ($\alpha = 0.05$) was used to test for annual differences (Zar 1999).

Condition was calculated as the Fulton-type Condition Factor, *k*, where *k* is = body weight (g) x 10^5 / length (mm)^3 [Note: Fulton's Condition Factor was multiplied by 10^5 to scale *k* close to 1.0, as per Mackay et al. 1990]. Data was screened prior to the condition factor analysis to check for outlying data points by plotting length versus weight. Outliers were recording or transcription errors and were dropped from the analysis [Note: in total, data from only seven fish were removed]. For comparisons to previous inventories (1995 to 1999), the parametric one-way analysis of variance test (ANOVA) was used to determine if mean condition factor differed significantly among years (Zar 1999). For between year comparisons of fish condition, condition factor was estimated for adult fish only.

An external pathology index was calculated for each fish as the sum of the index values for each abnormality recorded (Appendix XIV). Individual external pathology indices were used to calculate the mean for each species.

The 2002 inventory data were compared to previous RAMP data and to historical data presented in the RAMP Five Year Report (Golder 2003a). To remove the influences of seasonal variations on population parameters, the 2002 data were compared to previous spring data only.

3.5.3.2 Muskeg River and Tributaries

The RAMP fish inventory in the Muskeg River basin obtains data on species presence and relative abundance in years when the Muskeg River fish fence is not deployed. In 2002, summer fish inventories were conducted in the lower Muskeg River and lower Jackpine Creek as part of the ongoing monitoring program.

Fish Sampling and Handling

Fish inventories were conducted from July 19 to 22 (Jackpine Creek) and July 23 to 26 (Muskeg River). The portions of each watercourse sampled are in Figure 3.10, by sampling technique. The general locations and UTM coordinates for the inventoried sites are in Table 3.26.

The Muskeg River was sampled primarily with a boat electrofisher. Jackpine Creek was sampled using both backpack and boat electrofishing. Backpack electrofishing gear was a Smith-Root Type 15-D electrofishing unit powered by a 350-watt generator and configured with an anode pole (27.9-cm diameter ring) and a rattail cathode. Boat electrofishing gear consisted of a Smith-Root model 5.0 GPP boat electrofishing unit mounted in a Zodiac MK2C inflatable boat, as described in Section 3.5.2.1. Gill net (single panel nets 15.2 x 1.8 m with 5.1 cm mesh) and standard Gee minnow traps (baited) were also deployed in both watercourses. Gill nets were used in deep, slow moving habitats associated with pools (Muskeg River) or beaver impoundments (Jackpine Creek) and minnow traps were set for small-bodied fish species and young-of-the-year or juvenile life stages of large-bodied species.

Sampling effort was recorded for all fishing activities. Electrofishing units were equipped with timers that recorded the seconds of active electrofishing (i.e., the number of seconds that electrical current was applied to the water). Set duration in hours was recorded for each gill net and minnow trap set.

All fish captured or observed during sampling were enumerated by species and life stage. For captured fish, fork length (nearest 1.0 mm) and weight (nearest 1.0 g) were measured for large-bodied fish and a representative sample of each small-bodied species. Sex and state-of-maturity were determined, when discernable by external examination. An external pathology examination was conducted for each fish prior to release to provide an external pathology index (EPI) (as per Appendix XIV). Sport fish and longnose suckers of sufficient size (i.e., >300 mm) were tagged with RAMP Floy tags.

Table 3.26 Location of Sampling Sites and Sampling Method Used for the Jackpine Creek and Muskeg River Fish Inventories, Summer 2002

Watercourse	Sampling Technique	UTM Coordinates (NAD 83)		
		Sampling Reach		Sampling Point
		Start of Reach	End of Reach	
Jackpine Creek	backpack electrofishing	474848 E / 6344296 N	475098 E / 6343575 N	-
		474712 E / 6344435 N	475463 E / 6344531 N	-
	boat electrofishing	474403 E / 6344762 N	473687 E / 6345532 N	-
	gill net	-	-	474670 E / 6344551 N
		-	-	475470 E / 6344575 N
	minnow trap	-	-	474605 E / 6344604 N
Muskeg River	boat electrofishing	466489 E / 6340001 N	465437 E / 6338936 N	-
		465283 E / 6332565 N	463382 E / 6332377 N	-
	gill net	-	-	466497 E / 6344007 N
		-	-	465148 E / 6337614 N
	minnow trap	-	-	465496 E / 6339618 N
		-	-	465040 E / 6337807 N

Data Analysis

Fish species composition (% of total by species) and relative abundance (CPUE) was estimated using fish captured and observed. Percent composition was calculated as the number of fish recorded (all sampling techniques) as a percentage of the total for all species combined. CPUE was calculated for each sampling technique: for electrofishing as number of fish per 100 seconds of effort, and for gill net and minnow trap sets as the number of fish per hour.

For large-bodied species with suitable sample size (i.e., $n \geq 30$ individuals measured), length frequency analyses were conducted, and mean Fulton-type Condition Factor (*k*) and external PI were calculated.

Results of the 2002 inventories were compared to previous RAMP inventory data from 1997 (Muskeg River) and 2001 (Muskeg River and Jackpine Creek). To facilitate comparison of frequency distributions to previous Muskeg River inventory data, the length frequency distributions were transformed to percent frequency. Because there were only two years of data (2001 and 2002) with sufficient sample sizes, the non-parametric Kolmogorov-Smirnov two sample test ($\alpha = 0.05$) was used to determine if there was a significant difference in the length frequency distributions between the two years (Zar 1999).

3.5.4 Sentinel Species Monitoring

3.5.4.1 Athabasca River

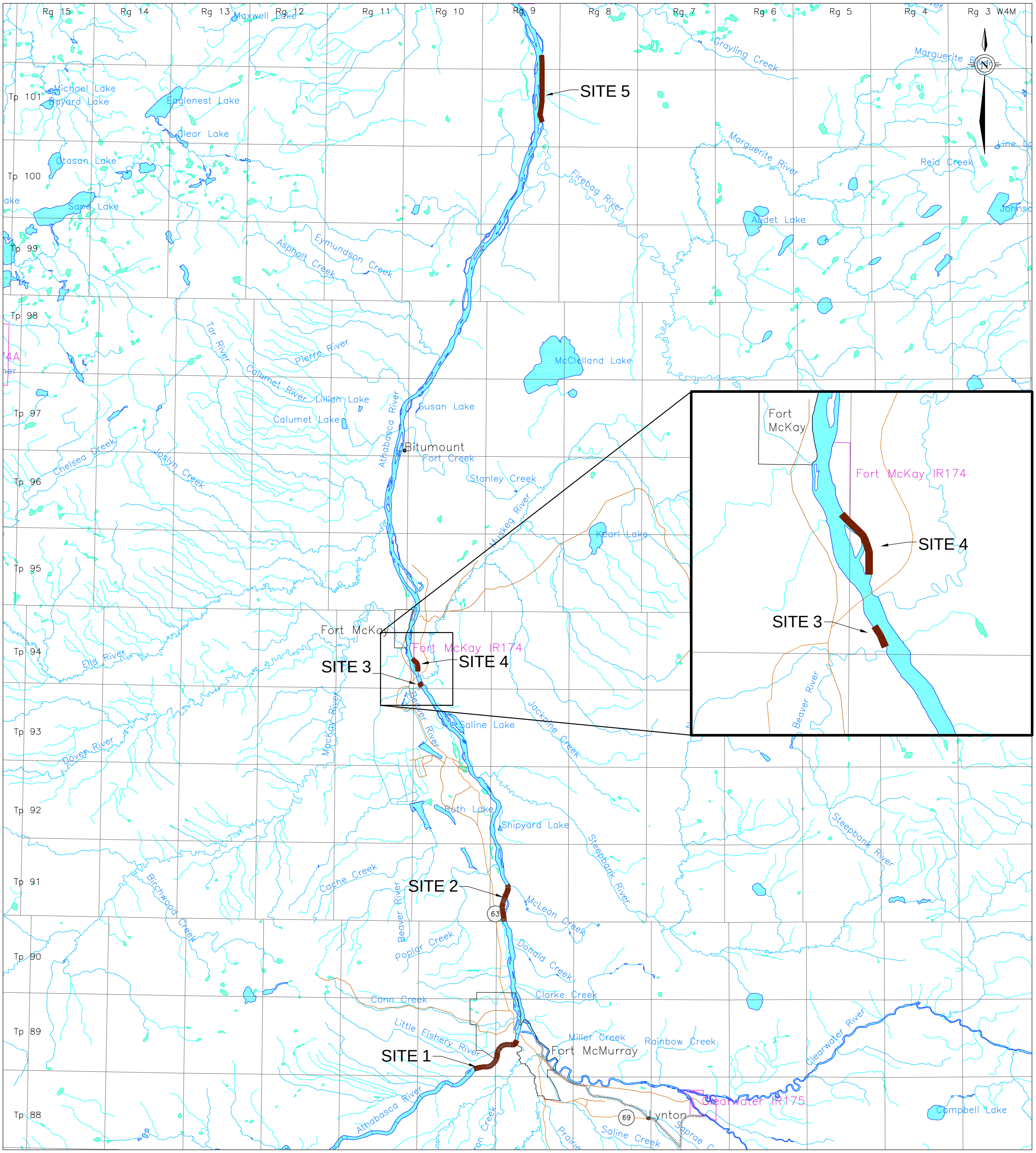
The sentinel species monitoring program for the Athabasca River assesses the response of individuals and the population to the potential effect from oil sands development, over time and in relation to populations outside the area of development. In 2002, the sentinel program examined trout-perch populations as part of the ongoing monitoring program initiated in 1999 for this species. The monitoring program in 2002 was changed from the 1999 program with respect to sampling sites and sample sizes. In 2002, the program added two sampling sites, relocated one sampling site and increased the number of fish sampled per site.

Sentinel species monitoring includes collections of trout-perch at exposure and reference sites. Exposure sites are in the vicinity of, or downstream of, current or future oil sands developments. These sites are not necessarily exposed to industrial discharges, but have the potential to be impacted by oil sands operations because of their location. Reference sites are in the Athabasca River upstream of the oil sands development. The number of sampling sites increased from three in 1999 to five in 2002 through the addition of one reference site and one exposure site. Table 3.27 provides sampling site details; site locations are presented in Figure 3.11.

Table 3.27 Sampling Locations for the Athabasca River Sentinel Fish Species Monitoring Program, Fall 2002

Site Number	General Location[(a)]	UTM Coordinates of Sampling Reaches (NAD 83)		Site History and Rationale
		Start of Reach	End of Reach	
1	upstream of the Ft. McMurray Sewage Treatment Plant (STP)	475650 E / 6286679 N	470302 E / 6283093 N	*Reference Site* – new site added in 2002 to provide a reference population not exposed to the STP discharge, to help isolate potential effects due to oil sands development from effects related to the STP
2	between the STP discharge and the Suncor/Syncrude area	474476 E / 6306201 N	474101 E / 6301565 N	*Reference Site* – site used in 1999 and 2002 as a reference population exposed to the STP discharge but not oil sands development
3	below the Suncor/Syncrude area, sampling on the west bank	463407 E / 6331547 N	463707 E / 6330992 N	*Exposure Site* – site moved from immediately below the Suncor discharge (1999) to below the Beaver River confluence (2002) to provide exposure to both the Suncor and Syncrude existing operations
4	below the Muskeg River confluence, sampling on the east bank	462534 E / 6334554 N	463263 E / 6332929 N	*Exposure Site* – site used in 1999 and 2002 as a population exposed to influences from development in the Muskeg River watershed
5	below the Firebag River confluence, sampling on the east bank	478761 E / 6410216 N	478852 E / 6401786 N	*Exposure Site* – new site added in 2002 to provide a population downstream of all tributary watersheds with potential oil sands development

(a) See Figure 3.11 for sampling locations.



LEGEND

TROUT–PERCH MONITORING SITES

15 0 15

SCALE KILOMETRES

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUGUST 2001. NAD 83 ZONE 12. SHEETS 74D, E AND 74L IN NAD 27 ZONE 12.
SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG. 2001. NAD 83 ZONE 13.
ALL DATA CONVERTED TO NAD 83 UTM ZONE 12.
OIL & GAS AND ENVIRONMENTAL DATA PROVIDED BY VERITAS GeoSERVICES LTD., CURRENT AS OF MAY 2001.

PROJECT

RAMP 2002

TITLE

SENTINEL SPECIES (TROUT-PERCH) MONITORING SITES, ATHABASCA RIVER, FALL 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022–2301.5300			FILE No. fish sentinel species	
DESIGN	LG	22/01/03	SCALE AS SHOWN	REV. 0
CADD	AS	13/02/03	**FIGURE: 3.11**	
CHECK				
REVIEW				

R:\CAD\2300\022–2301\5300\Final 2002 Annual Report\ Drawing file: Fish sentinel species monitoring sites.dwg Mar 15, 2003 – 5:25pm

Fish Capture and Handling

In 2002, trout perch were captured at five sites using electrofishers and beach seines (Table 3.28) from September 4 to 21. The target number of trout-perch to be collected at each site was 80 mature fish, with the sexes represented equally. The sample size was increased by 10 fish per sex from 1999. Sampling was conducted jointly by Syncrude, ASRD and Al-Pac during surveys associated with the IBI test program, or specifically for the sentinel species program by Golder. The method of fish capture and equipment used by each crew is in Table 3.28.

Larger trout-perch considered to be adults were transported to the fish processing location (indoor facility in Fort McMurray) in a closed carrying container filled with site water and equipped with an aerator. For the health assessment, fish were killed by a lethal dose of anesthetic. Fish were measured, fork length (±1 mm), and weighed (±0.001 g). Following dissection, both gonads, liver and carcass were weighed (±0.001 g). An external/internal pathology examination was conducted for abnormalities, disease and parasites, and to determine sex and state-of-maturity. For females, both whole ovaries were preserved for fecundity analysis. Ageing structures (saggital otoliths) were collected, as per MacKay et al. (1990). All ageing structures were analyzed by Jon Tost of North Shore Environmental Services, Ontario.

Table 3.28 Sampling Methods Used for Capturing Trout-perch in the Athabasca River for Sentinel Species Monitoring, Fall 2002

Sampling Site[(a)]	Fish Collection Crew	Sampling Equipment Details
1, 2, 3, 4	Syncrude, ASRD and Al Pac	Smith-Root model SR-18 electrofishing boat with 5.0 GPP electrofishing unit, configured with two anode boom arrays with multiple dropper-cables and utilizing the boat hull as the cathode
1, 2, 5	Golder	Zodiac MK2C with a Smith-Root model 5.0 GPP boat electrofishing unit, configured with two anode and two cathode boom arrays with multiple dropper-cables
1, 2, 4	Golder	Small-mesh beach seine; 8.3 m x 1.2 m with 4 mm mesh
2,4	Golder	Smith-Root Type 15-D backpack electrofishing unit powered by 350 w generator, configured with anode pole (27.9 cm diameter ring) and rattail cathode
5	Golder	Marathon jet boat with a Smith-Root model 5.0 GPP boat electrofishing unit, configured with two anode boom arrays with multiple dropper-cables and utilizing the boat hull as the cathode

(a) See Figure 3.11 for sampling sites.

Metrics and Indices

To evaluate the health of the trout-perch populations, the following were estimated:

- growth (size and age);
- Fulton-type Condition Factor;
- Gonad Somatic Index (GSI);
- Liver Somatic Index (LSI);
- Fecundity Index; and
- Pathology Index (PI).

The indices that describe relationships between body metrics were calculated using whole body weight for condition factor and carcass weight for GSI, LSI and fecundity index.

Growth (Size and Age)

For the adult fish sampled from each of the five trout-perch populations, mean fork length and mean weight were calculated. Age estimated from saggital otoliths was used to produce an age-frequency distribution and calculate mean age. Age was related to fish size (i.e., length) to assess fish growth for the different populations using a regression of mean fork length versus age.

Fulton-Type Condition Factor

Fulton-type Condition Factor (k) is a growth descriptor suitable for comparing different individuals of the same species and can indicate differences related to sex, season or place of capture (i.e. exposure to Oil Sands development). The k is a measure of the weight of a fish relative to the cube of its length (Ricker 1975) and is defined as follows:

$$k = \text{body weight (g)} \times 10^5 / \text{fork length (mm)}^3$$

The condition factor indicates the weight achieved in relation to fish size and reflects the nutritional state or well-being of the individual. The calculated k will be 1.0 for a fish whose weight is equal to the cube of its length. Fish with a low k are considered to be less robust (MacKay et al. 1990).

Gonad Somatic Index (GSI)

The GSI is a measure of the size of the gonad relative to body size and is defined as:

$$GSI = \text{gonad weight (g)} / \text{carcass weight (g)} \times 100.$$

The GSI is an index of the proportion of growth allocated to reproductive tissues in relation to somatic growth. This sign of reproductive health can be affected by exposure to chemical stressors in the environment. A population with a comparatively low GSI may have insufficient energy available for gonad growth and development.

Liver Somatic Index (LSI)

The LSI is a measure of liver size relative to body size and is defined as:

$$LSI = \text{liver weight (g)} / \text{carcass weight (g)} \times 100$$

The LSI is an indicator of fish health. Energy stored in the liver in the form of glycogen and the relative size of the liver are believed to correlate with nutritional state. Also, liver size may increase in relation to the level of detoxification required due to chemical stressors in the environment (Hodson et al. 1991).

Fecundity Index

Fecundity is the total number of eggs in both ovaries of a female fish. For each female trout-perch, the preserved ovaries were examined and the total number of eggs counted under a dissecting microscope at 10x magnification. Because fecundity often increases with fish size, a fecundity index was calculated as:

$$\text{Fecundity Index} = \text{total number of eggs} / \text{carcass weight (g)}.$$

Pathology Index (PI)

A pathology Index (PI) was calculated based on the Health Assessment Index (HAI) developed by Adams et al. (1993). Fish exposed to environmental contaminants or stresses frequently show visible external and/or internal signs of disease as abnormal conditions in tissues or organs. Because the incidence of pathological conditions may be related to degradation of the aquatic environment (Adams et al. 1993), a pathological examination was conducted for the sentinel species. The fish were examined for parasites and non-specific abnormalities such as growths, lesions and deformities.

The 14 parameters in the pathology examination that were used in calculating PI are in Appendix XIV. Each parameter was assigned a numerical value based on the condition or appearance of the tissue/organ. Normal conditions have a value of zero and abnormal conditions have a higher value, to a maximum index of 30 per parameter. For nine parameters, any abnormal condition was assigned a value of 30. For the other five parameters, the severity of the abnormality was rated as low (value of 10), moderate (value of 20) or high (value of 30). The PI for each fish was the sum of the values for each of the 14 parameters. Therefore, the higher the PI for a fish, the higher the number and/or severity of abnormalities. A mean PI was then calculated for the trout-perch populations (sexes separate) from each of the five exposure and reference sites.

A fifteenth parameter recorded during the pathology examination was the level of mesenteric fat. This parameter was not assigned an index value and was not used in the calculation of the PI.

Statistical Analysis

Analysis of Variance (ANOVA) was used to compare length, weight and age estimates for trout-perch populations among reference and exposure sites. Estimates of size-at-age (length-at-age), condition (*k*), gonad size (gonad weight/carcass weight), fecundity (number of eggs/carcass weight) and liver size (liver weight/carcass weight) were evaluated using ANCOVA. With the exception of size-at-age and condition, carcass (i.e., eviscerated) weight was used as a covariate to adjust for any differences in body size. Using carcass weight instead of whole body weight reduced confounding effects from altered organ weight (e.g., gonad weight, liver weight), should it occur, on the interpretation of variables related to body weight. To ensure statistical robustness, ANCOVA also were performed with whole body weight and length as estimates of body size. An assumption of the ANCOVA model is that the slopes of the regression lines are equal among regions; therefore, differences in slopes were tested prior to conducting the ANCOVA. Data were $\log_{10}$ transformed where appropriate, and sexes were analyzed separately. Statistical analyses were conducted with SYSTAT® statistical software (Wilkinson 1990).

Following an overall ANOVA or ANCOVA using data for all sites, contrasts were conducted to make comparisons in fish performance:

- Site 2 (downstream of Ft. McMurray STP) vs. Site 1 (upstream of STP);
- Site 3 (downstream of the Suncor/Syncrude area) vs. Site 2;
- Site 4 (downstream of the Muskeg River confluence) vs. Site 2; and
- Site 5 (downstream of the Firebag River confluence) vs. Site 2.

Site 2 was used as the reference against which the exposure sites (i.e., Sites 3 to 5) were compared, rather than Site 1, because Site 2 provided a more similar chemical environment to those of the exposure sites (i.e., sites 2 through 5 are all downstream of the STP discharge). Site 1 is not exposed to the Ft. McMurray STP and, therefore, does not constitute an ideal reference site for any of the oil sands exposure sites. Bonferroni's adjustment was used to control experiment-wise error in these comparisons; therefore, a significance level of $P = 0.0125$ (i.e., α/no. of comparisons or 0.05/4) rather than $P = 0.05$ was used.

Data were initially screened for outliers by visual examination of scatterplots and box plots. Outliers were removed using an evaluation of Studentized Residuals (SR). Observations of four standard deviations or more (i.e., SR $\geq$4) from the cell mean were removed and the analysis repeated. If any new outliers (SR $\geq$ 4) occurred, they were also removed and the analysis was redone. No further outliers were deleted after this point. Adopting SR $\geq$4 as a cut-off is conservative, as greater than 99% of Studentized residuals were expected to have lower values (Grubbs 1971).

Power analysis was conducted to evaluate the adequacy of sample sizes for detecting differences in fish performance. This analysis is valuable for refining the sampling design for subsequent sentinel monitoring surveys. Specifically, power analysis was used to estimate the appropriate sample size required to detect a given effect size (or difference in performance between sites). Because the study design consists of five sites, simple power equations comparing two samples cannot be used. Cohen (1988) provides methods for power analyses with more than two sites and for a variety of statistical tests (e.g., ANOVA, ANCOVA). Power analyses were conducted using G*Power software (Faul and Erdfelder 1992), which performs computations based on methods described by Cohen (1988).

The effect size or difference to be detected is not easily defined. In wild fish, differences as high as 20% have been observed in parameters between reference areas (Environment Canada 2002). The Environmental Effects Monitoring program for the pulp and paper industry have set an effect size of ±25% difference in gonad weight (Environment Canada 1997a). Since variability will also vary between sampling campaigns, the target effect size should not be a fixed number, but rather a range of changes that one wishes to detect, such as a 20 to 50% difference. For the purposes of refining the RAMP study design, parameter-specific sample sizes were estimated for an effect size of 20, 30, and 50% (i.e., differences between sites). The mean squared error (MSE) term from the ANOVA or ANCOVA statistical model provided the estimate of among-site-variance for each fish parameter.

3.5.5 Muskeg River Fish Fence Reconnaissance

The Muskeg River fish fence was unsuccessful in 2001 because spring discharge was high (i.e., 12.2 m^3/s). Analysis of previous counting fence operations in the Muskeg River (Golder 2003a) indicated that fish fence deployments were successful at flows less than 6.5 m^3/s. Counting fences operating at higher discharges failed. To increase the probability of successful deployment of the Muskeg River counting fence, a reconnaissance of the lower Muskeg River was conducted to evaluate potential fish fence sites.

Two site visits were conducted to examine the lower 1.5 km of the Muskeg River to identify candidate counting fence sites. The site visits were on July 10 at a discharge of 5.5 m^3/s and October 24 at a flow of 7.3 m^3/s (flow data from Water Survey of Canada gauging station).

Within the 1.5 km section of the Muskeg River, candidate counting fence sites should have:

- a straight section of channel;
- uniform cross-section with respect to depth and velocity;
- rocky substrate with minimal amount of bitumen;
- a safe working area on at least one bank for staging and fish processing; and
- access to the site for fence transport and installation.

The location of each candidate site was recorded by GPS and on a 1:10,000 scale air photo of the river. The depth and velocity profile was measured at each candidate site using a tagline stretched across the river channel and measuring water depth and velocity at 2 m intervals across the channel width. Velocity and depth profiles were measured during the July visit only. Substrate composition at each site was assessed qualitatively by making a visual estimation of the substrate particle sizes present and by digging in the riverbed to assess substrate compaction.

3.5.6 Fyke Net Monitoring (Non-Core)

3.5.6.1 Muskeg River Tributaries

Fyke nets were used to assess the populations and movements of fish in tributaries of the upper Muskeg River basin, with emphasis on small-bodied forage fish species. Within the RAMP fish program, the fyke net monitoring was conducted in 2002 only. Fyke nets were used to monitor upstream movements in the spring and downstream movements in the fall in Muskeg and Wapasu creeks.

Fyke net sampling times and locations are in Table 3.29 and Figure 3.10. Spring sampling occurred shortly after ice-out. Although Wapasu Creek was ice free in mid-May, extreme ice conditions (95% ice cover) on Muskeg Creek at that time postponed the installation of the fyke net until late May (Table 3.29). The fyke net placed in Wapasu Creek fyke was 3.5 km downstream of the Canterra Road bridge. The Muskeg Creek fyke net was placed a short distance downstream of the Canterra Road bridge.

Fyke net mesh size was 5 mm. Mouth measurements were 1.5 m wide x 0.8 m high and 5 m long wings extended off each side. Additional small-mesh block-netting material was used when necessary to extend the wings to completely block the watercourse. Once installed, the fyke nets were checked a minimum of twice per day (morning and evening) and the number of fish captured per net check was recorded.

The Muskeg Creek fyke net was subject to high flows and a large amount of leaf debris in the fall. The initial fyke net set was washed out on the first sampling day and was re-installed with only partial channel blockage. Deflector nets were installed upstream of the fyke nets in both watercourses in the fall to reduce the accumulation of leaves and debris.

Table 3.29 Sampling Dates and Locations for Fyke Nets Installed in Muskeg and Wapasu Creeks, Spring and Fall 2002

Season	Site[a]	UTM Coordinates (NAD 83)	Date of Net Installation	Date of Net Removal
spring	Wapasu Creek	488578 E / 6358498 N	May 18, 2002	May 31, 2002
	Muskeg Creek	480969 E / 6349060 N	May 24, 2002	June 1, 2002
fall	Wapasu Creek	488604 E / 6358491 N	October 3, 2002	October 12, 2002
	Muskeg Creek	480960 E / 6349060 N	October 3, 2002	October 12, 2002

[a] See Figure 3.10 for sampling sites.

General inventory surveys were conducted during the spring and fall fyke net monitoring periods. A backpack electrofisher and minnow traps were used in the vicinity of the fyke nets. The electrofisher was a Smith-Root Type 15-D electrofishing unit, powered by a 350-watt generator and configured with an anode pole (27.9-cm diameter ring) and a rattail cathode. Minnow traps were Gee traps, baited and set overnight. All monitoring locations were determined by GPS and marked on a 1:50,000 scale map. Details of inventory sampling are in Table 3.30 and sampling locations are shown in Figure 3.10.

Table 3.30 Fish Inventory Locations for Muskeg and Wapasu Creeks, Spring and Fall 2002

Season	Site[a]	Sampling Technique	UTM Coordinates (NAD 83)		
			Sampling Reach		Sampling Point
			Start of Reach	End of Reach	
spring	Muskeg Creek	backback electrofishing	477535 E / 6346564 N	477735 E / 6346664 N	
		minnow trap	-	-	481025 E / 6348857 N
	Wapasu Creek	backback electrofishing	488578 E / 6358498 N	488600 E / 6351484 N	-
			488891 E / 6358343 N	489041 E / 6358199 N	-
			488512 E / 6358615 N	488578 E / 6358498 N	-
		minnow trap	-	-	488087 E / 6359334 N
			-	-	488165 E / 6359223 N
			-	-	488114 E / 6359256 N
			-	-	486372 E / 6359134 N
			-	-	488147 E / 6359251 N
			-	-	488114 E / 6359256 N
			-	-	490267 E / 6355966 N
fall	Muskeg Creek	backpack electrofishing	480663 E / 6349072 N	480988 E / 6349045 N	-
		minnow trap	-	-	480980 E / 6349019 N
			-	-	480955 E / 6349082 N
			-	-	480989 E / 6349019 N
			-	-	480897 E / 6349065 N
	Wapasu Creek	backpack electrofishing	488571 E / 6358498 N	488591 E / 6358381 N	-
			488894 E / 6358360 N	489011 E / 6358225 N	-
			490111 E / 6356166 N	490184 E / 6355923 N	-
		minnow trap	-	-	488581 E / 6358543 N
			-	-	488603 E / 6358462 N
			-	-	488894 E / 6358360 N
			-	-	488894 E / 6358360 N
			-	-	489258 E / 6357805 N
			-	-	490268 E / 6355983 N

[a] See Figure 3.10 for sampling sites.

All fish captured and observed were enumerated by species, life stage and sampling technique. Minnow identification keys were used for proper identification of small-bodied species and voucher samples were collected and preserved for any species requiring confirmation of identification. All fish were measured (fork length – nearest 1.0 mm) and weighed (nearest 0.1 g) and were examined externally to record pathology information. Sex and state of maturity of each fish were determined if discernible by external examination.

Maximum-minimum recording thermometers were installed at each fyke net location to measure temperatures every 24-hour period. Conductivity, pH, and dissolved oxygen were measured daily at each site. Stream discharge was measured at the start of each study period and at any time that discharge levels changed.

3.5.6.2 Data Analysis

Catch-per-unit-effort (CPUE) was calculated for each inventory sampling technique to determine species relative abundance. CPUE was calculated for electrofishing as number of fish per 100 seconds of effort, and for minnow trapping as the number of fish captured per hour of trap set.

3.6 ACID SENSITIVE LAKES

3.6.1 Overview

Lakes forming the acid sensitive lakes monitoring network were selected to represent a cross-section of lake characteristics in northeastern Alberta. The term "lake" is used to refer to standing waters of all sizes monitored by this component, although a number of waterbodies monitored could be more accurately described as ponds. The following primary criteria were used for the original lake selection:

- moderate to high sensitivity to acidification, defined as total alkalinity <20 mg/L as $CaCO_3$;
- range in organic content, from clear to brown water lakes;
- location along a gradient of acidic deposition radiating from the Oil Sands Region, as predicted in recent Environmental Impact Assessments (EIAs), or location away from the oil sands area (in the case of the lakes in the Caribou Mountains and the Canadian Shield); and
- access by float plane to ensure a cost-effective program.

In 2002, the monitoring network was expanded by 17 lakes to increase the number of lakes sampled near oil sands developments, including lakes relevant to new projects and their EIAs, and to reflect new information on critical loads and potential acid input.

Critical load (keq H^+/ha/yr) is defined as the highest load of acid deposition that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems. Estimation or modelling of potential acid input (PAI, in units of keq H^+/ha/yr) includes the amount of wet and dry deposition by sulphur and nitrogen compounds from sources within the area being evaluated as well as background sources. PAI also accounts for the mitigating effects of base cations. Acid deposition may be a concern when PAI values for a given lake exceed critical loads.

The following specific criteria were used to select the 17 new lakes added in 2002:

- adding lakes between 55.7 N and 57.7 N and from 110 W to 113.2 W, corresponding to the area with the greatest density of existing and planned oil sands developments;
- including lakes where PAI exceeded critical loads under cumulative effects assessment (CEA) scenarios from EIAs of recent oil sands developments; and
- selecting lakes with low critical loads (i.e., highly acid sensitive lakes) from each of four separate quadrants (NE, SE, SW, and NW) relative to Fort McMurray.

3.6.2 Lakes Sampled

Forty nine lakes were sampled in 2002, including 39 lakes in the Oil Sands Region, five lakes in the Caribou Mountains and five lakes on the Canadian Shield (Table 3.31; Figure 3.12). This is an addition of 17 new lakes. Another difference in lakes sampled in 2002 compared to 2001 involved Lake A47 replacing Lake A300.

Table 3.31 Characteristics of the Lakes Selected for Monitoring in 2002

Lake	Year Sampled[a]				Latitude	Longitude	Altitude (m)	Max. Depth (m)	Alkalinity[b] (mg/L as $CaCO_3$)
	1999	2000	2001	2002					
Oil Sands Sub-Regions									
1. North East of Fort McMurray									
L4 (A-170)	Y	Y	Y	Y	57.1519	110.8514	549	2.1	4.7 – 10.4
L7	Y	Y	Y	Y	57.0903	110.7519	594	1.7	7.1 – 13.1
L8	Y	Y	Y	Y	57.0458	110.5975	610	2.0	14.2 – 21.7
L39 (A-150)	Y	Y	Y	Y	57.9600	110.3969	427	1.5	9.9 – 12.2
E15 (268)	N	Y (new)	Y	Y	56.8917	110.9000	457	1.7	20.0 - 27.9
182 (P23)	N	N	N	Y (new)	57.2630	110.8510	- [c]	-	11.9 – 17[d]
185 (P27)	N	N	N	Y (new)	57.1470	110.8630	-	-	3.4 – 5[d]
209 (P7)	N	N	N	Y (new)	57.2320	110.7450	-	-	7.2 – 12[d]
270	N	N	N	Y (new)	56.7667	110.9000	-	-	81.0 (*n* = 1)
271	N	N	N	Y (new)	56.6417	110.2000	-	-	84.5 (*n* = 1)
2. Stony Mountains									
A21	Y	Y	Y	Y	56.2667	111.2583	719	1.2	0.8 – 2.0
A24	Y	Y	Y	Y	56.2167	111.2500	710	1.6	0 – 1.3
A26	Y	Y	Y	Y	56.2153	111.1869	712	1.5	1.7 – 9.3
A29	Y	Y	Y	Y	56.1667	111.5417	714	1.4	2.3 – 3.2
A86	Y	Y	Y	Y	55.6833	111.8250	712	2.7	5.6 – 7.8
287	N	N	N	Y (new)	56.2083	111.2000	-	-	1.9 (*n* = 1)
289	N	N	N	Y (new)	56.2000	111.3667	-	-	5.2 (*n* = 1)
290	N	N	N	Y (new)	56.1750	111.2083	-	-	3.9 (*n* = 1)
342	N	N	N	Y (new)	55.7917	111.8250	-	-	11.4 (*n* = 1)
354	N	N	N	Y (new)	55.7583	110.7500	-	-	26.6 (*n* = 1)
3. West of Fort McMurray									
A42	Y	Y	Y	Y	56.3500	113.1833	643	1.3	9.2 – 18.6
A47	Y	Y	N	Y	56.2440	113.1410	643	1.7	2.0 – 9.6
A59	Y	Y	Y	Y	55.9083	112.8667	555	2.0	2.1 – 3.5
223 (P94)	N	N	N	Y (new)	57.1460	111.9820	-	-	37 - 40.1[d]
225 (P96)	N	N	N	Y (new)	56.8000	111.9170	-	-	31 - 37.5[d]
226 (P97)	N	N	N	Y (new)	56.8100	111.7210	-	-	15 - 15.3[d]
227 (P98)	N	N	N	Y (new)	56.7830	111.7890	-	-	35 - 35.3[d]
267	N	N	N	Y (new)	56.7583	111.9500	-	-	46.3 (*n* = 1)
4. Birch Mountains									
L18 (Namur)	Y	Y	Y	Y	57.4444	112.6211	722	24.0	18.9 – 21.3
L23 (Otasan)	Y	Y	Y	Y	57.7072	112.3875	732	7.6	6.4 – 9.54
L25 (Legend)	Y	Y	Y	Y	57.4122	112.9336	789	10.2	8.6 – 10.5
L28	Y	Y	Y	Y	57.8556	112.9717	716	1.9	0 – 3.0
L29 (Clayton)	N	N	Y (new)	Y	58.0572	112.2761	-	1.1	0 (*n*=2)
L46 (Bayard)	Y	Y	Y	Y	57.7725	112.3964	640	1.8	6.9 – 24.2
L47	Y	Y	Y	Y	57.6894	112.7361	643	1.3	7.9 – 16.0
L49	Y	Y	Y	Y	57.7600	112.5967	671	1.4	6.6 – 10.1
L60	Y	Y	Y	Y	57.6533	112.6142	671	2.7	9.6 – 16.1
175 (P13)	N	N	N	Y (new)	57.3140	112.3950	-	-	37 - 49.3 [d]
199 (P49)	N	N	N	Y (new)	57.6940	111.9060	-	-	9 - 9.2[d]
Comparison Regions									
1. Caribou Mountains									
E52 (Fleming)	Y	Y	Y	Y	58.7708	115.4342	853	8.5	13.0 – 20.0

Table 3.31 Characteristics of the Lakes Selected for Monitoring in 2002 (continued)

Lake	Year Sampled[a]				Latitude	Longitude	Altitude (m)	Max. Depth (m)	Alkalinity[b] (mg/L as $CaCO_3$)
	1999	2000	2001	2002					
E59 (Rocky Island)	Y	Y	Y	Y	59.1350	115.1336	914	>6	9.0 – 15.0
E68 (Whitesand)	N	Y (new)	Y	Y	59.1905	115.4490	911	1.5	11.7 – 14.8
O1 (Unnamed #6) (E55)	Y	Y	Y	Y	59.2378	114.5200	823	1.8	3.9 – 4.8
O2 (Unnamed #9) (E67)	Y	Y	Y	Y	59.3108	115.3589	890	11.5	8.0 – 11.5
2. Canadian Shield									
A301	N	N	Y (new)	Y	59.1760	110.5600	-	8.2	22.5 (*n*=2)
L107 (Weekes)	N	Y (new)	Y	Y	59.7219	110.0158	320	7.8	23.2 – 24.8
L109 (Fletcher)	Y	Y	Y	Y	59.1206	110.8197	268	13.7	18.2 – 22.0
O10	Y	Y	Y	Y	59.1436	110.6847	308	1.8	8.0 – 13.1
R1	Y	Y	Y	Y	59.1985	110.6868	305	13.1	13.5 – 15.8

[a] Lakes added in each year are identified in parentheses as “new”.

[b] Unless otherwise noted, the alkalinity ranges were based on all available data, including historical data (summarized by Saffran and Trew 1996) and RAMP data collected in 1999, 2000, 2001 and 2002.

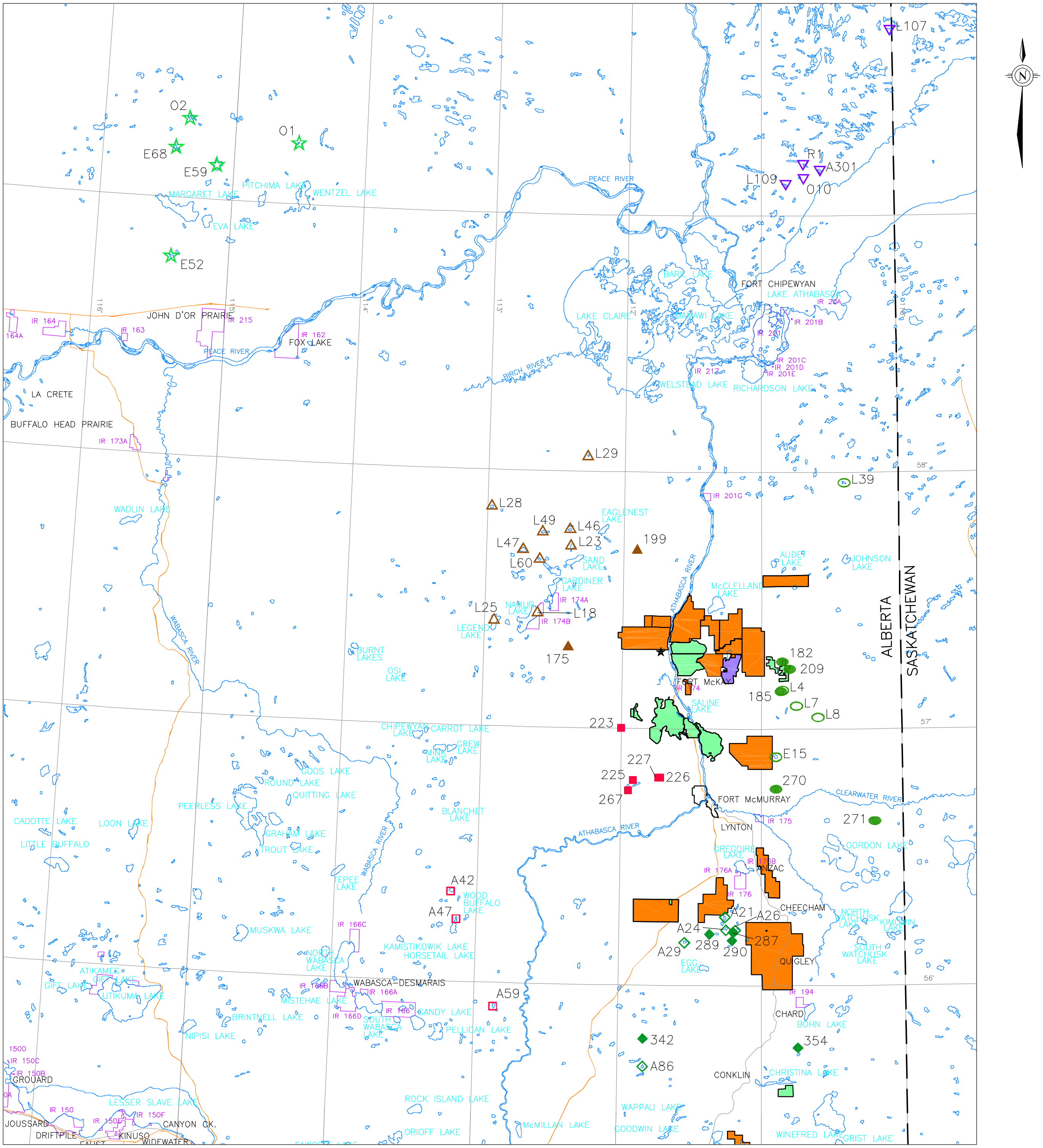
[c] - = data not available.

[d] The range of alkalinity for these new lakes is based on historical data from WRS (2001) and data collected for the RAMP acidification monitoring network in 2002; therefore, *n* = 2.

Four lakes, specifically L1, L30, R2 and A300, were not included in the 2002 monitoring program even though they were sampled in various years prior to 2002. These lakes were dropped from the program because of difficulties in locating them and landing on them via float plane, or due to low acid sensitivity. Water chemistry data for these lakes are reported in Volume I of the 2001 RAMP report (Golder 2002c).

Fleming Lake in the Caribou Mountains (E52) was impacted by a forest fire in 1995-96. As much as 90% of its catchment was burnt. Despite this obvious difference from the other lakes, Lake E52 was included in the 2002 analyses for continuity, because it was also included in past assessments. However, the effects of the recent fire were taken into account when comparing water chemistry from this lake to others.

The 2002 program represents the fourth year of monitoring. That fact, coupled with the addition of the new lakes, has resulted in a substantial increase in the quantity of data, which in turn precipitated the need to re-organize the data. The Caribou Mountain and Canadian Shield Regions have been maintained as in prior years. However, the lakes in the Oil Sands Region have been divided into the following four sub-regions:



LEGEND

OIL SANDS SUB-REGIONS

- NORTH EAST FORT McMURRAY – SITE SAMPLED IN AND PRIOR TO 2002
- NORTH EAST FORT McMURRAY – NEW SITE IN 2002
- STONY MOUNTAINS – SITE SAMPLED IN AND PRIOR TO 2002
- STONY MOUNTAINS – NEW SITE IN 2002
- WEST FORT McMURRAY – SITE SAMPLED IN AND PRIOR TO 2002
- WEST FORT McMURRAY – NEW SITE IN 2002
- BIRCH MOUNTAINS – SITE SAMPLED IN AND PRIOR TO 2002
- BIRCH MOUNTAINS – NEW SITE IN 2002

COMPARISON REGIONS

- CARIBOU MOUNTAINS – SITE SAMPLED IN AND PRIOR TO 2002
- CANADIAN SHIELD – SITE SAMPLED IN AND PRIOR TO 2002

- EXISTING OR APPROVED PROJECTS
- PLANNED PROJECTS
- EUB APPROVED DEVELOPMENT

REFERENCE

ORIGINAL BASE MAP OF ALBERTA WAS PRODUCED IN 10TM FORMAT. THE MAP WAS CONVERTED FROM DGN FORMAT TO DWG FORMAT IN NAD 83 ZONE 12 UTM PROJECTION.

PROJECT

RAMP 2002

TITLE

LOCATIONS OF ACID SENSITIVE LAKES SURVEYED IN 2002

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Acid-Sensitive-Lakes	
DESIGN	ZK	13/05/02	SCALE AS SHOWN	REV. 0
CADD	DLM	14/02/03		
CHECK				
REVIEW				

FIGURE: 3.12

1. north east of Fort McMurray;
2. Stony Mountains;
3. west of Fort McMurray; and
4. Birch Mountains.

Sub-regions contain lakes in relatively close proximity to each other and/or lakes with similarities in terrain (i.e., upland versus lowland areas) (Figure 3.12). There were, however, some lakes that did not obviously belong to any of these groups (e.g., L39, 271), largely because they were distant from other clusters of lakes. These lakes were assigned to sub-regions based on direction from Fort McMurray.

3.6.3 Field Methods

Acid sensitive lakes were sampled during September 30 to October 10, 2002, by AENV personnel. AENV also provided sampling equipment and logistical support. A float plane was used to access larger lakes, while a helicopter was used to access smaller lakes. Water quality and plankton samples were collected at each lake, as were water samples for stable isotope analysis. Bathymetry information was also collected for several lakes.

In lakes with depths of 2 m or less, a composite water sample was created by combining discrete samples collected with a drop-sleeve bottle at half metre intervals (surface, 0.5 m, 1 m and 1.5 m). In deeper lakes, vertically integrated euphotic zone samples were collected from up to five sites per lake using weighted Tygon tubing. These samples were then combined to form a single composite sample from each lake for chemical analysis.

The euphotic zone was defined as the depth of 1% of surface penetrating light, using a light meter. Vertical profiles of dissolved oxygen, temperature, conductivity and pH were measured at the deepest location using a Hydrolab water quality meter, calibrated daily before the start of sampling. Secchi depth was also recorded. Samples for chemical analysis were stored on ice and were shipped to the Limnology Laboratory, University of Alberta, Edmonton, within 48 hours of collection.

Subsamples of 150 mL volume were taken from the euphotic zone composite samples for phytoplankton taxonomy. These samples were preserved using Lugol’s solution. One or two replicate zooplankton samples were also collected in each lake as horizontal tows, using a 63 µm mesh, conical plankton net. Zooplankton samples were preserved in approximately 5% formalin after anaesthetizing in club soda.

Plankton samples are being stored at AENV. Stable isotope samples are currently being analyzed by the National Hydrology Research Institute (results will be reported during the next RAMP cycle).

The water quality samples were analyzed for the following parameters:

- pH
- turbidity
- colour
- total suspended solids (TSS)
- total dissolved solids (TDS)
- dissolved organic carbon (DOC)
- dissolved inorganic carbon (DIC)
- conductivity
- total alkalinity (fixed point titration to pH 4.5)
- Gran alkalinity
- bicarbonate
- Gran bicarbonate
- chloride
- sulphate (SO_4)
- calcium
- potassium
- sodium
- magnesium
- iron
- total dissolved nitrogen (TDN)
- ammonium (NH_4^+)
- nitrite + nitrate (NO_2 + NO_3)
- total Kjeldahl nitrogen (TKN)
- total nitrogen (TN)
- total phosphorus (TP)
- total dissolved phosphorus (TDP)
- chlorophyll *a*

As part of the QA/QC program, field blanks were collected using deionized water from the Limnology Laboratory, University of Alberta, and duplicate water samples were analyzed internally at the lab. Quality control samples were analyzed for all parameters listed above.

3.7 AQUATIC VEGETATION

3.7.1 Overview

Aquatic vegetation was monitored through the comparison of a series of aerial photographs. Aerial photographs from 1997 and 2001 for Kearl Lake and Isadore's Lake and from 1997, 2001 and 2002 for Shipyard Lake were compared. The lake boundaries and surrounding wetlands polygons were interpreted and digitized onto a scanned coverage of the aerial photograph. Visual examinations and area analysis were performed of wetlands types. Digitizing and area analysis of polygons was conducted using AUTOCAD programs.

3.7.2 Air Photo Interpretation Methods

Wetlands were originally identified from black and white or true colour aerial photographs. More recent photograph interpretation includes false colour infrared images when possible.

3.7.2.1 Black and White Aerial Photograph Interpretation

Black and white, or panchromatic film, records electromagnetic radiation from the ultraviolet through the visible spectrum, as does true color film. Black and white film records the reflected radiation in tones of gray, while color film records it in color. This type of imagery detects texture and tone variation well; however, it is difficult to differentiate communities where textures may be similar (i.e., MONG [open, non-patterned graminoid marsh] and FONG [open, non-patterned graminoid fen]).

3.7.2.2 True Colour Aerial Photograph Interpretation

True colour, aerial photographs were used for Isadore's Lake in 1997, Kearl Lake in 1997 and Shipyard Lake in 2002. The colour photographs show the same details as black and white photos; however, the use of color allows the human eye to discriminate between many more shades of color than shades of gray. Colour variation can help to discern the shoreline from the emergent vegetation community.

3.7.2.3 Colour Infrared Aerial Photography Interpretation

False-colour infrared (CIR) photography, at a scale of 1:10,000, was used in 2002 to record the vegetation and disturbance features of the areas surrounding plots in the wetlands monitoring program. CIR is widely used for the interpretation of natural resources (CAMFER 2002) as it provides very good distinction between vegetation types due to differences in their reflective properties. Below is a general description of the colours and associated features typical of CIR photography in a natural vegetated landscape.

The colour red is most commonly associated with live vegetation. Very intense shades of red indicate dense vegetation that is growing quite vigorously (e.g., a closed aspen stand). A dense black spruce coniferous forest would not appear in a similar red tone since its level of growth activity is less compared to that of a deciduous stand.

As the amount of vegetation density and vigour decreases, the different red tones may change to lighter red and pink colours (CAMFER 2002). When the plant vigour decreases, the vegetation would show as paler shades of red and pink, various shades of green, and possibly tan in colour. Dead vegetation may be shown in colours of green or tan.

Water appears as various shades of blue ranging from nearly black to very pale (CAMFER 2002). Water with a low sediment loads would appear black. With the increase of sediment deposits in beds of water, the colours gradually turn to lighter blue tones. Shallow water would reflect the material present in its stream bottom. Floating vegetation is often observed as white.

3.7.3 Data Analysis

Analysis of the aerial photographs has been carried out by qualitative assessments of the vegetation (which may represent subtle differences between years) based on visual inspections of photos.

4 QUALITY ASSURANCE AND QUALITY CONTROL

4.1 QUALITY ASSURANCE PROCEDURES

Quality assurance (QA) refers to plans or programs that encompass a wide range of internal and external management and technical practices designed to ensure that the collection of data of known quality matches the intended use of the data (Environment Canada 1998). Golder has developed QA principles that, if diligently followed, will produce data of known and defensible quality. Golder's QA procedures for RAMP 2002 cover three areas of internal and external management and are outlined in more detail below.

Field Staff Training

To ensure that field data collected are of known, acceptable and defensible quality, Golder field staff are trained to be proficient in standardized field sampling procedures, data recording and equipment operations applicable to RAMP, and all field work is completed according to specified instructions and established technical procedures.

All field crews use RAMP specific work instructions (SWIs). SWIs are standardized forms that detail specific sampling instructions, equipment needs, required technical procedures, sample labeling and shipping protocols, laboratory contacts and estimated time required to complete the specified field work.

Field crew responsibilities for the field crew leader and field crew members are clearly defined and procedures are in place to deal with unforeseen circumstances that may occur in the field. To ensure compliance with QA/QC guidelines, audits of field operations and/or field records are conducted periodically during the sampling year.

Field Operations

Field work for RAMP is conducted according to the appropriate Golder Technical Procedures and SWIs. The field crew ensures that:

- equipment and meters are properly functioning, maintained and calibrated;
- all fish collection licences and permits have been obtained;
- a Health and Safety Plan is prepared and followed by the field crew for each RAMP field component;
- a Contact Form is completed detailing crew location, contact numbers and schedule of dates that the project manager will be contacted; and

- the project/task manager is notified if conditions in the field warrant changes to the study plan and SWI, or require deviations in sampling protocols from the technical procedure.

Field data for RAMP are recorded as per Golder protocols, which include the following requirements:

- All pertinent information on field activities, sampling efforts and results are recorded on the appropriate waterproof field data sheets and in a waterproof, bound notebook.
- Field notes are complete enough to enable someone unfamiliar with the project to completely reconstruct field activities without relying on the memory of the field crew.
- Entries in the field book include the following, when appropriate:
  - names of field supervisor and field crew
  - purpose of proposed sampling effort
  - clear identification of sampling site name/number
  - location of each sampling site or area (including map reference or position data such as UTM coordinates)
  - description of each sampling site or area
  - time of sampling
  - details of sampling effort (method, area covered, etc.)
  - deviations from technical procedures, if any
  - sample identification codes
  - field measurements (e.g., temperature, flow, D.O., etc.)
  - field observations
  - reference to field data sheets or any other methods used to record data
  - information for photographs taken (roll no./photo no.)
  - video tape reference (tape no./timer reference)
  - sample shipping/tracking information
- All samples collected for RAMP are collected in accordance with Golder Associates Technical Procedures. For example, Golder Technical Procedures 8.3-1 and 8.2-2, respectively (Golder 1997b, c) for the collection of water and sediment samples outline standard sample collection, preservation, storage and shipping protocols. Golder

Technical Procedures also provide specific guidelines for field record keeping and sample tracking.

Laboratory

To ensure that high quality data are generated, laboratories used for RAMP water and sediment sample analysis are accredited by the Canadian Association for Environmental Analytical Laboratories (CAEAL). Under CAEAL's accreditation program, performance evaluation assessments are conducted annually for laboratory's procedures, methods and internal quality control.

Biological analyses, such as benthic invertebrate taxonomy and fish ageing, are typically performed for RAMP by small laboratories or private individuals. These laboratories or individuals are required to perform standard QA/QC functions based on established procedures deemed necessary by the RAMP component leader.

Data Management

A data management system is in place to ensure that an organized, consistent system of data control, data analysis and filing was used for the project.

At the end of each day, all RAMP data records (field forms, etc.) that are separate from the field book are properly organized and stored. As RAMP requires multiple field visits, where the field book is taken into the field on one or more different occasions, the field book is copied between visits and the copies left at the office. Immediately upon return from the field, all field data (field books, maps, field forms, photographs, etc.) are properly stored in a fireproof file cabinet.

Data entries are checked, as a specific QC measure. Following data entry by one person, the database is reviewed for errors by a second person. Accuracy checks are also conducted for some analysis of RAMP field data such as fish ageing.

Sample Management

Sampling protocols, sample containers and the amount of material collected follows the relevant Golder Technical Procedure or the requirements of the analytical lab.

All RAMP samples are documented in the field book by a field crew member, by providing reference to sampling site, time, field parameters and other relevant information. All RAMP samples are labelled, at a minimum, with the following:

- project number
- date
- location and/or site number
- sample number
- sampling personnel
- sample material/type
- company name

RAMP samples are preserved, handled and stored in the field as specified in the appropriate Golder Technical Procedure or by the analytical lab. Restrictions on sample holding typically include temperature and time and provisions are made for proper storage during field operations and timely delivery to the analytical laboratory.

Shipping of RAMP samples requires the use of Chain-Of-Custody (COC) forms, which document the fate of the samples once they have left possession of the field crew. Sample tracking is an additional part of sample shipping and is conducted by the RAMP QA manager through telephone contact with the lab.

Quality Assurance Plan Specific to RAMP

In 2002, a formal Quality Assurance Plan (QAP) specific to the RAMP field sampling program was applied. The QAP established the following requirements:

- pre-field meetings to discuss SWIs and review relevant technical procedures with field crew(s);
- post-field meetings to discuss the field program and identify areas of concern or improvement;
- field crews to check-in with task managers every 24 to 48 hours with an update on work completed over that period of time;
- designation of one Golder field crew member who will be responsible for managing the sample shipping process to ensure that:
  - all required samples are collected;
  - chain-of-custody and analytical request forms are completed and correct;
  - proper labelling and documentation procedures are followed;
  - samples are delivered to shipping agents in a timely manner; and

- samples have arrived at the designated laboratory(ies) within two days of being shipped;

- internal check of chain-of-custody forms by the Task Manager when crews return from the field (the appropriate laboratory would be alerted immediately if analysis request errors were found);
- internal check of laboratory data once it is received to ensure data quality; and
- documentation of all samples collected for RAMP on a sample tracking sheet. Table 4.1 contains an example of how RAMP samples were tracked as part of the 2002 QA process.

Table 4.1 Example of RAMP Sample Tracking Sheet

Season	Crew	Waterbody	Sample Site	Sample Media	Samples Collected	Date Collected	Lab	Sample Arrival	COC Correct	Results Received	Results Checked	Invoice
fall	KA,LG	McLean Creek	MCC-1	water	groups 1-7	Sept. 15/03	ETL	Sept. 16	yes	digital-Sept. 25	yes-Sept. 30	Oct. 15

4.2 QUALITY CONTROL PROCEDURES

Quality Control (QC) is a specific aspect of QA that refers to the internal techniques used to measure and assess data quality (APHA 1989). QC procedures implemented in 2002 for all components are described in the following sections.

4.2.1 Climate and Hydrology

Climatic and hydrologic data collection and processing were subject to the following quality control procedures to ensure that the published data were as accurate as possible:

- Sensors from climatic and hydrologic monitoring stations were calibrated on a regular basis. Sensors at climatic stations have been rotated with spare units on a two-year frequency and the units retrieved from the field were recalibrated by the manufacturer. Calibration curves for pressure transducers installed at hydrologic monitoring stations were checked in the Golder laboratory before they were reinstalled in the spring. Pressure transducers at year-round monitoring stations were checked on a less frequent basis, but consistency between water level surveys and pressure transducer readings was checked during every field visit and the sensor was replaced if calibration problems were evident.

- Stream discharge measurements and water level surveys were performed in accordance with Golder Technical Procedure 8-24-0 (Golder 1997a).
- All discharge measurements were prepared by one person and checked by another person. The check included review of the original field notes and calculations.
- Water level surveys were compared to pressure transducer readings measured at the same time. Inconsistencies in the two measurements indicated either a faulty survey or malfunctioning pressure transducer or data logger. Where inconsistencies were noted, data were discarded where appropriate.
- Water level surveys performed at the same time as discharge measurements were used to establish a stage-discharge rating curve. New measurements were compared to the established curves. Inconsistencies indicated either a faulty survey, faulty discharge measurement, or shifted rating curve. Rating curves may shift due to changes in downstream controls or channel bed elevation. Where inconsistencies were noted, data were discarded where appropriate or the rating curve was revised to reflect changed site conditions.
- Processing of continuous discharge data incorporated all valid discharge measurements, manual water level surveys and continuous water level measurements. The resulting hydrographs were reviewed for consistency of these data.
- Anomalies in the hydrographs, such as rapid changes in water level or indicated short-term flood events, were examined in detail to confirm whether the calculated discharges were likely to be representative of actual conditions. In cases where the anomalous data were inconsistent with other local and regional data (for instance, an isolated high water reading, without a subsequent recession curve), they were discarded.
- Snow course surveys were performed according to a standard protocol as described in Section 3.1.3.
- Rainfall and snowfall data from tipping bucket rain gauges were compared to other local and regional precipitation and temperature data and observations recorded during site visits. Some climatic stations include tipping bucket rainfall and snowfall gauges operating in tandem, and these data were compared to filter out problem data. For example, snow may accumulate during the winter in a tipping bucket rain gauge, and melt during a subsequent warm period, indicating rainfall where none occurred. This can be assessed by comparing temperature and snowfall readings at the station during the same period.

4.2.2 Water Quality

The 2002 water quality QC program consisted of the preparation and submission of a series of QC samples to evaluate potential sample contamination and analytical bias. An outline of the QC samples submitted in each season of 2002 is provided in Section 4.2.2.2, preceded by a summary of QC sample definitions in Section 4.2.2.1. The assessment criteria used to determine if QC sample results were indicative of sample contamination or analytical bias are described in Section 4.2.2.3. Results of the 2002 water quality QC program are discussed in Section 4.2.2.4.

4.2.2.1 QC Sample Definitions

Field Blank

A separate sample prepared in the field during a sampling event using laboratory-provided deionized water to fill a set of sample bottles that are submitted to the laboratory for the same analysis as the field samples. Field blanks are used to detect potential sample contamination during collection, shipping and analysis.

Trip Blank

A set of sealed bottles provided by the analytical laboratory that are pre-filled with deionized water and accompany sample bottles to and from the field site. The unopened trip blanks undergo the same analysis as the field samples and are used to determine if sample contamination may have occurred during transport and analysis.

Split Sample

A single sample collected from a given location that is then split into two or more sample containers. Split samples are labelled, preserved individually and submitted separately to the analytical laboratory for identical analyses. These samples are used to assess intra-laboratory precision. Split samples can also be sent to separate laboratories for identical analyses to assess inter-lab variation.

Duplicate Sample

Two samples are collected from one location using identical sampling procedures. They are labelled, preserved individually and submitted separately to the analytical laboratory for identical analyses. Duplicate samples are used to check intra-site variation and precision of field sampling methodology.

Spiked Sample

A known amount of one or more target compounds are added to a portion of a given field sample. The percent recovery is measured and compared to specified guidance limits defined by each laboratory. Matrix spikes are used to determine if the sample matrix is interfering with the analysis (i.e., experiencing method bias).

Laboratory Control Sample or Reference Standard

A laboratory control sample (LCS) or reference standard can be purchased directly from a supplier or created in the laboratory by adding a known amount of one or more target compounds to deionized water or another suitable certified reference material. The resulting LCS or reference standard is then analyzed along with the field samples to assess analytical accuracy. Multiple reference standard samples can be used to assess both analytical accuracy and precision.

4.2.2.2 QC Samples Included in 2002 Water Quality Program

Pursuant to Golder (2002d), one field blank, trip blank and split sample was collected or prepared during each sampling survey, with an extra set included in the fall sampling program (Table 4.2). Following a review of the RAMP 2001 water quality sample results, as well as those generated from the winter 2002 sampling survey, the 2002 QC program was expanded to include additional QC samples. In particular, extra dissolved metal field blanks were added to the spring and summer surveys to address concerns that the dissolved metal sampling equipment may have resulted in sample contamination. Additional split total metal, dissolved metal and sulphide samples, along with select reference standards, were also prepared in the spring and summer of 2002 to compare the performance of Enviro-Test Laboratories (ETL) and Alberta Research Council located in Vegreville (ARC-Vegreville).

The eight reference standards included in the 2002 water quality QC program consisted of the following:

- 2 μg/L total barium;
- 2 μg/L total strontium;
- 40 μg/L and 80 μg/L total zinc;
- 20 μg/L and 40 μg/L dissolved zinc;
- 1 μg/L dissolved barium; and
- 1 μg/L dissolved strontium.

Table 4.2 QC Samples Collected and/or Prepared as Part of the RAMP 2002 Water Quality Program

Season	Sample Site	QC Sample
Winter (2002)	Ells River	field blank
	-	trip blank
	Athabasca River downstream of development	intra-lab split sample
Spring	Ells River	field blank
	-	trip blank
	Tar River	intra-lab split sample
	North Steepbank River	inter-lab split sample[(a)]
	Athabasca River downstream of development	inter-lab split sample[(a)]
	Stanley Creek	additional dissolved metals field blank
Summer	Clearwater River	field blank
	-	trip blank
	Athabasca River downstream of development	intra-lab split sample[(b)]
		inter-lab split sample[(a)]
	Christina River upstream of Janvier near Pony Creek	additional dissolved metals field blank
	-	reference standards for total and dissolved barium, strontium and zinc
Fall	Steepbank River	field blank
	Kiskatinaw Lake	field blank
	-	trip blank
	-	trip blank
	Athabasca River downstream of Donald Creek	intra-lab split sample
	Canoe Lake	intra-lab split sample
Winter (2003)	Athabasca River downstream of development	intra-lab split sample

(a) Analyzed for sulphide, total metals and dissolved metals.

(b) Analyzed for conventional parameters, major ions (except sulphide), nutrients, biological oxygen demand (BOD) and the general organics listed in Table 3.1.

\- = Deionized water provided by analytical laboratories.

Barium, strontium and zinc were selected for inclusion in the reference standards, because these elements were identified in the RAMP 2001 report (Golder 2002c) as being problematic (i.e., evidence of widespread sample contamination with respect to these parameters, and/or high levels of variability observed between split samples). With the exception of the 40 and 80 µg/L zinc standards, selected concentrations were set equivalent to 10 times the relevant method detection limits (MDLs) reported by ETL in 2001 to avoid the ambiguity that can occur when concentrations are close to MDL. The 40 and 80 µg/L zinc standards were included to provide additional information concerning the accuracy of total and dissolved zinc analyses at both ETL and ARC-Vegreville. All of the QC sample results discussed herein are reported in Appendix XX.

4.2.2.3 Assessment Criteria

The assessment criteria used to determine if QC sample results may be indicative of sample contamination or analytical bias are described below.

Field and/or Trip Blanks

Although parameters should not be detected in the field or trip blanks, parameter concentrations were considered significant if they were greater than five times the corresponding MDL. This threshold is based on the Practical Quantitation Limit defined by the United States Environmental Protection Agency (U.S. EPA) (1985), which takes into account the potential for data accuracy error when parameter concentrations approach or are below MDLs.

Significant results observed in a field or trip blank were evaluated relative to parameter concentrations observed in field samples and other blank samples collected during the corresponding sampling trip to determine if sample contamination was limited to that particular QC sample or apparent in other samples collected at that time. If, based on this comparison, sample contamination did not appear to have been an isolated error, field data were flagged and interpreted with this limitation in mind.

There has been some suggestion by members of the RAMP Steering Committee that this threshold (i.e., five times the corresponding method detection limit) could be improved for major ions and several other parameters. The RAMP Technical Subcommittee discussed this issue in 2002, but new criteria for assessing the significance of reported concentrations in blank samples were not chosen.

Split and Duplicate Samples

Differences[1] between parameter concentrations in split or duplicate water samples were considered significant if:

- they were greater than 20% (ETL and ARC samples); and
- parameter concentrations were greater than five times the relevant reported MDL.

[1] Difference was expressed in terms of percent difference calculated using the following formula: (maximum concentration - minimum concentration) / minimum concentration.

These criteria are consistent with those used by ETL for their internal QC procedures and take into account the potential for data accuracy error as parameter concentrations approach MDLs.

Analytical precision was then rated as:

- high if less than 10% of the parameters included in the split sample analysis were significantly different from one another;
- moderate if 10 to 30% of the parameters included in the split sample analysis were significantly different from one another; or
- low if more than 30% of the parameters included in the split sample analysis were significantly different from one another.

Similarly, intra-site variability and field sampling precision was rated as:

- low and high, respectively, if less than 10% of the parameters included in the duplicate sample analysis were significantly different from one another;
- moderate if 10 to 30% of the parameters included in the duplicate sample analysis were significantly different from one another; or
- high and low, respectively, if more than 30% of the parameters included in the duplicate sample analysis were significantly different from one another.

4.2.2.4 QC Sample Results

Potential Sample Contamination

An initial review of the winter 2002 total and dissolved metal sample results uncovered several instances where reported dissolved metal concentrations were higher than corresponding total levels (see Appendix XX). In 2001, similar patterns had been observed, particularly with zinc (Golder 2002c). Following this discovery, the practice of field filtering dissolved metal samples was abandoned[2], and two additional dissolved metal field blanks were prepared to determine if the filtering equipment may have been responsible for the higher dissolved metal levels.

[2] As all samples arrived at the relevant laboratory within 48 hours of collection, it is unlikely that this deviation from standard collection and preservation protocols affected sample results (A. Wharmby, ARC-Vegreville, pers. comm).

Dissolved metal levels in the winter and summer field filtered, dissolved metal field blanks were all either below MDLs or below the assessment criteria (i.e., < five times the relevant MDL) (Table 4.3). Six metals, including barium, boron, iron, lithium, manganese and strontium, were detected in the spring field filtered, dissolved metal field blank at concentrations well above the relevant MDLs. However, the magnitude of difference between these spring results and those produced in winter and summer samples suggests that the spring results are likely erroneous. The filtering equipment used by RAMP does not, therefore, appear to result in sample contamination.

In 2001, high levels of total zinc, dissolved zinc and total Kjeldahl nitrogen (TKN) were present in the trip and/or field blanks collected during the fall (Golder 2002c). Concentrations of these three parameters were also elevated in other fall samples collected in 2001, leading to the belief that sample contamination had occurred. There was little evidence of continued zinc or TKN contamination in 2002 (Tables 4.3 and 4.4). TKN concentrations in nine of the ten blanks collected in 2002 were below detection limits (Appendix XX; Tables XX.1 and XX.2). In the remaining trip blank, the TKN concentration was reported as 0.3 mg/L, with a corresponding detection limit of 0.2 mg/L (Appendix XX; Table XX.2). Similarly, although total and dissolved zinc were detected in several of the blank samples at levels greater than five times the respective detection limits (Tables 4.3 and 4.4), these results appear to have been isolated incidents that are not indicative of widespread sample contamination.

Table 4.3 Summary of Water Quality Parameters in RAMP 2002 Field Blanks That Exceeded Five Times the Method Detection Limit

Parameter	Units	Winter, Spring and Summer (a)						Fall (a)			Comments(e)
		Relevant Detection Limit	Winter (2002)(b)	Spring		Summer		Relevant Detection Limit	Sample 1(c,d)	Sample 2(c,d)	
				Sample 1(c)	Sample 2(b)	Sample 1(c)	Sample 2(b)				
Total Metals											
aluminum (Al)	µg/L	20	-	-	n/a	-	n/a	1	54	14	C, A
antimony (Sb)	µg/L	5	-	-	n/a	-	n/a	0.004	-	0.067	A
arsenic (As)	µg/L	0.4	-	-	n/a	-	n/a	0.02	-	0.43	A
barium (Ba)	µg/L	0.2	-	-	n/a	-	n/a	0.1	-	14.7	A
beryllium (Be)	µg/L	1	-	-	n/a	-	n/a	0.04	0.21	-	A
boron (B)	µg/L	20	-	-	n/a	-	n/a	0.08	1.2	52.9	C, A
cadmium (Cd)	µg/L	0.2	-	-	n/a	-	n/a	0.02	-	0.21	A
iron (Fe)	µg/L	5	-	-	n/a	-	n/a	3	-	129	A
lead (Pb)	µg/L	0.1	-	-	n/a	-	n/a	0.01	-	0.92	A
lithium (Li)	µg/L	6	-	-	n/a	-	n/a	0.1	-	4.9	A
manganese (Mn)	µg/L	1	-	-	n/a	-	n/a	0.01	0.06	26.8	C, A
strontium (Sr)	µg/L	0.2	1.3	-	n/a	-	n/a	0.004	0.67	68.2	D, C, A
titanium (Ti)	µg/L	5	-	-	n/a	-	n/a	0.2	-	1.1	A
uranium (U)	µg/L	0.1	-	-	n/a	-	n/a	0.003	-	0.062	A
zinc (Zn)	µg/L	4	-	-	n/a	23	n/a	0.2	1.1	5.3	B, A, A
Dissolved Metals											
aluminum (Al)	µg/L	10	-	-	-	-	-	0.1	1.6	-	C
barium (Ba)	µg/L	0.1	-	-	41	-	-	0.02	-	-	E
boron (B)	µg/L	2	-	-	13	-	-	0.1	-	-	E
iron (Fe)	µg/L	5	-	-	99	-	-	3	-	-	E
lithium (Li)	µg/L	0.1	-	-	5.9	-	-	0.1	-	-	E

Table 4.3 Summary of Water Quality Parameters in RAMP 2002 Field Blanks That Exceeded Five Times the Method Detection Limit (continued)

Parameter	Units	Winter, Spring and Summer [(a)]						Fall [(a)]			Comments[(e)]
		Relevant Detection Limit	Winter (2002)[(b)]	Spring		Summer		Relevant Detection Limit	Sample 1[(c,d)]	Sample 2[(c,d)]	
				Sample 1[(c)]	Sample 2[(b)]	Sample 1[(c)]	Sample 2[(b)]				
manganese (Mn)	µg/L	1	-	-	11	-	-	0.01	-	-	E
strontium (Sr)	µg/L	0.1	-	-	63	-	-	0.004	0.10	-	E, C
vanadium (V)	µg/L	0.1	-	-	-	-	-	0.01	0.08	-	C
zinc (Zn)	µg/L	2	-	-	-	-	-	0.2	1.4	-	C

(a) - = Parameter concentrations did not exceed five times the relevant method detection limit; n/a = not applicable.

(b) Dissolved metals field blank was prepared by field filtering deionized water, adding appropriate preservative and submitting sample to ETL for analysis.

(c) Dissolved metals field blank was not filtered or preserved in the field; filtering and preservation were completed in the lab.

(d) Total and dissolved metals analyses were completed by ARC-Vegreville in the fall of 2002.

(e) A = Concentration in the field blank was higher than that observed in the water sample collected from the site where the field blank was prepared; therefore, this finding was assumed to be an isolated error.
B = Concentration in the field blank was higher than levels observed in the majority of the water samples collected in the same season; therefore, this finding was assumed to be an isolated error (i.e., sample contamination is limited to the field blank).
C = Concentrations in the water sample collected from the site where the field blank was prepared were consistent with historical data from the relevant season; therefore, this finding was assumed to be an isolated error (i.e., sample contamination is limited to the field blank).
D = Result may be indicative of sample contamination.
E = Concentrations in field blank were far higher than those observed in other field blanks prepared in a similar manner; therefore, this finding was assumed to be an isolated error (i.e., sample contamination is limited to the field blank in question).

Table 4.4 Summary of Water Quality Parameters in RAMP 2002 Trip Blanks That Exceeded Five Times the Method Detection Limit

Parameter	Units	Winter, Spring and Summer [(a)]				Fall[(a,b)]			Comments[(c)]
		Relevant Detection Limit	Winter (2002)	Spring	Summer	Relevant Detection Limit	Sample 1	Sample 2	
Conventional Parameters									
total suspended solids	mg/L	3	-	-	479	3	-	-	A
Total Metals									
strontium (Sr)	µg/L	0.2	-	-	-	0.004	0.047	-	C
Dissolved Metals									
vanadium (V)	µg/L	0.1	-	-	-	0.01	0.14	-	A
Polycyclic Aromatic Hydrocarbons									
pyrene	µg/L	0.02	-	-	-	0.02	-	0.34	B

(a) - = Parameter concentrations did not exceed five times the relevant method detection limit.

(d) Total and dissolved metals analyses were completed by ARC-Vegreville in the fall of 2002.

(c) A = Concentration in the trip blank was higher than corresponding concentrations in the field blank(s) collected in the same season; therefore, this finding was assumed to be an isolated error (i.e., sample contamination was limited to the trip blank).

B = Concentration in the trip blank was higher than levels observed in the majority of the water samples collected in the same season; therefore, this finding was assumed to be an isolated error (i.e., sample contamination is limited to the trip blank).

C = Result may be indicative of sample contamination.

Overall, analysis of the trip and field blanks included in the 2002 water quality QC program indicates that water quality samples collected this year by RAMP were largely free of contamination, with the possible exception of strontium (Tables 4.3 and 4.4). Low levels of total and dissolved strontium were detected in the winter field blank and fall trip blank, respectively. However, the apparent degree of potential strontium contamination was sufficiently low that it is unlikely to affect the interpretation of the 2002 water quality sample results.

Analytical Precision and Accuracy

Throughout the 2002 sampling program, ETL exhibited a high level of analytical precision, with respect to the analysis of conventional parameters, major ions, nutrients, biological oxygen demand, total phenols, total recoverable hydrocarbons and naphthenic acids. Out of the 162 tests completed, the variation in only seven sets of results exceeded the assessment criteria (Table 4.5). Sulphide concentrations reported by ETL also appear to be accurate, as assessed indirectly through the submission of split sulphide samples to ETL and ARC-Vegreville (Table 4.6). Sulphide concentrations reported by the two laboratories were very similar, with a maximum observed variation of 2 μg/L (Appendix XX; Table XX.7).

Although ETL demonstrated a high level of analytical precision in the analysis of total and dissolved metals in the winter and spring of 2002 (Table 4.5), large variations in total and dissolved zinc concentrations were observed in the spring intra-lab split sample. Variations in the total and dissolved metal concentrations reported for the two inter-lab split samples submitted in the spring of 2002 also suggested that ETL's analytical process may result in an upward bias (i.e., overestimation of total and dissolved metal concentrations) (Table 4.6). Based on this information, which became available near the end of the summer, it was decided that all fall total and dissolved metal samples were to be analyzed by ARC-Vegreville. Six reference standards were also prepared and submitted, as discussed in Section 4.2.1.2, to both ETL and ARC-Vegreville to check analytical accuracy at both facilities.

Reported concentrations for the six reference standards indicates that ETL and ARC-Vegreville can achieve comparable levels of accuracy, with respect to total and dissolved strontium, barium and zinc analyses (Table 4.7). However, QC sample results from the fall 2002 and winter 2003 surveys indicate that ARC-Vegreville experiences low to moderate levels of analytical precision when analyzing total metal samples (Table 4.6). Total metal concentrations reported by ARC-Vegreville are also not consistently lower than those reported by ETL, as illustrated in Table 4.7. This information suggests that the variations in the spring, inter-lab, total metal split samples were incorrectly identified as analytical bias, and that they may be a reflection of the limited precision achieved by ARC-Vegreville. Consequently, it is recommended, based on the analytical accuracy and precision described herein, that future total metals analyses continue to be completed by ETL, except where trace analyses unavailable at ETL are required to produce data comparable to in-stream guidelines.

With respect to dissolved metals, concentrations in the summer, inter-lab split samples reported by ARC-Vegreville were consistently lower than those reported by ETL (Table 4.6). Similar trends were observed, as previously noted, in the two spring, inter-lab split samples. Together, these results would suggest a constant analytical bias whereby either ETL was overestimating dissolved metal content or, conversely, ARC-Vegreville was underestimating it. However, the analysis of the reference standards indicated that, as previous noted, both laboratories can achieve comparable levels of accuracy, as assessed using dissolved strontium, barium and zinc standards (Table 4.7).

Table 4.5 Differences Between Intra-lab Split Water Quality Samples That Exceeded Assessment Criteria

Parameter	Units	Season [(a)]														
		Winter (2002)			Spring			Summer			Fall						Winter (2003)		
		Athabasca River d/s of development[(b)]		Percent Difference	Tar River		Percent Difference	Athabasca River d/s of development[(b,c)]		Percent Difference	Athabasca River d/s of Donald Creek[(b)]		Percent Difference	Canoe Lake[(d)]		Percent Difference	Athabasca River d/s of development[(b)]		Percent Difference
Conventional Parameters																			
colour	T.C.U.	-	-	-	-	-	-	25	20	25	35	15	133	50	70	40	-	-	-
total dissolved solids	mg/L	-	-	-	-	-	-	-	-	-	80	110	38	-	-	-	-	-	-
total suspended solids	mg/L	-	-	-	-	-	-	27	20	35	-	-	-	-	-	-	-	-	-
Major Ions																			
sulphate	mg/L	-	-	-	-	-	-	33.2	26.6	25	-	-	-	-	-	-	-	-	-
Nutrients and Chlorophyll *a*																			
total phosphorus	mg/L	-	-	-	-	-	-	0.034	0.056	65	-	-	-	-	-	-	-	-	-
Total Metals																			
aluminum (Al)	µg/L	-	-	-	-	-	-	n/a	n/a	n/a	522	416	25	14	17	21	45.2	92	104
arsenic (As)	µg/L	-	-	-	-	-	-				0.64	0.52	23	0.23	0.51	122	-	-	-
boron (B)	µg/L	-	-	-	-	-	-				-	-	-	17.6	40.4	129	-	-	-
cobalt (Co)	µg/L	-	-	-	-	-	-				-	-	-	-	-	-	0.14	0.11	27
iron (Fe)	µg/L	-	-	-	-	-	-				-	-	-	165	63	162	-	-	-
lead (Pb)	µg/L	-	-	-	-	-	-				0.43	0.3	43	0.46	0.7	52	0.17	0.13	31
lithium (Li)	µg/L	-	-	-	-	-	-				-	-	-	2.3	7.6	230	-	-	-
manganese (Mn)	µg/L	-	-	-	-	-	-				-	-	-	73.2	36.5	101	-	-	-
mercury (Hg)	µg/L	-	-	-	-	-	-				0.0036	< 0.0006	497	-	-	-	-	-	-
nickel (Ni)	µg/L	-	-	-	3.3	2.5	32				-	-	-	-	-	-	0.41	0.26	58
silver (Ag)	µg/L	-	-	-	-	-	-				-	-	-	-	-	-	0.10	0.05	98
strontium (Sr)	µg/L	-	-	-	-	-	-				-	-	-	36.6	93.3	154	-	-	-
thallium (Tl)	µg/L	-	-	-	-	-	-				0.043	0.025	72	-	-	-	0.034	0.009	278
titanium (Ti)	µg/L	37	< 5	640	-	-	-				11.7	9.3	26	-	-	-	-	-	-
uranium (U)	µg/L	-	-	-	-	-	-				-	-	-	0.011	0.034	209	-	-	-
zinc (Zn)	µg/L	-	-	-	414	26	1492				20	14.3	40	20.7	7.2	188	-	-	-
Dissolved Metals																			
antimony (Sb)	µg/L	-	-	-	-	-	-	n/a	n/a	n/a	0.044	0.068	55	n/a	n/a	n/a	-	-	-
arsenic (As)	µg/L	-	-	-	-	-	-				0.44	0.3	47				-	-	-
lead (Pb)	µg/L	-	-	-	-	-	-				0.09	0.07	29				0.26	0.16	63
manganese (Mn)	µg/L	-	-	-	23	16	44				-	-	-				-	-	-
thallium (Tl)	µg/L	-	-	-	-	-	-				0.032	0.01	220				0.07	0.03	127
titanium (Ti)	µg/L	-	-	-	2.0	1.6	25				-	-	-				1.9	1.4	36
zinc (Zn)	µg/L	-	-	-	341	6	5583				10	6.8	47				3.5	1.8	94

(a) - = Differences between split samples did not exceed the relevant assessment criteria; n/a = not applicable.

(b) d/s = Downstream.

(c) Split total and dissolved metal samples were analyzed by separate laboratories.

(d) Samples collected at the time this split sample was prepared were only analyzed for total metals; as a result, this split sample was only analyzed for total metals.

Table 4.6 Differences Between Inter-lab Split Water Quality Samples That Exceeded Assessment Criteria

Parameter	Units	Spring[(a)]						Summer (Athabasca River d/s of development)[(a,b)]		
		North Steepbank River			Athabasca River d/s of development[(b)]					
		ETL	ARC	Percent Difference	ETL	ARC	Percent Difference	ETL	ARC	Percent Difference
Total Metals										
aluminum (Al)	µg/L	-	-	-	6560	3744	75	890	1663	87
barium (Ba)	µg/L	-	-	-	116	92	27	-	-	-
chromium (Cr)	µg/L	-	-	-	7.6	3.5	115	-	-	-
copper (Cu)	µg/L	-	-	-	7	5.5	27	-	-	-
iron (Fe)	µg/L	-	-	-	5270	4303	22	841	1385	65
lead (Pb)	µg/L	-	-	-	-	-	-	0.6	0.82	37
manganese (Mn)	µg/L	-	-	-	-	-	-	47	69	47
molybdenum (Mo)	µg/L	-	-	-	1.0	0.5	113	1.1	0.56	96
nickel (Ni)	µg/L	-	-	-	7.2	5.8	23	8.3	1.9	337
silver (Ag)	µg/L	-	-	-	-	-	-	0.14	0.09	51
titanium (Ti)	µg/L	-	-	-	192	49.4	289	-	-	-
uranium (U)	µg/L	-	-	-	0.70	0.54	29	0.6	0.41	46
vanadium (V)	µg/L	-	-	-	16.6	6.71	147	-	-	-
Dissolved Metals										
aluminum (Al)	µg/L	-	-	-	-	-	-	140	10.6	1221
boron (B)	µg/L	-	-	-	14.0	18.2	30	61	22	177
iron (Fe)	µg/L	962	734	31	120	76	58	56	20	180
lithium (Li)	µg/L	11	8.0	38	-	-	-	5.1	4.0	28
manganese (Mn)	µg/L	14	1.5	859	-	-	-	9	0.7	1186
nickel (Ni)	µg/L	-	-	-	-	-	-	0.7	0.5	37
titanium (Ti)	µg/L	-	-	-	3.1	1.6	94	3.6	1.1	227
vanadium (V)	µg/L	-	-	-	-	-	-	1.7	0.43	295
zinc (Zn)	µg/L	173	1.8	9511	68	56.4	21	-	-	-

(a) - = Differences between split samples did not exceed the relevant assessment criteria; ETL = EnviroTest Laboratories; ARC = Alberta Research Council in Vegreville.

(b) d/s = Downstream.

Table 4.7 Results of the Analysis of Selected Reference Standards

Parameter	Units	Concentration in Reference Standard	Results produced by[(a)]	
			ARC	ETL
total barium	µg/L	2.0	2.1	2.1
total strontium	µg/L	2.0	2.3	2.7
total zinc	µg/L	40	45	42
		80	82	71
dissolved barium	µg/L	1	1.1	1.3
dissolved strontium	µg/L	1	1.2	1.0
dissolved zinc	µg/L	20	23	21
		40	43	39

(a) ETL = EnviroTest Laboratories; ARC = Alberta Research Council in Vegreville.

The cause of this apparent paradox may lie with the analytical precision of ETL's dissolved metals analysis. Although a high level of analytical precision by ETL was observed with the winter and spring 2002 intra-lab split samples (Table 4.5), the inconsistent patterns discussed above, as well as the large magnitude of variation observed in the inter-lab split samples (e.g., differences of > 1000% recorded with zinc, manganese and aluminum - Table 4.6), point to imprecision in ETL's analytical techniques. Therefore, it is recommended that future dissolved metal analyses be completed by ARC-Vegreville.

With regards to data analysis, total metal levels reported for the fall of 2002 and the winter of 2003, as well as dissolved metal concentrations reported for the winter, spring and summer of 2002, were all produced by analytical techniques containing low to moderate levels of analytical precision. Future data interpretation should be conducted with this limitation in mind.

4.2.2.5 Conclusions

As discussed above, water samples collected by RAMP in 2002 were generally free of contamination and analyzed with methods showing adequate levels of analytical precision and accuracy. Therefore, the data produced by the RAMP 2002 water quality sampling program are considered, on the whole, to be of acceptable quality. However, as previously noted, total metal levels reported for the fall of 2002 and the winter of 2003, as well as dissolved metal concentrations reported for the winter, spring and summer of 2002, were produced using analytical techniques that contained low to moderate levels of analytical precision. Future data interpretation should be conducted with this limitation in mind.

4.2.3 Sediment Quality

The 2002 sediment quality QC program consisted of the collection and analysis of two sets of duplicate samples and two sets of split samples. These samples were used to evaluate potential sample heterogeneity and analytical bias, respectively. The split samples were collected from McClelland Lake and along the east bank of the Athabasca River upstream of the Steepbank River. The two duplicate samples were both taken from the Athabasca River: one along the east bank of the river near the Susan Lake outlet (downstream of development), and the other a cross-channel composite sample collected upstream of the Embarras River.

All eight sediment QC samples were submitted to ETL and AXYS Analytical Services Ltd. (AXYS) for the same type of analyses outlined in Section 3.3.2.1, including carbon content, particle size, metal and polycyclic aromatic hydrocarbon (PAH) analysis. Differences[3] between parameter concentrations in split or duplicate samples were considered significant if:

[3] Difference was expressed in terms of percent difference calculated using the following formula: (maximum concentration - minimum concentration) / minimum concentration.

- they were greater than 20% (ETL and ARC samples);
- parameter concentrations were greater than or less than the average concentration reported for the split or duplicate samples +/- 30% (AXYS samples); and
- parameter concentrations were greater than five times the relevant reported MDL.

These criteria are consistent with those used by ETL and AXYS for their internal QC procedures and take into account the potential for data accuracy error as parameter concentrations approach MDLs. Analytical precision, intra-site variability and field sampling precision were then rated as high, moderate or low based on the number of significant results observed, in accordance to the protocol outlined in Section 4.2.2.3. Results of the analysis are discussed below.

4.2.3.1 Analytical Precision

Between the two sets of split samples collected as part of the 2002 RAMP sediment sampling survey, there were 29 instances where parameter concentrations were notably different in one or both sets of split samples (Table 4.8). Eleven of the 29 instances related to PAH concentrations reported by AXYS, with the remaining 18 instances related to analyses performed by ETL. Given the total number of parameters analyzed (i.e., 86 for AXYS and 74 for ETL), the analytical precision of both laboratories was rated as moderate.

Table 4.8 Differences Between Split Sediment Samples That Exceeded Assessment Criteria

Parameter[a]	Units	Detection Limit[b]	Athabasca River Upstream of the Steepbank River		Percent Difference	Acceptable Range	McClelland Lake		Percent Difference	Acceptable Range
Organics										
total recoverable hydrocarbons	mg/kg	100	-	-	-	-	1200	1600	33	-
total volatile hydrocarbons	mg/kg	0.5	5.1	11	116	-	9.3	12	29	-
total extractable hydrocarbons	mg/kg	5	-	-	-	-	310	200	55	-
Total Metals										
barium (Ba)	µg/g	5	200	159	26	-	-	-	-	-
calcium (Ca)	µg/g	100	29300	23000	27	-	-	-	-	-
chromium (Cr)	µg/g	0.2	35.1	29.1	21	-	-	-	-	-
copper (Cu)	µg/g	2	21	16	31	-	-	-	-	-
iron (Fe)	µg/g	200	25600	18200	41	-	-	-	-	-
lead (Pb)	µg/g	0.5	10.9	8	36	-	-	-	-	-
manganese (Mn)	µg/g	0.5	456	374	22	-	-	-	-	-
nickel (Ni)	µg/g	0.5	27.2	21.9	24	-	-	-	-	-
sodium (Na)	µg/g	20	-	-	-	-	150	120	25	-
strontium (Sr)	µg/g	1	86	69	25	-	-	-	-	-
titanium (Ti)	µg/g	0.5	37.9	31.4	21	-	-	-	-	-
uranium (U)	µg/g	0.1	1.3	0.9	44	-	-	-	-	-
zinc (Zn)	µg/g	5	58	48	21	-	86	59	46	-
Target PAHs and Alkylated PAHs										
C1 substituted naphthalenes	ng/g	1.00	-	-	-	-	7.68	18.8	-	9.3 - 17.2
C3 substituted naphthalenes	ng/g	1.34	-	-	-	-	14.9	32.4	-	17 - 31
C2 substituted biphenyl	ng/g	0.44	-	-	-	-	2.01[c]	4.88[c]	-	2.4 - 4.5
C1 substituted dibenzothiophene	ng/g	0.47	-	-	-	-	2.88	5.47	-	2.9 - 5.4
C4 substituted dibenzothiophene	ng/g	3.04	-	-	-	-	8.61	16.4	-	8.8 - 16.3
C1 substituted fluorene	ng/g	0.67	-	-	-	-	9.08	17.1	-	9.2 - 17
C2 substituted fluorene	ng/g	0.70	-	-	-	-	18.3	52.9	-	25 - 46
C3 substituted fluorene	ng/g	4.44	-	-	-	-	12.1	31.8	-	15 - 29
C4 substituted phenanthrene/anthracene	ng/g	4.79	931	473	-	491 - 913	42.8	83	-	44 - 82
1-Methyl-7-isopropyl-phenanthrene (Retene)	ng/g	4.79	-	-	-		19.3	46.5	-	23 - 43

(a) - = not applicable / parameter results do not exceed assessment criteria.

(b) PAH detection limits varied by sample; average detection limit calculated based on the two split samples is shown.

(c) PAH concentrations are reported with the limitation that interference from the sample matrix resulted in a GCMS spectrum without clear, easy to identify peaks (i.e., these numbers may contain a larger degree of error than those produced from clearly defined spectra.

4.2.3.2 Intra-site Variability and Field Sampling Precision

Variations in the duplicate sediment samples collected in the Athabasca River upstream of the Embarras River were limited to two parameters: total recoverable hydrocarbons (TRH) and C1 substituted benzo(b&k) fluoranthene/ benzo(a)pyrene (Table 4.9). A greater amount of variation was observed between the two duplicate samples collected in the Athabasca River near the Susan Lake outlet. The concentrations of total volatile hydrocarbons (TVH), total extractable hydrocarbons, seven metals and 14 individual PAHs were notably different between the two samples. The extent of the variation ranged from 21% for nickel to 377% for TVH.

TRH concentrations in sediments from the lower Athabasca River watershed tend to be positively correlated to PAH levels (Golder 2003a). Based on this relationship, it is surprising that TRH concentrations in the two duplicate samples collected from the Athabasca River near the Susan Lake outlet were not substantially different from one another, given the above-noted variations in PAH levels in the two samples. This unexpected result suggests that analytical imprecision may be responsible for these differences, rather than intra-site variability or imprecise field sampling.

In light of the moderate level of analytical precision identified in Section 4.2.2.4, the limited variation observed between the duplicate samples collected from the Athabasca River upstream of the Embarras River and the inconsistent TRH - PAH results observed in the second set of duplicate samples, overall intra-site variability and field sampling precision were rated as low and high, respectively.

Table 4.9 Differences Between Duplicate Sediment Samples That Exceeded Assessment Criteria

Parameter[a]	Units	Detection Limit[b]	Athabasca River Downstream of Development		Percent Difference	Acceptable Range	Athabasca River Upstream of Embarras R.		Percent Difference	Acceptable Range
Organics										
total recoverable hydrocarbons	mg/kg	100	-	-	-	-	900	600	50	-
total volatile hydrocarbons	mg/kg	0.5	42	8.8	377	-	-	-	-	-
total extractable hydrocarbons	mg/kg	5	18000	28000	56	-	-	-	-	-
Total Metals										
arsenic (As)	µg/g	0.5	2.9	3.6	24	-	-	-	-	-
cobalt (Co)	µg/g	0.1	5	6.9	38	-	-	-	-	-
iron (Fe)	µg/g	200	8200	10600	29	-	-	-	-	-
lead (Pb)	µg/g	0.5	4.5	5.9	31	-	-	-	-	-
manganese (Mn)	µg/g	0.5	260	343	32	-	-	-	-	-
nickel (Ni)	µg/g	0.5	10.2	12.3	21	-	-	-	-	-
titanium (Ti)	µg/g	0.5	53.4	37.3	43	-	-	-	-	-
Target PAHs and Alkylated PAHs										
C2 substituted naphthalenes	ng/g	2.01	184	47	-	81 - 150	-	-	-	-
C3 substituted naphthalenes	ng/g	4.02	794	293	-	380 - 707	-	-	-	-
C4 substituted naphthalenes	ng/g	15.3	3540	1600	-	1799 - 3341	-	-	-	-
C1 substituted benzo(b&k) fluoranthene/benzo(a)pyrene	ng/g	25.2	-	-	-	-	67	22.3	-	31 - 58
C2 substituted biphenyl	ng/g	2.53	53.7[c]	20.5[c]	-	26 - 48	-	-	-	-
C1 substituted dibenzothiophene	ng/g	7.05	1190	494	-	589 - 1095	-	-	-	-
C2 substituted dibenzothiophene	ng/g	89.8	5400	2490	-	2762 - 5129	-	-	-	-
C3 substituted dibenzothiophene	ng/g	127	12700	6720	-	6797 - 12623	-	-	-	-
C1 substituted fluorene	ng/g	5.60	111	51.6	-	57 - 106	-	-	-	-
C2 substituted fluorene	ng/g	2.62	912	479	-	487 - 904	-	-	-	-
C3 substituted fluorene	ng/g	117	2000	949	-	1032 - 1917	-	-	-	-
C1 substituted phenanthrene/anthracene	ng/g	8.09	565	205	-	270 - 501	-	-	-	-
C2 substituted phenanthren/anthracene	ng/g	9.01	2540	997	-	1238 - 2299	-	-	-	-
C3 substituted phenanthrene/anthracene	ng/g	30.3	7910	4010	-	4172 - 7748	-	-	-	-

(a) - = Not applicable/parameter results do not exceed assessment criteria.

(b) PAH detection limits varied by sample; average detection limit calculated based on the two split samples is shown.

(c) PAH concentrations are reported with the limitation that interference from the sample matrix resulted in a GCMS spectrum without clear, easy to identify peaks (i.e., these numbers may contain a larger degree of error than those produced from clearly defined spectra.

4.2.3.3 Conclusions

As discussed above, sediment samples collected by RAMP in 2002 were analyzed using methods demonstrating adequate levels of analytical precision. Intra-site variability and field sampling precision were also rated as low and high, respectively. Consequently, the data produced by the RAMP 2002 sediment quality sampling program are considered to be of acceptable quality.

4.2.4 Benthic Invertebrate Communities

Field methods and procedures for benthic invertebrate sample processing and invertebrate taxonomy were developed according to guidelines established by federal and provincial agencies (AENV 1990; Environment Canada 1993).

Laboratory analysis of benthic invertebrate samples incorporated an evaluation of invertebrate removal efficiency in 5% of the samples (13 samples, randomly selected) collected during the 2002 program. Sorted portions of these samples were re-sorted by an independent consultant. In light of the large number of depositional samples, which contained a large amount of organic material but relatively few invertebrates (e.g., frequently fewer than 100 organisms), minimum removal efficiency of 90% was considered acceptable. 90% removal efficiency is the data quality objective recommended by Environment Canada (2002) for benthic surveys conducted as part of Environmental Effects Monitoring (EEM) for metal mines. Quality control results indicate that the data quality objective was consistently achieved during the 2002 RAMP surveys (Table 4.10).

Identifications of questionable specimens were verified by a taxonomic expert (Dr. Gordon Pritchard, Biological Sciences, University of Calgary). The taxonomist (Dr. J. Zloty) has several years of experience identifying benthic invertebrates from the Oil Sands Region and extensive experience identifying invertebrates collected throughout Alberta. Therefore, data quality was deemed acceptable.

The benthic invertebrate abundance data were received in electronic format from the taxonomist. Before releasing the data, data entry was checked by the taxonomist by verifying each number entered. During data manipulation and analysis, backup files were generated before each major operation, and appropriate logic checks were performed to ensure the accuracy of calculations. Benthic invertebrate data and results of analyses are stored in printed and electronic format with appropriate documentation and backups to ensure that analyses may be reproduced if necessary.

Table 4.10 Quality Control Data for Re-sorted Benthic Invertebrate Samples

Taxon	STR-E-9	MUR-E-5		MCL-7		JAC-D-8		TAR-D-6		MUR-E-8		CAL-D-1	
	C+F	C	F (1/2)	C	F (1/10)	C	F (1/8)	C	F (1/10)	C	F (1/4)	C	F (1/10)
Naididae													
Tubificidae													
Enchytraeidae	1												
Ostracoda													
Amphipoda													
Ephemeroptera													
Ophiogomphus										1			
Dasyhelea													
Chironomidae			1								1		
Chironomini				1			1		1				
Tanypodinae									1				
Tanytarsini	1												
Empididae													
total missed	2	0	1	1	0	0	1	0	2	1	1	0	0
total in sample	91	392		90		422		3,212		1,105		14	
percentage missed (%)	2.2	0.5		1.1		1.9		0.6		0.5		0	
sorting efficiency (%)	97.8	99.5		98.9		98.1		99.4		99.5		100	

Notes: Numbers of organisms were multiplied by the subsampling factor to calculate the percentage missed and the sorting efficiency.
C = coarse (>1 mm) fraction.
F = fine (0.25 to 1 mm) fraction.
In the event that a sample fraction was subsampled, the amount sorted is indicated in parentheses.

Table 4.10 Quality Control Data for Re-sorted Benthic Invertebrate Samples (continued)

Taxon	SHL-3		KEL-6		CHR-D-21		CLR-D-16		MAR-E-11		MUR-D-20	
	C	F (1/10)	C	F (1/10)	C	F (1/10)	C	F (1/10)	C	F (1/4)	C	F (1/10)
Naididae						1						
Tubificidae								1				
Enchytraeidae												
Ostracoda						1				1		
Amphipoda								1				
Ephemeroptera										1		
Ophiogomphus												
Dasyhelea										1		
Chironomidae												
Chironomini												
Tanypodinae		4					2	5				1
Tanytarsini								1				
Empididae						1						
total missed	0	4	0	0	0	3	2	8	0	3	0	1
total in sample	987		164		1,030		1,333		896		176	
percentage missed (%)	4.1		0		2.9		6.2		1.3		5.7	
sorting efficiency (%)	95.9		100		97.1		93.8		98.7		94.3	

Notes: Numbers of organisms were multiplied by the subsampling factor to calculate the percentage missed and the sorting efficiency.
C = coarse (>1 mm) fraction.
F = fine (0.25 to 1 mm) fraction.
In the event that a sample fraction was subsampled, the amount sorted is indicated in parentheses.

4.2.5 Fish Populations

4.2.5.1 Field Sampling

Fish collections for sentinel monitoring and inventory work were conducted in accordance to Golder Technical Procedure 8.1.3 "Fish Inventory Methods" (Golder 1997e). Fish collected for tissue analyses were processed according to procedures outlined in the Technical Procedure 8.15-0 "Fish Health Assessment – Organics" and 8.16-0 "Fish Health Assessment – Metals" (Golder 1997f, g). Detailed field notes were maintained in a perfect-bound notebook and fisheries data were recording using appropriate data sheets.

Routine water quality data (pH, conductivity, temperature, dissolved oxygen) were collected at each site. Water quality instruments were calibrated as needed. The start and finish of each fisheries sampling reach was recorded using a GPS unit. A photograph of each fish collection site was taken and photograph details were recorded on a Photo Log Form.

Chain-of-custody forms were completed when shipping all samples to the appropriate laboratory for analysis.

4.2.5.2 Laboratory Analysis

Fish ageing was conducted by Northshore Environmental Services, Thunder Bay, Ontario. Jon Tost (proprietor) is recognized as an expert in ageing fish. Ageing structures were read independently at least three times and a numerical confidence level was assigned to each age estimate. The confidence level for walleye, lake whitefish and northern pike was moderately high. Confidence level for trout-perch ageing was moderate due to poor annular definition and possible differential growth in various areas of the otoliths.

A single Golder Associates' Technician conducted all fecundity analyses. At least 10% of all fecundity samples were re-counted by a second independent reader. However, precision of estimates was difficult to evaluate because re-counts were strongly influenced by eggs breaking due to additional handling. The average variability in fecundity estimates was less than 5%.

ETL QC Program

ETL provided a QC report for every RAMP fish tissue analysis report. For every sample processed, the QC report documented the QC procedure used for each corresponding parameter analysis. In general, each QC result must meet acceptance guidelines specified for that particular method. A column in the QC report details the type of corrective action taken if the result fell outside the acceptable limit. QC procedures included method blanks, laboratory duplicates, spiked samples, use of certified reference materials, calibration control and internal standard.

4.2.5.3 Data Entry

Fisheries data were entered into the project database from field and laboratory data sheets. All entries were independently checked for errors by a second person. All data were again screened graphically and using summary statistics for possible data entry errors and/or "suspicious" data points prior to data analyses. All entry errors were corrected. All raw data for tissue collection and sentinel species have been provided in Appendix XV and XVII, respectively.

4.2.6 Acid Sensitive Lakes

The QC program for the 2002 Acid Sensitive Lakes component included use of standardized field and laboratory procedures, and evaluation of precision and recovery in the laboratory. Field sampling was conducted by AENV personnel and laboratory analyses were performed at the University of Alberta Limnology Laboratory. Descriptions of the procedures and results of the QC program are provided below.

Field Quality Control Procedures

Water quality sampling in the field incorporated general QC procedures to minimize sample contamination and ensure proper functioning of field instruments. Briefly, these included:

- proper cleaning of sampling equipment between sites;
- collecting samples away from the boat or float plane;
- rinsing sample containers with sample water before filling them;
- filling the sample bottles completely so that there is no head space;
- storing samples in appropriate containers and keeping them cool (4°C) and in the dark;
- delivering samples to the analytical laboratory within 48 h of collection; and
- proper calibration of field water quality meters.

Laboratory Quality Control Procedures

The Limnology Laboratory of the University of Alberta has an internal QA/QC program, which includes the use of standard reference samples, inter-laboratory comparisons and corrective actions if QC objectives are not met. Standard QC samples are prepared for each batch of analysis from analytical grade chemicals or certified standards. Inter-laboratory comparisons are performed twice a year against 10 samples supplied by the National Water Research Institute (NWRI) and once a year against 2 samples provided by the Norwegian Institute for Water Research (NIVA).

Standards are run with each set of analyses to establish a standard curve, followed by QC solutions analyzed in duplicate. If the QC results are unacceptable at this point, corrective action is taken. If the analysis is deemed consistent over the length of the run, these are the only QC solutions analyzed. When a new QC sample is prepared, it is run with the previous QC sample to develop a new control chart.

Quality Control Results

QC solutions of known concentration were analyzed for specific parameters in 2002 (Table 4.11). Mean percent recoveries ranged from 85% to 104%. The percent recovery for anions ranged from 85 to 115% (mean recovery not available). Based on the internal laboratory QC results and procedures applied at the Limnology Laboratory, the quality of the water chemistry data for acid sensitive lakes was considered acceptable.

Table 4.11 Number and Mean Recovery (%) of Quality Control Solutions of Known Concentration in 2002

Parameter	Number of QC Solutions Analyzed	Standard Solutions	Mean Recovery (%)	Sample Size
nitrogen (total, total dissolved, total Kjeldahl)	2	glycine-360 µg/L and EDTA-7677 µg/L	99	10
ammonium	3	ammonium chloride: 20, 100 and 450 µg/L	101	7
nitrite+nitrate	3	potassium nitrate: 25, 55 and 100 µg/L	101	7
total phosphorus	2	75 and 400 µg/L	100	5
anions	4	n/a[(a)]	range = 85 to 115	n/a
sodium	n/a	n/a	95	n/a
potassium	n/a	n/a	98	n/a
calcium	n/a	n/a	98	n/a
magnesium	n/a	n/a	98	n/a
iron	5	0.20, 0.50, 1.00, 2.00 and 5.00 mg/L	97	5
dissolved organic carbon	3	n/a	85	n/a
dissolved inorganic carbon	3	n/a	104	n/a
alkalinity	2	working sodium carbonate (WSC): 20 and 100 mg/L as $CaCO_3$	95	n/a

Note: Data from University of Alberta Limnology Laboratory.
[(a)] n/a = Not available.

4.2.7 Aquatic Vegetation

The QA/QC program for aerial photograph interpretation included checking polygon classifications and the digitized boundaries for accuracy. Area of polygons was confirmed and figures showing the aerial photographs of the lakes went through a check and review process.

Field Quality Control Procedures

Water quality sampling in the field incorporated general QC procedures to minimize sample contamination and ensure proper functioning of field instruments, as described in Golder Technical Procedures 8.3-1 and 8.23-0 (Golder 1997b, h). Briefly, these included:

- proper cleaning of sampling equipment between sites;
- collecting samples upstream of the boat or float plane;
- rinsing sample containers three times before filling them;
- filling the sample bottles completely so that there is no head space;
- storing samples in appropriate containers and keeping them cool (4°C) and in the dark;
- delivering samples to the analytical laboratory within 48 h of collection; and
- proper calibration of field water quality meters.

Laboratory Quality Control Procedures

The Limnology Laboratory of the University of Alberta has an internal QA/QC program, which includes the use of standard reference samples, inter-laboratory comparisons and corrective actions if QC objectives are not met. Standard QC samples are prepared for each batch of analysis from analytical grade chemicals or certified standards. Inter-laboratory comparisons are performed twice a year against 10 samples supplied by the National Water Research Institute (NWRI) and once a year against two samples provided by the Norwegian Institute for Water Research (NIWA).

Standards are run with each set of analyses to establish a standard curve, followed by QC solutions, analyzed in duplicate. If the QC results are unacceptable at this point, corrective action is taken. If the analysis is deemed consistent over the length of the run, these are the only QC solutions analyzed. When a new QC sample is prepared, it is run with the previous QC sample to develop a new control chart.

Quality Control Results

QC solutions of known concentration were analyzed for specific parameters in 2002 (Table 4.12). Mean percent recoveries of these QC solutions ranged from 85% to 104%. The percent recovery for anions ranged from 85 to 115% (mean recovery not available).

Table 4.12 Number and Mean Recovery (%) of Quality Control Solutions of Known Concentration in 2002

Parameter	Number of QC Solutions Analyzed	Types of Solutions	Mean Recovery (%)	Sample Size
Nitrogen (Total, Total Dissolved, Total Kjeldahl)	2	Glycine-360 µg/L and EDTA-7677 µg/L	99	10
Ammonium	3	Ammonium Chloride: 20, 100 and 450 µg/L	101	7
Nitrite+Nitrate	3	Potassium Nitrate: 25, 55 and 100 µg/L	101	7
Total Phosphorus	2	75 and 400 µg/L	100	5
Anions	4	na	range = 85 to 115	na
Sodium	na	na	95	na
Potassium	na	na	98	na
Calcium	na	na	98	na
Magnesium	na	na	98	na
Iron	5	0.20, 0.50, 1.00, 2.00, and 5.00 mg/L	97	5
Dissolved organic carbon	3	na	85	na
Dissolved inorganic carbon	3	na	104	na
Alkalinity	2	Working Sodium Carbonate (WSC): 20 and 100 mg/L as $CaCO_3$	95	na

na = Data not available.

5 CLIMATE AND HYDROLOGY

This section presents details of the climate and hydrology component of the Regional Aquatics Monitoring Program (RAMP) in 2002. The monitoring approach used is outlined in Section 2.1.1. A description of the methods of analysis is presented in Section 3.1. Measurement of climate parameters was conducted at six stations and one snow course survey was completed in the Birch Mountains east slope basins. Hydrologic monitoring of stream flows and water levels was performed at 12 Athabasca River tributary stations, one main stem station, 12 Muskeg River basin stations, 4 stations south of Gregoire Lake and 3 wetland stations.

The core components of the 2002 chemical and biological monitoring program (water and sediment quality, benthic invertebrate communities and fish populations) are all influenced by climatic and hydrologic conditions. In particular, changes that alter the quantity of water in the Athabasca River, the tributaries of the Athabasca River, wetlands and lakes will influence these core components. Since changes in flows and water levels may affect both the success and the results of RAMP sampling throughout the study area, a summary of the 2002 conditions is also provided as background information in this section.

5.1 CLIMATE MONITORING

5.1.1 Aurora Climate Station

5.1.1.1 Station Description

The Aurora Climate Station was initially installed for the OSLO project, known as station 271, at the abandoned airstrip in Lease 34. The station was operated for only one year in 1988. Syncrude restored the operation of the climatic station in May 1995 as part of the baseline data collection program for the Aurora Mine Project. The Aurora Climate Station is located at 57° 14’ 16” north latitude and 111° 24’ 27” west longitude (SW-16-95-9-W4).

Table 5.1 summarizes the monitoring equipment installed at the climatic station. The devices for monitoring wind speed, wind direction, solar radiation and air temperature are mounted on a 10 m high tower set into a concrete base. The relative humidity meter, data logger, storage module and battery pack are mounted approximately 1.5 m above the ground level. The tipping-bucket rain and snow gauges are located away from the tower, approximately 1.0 m high on a base constructed from a section of steel culvert.

Table 5.1 Monitoring Equipment at the Aurora Climate Station

Type of Monitoring Equipment	Parameter Monitored or Function
Tipping-Bucket Rain Gauge (Campbell Scientific Model CS700-L)	total rainfall and rate of rainfall
Tipping-Bucket Snow Gauge (Texas Electronics TE525WS-L with CS705 snowfall adaptor)	total snowfall and rate of snowfall
Anemometer (Young Model 05103-10)	wind speed and direction
Silicon Pyranometer (LI-COR Model LI200S)	solar radiation
Temperature and Relative Humidity Probe (Vaisala Model HMP45C with 41002 12-Plate Radiation Shield)	ambient temperature and relative humidity
Sonic Ranger (Campbell Scientific Model SR50)	snow depth on ground
Measurement and Control Module (Campbell Scientific Model CR10)	data logging
Solid State Storage Module (Campbell Scientific Model SM192)	storing data
Solar Panel and Battery Pack	solar panel for charging the battery pack

5.1.1.2 Station Operation and Maintenance

The station operation in 2002 included periodic site visits, inspection of the monitoring equipment, and exchange of data storage modules. During each visit, the storage modules were swapped and returned to the office to be downloaded without missing periods of data. The station was visited on January 11, February 7, March 13, April 8, April 23, May 14, June 9, July 9, August 11, September 13, and October 25, 2002 and January 7, 2003. The Aurora Climate Station operated continuously in 2002 with no data gaps.

5.1.1.3 Data Processing and Compilation

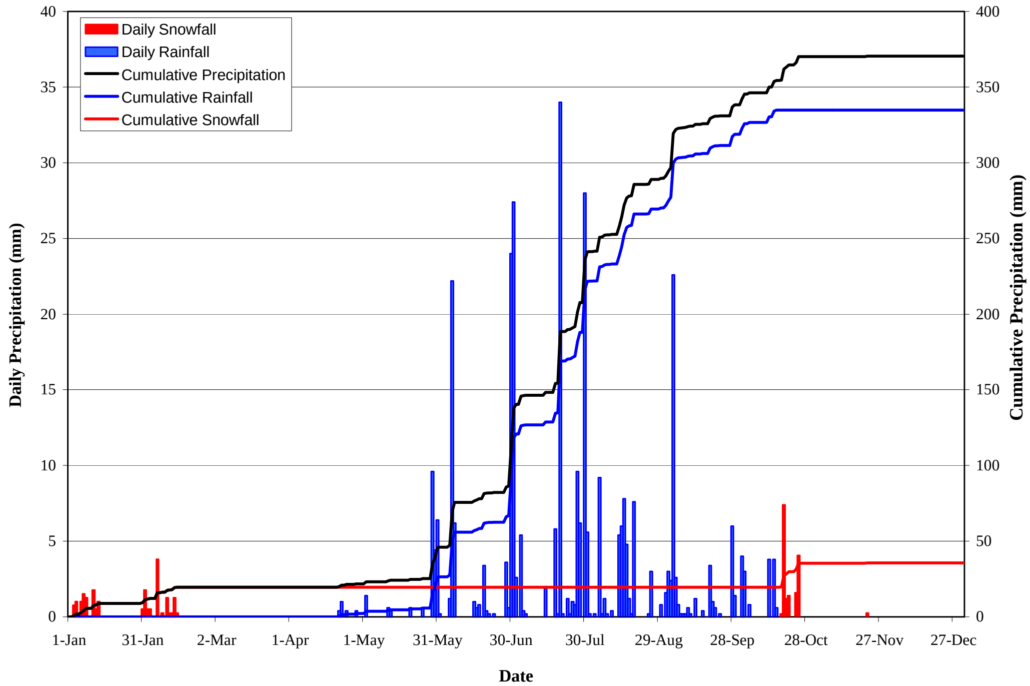
The hourly climatic data recorded in the data logger storage modules were downloaded 12 times as part of the 2002 program. Continuous measurements were available from January 1 to December 31, 2002. These hourly data were processed to derive the daily and monthly data. The daily data are presented in Appendix I. Table 5.2 presents the monthly climatic data statistics based on the recorded data, including air temperature, rainfall, snowfall, solar radiation, atmospheric pressure, and wind speed and direction. Recorded and processed hourly climatic data collected in 2002 are stored on a compact disc in Appendix II. Figure 5.1 presents the daily and cumulative rainfall and snowfall measured in 2002.

Table 5.2 Monthly Climatic Data Statistics for the Aurora Climatic Station, 2002

Month	Temperature			Total Rainfall	Total Snowfall	Mean Relative Humidity	Total Global Solar Radiation	Wind Speed and Direction				
								Mean Daily Wind		Maximum Sustained Gusts		
	Minimum	Mean	Maximum					Speed	Direction	5 Second	2 Minute	10 Minute
	(°C)	(°C)	(°C)	(mm)	(mm SWE)	(%)	(kW·h/m^2)	(km/h)	(degrees)	(km/h)	(km/h)	(km/h)
January	-39.9	-19.3	5.0	0.0	9.4	80.5	14.9	3.4	165	31.7	21.8	16.2
February	-37.3	-11.8	7.2	0.0	10.2	76.0	36.9	4.4	158	48.1	29.5	22.3
March	-37.4	-15.3	10.4	0.0	0.0	62.5	100.5	4.9	142	36.3	20.9	17.0
April	-26.6	-3.2	18.0	2.2	0.0	58.3	140.9	6.3	142	48.4	29.1	22.5
May	-19.2	6.6	23.7	24.0	0.0	47.7	189.5	6.8	157	42.6	25.5	19.6
June	-1.9	16.3	36.0	64.6	0.0	60.2	187.6	4.0	166	42.3	23.6	18.3
July	3.6	16.7	32.6	130.8	0.0	72.2	159.9	4.2	203	39.3	20.6	17.4
August	-1.3	13.9	31.4	48.6	0.0	77.4	138.8	3.6	209	43.0	24.4	18.6
September	-9.8	8.3	23.7	48.6	0.0	79.0	94.0	3.9	223	39.7	24.8	18.6
October	-22.3	-2.3	14.7	16.0	8.6	81.6	47.1	4.0	168	42.1	21.3	15.7
November	-28.0	-8.1	10.0	0.0	0.3	87.3	15.3	4.1	173	60.7	36.6	29.4
December	-28.8	-10.4	1.5	0.0	0.0	91.6	7.4	3.0	176	24.1	14.6	12.2

Note: SWE - Snow Water Equivalent.
kW·h/m^2 - Total Global Solar Radiation.

Figure 5.1 Daily and Cumulative Rainfall and Snowfall Data for RAMP Station C1 (Aurora Climate Station), 2002



5.1.2 Other Climatic Stations

Climatic parameters were monitored at selected RAMP hydrologic monitoring stations during 2002. The RAMP stations with climatic monitoring sensors included:

- S16 (Calumet River): rainfall, snowfall, and air temperature;
- S3 (Iyinimin Creek): rainfall;
- S19 (Lowland Tar River): rainfall;
- S29 (Christina River): rainfall;
- L1 (McClelland Lake): rainfall; and
- S5A (Muskeg River Aurora): atmospheric pressure.

Table 5.3 represents a summary of the climatic data statistics that were recorded at each station, including data from the Aurora Climate Station for comparison purposes. Descriptions of climatic monitoring activities and detailed rainfall data are presented by station in the following subsections.

Table 5.3 Summary of 2002 Monthly Mean Climatic Data Recorded at the Aurora, Calumet, Iyinimin, McClelland, Tar River Lowland and Christina River Climate Stations

Operational Period	Aurora Climate Station (RAMP Station C1)					Calumet River (RAMP Station S16)					Iyinimin Creek (RAMP Station 3)	McClelland Lake (RAMP Station L1)	Tar Lowland (RAMP Station S19)	Christina River (RAMP Station S29)
	1 Jan - 31 Dec					1 Jan - 31 Dec					27 Apr - 5 Aug 11 Sep - 26 Oct	9 Aug - 3 Sep	14 Jun - 21 Oct	8 Jul - 22 Oct
Month	Temperature			Total Rainfall	Total Snowfall[a]	Temperature			Total Rainfall	Total Snowfall[a]	Total Rainfall[b]	Total Rainfall[c]	Total Rainfall	Total Rainfall
	Min	Mean	Max			Min	Mean	Max						
	(°C)	(°C)	(°C)	(mm)	(mm SWE)	(°C)	(°C)	(°C)	(mm)	(mm SWE)	(mm)	(mm)	(mm)	(mm)
Jan	-39.9	-19.3	5.0	0	9.4	-44.7	-20.3	4.8	0	18.8	-	-	-	-
Feb	-37.3	-11.8	7.2	0	10.2	-36.7	-12.5	9.0	0	0.0	-	-	-	-
Mar	-37.4	-15.3	10.4	0	0.0	-36.9	-14.7	11.5	2.3	0.0	-	-	-	-
Apr	-26.6	-3.2	18.0	2.2	0.0	-26.0	-3.2	17.6	4.6	0.0	0.0 P	-	-	-
May	-19.2	6.6	23.7	24	0.0	-19.7	5.8	25.6	18.4	0.0	19.3	-	-	-
Jun	-1.9	16.3	36.0	64.6	0.0	-3.7	15.5	37.9	39.9	0.0	39.4	-	24.0 P	-
Jul	3.6	16.7	32.6	130.8	0.0	-0.1	16.0	34.9	137.9	0.0	106.4	-	110.0	59.2 P
Aug	-1.3	13.9	31.4	48.6	0.0	-2.8	13.3	32.6	47.4	0.0	7.1 P	31.5 P	43.1	61.6
Sep	-9.8	8.3	23.7	48.6	0.0	-13.8	7.6	25.9	37.5	0.0	22.1 P	2.7 P	27.0	34.5
Oct	-22.3	-2.3	14.7	16	8.6	-25.2	-3.2	17.7	12.5	7.2	6.9 P	-	8.1 P	19.5 P
Nov	-28.0	-8.1	10.0	0	0.3	-29.2	-9.0	9.5	0.9	0.0	-	-	-	-
Dec	-28.8	-10.4	1.5	0	0.0	-31.6	-12.2	-0.4	0	0.0	-	-	-	-

(a) SWE = Snow Water Equivalent.

(b) The rain gauge at RAMP Station S3 was damaged by an animal or human in early August and was repaired when this was discovered on 12 September, 2002.

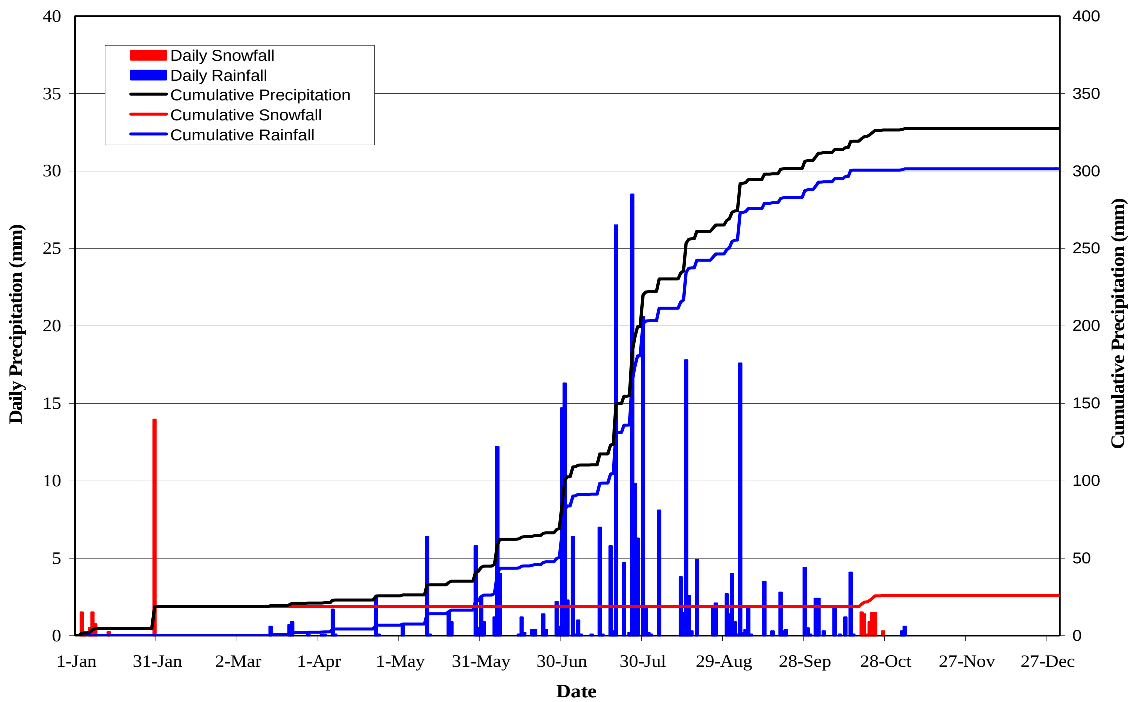
(c) The rain gauge at RAMP Station L1 was vandalized in mid-September and was taken from the station when this was discovered on 12 September, 2002.

5.1.2.1 Calumet River Station

RAMP Station S16 is located on the Calumet River, near the inactive Environment Canada hydrometric station 07DA014. Climatic parameter sensors installed at this station include a tipping bucket rain gauge, a tipping bucket snow gauge, and a shielded air temperature sensor. Each rainfall and snowfall gauge tip is logged, as are air temperatures on a 15-minute interval. Climatic parameter sensors were inspected during regular site visits to perform hydrologic measurements, as described in Section 5.3.

The climate sensors operated continuously through 2002. Monthly data, including rainfall, snowfall and minimum, mean and maximum air temperatures, are presented in Table 5.3. Daily data are presented in Appendix I and the complete data set is provided in the updated RAMP Climate and Hydrology database in Appendix II. Figure 5.2 presents the daily and cumulative rainfall and snowfall measured in 2002.

Figure 5.2 Daily and Cumulative Rainfall and Snowfall Data for RAMP Station S16 (Calumet River), 2002

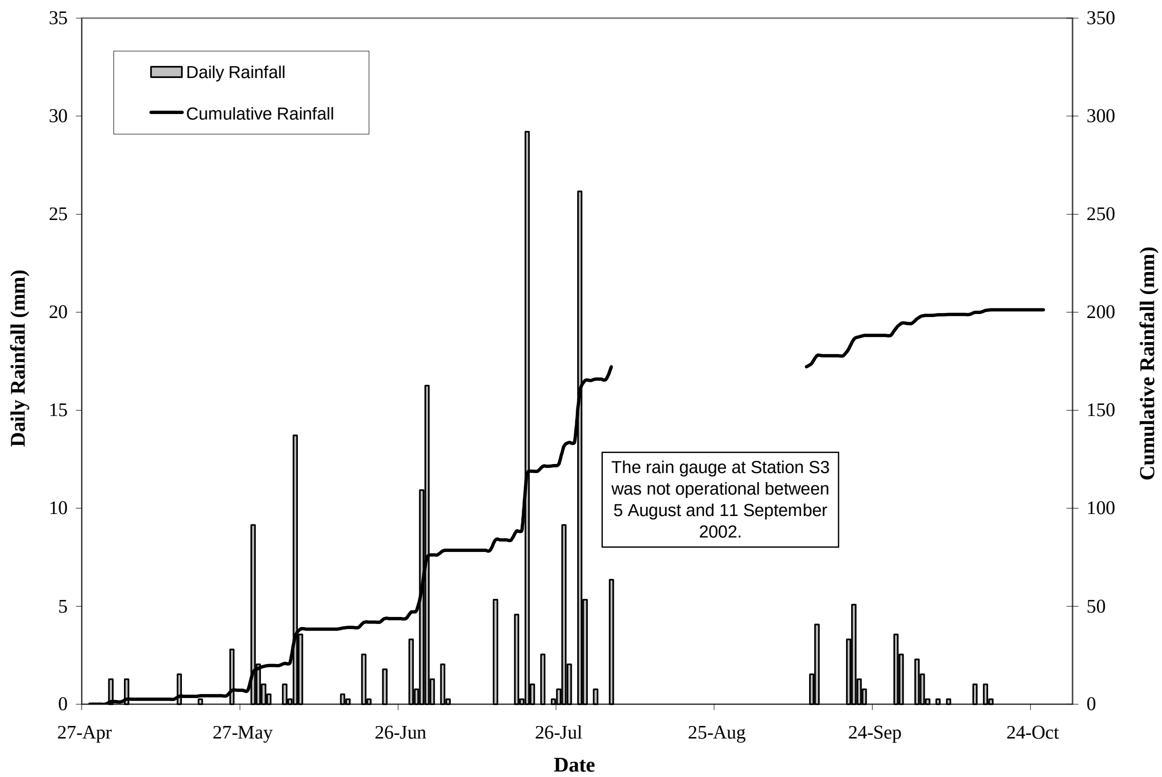


5.1.2.2 Iyinimin Creek Station

RAMP Station S3 is located on the west slope of Muskeg Mountain. A tipping bucket rain gauge was installed at the hydrologic monitoring station at this site, and each rainfall gauge tip was logged. The rain gauge was inspected during regular site visits to perform hydrologic measurements, as described in Section 5.3.

The rain gauge at this station operated from April 27 to October 26, 2002. The gauge was damaged by an animal or human in early August and was repaired when this was discovered on September 11, but no data were measured during this period. Monthly rainfall data were presented in Table 5.3. Daily data are presented in Appendix I and the complete data set is provided in the updated RAMP Climate and Hydrology database in Appendix II. Figure 5.3 presents the daily and cumulative rainfall measured in 2002.

Figure 5.3 Daily and Cumulative Rainfall Data for RAMP Station S3 (Iyinimin Creek), 2002

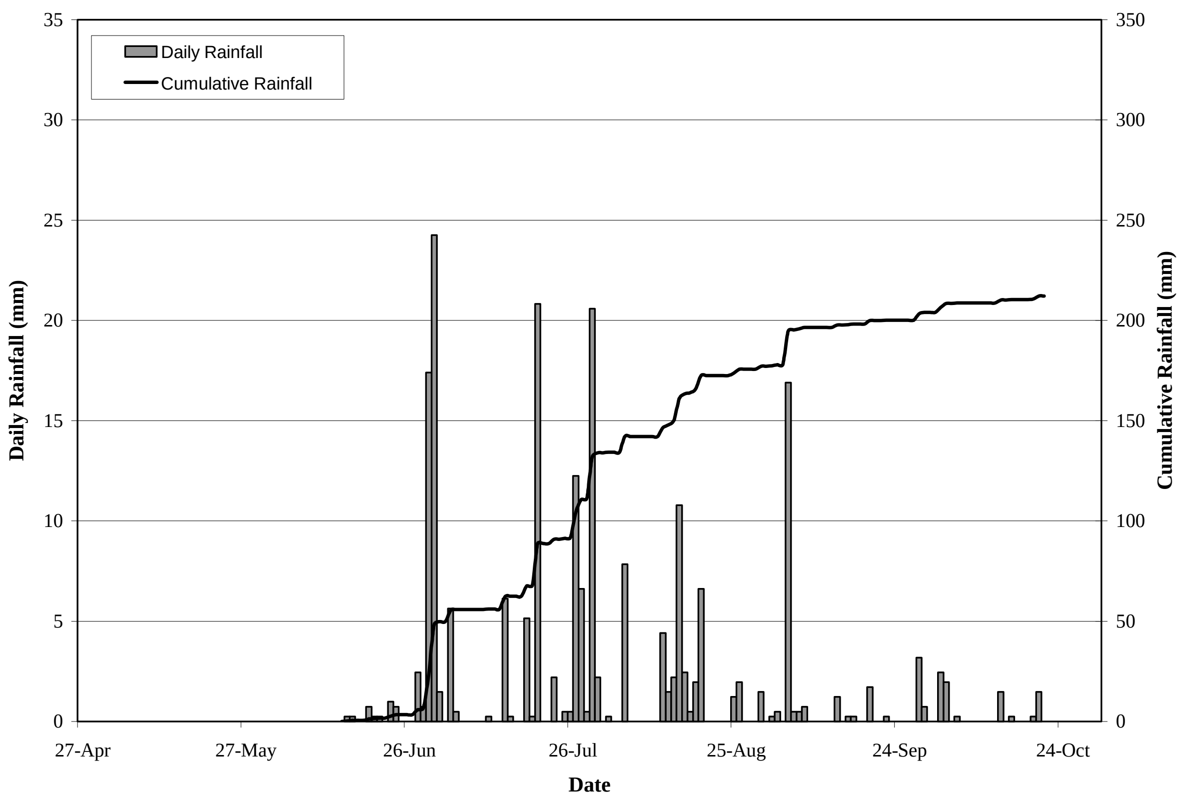


5.1.2.3 Tar River Lowland Station

RAMP Station S19 is located on a lowland southern tributary of the Tar River. A tipping bucket rain gauge was installed at the hydrologic monitoring station at this site, and each rainfall gauge tip was logged. The rain gauge was inspected during regular site visits to perform hydrologic measurements, as described in Section 5.3.

The rain gauge at this station was first installed on June 14, 2002 and operated from June 14 to October 21, 2002. Monthly rainfall data are presented in Table 5.3. Daily data are presented in Appendix I and the complete data set is provided in the updated RAMP Climate and Hydrology database in Appendix II. Figure 5.4 presents the daily and cumulative rainfall measured in 2002.

Figure 5.4 Daily and Cumulative Rainfall Data for RAMP Station S19 (Tar River Lowland), 2002

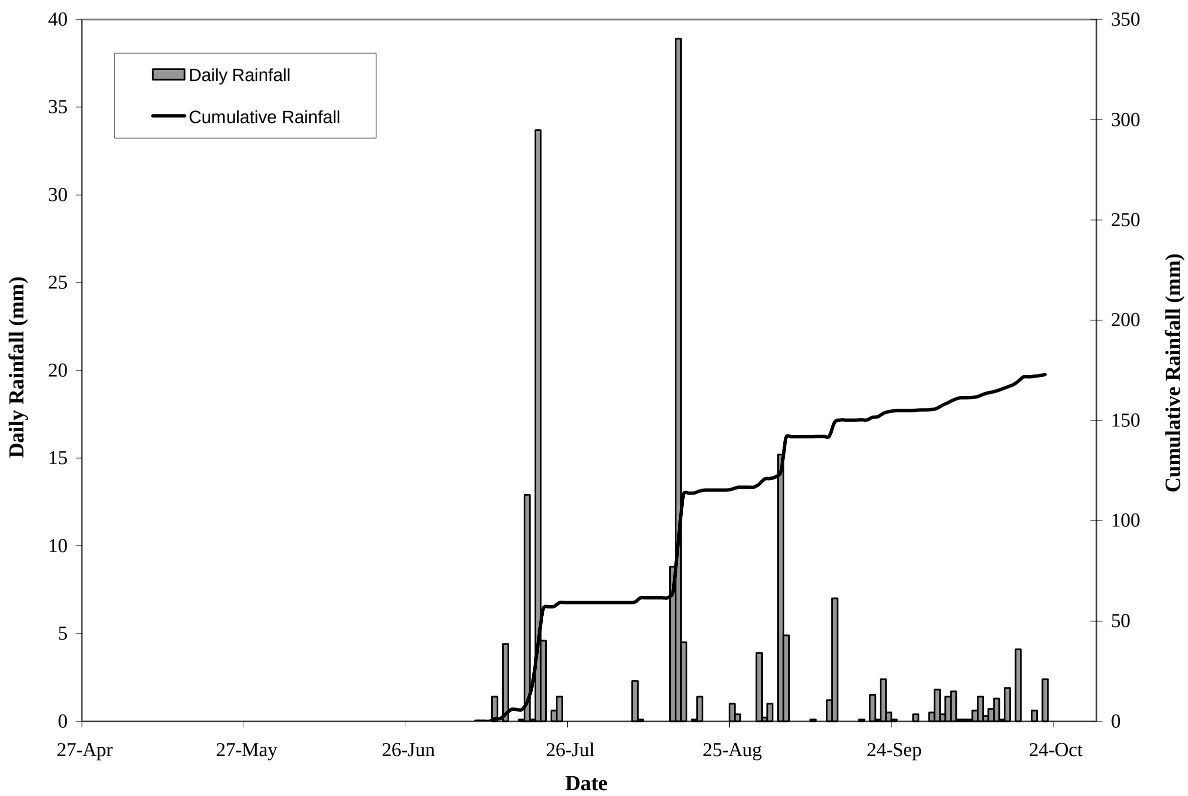


5.1.2.4 Christina River Station

RAMP Station S29 is located on the Christina River, near the active Environment Canada hydrometric station 07CE002. A tipping bucket rain gauge was installed at the hydrologic monitoring station at this site, and each rainfall gauge tip was logged. The rain gauge was inspected during regular site visits to perform hydrologic measurements, as described in Section 5.3.

The rain gauge at this station was first installed on July 8, 2002 and operated from July 8 to October 22, 2002. Monthly rainfall data are presented in Table 5.3. Daily data are presented in Appendix I and the complete data set is provided in the updated RAMP Climate and Hydrology database in Appendix II. Figure 5.5 presents the daily and cumulative rainfall measured in 2002.

Figure 5.5 Daily and Cumulative Rainfall Data for RAMP Station S29 (Christina River), 2002

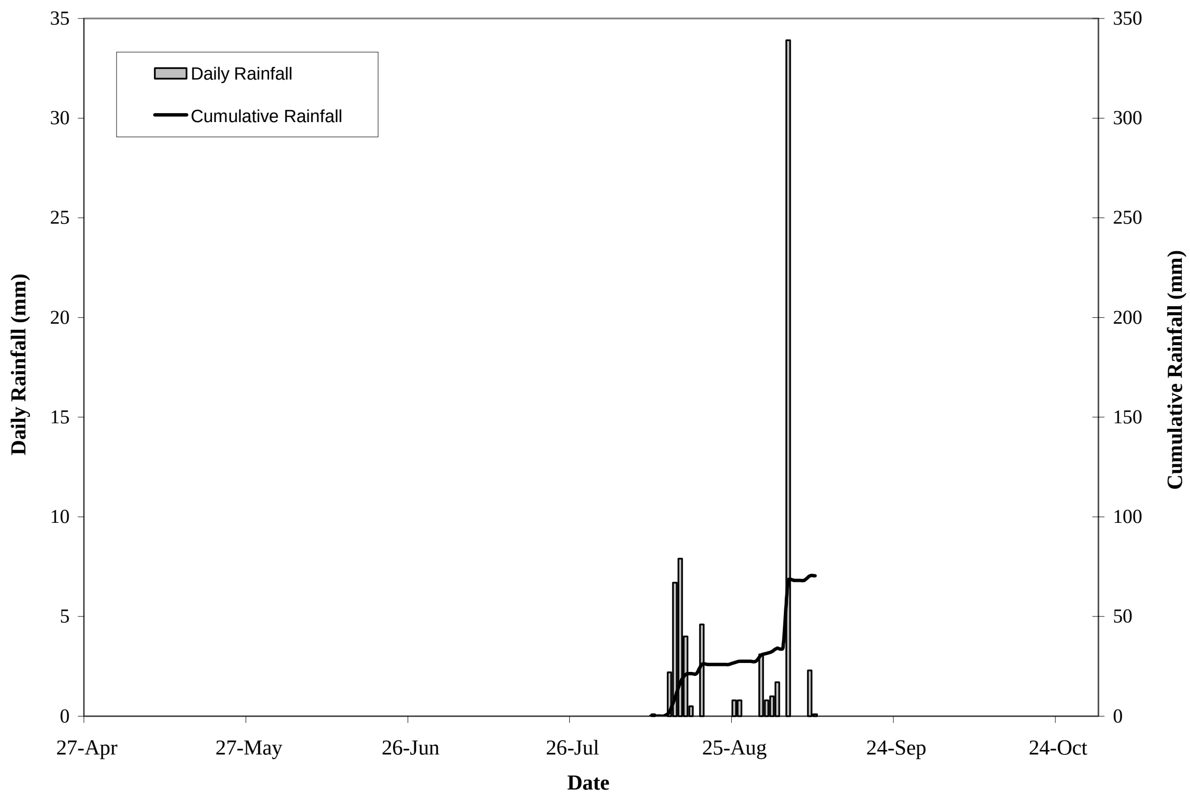


5.1.2.5 McClelland Lake Station

RAMP Station L1 is located at the outlet of McClelland Lake. A tipping bucket rain gauge was installed at the hydrologic monitoring station at this site, and each rainfall gauge tip was logged. The rain gauge was inspected during regular site visits to perform hydrologic measurements, as described in Section 5.3.

The rain gauge at this station was first installed on August 9, 2002 and operated from August 9 to September 3, 2002. The gauge was vandalized in early September and was removed for the season when this was discovered on September 11. Monthly rainfall data are presented in Table 5.3. Daily data are presented in Appendix I and the complete data set is provided in the updated RAMP Climate and Hydrology database in Appendix II. Figure 5.6 presents the daily and cumulative rainfall measured in 2002.

Figure 5.6 Daily and Cumulative Rainfall Data for RAMP Station L1 (McClelland Lake), 2002



5.1.2.6 Muskeg River Aurora Station

RAMP Station S5A is located on the Muskeg River at the Syncrude Aurora North Project. A Vaisala PTB 101B barometric sensor was installed at the hydrologic monitoring station at this site, and air pressure was recorded every 15 minutes. These readings were used to adjust readings from non-vented pressure transducers at hydrologic monitoring stations in the local area. Sensor readings were measured during remote downloads and during regular site visits to perform hydrologic measurements, as described in Section 5.3.

The barometric sensor at this station was first installed on March 16, 2002 and operated from March 16 to December 31, 2002. Prior to March 16, barometric pressure was measured by a sensor installed in a data logger at the Aurora Climate Station. That sensor failed in early 2002 and was replaced with a sensor at RAMP Station S5A to take advantage of its telemetric capability. Barometric data from the Environment Canada station at Fort McMurray Airport were used to process data from non-vented transducers for the period where no local barometric data were available. Monthly barometric data are presented in Table 5.3. Daily data are presented in Appendix I and the complete data set is provided in the updated RAMP Climate and Hydrology database in Appendix II.

5.2 SNOW COURSE SURVEY

The purpose of a snow course survey is to provide data for determining average, accumulated snow depth for a watershed during a winter as well as snow re-distribution in various terrain types. The resulting snowpack accumulation data are correlated with recorded snowfall data at a climate station to determine the snowfall undercatch correction factor and to provide accurate snowfall input to a hydrologic model for accurate model calibration and verification.

A program of snow course survey for a number of years (e.g., five years) is recommended to collect sufficient data for accomplishing the program objectives. Snow course surveys were previously undertaken in the Muskeg River basin in 1997, 1998, 1999, 2000 and 2001, in the Fort Creek basin in 2000, and on the Birch Mountains east slope basins in 2001. The 2002 program was a continuation of this systematic snow course survey program and examined the Birch Mountains east slope basins

5.2.1 Snowpack and Terrain Types

Snowpack accumulation is dependent on terrain type, which is a function of both topography and vegetation. In the Birch Mountains east slope basins, vegetation is the dominant feature dictating classification of the terrain types. The main terrain types defined for the snow course surveys undertaken from 1997 to 2002 included the following:

- flat low-lying areas (with a mix of willow and shrub vegetation);
- mixed deciduous areas (with a mix of aspen, spruce and other trees);
- open land areas (such as harvested areas with little vegetation);
- jack pine areas; and
- open lake areas.

Sixteen snow course survey plots were selected each year based on this terrain classification. Plots were identified by a visual assessment of the site.

5.2.2 Snow Course Measurements

The water equivalent of a snowpack (the equivalent depth of water if the snowpack is melted) is a product of snow depth and snow density. At each snow course survey plot, snow depths and snow densities were measured as described below.

Snow Depth Measurements

At each plot, 30 depth measurements were made at randomly selected locations on a large circle. These depth measurements were taken by inserting a sharp rebar into the snowpack, reading the snowline mark and then measuring it with a tape.

Snow Density Measurement

Three density measurements were taken at each plot, using an Atmospheric Environment Services (AES) density sampler. The AES sampler was inserted carefully into the snowpack. Snow depth was read on the tube, when the corer reached the soil surface. The corer was then inserted/twisted more deeply into the ground to get a plug of soil to prevent the granular snow falling out of the bottom of the snow profile. The tube weight was measured (with and without snow) using the spring scale. The units of the spring scale directly provided the snow water equivalent (SWE) of the snowpack in centimetres.

Additional notes were taken on vegetation cover type, colour of snow surface, and snow consistency. Appendix III presents the terrain type, snow cover information and snowpack measurement data collected on March 12 and 13, 2002. For comparison with previous snow course data, the appendix includes the data collected from 2001. No photographs of sampling locations were presented in 2001 or 2002, but photos representative of the various terrain types were provided in previous reports.

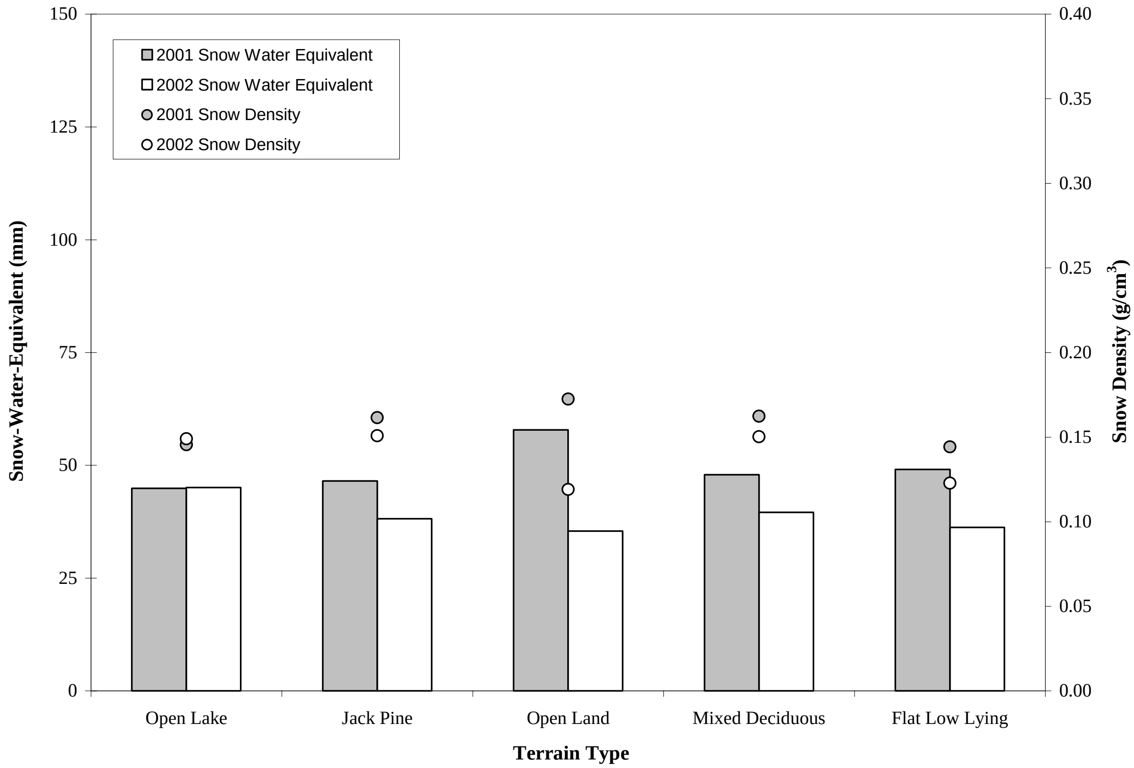
5.2.3 Snow Course Survey Results 2002

The snow course survey sampling locations for the 2001 to 2002 programs are shown on Figure 3.6. The snow course data collected for 2001 to 2002 are summarized in Table 5.4 and on Figure 5.7.

Table 5.4 Summary of 2001-2002 Birch Mountains East Slope Basins Snow Course Survey Data

Terrain Type	2001 Snow Course Survey				2002 Snow Course Survey			
	Survey Plot No.	Snow Density (g/cm^3)	Snow Depth (cm)	Snow Water Equivalent (mm)	Survey Plot No.	Snow Density (g/cm^3)	Snow Depth (cm)	Snow Water Equivalent (mm)
flat low lying	FL-01-1	0.156	34.9	54.3	FL-02-1	0.070	31.9	22.4
	FL-01-2	0.123	33.9	41.8	FL-02-2	0.159	28.0	44.7
	FL-01-3	0.158	35.2	55.8	FL-02-3	0.133	29.5	39.1
	FL-01-4	0.140	31.7	44.4	FL-02-4	0.129	30.1	38.8
	2001 Mean	**0.144**	**33.9**	**49.1**	**2002 Mean**	**0.123**	**29.9**	**36.3**
open land area	OP-01-1	0.155	36.7	57.0	OP-02-1	0.086	31.0	26.7
	OP-01-2	0.190	30.8	58.7	OP-02-2	0.152	29.1	44.2
	2001 Mean	**0.173**	**33.8**	**57.9**	**2002 Mean**	**0.119**	**30.1**	**35.5**
open lake/pond	OP-01-3	0.151	30.1	45.4	OP-02-3	0.154	28.9	44.5
	OP-01-4	0.140	31.7	44.4	OP-02-4	0.144	31.7	45.7
	2001 Mean	**0.146**	**30.9**	**44.9**	**2002 Mean**	**0.149**	**30.3**	**45.1**
mixed deciduous	MD-01-1	0.156	32.5	50.7	MD-02-1	0.122	27.1	33.2
	MD-01-2	0.183	28.5	52.2	MD-02-2	0.135	26.0	35.1
	MD-01-3	0.108	31.4	33.9	MD-02-3	0.189	23.1	43.7
	MD-01-4	0.152	32.1	48.7	MD-02-4	0.155	29.9	46.3
	MD-01-5	0.213	25.3	54.0				
	2001 Mean	**0.162**	**30.0**	**47.9**	**2002 Mean**	**0.150**	**26.5**	**39.6**
jack pine	JP-01-1	0.159	30.1	48.0	JP-02-1	0.144	26.7	38.3
	JP-01-2	0.160	31.7	50.7	JP-02-2	0.141	24.0	33.8
	JP-01-3	0.183	26.7	48.9	JP-02-3	0.175	26.0	45.5
	JP-01-4	0.144	26.7	38.5	JP-02-4	0.143	24.6	35.0
	2001 Mean	**0.162**	**28.8**	**46.5**	**2002 Mean**	**0.151**	**25.3**	**38.2**

Figure 5.7 Snow Water Equivalent and Snow Density Data of Various Terrain Types for Birch Mountains East Slope Basins Snow Course Survey, 2001-2002



The data in Table 5.4 show that the snow density is relatively consistent throughout the five different terrain types surveyed. Therefore, the relative differences of snow depths between terrain types and years are directly reflected in variations in snow water equivalent (SWE) as described below. Differences in snow accumulation appear to be much less pronounced in 2002 than in previous years, likely due to the very low snowfall during the winter of 2001-2002.

The two terrain types, jack pine and mixed deciduous, have similar snow-water-equivalent depths (46.5 and 47.9 mm in 2001; 38.2 and 39.6 mm in 2002). Forest canopies intercept a percentage of precipitation (for both rain or snow) before it reaches the ground. The interception rate is proportional to the canopy coverage. Mixed deciduous tree sites, without leaves, have a more open canopy than jack pine sites and generally have a slightly greater snow-water-equivalent.

Flat low-lying areas feature a dense shrub coverage, which has a low interception rate, yet provides a wind-sheltered, calm area that maximizes snow accumulation potential (49.1 mm in 2001; 36.3 mm in 2002).

Open lake areas generally have the smallest snow-water-equivalent depth (44.9 mm in 2001; 45.1 mm in 2002), due to the wind swept, open nature of the site.

Open land areas (clearings) have snow-water-equivalent similar to that of the forest covers (57.9 mm in 2001; 35.5 mm in 2002). The original survey design called for only one category of open area. However, the past survey results indicated that open land and open lake sites have distinctly different snow accumulations. Interception at the two sites is zero and the difference between the sites is likely due to differences in wind exposure.

5.3 HYDROLOGIC MONITORING

5.3.1 Descriptions of Stations

Hydrologic monitoring included the collection of streamflow, TSS and lake water level data. The streamflow monitoring stations included in this program are named S1 to S32 and the lake level monitoring stations are named L1 to L3. The stations at Susan Lake Outlet (S25), Mackay River (S26), Firebag River (S27) and Christina River (S29) were installed and commenced operation as part of the 2002 program. The monitoring stations at Hangingstone River (S30), Hangingstone Creek (S31) and Surmont Creek (S32) were previously installed for the Petro-Canada Meadow Creek EIA Baseline Study and were incorporated into RAMP in 2002. The monitoring station at Blackfly Creek (S4) was inactive in 2002. Table 5.5 summarizes the pertinent details of the hydrologic monitoring stations included in the 2002 program. Additional information for stations first incorporated into RAMP in 2002, including photographs and descriptions of equipment, is provided on Factsheets in Appendix IV.

Table 5.5 Details of Hydrologic Monitoring Stations

Station No.	Stream Name	Station Location		Basin Area (km^2)	Period of Record
		Latitude (N)	Longitude (W)		
S1	Alsands Drain	57° 15' 12"	111° 29' 52"	15.8	1995 – 2002
S2[(a)]	Jackpine Creek	57° 14' 21"	111° 24' 53"	358	1995 – 2002
S3	Iyinimin Creek	57° 15' 00"	111° 10' 27"	24.5	1995 – 1999; 2001 – 2002
S4	Blackfly Creek	57° 12' 20"	111° 15' 22"	38.2	1995 – 1998
S5A[(b)]	Muskeg River Aurora	57° 18' 30"	111° 23' 43"	552	1995 – 2002
S6	Mills Creek	57° 14' 44"	111° 35' 57"	23.8	1997 – 2002
S7	Muskeg River WSC	57° 11' 29"	111° 34' 10"	1,460	1975 – 2002
S8	Stanley Creek	57° 21' 06"	111° 22' 26"	71.8	1999 – 2002
S9	Kearl Lake Outlet	57° 15' 57"	111° 15' 57"	73.6	1998 – 1999; 2001 – 2002
S10	Wapasu Creek	57° 20' 35"	111° 09' 40"	90.7	1997 – 1999; 2001 – 2002
S11	Poplar Creek	56° 54' 46"	111° 27' 44"	422	1995 – 2002
S12	Fort Creek	57° 24' 48"	111° 37' 18"	35.5	2000 – 2002
S13	Albian Pond #3	57° 14' 47"	111° 30' 58"	disturbed	2000 – 2002
S14	Ells River	57° 17' 10"	111° 42' 30"	2,450	2001 – 2002
S15	Tar River	57° 21' 12"	111° 45' 25"	301	2001 – 2002
S16	Calumet River	57° 23' 46"	111° 41' 47"	182	2001 – 2002
S17	Upland Tar River	57° 21' 35"	111° 55' 22"	13.8	2001 – 2002
S18A[(c)]	Upland Calumet River	57° 26' 40"	111° 47' 17"	48	2001 – 2002
S19	Lowland Tar River	57° 19' 00"	111° 42' 30"	11.5	2001 – 2002
S20	Upland Muskeg	57° 20' 09"	111° 07' 48"	157	2001 – 2002
S21	Shelley Creek	57° 16' 26"	111° 23' 28"	16	2001 – 2002
S22	Muskeg Creek	57° 16' 56"	111° 18' 52"	345	2001 – 2002
S23	Aurora Boundary Weir	57° 17' 30"	111° 29' 33"	disturbed	2001 – 2002
S24	Athabasca River	57° 29' 46"	111° 33' 43"	146,000	2001 – 2002
S25	Susan Lake Outlet	57° 27' 28"	111° 35' 31"	13.6	2002
S26	Mackay River WSC	57° 12' 39"	111° 41' 41"	5,570	2002
S27	Firebag River WSC	57° 38' 26"	111° 11' 22"	5,990	2002
S28	Khahago Creek	57° 13' 21"	111° 19' 23"	212	2001 – 2002
S29	Christina River WSC	56° 26' 30"	111° 05' 10"	4,860	2002
S30	Hangingstone River	56° 25' 04"	111° 22' 26"	520	2001 – 2002
S31	Hangingstone Creek	56° 16' 07"	111° 29' 21"	160	2001 – 2002
S32	Surmont Creek	56° 26' 06"	111° 09' 29"	158	2000 – 2002
L1	McClelland Lake	57° 29' 30"	111° 16' 37"	191	1997 – 2002
L2	Kearl Lake	57° 18' 15"	111° 14' 40"	72.6	1999 – 2002
L3	Isadore's Lake	57° 13' 15"	111° 36' 24"	28.0	2000 – 2002

(a) Relocated in 2000.
(b) Relocated in 1998.
(c) Relocated in 2002.

5.3.2 Streamflow Measurements and Monitoring

5.3.2.1 Summary

This section describes routine monitoring and non-routine installation and maintenance of climatic and hydrologic monitoring equipment. It includes installation of new equipment and maintenance or replacement of damaged equipment. It summarizes work performed in 2002 and recommended for 2003, on a station-by-station basis. Station survey dates and hydrograph continuous record dates are summarized in Table 5.6.

Manual measurements of stream discharges were performed at intervals over the winter (January to March and November to December), spring snowmelt (April) and summer months (May to October) as part of the 2002 program. The water levels at these streamflow stations were continuously monitored by pressure transducers and recorded by data loggers over the summer months in 2002. The continuous monitoring period was extended in winter at several stations where freezing to the streambed was unlikely. Appendix V presents a summary table of manual discharge measurements and the detailed calculation sheets for measurements performed in 2002.

Manual discharge measurements from the 2002 program and previous years were used to develop stage-discharge rating curves for the streamflow monitoring stations. These rating curves were used to derive discharges from the continuous record of water level measurements. The resulting stage-discharge rating curves are presented in Appendix VI. Appendix VII contains recorded daily water levels and derived stream discharges. A database containing the detailed raw and processed, water level and stream discharge data is stored on a compact disc in Appendix II.

Table 5.6 Station Survey Dates and Continuous Hydrometric Record Dates

Station No.	Stream Name	Dates Visited in 2002	Continuous Hydrograph Record in 2002
S1	Alsands Drain	January 11, February 7, March 15, April 9 and 24, June 9	January 1 to December 31
S2	Jackpine Creek	January 16, April 8 and 23, May 14, June 11, July 11, August 11, September 13 and October 25	April 28 to October 25
S3	Iyinimin Creek	April 28, May 16, June 10, August 9, September 12 and October 26	June 10 to October 19 and from October 23 to October 26
S4	Blackfly Creek	Not operational from 2000 to 2002	Not operational from 2000 to 2002
S5A	Muskeg River Aurora	January 12, February 8 and 24, March 15, April 9 and 25, May 14, October 25 and November 28. Also visited January 7, 2003.	January 1 to December 31

Table 5.6 Station Survey Dates and Continuous Hydrometric Record Dates (continued)

Station No.	Stream Name	Dates Visited in 2002	Continuous Hydrograph Record in 2002
S6	Mills Creek	January 15, March 13, April 9 and 23, May 14, June 9, July 8, August 10 and October 21.	April 11 to October 21
S7	Muskeg River WSC	January 10, February 6, March 15, April 8 and 23, May 14, October 25. Also visited January 7, 2003.	January 1 to December 31
S8	Stanley Creek	April 28, May 16, August 9 and October 26	April 28 to July 23 and from August 9 to October 26
S9	Kearl Lake Outlet	April 8, 23 and 25, May 15, June 9, July 11, August 11, September 13 and October 25.	June 9 to October 25
S10	Wapasu Creek	April 8 and 23, May 15 and 17, June 9, July 11 and 31, August 11 and October 25	April 23 to May 6, May 16 to 17, May 19 to 20 and from July 31 to October 18.
S11	Poplar Creek	April 10 and 23, May 18, June 13, July 9, August 11 and October 29.	April 23 to October 15 except for periods on August 12, 14 and 15.
S12	Fort Creek	April 9 and 25, May 14, June 9, July 8, August 10 and October 23.	June 9 to October 23.
S13	Albian Pond #3	January 11, April 9 and 24, June 9 and August 8	January 1 to December 31
S14	Ells River	April 28, May 16, July 10, August 9, September 12 and October 27	April 28 to October 20
S15	Tar River	January 11, April 11 and 24, May 16, June 13, July 8 and 9, August 11, September 12 and October 21.	May 1 to October 16
S16	Calumet River	January 14, February 25, April 28, May 16, July 10, August 9, September 12 and October 27.	May 16 to October 27
S17	Upland Tar River	April 28, May 16, September 12 and October 27.	May 16 to October 15
S18A	Upland Calumet River	April 28, May 16, June 10, August 9, September 12 and October 27.	September 12 to October 17
S19	Lowland Tar River	April 11 and 24, May 18, June 13, July 8, August 10, September 11 and October 21.	April 24 to October 21
S20	Upland Muskeg River	April 8, 23 and 25, May 15, June 9, July 11, August 11, September 14 and October 25.	April 25 to June 9
S21	Shelley Creek	April 28, May 16, June 10, July 11, August 9 and October 26.	May 16 to October 23
S22	Muskeg Creek	January 11, April 8 and 23, May 15 and 17, June 9, July 9 and 11, August 11, September 13 and October 25.	May 18 to June 9 and from July 10 to October 17
S23	Aurora Boundary Weir	January 12, February 8 and 24, March 15, April 9 and 25, May 14, June 9 and October 21.	January 1 to December 31
S24	Athabasca River	February 5, March 22, May 31 and September 11.	January 1 to December 31
S25	Susan Lake Outlet	June 11, August 10 and 19, September 11 and October 18.	August 19 to October 18
S26	Mackay River WSC	January 15, February 8, March 18, April 11 and 24, May 16 and October 24. Also visited January 8, 2003.	January 1 to January 8, 2003
S27	Firebag River WSC	January 14, February 7, March 16, April 28, May 14 and October 23. Also visited January 7, 2003.	January 1 to January 7, 2003

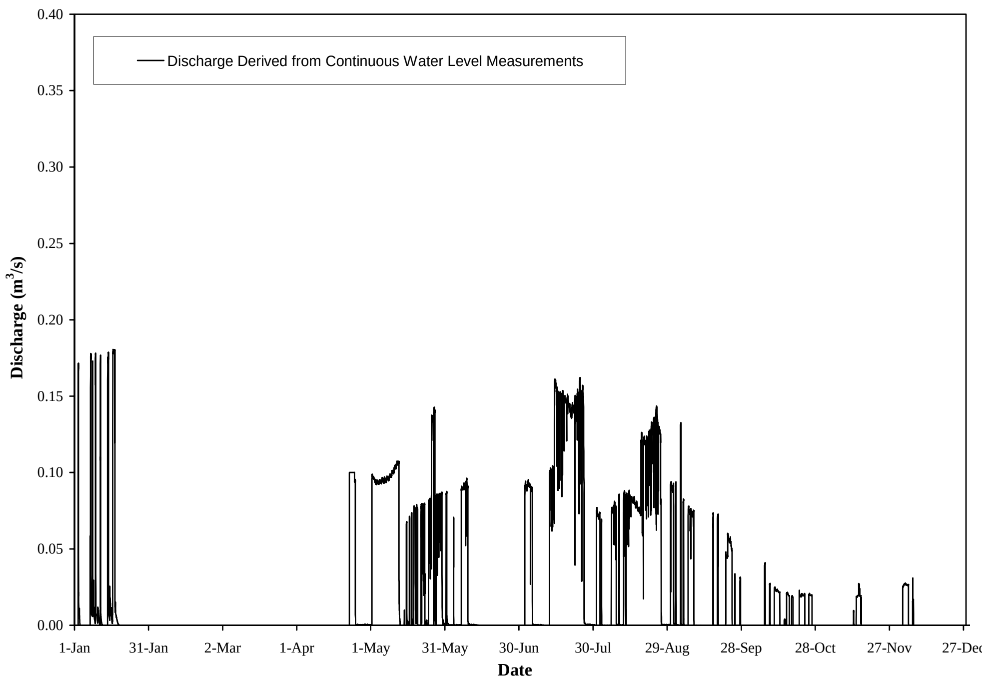
Table 5.6 Station Survey Dates and Continuous Hydrometric Record Dates (continued)

Station No.	Stream Name	Dates Visited in 2002	Continuous Hydrograph Record in 2002
S28	Khahago Creek	April 28, May 16, July 10, August 9, September 12 and October 26.	May 17 to October 26
S29	Christina River WSC	January 13, February 4, March 17, April 10, May 13, September 11 and October 22. Also visited January 6, 2003.	February 4 to June 18, July 25 to August 27 and from October 27 to January 6, 2003
S30	Hangingstone River	April 10 and 22, May 13, June 8, July 8 and 9, August 7 and October 22.	July 9 to October 21
S31	Hangingstone Creek	April 10 and 22, May 13, June 8, July 8, August 7 and October 22.	April 10 to October 15
S32	Surmont Creek	April 10, 22 and 29, May 13 and 18, June 8, July 8, August 7 and October 22.	May 18 to October 22
L1	McClelland Lake	January 14, April 28, May 16, June 8, July 10, august 9 and September 12.	April 28 to December 31
L2	Kearl Lake	January 11, February 7, March 13, April 8 and 23, May 15, June 9, July 11, August 11, September 13 and October 25.	January 1 to March 27, from April 9 to May 10 and from May 17 to December 31
L3	Isadore's Lake	January 11, April 28, August 8, October 27 and 29.	January 1 to August 8 and October 27 to December 31

5.3.2.2 Alsands Drain Streamflow Monitoring Station (S1)

The recorded hydrograph for this station is presented on Figure 5.8. No water levels were recorded between February 24 and April 24, but observations by Golder and Albian Sands personnel indicate that there were no discharges during this period. A frost-damaged pressure transducer was replaced on April 24, 2002. On October 25, 2002, Albian Sands informed Golder that Albian would take over operation of this station and would leave the transducer in for the winter.

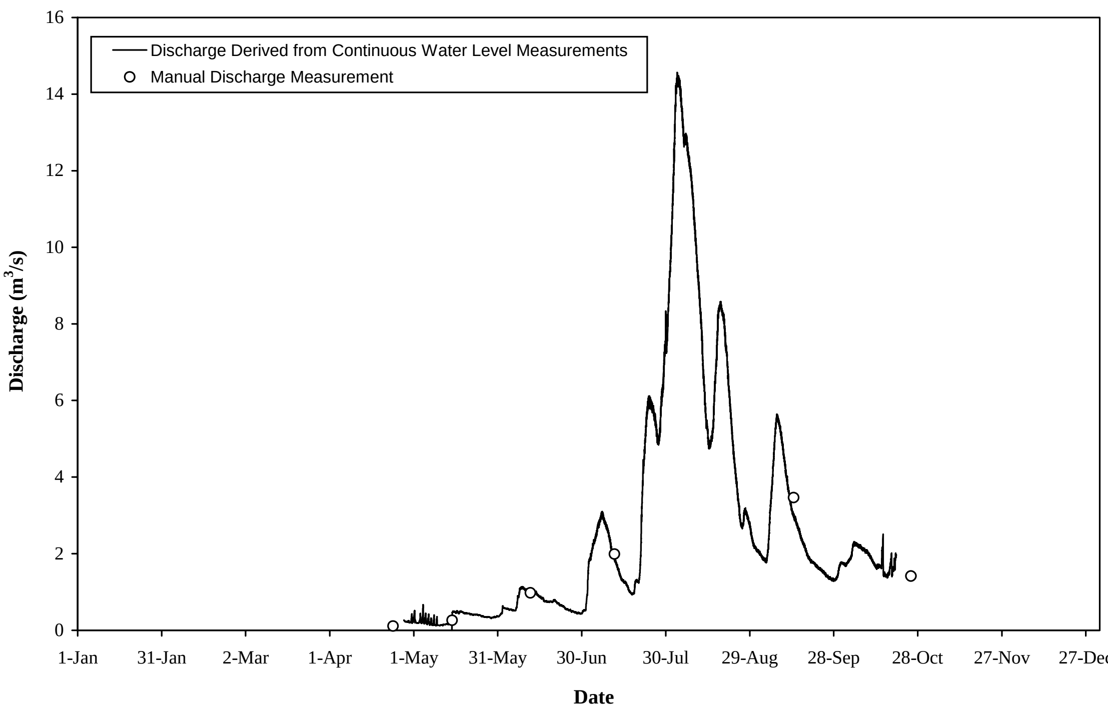
Figure 5.8 2002 Discharge Hydrograph at Alsands Drain Station (S1)



5.3.2.3 Jackpine Creek Streamflow Monitoring Station (S2)

The recorded hydrograph for this station is presented on Figure 5.9. The pressure transducer and data logger were installed at the station from April 8 to October 25, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until April 28 and after October 20. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

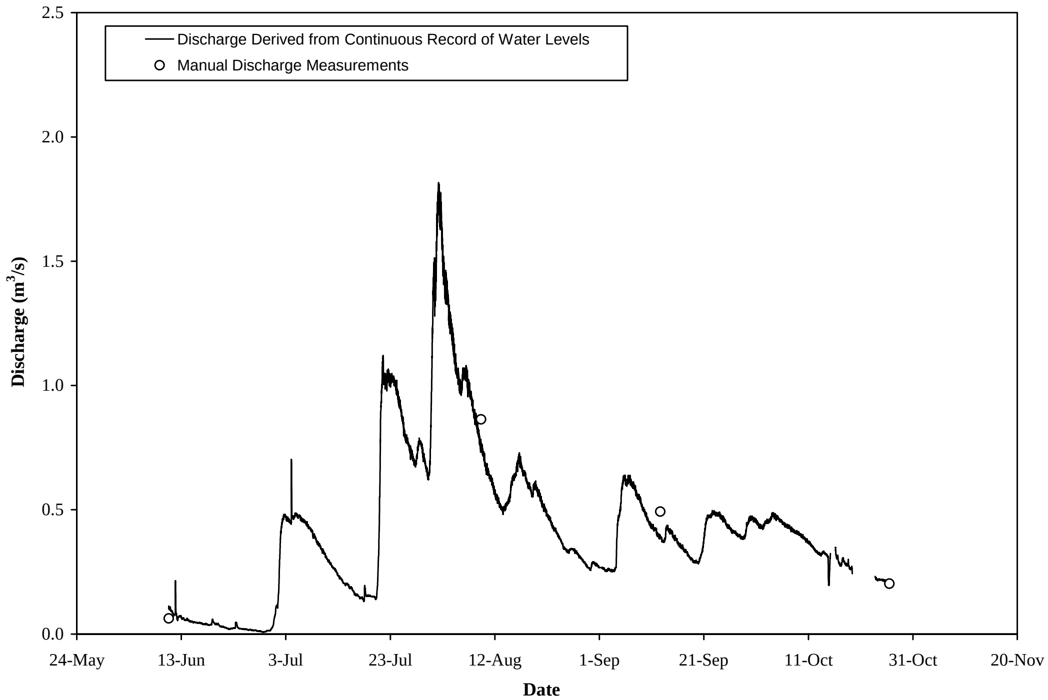
Figure 5.9 2002 Discharge Hydrograph at Jackpine Creek Station (S2)



5.3.2.4 Iyinimin Creek Streamflow Monitoring Station (S3)

The recorded hydrograph for this station is presented on Figure 5.10. The pressure transducer and data logger were installed at the station from April 28 to October 26, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until June 10, from October 20 to October 22, and after October 26. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

Figure 5.10 2002 Discharge Hydrograph at Iyinimin Creek Station (S3)



During the field visit on September 12, 2002, the tipping bucket rain gauge was found to have been bent off its axis by human or animal interference. The rain gauge was not functioning properly because of this disturbance. This problem was remedied in the field and the rain gauge resumed operation.

5.3.2.5 Blackfly Creek Streamflow Monitoring Station (S4)

This hydrometric monitoring station was not operated from 2000 to 2002. The decision to discontinue operation was based on its location in the Aurora South Lease area. It is recommended that the station be reinstalled three to five years before development commences in the Aurora South Lease. When the station is reinstalled, it may be necessary to remove several beaver dams or relocate the gauge upstream or downstream of the current site.

5.3.2.6 Muskeg River Aurora Streamflow Monitoring Station (S5A)

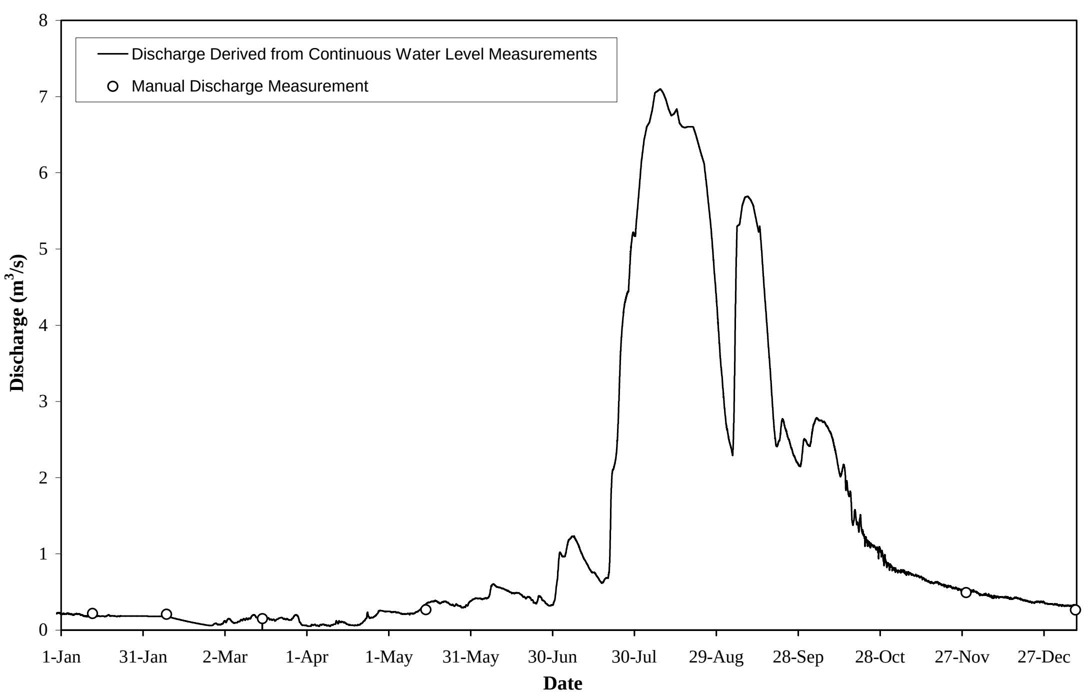
The recorded hydrograph for this station is presented on Figure 5.11. This station operates year-round since flow is sustained over the winter months.

A new Data Dolphin data logger with telemetry capability was installed at this station on January 15, 2002. This was done to satisfy monthly reporting requirements for Syncrude.

A Vaisala PTB101B barometer was installed at this station on March 16, 2002. This unit was a replacement for the failed barometer that had previously operated at the Aurora Climate Station. It was installed at this station to take advantage of the telemetric capability of the data logger.

On October 21, 2002, the 3 psi pressure transducer at this station was removed and replaced with a 5 psi transducer, to prevent future overpressure events as experienced in 2002.

Figure 5.11 2002 Discharge Hydrograph at Muskeg River Aurora Station (S5A)

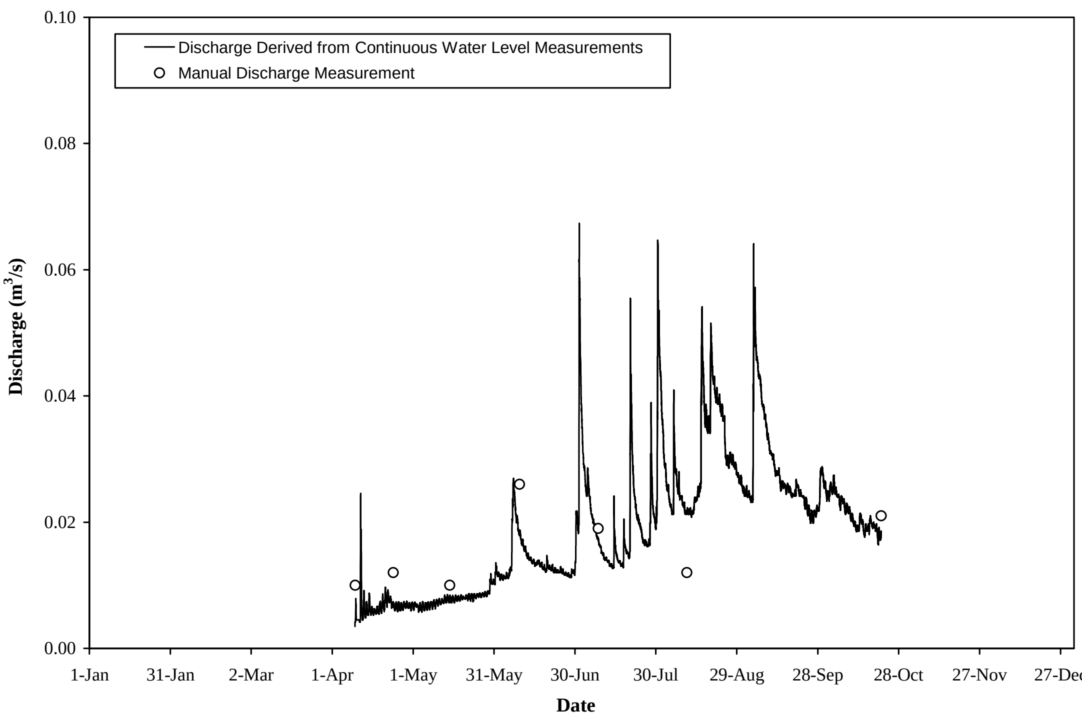


5.3.2.7 Mills Creek Streamflow Monitoring Station (S6)

The recorded hydrograph for this station is presented on Figure 5.12. The pressure transducer and data logger were installed at the station from April 9 to October 21, 2002. However, no data were collected on April 10. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage.

The existing weir at Mills Creek Station has deteriorated since it was installed in 1998, primarily due to frost jacking and exposure to freeze-thaw cycles. It is recommended that the weir be replaced with a new structure, similar to that installed at the Alsands Drain (S1) and Albian Pond #3 (S13), with a service life of at least 20 years. Mine development in this area means that monitoring of this station is likely to be required for several decades.

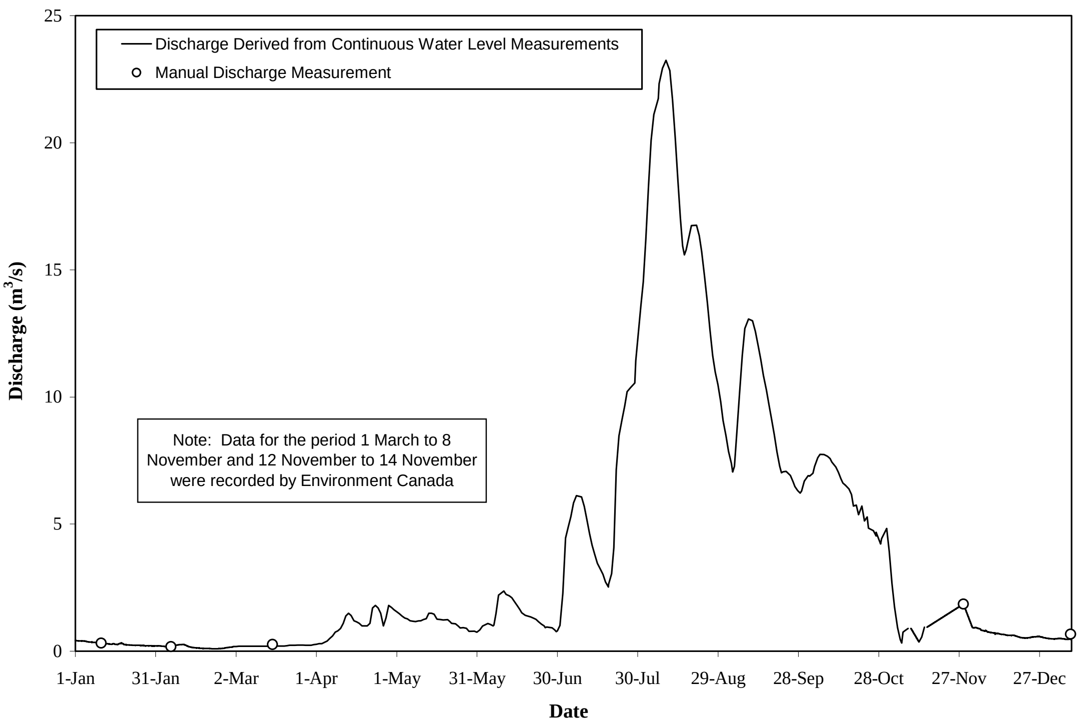
Figure 5.12 2002 Discharge Hydrograph at Mills Creek Station (S6)



5.3.2.8 Muskeg River WSC Streamflow Monitoring Station (S7)

The recorded hydrograph for this station is presented on Figure 5.13. This station operates as a RAMP station during ice-covered conditions only. Data for the period March 1 to November 8 and November 12 to November 14 were provided by Environment Canada, which operates monitoring station 07DA008 at this location.

Figure 5.13 2002 Discharge Hydrograph at Muskeg River WSC Station (S7)

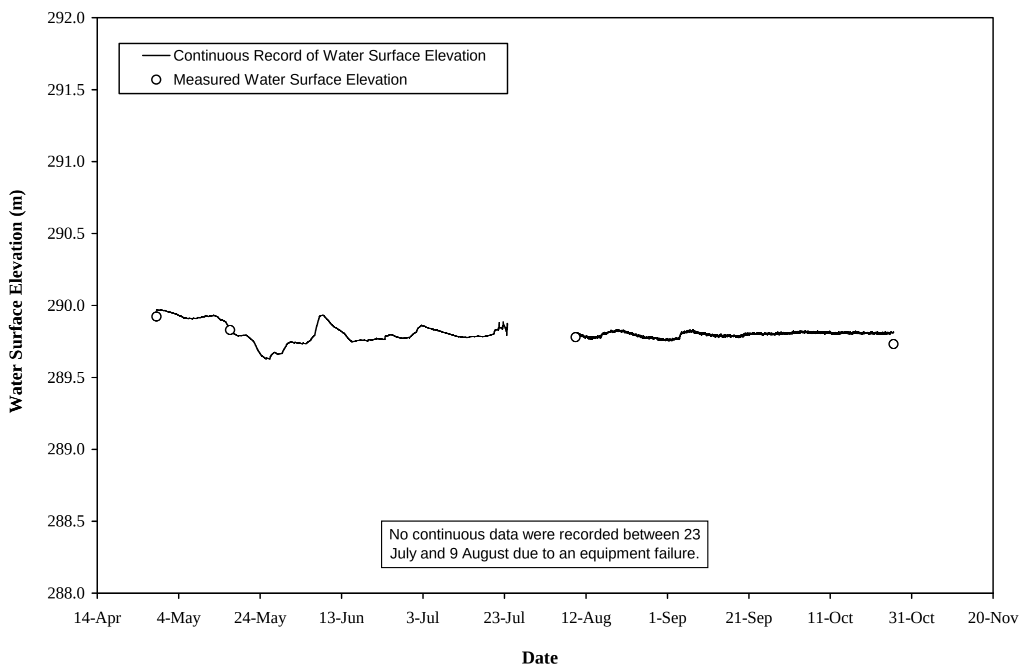


5.3.2.9 Stanley Creek Streamflow Monitoring Station (S8)

The recorded hydrograph for this station is presented on Figure 5.14. The data gap from July 23 to August 9 was due to failure of the data logger at this station. The monitoring equipment installed at this station was found to have sustained water damage on August 9, 2002. It was immediately replaced with a spare non-vented transducer and data logger and the damaged equipment was retrieved for repairs.

As in 1999 and 2000, only water levels were monitored at this station. The station is at a site where the muskeg area narrows to less than 100 m, but the channel is ill-defined and it is not possible to traverse the wet ground on foot. The ill-defined channel does not permit accurate discharge measurements.

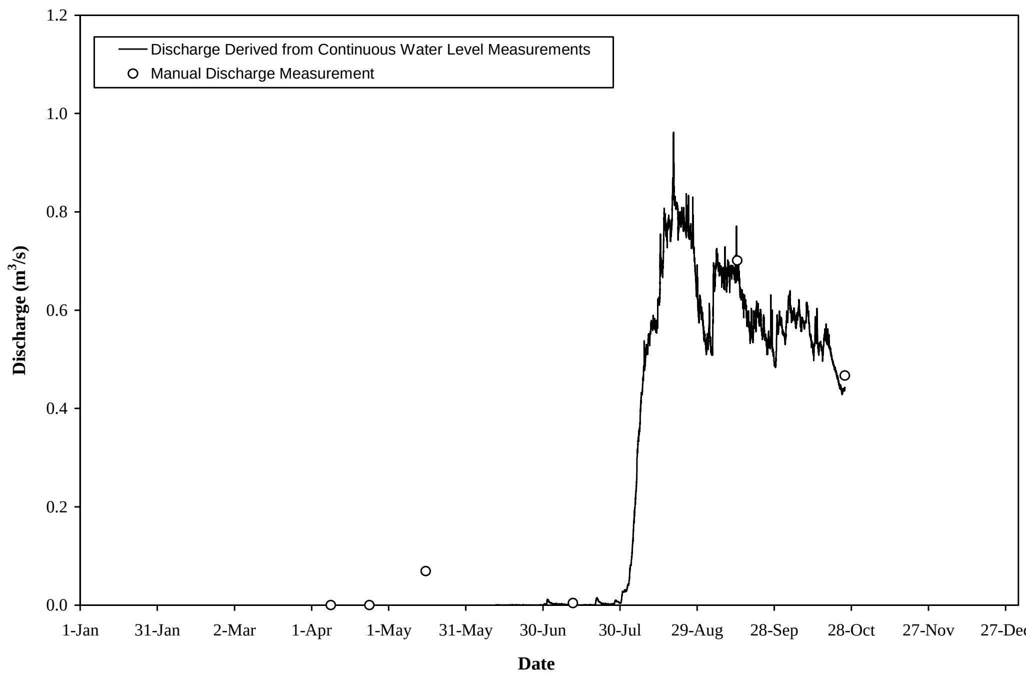
Figure 5.14 2002 Water Level Hydrograph at Stanley Creek Station (S8)



5.3.2.10 Kearl Lake Outlet Streamflow Monitoring Station (S9)

The recorded hydrograph for this station is presented on Figure 5.15. The pressure transducer and data logger were installed at the station from May 15 to October 25, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until June 9 and after October 25. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

Figure 5.15 2002 Discharge Hydrograph at Kearl Lake Outlet Station (S9)

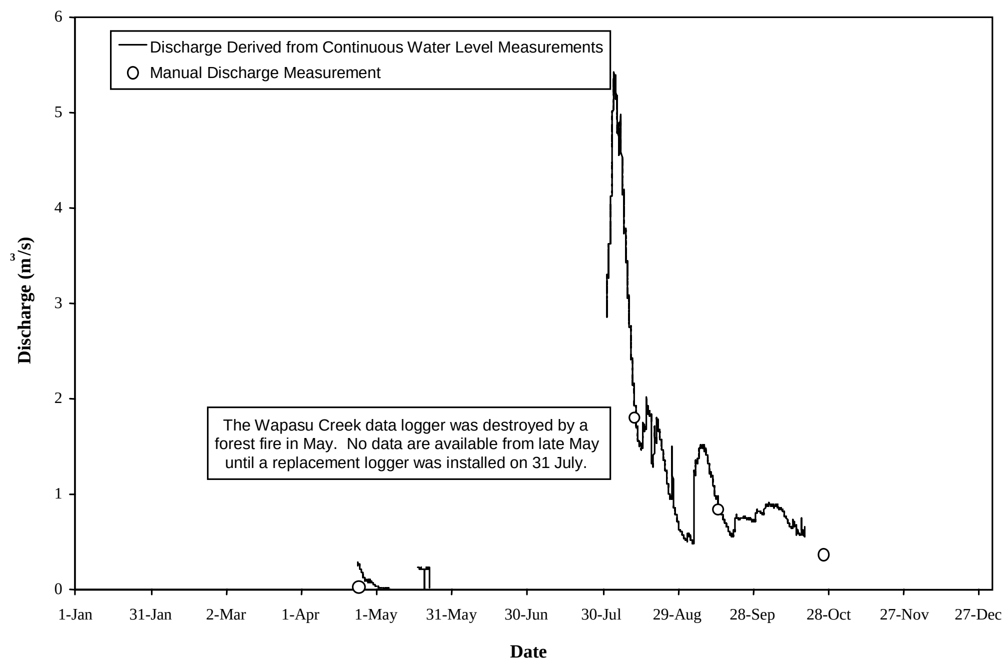


5.3.2.11 Wapasu Creek Streamflow Monitoring Station (S10)

The recorded hydrograph for this station is presented on Figure 5.16. The pressure transducer and data logger were installed at the station from April 8 to October 25, 2002. Data gaps in May were due to failure of the pressure transducer at the station. On June 9, 2002, the Lakewood data logger at this station was found to be malfunctioning and it was replaced with a spare unit. On July 11, 2002, the replacement data logger and pressure transducer cable were found to have been destroyed by a forest fire. The data logger was sent to the manufacturer to see if any data could be recovered, but none were salvaged. The pressure transducer was sent to the manufacturer for repair. On July 31, 2002, a replacement data logger and pressure transducer were installed at the station.

Ice conditions in the creek prevented reliable discharges from being derived after October 20. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

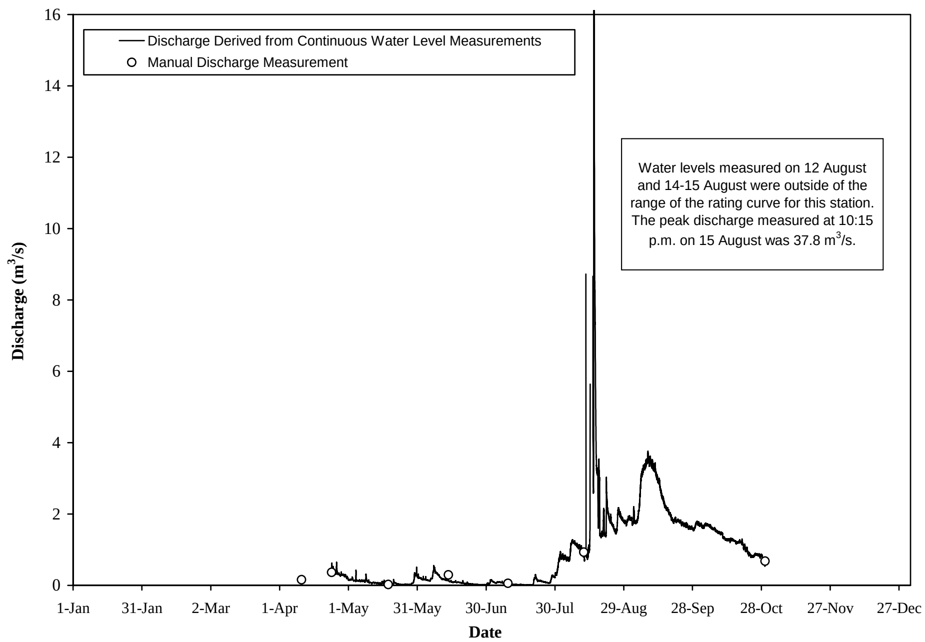
Figure 5.16 2002 Discharge Hydrograph at Wapasu Creek Station (S10)



5.3.2.12 Poplar Creek Streamflow Monitoring Station (S11)

The recorded hydrograph for this station is presented on Figure 5.17. The pressure transducer and data logger were installed at the station from April 10 to October 25, 2002. During these periods, very high water levels were recorded and the resulting values were well above the range of the stage-discharge rating curve for this station. Ice conditions in the creek prevented reliable discharges from being derived before April 23 and after October 15. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

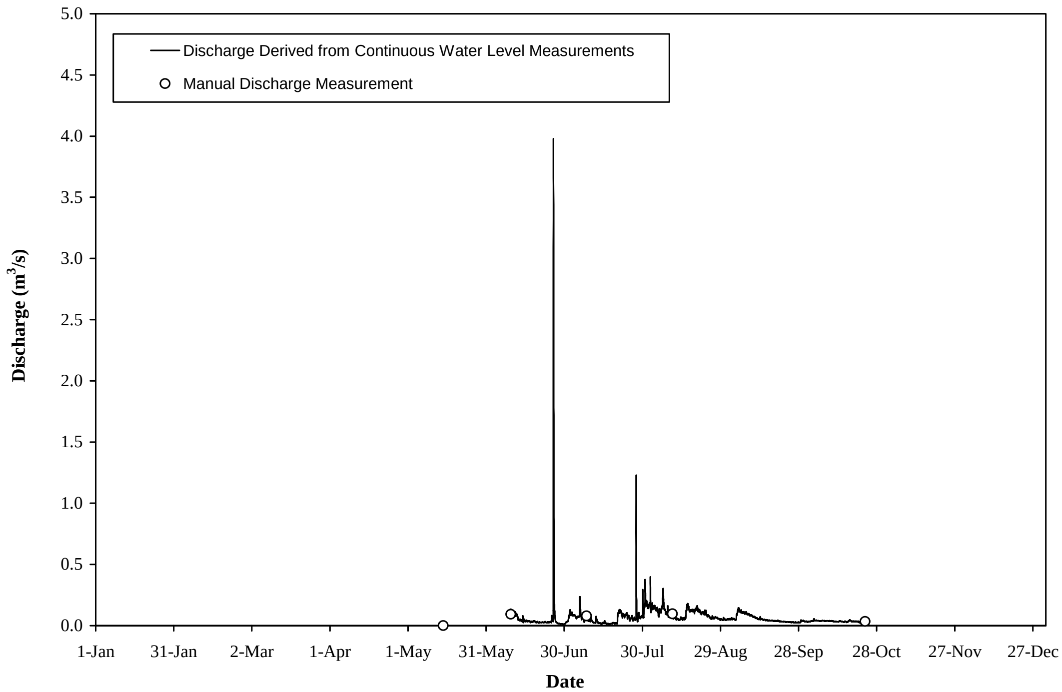
Figure 5.17 2002 Discharge Hydrograph at Poplar Creek Station (S11)



5.3.2.13 Fort Creek Streamflow Monitoring Station (S12)

The recorded hydrograph for this station is presented on Figure 5.18. The pressure transducer and data logger were removed from this site in late fall 2001 to prevent ice damage, as it was expected that the creek would freeze solid over the winter. Due to accumulations of snow and ice in the creek, it was not possible to reinstall the monitoring equipment until early June. The monitoring equipment was removed again in the late fall of 2002.

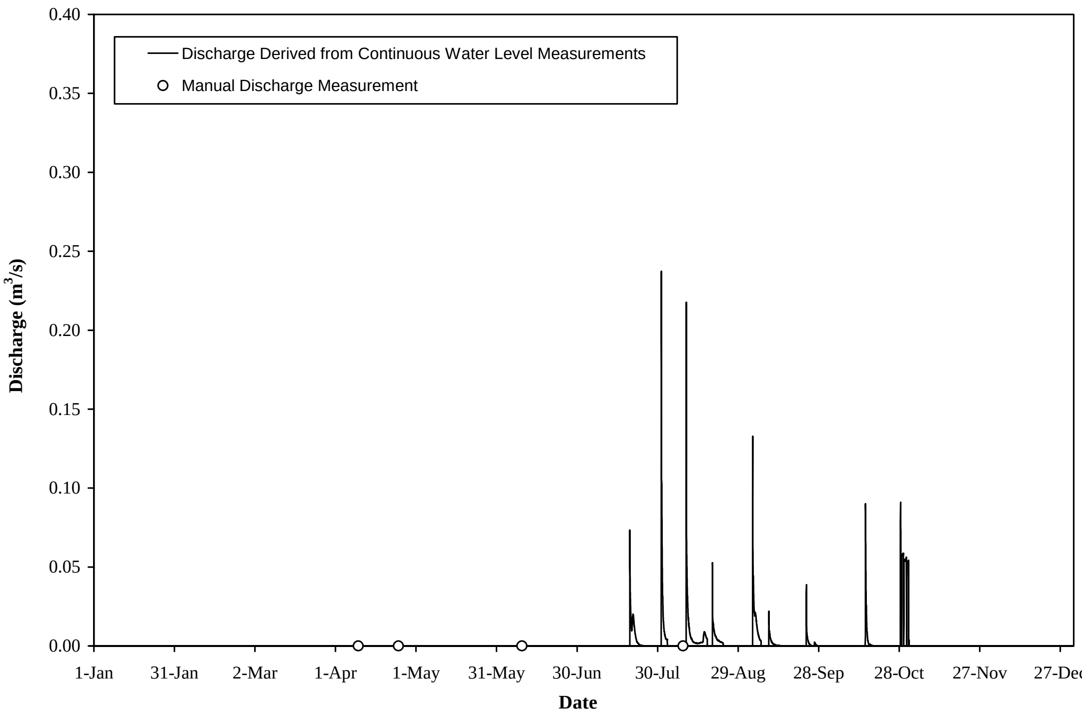
Figure 5.18 2002 Discharge Hydrograph at Fort Creek Station (S12)



5.3.2.14 Albian Pond #3 Streamflow Monitoring Station (S13)

The recorded hydrograph for this station is presented on Figure 5.19. No water levels were recorded before April 29 or after December 7, 2002, but observations by Golder and Albian Sands personnel indicate that there were no discharges during this period. On October 25, 2002, Albian Sands informed Golder that Albian would take over operation of this station and would leave the transducer in for the winter.

Figure 5.19 2002 Discharge Hydrograph at Albian Pond #3 Station (S13)

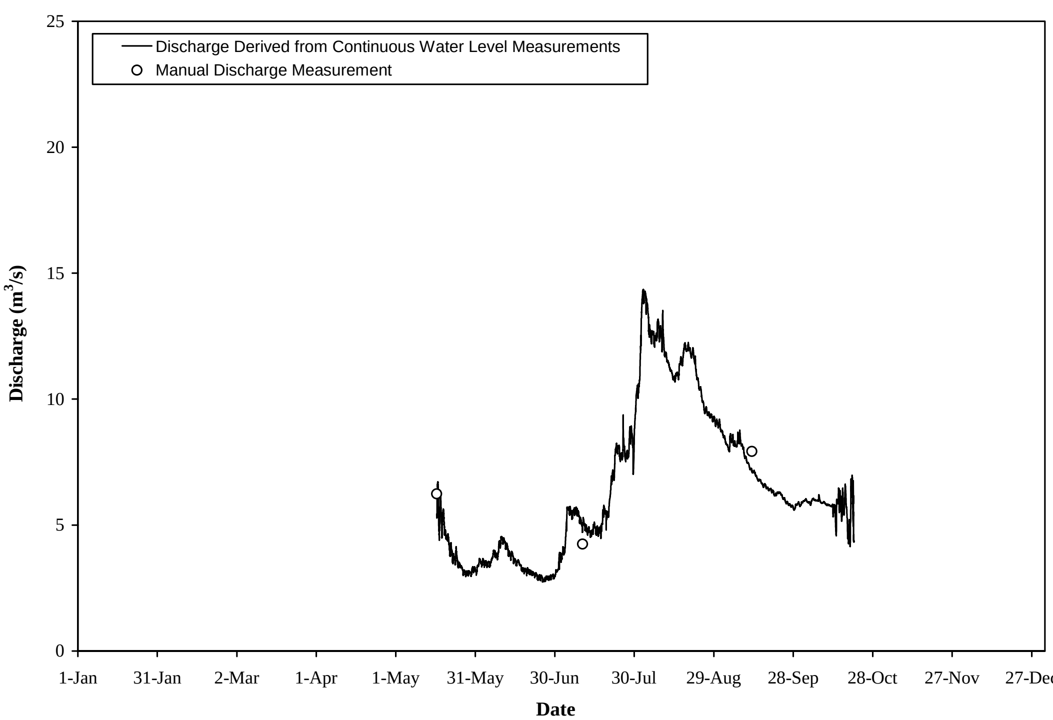


5.3.2.15 Ells River Streamflow Monitoring Station (S14)

The recorded hydrograph for this station is presented on Figure 5.20. The pressure transducer and data logger were installed at the station from April 28 to October 27, 2002. However, ice conditions in the creek prevented reliable discharges from being derived after October 20. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys. On August 9, 2002, the data logger and modem were exchanged for new ones to repair a telemetry problem. No data were lost.

Figure 5.20 2002 Discharge Hydrograph at Ells River Station (S14)

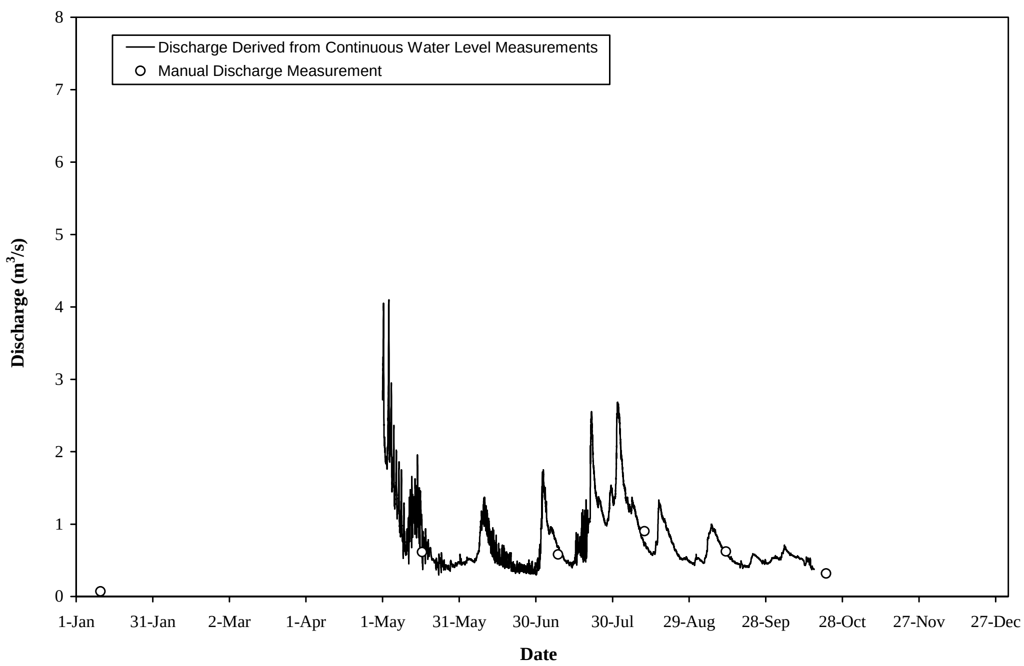


5.3.2.16 Tar River Streamflow Monitoring Station (S15)

The recorded hydrograph for this station is presented on Figure 5.21. The pressure transducer and data logger were installed at the station from April 24 to October 25, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until April 28 and after October 16. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys. On April 11, 2002, a new solar panel and antenna were installed at this station to replace those that were stolen over the winter. On July 9, 2002, the antenna was reinstalled at a higher elevation to provide better telemetry performance. On August 10, 2002, the data logger and modem were exchanged for new ones to repair a telemetry problem. A lightning arrestor was installed on the antenna cable.

Figure 5.21 2002 Discharge Hydrograph at Tar River Station (S15)

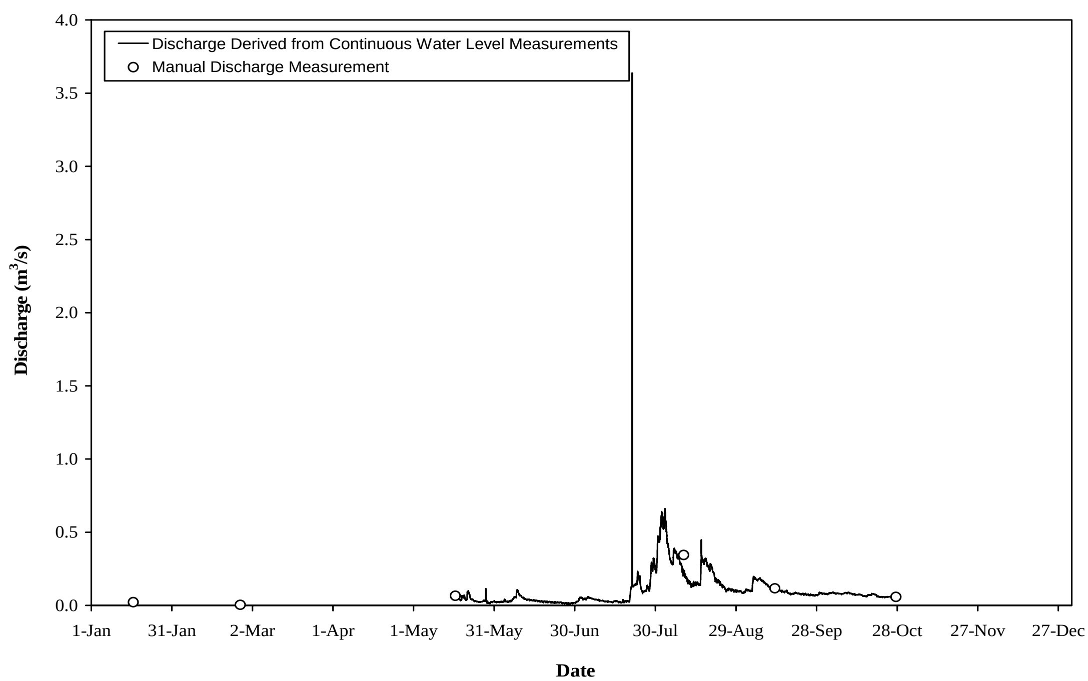


5.3.2.17 Calumet River Streamflow Monitoring Station (S16)

The recorded hydrograph for this station is presented on Figure 5.22. The pressure transducer and data logger were installed at the station from April 28 to October 27, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until May 16. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys. On September 12, 2002, a small beaver dam was removed by hand from approximately 100 m upstream of the gauging station.

Figure 5.22 2002 Discharge Hydrograph at Calumet River Station (S16)

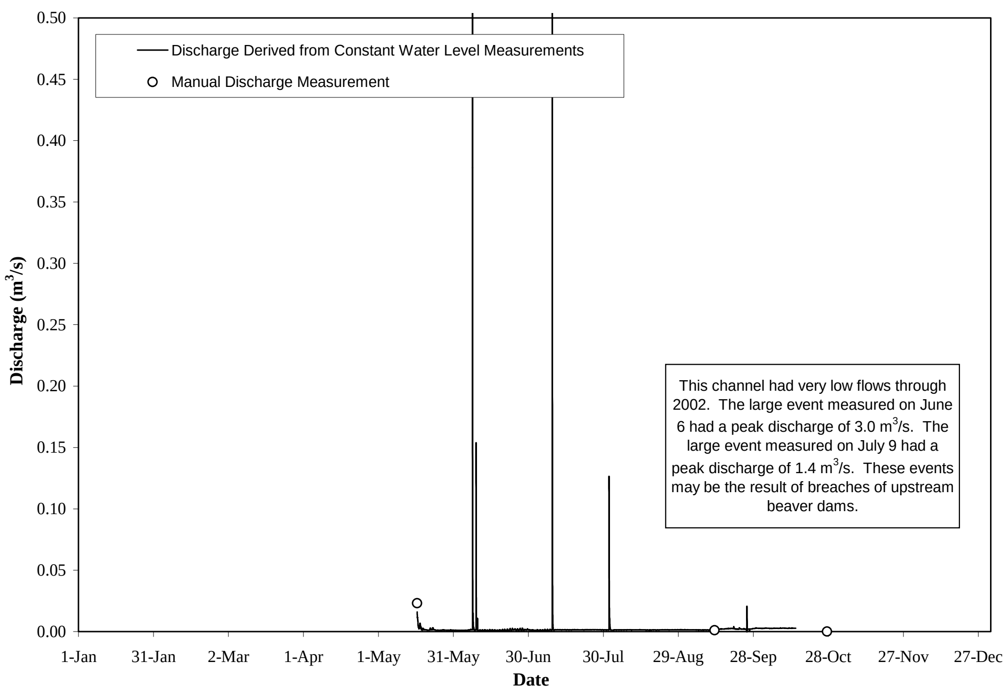


5.3.2.18 Upland Tar River Streamflow Monitoring Station (S17)

The recorded hydrograph for this station is presented on Figure 5.23. The pressure transducer and data logger were installed at the station from April 28 to October 27, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until May 16 and after October 20. The two large discharge events recorded at this station in 2002 appear to be real and may be the result of upstream beaver dam failures. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys.

Figure 5.23 2002 Discharge Hydrograph at Upland Tar River Station (S17)

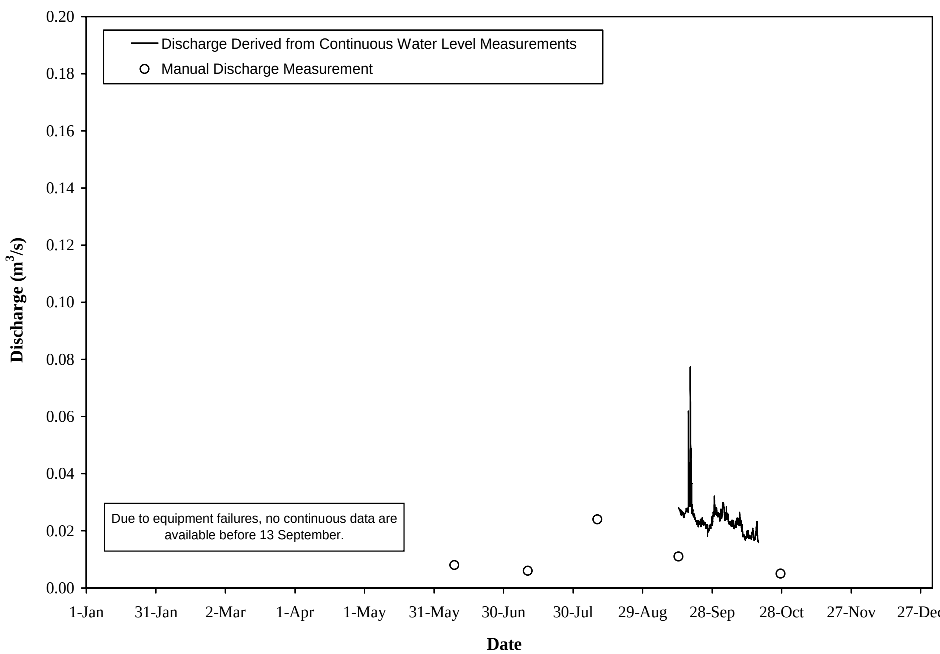


5.3.2.19 Upland Calumet River Streamflow Monitoring Station (S18A)

The recorded hydrograph for this station is presented on Figure 5.24. The pressure transducer and data logger were installed at this site during the June 10 visit, after a site reconnaissance confirmed this location, and were present at the station until October 27, 2002. However, a pressure transducer failure prevented continuous data from being collected before September 12, and ice conditions in the creek prevented reliable discharges from being derived after October 17.

This station was reinstalled at a new location on June 10, 2002 because the 2001 location was flooded by a beaver dam. A temporary installation, with no excavation, was used. Should this location prove adequate, the site will need to be permitted by Alberta Environment before a permanent installation is completed.

Figure 5.24 2002 Discharge Hydrograph at Upland Calumet River Station (S18A)

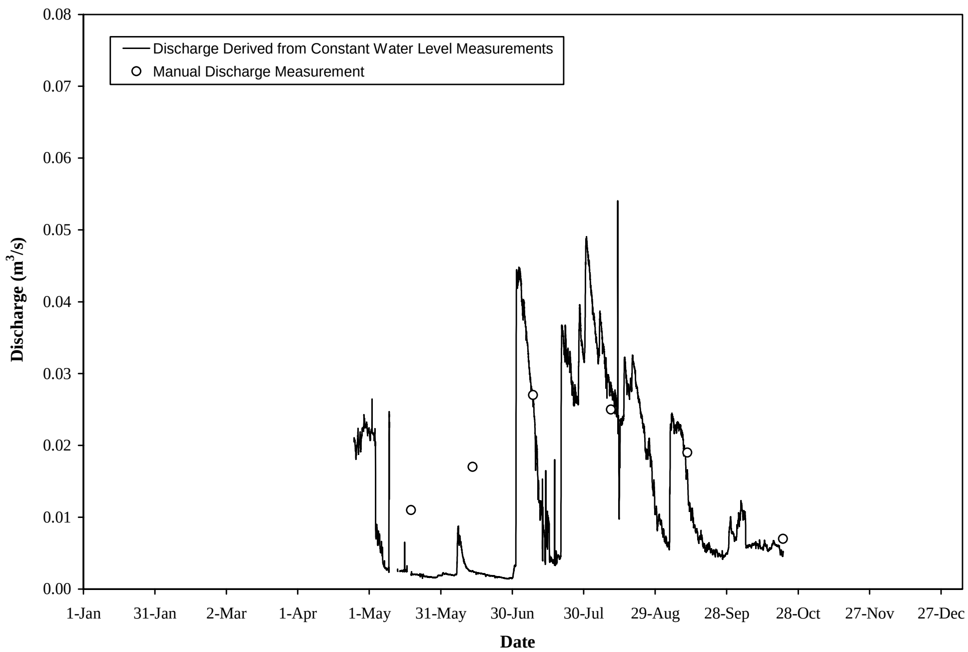


5.3.2.20 Lowland Tar River Streamflow Monitoring Station (S19)

The recorded hydrograph for this station is presented on Figure 5.25. The pressure transducer and data logger were installed at the station from April 24 to October 27, 2002. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

On June 13, 2002, a tipping bucket rain gauge was installed at this station.

Figure 5.25 2002 Discharge Hydrograph at Lowland Tar River Station (S19)

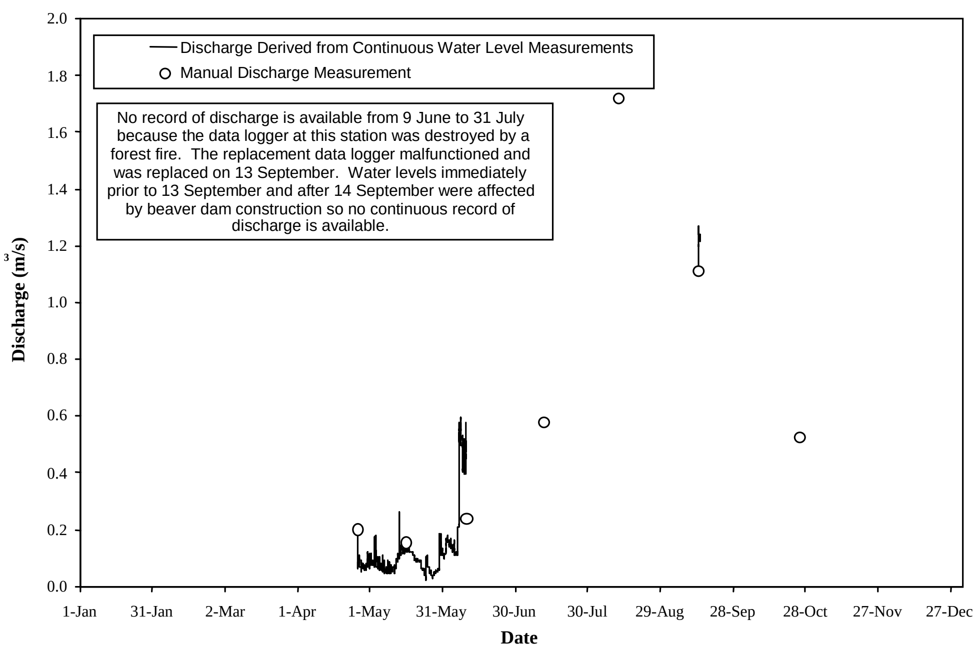


5.3.2.21 Upland Muskeg River Streamflow Monitoring Station (S20)

The recorded hydrograph for this station is presented on Figure 5.26. This station was relocated in 2002, after the 2001 site was flooded by beaver activity. The pressure transducer and data logger were installed at this site during the April 25 visit, after a site reconnaissance confirmed this location, and were present at the station until October 25, 2002. A temporary installation, with no excavation, was used. Should this location prove adequate, the site will need to be permitted by Alberta Environment before a permanent installation is completed.

Data from June 9 to September 13 were lost. On July 11, 2002, the replacement data logger and pressure transducer cable were found to have been destroyed by a forest fire. The data logger was sent to the manufacturer to see if any data could be recovered, but none were salvaged. The pressure transducer was sent to the manufacturer for repair. On July 31, 2002, a replacement data logger and pressure transducer were installed at the station. On September 13, 2002, the replacement data logger at this station was found to be malfunctioning and was replaced with a spare unit. Also on that date, a small beaver dam, located at a bridge crossing downstream of the station, was removed by hand. Water levels were collected from September 13 to October 25, but further beaver activity prevented reliable discharges from being derived after September 14.

Figure 5.26 2002 Discharge Hydrograph at Upland Muskeg River Station (S20)

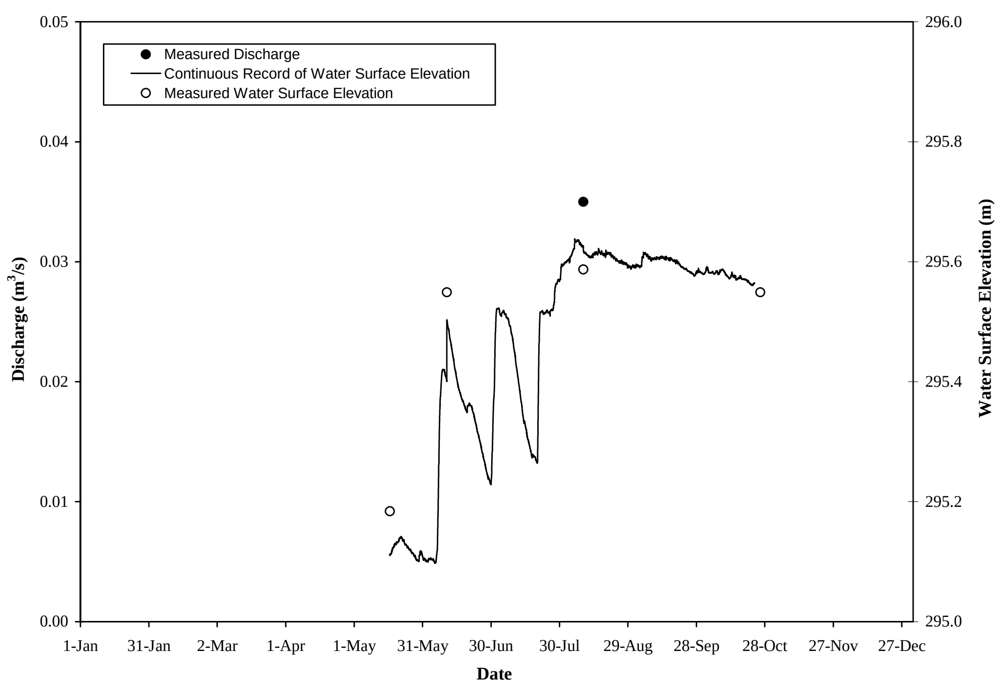


5.3.2.22 Shelley Creek Streamflow Monitoring Station (S21)

As in 2001, only water levels were recorded continuously at this station, since the low creek slope and effects of beaver dams prevent the development of a reliable stage-discharge rating curve. The recorded hydrograph for this station is presented on Figure 5.27. The pressure transducer and data logger were installed at the station from April 8 to October 26, 2002. However, ice conditions in the creek prevented reliable water levels from being measured after October 23. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys.

Figure 5.27 2002 Discharge Hydrograph at Shelley Creek Station (S21)



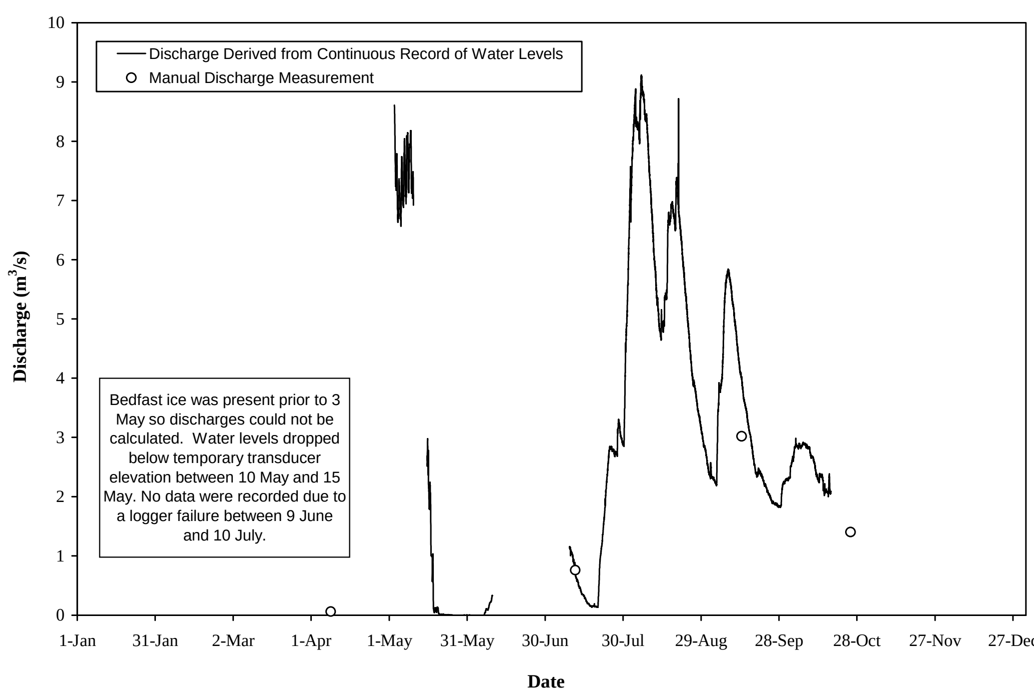
5.3.2.23 Muskeg Creek Streamflow Monitoring Station (S22)

The recorded hydrograph for this station is presented on Figure 5.28. The pressure transducer and data logger were installed at the station from April 8 to October 25, 2002. However, ice conditions in the creek prevented reliable discharges from being derived until May 18 and after October 17. The data gap between June 9 and July 10 was due to a data logger failure. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

On May 15, 2002, the antenna at this station was replaced. On July 9, 2002, the antenna was extended to a higher elevation. The external battery in the data logger was found to have a low voltage and was replaced, and the data logger and modem were exchanged with a new unit to repair a telemetry problem. On August 11, 2002, a lightning surge protector was installed on the antenna cable at this station.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys.

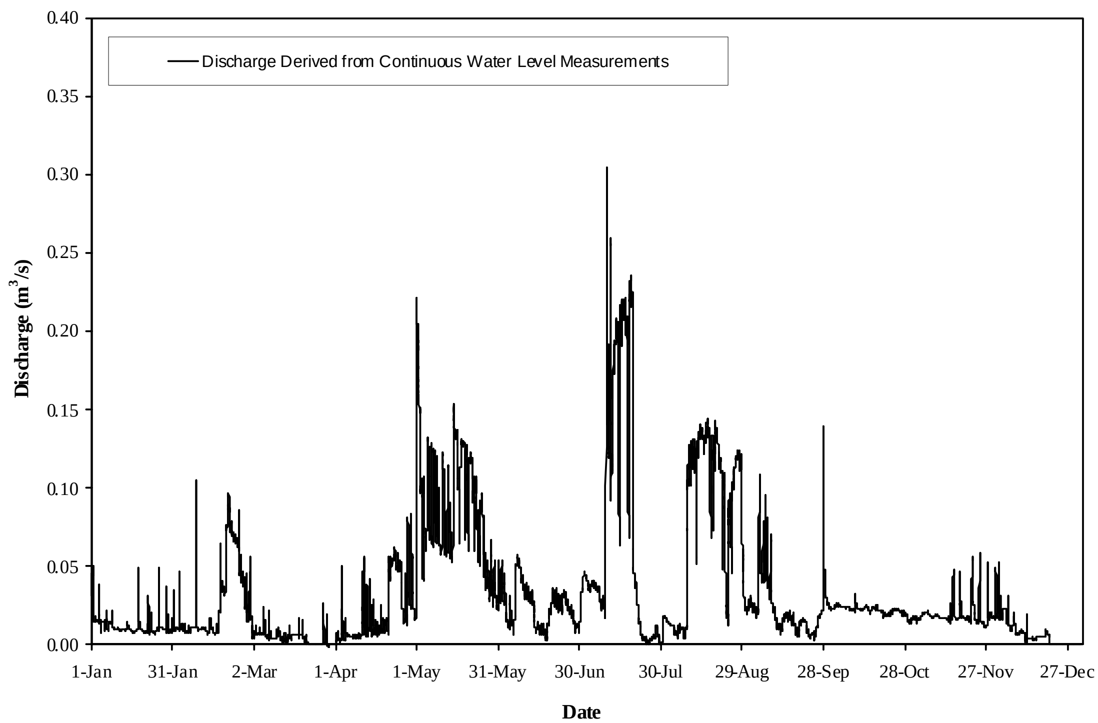
Figure 5.28 2002 Discharge Hydrograph at Muskeg Creek Station (S22)



5.3.2.24 Aurora Boundary Weir Streamflow Monitoring Station (S23)

The recorded hydrograph for this station is presented on Figure 5.29. The pressure transducer and data logger remained at this station over the winter of 2001 - 2002. This station was discontinued at the end of 2002, because Syncrude will now discharge their clean water drainage to Stanley Creek. In December, 2002 all equipment from this station was retrieved, due to station deactivation. The equipment was stored at the Golder office in Fort McMurray at Syncrude's request.

Figure 5.29 2002 Discharge Hydrograph at Aurora Boundary Weir Station (S23)

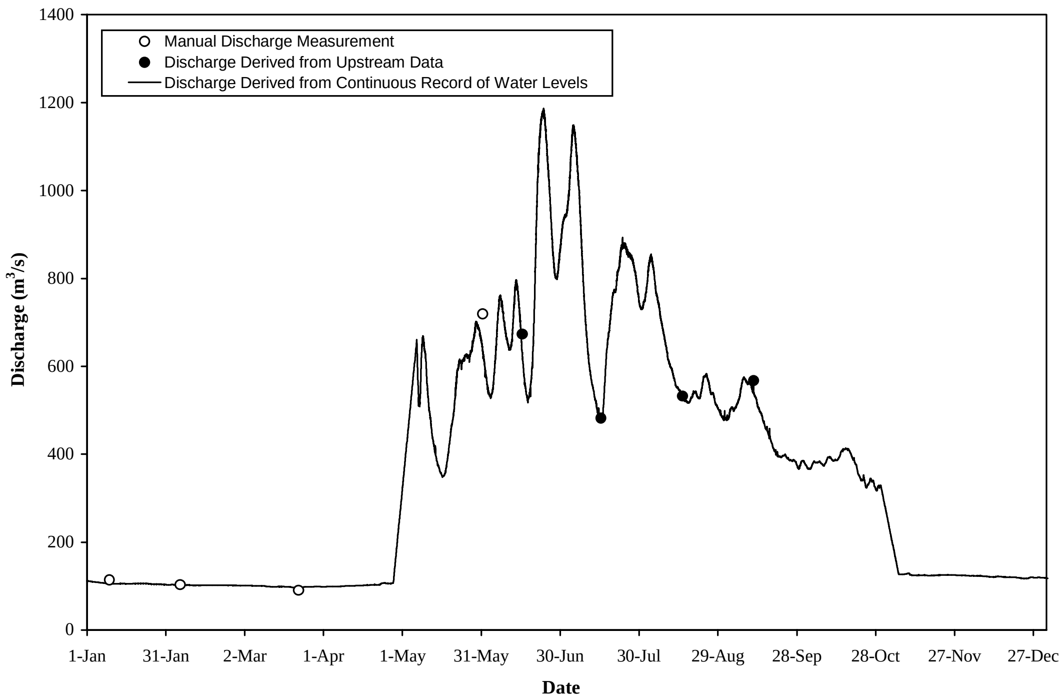


5.3.2.25 Athabasca River Streamflow Monitoring Station (S24)

The recorded hydrograph for this station is presented on Figure 5.30. This station operates year-round.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys.

Figure 5.30 2002 Discharge Hydrograph at Athabasca River Station (S24)

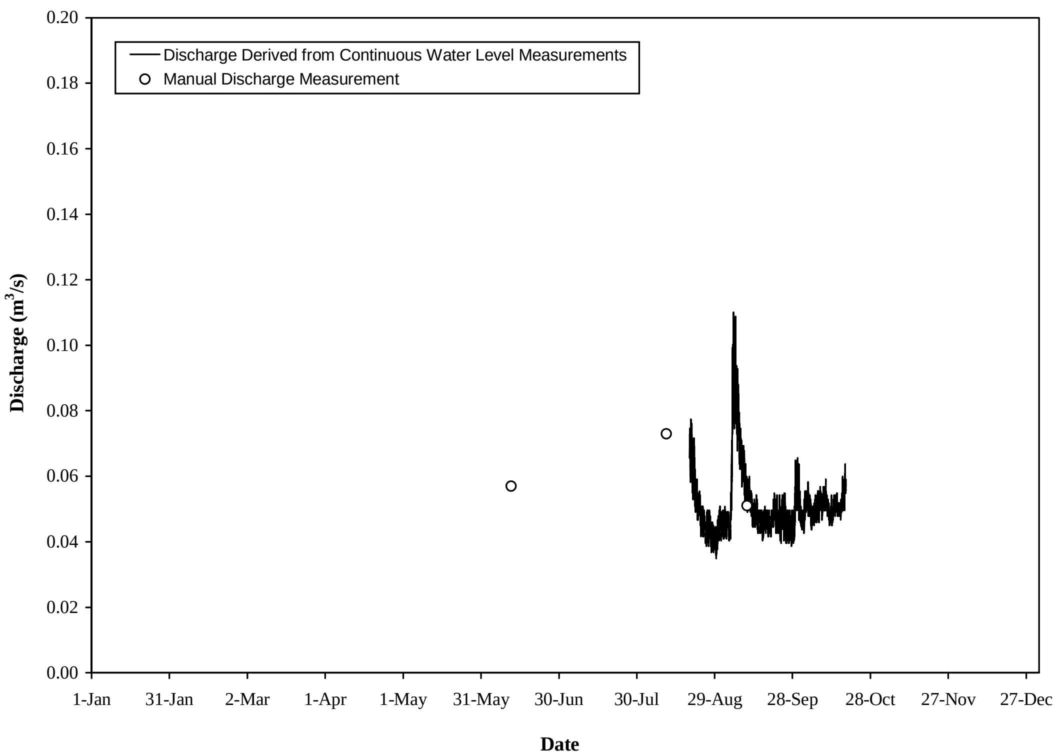


5.3.2.26 Susan Lake Outlet Streamflow Monitoring Station (S25)

The recorded hydrograph for this station is presented on Figure 5.31. The pressure transducer and data logger were first installed at this station on June 11. When the site was visited on August 10, it was found that the data logger had malfunctioned. The data logger was replaced on August 19 and operated until it was removed on October 18, 2002. This station will not be operated in 2003.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys. On September 11, 2002, this station was inspected and a decision was made to move the station further upstream to eliminate the potential for backwater effects from the Athabasca River. A new benchmark was established at the upstream site and tied into the previous benchmark.

Figure 5.31 2002 Discharge Hydrograph at Susan Lake Outlet Station (S25)



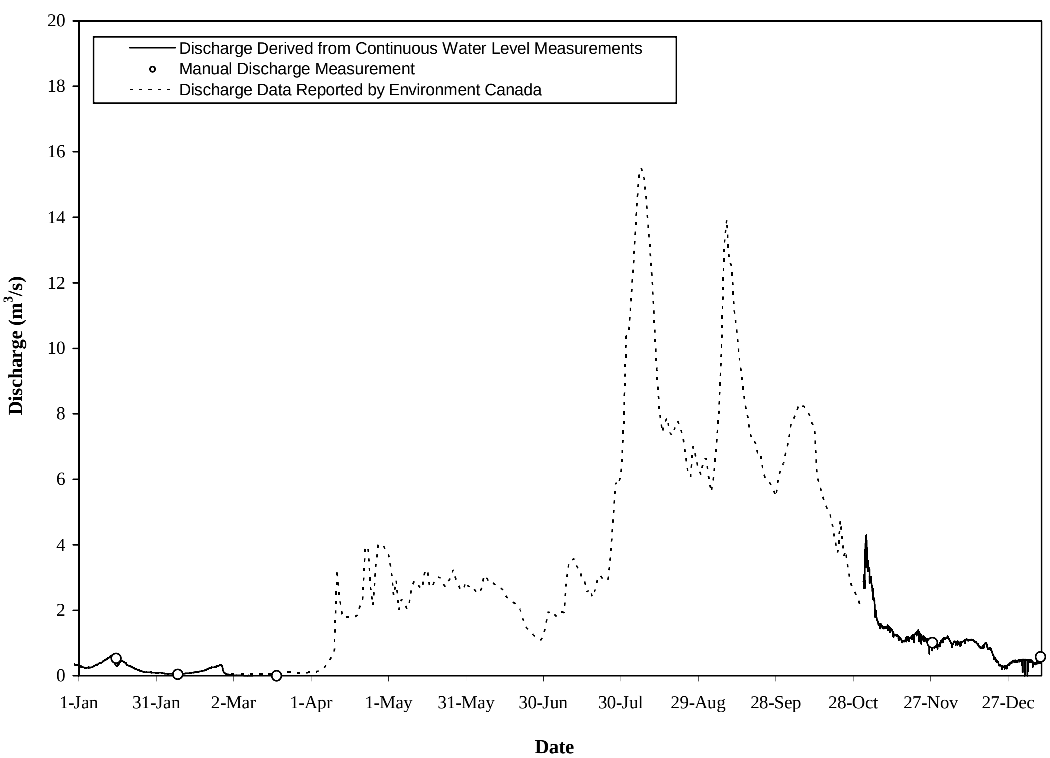
5.3.2.27 MacKay River WSC Monitoring Station (S26)

The recorded hydrograph for this station is presented on Figure 5.32. This station operates as a RAMP station during ice-covered conditions only. Data for the period March 1 to October 31 were provided by Environment Canada, which operates monitoring station 07DB001 at this location.

This station operated with spare equipment in early 2002. On October 24, 2002 a new Data Dolphin data logger with telemetry capability was installed at this site as a temporary installation, with no excavation. Should this location prove adequate, the site will need to be permitted by Alberta Environment before a permanent installation is completed.

The temporary installation at this station is located close to the riverbank. This station is only required to monitor flows until March 1 of each year, and the equipment should be removed soon after that date and prior to snowmelt, to prevent damage during spring or summer floods.

Figure 5.32 2002 Discharge Hydrograph at MacKay River WSC Station (S26)

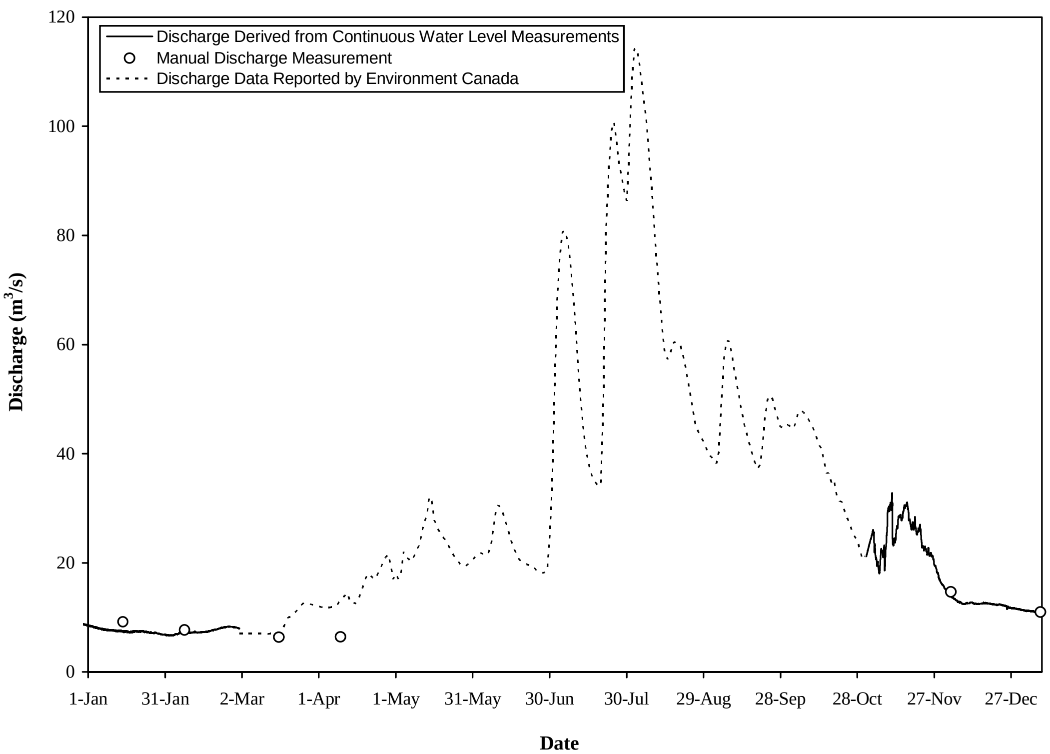


5.3.2.28 Firebag River WSC Monitoring Station (S27)

The recorded hydrograph for this station is presented on Figure 5.33. This station operates as a RAMP station during ice-covered conditions only. Data for the period March 1 to October 31 were provided by Environment Canada, which operates monitoring station 07DC001 at this location. This station will not be operated in 2003.

This station operated with spare equipment in early 2002. On October 23, 2002 a new Data Dolphin data logger without telemetry capability was installed at this site as a temporary installation, with no excavation. Should this location prove adequate, the site will need to be permitted by Alberta Environment before a permanent installation is completed.

Figure 5.33 2002 Discharge Hydrograph at Firebag River WSC Station (S27)

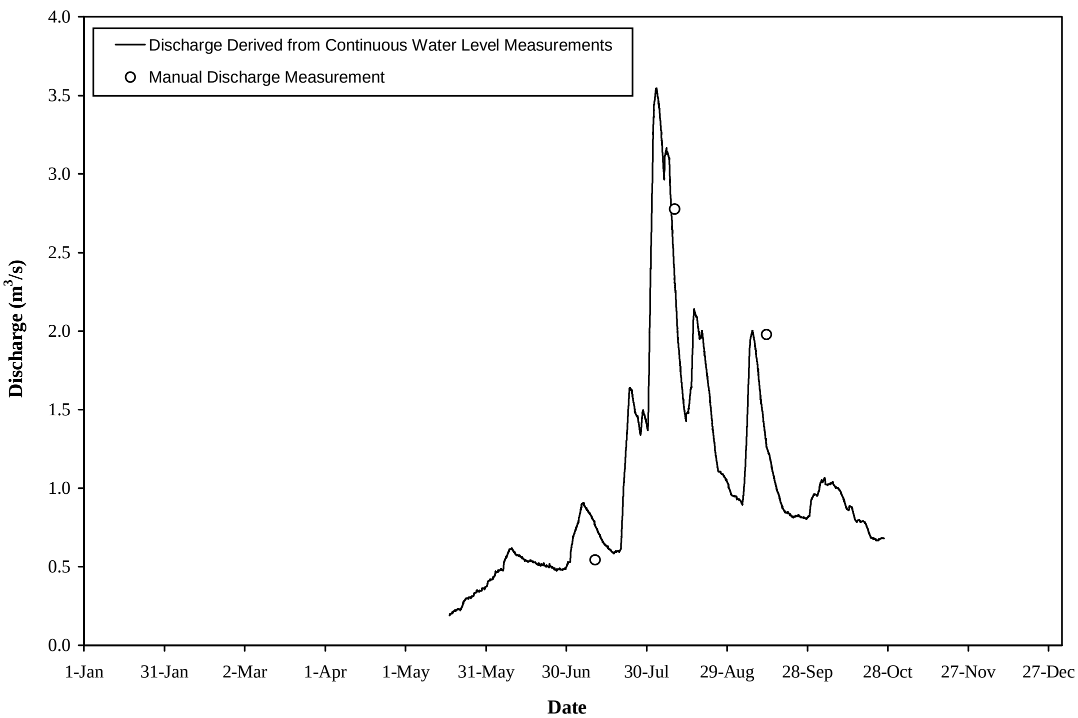


5.3.2.29 Khahago Creek Streamflow Monitoring Station (S28)

The recorded hydrograph for this station is presented on Figure 5.34. The pressure transducer and data logger were installed at the station from May 16 to October 26, 2002. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

In January 2002, the permanent benchmark at this station was tied into a geodetic elevation by Can-Am Surveys.

Figure 5.34 2002 Discharge Hydrograph at Khahago Creek Station (S28)



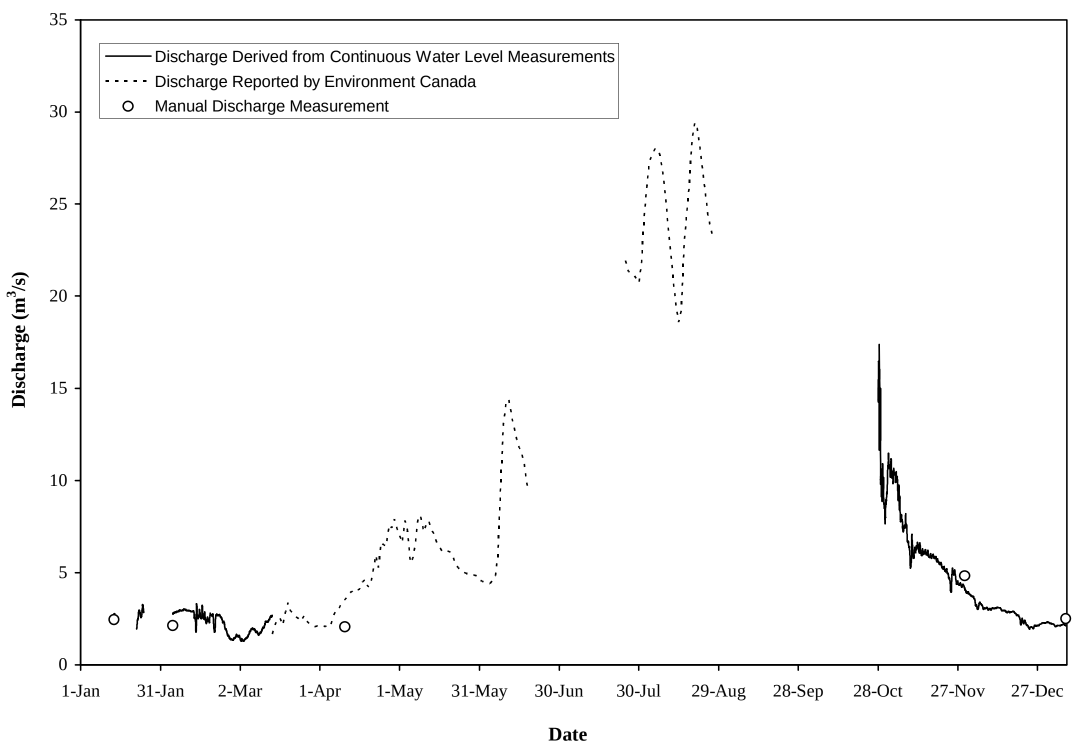
5.3.2.30 Christina River WSC Streamflow Monitoring Station (S29)

The recorded hydrograph for this station is presented on Figure 5.35. This station was first installed by RAMP on January 13, 2002. During the next visit on February 4, the pressure transducer cable was found to have been chewed through, therefore few usable data were available prior to that date. This station operates as a RAMP station during ice-covered conditions only. Data for the period March 1 to October 31 were provided by Environment Canada, which operates monitoring station 07DC001 at this location. Environment Canada was responsible for the data gaps at this station between June 18 to July 25 and August 27 to October 27.

This station operated with spare equipment in early 2002. On October 22, 2002 a new Data Dolphin data logger without telemetry capability was installed at this site as a temporary installation, with no excavation. Should this location prove adequate, the site will need to be permitted by Alberta Environment before a permanent installation is completed.

On July 8, 2002, a tipping bucket rain gauge was installed at this station.

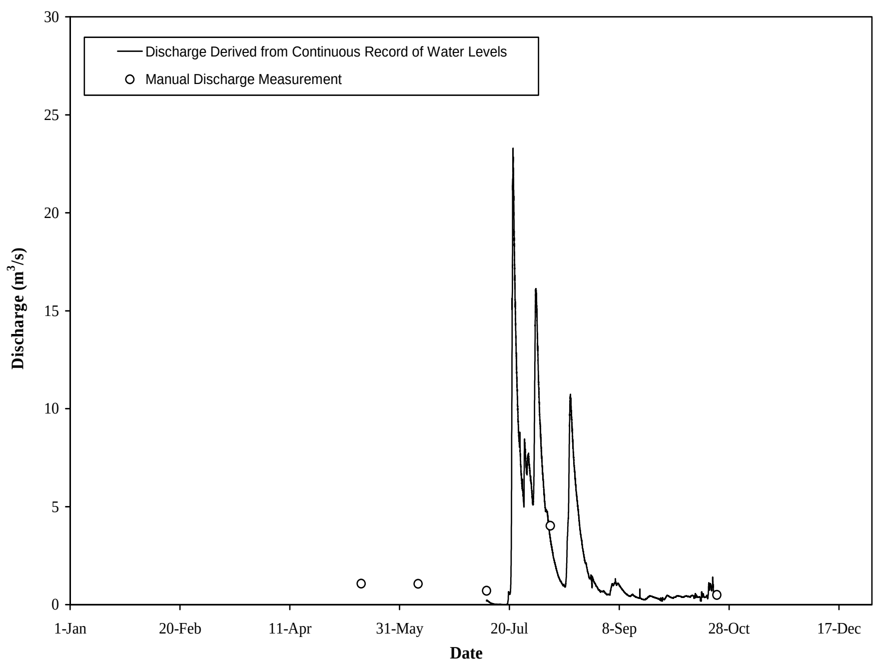
Figure 5.35 2002 Discharge Hydrographs at Christina River WSC Station (S29)



5.3.2.31 Hangingstone River Streamflow Monitoring Station (S30)

This station was previously operated to collect baseline data for the Petro-Canada Meadow Creek EIA and was incorporated into RAMP in 2002. The recorded hydrograph for this station is presented on Figure 5.36. The pressure transducer and data logger were installed at the station from April 22 to October 22, 2002. However, a transducer failure meant that no reliable data were collected before July 9. On July 9, 2002, the malfunctioning pressure transducer and data logger at this station were replaced with spare equipment. Ice conditions in the creek prevented reliable discharges from being derived after October 21. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

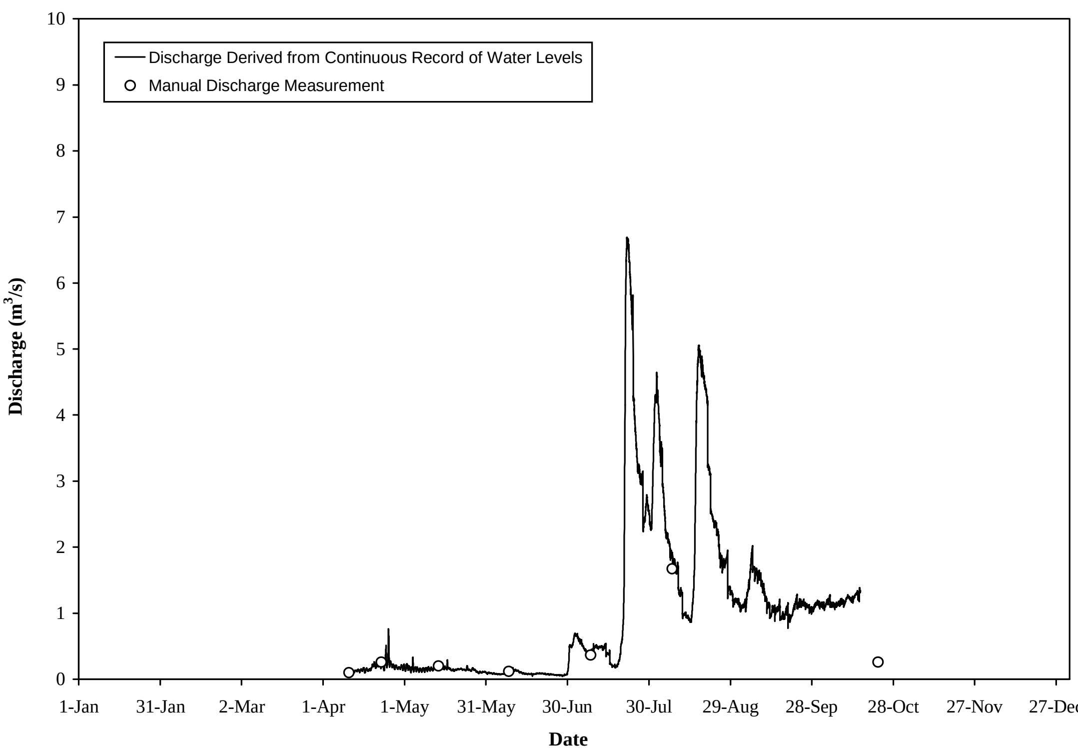
Figure 5.36 2002 Discharge Hydrographs at Hangingstone River Station (S30)



5.3.2.32 Hangingstone Creek Streamflow Monitoring Station (S31)

This station was previously operated to collect baseline data for the Petro-Canada Meadow Creek EIA and was incorporated into RAMP in 2002. The recorded hydrograph for this station is presented on Figure 5.37. The pressure transducer and data logger were installed at the station from April 10 to October 22, 2002. On August 7, 2002, the data logger battery at this station was replaced due to low voltage. No data were lost. Ice conditions in the creek prevented reliable discharges from being derived after October 15. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

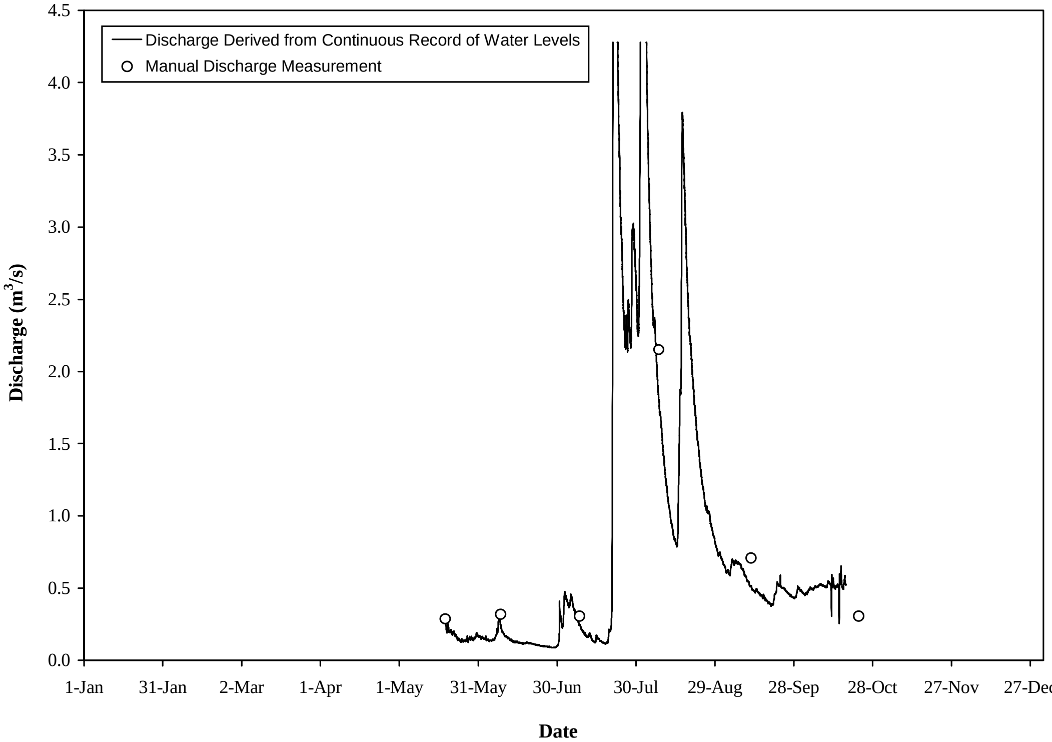
Figure 5.37 2002 Discharge Hydrographs at Hangingstone Creek Station (S31)



5.3.2.33 Surmont Creek Streamflow Monitoring Station (S32)

This station was previously operated to collect baseline data for the Petro-Canada Meadow Creek EIA and was incorporated into RAMP in 2002. The recorded hydrograph for this station is presented on Figure 5.38. The pressure transducer and data logger were installed at the station from May 18, the earliest date possible due to ice conditions, to October 22, 2002. The pressure transducer and data logger were removed from this site in late fall 2002 to prevent ice damage, as it was expected that the creek would freeze solid over the winter.

Figure 5.38 2002 Discharge Hydrographs at Surmont Creek Station (S32)



5.3.2.34 McClelland Lake Water Level and Outflow Monitoring Station (L1)

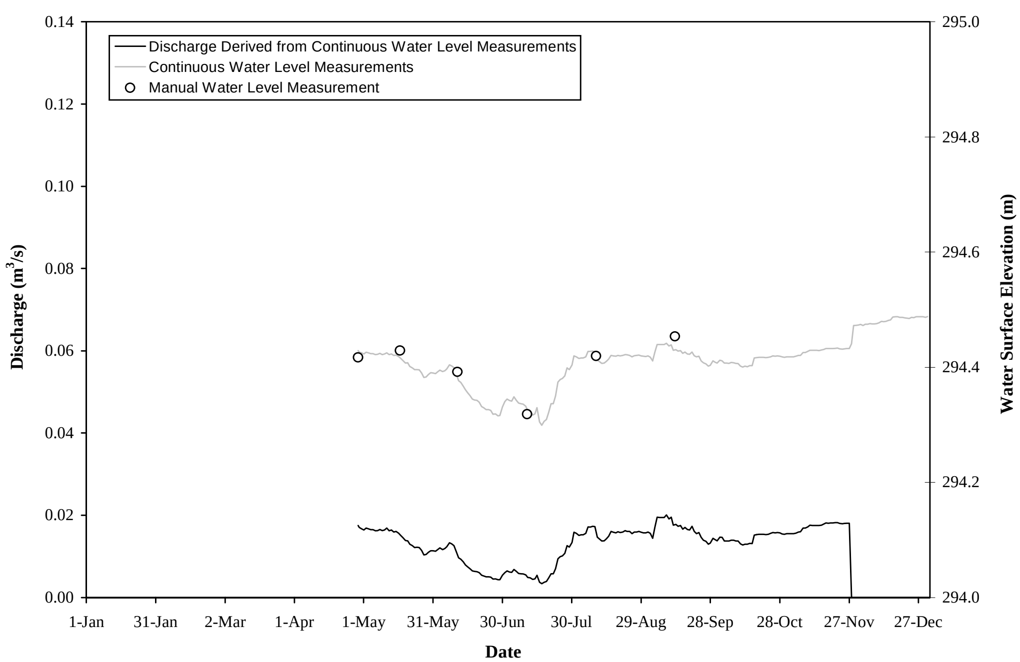
The recorded hydrograph for this station is presented on Figure 5.39. The pressure transducer and data logger were installed at the station from April 28 to December 31, 2002. The pressure transducer was moved to deeper water in 2002 and will operate over the winter of 2002-2003.

On June 10, 2002, a new Data Dolphin data logger with telemetric capability and pressure transducer with a 60 m long cable were installed at this station. These improvements were undertaken to allow remote downloads from the station and to allow year-round measurement of water levels.

On July 10, 2002, a tipping bucket rain gauge was installed at this station. On September 12, 2002, the tipping bucket rain gauge was found to have been vandalized. Its support pole had been cut down and it was lying on the ground with a severed cable. The rain gauge was returned to Fort McMurray for repairs.

On August 9, 2002, the data logger and modem were exchanged for new units to repair a telemetry problem.

Figure 5.39 2002 Water Level and Discharge Hydrographs at McClelland Lake Station (L1)

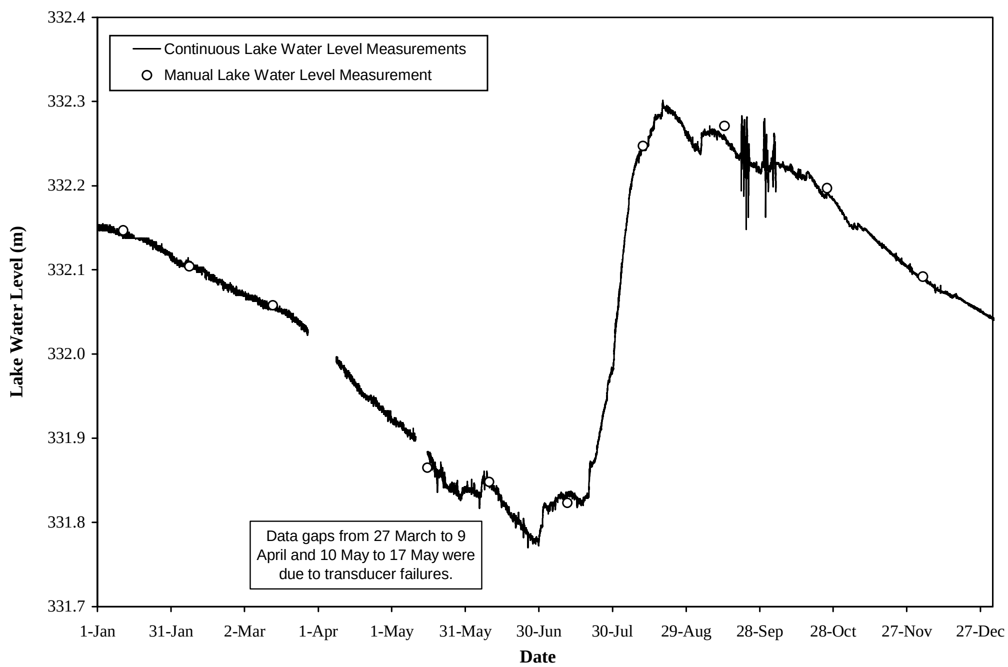


5.3.2.35 Kearl Lake Water Level Monitoring Station (L2)

After being vandalized twice in 2001, the monitoring equipment was moved to a more protected location in November 2001. From January 1 to December 31, 2002, a pressure transducer and data logger were installed at the station. The recorded hydrograph for this station is presented on Figure 5.40.

However, pressure transducer failures resulted in data gaps from March 27 to April 9 and from May 10 to May 17. On May 15, 2002, the pressure transducer was found to be malfunctioning and was replaced with a spare unit. On October 25, 2002, a new Data Dolphin data logger with telemetry capability was installed at this site as a temporary installation, with no excavation. Should this location prove adequate, the site will need to be permitted by Alberta Environment before a permanent installation is completed.

Figure 5.40 2002 Water Level Hydrograph at Kearl Lake Station (L2)

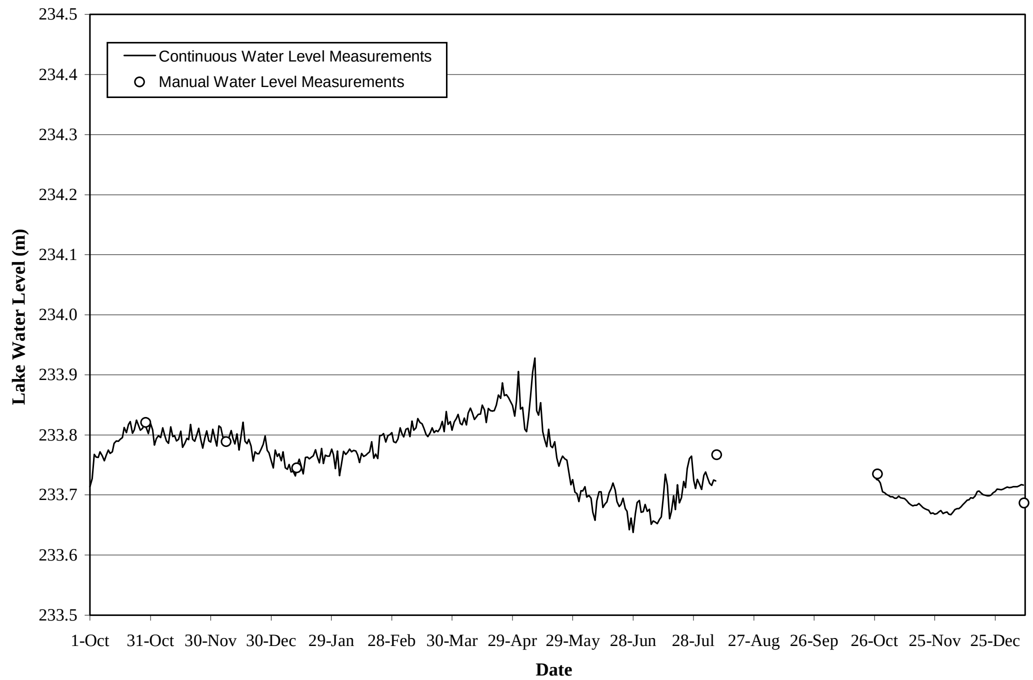


5.3.2.36 Isadore's Lake Water Level Monitoring Station (L3)

Attempts to reach the site on two other dates were thwarted by new access restrictions to the area. The recorded hydrograph for this station is presented on Figure 5.41. The data gap between August 8 and October 27 was due to a data logger failure.

On August 8, 2002, a Lakewood data logger with vented pressure transducer was installed at this station in place of the non-vented Solinst unit that was previously installed. On October 27, 2002, the Lakewood unit was found to have malfunctioned. This unit was replaced with a spare unit on October 29, 2002.

Figure 5.41 2002 Water Level Hydrograph at Isadore's Lake Station (L3)



5.3.3 Measurements of Total Suspended Solids

Measurements of total suspended solids (TSS) concentration are required to characterize the watershed and channel sediment yields and erosion, and to monitor streamflow water quality. As in previous years, water samples were regularly collected during site visits to each hydrologic monitoring station. These samples were tested in a laboratory to measure the concentration of TSS. For stations installed prior to 2000, enough data are generally available so that TSS samples were only taken during high discharges or when unusual conditions were observed. For stations established in 2000 or later, regular TSS sampling was undertaken in 2002. These stations are listed in Table 5.7.

TSS measurements undertaken in 2002 are summarized in Table 5.7. Sediment rating curves relating the variation of TSS with discharge at these stations can be prepared based on these data. All TSS data collected under RAMP are presented in the Climate and Hydrology Database that is presented in Appendix II.

Table 5.7 Total Suspended Solids Data Collected in 2002

Station No.	Stream Name	January	February	March	April	May	June	July(	August	September	October
S2	Jackpine Creek	-	-	-	-	-	-	-	-	4 (13)	1 (25)
S3	Iyinimin Creek	-	-	-	-	-	-	-	-	10 (12)	0 (26)
S5A	Muskeg River Aurora	3 (12)	<3 (8)	-	-	-	-	-	-	-	-
S6	Mills Creek	<3 (15)	-	-	-	-	-	-	-	-	0 (21)
S7	Muskeg River WSC	3 (11)	8 (6)	4 (15)	8 (8)	-	-	-	-	-	-
S9	Kearl Lake Outlet	-	<3 (7)	-	-	-	-	-	-	-	-
S10	Wapasu Creek	-	-	-	-	-	3 (9)	1 (11)	-	2 (13)	0 (25)
S12*	Fort Creek	-	-	-	-	-	4 (9)	1 (8)	-	-	0 (23)
S14*	Ells River	-	-	-	-	25 (16)	-	1 (10)	19 (9)	7 (12)	-
S15*	Tar River	7 (11)	-	-	-	55 (16)	-	17 (8)	19 (10)	14 (12)	5 (21)
S16*	Calumet River	14 (14)	-	-	-	-	-	-	1 (9)	4 (12)	-
S17*	Tar River Upland	-	-	-	-	130 (16)	-	-	-	-	-
S18A*	Calumet River Upland	-	-	-	-	24 (16)	6 (10)	1 (11)	20 (9)	4 (12)	-
S19*	Tar River Lowland	-	-	-	-	2 (16)	5 (13)	1 (8)	0 (10)	3 (11)	0 (21)
S20*	Muskeg River Upland	-	-	-	3 (25)	3 (15)	5 (9)	1 (11)	1 (11)	4 (13)	0 (25)
S21*	Shelley Creek	-	-	-	-	12 (16)	6 (10)	-	2 (9)	-	-
S22*	Muskeg Creek	3 (11)	-	-	2 (8) 2 (23)	11 (15)	10 (9)	1 (11)	4 (11)	4 (13)	0 (25)
S25*	Susan Lake Outlet	-	-	-	-	-	-	-	1 (10)	3 (11)	-
S26*	MacKay River	4 (14)	<3 (8)	-	-	-	-	-	-	-	-
S27*	Firebag River WSC	<3 (14)	<3 (8)	22 (16)	2 (9)	18 (14)	-	-	-	-	-
S28*	Khahago Creek	-	-	-	-	4 (16)	-	-	2 (9)	2 (12)	-
S29*	Christina River WSC	4 (13)	<3 (4)	3 (17)	3 (10)	-	-	-	-	-	-
S30*	Hangingstone River	-	-	-	6 (8) 2 (23)	18 (13)	3 (8)	-	47 (7)	-	0 (22)
S31*	Hangingstone Creek	-	-	-	6 (22)	4 (13)	9 (8)	-	8 (7)	-	1 (22)
S32*	Surmont Creek	-	-	-	-	23 (16)	11 (8)	7 (8)	56 (9)	4 (12)	3 (22)

Note: Bracketed numbers refer to the day of the month data were collected.

* = Stations established in 2000 or later.

5.3.4 Work Recommended for 2003

5.3.4.1 Aurora Climate Station (C1)

Spares for sensors at the Aurora Climate Station are available and should be recalibrated and exchanged for the ones currently in service.

5.3.4.2 Geodetic Benchmark Establishment

Stations installed or relocated in 2002 are not equipped with benchmarks tied into the geodetic datum. It is recommended that this be done for the following stations:

- S18A – Calumet River Upland
- S19 – Tar River Lowland
- S20 – Muskeg River Upland
- S26 – MacKay River WSC
- S29- Christina River WSC
- S30 – Hangingstone River
- S31 – Hangingstone Creek
- S32 – Surmont Creek

5.3.4.3 Telemetry Retrofitting

Nineteen of the 35 RAMP climatic and hydrometric stations active in 2002 were equipped with remote data download and programming capability. This has allowed the following:

- assessment of field conditions before visiting sites;
- identification of sensor problems before visiting sites;
- diagnosis of instrumentation problems from the office while field staff are on site; and
- download and reporting of site data without field visits.

These capabilities have greatly enhanced the QA/QC capacity of the program, allowed early detection of equipment malfunctions, and in the long term should reduce the cost of fieldwork by reducing the number of visits required per year.

It is recommended that instrumentation at non-equipped sites be replaced with telemetry-capable equipment, as required by equipment failure or retirement or on an opportunistic basis where possible within the existing maintenance budget. Recommendations for data logger replacement are shown in Table 5.8.

Table 5.8 Recommendations for Data Logger Replacement

Rank[a]	Station	Rationale
1	Jackpine Creek (S2)	old equipment, long-term site; reporting likely required due to mine development
2	Mills Creek (S6)	undertake in conjunction with weir reconstruction
3	Isadore's Lake (L3)	replace non-vented transducer, enable downloads during ice-covered conditions
4	Iyinimin Creek (S3)	old equipment at helicopter access site; Tipping bucket rain gauge at this site
5	Stanley Creek (S8)	old equipment at helicopter access site, water levels only
6	Kearl Lake Outlet (S9)	old equipment, long drive from mine sites
8	Wapasu Creek (S10)	old equipment, long drive from mine sites
9	Poplar Creek (S11)	old equipment, easy road access
10	Aurora Climate Station (C1)	Campbell Scientific data logger would be adapted with download device only (no new logger)
11	Hangingstone River (S30)	old equipment, south of Fort McMurray
12	Hangingstone Creek (S31)	old equipment, south of Fort McMurray
13	Surmont Creek (S32)	old equipment, south of Fort McMurray

[a] Stations S12 – Fort Creek, S25 – Susan Lake Outlet, S27 – Firebag River and S29 – Christina River are not recommended for replacement because they are either not scheduled to operate in 2003 or are out of the cell service area.

5.3.4.4 Improved Winter Monitoring

Consideration should be given to visiting all RAMP stations periodically over the winter months, and undertaking manual stream discharge measurements if possible. Most of the RAMP stations on smaller watersheds are not operated during the winter months, since they typically freeze to the bottom and cease to flow over the winter, and do not lend themselves to continuous year-round flow monitoring. However, most recent monitoring was undertaken during relatively dry conditions relative to the available record of precipitation, and it is possible that wetter conditions may result in higher winter flows.

5.3.4.5 Additions to Program Design

An additional hydrology-related data collection and analysis activity, also recommended in the RAMP 5-year Summary Report, was to undertake year-round hydrologic monitoring of a small watershed in conjunction with intensive rainfall and snowfall monitoring. One natural watershed should be examined to measure the temporal variation of stream discharge. These measurements would be used with detailed precipitation data to allow for more detailed analysis of watershed response to rainfall and snowfall.

5.4 2002 CLIMATIC AND HYDROLOGIC CONDITIONS SUMMARY

The core components of the 2002 chemical and biological monitoring program (water and sediment quality, benthic invertebrate communities and fish populations) are all influenced by climatic and hydrologic conditions. In particular, changes that alter the quantity of water in the Athabasca River, the tributaries of the Athabasca River, wetlands and lakes will influence these core components. Since changes in flows and water levels may affect both the success and the results of RAMP sampling throughout the study area, the following is a summary of the 2002 conditions to provide background information for the following sections.

Field observations indicate that 2002 was a relatively average year in the Muskeg River and adjacent basins, with lower snowpack and precipitation depth than recorded in 2000. A summary of precipitation measured at the Aurora Climate Station for the hydrologic year November 2001 to October 2002 is provided in Table 5.9. The snow water equivalent snowfall of 28.2 mm measured at the Aurora Climate Station was 8% of the total measured precipitation. However, snow water equivalent depths or the order of 40 mm were recorded for most terrain types during the Birch Mountains East Slope Basins snow survey. This indicates that the Aurora data is subject to undercatch due to wind effects and trace events, as is typical for these types of stations.

Table 5.9 Precipitation at Aurora Climate Station, Hydrologic Year November 2001 to October 2002

Month	Rainfall (mm water)	Snowfall[(a)] (mm snow water equivalent)	Precipitation (mm water)
November 2001	0.0	0.0	0.0
December 2001	0.0	0.0	0.0
January 2002	0	9.4	9.4
February 2002	0	10.2	10.2
March 2002	0	0.0	0.0
April 2002	2.2	0.0	2.2
May 2002	24	0.0	24.0
June 2002	64.6	0.0	64.6
July 2002	130.8	0.0	130.8
August 2002	48.6	0.0	48.6
September 2002	48.6	0.0	48.6
October 2002	16	8.6	24.6
Total	**334.8**	**28.2**	**363.0**

(a) No undercatch adjustment has been applied.

The highest monthly precipitation of 131 mm occurred in July at the Aurora Climate Station. The total rainfall measured at the Aurora Climate Station in 2002 was 335 mm. This is similar to that measured in 1997, 1999 and 2001 (382 mm, 303 mm, and 323 mm, respectively) and less than that measured in 1996 and 2000 (472 mm and 457 mm, respectively) as shown in Table 5.10.

Table 5.10 Annual Rainfall at Aurora Climate Station

Year	Rainfall (mm)
1996	472
1997	382
1998	212
1999	303
2000	457
2001	323
2002	335

The analysis of available data indicates that maximum daily stream discharges in 2002 were slightly higher than the long-term mean of annual maximum daily values for the Firebag River, slightly below the mean for the Steepbank and Muskeg rivers, and significantly below the mean for the Athabasca and Mackay rivers (Table 5.11). Minimum daily discharges were lower than the mean for most stations. The low flow of 80 m^3/s recorded on the Athabasca River in March, 2002 was the second lowest discharge on record, next to the value of 75 m^3/s that was reported in the revised Environment Canada report for December, 2001.

The cumulative flow volumes for the period from March to September 2002 (i.e., spring melt to late summer) were close to long term average for Jackpine Creek and the Muskeg, Steepbank and Firebag rivers (Table 5.12). Flows on the Mackay River were significantly lower than the long term average, and those on the Athabasca River were the lowest measured in 42 years of record. Annual mean daily flow hydrographs for the Athabasca River, Steepbank River, Muskeg River, Jackpine Creek, Mackay River and Firebag River are shown in Figures 5.42 to 5.47, respectively.

Table 5.11 Maximum and Minimum Mean Daily Discharges, RAMP Study Area

Stream Station ID Period of Record	Athabasca R. 07DA001 45 Years	Steepbank R. 07DA006 29 Years	Muskeg R. 07DA008 29 Years	Jackpine Cr. S2 26 Years	MacKay R. 07DB001 29 Years	Firebag R. 07DC001 27 Years
	Maximum Mean Daily Discharge					
2002 value (m^3/s)	1221	33.3	23.2	14.35	15.5	114
average recorded (m^3/s)	2555	35.5	26.4	8.62	118	104
maximum recorded (m^3/s)	4700	81.0	66.1	17.2	339	236
	Minimum Mean Daily Discharge					
2002 value (m^3/s)	80	0.078[(a)]	0.092	0.110[(b)]	0.05[(a)]	6.96[(a)]
average recorded (m^3/s)	133	0.285	0.272	0.015	0.341	7.94
minimum recorded (m^3/s)	75	0.022	0.095	0.000	0.023	4.24

(a) Assumes low flow occurred at end of recession in March. No data available for Jan-Feb and Nov-Dec.

(b) Data available for Apr 23 - Oct 20.

Source: Environment Canada, Water Survey Branch; Golder (200**3**).

Table 5.12 Cumulative Streamflow Volumes, RAMP Study Area, March to September

Stream Station ID Period of Record	Athabasca R. 07DA001 42 Years	Steepbank R. 07DA006 29 Years	Muskeg R. 07DA008 29 Years	Jackpine Cr. S2[(a)] 26 Years	MacKay R. 07DB001 30 Years	Firebag R. 07DC001 27 Years
2002 value (dam^3)	8,979,120	133,041	93,226	37,972	73,086	667,895
Maximum Recorded (dam^3)	25,279,862	273,634	187,146	59,051	904,734	903,836
average recorded (dam^3)	16,512,467	133,287	104,737	28,037	408,725	604,757
minimum recorded (dam^3)	8,979,120	36,670	17,995	1,000	26,372	344,469

(a) Data available for April 23 to October 20.

Source: Environment Canada, Water Survey Branch; Golder (200**3**).

Figure 5.42 Annual Mean Daily Flow Hydrograph for the Athabasca River, 2002

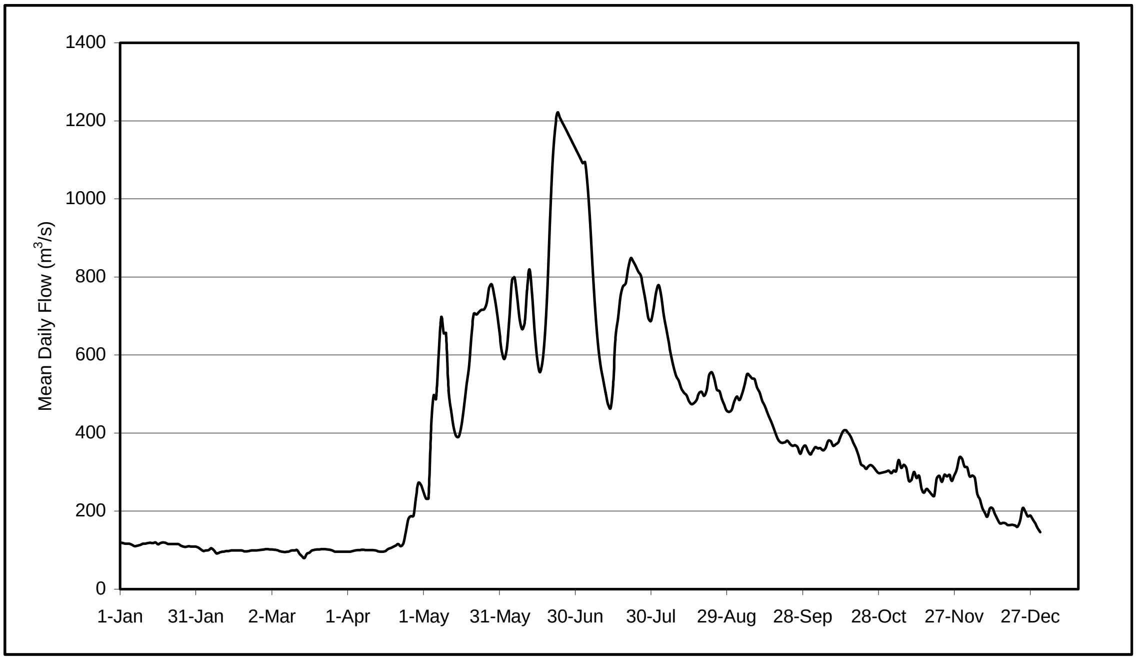


Figure 5.43 Annual Mean Daily Flow Hydrograph for the Steepbank River, 2002

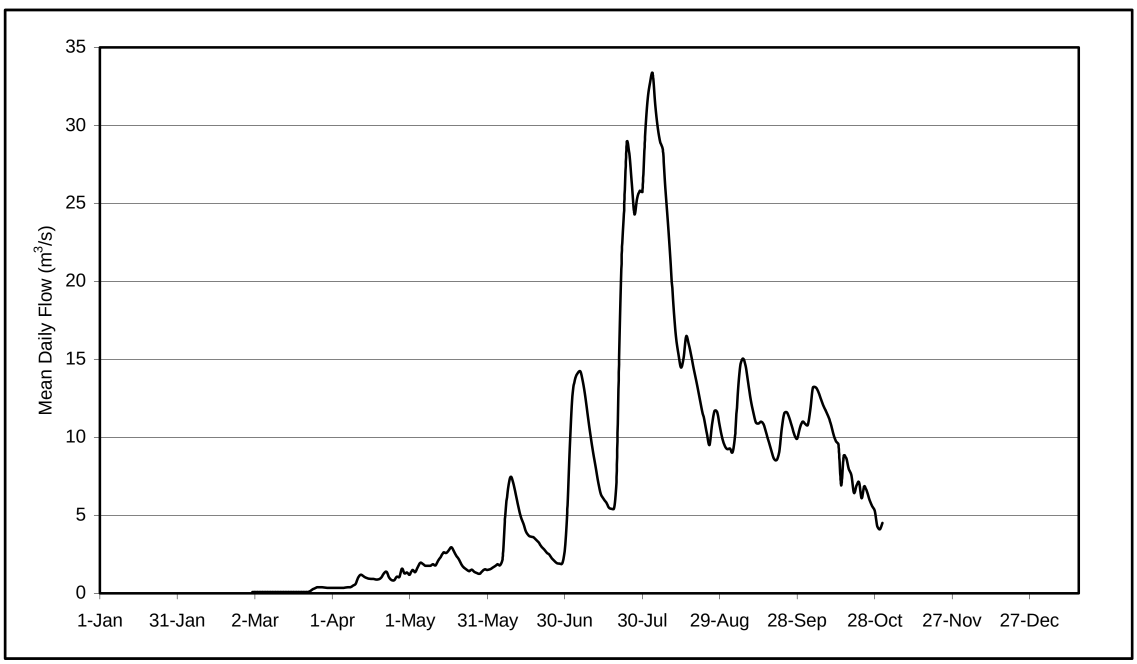


Figure 5.44 Annual Mean Daily Flow Hydrograph for the Muskeg River, 2002

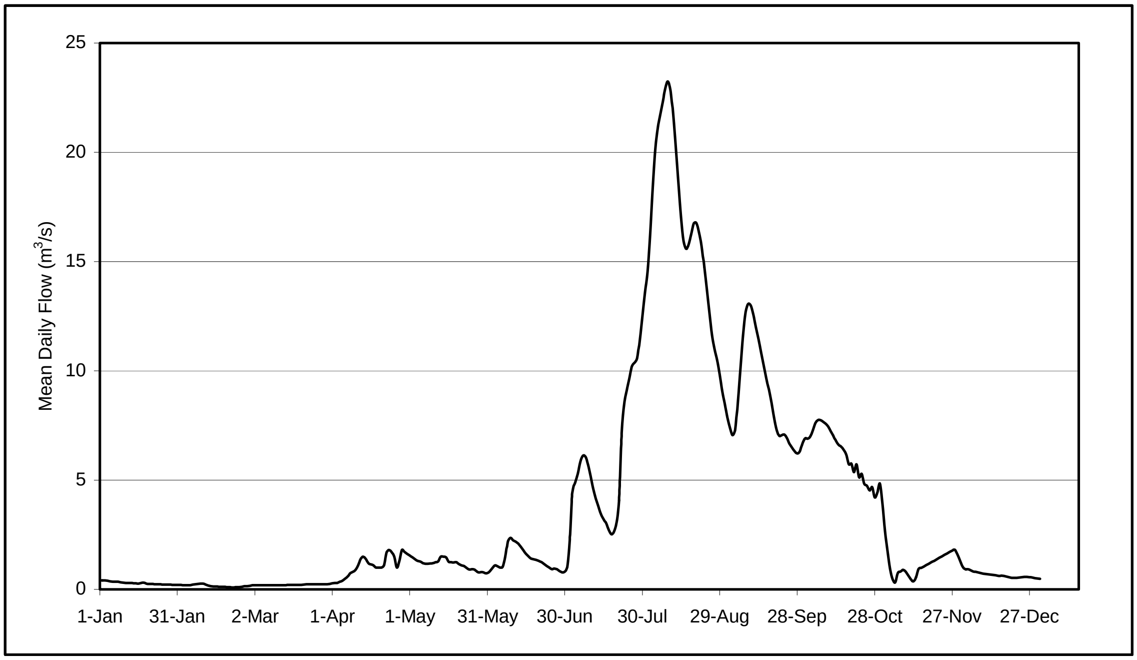


Figure 5.45 Annual Mean Daily Flow Hydrograph for Jackpine Creek, 2002

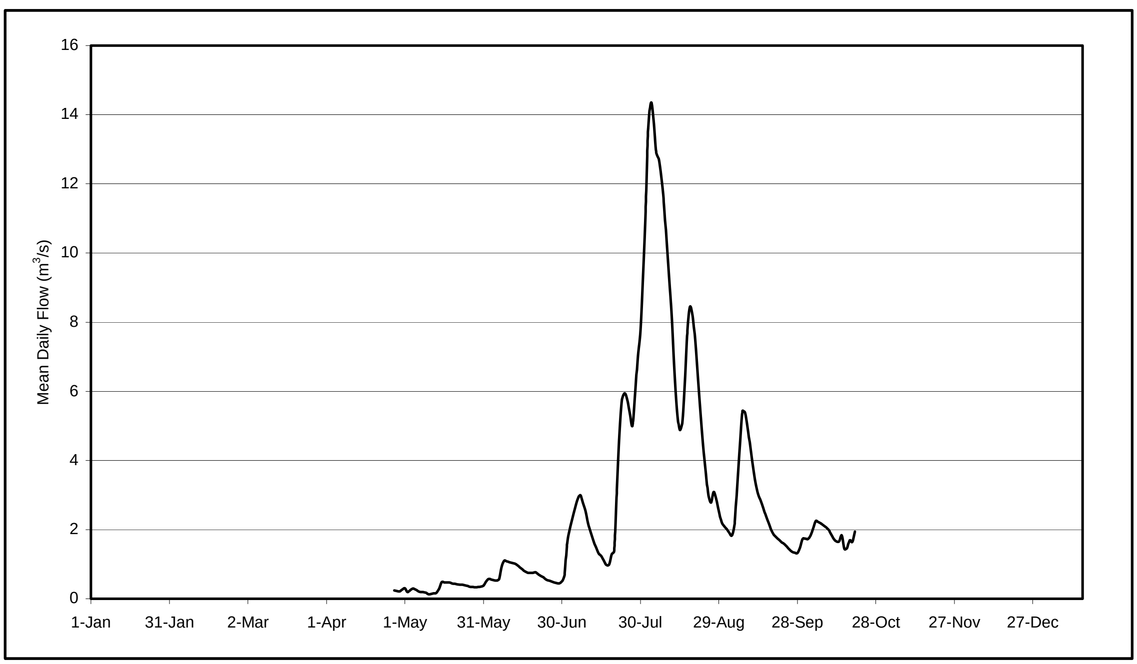


Figure 5.46 Annual Mean Daily Flow Hydrograph for the Mackay River, 2002

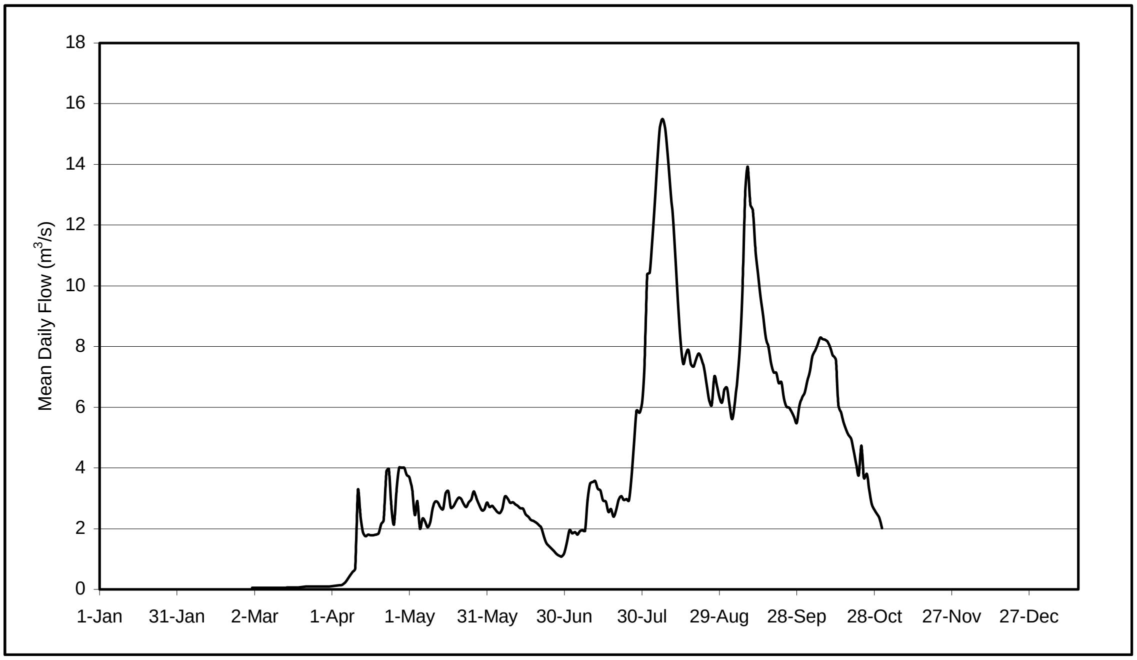
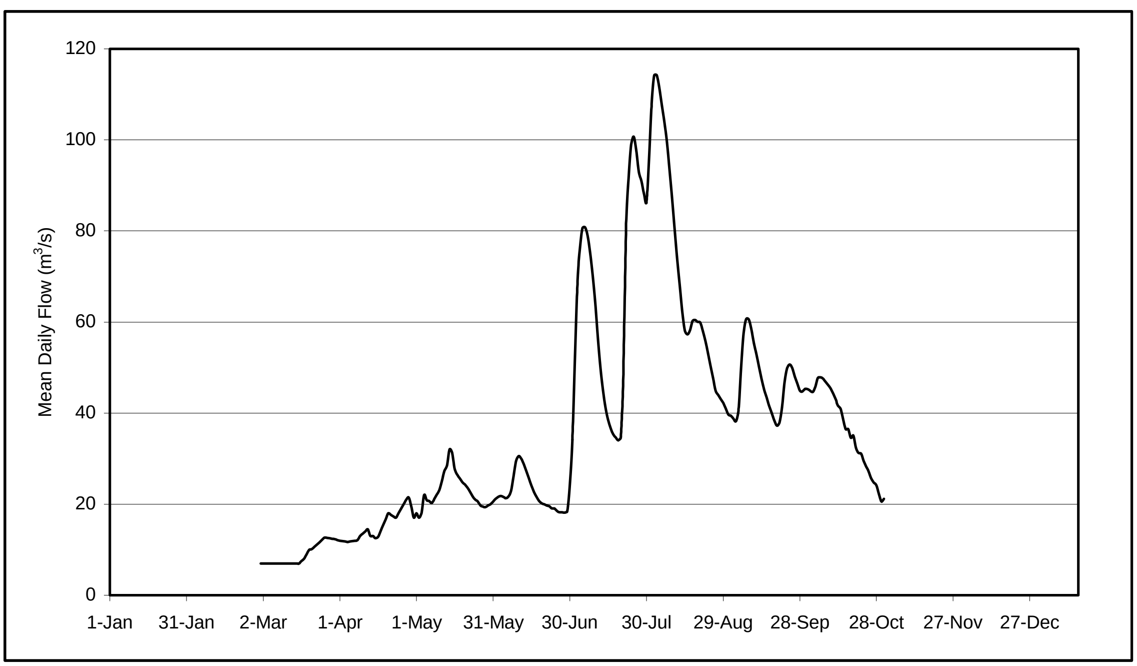


Figure 5.47 Annual Mean Daily Flow Hydrograph for Firebag River, 2002



6 WATER QUALITY

As outlined in Section 3.2.4, the analysis of the RAMP water quality data set consisted of an examination of temporal trends in the following waterbodies:

- the Steepbank, Firebag and MacKay rivers;
- McLean, Fort and Poplar creeks; and,
- Shipyard Lake.

For each waterbody, the Mann-Kendall test for trend in combination with Sen's slope estimation procedure (Gilbert 1987) was used to determine both the magnitude and potential significance of apparent temporal trends. In the six rivers and creeks, the analysis was completed using fall data collected from the mouth of each waterbody. With respect to Shipyard Lake, the analysis was focused on temporal trends in summer. Eleven parameters were considered in this investigation. They included the following:

- dissolved organic carbon (DOC)
- pH
- total alkalinity
- total dissolved solids (TDS)
- total suspended solids (TSS)
- sulphate
- total Kjeldahl nitrogen (TKN)
- total phosphorus
- total aluminum
- total boron
- total chromium

The rationale for selecting these locations, seasons and parameters is provided in Section 3.2.4. Summaries of all of the water quality sampling data collected by RAMP in 2002, including the continuous temperature measurements, are provided in Appendix X.

6.1.1 McLean Creek, Shipyard Lake and the Steepbank River

No significant[1] temporal variations in water quality were observed at the mouths of McLean Creek or the Steepbank River (Table 6.1). In contrast, significant temporal variations were observed in Shipyard Lake (Table 6.2). Specifically, sulphate and boron concentrations in the lake have increased over time, as

[1] Significant refers herein to a statistically significant trend identified using a two-tailed Mann-Kendall test with alpha set to 0.05.

illustrated in Figures 6.1 and 6.2, at a rate of 1.37 and 0.003 mg/L per year, respectively (Table 6.2). These rates were derived using Sen's slope estimation procedure (Gilbert 1987), a linear-based process focused in this instance on un-transformed data. However, sulphate concentrations in Shipyard Lake appear to be increasing exponentially, with concentrations appearing to double every 2.6 years (Figure 6.1).

The source of both the sulphate and boron entering Shipyard Lake cannot be clearly identified at this time. The rate at which sulphate concentrations appear to be increasing suggests that these changes are beyond natural. Comparable changes in sulphate concentrations have not been observed in McLean Creek and Steepbank River, two waterbodies located near Shipyard Lake.

Table 6.1 Summary of Temporal Trends Observed in McLean Creek and the Steepbank River Based on Fall Water Quality Data, 1995 to 2002

Location	Parameter	Sen's Slope (units/yr)[(a,b)]	Sample Size
mouth of McLean Creek	dissolved organic carbon	0.98	6
	pH	0.02	6
	total alkalinity	1.59	6
	total dissolved solids	12.0	6
	total suspended solids	9.59	6
	sulphate	-0.08	6
	total Kjeldahl nitrogen	0.17	5
	total phosphorus	0.003	6
	total aluminum	0.220	6
	total boron	-0.005	6
	total chromium	0	6
mouth of the Steepbank River	dissolved organic carbon	-0.16	7
	pH	0.08	7
	total alkalinity	4.30	7
	total dissolved solids	10.0	7
	total suspended solids	1.64	7
	sulphate	-0.08	7
	total Kjeldahl nitrogen	0.16	6
	total phosphorus	-0.004	7
	total aluminum	0.120	7
	total boron	0.001	7
	total chromium	-0.001	7

(a) Units are mg/L per year for all parameters, except pH (pH units/year).
(b) Significant slopes, which are indicative of significant temporal trends, are bolded ($p < 0.05$).

Table 6.2 Summary of Temporal Trends Observed in Shipyard Lake Based on Summer Water Quality Data, 1995 to 2002

Parameter	Sen's Slope (units/yr)[a,b]	Sample Size
dissolved organic carbon	0.59	5
pH	0.08	6
total alkalinity	7.37	6
total dissolved solids	18.5	6
total suspended solids	-2.67	6
sulphate	**1.37**	6
total Kjeldahl nitrogen	0.13	6
total phosphorus	-0.003	6
total aluminum	0.005	6
total boron	**0.003**	6
total chromium	0	6

(a) Units are mg/L per year for all parameters, except pH (pH units/year).

(b) Significant slopes, which are indicative of significant temporal trends, are bolded ($p < 0.05$).

Figure 6.1 Temporal Variations in Sulphate Concentrations Observed in Shipyard Lake Based on Summer Sampling

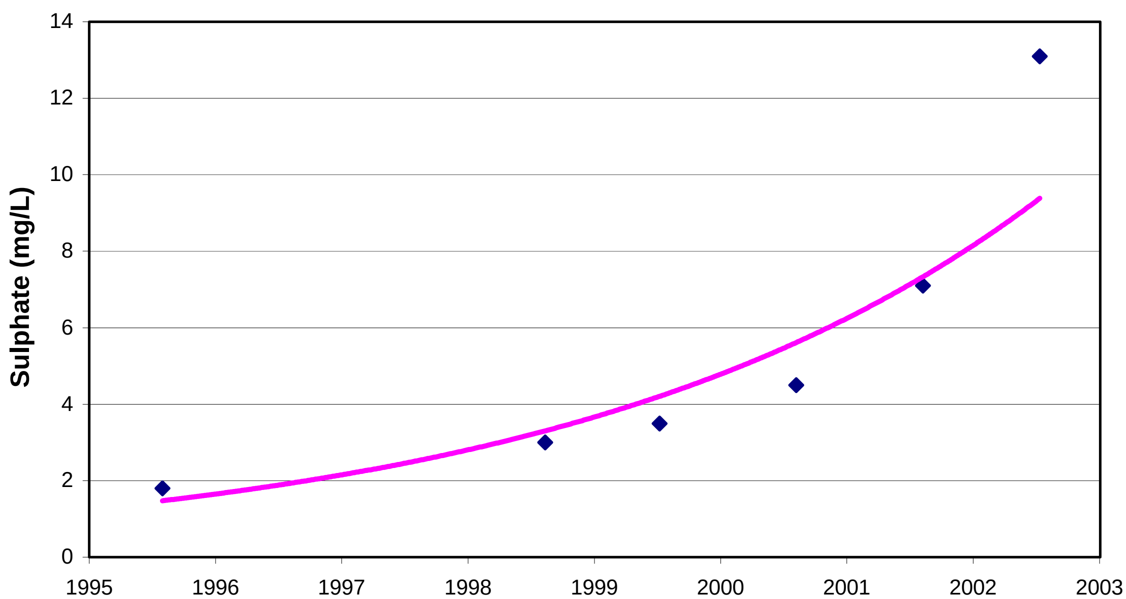
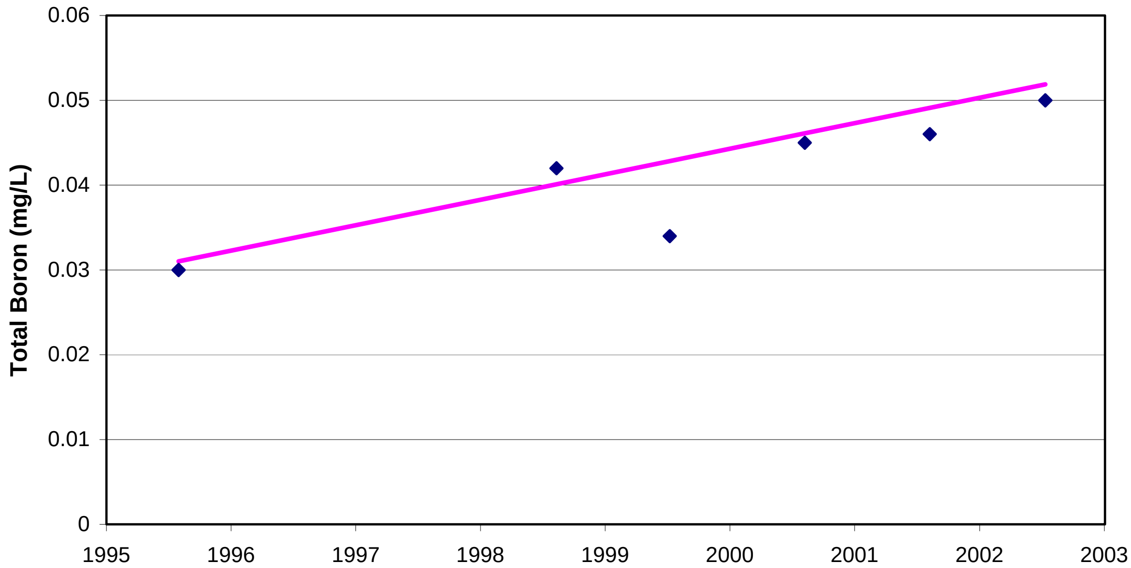


Figure 6.2 Temporal Variations in Boron Concentrations Observed in Shipyard Lake Based on Summer Sampling



The presence of significant temporal trends with respect to sulphate and boron concentrations in Shipyard Lake suggests that water quality in this wetland may have been affected by human activities within its watershed.

6.1.2 Poplar Creek and the MacKay River

No significant temporal variations were observed at the mouth of the MacKay River (Table 6.3). In Poplar Creek, pH levels were found to have significantly increased over time, even after accounting for variations in flow. The rate at which pH levels have been increasing over time was estimated at 0.02 pH units per year. However, as illustrated in Figure 6.3, available data for Poplar Creek represent two distinct time periods separated by a 10-year gap during which time no samples were collected. As such, the estimate rate of 0.02 pH units per year may be inaccurate.

It is recommended that RAMP wait until data scheduled for collection in the fall of 2003 are available prior to initiating any additional study of this watershed. After the 2003 field season, sufficient data will be available to repeat the analysis using data collected since 1996. This will eliminate the current reliance on the historical 1976 to 1985 dataset and provide a more relevant description of potentially significant temporal trends in Poplar Creek.

Table 6.3 Summary of Temporal Trends Observed in Poplar Creek and the MacKay River Based on Fall Water Quality Data, 1976 to 2002

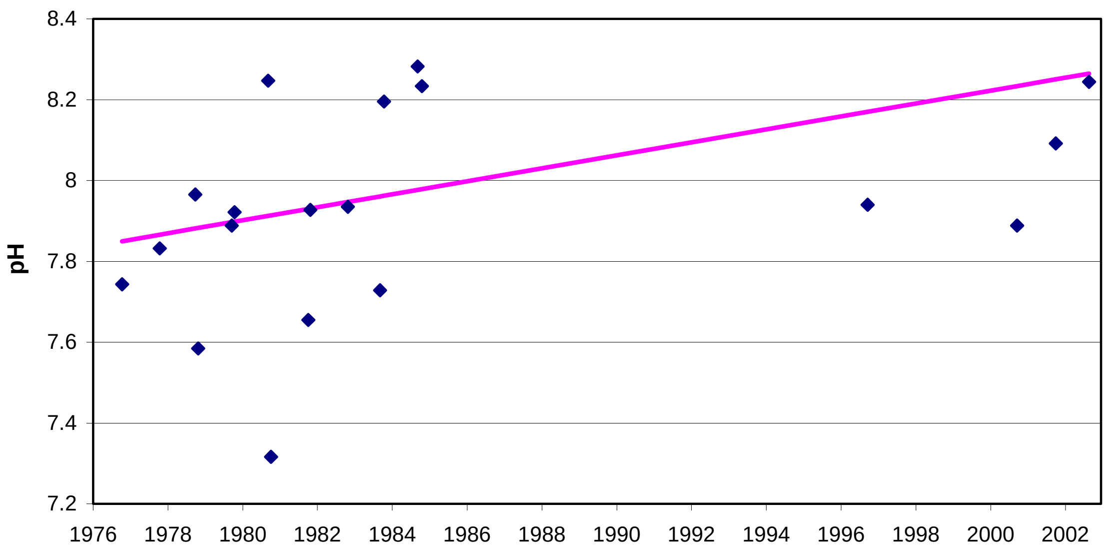
Location	Parameter	Sen's Slope (units/yr)[a,b]	Sample Size
mouth of Poplar Creek	dissolved organic carbon	-0.06	15
	pH[c]	**0.02 (0.02)**	20 (19)
	total alkalinity	2.39	20
	total dissolved solids	4.43	20
	total suspended solids	0.17	20
	sulphate	0.22	20
	total Kjeldahl nitrogen	0.01	14
	total phosphorus	0	20
	total aluminum	0.091	5
	total boron	0.005	5
	total chromium	0	7
mouth of the MacKay River	dissolved organic carbon	-0.25	12
	pH	-0.003	12
	total alkalinity	-0.48	12
	total dissolved solids	2.96	12
	total suspended solids	-0.13	12
	sulphate	0.36	12
	total Kjeldahl nitrogen	0.01	12
	total phosphorus	0	12
	total aluminum	0.045	5
	total boron	-0.003	5
	total chromium	-0.001	5

(a) Units are mg/L per year for all parameters, except pH (pH units/year).

(b) Significant slopes, which are indicative of significant temporal trends, are bolded ($p < 0.05$).

(c) Slope and sample size statistics developed after adjusting for variations in flow are shown in parentheses.

Figure 6.3 Temporal Variations in pH Levels Observed in Poplar Creek Based on Fall Sampling



Note: Concentrations have been adjusted to account for variations in flow following the methods outlined in IDT (1998).

6.1.3 Fort Creek and the Firebag River

Total Kjeldahl nitrogen concentrations at the mouth of the Firebag River varied significantly over time, although this trend was found to be related to variations in flow (Table 6.4). No significant temporal trends were observed at the mouth of Fort Creek.

Table 6.4 Summary of Temporal Trends Observed in Fort Creek and the Firebag River Based on Fall Water Quality Data, 1976 to 2002

Location	Parameter	Sen's Slope (units/yr)[a,b]	Sample Size[c]
mouth of Fort Creek	dissolved organic carbon	0	6
	pH	-0.007	6
	total alkalinity	-0.51	6
	total dissolved solids	-5.20	6
	total suspended solids	0.81	6
	sulphate	0.52	6
	total Kjeldahl nitrogen	0.002	6
	total phosphorus	-0.002	6
	total aluminum	0	6
	total boron	0.004	6
	total chromium	0	6

Table 6.4 Summary of Temporal Trends Observed in Fort Creek and the Firebag River Based on Fall Water Quality Data, 1976 to 2002 (continued)

Location	Parameter	Sen's Slope (units/yr)[a,b]	Sample Size[c]
mouth of the Firebag River	dissolved organic carbon	0.49	7
	pH	0.004	7
	total alkalinity	-0.75	7
	total dissolved solids	0.64	7
	total suspended solids	0.29	7
	sulphate	0.12	7
	total Kjeldahl nitrogen [d]	**0.41** (0.02)	7 (7)
	total phosphorus	-0.001	7
	total aluminum	-	-
	total boron	-	-
	total chromium	-	-

(a) Units are mg/L per year for all parameters, except pH (pH units/year).

(b) Significant slopes, which are indicative of significant temporal trends, are bolded ($p < 0.05$).

(c) - = insufficient samples available to meet minimum statistical requirements.

(d) Slope and sample size statistics developed after adjusting for variations in flow are shown in parentheses.

7 SEDIMENT QUALITY

As outlined in Section 3.3.3, the analysis of the RAMP sediment data set consisted of an examination of how sediment composition (i.e., sand, silt and clay content), metal content and/or polycyclic aromatic hydrocarbon (PAH) content correlate to observed sediment toxicity within the lower Athabasca River watershed. Principal Component Analysis (PCA) was used to reduce the number of parameters included in the sediment toxicity – sediment chemistry comparisons. In particular, one PCA was used to reduce the 26 metal parameters included in the standard RAMP test suite (Table 3.13) to two key Principal Components (PCs): metal PC1 and metal PC3. A second PCA was similarly used to reduce the PAH parameter list to two organic PCs: PAH PC1 and PAH PC2. Explicit pairwise Pearson correlations were then used to complete the investigation into how sediment chemistry and composition may influence the growth and survival of *Chironomus tentans*, *Hyalella azteca* and *Lumbriculus variegatus*, the three standard test species used by RAMP to assess sediment toxicity.

A description of the PCAs and the rationale used to identify key PCs is provided in Section 3.3.3. Included in that section are Tables 3.16 and 3.17, which provide a summary of the individual parameters represented by metal PC1, metal PC3, PAH PC1 and PAH PC2. Summaries of all of the sediment quality sampling data collected by RAMP in 2002 are provided in Appendix XI.

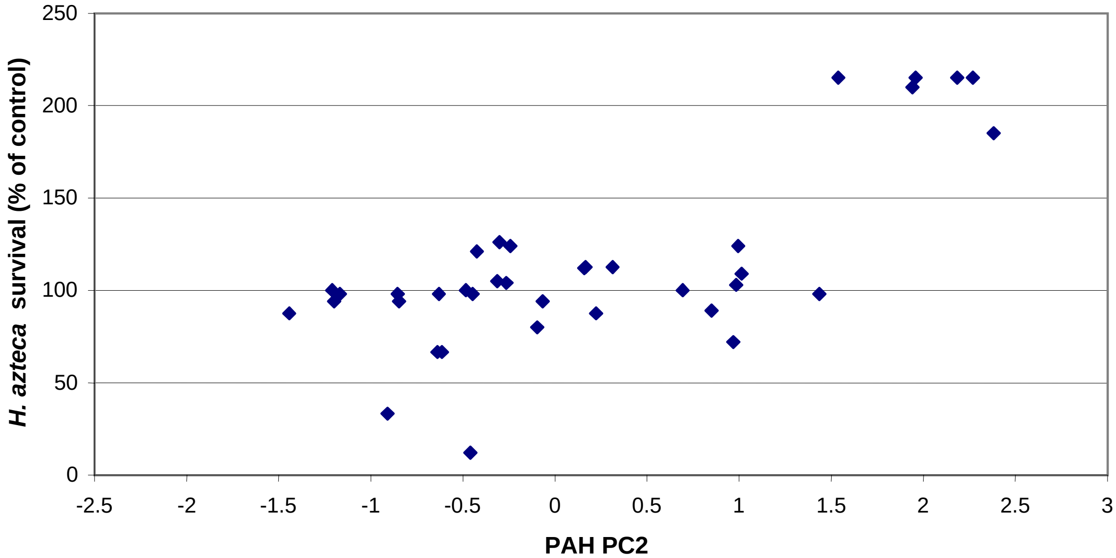
With respect to the results of the Pearson correlations, the survival of *H. azteca* was found to be significantly positively correlated to PAH PC2 when sediment toxicity was initially compared to sediment chemistry and composition using the entire sediment toxicity data set, including all non-toxic results (Table 7.1). The resulting relationship is presented in Figure 7.1.

Table 7.1 Correlation Between Parameters Describing Sediment Toxicity and Those Describing Sediment Composition and Chemistry - Based on Entire Sediment Toxicity Data Set

Parameter	*Chironomus tentans*[(a)]		*Hyalella azteca*[(a)]		*Lumbriculus variegatus*[(a)]	
	Survival	Growth	Survival	Growth	Survival	Growth
percent clay	-0.052 (48)	-0.192 (47)	-0.161 (48)	-0.271 (48)	0.193 (48)	-0.267 (48)
percent sand	0.011 (48)	0.241 (47)	-0.081 (48)	0.321 (48)	-0.273 (48)	0.219 (48)
percent silt	-0.013 (48)	-0.254 (47)	0.026 (48)	-0.325 (48)	0.301 (48)	-0.170 (48)
Metal PC1	0.147 (49)	-0.001 (48)	0.209 (49)	-0.020 (49)	0.191 (49)	-0.116 (49)
Metal PC3	-0.135 (49)	0.053 (48)	0.060 (49)	-0.122 (49)	-0.009 (49)	0.043 (49)
PAH PC1	-0.312 (37)	-0.049 (36)	-0.096 (37)	-0.142 (37)	0.249 (37)	-0.272 (37)
PAH PC2	-0.061 (37)	-0.276 (36)	**0.733** (37)	-0.428 (37)	0.325 (37)	-0.326 (37)

(a) Correlation coefficients are presented with sample numbers in parentheses. Significant correlations are bolded ($p < 0.05$).

Figure 7.1 Response in the Survival of *Hyalella azteca* to Variations in Naphthalene and C1 Substituted Naphthalene Concentrations as Represented by PAH PC2



When the Pearson correlation analysis was repeated using only those samples wherein a significant toxic response had been detected[1], the following significant correlations were observed (Table 7.2):

- *L. variegatus* survival was negatively correlated to sand content and positively correlated to silt and clay content;
- *L. variegatus* growth was negatively correlated to sand content and positively correlated to silt content, metal PC1 and PAH PC2; and
- *H. azteca* survival was positively correlated to metal PC3.

However, after adjusting for silt content, the positive correlation of *L. variegatus* growth to metal PC1 was no longer significant (Table 7.2). In contrast, the correlation of *L. variegatus* growth to PAH PC2 remained significant after adjusting for silt content. The resulting relationship is illustrated in Figure 7.2. The degree to which sand and silt content affected both the growth and survival of *L. variegatus* is illustrated in Figures 7.3 and 7.4, respectively. The positive correlation between *H. azteca* survival and metal PC3 is presented in Figure 7.5.

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[1] A significant toxic response is defined as a test result wherein the growth and/or survival of the test species was < 75% of that observed in the control sample (Golder 2002d). Sample sites where toxic responses have been observed include the mouths of McLean Creek, Fort Creek and the Ells, Clearwater, Steepbank and MacKay rivers, as well as Shipyard Lake, Isadore's Lake, the Athabasca Delta and the Athabasca River upstream of Donald Creek.

Table 7.2 Correlation Between Parameters Describing Sediment Toxicity and Those Describing Sediment Composition and Chemistry - Based on Only Those Samples That Exhibited a Toxic Response

Parameter	*Chironomus tentans*		*Hyalella azteca*		*Lumbriculus variegatus*[a]	
	Survival	Growth	Survival	Growth[b]	Survival	Growth[c]
percent clay	-0.083 (7)	0.297 (8)	-0.106 (10)	0.029 (4)	**0.921** (6)	0.533 (14)
percent sand	-0.048 (7)	-0.314 (8)	0.059 (10)	-0.324 (4)	**-0.924** (6)	**-0.669** (14)
percent silt	0.090 (7)	0.290 (8)	0.190 (10)	0.558 (4)	**0.901** (6)	**0.695** (14)
Metal PC1	0.337 (7)	0.663 (8)	-0.113 (10)	0.304 (4)	0.772 (6)	**0.637** / 0.217 (14)
Metal PC3	0.118 (7)	-0.378 (8)	**0.671** (10)	0.663 (4)	0.762 (6)	0.025 (14)
PAH PC1	-0.368 (4)	-0.695 (5)	-0.655 (5)	-	0.631 (6)	-0.034 (8)
PAH PC2	-0.013 (4)	-0.069 (5)	0.426 (5)	-	0.531 (6)	**0.894 / 0.842** (8)

(a) Correlation coefficients are presented with sample numbers in parentheses. Significant correlations are bolded ($p < 0.05$).

(b) - = insufficient samples available to meet minimum statistical requirements.

(c) With respect to metal PC1 and PAH PC2, correlation coefficients developed before and after adjusting for silt content are separated by a backslash (i.e., "/").

Figure 7.2 Response in the Growth of *Lumbriculus variegatus* to Variations in Naphthalene and C1 Substituted Naphthalene Concentrations as Represented by PAH PC2

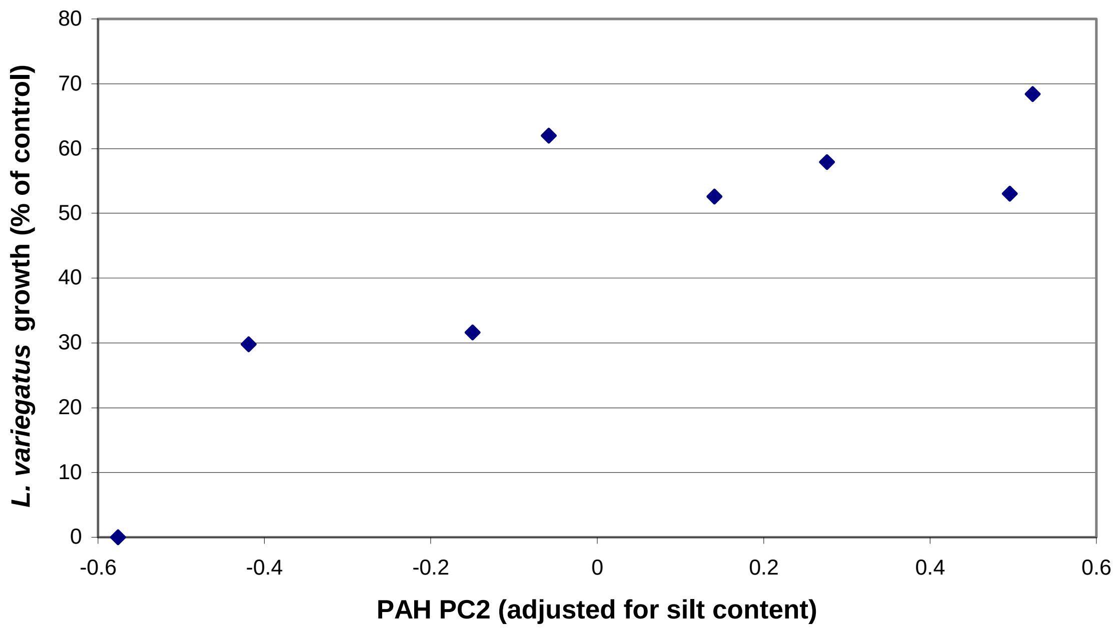


Figure 7.3 Response of *Lumbriculus variegatus* to Variations in Sand Content

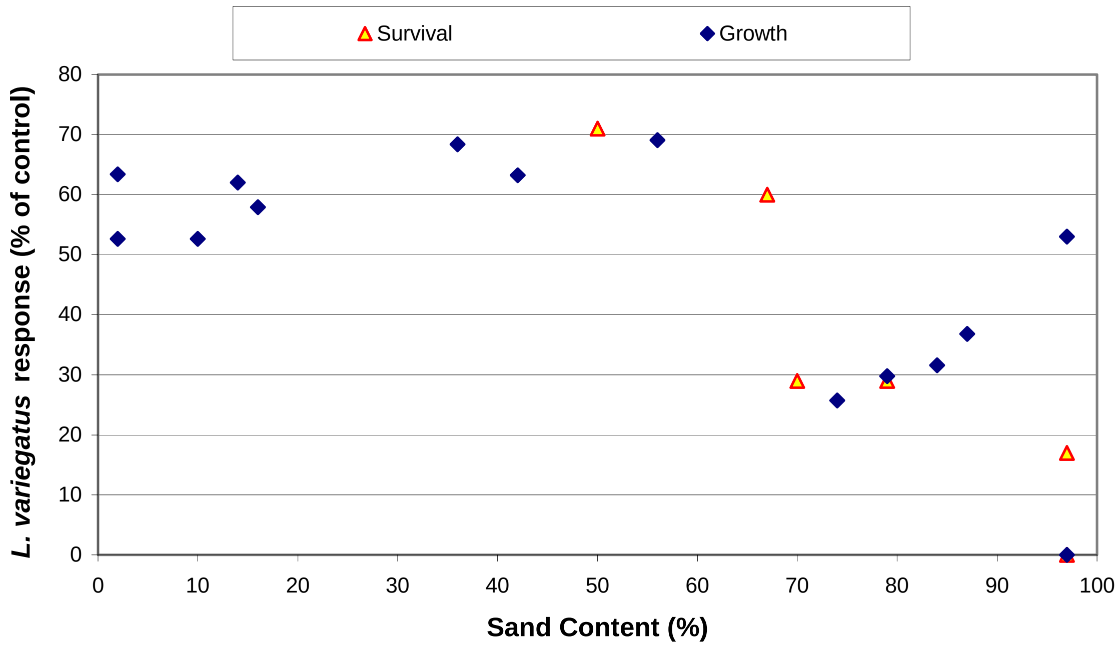


Figure 7.4 Response of *Lumbriculus variegatus* to Variations in Silt Content

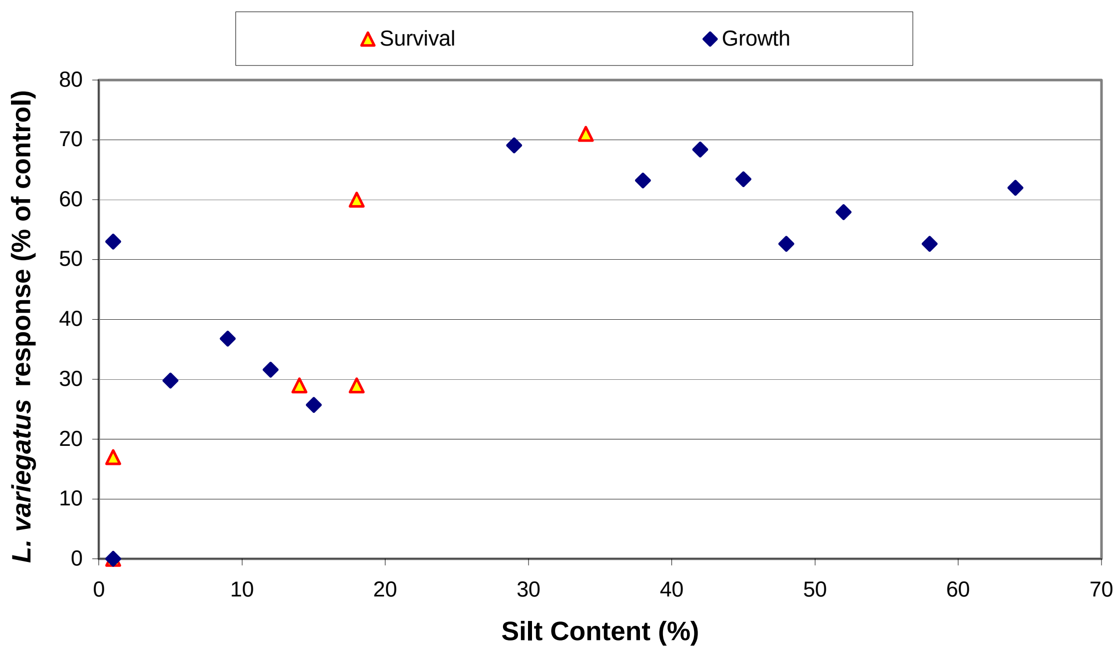
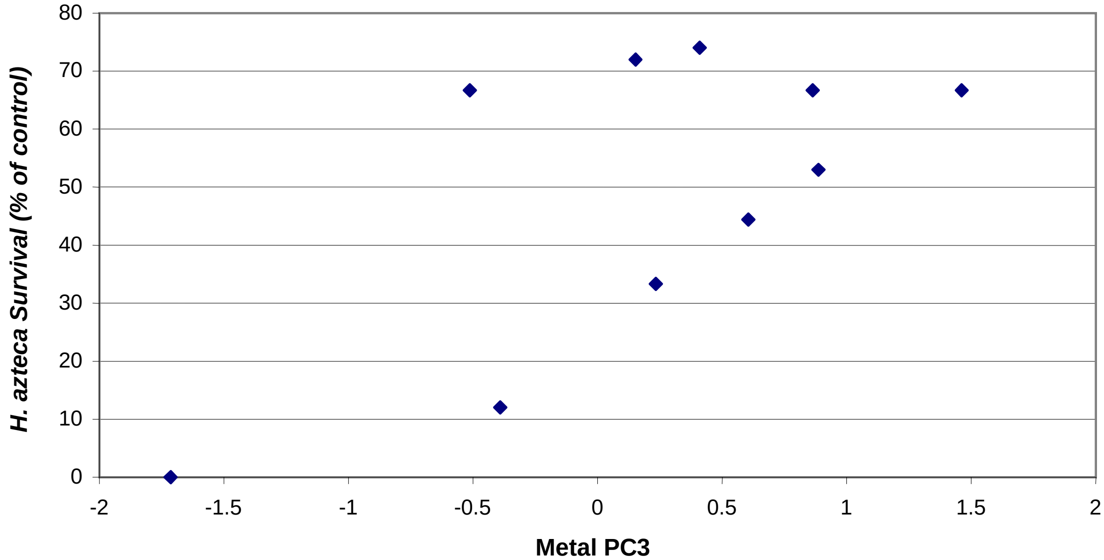


Figure 7.5 Response in the Survival of *Hyalella azteca* to Variations in Mercury and Molybdenum Concentrations as Represented[(a)] by Metal PC3



(a) Mercury and molybdenum concentrations are negatively correlated with Metal PC3.

The significant correlations observed between *L. variegatus* growth and survival and sediment composition are likely a reflection of this organism's habitat requirements. As discussed in Golder (2002d), *L. variegatus* typically tunnel in the upper zone of bed sediment. For these organisms to survive and thrive, sediment composition must be such that created tunnels do not collapse. Sediments that contain high amounts of sand with little clay and/or silt tend to be more fluid than those containing greater amounts of silt and/or clay. As a result, tunnels created in sediment with high sand content would be more likely to collapse than in those created in sediments with lower sand and higher silt content.

As presented in Table 3.16 (Section 3.3.3.2), molybdenum and mercury are negatively correlated to metal PC3. Therefore, the significant positive correlation of *H. azteca* survival and metal PC3 suggests that these species may be negatively influenced by mercury and/or molybdenum, due to the inverse relationship of these metals to metal PC3.

The positive correlations observed between *L. variegatus* growth and PAH PC2 and *H. azteca* survival and PAH PC2 (based on entire sediment toxicity data set) were unexpected. As discussed in Section 3.3.3, naphthalene and C1 substituted naphthalene were found to be significantly, positively correlated to PAH PC2

8 BENTHIC INVERTEBRATE COMMUNITY

The rationale for sampling benthic invertebrates is provided in Section 2.1.3. Monitoring of Athabasca River tributaries mostly focused on the lower river reaches to allow detection of the cumulative effects of all developments within each basin. Both upper and lower reaches were sampled in some rivers to increase the amount of reference site data and allow future upstream-downstream comparisons. In lakes, sampling effort was distributed over the entire open-water area of a lake, but was restricted by depth.

The fall 2002 benthic invertebrate program consisted of sampling the following locations:

- three depositional sites in the Athabasca River delta (samples were analyzed from two of these sites);
- lower depositional reach of the Calumet River (samples were lost during shipping from Fort McMurray to Calgary);
- lower and upper depositional reaches in the Christina River;
- depositional reaches in the Clearwater River upstream and downstream of the Christina River;
- lower depositional reach of the Ells River;
- lower and upper erosional reaches in the MacKay River;
- lower erosional reach, and middle and upper depositional reaches in the Muskeg River;
- lower erosional reach of the Steepbank River;
- lower depositional reach of the Tar River;
- lower depositional reach of the Fort Creek;
- lower depositional reach of the Jackpine Creek;
- Kearl Lake;
- McClelland Lake; and
- Shipyard Lake.

Sampling site locations, habitat sampled and methods are provided in Section 3.4. Consistent with the scope described in Section 1.2.4 data summaries were generated for the Athabasca River delta, the MacKay, Muskeg and Steepbank rivers, Fort Creek and Shipyard Lake. All benthic invertebrate data collected by RAMP in 2002, including supporting variables, are provided in Appendix XII.

8.1 ATHABASCA RIVER DELTA

8.1.1 Habitat Characteristics

The two sites selected for analysis of benthic invertebrate samples were similar in terms of habitat characteristics. Both sites were in run habitat of 1.5 to 2 m depth, with predominantly sand and silt sediments (Table 8.1). Total organic carbon (TOC) in the sediment was low at both sites (<2%) and field water quality measurements were similar. The only appreciable difference between these sites was the difference in macrophyte cover: no macrophytes were observed in the Fletcher Channel, whereas a 20% cover was present in the Goose Island Channel.

Table 8.1 Habitat Characteristics of Depositional Sites in the Athabasca River Delta, Fall 2002

Variable	Units	Fletcher Channel	Goose Island Channel
sample date	-	Sept. 12, 2002	Sept. 12, 2002
habitat	-	run	run
water depth	m	1.5	1.5 - 2.0
current velocity	m/s	0	0
macrophyte cover	%	0	20
Field Water Quality			
dissolved oxygen	mg/L	10.1	9.6
conductivity	µS/cm	245	244
pH	-	7.9	7.9
water temperature	^oC	14.25	15.3
Sediment Composition			
sand	%	51	32
silt	%	35	46
clay	%	14	22
total organic carbon	%	1	1.7

Note: - = Not applicable.

8.1.2 Benthic Community

The original objective of this study component was to examine the benthic community in both the least and the most toxic bottom sediments in the Athabasca River Delta, based on toxicity data collected from three sites in fall 2002. Reduced growth and survival of the bristle worm *Lumbriculus variegatus* was observed in bottom sediments from the Fletcher Channel in 2001

(Golder 2002c). Sediment and benthic invertebrates were sampled simultaneously from three sites in 2002, including one in each of the Big Point Channel, the Fletcher Channel and the Goose Island Channel.

The 2002 data showed no toxicity at any of these sites (Table XI.1, Appendix XI), but the Benthic Invertebrate Subgroup of the Technical Subcommittee decided to proceed with analysis of samples from two of the three sites to begin collecting baseline data for the Athabasca Delta. The sites located in the Fletcher Channel and the Goose Island Channel were selected for analysis of benthic invertebrate samples based on the 2001 sediment toxicity results. In 2001, the most toxic sediment occured in the Fletcher channel, where survival of *Lumbriculus variegatus* was 29% (there was no toxicity to other test organisms). The lowest degree of toxicity (i.e., highest survival expressed as % of control values) was found in the Goose Island Channel in 2001 based on all tests combined.

The site in the Fletcher Channel supported a community of lower total abundance and richness compared to the community in the Goose Island Channel (Figure 8.1). Community composition at the major group level was also more diverse in the Goose Island Channel. Most of the common taxa were the same at both sites (Tables 8.2 and 8.3). The greater abundance and richness in the Goose Island Channel may be a reflection of the presence of macrophytes at that site. Overall, the two sites supported similar benthic communities.

Figure 8.1 Total Invertebrate Abundance, Richness and Community Composition at Depositional Sites in the Athabasca River Delta, Fall 2002

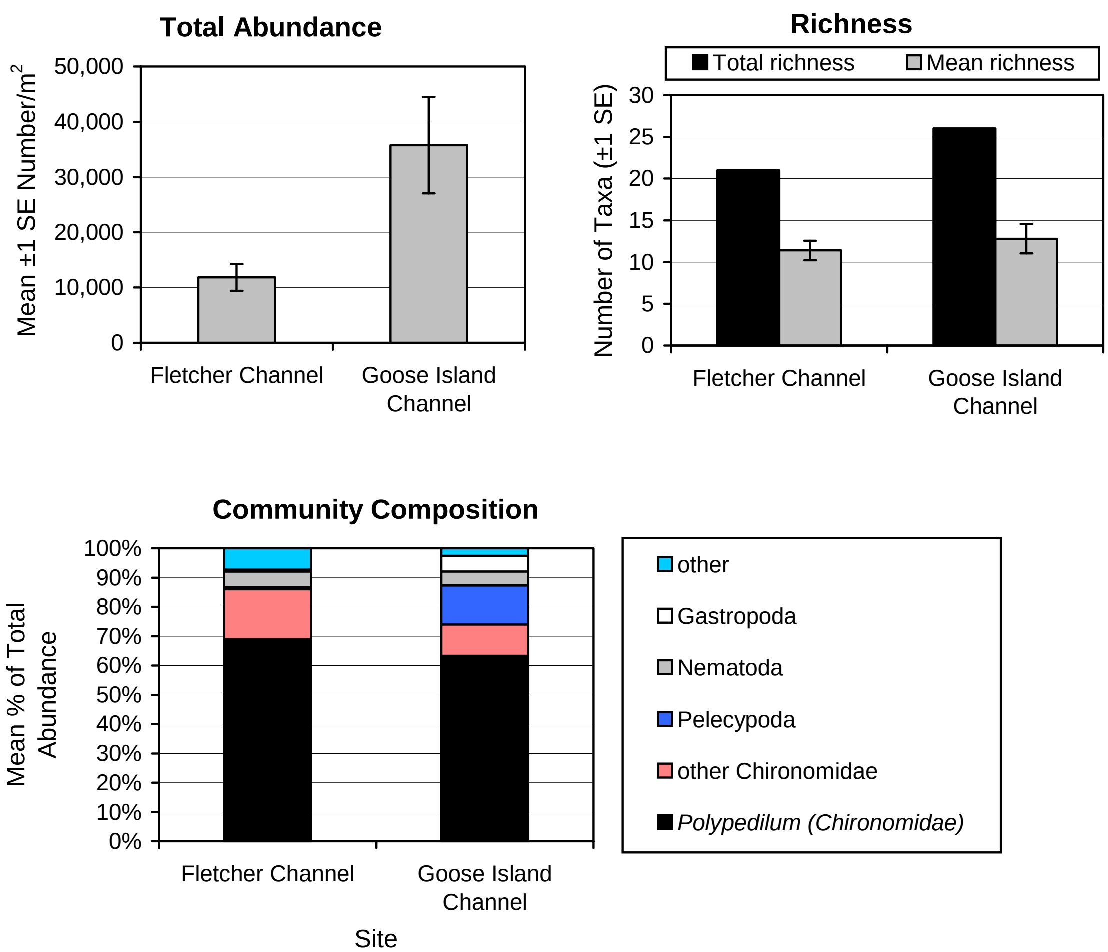


Table 8.2 Abundances of Common Invertebrates in Fletcher Channel of the Athabasca River Delta, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Polypedilum	Chironomidae	8,161	1,806	69.0
Paralauterborniella	Chironomidae	886	254	7.5
Nematoda	Nematoda	645	248	5.5
Paracladopelma	Chironomidae	464	140	3.9
Ostracoda	Ostracoda	310	192	2.6
Ceratopogoninae	Ceratopogonidae	232	113	2.0
Tubificidae	Oligochaeta	206	132	1.7
Cryptochironomus	Chironomidae	181	52	1.5
Procladius	Chironomidae	163	93	1.4
Microchironomus	Chironomidae	138	71	1.2
total % for common taxa				(96.2)
total abundance		11,834	2,418	-
richness		11.4	1.2	-
total richness		21	-	-

Table 8.3 Abundances of Common Invertebrates in Goose Island Channel in the Athabasca River Delta, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Polypedilum	Chironomidae	22,627	7,291	63.2
Sphaeridae	Pelecypoda	4,756	2,356	13.3
Probithinella[(a)]	*Gastropoda*	1,901	799	5.3
Nematoda	Nematoda	1,720	598	4.8
Paralauterborniella	Chironomidae	1,453	292	4.1
Procladius	Chironomidae	1,144	494	3.2
Paracladopelma	Chironomidae	550	333	1.5
Ostracoda	Ostracoda	482	324	1.3
total % for common taxa				(96.8)
total abundance		35,776	8,745	-
richness		12.8	1.8	-
total richness		26	-	-

(a) Tentative identification.

8.2 MACKAY, MUSKEG AND STEEPBANK RIVERS

8.2.1 Erosional Habitat

8.2.1.1 Habitat Characteristics

The MacKay, Muskeg and Steepbank rivers are of medium size, with wetted channel widths generally between 15 and 50 m during the fall low-flow period in 2002 (Table 8.4; detailed supporting data in Appendix XII). Erosional reaches were characterized by similar ranges in current velocity (0.3 to 0.8 m/s), with generally higher velocities in the Steepbank River. Depth varied from 0.2 to 0.5 m, corresponding to the depth range that can be sampled by the Neill cylinder (0.2 to 0.6 m). All sites were in run or riffle habitat and macrophytes were absent.

The substratum was dominated by sand, gravel and small cobbles in the lower MacKay and Steepbank rivers (Table 8.4). The reaches sampled in the upper MacKay and lower Muskeg rivers had a larger average substrate particle size due to higher percentages of large cobbles. The mean benthic algal biomass on cobble surfaces was lowest in the Steepbank River, intermediate in the Muskeg and lower MacKay rivers and highest in the upper MacKay River. Field water quality measurements were typical of rivers and streams in the region and varied little among the rivers sampled.

The habitat data indicate that all three rivers represented high quality erosional habitat for benthic invertebrates during the fall of 2002.

Table 8.4 Habitat Characteristics of Erosional Sampling Reaches in the MacKay, Muskeg and Steepbank Rivers, Fall 2002

Variable	Units	Lower MacKay River Mean (range)	Upper MacKay River Mean (range)	Muskeg River Mean (range)	Steepbank River Mean (range)
sample date	-	Sept. 13, 2002	Sept. 17, 2002	Sept. 19, 2002	Sept. 16, 2002
habitat	-	run / riffle	riffle	run / riffle	run / riffle
wetted channel width	m	42 (20 - 57)	43 (38 - 52)	24 (13 - 42)	28 (20 - 44)
bankfull channel width	m	55 (35 - 71)	57 (46 - 68)	38 (24 - 65)	46 (23 - 59)
water depth	m	0.4 (0.3 - 0.5)	0.4 (0.3 - 0.5)	0.3 (0.3 - 0.4)	0.4 (0.2 - 0.5)
current velocity	m/s	0.61 (0.30 - 0.75)	0.60 (0.32 - 0.76)	0.66 (0.51 - 0.82)	0.73 (0.61 - 0.81)
macrophyte cover	%	0	0	0	0
Field Water Quality					
dissolved oxygen	mg/L	10.4 (9.6 - 10.8)	11.3 (10.5 - 11.9)	10.4 (10.2 - 10.8)	11.0 (10.6 - 11.4)
conductivity	µS/cm	176 (169 - 179)	147 (142 - 151)	170 (168 - 172)	108 (104 - 110)
pH	-	7.4 (7.2 - 7.7)	7.8 (7.2 - 8.2)	7.4 (7.1 - 7.6)	7.4 (7.2 - 7.5)
water temperature	^{o}C	13.9 (12.8 - 14.5)	12.9 (11.5 - 14.1)	11.8 (11.3 - 12.1)	10.6 (10.2 - 11.3)
Benthic Algae					
benthic algal chlorophyll *a* (15 samples/river)	mg/m^2	36 (4 - 100)	94 (61 - 150)	23 (8 - 39)	16 (1 - 58)
Substrate					
sand/silt/clay	%	24 (15 - 30)	19 (15 - 25)	19 (10 - 30)	16 (10 - 25)
small gravel	%	21 (15 - 30)	9 (5 - 15)	13 (5 - 25)	20 (10 - 25)
large gravel	%	33 (20 - 40)	16 (10 - 25)	17 (5 - 25)	28 (20 - 40)
small cobble	%	15 (0 - 25)	28 (20 - 40)	27 (15 - 45)	32 (25 - 40)
large cobble	%	8 (0 - 30)	22 (10 - 35)	21 (0 - 35)	4 (0 - 15)
boulder	%	0 (0 - 0)	6 (0 - 15)	4 (0 - 10)	1 (0 - 5)
weighted average index	-	3.6 (3.2 - 4.1)	4.4 (4.1 - 4.8)	4.4 (4.0 - 4.9)	3.9 (3.7 - 4.4)

Note: - = Not applicable or no data.

8.2.1.2 Benthic Community

As in previous years of monitoring, total benthic invertebrate abundance was lowest in the Steepbank River, where mean abundance was <2000 organisms/m^2 in 2002 (Figure 8.2; raw data in Appendix XII). Total abundance was intermediate in the Muskeg River and highest in the MacKay River (Figures 8.3 and 8.4, respectively). In particular, the upper reach in the MacKay River, which also had the highest benthic algal biomass based on the chlorophyll *a* data (Table 8.4), supported the highest numbers of invertebrates.

Total abundance varied without an apparent trend over time in all three rivers (Figures 8.2, 8.3 and 8.4). Assessment of temporal trends is complicated by differences in sampling design among surveys. Single sites were sampled in years prior to 1998, three distinct sites were sampled in 1998 and 4 to 6 km long reaches were sampled in 2000 and thereafter, suggesting that direct comparisons of the post 1998 data with the previous data are not appropriate.

Figure 8.2 Total Invertebrate Abundance, Richness and Community Composition in the Steepbank River, Fall 1995 to 2002

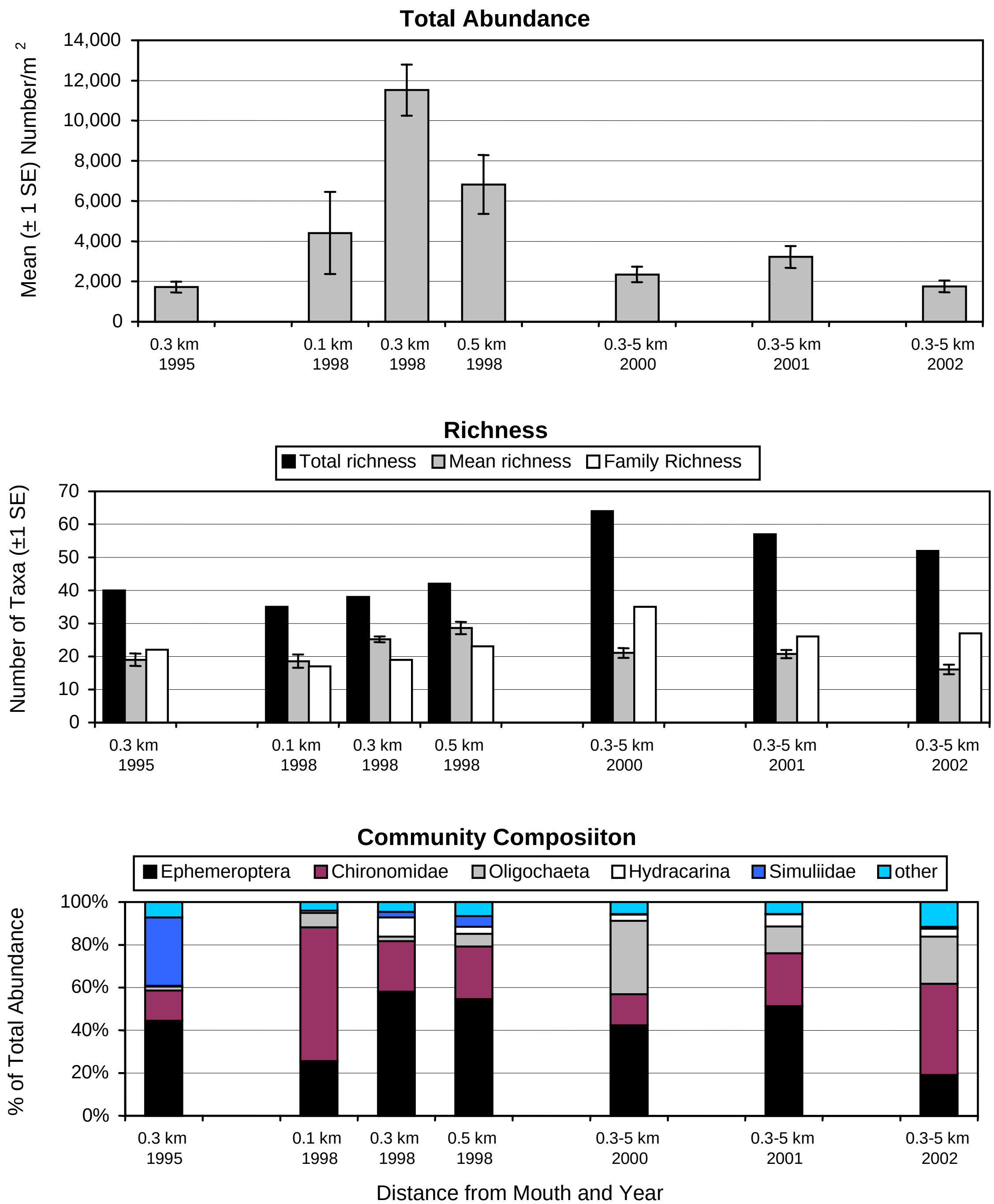


Figure 8.3 Total Invertebrate Abundance, Richness and Community Composition in Erosional Sampling Reaches of the Muskeg River, Fall 1979 to 2002

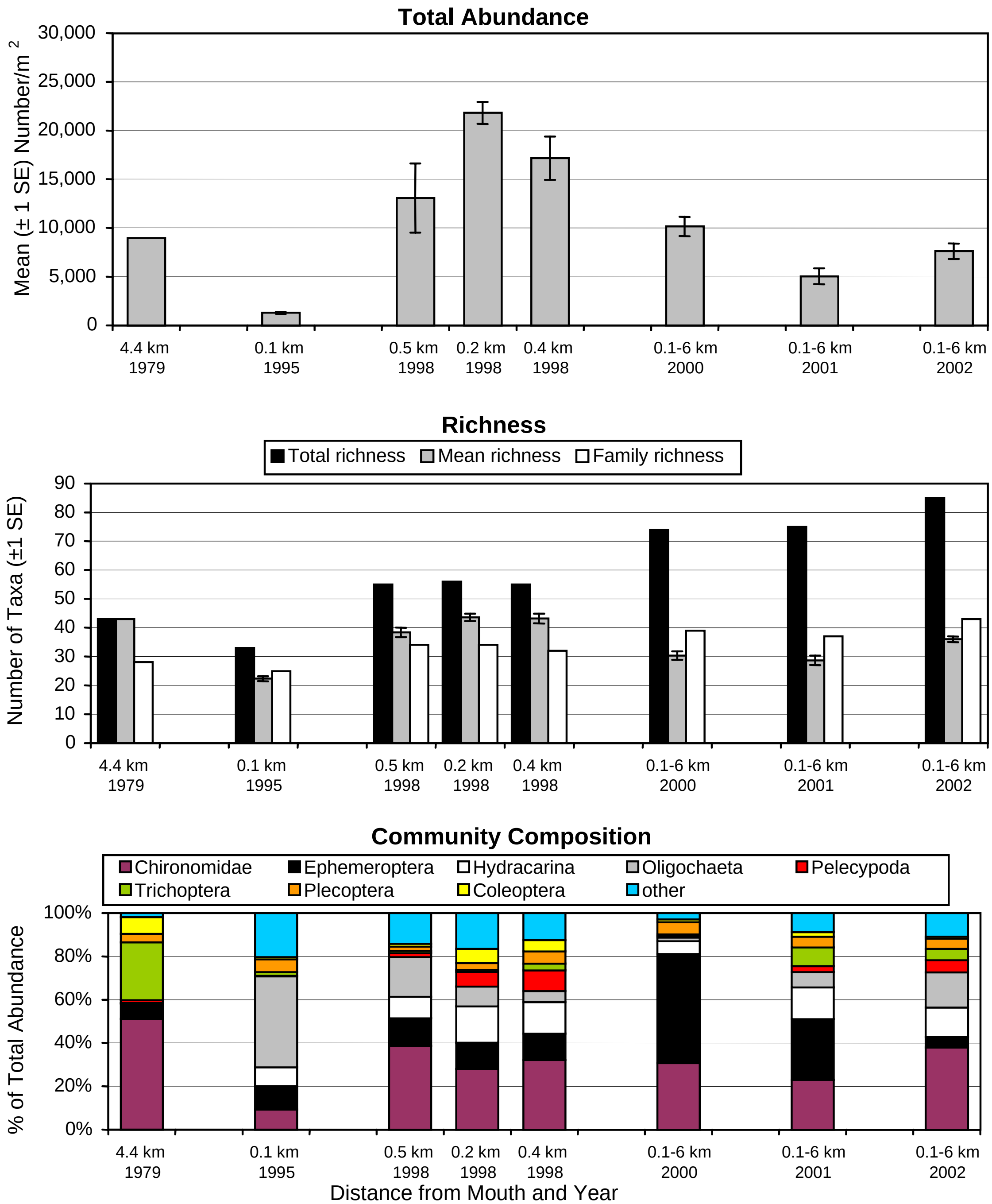
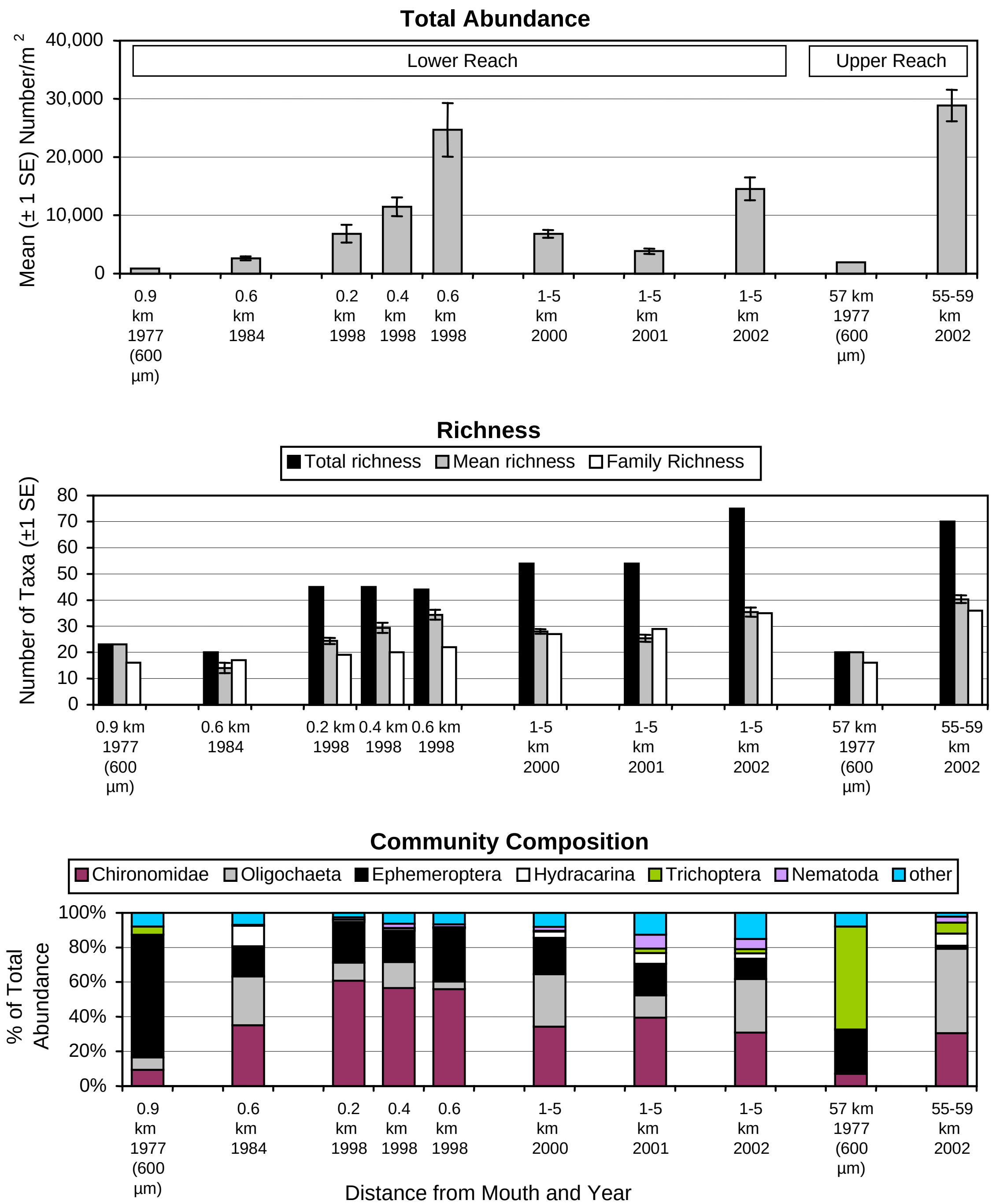


Figure 8.4 Total Invertebrate Abundance, Richness and Community Composition in the MacKay River, Fall 1977 to 2002



Taxonomic richness was less variable among years and rivers than total abundance (Figures 8.2 to 8.4). In the MacKay and Muskeg rivers, taxonomic richness was highest in fall 2002 compared to previous years. Although highest richness was observed in 2002, the apparent increasing trend in richness over time in these rivers is an artifact of the differences in sampling design among years (i.e., greater spatial coverage in recent years has resulted in a larger number of taxa). In the Steepbank River, richness was lower in 2002 than in the two previous years with comparable data (2000 and 2001). As in previous years of monitoring, the Muskeg River supported the most diverse benthic fauna of the three rivers, with over 80 taxa in the lower erosional reach.

Taxonomic composition at the level of major taxon showed some consistent patterns within rivers (Figures 8.2 to 8.4). The benthic faunas of the MacKay and Steepbank rivers were usually dominated by midges (Chironomidae), bristle worms (Oligochaeta) and mayflies (Ephemeroptera), with a generally higher percentage of mayflies in the Steepbank River. Exceptions included the upper site in the MacKay River in 1977, where caddisflies (Trichoptera) were also dominant (Figure 8.4) and the lower Steepbank River in 1995, where blackflies (Simuliidae) were abundant (Figure 8.2). The unusual communities observed at both locations in the MacKay River in 1977 (i.e., low percentage of Chironomidae; Figure 8.4) most likely resulted from using a sampling device with a larger mesh net (600 µm) compared to all other surveys (250 µm). Benthic communities in the Muskeg River were more diverse than those in the MacKay and Steepbank rivers, even at the level of major taxon (Figure 8.3). Although midges, mayflies and bristle worms were dominant in this river as well, a number of other groups were also abundant, including water mites (Hydracarina), fingernail clams (Pelecypoda), caddisflies (Trichoptera), stoneflies (Plecoptera) and beetles (Coleoptera).

At the level of individual taxa, the dominant organisms (operationally defined as those accounting for ≥5% of total abundance) in the lower MacKay River included two bristle worm families (Naididae and Enchytraeidae), the mayfly *Baetis*, two midge genera, roundworms (Nematoda) and ostracods (Ostracoda) (Table 8.5). Only one of these taxa (Naididae) was dominant in the upper reach, where dominant organisms also included midges and water mites (Table 8.6). Nearly half of the community in the upper reach consisted of bristle worms. Bristle worms (Naididae), water mites and four midge genera were dominant in the lower Muskeg River (Table 8.7). In addition to midges and bristle worms, the mayfly *Baetis* was also dominant in the lower Steepbank River (Table 8.8).

There were few significant correlations between habitat variables and benthic community variables (Table 8.9). There were no significant correlations in the Muskeg River. Total abundance and richness were weakly correlated with chlorophyll *a* in the Steepbank River. Abundances of a number of individual taxa were also positively correlated with chlorophyll *a* in the MacKay and Steepbank Rivers, whereas the abundance of enchytraeid bristle worms was negatively correlated with this variable. The abundance of the midge *Sublettea* was negatively correlated with current velocity. Total abundance in the upper MacKay River, naidid bristle worm abundance in the lower MacKay River and tubificid bristle worm abundance in the Steepbank River were correlated with substrate particle size (expressed as the weighted average index [WAI]). Visual examination of scatter-plots revealed that correlations in the lower MacKay River were very weak, frequently resulting from single atypical points with high leverage on the analysis. The directions of significant correlations in the Steepbank and upper MacKay rivers were consistent with expected directions based on habitat preferences, with the exception of the positive correlation between substrate particle size and tubificid worm abundance in the Steepbank River.

Table 8.5 Abundances of Common Invertebrates in the Lower MacKay River, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Naididae	Oligochaeta	3,480	822	23.9
Baetis	Ephemeroptera	1,376	246	9.5
Tanytarsus	Chironomidae	1,045	268	7.2
Ostracoda	Ostracoda	922	263	6.3
Nematoda	Nematoda	840	195	5.8
Enchytraeidae	Oligochaeta	769	306	5.3
Thienemannimyia complex	Chironomidae	661	139	4.5
Hydracarina	Hydracarina	441	116	3.0
Hemerodromia	Empididae	411	81	2.8
Rheotanytarsus	Chironomidae	337	97	2.3
Polypedilum	Chironomidae	287	97	2.0
Tvetenia	Chironomidae	268	93	1.8
Hydropsyche	Trichoptera	254	76	1.7
Tubificidae	Oligochaeta	249	96	1.7
Stempellina	Chironomidae	224	66	1.5
Stempellinella	Chironomidae	198	61	1.4
Planorbidae	Gastropoda	193	85	1.3
Ophiogomphus	Anisoptera	161	46	1.1
Saetheria	Chironomidae	161	104	1.1
Tanypodinae	Chironomidae	153	30	1.1
Tanytarsini	Chironomidae	143	49	1.0
Hydra	Hydrozoa	139	43	1.0
total % for common taxa				(87.4%)
total abundance		14,550	1,975	-
richness		35.4	1.7	-
total richness		75	-	-

Table 8.6 Abundances of Common Invertebrates in the Upper MacKay River, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Naididae	Oligochaeta	13,778	1,653	47.7
Sublettea	Chironomidae	2,017	312	7.0
Hydracarina	Hydracarina	1,994	262	6.9
Lopescladius	Chironomidae	1,061	296	3.7
Rheotanytarsus	Chironomidae	1,046	282	3.6
Nematoda	Nematoda	991	201	3.4
Psychomyia	Trichoptera	859	156	3.0
Cladotanytarsus	Chironomidae	841	365	2.9
Tanytarsus	Chironomidae	683	124	2.4
Saetheria	Chironomidae	633	254	2.2
Thienemannimyia complex	Chironomidae	469	107	1.6
Orthocladiinae	Chironomidae	450	211	1.6
Hydropsyche	Trichoptera	386	116	1.3
Tvetenia	Chironomidae	386	87	1.3
Baetis	Ephemeroptera	345	61	1.2
total % for common taxa				(89.9%)
total abundance		28,863	2,699	-
richness		40.3	1.5	-
total richness		70	-	-

Table 8.7 Abundances of Common Invertebrates in the Erosional Sampling Reach of the Muskeg River, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Naididae	Oligochaeta	1,135	440	14.9
Hydracarina	Hydracarina	1,044	136	13.7
Micropsectra	Chironomidae	853	156	11.2
Lopescladius	Chironomidae	718	261	9.4
Pisidium/Sphaerium	Pelecypoda	431	100	5.7
Rheotanytarsus	Chironomidae	398	138	5.2
Baetis	Ephemeroptera	279	66	3.7
Chloroperlidae	Plecoptera	274	48	3.6
Ostracoda	Ostracoda	227	68	3.0
Stempellinella	Chironomidae	208	70	2.7
Nematoda	Nematoda	193	67	2.5
Hemerodromia	Empididae	186	28	2.4
Protoptila	Trichoptera	169	51	2.2
Polypedilum	Chironomidae	128	30	1.7
Stempellina	Chironomidae	84	34	1.1
Optioservus	Coleoptera	79	17	1.0
Brachycentrus	Trichoptera	78	21	1.0
Thienemannimyia complex	Chironomidae	76	16	1.0
Lepidostoma	Trichoptera	75	21	1.0
total % for common taxa				(87.1%)
total abundance		7,613	792	-
richness		36.0	1.0	-
total richness		85	-	-

Table 8.8 Abundances of Common Invertebrates in the Steepbank River, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Rheotanytarsus	Chironomidae	262	104	14.9
Baetis	Ephemeroptera	227	40	12.9
Cricotopus/Orthocladius	Chironomidae	199	39	11.3
Tubificidae	Oligochaeta	178	63	10.1
Enchytraeidae	Oligochaeta	166	44	9.5
Hemerodromia	Empididae	84	18	4.8
Saetheria	Chironomidae	82	26	4.7
Polypedilum	Chironomidae	66	17	3.8
Hydracarina	Hydracarina	65	29	3.7
Naididae	Oligochaeta	42	17	2.4
Tricorythodes	Ephemeroptera	39	22	2.2
Nematoda	Nematoda	29	13	1.6
Chelifera	Empididae	29	11	1.6
Ephemerellidae	Ephemeroptera	24	16	1.4
Orthocladiinae	Chironomidae	23	12	1.3
Thienemannimyia complex	Chironomidae	21	18	1.2
Demicryptochironomus	Chironomidae	21	9	1.2
Tvetenia	Chironomidae	21	9	1.2
Acentrella	Ephemeroptera	18	7	1.0
total % for common taxa				(90.8%)
total abundance		1,757	292	-
richness		16.1	1.4	-
total richness		52	-	-

Table 8.9 Correlations Between Benthic Community Variables and Habitat Variables in Erosional Habitat in the MacKay, Muskeg and Steepbank Rivers, Fall 2002

Benthic Community Variable	Current Velocity	Chorophyll *a*	WAI[(a)]
Lower MacKay River (*n*=15)			
Naididae abundance	-	0.535*	-0.521*
Tanytarsus abundance	-	0.529*	-
Enchytraeidae abundance	-	-0.545*	-
Upper MacKay River (*n*=15)			
total abundance	-	-	0.688**
Sublettea abundance	-0.562*	0.706***	
Steepbank River (*n*=15)			
total abundance	-	0.539*	-
richness	-	0.530*	-
Cricotopus/Orthocladius abundance	-	0.631*	-
Tubificidae abundance	-	-	0.660**

(a) WAI = weighted average index of substrate particle size.

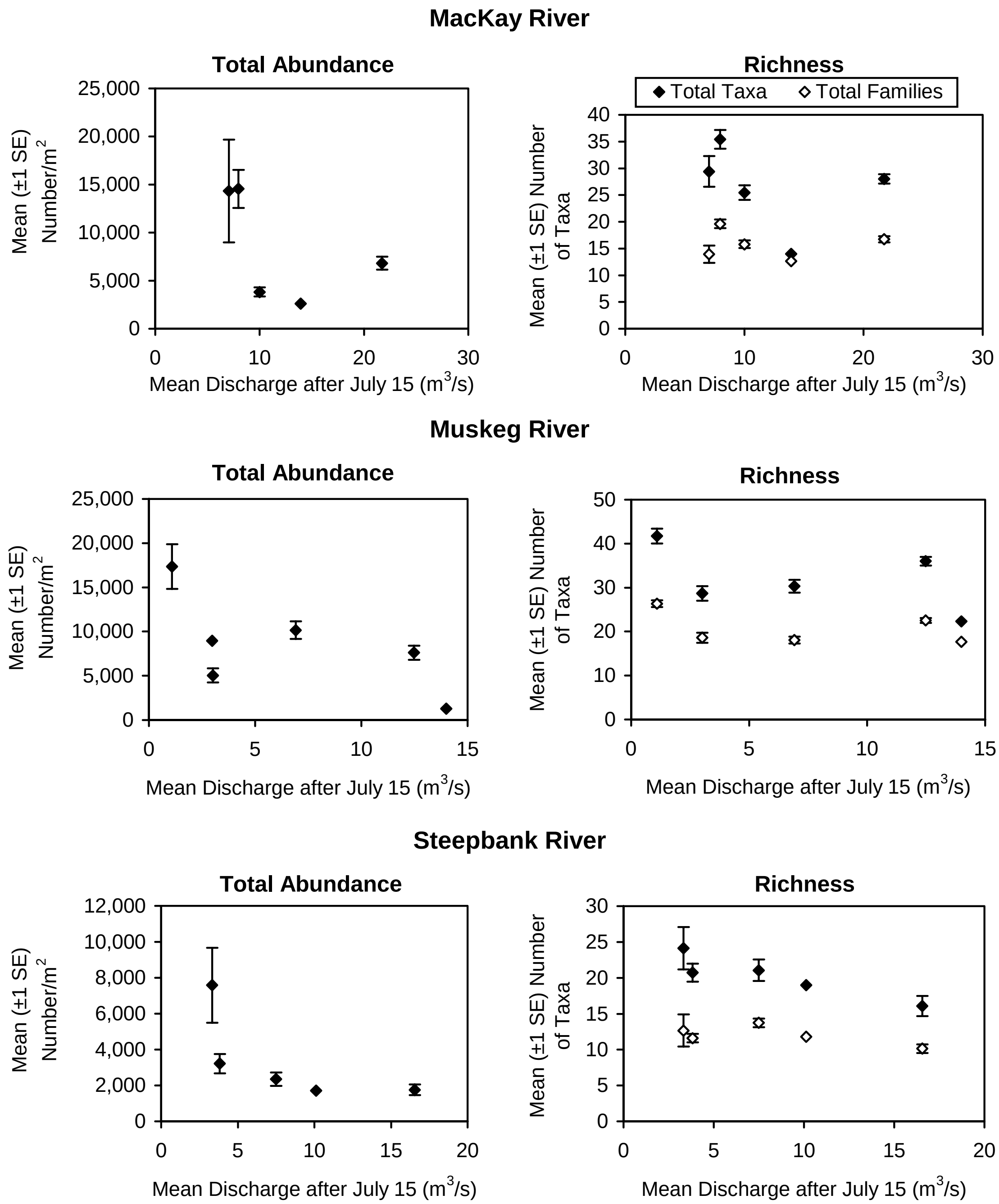
Notes: Spearman rank correlation coefficients (r_S) shown.
Symbols below correspond to unadjusted probability values:
- = no significant correlation; P>0.05;
* = significant correlation; P<0.05;
** = significant correlation; P<0.01;
*** = significant correlation; P<0.005.

The relationship between river discharge and major benthic community variables (total abundance and richness) was also examined to investigate the possibility that the year-to-year variation in benthic community characteristics is related to hydrological factors. Mean discharge was calculated for each river and each year with available benthic community data, based on daily flows from July 15 to the sampling date in the fall (usually a two month period). This period was considered relevant for the following reasons:

- It excludes the spring freshet and early summer high flows from which communities present in the fall may have recovered previously.
- It represents the time elapsed since emergence and subsequent egg deposition by insects with the slow-seasonal life cycle (as described for the Oil Sands Region by Barton and Wallace 1980). These include a number of common mayflies, which were a major component of the benthic communities of the rivers included in the analysis, as documented by fall surveys.
- It encompasses one to several generations of midges, which constitute another major component of the benthic communities of the rivers included in the analysis.

The plots of total abundance and richness versus flow suggest that flow may influence total abundance, but not richness. Each data point in Figure 8.5 represents one year's data (fall season only; same mesh size); reach means based on RAMP surveys are identified by error bars, whereas site means from previous surveys do not have error bars. Declining trends in total abundance were apparent with increasing flow in all thee rivers (Figure 8.5), suggesting the build-up of algae and lack of scouring in low flow years may allow the development of communities with greater abundances. A similar trend was apparent in richness at the lowest level of taxonomy in the Steepbank River (Total Taxa in Figure 8.5). However, there were no trends in any of the rivers after adjusting the lowest level of taxonomy to family to achieve consistency among studies (Total Families in Figure 8.5).

Figure 8.5 Relationships Between Total Abundance, Richness and River Discharge in Erosional Habitat in the MacKay, Muskeg and Steepbank Rivers, Fall 2002



8.2.2 Depositional Habitat

8.2.2.1 Habitat Characteristics

The Muskeg River is of medium size, with a wetted channel width between 10 and 35 m in its depositional reaches during the fall low-flow period in 2002 (Table 8.10; detailed supporting data in Appendix XII). The depositional reaches were deeper and had a narrower channel compared to the lower erosional reach (Table 8.4). Physical features of the two depositional reaches were similar. Mean current velocity was close to zero and depth varied between 0.5 and 0.9 m. Sparse macrophyte growth was present in both reaches.

Conductivity and pH were similar in the two reaches, but water temperature was slightly higher in the upper reach (Table 8.10). Dissolved oxygen was lower in the upper reach, which is consistent with the higher water temperature and the considerably higher sediment TOC in that reach. Sediment particle size distribution also differed between reaches, with a higher proportion of sand in the lower reach.

Table 8.10 Habitat Characteristics of Depositional Sampling Reaches in the Muskeg River, Fall 2002

Variable	Units	Lower Reach Mean (range)	Upper Reach Mean (range)
sample date	-	Sept 23, 2002	Sept. 18 and 20, 2002
habitat	-	run / backwater	run / backwater
wetted channel width	m	18 (15 - 33)	16 (11 - 20)
bankfull channel width	m	20 (17 - 34)	17 (11 - 21)
water depth	m	0.7 (0.5 - 0.9)	0.7 (0.6 - 0.9)
current velocity	m/s	0.03 (0 - 0.06)	0.03 (0 - 0.12)
macrophyte cover	%	12 (0 - 35)	10 (0 - 30)
Field Water Quality			
dissolved oxygen	mg/L	10.1 (9.5 - 10.5)	6.6 (6.2 - 7)
conductivity	µS/cm	163 (161 - 167)	195 (191 - 201)
pH	-	7.0 (6.8 - 7.2)	6.8 (6.7 - 6.9)
water temperature	^{o}C	8.0 (7.7 - 8.8)	10.5 (10.3 - 10.9)
Substrate			
sand	%	64 (29 - 82)	44 (15 - 84)
silt	%	24 (10 - 47)	23 (4 - 39)
clay	%	12 (5 - 24)	33 (12 - 48)
total organic carbon	%	4.5 (1.5 - 10.3)	29.5 (14.8 - 38.7)

Note: - = Not applicable.

8.2.2.2 Benthic Community

Compared to the erosional reaches discussed earlier, total benthic invertebrate abundance was higher in the lower depositional reach of the Muskeg River in all years, with means of 30,000 to 60,000 organisms/m^2 (Figure 8.6; raw data in Appendix XII). The upper depositional reach supported a community with a considerably lower total abundance (10,000 to 20,000 organisms/m^2). Although lowest total abundance was found in 2002 in both depositional reaches, there are insufficient data at this time to assess temporal trends. The 1985, 1988 and 2001 data collected in the upper reach before the 2002 RAMP survey represent individual sites rather than reaches, which reduces comparability among years in this reach.

Based on the comparable data sets (all years for the lower reach, 2002 for the upper reach), taxonomic richness was lower in the upper depositional reach than in the lower reach (Figure 8.6). Mean richness and family richness showed the same pattern among years as total richness.

Depositional benthic communities were dominated by chironomid midges in both reaches and all years (Figure 8.6). Other common groups included bristle worms, fingernail clams, roundworms and ostracods, which usually accounted for 20 to 30% of total abundance. Bristle worms and fingernail clams tended to be the most numerous among the non-midge fauna.

At the lowest level of taxonomy, the depositional benthic fauna of the Muskeg River was dominated by the midges *Procladius*, *Micropsectra*, *Pagastiella*, *Chironomus* and the subfamily Tanypodinae (small midges that could not be identified to a lower level), fingernail clams in the family Sphaeriidae, roundworms and ostracods (Tables 8.11 and 8.12). The upper Muskeg River community was characterized by a greater dominance by the most abundant invertebrates; nearly 70% of total abundance consisted of a single midge genus (Procladius) and fingernail clams.

There were no significant correlations between habitat variables and benthic community variables.

Figure 8.6 Total Invertebrate Abundance, Richness and Community Composition in Depositional Sampling Reaches in the Muskeg River, Fall 1985 to 2002

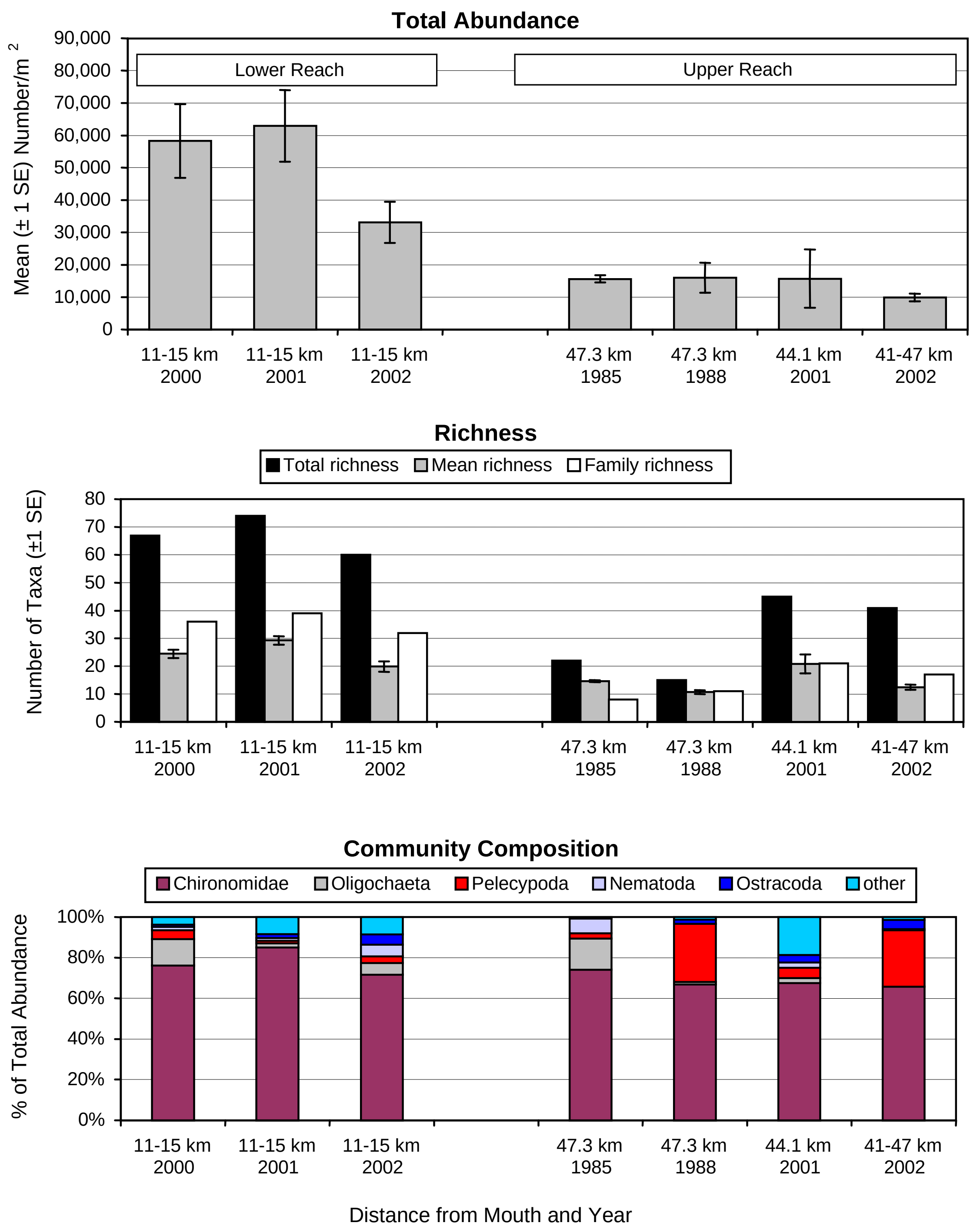


Table 8.11 Abundances of Common Invertebrates in the Depositional Sampling Reach in the Lower Muskeg River, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Procladius	Chironomidae	6,817	1,894	20.6
Micropsectra	Chironomidae	5,931	1,717	17.9
Tanypodinae	Chironomidae	2,236	616	6.7
Pagastiella	Chironomidae	1,958	508	5.9
Nematoda	Nematoda	1,912	521	5.8
Ostracoda	Ostracoda	1,657	756	5.0
Stempellinella	Chironomidae	1,505	920	4.5
Pisidium/Sphaerium	Pelecypoda	1,127	428	3.4
Tubificidae	Oligochaeta	1,035	190	3.1
Polypedilum	Chironomidae	929	327	2.8
Tanytarsus	Chironomidae	889	425	2.7
Dicrotendipes	Chironomidae	886	671	2.7
Enchytraeidae	Oligochaeta	791	180	2.4
Ceratopogoninae	Ceratopogonidae	613	151	1.9
Hydracarina	Hydracarina	545	208	1.6
Ablabesmyia	Chironomidae	490	182	1.5
Caenis	Ephemeroptera	401	185	1.2
Heterotrissocladius	Chironomidae	384	159	1.2
Parakiefferiella	Chironomidae	373	209	1.1
Tanytarsini	Chironomidae	350	125	1.1
total % for common taxa				(93.0%)
total abundance		33,147	6,384	-
richness		19.9	1.9	-
total richness		60	-	-

Table 8.12 Abundances of Common Invertebrates in the Depositional Sampling Reach in the Upper Muskeg River, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Procladius	Chironomidae	3,973	608	40.2
Pisidium/Sphaerium	Pelecypoda	2,741	494	27.7
Chironomus	Chironomidae	854	628	8.6
Micropsectra	Chironomidae	593	210	6.0
Ostracoda	Ostracoda	441	202	4.5
Tanytarsus	Chironomidae	267	121	2.7
Heterotrissocladius	Chironomidae	192	60	1.9
total % for common taxa				(91.7%)
total abundance		9,881	1,223	-
richness		12.5	0.9	-
total richness		41	-	-

8.3 FORT CREEK

8.3.1 Habitat Characteristics

Fort Creek is a small depositional stream that flows into the Athabasca River. During the fall low-flow period in 2002, the mean wetted channel width was 2.6 m, with a bankfull channel width of 12.4 m (Table 8.13). The mean depth and current velocity along the sampling reach were 0.16 m and 0.09 m/s, respectively. The substratum was dominated by fine material, consisting predominantly of sand. Sediment TOC was relatively low (2.4%) and no macrophytes were recorded in the reach sampled.

Table 8.13 Habitat Characteristics of Depositional Sampling Reaches in Fort Creek, Fall 2002

Variable	Units	Mean (range)
sample date	-	Sept. 24, 2002
habitat	-	depositional
wetted channel width	m	2.6 (1 - 4)
bankfull channel width	m	12.4 (9 - 20)
water depth	m	0.16 (0.07 - 0.23)
current velocity	m/s	0.09 (0 - 0.27)
macrophyte cover	%	0
Field Water Quality		
dissolved oxygen	mg/L	11.9 (11.7 - 12.1)
conductivity	µS/cm	257 (256 - 258)
pH	-	7.2 (7.0 - 73)
water temperature	°C	4.9 (4.7 - 4.9)
Substrate		
sand	%	79 (71 - 89)
silt	%	13 (7 - 17)
clay	%	8 (4 - 12)
total organic carbon	%	2.4 (0.9-3.9)

Note: - = not applicable or no data.

8.3.2 Benthic Community

Total benthic invertebrate abundance was considerably higher in Fort Creek in 2002 than in 2001 (mean of >41,000 organisms/m^2 compared to 4,041 organisms/m^2 in 2001) (Figure 8.7; raw data in Appendix XII). Taxonomic richness at the lowest taxonomic level was similar in both years, with totals of 32 to 34 groups. The benthic community was dominated by midges in both years, contributing about 80% of the community in 2001 and >90% in 2002. Mayflies and water mites, which were present in 2001, were absent in 2002 (Figure 8.7).

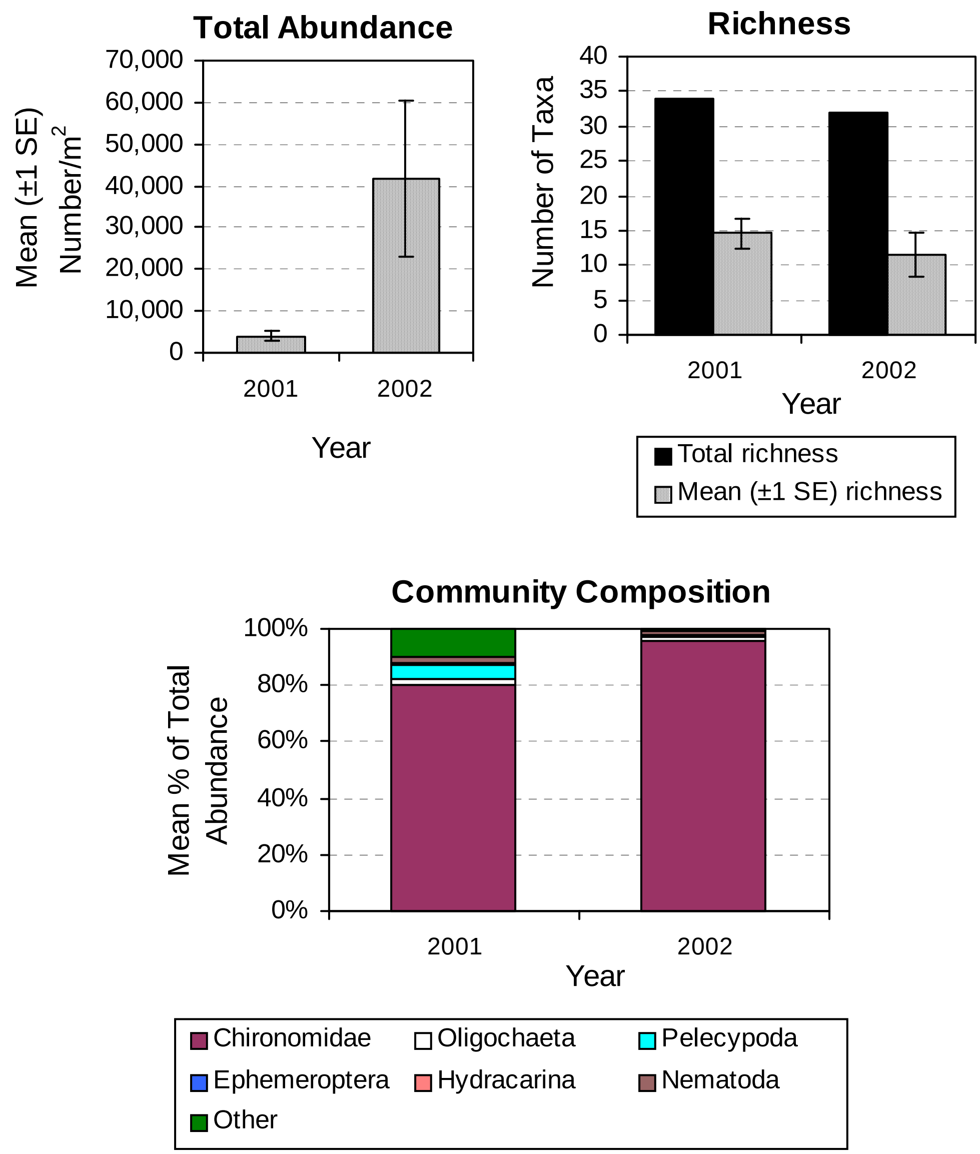
At the level of individual taxa, the dominant organisms in Fort Creek were the midge genera *Paratendipes* and *Tanytarsus*, which accounted for over two thirds of the total abundance. The next four most numerous invertebrates were also midges and contributed another 18% of the mean total abundance. Roundworms, bristle worms and fingernail clams together contributed less than three percent of total abundance (Table 8.14).

There were no significant correlations between habitat variables and benthic community variables in Fort Creek, which is partly the function of the low samples size available (n=5). However, upon visual inspection of scatter-plots, there appeared to be weak relationships between total abundance, richness at the lowest taxonomic level as well as abundances of several dominant taxa, and sediment TOC and % fine sediments.

Table 8.14 Abundances of Common Invertebrates in Fort Creek, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Paratendipes	Chironomidae	15,566	8,220	37.4
Tanytarsus	Chironomidae	12,367	6,375	29.7
Heterotrissocladius	Chironomidae	3,535	1,530	8.5
Parakiefferiella	Chironomidae	2,976	2,124	7.1
Tanytarsini	Chironomidae	2,408	1,377	5.8
Polypedilum	Chironomidae	1,015	631	2.4
Nematoda	Nematoda	439	139	1.1
Naididae	Oligochaeta	430	139	1.0
Orthocladiinae	Chironomidae	327	160	0.8
Procladius	Chironomidae	318	203	0.8
Sphaeriidae	Pelecypoda	258	258	0.6
total % for common taxa				(95.2%)
total abundance		41,632	18,590	-
richness		12	3.2	-
total richness		32	-	-

Figure 8.7 Total Invertebrate Abundance, Richness and Community Composition in Fort Creek, Fall 2001 and 2002



8.4 KEARL AND SHIPYARD LAKES

8.4.1 Habitat Characteristics

The sampling locations in Kearl and Shipyard lakes were 1.6 to 2.9 m deep (Table 8.15; detailed supporting data in Appendix XII). Conductivity was about two times higher in Shipyard Lake than in Kearl Lake, which may reflect the periodic influence of Athabasca River water in Shipyard Lake or differences between the lakes in drainage basin characteristics. The pH values measured in these lakes were slightly lower than typical values in nearby streams, but were not unusual for the region. Dissolved oxygen was within the expected range (6.7 mg/L) in Kearl Lake, but was low (<4 mg/L) in Shipyard Lake. Water temperature was within the expected range for the fall season. Bottom sediments consisted mostly of silt and clay, and contained moderate to high amounts of organic material (Table 8.15). In particular, TOC was very high (>30%) in Kearl Lake. Although these lakes support abundant submergent macrophyte growth, bottom cover by macrophytes was low, possibly because of local habitat type at the sample locations or sampling after the seasonal senescence and decay of submergent plants. Since samples were taken in early to mid-September, the former is the more likely cause.

Table 8.15 Habitat Characteristics in Kearl and Shipyard Lakes, Fall 2002

Variable	Units	Kearl Lake Mean (range)	Shipyard Lake Mean (range)
sample date	-	Sept 4, 2002	Sept 12, 2002
water depth	m	2.2 (2.0 - 2.9)	1.8 (1.6 - 2.0)
Field Water Quality			
dissolved oxygen	mg/L	6.7 (6.4 - 6.9)	3.8 (3.6 - 4.3)
conductivity	µS/cm	146 (143 - 149)	297 (286 - 302)
pH	-	7.0 (6.9 - 7.0)	6.6 (6.6 - 6.7)
water temperature	^{o}C	16.8 (16.7 - 17.0)	15.1 (14.5 - 15.8)
Bottom Sediments and Macrophyte Cover			
sand	%	14.8 (6 - 24)	1.5 (1 - 3)
silt	%	39.5 (32 - 51)	44.8 (42 - 50)
clay	%	45.5 (37 - 58)	53.8 (47 - 62)
total organic carbon	%	37.4 (30.5 - 41.7)	15.5 (6.0 - 24.5)
macrophyte cover	%	0.7 (0 - 5)	10.5 (0 - 30)

Note: - = Not applicable.

8.4.2 Benthic Community

Lake benthic communities were characterized by variable total abundance (Figure 8.8; raw data in Appendix XII). The mean total abundance varied by nearly ten-fold among years in each lake, without apparent trends over time. Based on the recent surveys, richness was slightly higher in Shipyard Lake. Variability of richness measures was within normal limits in both lakes, excluding the data collected from 1985 to 1995 in Kearl Lake (single sites were sampled in these years and the level of taxonomy was inconsistent with later surveys). Standardizing richness to the family level revealed no trends over time.

Samples collected from Kearl Lake were dominated by amphipods and midges, which accounted for about 80% of the total abundance in most years (Figure 8.8; Table 8.16). Other common groups in this lake included ostracods, fingernail clams and snails. Midge dominance was less pronounced in Shipyard Lake, where amphipods, ostracods, fingernail clams, snails and mayflies were also abundant (Table 8.17). The dominance of *Chironomus* in Shipyard Lake in 2002 may have been partly due to the low dissolved oxygen levels, where *Chironomus* tends to have a competitive advantage over many other invertebrates. Compared to the previous years' data, long term trends in community composition were not apparent.

The increasing trends in boron and sulphate over time in Shipyard Lake identified in Section 6.1.1 had no apparent effects on the benthic community. Even the maximum concentrations measured (boron: 0.05 mg/L; sulphate: 13.1 mg/L) were at levels commonly observed in surface waters in the region (e.g., other waterbodies sampled by RAMP; Appendix X) and would not be expected to adversely affect the benthic community.

There were very few significant correlations between the benthic invertebrate data and habitat data. Ostracod abundance was correlated with sediment TOC in Kearl Lake (r_s=0.68, P<0.05, n=10). In Shipyard Lake, water depth was negatively correlated with richness (r_s=-0.73, P<0.05, n=10) and Sphaeriidae abundance (r_s=-0.78, P<0.05, n=10).

Figure 8.8 Total Invertebrate Abundance, Richness and Community Composition in Kearl and Shipyard Lakes, Fall 2002

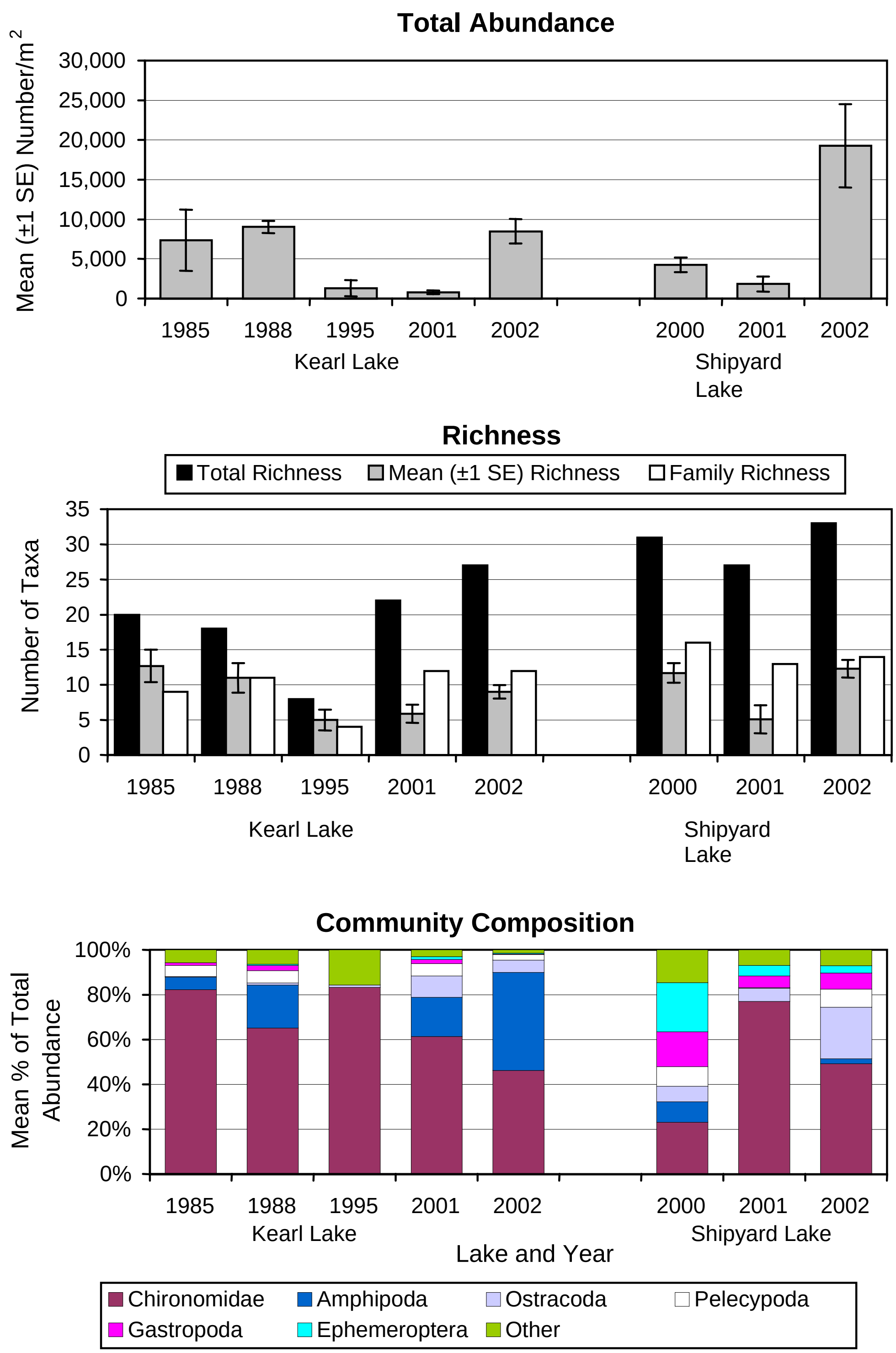


Table 8.16 Abundances of Common Invertebrates in Kearl Lake, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Hyalella azteca	Amphipoda	3,685	279	43.5
Procladius	Chironomidae	1,479	74	17.4
Microtendipes	Chironomidae	1,230	153	14.5
Einfeldia	Chironomidae	546	162	6.4
Ostracoda	Ostracoda	460	61	5.4
Sphaeriidae	Pelecypoda	219	37	2.6
Pseudochironomus	Chironomidae	211	39	2.5
Parametriocnemus	Chironomidae	146	40	1.7
Tanytarsus	Chironomidae	112	21	1.3
total % for common taxa				(95.4%)
total abundance		8,480	484	-
richness		9.0	1.0	-
total richness		27		-

Table 8.17 Abundances of Common Invertebrates in Shipyard Lake, Fall 2002

Taxon	Major Group	Mean (no./m^2)	Standard Error	% of Total Abundance
Chironomus	Chironomidae	5,861	811	30.4
Ostracoda	Ostracoda	4,425	403	23.0
Procladius	Chironomidae	1,651	169	8.6
Sphaeriidae	Pelecypoda	1,565	220	8.1
Naididae	Oligochaeta	796	125	4.1
Tanytarsus	Chironomidae	654	93	3.4
Caenis	Ephemeroptera	645	189	3.3
Valvata tricarinata	Gastropoda	473	51	2.5
Hyalella azteca	Amphipoda	434	46	2.3
Valvata sincera	Gastropoda	434	53	2.3
Armiger crista	Gastropoda	391	48	2.0
Cladopelma	Chironomidae	288	58	1.5
Ablabesmyia	Chironomidae	267	65	1.4
Endochironomus	Chironomidae	267	39	1.4
Nematoda	Nematoda	262	65	1.4
total % for common taxa				(95.6%)
total abundance		19,264	1,660	-
richness		12.0	1.3	-
total richness		33	-	-

(Table 3.17). The trends illustrated in Figures 7.1 and 7.2 would, therefore, suggest that growth and survival rates for *L. variegatus* and *H. azteca* increase, respectively, as the concentrations of naphthalene and C1 substituted naphthalene increase. The cause of these trends is unknown. These relationships may result from the relative nature of the *L. variegatus* and *H. azteca* tests (results are expressed as a percentage of the observed performance of each test species in control sediments). For example, the test sediments may be less than optimal and/or the sediments containing naphthalene or C1 substituted naphthlene may have unexpected positive characteristics (e.g., better physical properties than the controls).

Given the importance of the sediment used for the control samples, it is recommended that the RAMP Water and Sediment Subgroup of the Technical Subcommittee consider the following:

- submitting several samples of the control sediments used by HydroQual for analysis to determine how their chemical and physical composition compares to sediments collected from the lower Athabasca River watershed; and,
- identifying an area within the Athabasca River watershed where reference sediment could be collected to ensure that the control samples used in the toxicity tests are appropriate.

9 FISH POPULATIONS

The approach for the RAMP 2002 fish program is provided in Section 2.1.4 and the methods used to collect fish population data are described in Section 3.5. The following sections provide the results for each of the components of the 2002 fish program. Where possible, the 2002 results are provided in comparison to previous RAMP data and other historical data to assess if changes appear to have occurred over time. Data comparisons conducted for the RAMP Five Year Report were extended using 2002 data.

9.1 FISH TISSUE COLLECTION

9.1.1 Athabasca River

9.1.1.1 Metal Concentrations in Composite Fish Tissue Samples

The results of field measurements and examinations of the 10 walleye and 10 lake whitefish used for the Athabasca River composite tissue samples in 2002 are presented in Appendix XV. The range in size and age of the fish used for composite samples is in Table 9.1. Fish used for composite analyses were adults, with the exception of one juvenile male walleye (Appendix XV).

Table 9.1 Size and Age of Walleye and Lake Whitefish Used for Composite Tissue Analysis, Athabasca River, Fall 2002

Species	Sex	*n*	Fork Length (mm)		Age (years)	
			Minimum	Maximum	Minimum	Maximum
lake whitefish	female	5	370	505	4	12
	male	5	452	603	5	13
walleye	female	5	400	475	6	16
	male	5	422	486	6	13

Suitability of Fish for Consumption

Results for tissue analyses of the composite samples by species and sex are in Appendix XV. Results for the analyses that were reported to be at concentrations above the analytical detection limits are in Table 9.2. Results are expressed on a wet tissue weight basis. Metal concentrations in composite tissue samples were compared with risk-based concentrations (RBCs) in fish tissue for the protection of human health (U.S. EPA 2002). Although these RBC are not enforceable fish consumption guidelines, they do provide useful health benchmarks for evaluation of fish tissue concentrations. Health Canada has provided fish tissue consumption guidelines only for mercury. Mercury concentrations in Athabasca River fish tissues are provided and evaluated in Section 9.1.1.2. Thirteen inorganic parameters were detected in one or more composite tissue samples from the Athabasca River in 2002 (Table 9.2). Of these thirteen parameters, RBC are provided for eight. The concentrations of the eight inorganic parameters were considerably less (<6%) than the corresponding RBC (Table 9.2), indicating that there are no human health concerns for fish consumption based on these parameters. The remaining five parameters for which RBC are not defined (calcium, magnesium, phosphorus, potassium and sodium) are all elements that are considered essential ions for cellular function.

Table 9.2 Metal Concentrations in Composite Tissue Samples from the Athabasca River, Fall 2002, Compared With Risk-Based Concentrations

Parameter	Units[(a)]	Detection Limit	Tissue Concentration				RBC[(b)]
			Lake Whitefish		Walleye		
			Female	Male	Female	Male	
barium	mg/kg	0.08	0.10	0.10	0.11	0.11	95
calcium	mg/kg	10	120	90	80	100	-
copper	mg/kg	0.08	0.20	0.21	0.16	0.20	54
iron	mg/kg	2	3	4	3	3	410
magnesium	mg/kg	2	299	301	298	291	-
manganese	mg/kg	0.04	0.16	0.17	0.11	0.14	190
phosphorus	mg/kg	2	2390	2540	2490	2450	-
potassium	mg/kg	2	3920	4230	4380	4180	-
selenium	mg/kg	0.2	0.4	0.4	0.3	0.3	6.8
sodium	mg/kg	2	296	308	260	237	-
strontium	mg/kg	0.04	0.13	0.12	0.06	0.05	810
titanium	mg/kg	0.05	0.67	<0.05	<0.05	<0.05	5400
zinc	mg/kg	0.2	9.6	4.6	5.2	6.7	410

(a) Data reported in mg/kg wet weight.

(b) Risk-based concentrations (RBC) in fish tissue for the protection of human health (U.S. EPA 2002).

Note: "-" = no RBC.

Potential Effects on Fish Health

The maximum measured tissue concentrations from the 2002 composite samples were compared with tissue residue concentrations that have been shown to cause effects in fish (Table 9.3; Jarvinen and Ankley 1998). Of the 13 parameters detected in the composite tissue samples in 2002 (Table 9.2), data linking fish tissue concentrations with effects in fish were only available for copper, selenium and zinc. The maximum measured tissue concentrations of copper, selenium and zinc were lower than effect concentrations (Table 9.3). Therefore, effects on fish health from the measured concentrations in fish tissue are not predicted for these parameters. Potential effects for the ten parameters for which there are no effects data cannot be determined.

Table 9.3 Maximum Metal Concentrations in Composite Tissue Samples from the Athabasca River, Fall 2002, Compared With Fish Tissue Effect Concentrations

Parameter	Maximum Concentration (mg/kg)	Effects Concentration (mg/kg)	Endpoint	Tissue	Fish – Size, Life Stage
copper	0.21	0.5	survival – no effect	muscle	rainbow trout – 138 g
		3.4	survival, growth, reproduction – no effect	muscle	brook trout – embryo, adult, juvenile
selenium	0.4	0.8	growth – no effect	whole body	chinook salmon – fingerling
		0.8	survival – no effect; growth – reduced	carcass	rainbow trout – juvenile
		0.2	growth – no effect	carcass	rainbow trout – juvenile
zinc	9.6	13.6	immobilized; survival – reduced	muscle	dogfish – 140 to 330 g
		60	survival, growth – no effect	whole body	Atlantic salmon – juvenile

Source: Jarvinen and Ankley (1998).

9.1.1.2 Mercury Concentrations in Individual Fish

The results of field measurements and examinations of all fish used for the Athabasca River tissue samples in 2002 are in Appendix XV. The size class and sex of the 25 walleye and 25 lake whitefish used for tissue mercury analysis are in Table 9.4. For walleye, an even number of fish was sampled for each of the size classes between 200 and 600 mm, with larger fish being rare. For lake whitefish, smaller individuals were not sampled because the fall spawning run consists primarily of adult fish. Also, lake whitefish >600 mm were not captured. Fewer females than males were sampled of both species.

Table 9.4 Size and Sex Distribution of Walleye and Lake Whitefish Used for Tissue Mercury Analysis, Athabasca River, Fall 2002

Species	Sex	Fork Length Class (mm)					Total
		200-300	301-400	401-500	501-600	601-700	
walleye	male	1	4	4	2	0	11
	female	0	1	3	3	1	8
	unknown	5	1	0	0	0	6
	total	**6**	**6**	**7**	**5**	**1**	**25**
lake whitefish	male	0	5	5	6	0	16
	female	0	1	6	2	0	9
	total	**0**	**6**	**11**	**8**	**0**	**25**

Suitability of Fish for Consumption

Mercury concentrations in individual lake whitefish and walleye collected from the Athabasca River in 2002 are in Tables 9.5 and 9.6, respectively. For each sex, the results are arranged from smallest to largest fish, based on fork length. Health Canada (1999) recommends two fish consumption guidelines for maximum acceptable fish tissue mercury concentrations. These guidelines are an occasional consumption guideline of 0.5 mg/kg, and a subsistence consumption guideline of 0.2 mg/kg. An occasional fish consumer is assumed to be a person eating an average of 310 g of fish per week (approximately three meals) while a subsistence level consumer is assumed to eat an average of 780 g of fish per week (about eight servings) (Health and Welfare Canada 1984).

Seven lake whitefish (two female and five male) had mercury concentrations above the subsistence consumption guideline of 0.2 mg/kg (Table 9.5). However, all samples of lake whitefish fillet contained mercury concentrations less than the occasional consumption guideline of 0.5 mg/kg. The highest mercury concentration measured for lake whitefish fillet in 2002 was 0.45 mg/kg. As expected for fish with a more piscivorous diet, mercury concentrations were higher in walleye tissues than lake whitefish. The majority of the walleye sampled (16 of 25) exceeded the subsistence consumption guideline; this included all but one female, the majority of males and two immature fish (Table 9.6). Six of these walleye (one female, four males and one immature fish) also contained mercury concentrations above the occasional consumption guideline. The highest mercury concentration found in walleye fillet in 2002 was 0.84 mg/kg.

Length standardized mercury concentrations for both lake whitefish and walleye were variable, indicating that the relationship between fork length and mercury concentrations is not consistent for either of these species (Tables 9.5 and 9.6).

Table 9.5 Mercury in Fillets from Lake Whitefish, Athabasca River, Fall 2002

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg)[(a)]	Length Standardized Mercury[(b)]
female	393	980	mature	7	0.21	5.3
	422	1080	mature	8	0.09	2.1
	422	1300	mature	8	0.13	3.1
	424	1100	mature	7	0.07	1.7
	425	1224	mature	6	0.04	0.9
	430	1410	mature	7	0.06	1.4
	439	1530	mature	8	0.06	1.4
	460	1770	mature	11	0.22	4.8
	486	1625	mature	13	0.17	3.5

Table 9.5 Mercury in Fillets from Lake Whitefish, Athabasca River, Fall 2002 (continued)

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg)[(a)]	Length Standardized Mercury[(b)]
male	362	615	mature	5	0.05	1.4
	368	750	mature	6	0.21	5.7
	379	870	mature	6	0.06	1.6
	396	1100	mature	7	0.27	6.8
	400	1120	mature	6	0.21	5.3
	405	1300	mature	8	0.06	1.5
	411	940	mature	6	0.06	1.5
	425	1150	mature	7	0.09	2.1
	438	1200	mature	12	0.07	1.6
	450	1280	mature	13	0.11	2.4
	455	1350	mature	16	0.08	1.8
	457	1520	mature	16	0.22	4.8
	460	1370	mature	12	0.08	1.7
	462	1625	mature	12	0.45	9.7
	475	1220	mature	9	0.07	1.5
	484	1607	mature	14	0.09	1.9

(a) Data reported in mg/kg wet weight.

(b) Length standardized mercury = mercury concentration/fork length x 10^4.

Table 9.6 Mercury in Fillets from Walleye, Athabasca River, Fall 2002

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg)[(a)]	Length Standardized Mercury[(b)]
female	360	460	immature	4	0.32	8.9
	450	920	immature	12	0.30	6.7
	452	1010	mature	8	0.41	9.1
	465	1000	mature	9	0.37	7.9
	508	1411	mature	5	0.17	3.4
	538	1596	mature	11	0.84	15.6
	577	2050	mature	8	0.37	6.4
	603	2402	mature	13	0.40	6.6
male	235	139	immature	2	0.13	5.5
	362	510	mature	4	0.19	5.3
	370	525	mature	4	0.11	2.9
	395	725	mature	5	0.24	6.1
	397	660	mature	8	0.34	8.6
	401	770	mature	9	0.71	17.7
	415	710	immature	5	0.18	4.3
	431	790	mature	7	0.57	13.2
	431	875	mature	12	0.70	16.2
	505	1260	mature	10	0.54	10.7
	509	1450	mature	12	0.47	9.2
unknown	227	130	immature	2	0.14	6.2
	229	190	immature	1	0.10	4.4
	230	120	immature	1	0.73	31.7
	242	230	immature	1	0.13	5.4
	295	320	immature	2	0.19	6.4
	372	500	immature	5	0.32	8.6

(a) Data reported in mg/kg wet weight.

(b) Length standardized mercury = mercury concentration/fork length x 10^4.

No relationship between mercury concentrations and either fork length or age was observed for lake whitefish (Figures 9.1 and 9.2). This may be due, in part, to the fact that fish were collected within a limited size range. Fish present in the Athabasca River in the fall are primarily adult fish undergoing a spawning migration. Therefore, smaller and younger fish were not represented in the sample. Because of this, regression analyses were not conducted for this species.

Based on regression analyses for walleye, no relationship was found between mercury concentrations and either fork length (R^2 = 0.16; Figure 9.1) or age (R^2 = 0.33; Figure 9.2) when using combined sexes. The relationship between mercury concentrations and weight (not shown) was weaker than the relationship with fork length (i.e., R^2 = 0.13). When separated by sex, the regression analyses indicated a slightly increased correlation between mercury concentration and fork length (Figure 9.3) for males (R^2 = 0.34), but not females (R^2 = 0.07). Analysis by sex also showed a much stronger relationship between mercury concentration and age (Figure 9.4) for male walleye (R^2 = 0.71), but not for female (R^2 = 0.19). However, the sample size for females was lower than males, which may partially explain the weaker trend for females.

The majority of walleye less than seven years of age and less than 400 mm in length were found to contain mercury at a concentration less than the occasional consumption guideline of 0.5 mg/kg. All but one walleye of two years of age or less and 300 mm or less were found to contain mercury at a concentration below the subsistence consumption guideline of 0.2 mg/kg. The exception is an immature walleye (one year of age and 230 mm in length), which was found to contain 0.73 mg/kg of mercury (Figures 9.1 and 9.2).

Despite the apparent trend in increasing mercury concentration with increasing age for male fish, there is considerable variability in walleye mercury concentrations, especially in larger and older fish. Neither a size or age threshold in either sex of walleye could be established where tissue mercury concentrations are consistently above the occasional consumption guideline.

Potential Effects on Fish Health

The tissue mercury concentrations measured for lake whitefish and walleye from the Athabasca River in 2002 were compared with tissue residue levels shown to cause effects in fish. Effects data for methylmercury was used because virtually all (over 99%) of the total mercury in fish muscle is in the form of methylmercury attached to muscle protein (Health and Welfare Canada 1984; Bloom 1992). Jarvinen and Ankley (1998) report that a methylmercury concentration of 4.9 mg/kg had no effect on the survival, growth or reproduction of brook trout (muscle concentration for embryo and adult). The maximum mercury concentrations from the Athabasca River were 0.45 mg/kg for lake whitefish and 0.84 mg/kg for walleye. Based on these results for the Athabasca River, it is unlikely that there would be effects on fish health because of mercury concentrations.

Figure 9.1 Tissue Mercury Concentrations in Relation to Fork Length for Walleye and Lake Whitefish from the Athabasca River, Fall 2002

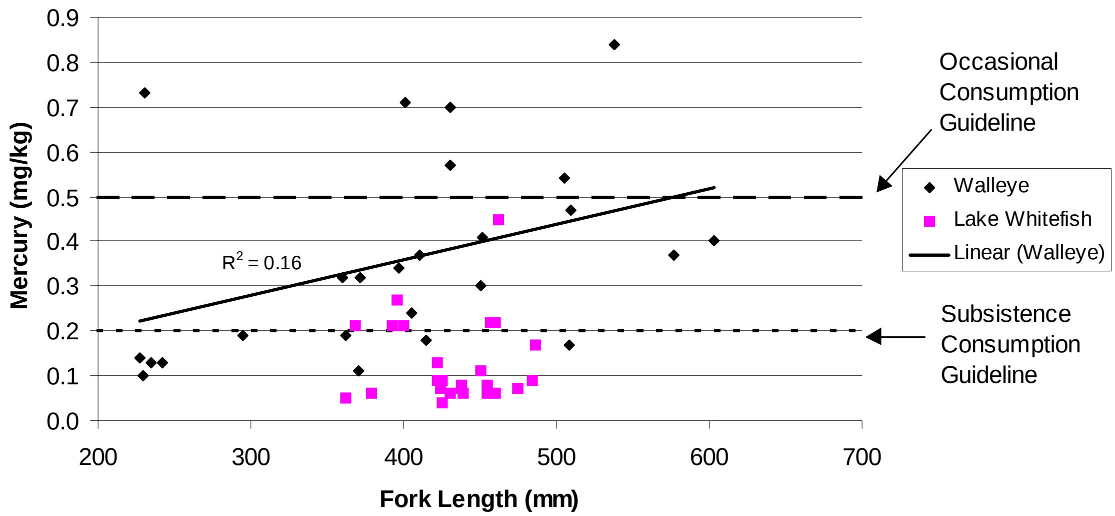


Figure 9.2 Tissue Mercury Concentrations in Relation to Age for Walleye and Lake Whitefish from the Athabasca River, Fall 2002

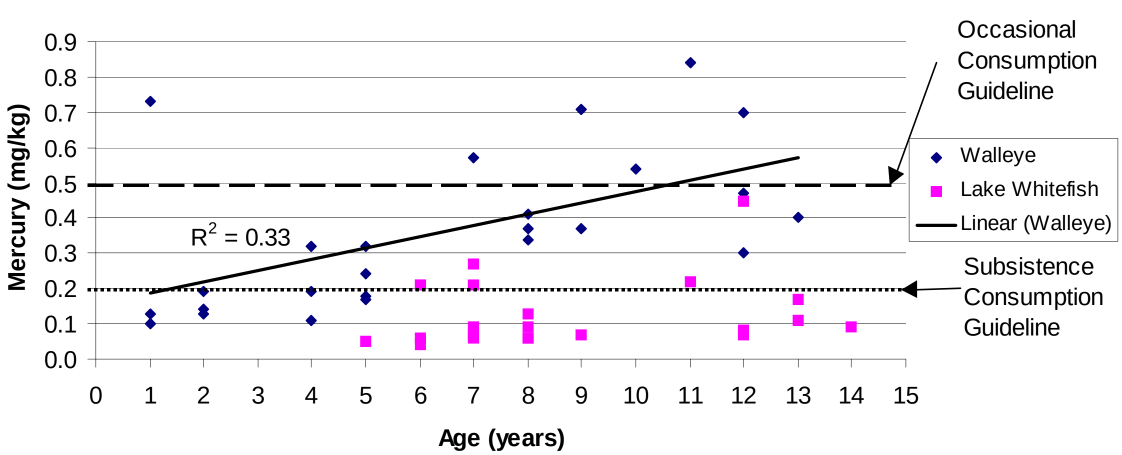


Figure 9.3 Tissue Mercury Concentrations in Relation to Sex and Length for Walleye from the Athabasca River, Fall 2002

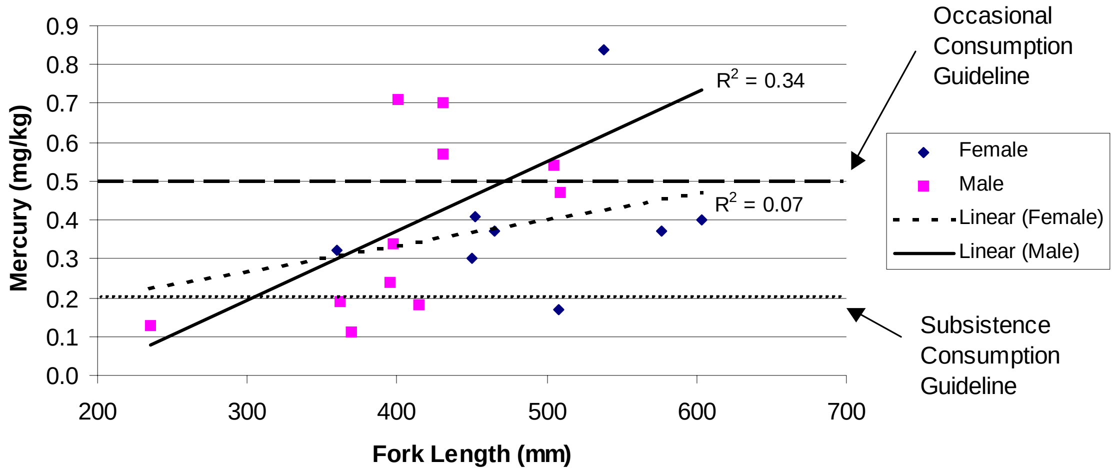
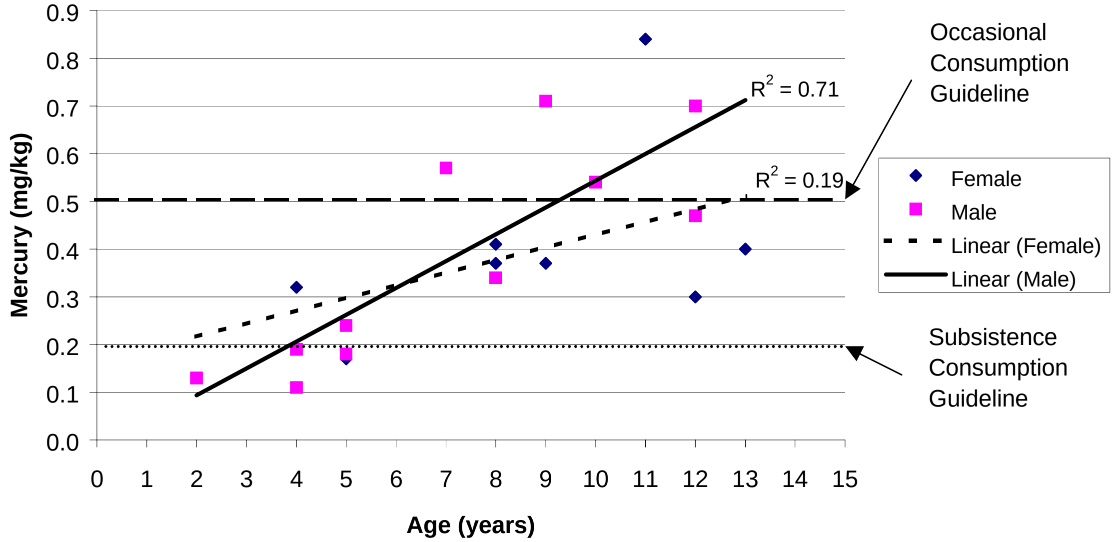


Figure 9.4 Tissue Mercury Concentrations in Relation to Sex and Age for Walleye from the Athabasca River, Fall 2002



9.1.1.3 Comparison of Tissue Concentrations to Previous Year

The concentrations of most metals in fillets of lake whitefish and walleye from the Athabasca River were lower in 2002 than in 2001 (Table 9.7). For example, iron was found to be at a much lower concentration in 2002 than in 2001 samples. In addition to the parameters shown in Table 9.7, aluminum, antimony, cadmium, chromium, lead, nickel, and vanadium were not detected in any of the

2002 samples, but were detected in some or all of the 2001 samples. However, the concentrations of potassium, phosphorus and zinc were higher in 2002 samples than in 2001 samples. Mercury concentrations were similar between years (note: 2002 results are presented as the mean of individual concentrations for adult fish, while 2001 results are for composite samples).

Table 9.7 Metal Concentrations in Composite Tissue Samples of Lake Whitefish and Walleye from the Athabasca River, Fall 2001 and 2002

Parameter	Units[(a)]	Lake Whitefish 2001		Lake Whitefish 2002		Walleye 2001		Walleye 2002	
		Female	Male	Female	Male	Female	Male	Female	Male
barium	mg/kg	0.14	<0.08	0.10	0.10	0.15	0.09	0.11	0.11
calcium	mg/kg	100	120	120	90	100	160	80	100
copper	mg/kg	0.32	0.45	0.20	0.21	0.36	0.32	0.16	0.20
iron	mg/kg	10	16	3	4	15	11	3	3
magnesium	mg/kg	243	299	299	301	261	289	298	291
manganese	mg/kg	0.21	0.22	0.16	0.17	0.12	0.24	0.11	0.14
mercury[(b)]	mg/kg	0.11	0.11	0.12	0.14	0.46	0.36	0.43	0.43
phosphorus	mg/kg	2,210	2,250	2,390	2,540	1,210	2,460	2,490	2,450
potassium	mg/kg	3,000	3,580	3,920	4,230	3,550	3,520	4,380	4,180
selenium	mg/kg	0.5	0.5	0.4	0.4	0.4	0.6	0.3	0.3
sodium	mg/kg	305	327	296	308	215	227	260	237
strontium	mg/kg	0.12	0.12	0.13	0.12	0.1	0.11	0.06	0.05
titanium	mg/kg	0.83	0.48	0.67	<0.05	0.11	0.49	<0.05	<0.05
zinc	mg/kg	4.8	3.3	9.6	4.6	7.4	4.3	5.2	6.7

(a) Data reported in mg/kg wet weight.

(b) Mercury concentrations for 2002 reported as the mean of individual adult fish (lake whitefish: n=9 female, n=16 male; walleye: n=6 female, n=9 male); mercury concentrations for 2001 are composite sample results.

Analyses conducted for the Athabasca River tissue program for the RAMP Five Year Report (Golder 2003a) indicated the possibility of emerging trends in fish tissue concentrations of selenium, strontium and mercury, but concluded additional years of data were required to assess these trends in relation to natural variability. Selenium concentrations increased between 1998 and 2001 for lake whitefish and walleye, but declined again in 2002 for both species, indicating that the higher levels detected in 2001 may have been due to natural variations in tissue concentrations. The apparent trend for strontium arose from decreasing concentrations between 1998 and 2001 for both walleye and lake whitefish. In 2002, strontium levels declined slightly for walleye and increased slightly for lake whitefish. In general, strontium levels were low in relation to 1998 data, further indicating an emerging trend for this parameter.

Mercury concentrations for composite tissue samples from adult fish increased between 1998 and 2001 for walleye (lake whitefish concentrations were similar and low in both years). Compared to 2001 data, the average mercury concentrations in walleye fillets in 2002 were similar, although they were slightly higher for males (Table 9.7). Based on comparisons of the RAMP tissue data with historical data for the Athabasca River in the Oil Sands Region and beyond (Golder 2003a), the mercury concentrations measured by RAMP do not appear to represent an increasing trend in concentration over time. Instead, the data appear to be consistent with regional and historical mercury concentrations. The available data indicate that fish tissue mercury concentrations in the Athabasca River upstream of the Oil Sands Region have ranged from 0.33 to 0.79 mg/kg, and have historically ranged from 0.15 to 0.79 within or downstream of the Oil Sands Region.

9.1.1.4 Concentrations of Tainting Compounds in Fish Tissue

Taint is typically defined as abnormal odour and/or flavour detected in the edible tissues of fish. Fish may become tainted naturally by diets or water quality. The presence of tainting compounds in fish tissue may not adversely affect the well-being of the fish, nor does it necessarily present a health concern to consumers of the fish. However, abnormal odour or flavour of the fish may make it unsuitable for commercial or subsistence use (LeBlanc et al. 2000).

Several fish tainting studies have been conducted in the Athabasca Oil Sands Region (HydroQual and Dominion Ecological Consulting 1986; Diversified Research 1992; Jardine and Hrudey 1988; Koning and Hrudey 1992; Golder 1996b; LeBlanc et al. 2000). Most of these studies focused on the potential for tainting by whole effluents (e.g., tailings pond water, refinery effluent water, dyke seepage water, consolidated tailings water). These studies do not provide parameter-specific information with which to evaluate measured concentrations of tainting compounds in fish tissue.

The most relevant study for evaluating fish tissue concentrations of tainting compounds is Jardine and Hrudey (1988). In this study, walleye muscle tissues were spiked with twelve compounds associated with oil sands development that are suspected of contributing to tainting in fish (including naphthalene and methylated naphthalenes, toluene, xylene, mesitylene, thiophene, benzothiophene, dibenzothiophene and 2,5-dimethylphenol). Fish tissues were then evaluated for taste and odour by a sensory panel during three separate sessions, and detection thresholds were established for 8 of the 12 parameters. The remaining four parameters (i.e., toluene, mesitylene, thiophene and 2-methylthiophene) were characterized as having poor detectability by panelists. The inability to detect the latter four compounds may be due to their extremely high vapour pressures, resulting in rapid evaporation of the compounds when exposed to air. The detection threshold was defined as the lowest concentration above which incorrect or anomalous responses did not occur in the sensory panel evaluation (Jardine and Hrudey 1988).

Concentrations of tainting compounds that were above the laboratory analytical detection limits are presented in Table 9.8. Although 14 compounds were originally requested for analysis, the laboratory was able to successfully analyze only four compounds (i.e., naphthalene, thiophene, toluene and *m*+*p*-xylenes). Naphthalene was not measured in any of the fish tissue samples. Toluene was measured in all samples. Thiophene and *m*+*p*-xylenes were not detected in walleye or female lake whitefish samples, but were detected in male lake whitefish samples. The measured concentration of *m*+*p*-xylenes was less than the taste and odour detection threshold (sensory panel) determined by Jardine and Hrudey (1988), while thiophene and toluene were characterized as having poor detectability by panelists. Toluene and xylene (mixed isomers) were also tested in Europe and were not found to cause tainting in fish tissues (OSPAR 2002). The results indicate that tissue tainting was unlikely for fish from the Athabasca River for the parameters that could be analyzed.

Table 9.8 Concentrations of Tainting Compounds in Composite Tissue Samples from the Athabasca River, Fall 2002

Parameter	Units[(a)]	Detection Limit	Lake Whitefish		Walleye		Detection Threshold[(b)]
			Female	Male	Female	Male	
thiophene	mg/kg	1	<1	3	<1	<1	poor detectability
toluene	mg/kg	1	270	130	73	36	poor detectability
m+p-xylenes	mg/kg	1	<1	5	<1	<1	9

(a) Data reported in mg/kg wet weight.
(b) Source: Jardine and Hrudey 1988.

9.1.2 Muskeg River

9.1.2.1 Metal Concentrations in Composite Fish Tissue Samples

During the 2002 sampling period in the Muskeg River only a small number of northern pike were captured. Only three fish (all male) were of suitable size (i.e., adult) to be used for the composite muscle tissue sample. The results of field measurements and examinations of the three fish used for the single Muskeg River composite tissue sample are in Appendix XV. The range of size and age of the three fish are in Table 9.9. All fish used for the composite tissue sample were adults.

Table 9.9 Size and Age of Northern Pike Used for Composite Tissue Analysis, Muskeg River, Fall 2002

Sex	*n*	Fork Length (mm)		Age (years)	
		Minimum	Maximum	Minimum	Maximum
male	3	465	540	2	5

Suitability of Fish for Consumption

Results for the analysis of contaminants in the composite tissue sample are presented in Appendix XV. Table 9.10 presents the results for the analyses that were reported to be at concentrations above the parameter detection limits. Metal concentrations in the composite tissue sample were compared with RBCs in fish tissue for the protection of human health (U.S. EPA 2002). Mercury concentrations in fish tissue are evaluated separately in Section 9.1.2.2. Eleven inorganic parameters were detected the northern pike composite tissue sample from the Muskeg River in 2002 (Table 9.10). Of these 11 parameters, RBC are provided for six. The concentrations of the six inorganic parameters were considerably less than the corresponding RBC (Table 9.10), indicating that there are no human health concerns for fish consumption based on these parameters. The remaining five parameters for which RBC are not defined (calcium, magnesium, phosphorus, potassium and sodium) are all elements that are considered essential ions for cellular function.

Table 9.10 Metal Concentrations in the Northern Pike Composite Tissue Sample from the Muskeg River, Fall 2002, Compared With Risk-Based Concentrations

Parameter	Units[(a)]	Detection Limit	Tissue Concentration	RBC[(b)]
barium	mg/kg	0.08	0.10	95
calcium	mg/kg	10	120	-
copper	mg/kg	0.08	0.24	54
iron	mg/kg	2	4	410
magnesium	mg/kg	2	334	-
manganese	mg/kg	0.04	0.17	190
phosphorus	mg/kg	2	2680	-
potassium	mg/kg	2	4370	-
sodium	mg/kg	2	314	-
strontium	mg/kg	0.04	0.06	810
zinc	mg/kg	0.2	5.6	410

(a) Data reported in mg/kg wet weight.

(b) Risk-based concentrations (RBC) in fish tissue for the protection of human health (U.S. EPA 2002).

Note: "-" = no RBC.

Potential Effects on Fish Health

The measured fish tissue concentrations were compared with tissue residue levels shown to cause effects in fish (Table 9.11; Jarvinen and Ankley 1998). Of the eleven parameters detected in the composite tissue sample in 2002 (Table 9.10), data linking fish tissue concentrations with effects in fish were only available for copper and zinc. Measured tissue concentrations of copper and zinc were lower than effect concentrations (Table 9.11). Therefore, effects on fish health from the measured concentrations in fish tissue are not predicted for these two parameters. Potential effects on fish health could not be determined for the nine chemicals for which there are no effects data.

Table 9.11 Metal Concentrations in the Northern Pike Composite Tissue Sample from the Muskeg River, Fall 2002, Compared With Fish Tissue Effect Concentrations

Parameter	Concentration (mg/kg)	Effects Concentration (mg/kg)	Endpoint	Tissue	Fish – Size, Life Stage
copper	0.24	0.5	survival – no effect	muscle	rainbow trout – 138 g
		3.4	survival, growth, reproduction – no effect	muscle	brook trout – embryo, adult, juvenile
zinc	5.6	13.6	immobilized; survival – reduced	muscle	dogfish – 140 to 330 g
		60	survival, growth – no effect	whole body	Atlantic salmon – juvenile

Source: Jarvinen and Ankley (1998).

9.1.2.2 Mercury Concentrations in Individual Fish

Only six northern pike were captured during the fish tissue collection program in the Muskeg River in 2002 (Appendix XV). The size and sex distribution of northern pike used for tissue mercury analysis are presented in Table 9.12. No females were collected.

Table 9.12 Size and Sex Distribution of Northern Pike Used for Tissue Mercury Analysis, Muskeg River, Fall 2002

Sex	Fork Length Class (mm)					Total
	101-200	201-300	301-400	401-500	501-600	
male	1	0	0	1	2	4
female	0	0	0	0	0	0
unknown	2	0	0	0	0	2
total	**3**	**0**	**0**	**1**	**2**	**6**

Suitability of Fish for Consumption

Mercury concentrations in individual northern pike collected from the Muskeg River in 2002 are presented in Table 9.13. All samples contained mercury concentrations less than the Health Canada (1999) occasional consumption guideline of 0.5 mg/kg (Table 9.13). Results for one adult fish were the same as (0.21 mg/kg) the subsistence consumption guideline of 0.2 mg/kg. Length standardized mercury concentrations were similar between the three mature males and between the three immature fish, indicating a possible relationship between northern pike fork length and mercury concentrations. Trends of increasing mercury concentrations with increasing fork length and age were observed (R^2 = 0.99 and 0.84, respectively; Figures 9.5 and 9.6). However; the absence of data from fish of fork length 200 to 400 mm is likely to have influenced the correlation, artificially increasing the strength of the relationship.

Table 9.13 Mercury in Fillets from Northern Pike, Muskeg River, Fall 2002

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg)[(a)]	Length Standardized Mercury[(b)]
male	186	47	immature	0	0.03	1.6
	465	775	mature	3	0.17	3.7
	530	1150	mature	5	0.21	3.9
	540	1050	mature	2	0.19	3.5
unknown	165	30	immature	0	0.03	1.8
	179	38	immature	0	0.04	2.2

(a) Data reported in mg/kg wet weight.

(b) Length standardized mercury = mercury concentration/fork length x 10^4.

Figure 9.5 Tissue Mercury Concentrations in Relation to Fork Length for Northern Pike from the Muskeg River, Fall 2002

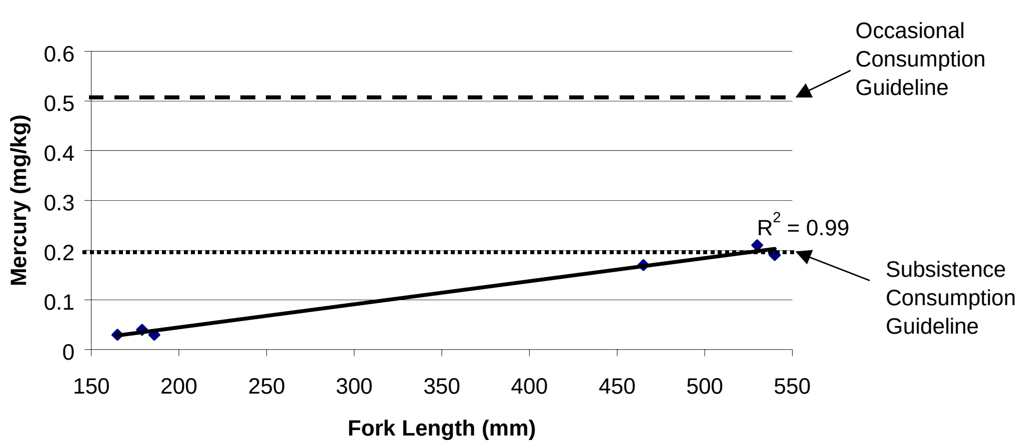
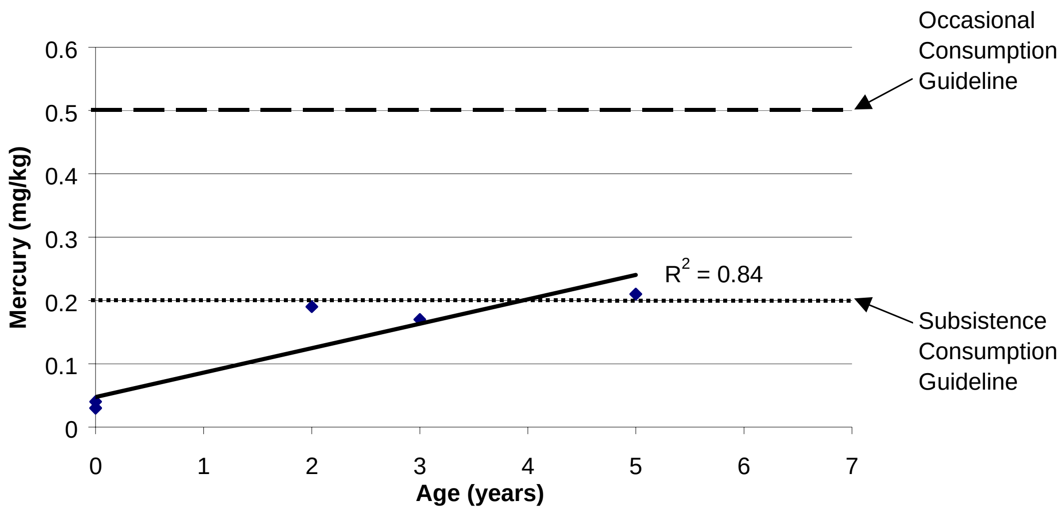


Figure 9.6 Tissue Mercury Concentrations in Relation to Age for Northern Pike from the Muskeg River, Fall 2002



Potential Effects on Fish Health

Mercury tissue concentrations measured in northern pike from the Muskeg River in 2002 were compared with tissue residue levels shown to cause effects in fish. Jarvinen and Ankley (1998) report that a methylmercury concentration of 4.9 mg/kg had no effect on the survival, growth or reproduction of brook trout (muscle concentration for embryo and adult life stages). The maximum tissue concentration of mercury found in northern pike in the Muskeg River was 0.21 mg/kg. Based on these results, it is unlikely that effects on fish health would occur due to tissue mercury concentrations.

9.1.2.3 Comparison of Tissue Concentrations to Previous Year

No consistent relationship with time could be found for the concentrations of inorganic parameters in northern pike tissue from the Muskeg River. For the twelve parameters detected in both 2001 and 2002 in northern pike fillets, half were lower and half were higher in the 2002 sample than in 2001 samples (Table 9.14). In addition, aluminum, lead, nickel and titanium were not detected in tissue collected in 2002, but were detected in 2001. Mercury concentrations in fillets were slightly higher in 2002 (note: 2002 results are presented as the mean of individual adult fish, while 2001 results are composite samples).

Table 9.14 Metal Concentrations in Northern Pike Composite Tissue Samples from the Muskeg River, Fall 2001 and 2002

Parameter	Units[a]	2001		2002
		Female	Male	Male
barium	mg/kg	0.09	<0.08	0.10
calcium	mg/kg	550	310	120
copper	mg/kg	0.29	1.18	0.24
iron	mg/kg	4	6	4
magnesium	mg/kg	313	324	334
manganese	mg/kg	0.42	0.30	0.17
mercury[b]	mg/kg	0.14	0.12	0.19
phosphorus	mg/kg	2,240	2,120	2,680
potassium	mg/kg	3,770	4,020	4,370
sodium	mg/kg	266	297	314
strontium	mg/kg	0.37	0.2	0.06
zinc	mg/kg	6.4	7.2	5.6

(a) Data reported in mg/kg wet weight.

(b) Mercury concentrations for 2002 reported as the mean of individual adult male fish (n=3); mercury concentrations for 2001 are composite sample results.

9.1.2.4 Concentrations of Tainting Compounds in Fish Tissue

Concentrations of tainting compounds in the composite northern pike tissue sample that were above the laboratory's analytical detection limits are presented in Table 9.15. Although 14 compounds were originally requested for analysis, the laboratory was only able to successfully analyze four compounds (i.e., naphthalene, thiophene, toluene and *m*+*p*-xylenes). Of these, only toluene was measured in the composite northern pike sample. Toluene was characterized as having poor detectability by panelists in the study by Jardine and Hrudey (1988). In addition, toluene was tested in Europe and found not to cause tainting in fish tissues (OSPAR 2002). Therefore, the results indicate that tissue tainting effects are unlikely to occur in the northern pike samples from the Muskeg River for the parameters that could be analyzed.

Table 9.15 Concentrations of Tainting Compounds in the Northern Pike Composite Tissue Sample from the Muskeg River, Fall 2002

Parameter	Units[a]	Detection Limit	Northern Pike Male	Detection Threshold[b]
toluene	mg/kg	1	65	poor detectability

(a) Data reported in mg/kg wet weight.

(b) Source: Jardine and Hrudey 1988.

9.1.3 Regional Lakes (Gregoire Lake)

9.1.3.1 Metal Concentrations in Composite Fish Tissue Samples

The results of field measurements and examinations of the eleven lake whitefish, ten northern pike and ten walleye used for the Gregoire Lake composite tissue samples in 2002 are presented in Appendix XV. The range of size and age of fish used for composite tissue samples are in Table 9.16. All fish used for the composite tissue analysis were adults.

Table 9.16 Size and Age of Lake Whitefish, Northern Pike and Walleye Used for Composite Tissue Analysis, Gregoire Lake, Fall 2002

Species	Sex	*n*	Fork Length (mm)		Age (years)	
			Minimum	Maximum	Minimum	Maximum
lake whitefish	male	6	435	511	4	23
	female	5	448	540	7	16
northern pike	male	5	470	542	5	7
	female	5	502	572	5	9
walleye	male	5	427	446	5	8
	female	5	522	598	8	13

Suitability of Fish for Consumption

Complete results of the analysis of contaminants in composite fillets of fish from Gregoire Lake are presented in Appendix XV. Table 9.17 presents the results of the analytes that were reported to be at a concentration above the parameter detection limit. Metal concentrations in the composite tissue samples were compared with RBCs in fish tissue for the protection of human health (U.S. EPA 2002). Mercury concentrations in fish tissue were evaluated separately, and are reported in Section 9.1.3.2. Fifteen inorganic parameters were detected in one or more composite tissue samples from Gregoire Lake in 2002 (Table 9.17). Of these 15 parameters, RBCs are provided for 10. The concentrations of the 10 inorganic parameters were considerably less than the corresponding RBCs (Table 9.2), indicating that there are no human health concerns for fish consumption based on these parameters. The remaining five parameters for which RBCs are not defined (calcium, magnesium, phosphorus, potassium and sodium) are all elements that are considered essential ions for cellular function.

Table 9.17 Metal Concentrations in Composite Tissue Samples from Gregoire Lake, Fall 2002, Compared With Risk-Based Concentrations

Parameter	Units[a]	Detection Limit	Tissue Concentration						RBC[b]
			Lake Whitefish		Northern Pike		Walleye		
			Female	Male	Female	Male	Female	Male	
aluminum	mg/kg	4	<4	<4	5	<4	5	<4	1,400
barium	mg/kg	0.08	0.09	0.10	0.18	0.09	0.11	0.11	95
calcium	mg/kg	10	60	50	140	80	110	110	-
copper	mg/kg	0.08	0.77	1.01	0.18	0.17	0.16	0.16	54
iron	mg/kg	2	15	14	3	2	4	<2	410
magnesium	mg/kg	2	261	250	327	280	318	347	-
manganese	mg/kg	0.04	0.17	0.21	0.20	0.12	0.15	0.16	190
nickel	mg/kg	0.08	<0.08	<0.08	<0.08	<0.08	<0.08	0.12	27
phosphorus	mg/kg	2	2,600	2,490	2,410	2,430	2,660	2,650	-
potassium	mg/kg	2	3,520	3,200	3,900	3,990	4,850	4,680	-
selenium	mg/kg	0.2	0.3	0.3	0.2	0.3	0.3	0.3	6.8
sodium	mg/kg	2	273	252	381	225	235	227	-
strontium	mg/kg	0.04	0.09	0.08	0.11	0.04	0.05	<0.04	810
titanium	mg/kg	0.05	<0.05	0.67	0.40	0.15	1.38	0.25	5,400
zinc	mg/kg	0.2	5.9	8.4	8.9	5.7	6.5	5.3	410

(a) Data reported in mg/kg wet weight.

(b) Risk-based concentrations (RBC) in fish tissue for the protection of human health (U.S. EPA 2002).

Note: "-" = no RBC.

Potential Effects on Fish Health

The measured tissue concentrations were compared with tissue residue levels shown to cause effects in fish (Table 9.18; Jarvinen and Ankley 1998). Of the 15 parameters detected in the composite tissue samples in 2002, data linking fish tissue concentrations with effects in fish were available for aluminum, copper, nickel, selenium and zinc only. Measured tissue concentrations of these parameters were lower than effect concentrations (Table 9.18). Therefore, effects on fish health from the measured concentrations in fish tissue are not predicted. The only exception may be aluminum in female walleye and northern pike. The measured fish tissue concentration of 5 mg/kg is less than the concentration shown to reduce survival in Atlantic salmon, but greater than the no effect concentration in rainbow trout (Jarvinen and Ankley 1998). Therefore, the potential effects of this tissue concentration cannot be reliably predicted.

Table 9.18 Maximum Metal Concentrations in Composite Tissue Samples from Gregoire Lake, Fall 2002, Compared With Fish Tissue Effect Concentrations

Parameter	Maximum Concentration (mg/kg)	Effects Concentration (mg/kg)	Endpoint	Tissue	Fish – Size, Life Stage
aluminum	5	20	survival – reduced	whole body	Atlantic salmon – alevin
		1.15	survival – no effect	muscle	rainbow trout – 171g
copper	1.01	0.5	survival – no effect	muscle	rainbow trout – 138g
		3.4	survival, growth, reproduction – no effect	muscle	brook trout – embryo, adult, juvenile
nickel	0.12	118.1	survival – reduced 50%	white muscle	carp – 15g
		0.82	survival – no effect	muscle	rainbow trout – 150 to 200g
selenium	0.3	0.8	growth – no effect	whole body	chinook salmon – fingerling
		0.8	survival – no effect growth – reduced	carcass	rainbow trout – juvenile
		0.2	growth – no effect	carcass	rainbow trout – juvenile
zinc	8.9	13.6	survival – reduced; immobilized	muscle	dogfish – 140 to 330 g
		60	survival, growth – no effect	whole body	Atlantic salmon – juvenile

Source: Jarvinen and Ankley (1998).

9.1.3.2 Mercury Concentrations in Individual Fish

The results of field measurements and examinations of all fish used for Gregoire Lake tissue samples in 2002 are presented in Appendix XV. The size and sex distribution of lake whitefish, northern pike and walleye from Gregoire Lake used for tissue mercury analysis is summarized in Table 9.19. The number of lake whitefish sampled was smaller (11) than the target number of 25 due an insufficient catch. For lake whitefish, the size range was limited with all fish within the 401 to 600 mm size range. A wider size range existed for the other species but an even distribution among size classes was not achieved. The majority of northern pike were 301 to 600 mm, while the majority of walleye were 201 to 300 and 401 to 600 mm.

Table 9.19 Size and Sex Distribution of Lake Whitefish, Northern Pike and Walleye Used for Tissue Mercury Analysis, Gregoire Lake, Fall 2002

Species	Sex	Fork Length Class (mm)						Total
		200-300	301-400	401-500	501-600	601-700	700+	
lake whitefish	male	0	0	2	4	0	0	6
	female	0	0	3	2	0	0	5
	total	**0**	**0**	**5**	**6**	**0**	**0**	**11**
northern pike	male	1	4	4	3	0	0	12
	female	0	3	1	5	2	2	13
	total	**1**	**7**	**5**	**8**	**2**	**2**	**25**
walleye	male	1	4	5	0	0	0	10
	female	1	1	4	5	1	0	12
	unknown	5	0	0	0	0	0	5
	total	**6**	**1**	**4**	**5**	**1**	**0**	**27**

Suitability of Fish for Consumption

Mercury concentrations in individual lake whitefish, northern pike and walleye collected from Gregoire Lake in 2002 are presented in Tables 9.20, 9.21 and 9.22, respectively. For each sex, fish are arranged from smallest to largest, based on fork length. All lake whitefish fillets contained mercury concentrations less than the Health Canada (1999) occasional and subsistence consumption guidelines of 0.5 mg/kg and 0.2 mg/kg, respectively (Table 9.20). Four northern pike (three female and one male) fillets contained mercury concentrations above the subsistence guideline, and one of these fish (female) was above the occasional consumption guideline (Table 9.21). For walleye, fillets from five females contained mercury concentrations above the subsistence consumption guideline, while all samples were below the occasional consumption guideline (Table 9.22).

Length standardized mercury concentrations were relatively consistent for the narrow size range of lake whitefish collected, especially for males, indicating a possible relationship between fork length and mercury concentrations (Table 9.20). Length standardized mercury generally increased with increasing size of female northern pike, but was variable for male northern pike (Table 9.21). For walleye, length standardized mercury was relatively consistent for males, but was variable for females, with a general increase with increasing size (Table 9.22).

Table 9.20 Mercury in Fillets from Lake Whitefish, Gregoire Lake, Fall 2002

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg) [(a)]	Length Standardized Mercury[(b)]
female	448	2390	mature	7	0.03	0.7
	474	2110	mature	7	0.05	1.1
	484	2260	mature	13	0.04	0.8
	515	2520	mature	15	0.08	1.6
	540	2780	mature	16	0.08	1.5
male	435	1450	mature	4	0.02	0.5
	472	1880	mature	9	0.03	0.6
	500	2050	mature	9	0.03	0.6
	502	2190	mature	12	0.03	0.6
	506	2270	mature	11	0.04	0.8
	508	2200	mature	23	0.05	1.0
	511	2150	mature	9	0.02	0.4

(a) Data reported in mg/kg wet weight.

(b) Length standardized mercury = mercury concentration/fork length x 10^4.

Table 9.21 Mercury in fillets from Northern Pike, Gregoire Lake, Fall 2002

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg)[(a)]	Length Standardized Mercury[(b)]
female	315	190	immature	1	0.04	1.3
	368	350	immature	1	0.05	1.4
	395	430	mature	2	0.05	1.3
	487	760	maturing	4	0.09	1.9
	502	960	mature	5	0.09	1.8
	506	800	mature	9	0.16	3.2
	557	1070	mature	7	0.17	3.1
	565	1470	mature	7	0.22	3.9
	572	1120	mature	6	0.13	2.3
	613	1440	mature	8	0.14	2.3
	643	2070	maturing	7	0.13	2.0
	723	2590	mature	10	0.36	4.9
	1190	6700	mature	13	0.81	6.8
male	281	150	immature	1	0.05	1.8
	315	220	immature	1	0.04	1.3
	386	420	mature	3	0.06	1.6
	392	480	mature	6	0.13	3.3
	393	430	mature	2	0.05	1.3
	463	700	mature	6	0.13	2.8
	470	670	immature	5	0.08	1.7
	472	640	maturing	6	0.17	3.6
	490	690	mature	5	0.17	3.5
	510	890	mature	7	0.25	4.9
	511	890	mature	5	0.14	2.7
	542	1170	mature	5	0.09	1.7

(a) Data reported in mg/kg wet weight.

(b) Length standardized mercury = mercury concentration/fork length x 10^4.

Table 9.22 Mercury in fillets from Walleye, Gregoire Lake, Fall 2002

Sex	Fork Length (mm)	Weight (g)	Maturity	Age (years)	Mercury Concentration (mg/kg)[a]	Length Standardized Mercury[b]
female	200	80	immature	1	0.05	2.5
	391	690	immature	5	0.07	1.8
	479	1260	mature	7	0.11	2.3
	482	1210	mature	8	0.13	2.7
	496	1370	mature	8	0.12	2.4
	498	1420	mature	8	0.27	5.4
	522	1670	mature	8	0.13	2.5
	528	1700	mature	9	0.21	3.9
	541	1790	mature	13	0.27	5.0
	545	1780	mature	11	0.19	3.5
	598	2920	mature	13	0.43	7.2
	601	2330	mature	14	0.33	5.5
male	227	120	immature	1	0.05	2.2
	352	500	mature	4	0.10	2.8
	364	540	mature	4	0.07	1.9
	364	550	mature	5	0.09	2.5
	381	630	immature	4	0.10	2.6
	427	790	immature	5	0.10	2.3
	429	870	maturing	5	0.10	2.3
	438	88	immature	5	0.10	2.3
	441	980	mature	8	0.13	2.9
	446	890	mature	8	0.15	3.4
unknown	201	90	immature	1	0.05	2.5
	203	80	immature	1	0.04	1.9
	205	80	immature	1	0.04	1.9
	208	90	immature	1	0.06	2.9
	212	100	immature	1	0.06	2.8

(a) Data reported in mg/kg wet weight.

(b) Length standardized mercury = mercury concentration/fork length x 10^4.

A correlation of increasing mercury concentrations with increasing fork length and age was apparent for walleye and northern pike (Figures 9.7 and 9.8). A weaker correlation was observed for lake whitefish. The relationships were slightly stronger for males than females for walleye (i.e., length: R^2 = 0.66 for males and 0.54 for females; age: R^2 = 0.87 for males and 0.70 for females). For northern pike, the relationship between mercury concentration and fork length was much stronger for females (R^2 = 0.91) than males (R^2 = 0.43), while the relationship of mercury concentration and age was slightly stronger for males (R^2 = 0.65 for females and 0.70 for males).

Figure 9.7 Tissue Mercury Concentrations in Relation to Fork Length for Lake Whitefish, Northern Pike and Walleye from Gregoire Lake, Fall 2002

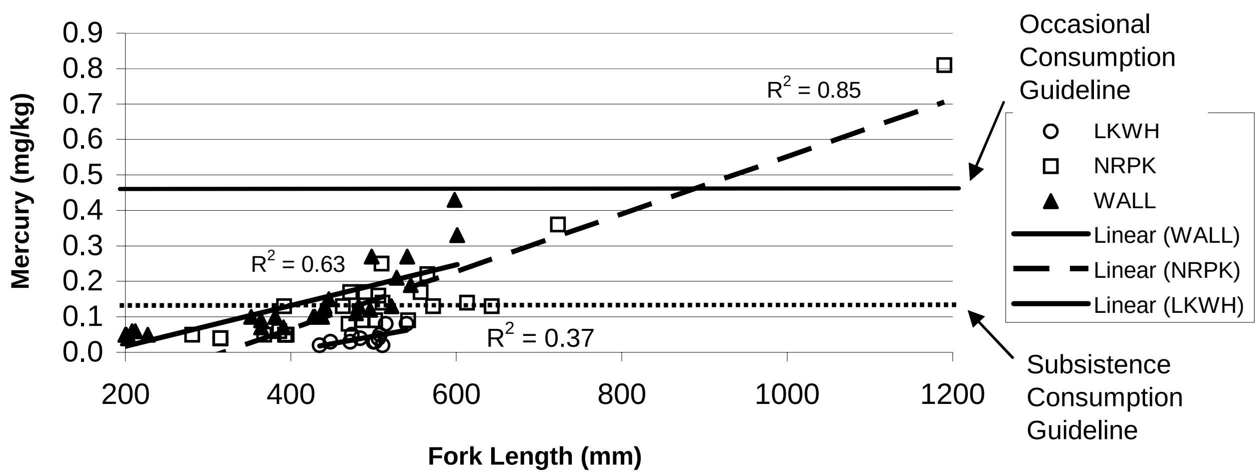
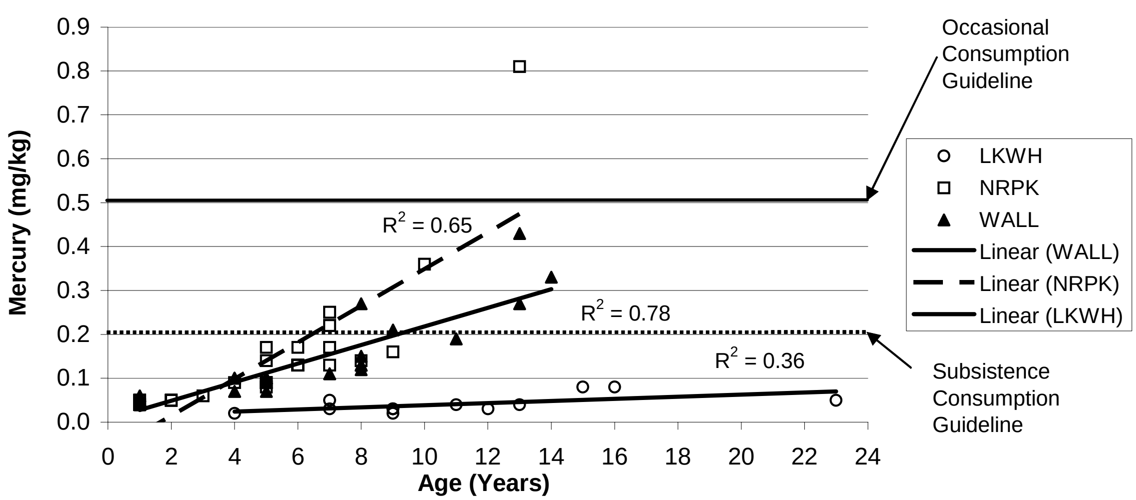


Figure 9.8 Tissue Mercury Concentrations in Relation to Age for Lake Whitefish, Northern Pike and Walleye from Gregoire Lake, Fall 2002



Potential Effects on Fish Health

The mercury tissue concentrations measured for lake whitefish, northern pike and walleye from Gregoire Lake in 2002 were compared with tissue residue levels shown to cause effects in fish. Jarvinen and Ankley (1998) report that a methylmercury concentration of 4.9 mg/kg had no effect on the survival, growth or reproduction of brook trout (muscle concentration for embryo and adult). The maximum mercury concentrations were 0.08 mg/kg for lake whitefish, 0.81 mg/kg for northern pike and 0.43 mg/kg for walleye. Based on these results, effects on fish health from mercury concentrations are not predicted.

9.2 FISH INVENTORY

9.2.1 Athabasca River

Based on all available fisheries information (Golder 2003a), 30 fish species have been captured in the mainstem of the Athabasca River in the Oil Sands Region (Table 9.23). Twenty of these fish species have been captured during the RAMP inventories. There are ten species known to occur in the Athabasca River that have not been found during the RAMP inventories, including three rare large-bodied species (bull trout, lake cisco and lake trout) and seven small-bodied species. Because the RAMP inventory sampling technique (boat electrofishing) selects for larger fish and because recent methods differ from historic sampling methods, the capture of fewer small-bodied species compared to historical reports is considered an artifact of the sampling program rather than a change in species diversity in the region.

Table 9.23 Fish Species Documented in the Athabasca River in the Oil Sands Region

Species	Reported from Historical Inventories[(a)]	Reported from the 1997 to 2002 RAMP Inventories[(b)]
Arctic grayling	●	●
brassy minnow	●	
brook stickleback	●	●
bull trout	●	
burbot	●	●
emerald shiner	●	●
fathead minnow	●	●
finescale dace	●	
flathead chub	●	●
goldeye	●	●

Table 9.23 Fish Species Documented in the Athabasca River in the Oil Sands Region (continued)

Species	Reported from Historical Inventories[(a)]	Reported from the 1997 to 2002 RAMP Inventories[(b)]
Iowa darter	●	
lake chub	●	●
lake cisco	●	
lake trout	●[(c)]	
lake whitefish	●	●
longnose dace	●	
longnose sucker	●	●
mountain whitefish	●	●
ninespine stickleback	●	
northern pike	●	●
northern redbelly dace	●	
pearl dace	●	
river shiner		●
slimy sculpin	●	●
spoonhead sculpin	●	●
spottail shiner	●	●
trout-perch	●	●
walleye	●	●
white sucker	●	●
yellow perch	●	●

(a) Data compiled from: McCart et al. 1977; Tripp and McCart 1979; Bond 1980; Tripp and Tsui 1980; Wallace and McCart 1984; RL&L 1994; Syncrude's unpublished fish inventories 1989-91; Nelson and Paetz 1992; Golder 1996a, 1996c.

(b) Golder 1998, 1999, 2000b.

(c) Angler reports to ASRD (L.Rhude, pers. comm.. 2003).

In total, 14 species were captured during the 2002 spring inventory (Table 9.24). The number of species was lower than the number recorded during RAMP inventories in 1997 (22 species) and 1998 (16 species) when sampling occurred in more than one season, but was similar to 1999 (13 species) when sampling was limited to spring. The total number of each fish species recorded and the catch-per-unit-effort (CPUE) are presented in Table 9.24. In order of relative abundance, the most common large-bodied species in 2002 were walleye, goldeye, white sucker, longnose sucker and northern pike. All previous inventory data (Golder 2003a) indicate that these five species are the most abundant large-bodied species in the Oil Sands Region, with one exception: inventory data that include fall sampling show lake whitefish to be the most abundant large-bodied species. However, lake whitefish were captured in low numbers in the spring of 2002, which is typical for this species in the spring.

Table 9.24 Total Number, Percent of Total Catch and CPUE by Fish Species, Athabasca River Inventory, Spring 2002

Species	Number of Fish		Percent[(a)]	CPUE[(a)] (No./100 s)
	Captured	Captured and Observed		
Arctic grayling	1	1	0.1	<0.01
burbot	0	3	0.2	0.01
emerald shiner	6	265	15.8	0.98
flathead chub	77	228	13.6	0.84
goldeye	84	144	8.6	0.53
lake whitefish	0	1	0.1	<0.01
longnose sucker	35	56	3.3	0.21
mountain whitefish	3	18	1.1	0.07
northern pike	22	37	2.2	0.14
slimy sculpin	1	1	0.1	<0.01
spottail shiner	1	4	0.2	0.02
trout-perch	19	403	24.0	1.48
walleye	334	428	25.5	1.58
white sucker	53	88	5.2	0.32
Total	**636**	**1677**	**100**	**6.17**

(a) Calculated using captured plus observed fish.

Note: total boat electrofishing effort = 27162 s.

Figure 9.9 presents percent composition for the five most abundant large-bodied species captured in the 2002 inventory in comparison to previous spring boat electrofishing inventories from the Oil Sands Region. Goldeye, longnose sucker and white sucker show a similar pattern of percent composition from 1995 to 2002; an increase in percent composition followed by a decrease. Walleye percent composition has been variable, but inconsistent. Northern pike have shown a consistently low percent composition.

Figure 9.9 Percent Composition for Common Large-Bodied Species, Athabasca River Spring Inventories, 1995 to 2002

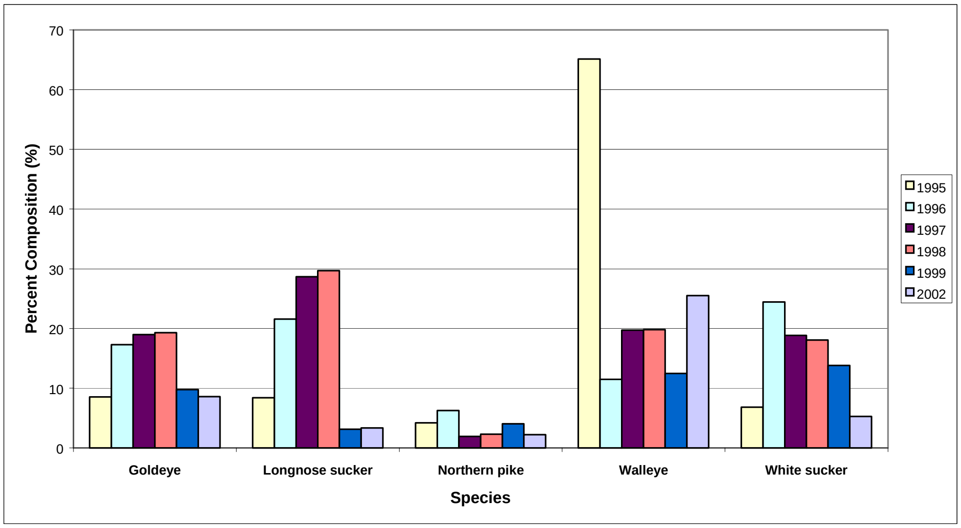


Figure 9.10 presents the CPUE for all species combined for boat electrofishing inventories from 1995 to 2002 (comparable CPUE estimates are not available for 1996). The total CPUE for 2002 is lower than for the three previous RAMP inventories (i.e., 1997 to 1999), but slightly higher than that estimated for 1995. As such, the 2002 CPUE is within the recorded range of variability for the Oil Sands Region, but is at the lower end of this range.

Figure 9.10 Catch-Per-Unit-Effort for all Species Combined, Athabasca River Spring Inventories, 1995 to 2002

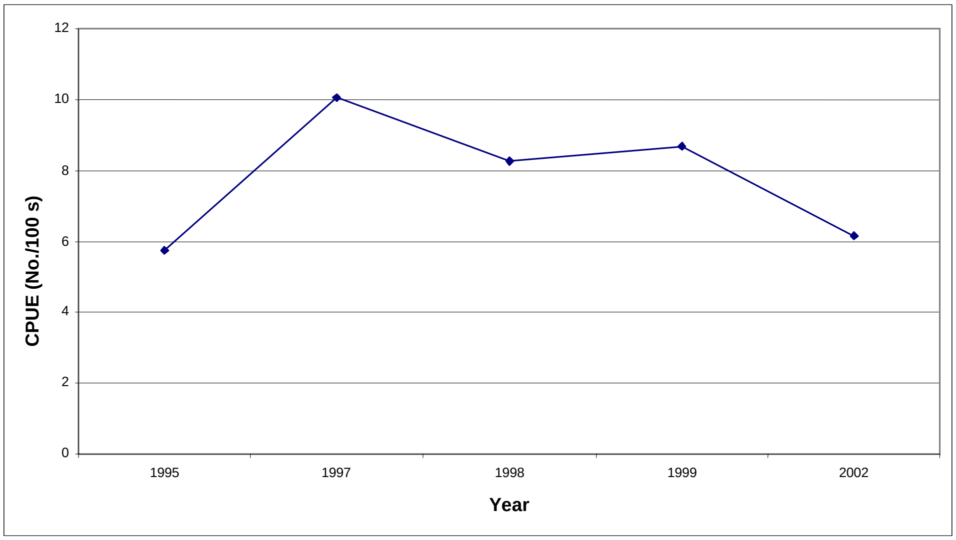
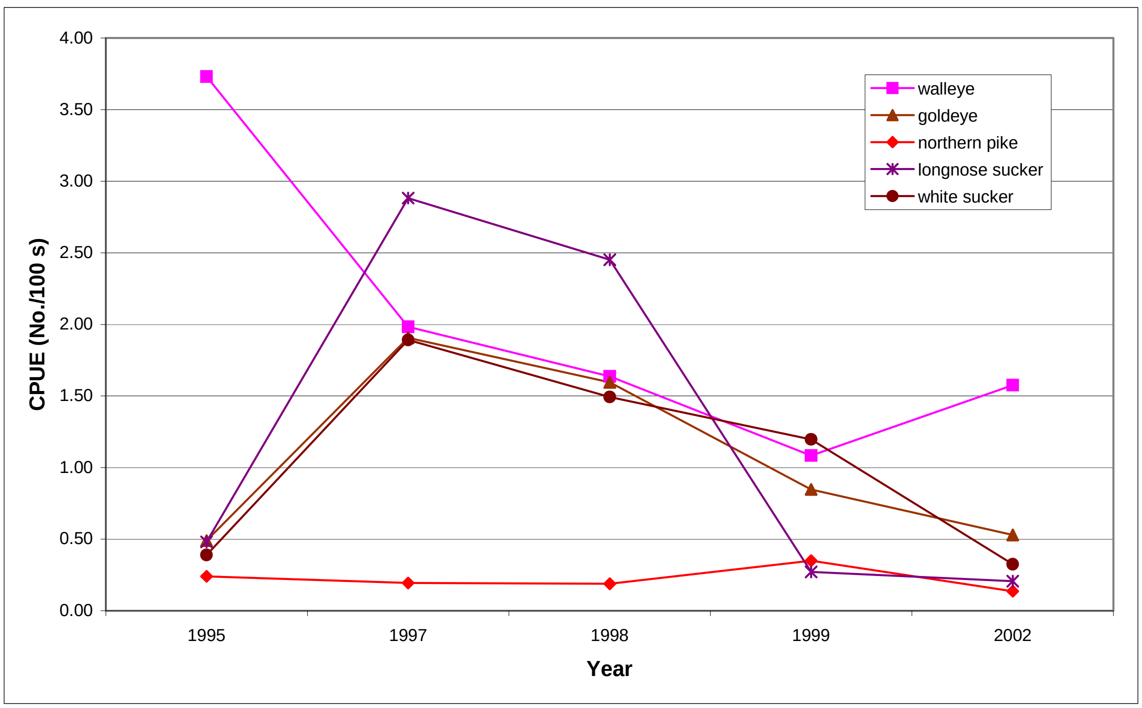


Figure 9.11 presents the spring CPUE for the five most common large-bodied species by year for all comparable spring inventory data (i.e., boat electrofishing). With the exception of northern pike, most species appear to show a decline in relative abundance in recent years, particularly between 1997 and 1999. Northern pike CPUE remained at a low, but relatively constant level.

The RAMP Five Year Report summarized all comparable Athabasca River inventory data and examined that data for trends in fish populations in the Oil Sands Region (Golder 2003a). One of the conclusions was that walleye CPUE values had declined and, as of 1999, had reached their lowest recorded level. It was concluded that additional data were required to determine if this was a trend or if the low 1999 CPUE was within the natural range of variability for this species. Although most of the previous inventory data were based on multi-season sampling, the spring 2002 data indicate an increase in walleye CPUE relative to spring 1999. In addition, the 2002 CPUE for walleye was similar to that estimated for 1997.

Figure 9.11 Catch-Per-Unit-Effort for the Main Large-Bodied Species, Athabasca River Spring Inventories, 1995 to 2002



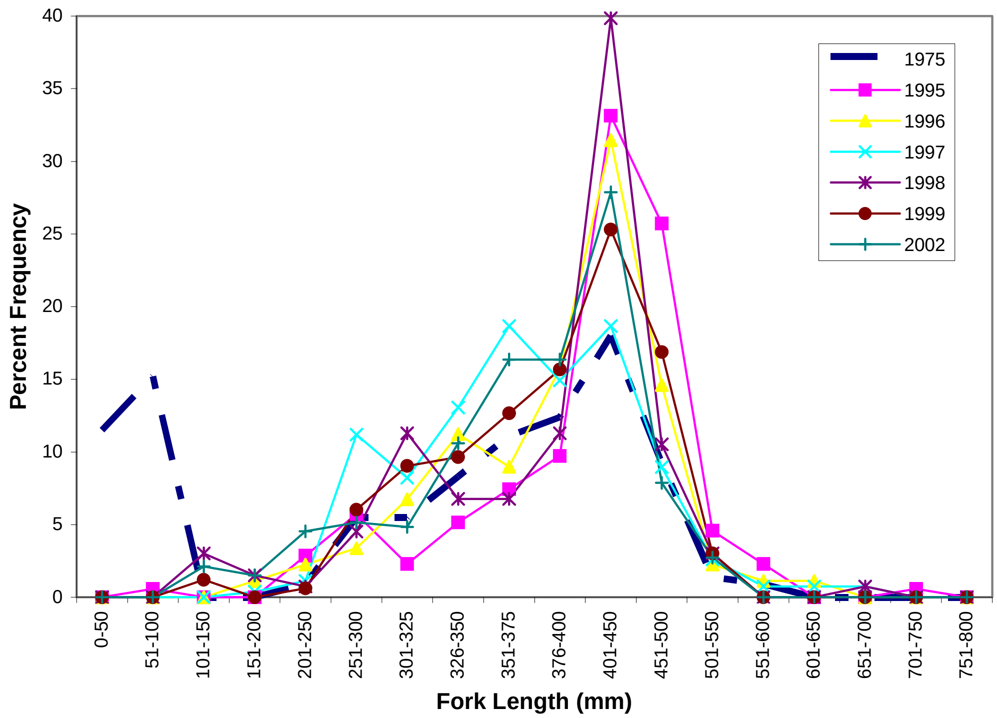
The only other potential trend in relative abundance indicated in the RAMP Five Year Report was a possible decline in abundance of lake whitefish. The possible decline was based on examination of the fall data, which is the only period when significant numbers of lake whitefish occur in the Athabasca River. As such, the 2002 data do not provide any additional information for this species.

Goldeye, longnose sucker and white sucker all show a similar change in relative abundance (Figure 9.11). This change in abundance includes an increase between 1995 and 1997, followed by a decline through to 2002. For goldeye and white sucker, the 2002 CPUE was similar to 1995, indicating the recent decline in relative abundance is probably within the range of variability for these populations. For longnose sucker, the 2002 CPUE is the lowest recorded and may indicate a declining trend for this species. As with walleye prior to 2002, additional data would be required to determine if the current low CPUE for longnose sucker represents a decline in abundance or is within the range of variability for this population.

Comparisons of population parameters are presented for four of the five main large-bodied species: walleye, goldeye, longnose sucker and white sucker. These are the species for which the 2002 data provided sufficient sample sizes for analysis (i.e., >30 fish captured and measured). In addition, the first three species have been identified as Key Indicator Resource species (KIRs) for the Oil Sands Region.

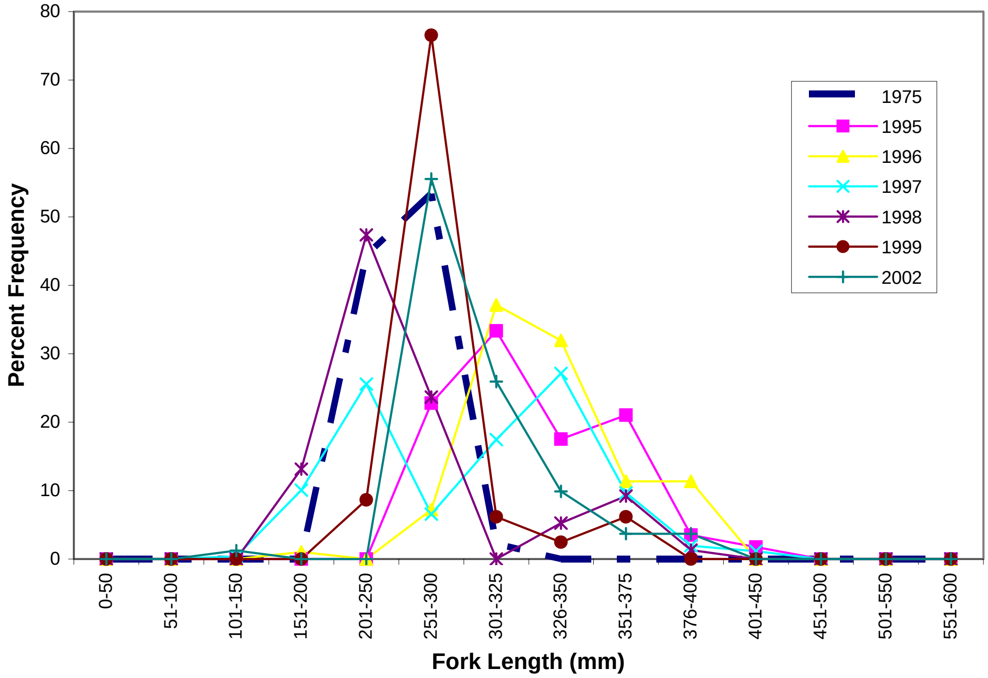
The length frequency distribution for walleye, 2002, is presented in Figure 9.12 with data from previous spring inventories. Data from 1975 is provided for comparison but represents combined seasons. For most years, the size distribution tends towards a greater proportion of medium size fish, with almost all years peaking in the 401 to 450 mm size class. One exception was the 1997 data, when the 351 to 375 mm and 401 to 450 mm size classes were equally represented. The 1975 data also show some differences relative to the other years, with a greater representation of small fish. However, the 1975 data include combined seasons, which would be expected to include smaller fish as the summer and fall distributions for walleye typically include younger fish (Golder 2003a). The results of the statistical comparison of walleye length frequency distributions (excluding 1975) are in Appendix XVI. Although variability is apparent in these data, none of the between year differences were found to be significant. In addition, there are no specific trends with respect to an increase or decrease over time in the size classes that are dominant.

Figure 9.12 Length Frequency Distributions for Walleye, Athabasca River Inventories, 1975 to 2002



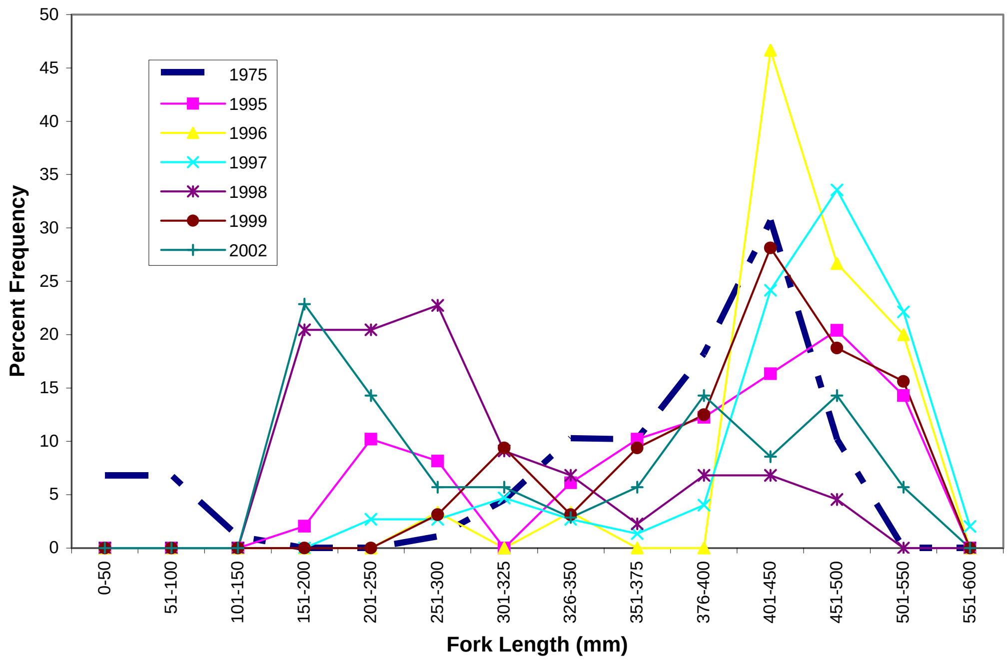
Length frequency distributions for goldeye are presented in Figure 9.13 by year. The data show a high degree of variability in the proportion of the population in each size class in spring. The spring 2002 data showed a strong peak in the 251-300 mm fork length class, as in 1975 (combined seasons) and spring 1999. Although variability is apparent in these data, none of the between year differences were found to be significant (Appendix XVI) and there are no specific trends over time in the size classes that are dominant.

Figure 9.13 Length Frequency Distributions for Goldeye, Athabasca River Inventories, 1975 to 2002



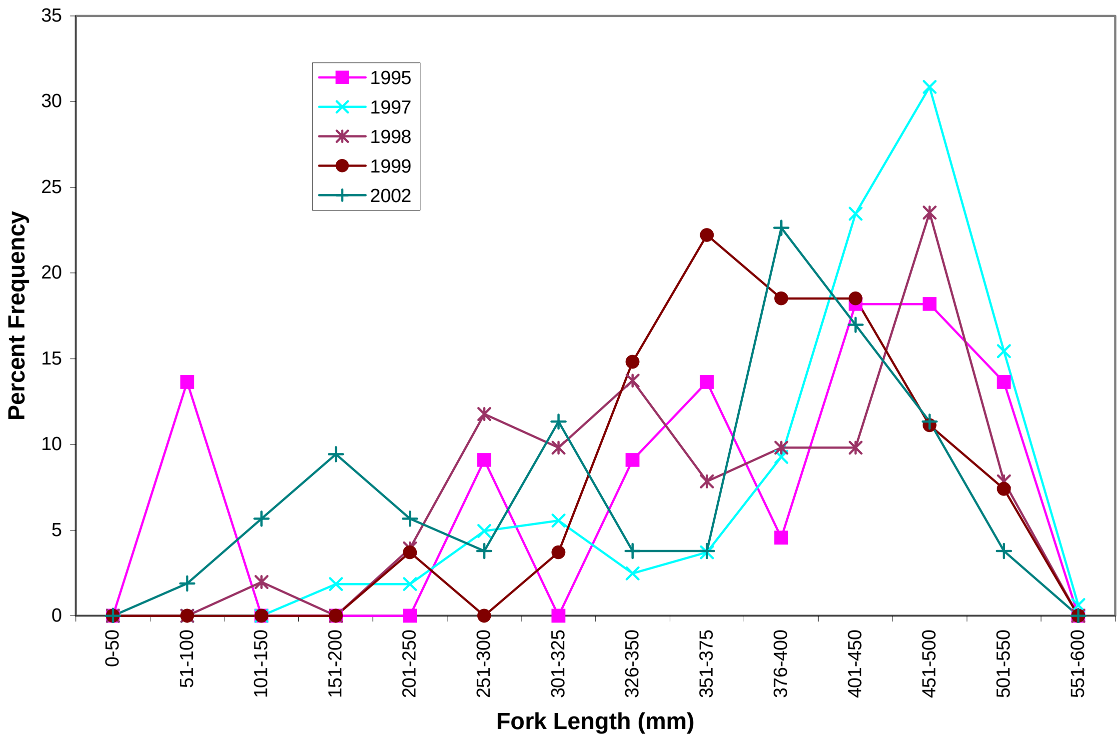
The spring length frequency distributions for longnose sucker (Figure 9.14) were variable. In several years (1975, 1996, 1997 and 1999), the population was dominated by larger fish (i.e., > 400 mm). In contrast, the 2002 size distribution was similar to 1998 and consisted of a larger proportion of smaller fish (i.e. < 301 mm). Overall, the proportion of the population in each size class was variable among years but did not show any trend over time. None of the between year differences were found to be significant (Appendix XVI).

Figure 9.14 Length Frequency Distributions for Longnose Sucker, Athabasca River Inventories, 1975 to 2002



The length frequency distributions for white sucker (Figure 9.15) were variable; however, there is a tendency for larger fish to dominate the captures. The proportion of the population consisting of smaller fish was slightly higher in spring 1995 and spring 2002, compared to the other years. Year-to-year variability is evident but is inconsistent. None of the between year differences were found to be significant (Appendix XVI).

Figure 9.15 Length Frequency Distributions for White Sucker, Athabasca River Inventories, 1995 to 2002



Fish Condition and Health

An evaluation of length-weight relationships was provided by comparison of condition factors for fish captured in the Athabasca River during spring inventories from 1995 to 2002. The size range (i.e., large fish) included in the comparison of condition factors for each species was selected to represent adult fish, based on the female mean size-at-maturity (Golder 2003a). Figure 9.16 provides the mean condition factor for each year along with the standard deviation.

Spring condition factor was found to be significantly different among years for walleye, goldeye, longnose sucker and white sucker (Appendix XVI). Condition factor for large (>400 mm) walleye was lower from 1997 to 2002 compared to 1995 and 1996 (Figure 9.16). Condition factor for large (>300 mm) goldeye was low in 2002 relative to all other years except 1997. Condition factor for large (>350 mm) longnose sucker was lower in 1995 and 1998 relative to the other years. Condition factor for large (>300 mm) white sucker was lower in 1998 and 2002 relative to other years. Despite significant variability in condition factor among years for these four species, there are no systematic changes over time for goldeye, longnose sucker and white sucker (Figure 9.16). There appears to be a consistent change for walleye, in that condition factor decreased in 1997 and has remained at this lower level through to 2002.

Mean external pathology index values for the main large-bodied species are presented in Table 9.25. The maximum index value for an individual would be 270, if the individual had an abnormal condition for all nine of the parameters examined.

Figure 9.16 Comparison of Mean Condition Factor for Adult Fish, Athabasca River Inventories, 1995 to 2002

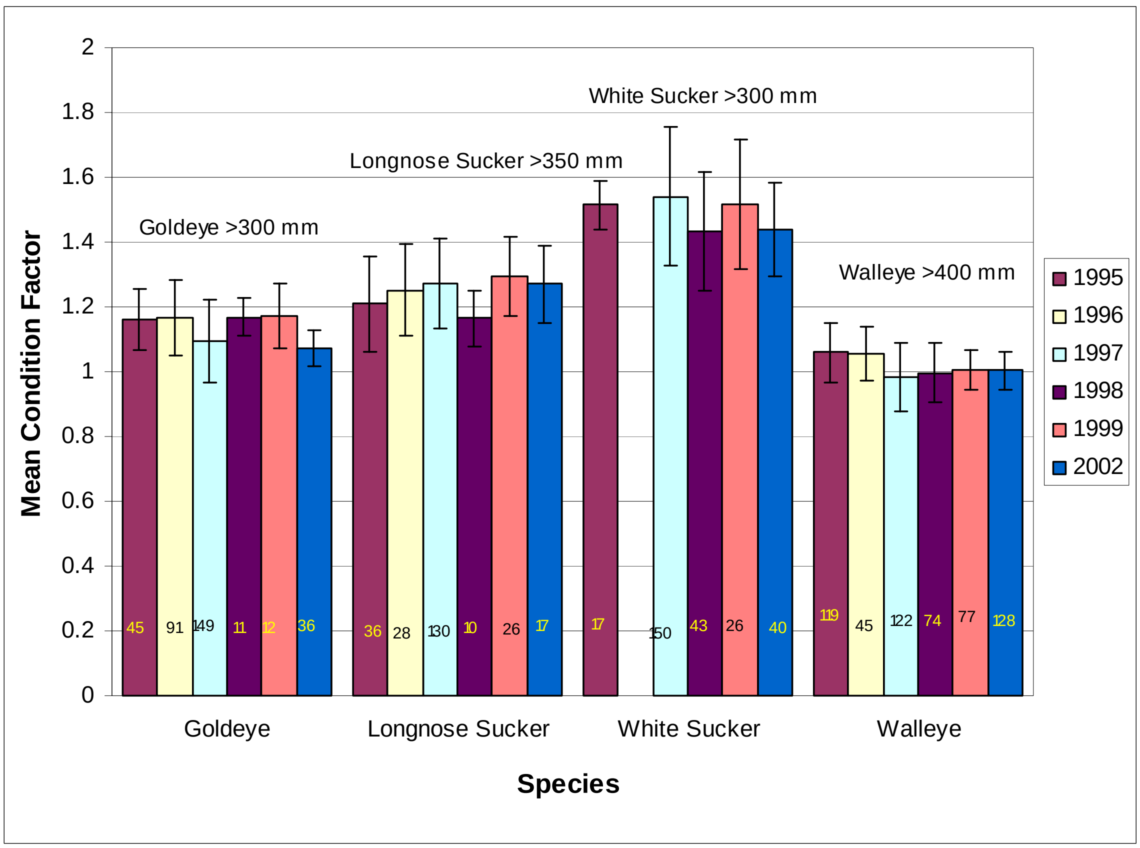


Table 9.25 Summary of External Pathology Indices, Athabasca River Inventories, 1995 to 2002

Species	Mean External Pathology index				
	1995	1997	1998	1999	2002
goldeye	9.6	4.3	0.5	3.7	0.4
longnose sucker	11.0	5.8	3.5	4.1	0.9
walleye	2.8	1.5	2.1	18.3	1.4
white sucker	18.6	3.2	9.6	5.7	0.6

For most species, and in most years, the percentage of fish with one or more external abnormalities was low, as were the mean pathology index values (Table 9.25). Some minor exceptions should be noted. In 1995, the incidences of abnormalities for longnose sucker, goldeye and white sucker were greater than 30%, although the average pathology index values were low. These high incidences were not observed in subsequent years. Walleye in 1999 showed a higher pathology index compared to previous years, but the index value was low again in 2002. Although some moderately high incidences of abnormalities or increases in index values have been recorded in some years, they have not occurred consistently and there is no indication of significant health problems for any species.

9.2.2 Muskeg River and Tributaries

9.2.2.1 Muskeg River

Ten fish species were captured during the Muskeg River inventory in 2002, including four sport species, two sucker species and four small-bodied species (Table 9.26). Sport fish were not abundant in 2002 and comprised 10% of the total catch, compared to 55% for sucker species and 35% for small-bodied fish.

Table 9.26 Species Percent Composition for all Sampling Methods Combined, Muskeg River Inventory, 2002

Species	Total Number[a]	Percent Composition (%)
goldeye	1	0.5
lake chub	13	6.3
longnose dace	1	0.5
longnose sucker	78	37.7
mountain whitefish	5	2.4
northern pike	7	3.4
spoonhead sculpin	1	0.5
trout-perch	57	27.5
walleye	7	3.4
white sucker	37	17.9
Total	**207**	**100**

[a] Includes captured and observed fish.

Boat electrofishing was the primary sampling technique and the electrofishing results (Table 9.27) provide the majority of the fisheries data for the inventory.

A small number of white sucker were captured in gill nets (Table 9.28), and no fish were captured in the baited minnow traps (total effort 48.3 hrs). Based on the electrofishing CPUE results, the most abundant species were longnose sucker (0.77 fish/100 s), trout-perch (0.56 fish/100 s), white sucker (0.34 fish/100 s) and lake chub (0.13 fish/100 s). The remaining species all had CPUE values of <0.1 fish/100 s.

Table 9.27 Boat Electrofishing Results, Muskeg River Inventory, 2002

Species	Number of Fish		CPUE (No./100 s)	
	Captured	Captured and Observed	Captured	Captured and Observed
goldeye	1	1	0.01	0.01
lake chub	13	13	0.13	0.13
longnose dace	1	1	0.01	0.01
longnose sucker	59	78	0.58	0.77
mountain whitefish	4	5	0.04	0.05
northern pike	3	7	0.03	0.07
spoonhead sculpin	1	1	0.01	0.01
trout-perch	7	57	0.07	0.56
walleye	3	7	0.03	0.07
white sucker	25	35	0.25	0.34
Total	**117**	**205**	**1.15**	**2.02**

Note: Total sampling effort = 10158 s.

Table 9.28 Gill Net Sampling Result, Muskeg River Inventory, 2002

Species	Number of Fish	CPUE (No./hr)
white sucker	2	0.25

Note: Total sampling effort = 8 hr

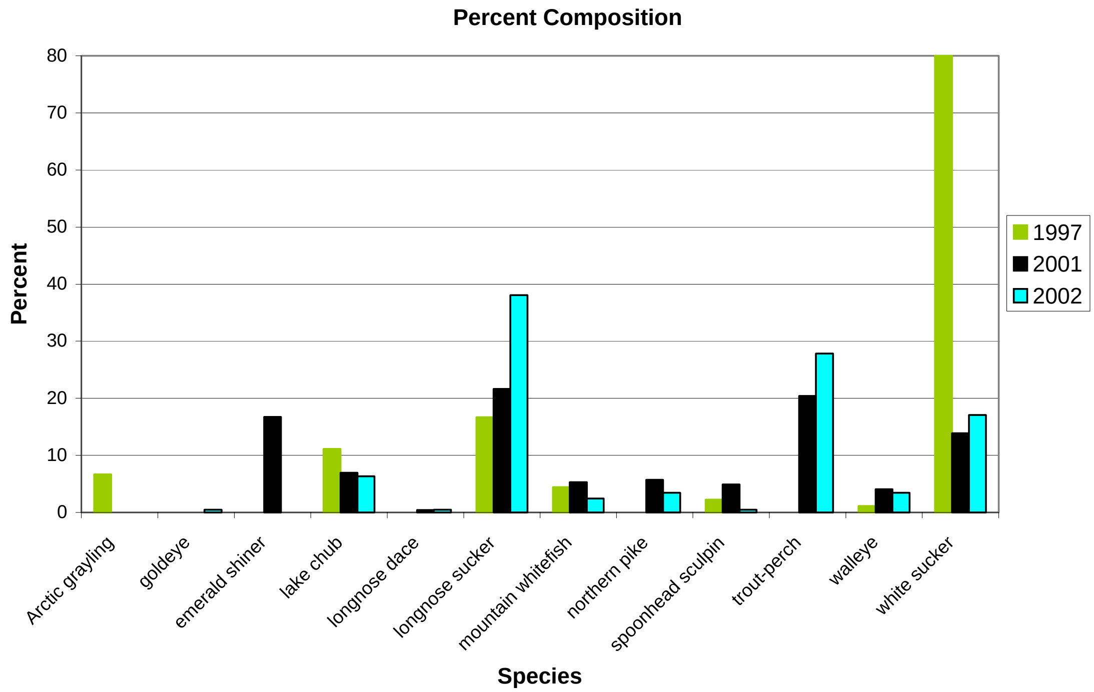
To some extent, fish distribution in the Muskeg River was related to the distance from the Athabasca River. Goldeye, northern pike and trout-perch were present only at the lower-most sampling site (Figure 3.10). Goldeye and trout-perch are typically associated with the Athabasca River and historically have been restricted to the lower-most portion of the Muskeg River (Golder 2003b). In contrast, northern pike are reported to have a wider distribution in the Muskeg River, suggesting that this species was present in low abundance in 2002. The remaining seven species recorded in 2002 had a wider distribution and were present at the upper sampling site.

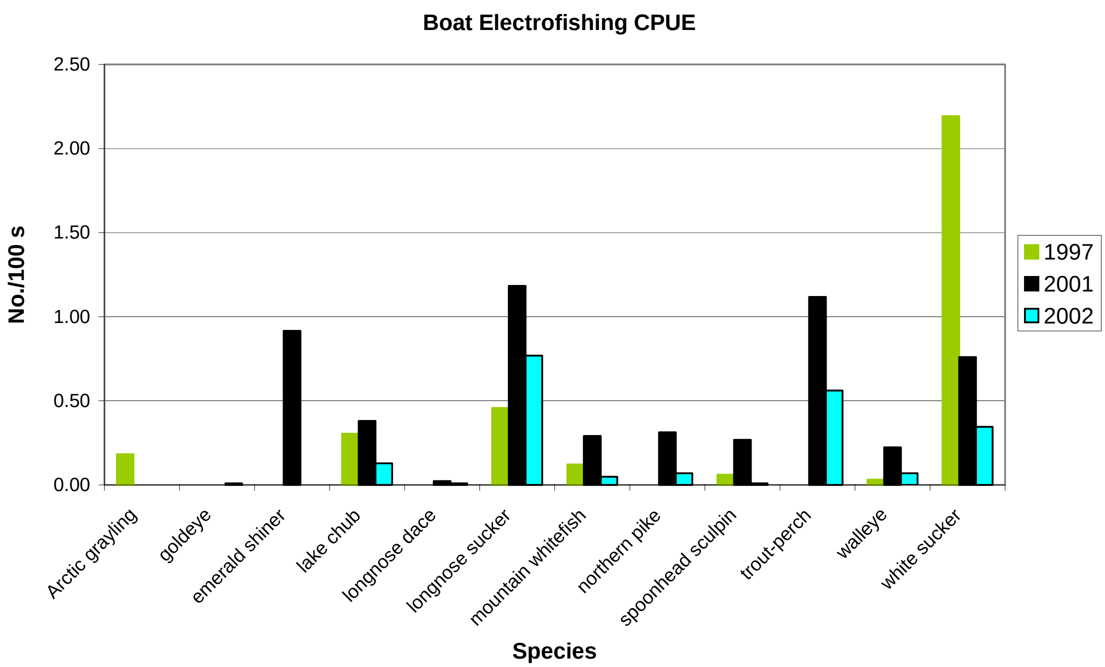
Most large-bodied fish present in the Muskeg River in the summer (longnose sucker, mountain whitefish, northern pike, walleye) were juvenile life stage, indicating that use of the river in the summer of 2002 may have been primarily for rearing activity. A small number of adult longnose sucker and walleye were also present, indicating lower level of use of the river by adults for feeding. In contrast, a large portion of the white sucker population consisted of adult fish.

In comparison to previous RAMP inventories in 1997 (Golder 1998) and 2001 (Golder 2002c), the species composition for the Muskeg River in 2002 was similar to that observed in 2001 (Figure 9.17), except that goldeye were found only in 2002. Both 2001 and 2002 inventory data show a greater species diversity than in 1997 when only six species were recorded. However, 1997 was the only year in which Arctic grayling were captured in the Muskeg River. Although not captured in 2001 inventory, Arctic grayling were found to be present in the watershed at that time, based on an angler report. Arctic grayling were not recorded in the Muskeg River watershed during any of the sampling activities conducted for RAMP in 2002 (i.e., Muskeg River inventory, Jackpine Creek inventory, Muskeg River fish tissue collections, Muskeg River tributary fyke net monitoring).

Comparison of relative abundance of fish species between years (Figure 9.17) shows that CPUE for most species increased from 1997 to 2001 and decreased from 2001 to 2002. The exceptions were Arctic grayling (present only in 1997) and white sucker (highest abundance in 1997).

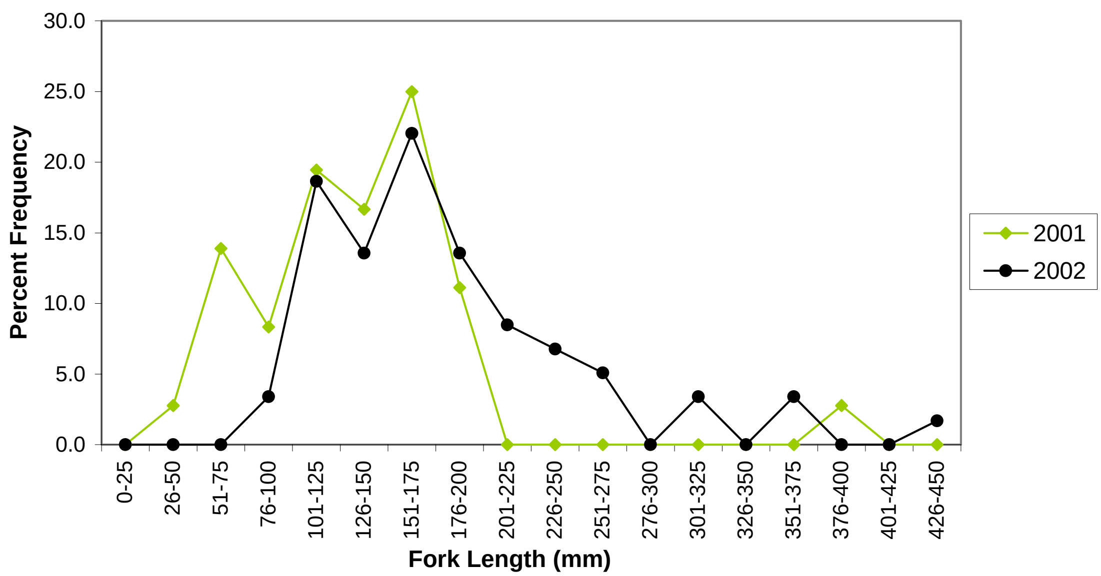
Figure 9.17 Comparison of Species Relative Abundance, Muskeg River Inventories, 1997 to 2002





Fish measurements and other sampling results are in Appendix XVI. Longnose sucker was the only large-bodied species collected in sufficient numbers (i.e., >30 individuals) in 2002 to conduct analysis for population parameters. The size distribution for longnose sucker was compared to 2001 data, the only other year with a sufficient sample size (Figure 9.18). Most fish captured in 2002 were similar in size to fish captured in 2001, ranging from 76 to 200 mm in length. However, fewer small fish and more large fish were captured in 2002 than in 2001. No fish under 75 mm (i.e., young-of-the-year) were captured in 2002 whereas fish this size were common in 2001. A greater proportion of fish captured in 2002 were 201 to 450 mm than in 2001. Statistical analysis indicates that the difference between the frequency distributions in 2001 and 2002 is not significant (p>0.05).

Figure 9.18 Length Frequency of Longnose Sucker, Muskeg River Inventories, 2001 and 2002



The mean condition factor for longnose sucker in 2002 (1.55 $\pm$ 0.07 SE) was higher than in 2001 (1.33 $\pm$ 0.1 SE). In both years, the condition factor was greater than 1.0, indicating that these fish were robust. The mean external pathology index for longnose sucker in 2002 was 0.2. This index is extremely low, and was similar to that measured in 1997 (0.0) and 2001 (0.8), indicating a low occurrence of abnormalities in this population.

The results for the water quality parameters that were measured at the time of inventory sampling are shown in Table 9.29.

Table 9.29 Mean Values (±SD) of Water Quality Parameters, Muskeg River Inventory, 2002

Field Parameter	Muskeg River (*n*=8)
Temperature (ºC)	18.12 ± 0.12
Dissolved oxygen (mg/L)	8.4 ± 0.16
Conductivity (µS/cm)	231.12 ± 1.2
pH	8.45 ± 0.19

9.2.2.2 Jackpine Creek

In total, seven fish species were recorded in Jackpine Creek during the summer 2002 inventory, including one sport species, two sucker species and four small-bodied species. Table 9.30 presents the total number of fish recorded (captured plus observed) for all sampling techniques combined, and the percent of total catch in comparison to captures in 2001. The fish fauna recorded in Jackpine Creek during 2002 consisted mainly of small-bodied fish species (84.2% of fish recorded). Based on percent composition, the most abundant species were pearl dace (42.1%), lake chub (33.1%) and longnose sucker (12.7%).

Ten fish species have been recorded in Jackpine Creek, 2001 and 2002 inventories combined (Table 9.30), with some differences in species composition between years. Longnose dace, northern pike and slimy sculpin were present in low abundance in 2001 but were not found in 2002. Mountain whitefish and white sucker were not recorded in 2001 but were present in low abundance in 2002. Pearl dace comprised a significant portion of the catch in 2002, but were not captured in 2001.

Table 9.30 Species Percent Composition for all Sampling Methods Combined, Jackpine Creek Inventories, 2001 and 2002

Species	2002[(a)]		2001[(a)]
	Total Number	Percent Composition (%)	Percent Composition (%)
brook stickleback	4	3.0	3.6
lake chub	44	33.1	85.4
longnose dace	0	0	0.4
longnose sucker	17	12.7	4.9
mountain whitefish	3	2.3	0
northern pike	0	0	0.4
pearl dace	56	42.1	0
slimy sculpin	0	0	0.4
spoonhead sculpin	8	6.0	4.9
white sucker	1	0.8	0
Total	**133**	**100**	**100**

(a) Includes captured and observed fish.

From examination of the fisheries data for Jackpine Creek (Golder 2003b), 14 fish species have been documented to occur in this watercourse, including the 10 species detected during the RAMP inventories. The four species not found in 2001 or 2002 were Arctic grayling, fathead minnow, flathead chub and northern redbelly dace. As in 2001, the lack of young-of-the-year and juvenile Arctic grayling indicated that spawning by this species was limited or did not occur in Jackpine Creek in 2002.

Additional sampling was conducted for RAMP in lower Jackpine Creek by Alberta Sustainable Resource Development (ASRD) and Syncrude Canada Ltd. An angling survey targeting Arctic grayling was conducted on July 11, 2002. The survey was conducted from the Canterra Road Crossing downstream to the creek mouth over the period 10:00 to 15:45 by three anglers using spinning gear. No fish were captured.

Catch-per-unit-effort (CPUE) for each fish species is presented separately for backpack electrofishing (Table 9.31), minnow trapping (Table 9.32) and boat electrofishing (Table 9.33). The 2002 results are presented in comparison to CPUE values from 2001, for the two sampling techniques used in both years (backpack electrofishing and minnow trapping). No fish were captured in the two Jackpine Creek gill net sets in 2002 (total effort 9.5 hr). With respect to the utility of the different sampling techniques, 46% of fish were recorded in minnow traps, 36% by backpack electrofishing, 18% by boat electrofishing and 0% in gill nets.

Table 9.31 Backpack Electrofishing Results, Jackpine Creek Inventories, 2001 and 2002

Species	2002				2001
	Number of Fish		CPUE (N0./100 s)		CPUE (No./100 s)
	Captured	Captured and Observed	Captured	Captured and Observed	Captured and Observed
brook stickleback	4	4	0.09	0.09	0.08
lake chub	11	11	0.26	0.26	0.72
longnose dace	0	0	0.00	0.00	0.01
longnose sucker	0	0	0.00	0.00	0.02
northern pike	0	0	0.00	0.00	0.01
pearl dace	24	24	0.57	0.57	0.00
slimy sculpin	0	0	0.00	0.00	0.01
spoonhead sculpin	7	7	0.17	0.17	0.12
TOTAL	**46**	**46**	**1.08**	**1.08**	**0.98**

Note: Total 2002 electrofishing effort = 4242 s.

Table 9.32 Minnow Trap Sampling Results, Jackpine Creek Inventories, 2001 and 2002

Species	2002		2001
	Number Captured	CPUE (No./hr)	CPUE (No./hr)
brook stickleback	0	0.00	0.05
lake chub	29	1.20	5.39
longnose sucker	7	0.29	0.48
pearl dace	31	1.29	0.00
white sucker	1	0.04	0.00
Total	**68**	**2.82**	**5.92**

Note: Total 2002 minnow trapping effort = 24.08 hr.

Table 9.33 Boat Electrofishing Results, Jackpine Creek Inventory, 2002

Species	Number of Fish		CPUE (No./100 s)	
	Captured	Captured and Observed	Captured	Captured and Observed
lake chub	4	4	0.25	0.25
longnose sucker	7	10	0.44	0.63
mountain whitefish	1	3	0.06	0.19
pearl dace	1	1	0.06	0.06
spoonhead sculpin	1	1	0.06	0.06
Total	**14**	**19**	**0.88**	**1.20**

Note: Total electrofishing effort = 1582 s.

The CPUE data indicate that pearl dace, lake chub and longnose sucker were the most abundant species in 2002, although relative abundance levels were different for different sampling techniques. The CPUE results for backpack electrofishing and minnow trapping indicate notable differences in species relative abundance between 2001 and 2002 for lake chub and pearl dace. Between 2001 and 2002, lake chub CPUE decreased from 0.72 to 0.26 fish/100 s (backpack electrofishing) and from 5.39 to 1.20 fish/hr (minnow trapping). Pearl dace were not captured in 2001 but were the most abundant species in 2002 according to backpack electrofishing (0.57 fish/100 s) and minnow trapping (1.29 fish/hr) results.

Of the three large-bodied species recorded in Jackpine Creek in 2002 (longnose sucker, mountain whitefish and white sucker), most fish were juvenile life stage. Young-of-the-year longnose and white sucker were present as was one adult longnose sucker. Overall, the data indicate that, during summer 2002, Jackpine Creek was primarily used as rearing habitat by these species.

Examination of population parameters (length frequency, condition factor) was not conducted for any large-bodied species because sample sizes were small.

The results for the water quality parameters that were measured during sampling activities are shown in Table 9.34.

Table 9.34 Mean Values (±SD) of Water Quality Parameters, Jackpine Creek Inventory, 2002

Field Parameter	Jackpine Creek (*n*=6)
temperature (ºC)	15.68 ± 1.27
dissolved oxygen (mg/L)	7.61 ± 0.16
conductivity (µS/cm)	141.5 ± 0.22
pH	7.38 ± 0.06

9.3 ATHABASCA RIVER SENTINEL SPECIES

The sample size of female and male trout-perch examined for the sentinel species health assessment from the reference and exposure sites is in Table 9.35. The target number of fish (i.e., 40 mature female and 40 mature male) was achieved at each site.

Table 9.35 Total Number of Adult Trout-Perch Examined for Sentinel Species Monitoring, Athabasca River, Fall 2002

Sex	Reference Sites[a]		Exposure Sites[a]		
	Site #1	Site #2	Site #3	Site #4	Site #5
female	42	40	40	40	40
male	43	47	40	40	40
total	**85**	**87**	**80**	**80**	**80**

(a) See Figure 3.11 for sampling site locations.

The frequency of internal and/or external abnormalities ranged from 16 to 26% of the total number of trout-perch captured at each site (Table 9.36). The incidence of abnormalities was slightly higher in fish captured immediately downstream of the Suncor/Syncrude area (Site 3), and then decreased with progression downstream (Table 9.36). With the exception of Site 5, the frequency of external abnormalities exceeded those detected internally. As well, with the exception of Site 3, trout-perch from the exposure sites did not exhibit increased abnormalities relative to fishes captured at the reference sites. The increased occurrence of pathology at Site 3 was due to a greater number of fish with mild skin aberrations and active erosion of the fins. In 1999, trout-perch from the reference site (Site 2) had the highest prevalence of abnormalities;

mostly related to a few fish that appeared to have a slightly enlarged spleen. The greatest occurrence of this pathology in 2002 was at reference Site 1, with only one such occurrence at Site 2. The pathology index (PI) scores were low, with the female fish from Site 3 (exposure site) and male fish from Site 1 (reference site) with the highest scores (Table 9.36).

Table 9.36 Number of Trout-Perch with External/Internal Abnormalities, Athabasca River, Fall 2002

Tissue	Reference Sites[a]		Exposure Sites[a]		
	Site #1	Site #2	Site #3	Site #4	Site #5
With External Abnormalities[b]					
eyes	0	1	0	0	0
gills	0	0	3	1	0
pseudobranchs	1	0	1	0	1
skin	0	4 (low)[c]	7 (low)	2 (mod.)	1 (low)
fins	1 (low)	2 (low)	5 (low)	0	3 (mod.)
opercles	10	5	8	6	0
With Internal Abnormalities[b]					
hindgut	0	1 (low)	0	0	1 (low)
liver	3	3	1	2	3
spleen	6	1	0	1	4
kidney	0	0	0	0	0
parasites	2 (low)	1 (low)	3 (low)	4 (low)	2 (low)
total no. fish evaluated	**85**	**80**	**80**	**80**	**80**
total no. fish affected[d]	**19**	**15**	**21**	**16**	**13**
% fish affected	22%	19%	26%	20%	16%
female PI	5.2	4.3	7.8	4.5	5.5
male PI	9.8	4.9	6.5	5.0	2.8

(a) See Figure 3.17 for sampling site locations.
(b) List of abnormalities is presented in Appendix XIV.
(c) Descriptor in parentheses indicates severity of abnormality.
(d) An individual fish may exhibit more than one type of abnormality.

Each adult trout-perch population consisted primarily of two and three year old individuals (Figure 9.19). These age classes also dominated the populations sampled in 1999. The shapes of the age distributions differed somewhat among sites. Age 2 and 3 female trout-perch dominated at the reference sites, while age 3 females dominated at the exposure sites. In contrast, three year olds dominated the male trout-perch populations at the reference sites with ages 2 and 3 dominating in populations from exposure sites. There were fewer fish in the older age classes in the exposure site populations, and Site 5 had the highest frequency of year 1 fish. These younger fish resulted in the lower mean age of both males and females at Site 5 (Table 9.37) compared to reference Site 2. The mean age of male trout-perch was also lower at Site 3 (compared to the reference population at Site 2) and, similarly, was likely due to the higher number of one and two year old fish at this site.

Figure 9.19 Age-frequency Distributions for Trout-Perch According to Site, Athabasca River, Fall 2002

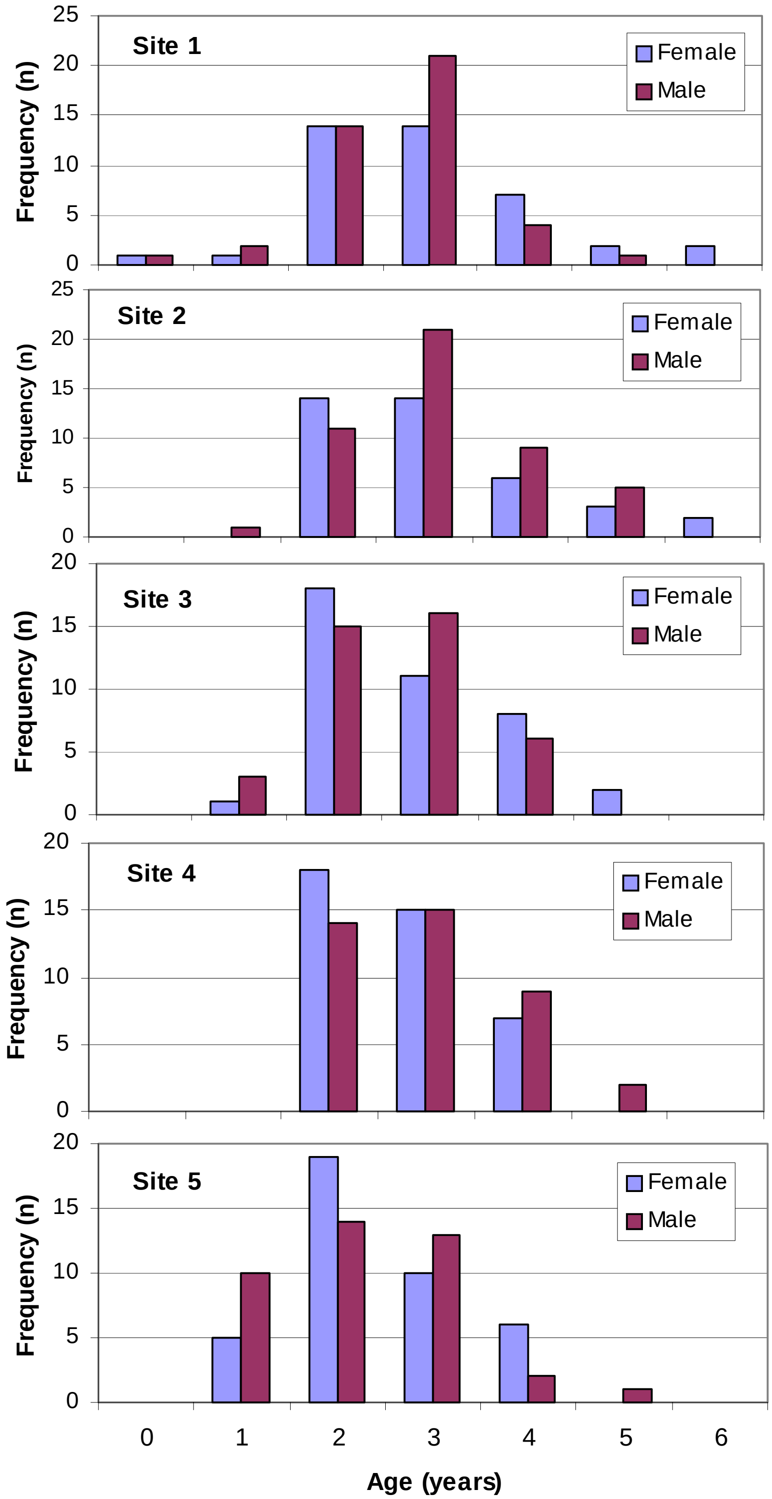


Table 9.37 Mean ± SE (*n*) of Population-Level Parameters in Trout-Perch, Athabasca River, Fall 2002

Sex	Parameter	Reference Sites[a]		Exposure Sites[a]		
		Site #1	Site #2	Site #3	Site #4	Site #5
female	age (y)	3.0 ± 0.18 (40)	3.1 ± 0.18 (39)	2.8 ± 0.15 (40)	2.7 ± 0.12 (40)	**2.4 ± 0.14 (40)**
	fork length (mm)	71.20 ± 1.05 (42)	71.30 ± 1.15 (40)	71.10 ± 0.78 (40)	69.88 ± 0.91 (40)	71.18 ± 0.95 (40)
	body weight (g)	4.50 ± 0.20 (42)	4.64 ± 0.21 (40)	4.60 ± 0.17 (40)	4.06 ± 0.22 (40)	4.40 ± 0.20 (40)
	length at age (mm)[b]	70.63 ± 1.01 (40)	70.54 ± 1.01 (39)	70.85 ± 1.01 (40)	69.53 ± 1.01 (40)	72.38 ± 1.01 (40)
	condition factor	1.22 ± 0.02 (42)	1.25 ± 0.01 (40)	1.27 ± 0.02 (40)	**1.18 ± 0.04 (40)[c]**	**1.21 ± 0.03 (40)[c]**
	LSI	1.71 ± 0.06 (42)	1.95 ± 0.08 (40)	1.76 ± 0.04 (40)	**1.58 ± 0.04 (40)**	2.04 ± 0.07 (40)
	GSI	5.24 ± 0.18 (42)	5.74 ± 0.23 (40)	5.46 ± 0.12 (40)	5.51 ± 0.13 (40)	5.98 ± 0.12 (39)[d]
	Fecundity (#eggs/g)	306.45 ± 1.58 (41)	286.24 ± 7.99 (40)[d]	**208.36 ± 6.25 (40)**	**244.72 ± 7.57 (40)**	294.10 ± 8.90 (39)
male	age (y)	2.7 ± 0.12 (42)	3.1 ± 0.14 (47)	**2.6 ± 0.13 (40)**	3.0 ± 0.14 (40)	**2.3 ± 0.16 (40)**
	fork length (mm)	66.86 ± 0.94 (43)	66.57 ± 0.67 (47)	64.88 ± 0.64 (40)	64.83 ± 0.61 (40)	64.33 ± 0.72 (40)
	body weight (g)	3.61 ± 0.15 (43)	3.74 ± 0.09 (47)	3.49 ± 0.10 (40)	**3.21 ± 0.10 (40)**	**3.26 ± 0.13 (40)**
	length at age (mm)[b]	66.91 ± 1.01 (42)	65.50 ± 1.01 (47)[e]	64.92 ± 1.01 (40)	64.01 ± 1.01 (40)[e]	65.53 ± 1.01 (40)
	condition factor	1.18 ± 0.02 (43)	**1.27 ± 0.02 (47)[f]**	1.27 ± 0.02 (40)	**1.18 ± 0.02 (40)**	1.22 ± 0.03 (40)
	LSI	1.31 ± 0.03 (43)	**1.47 ± 0.04 (47)**	1.47 ± 0.04 (40)	**1.22 ± 0.03 (39)**	1.60 ± 0.07 (40)
	GSI	1.10 ± 0.04 (43)	1.20 ± 0.17 (47)	**1.30 ± 0.05 (40)**	**1.46 ± 0.24 (39)**	**1.66 ± 0.09 (40)**

Note: **bold** values indicate a statistically significant difference ($P < 0.0125$, Bonferroni's adjusted α) between reference Site 1 and 2, or between exposure site and reference Site 2.

(a) See Figure 3.17 for sampling site locations.

(b) Age-adjusted fork length from ANCOVA.

(c) Not significant if carcass weight used as dependent variable in ANCOVA.

(d) Significant if body weight used as covariate in ANCOVA.

(e) Significant if body weight or carcass weight used as dependent variable in ANCOVA.

(f) ANCOVA not performed due to significant differences in slopes.

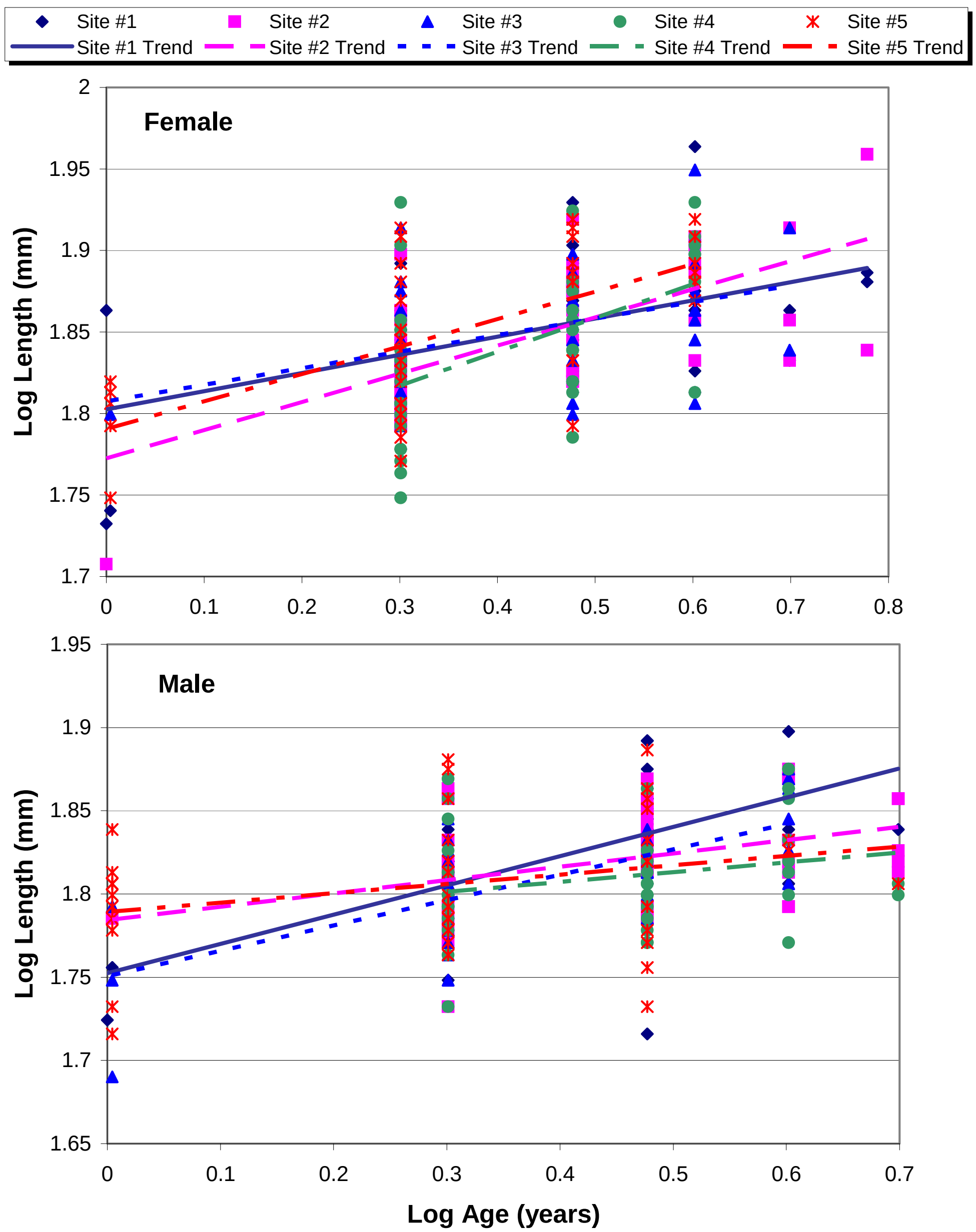
Note: LSI (liver-somatic index) = liver weight/carcass weight x 100
GSI (gonad-somatic index) = gonad weight/carcass weight x 100

There were few differences in body size (mean length and mean weight) of trout-perch among the sites (Table 9.37). The exceptions were the smaller body weights of males from Sites 4 and 5 relative to reference Site 2. Of the five sites sampled in 2002, only Sites 2 and 4 were sampled in 1999. In contrast to 2002 results, there were no differences in body size between these two sites in 1999. Length-at-age relationships (i.e., growth) among sites were the same (Figure 9.20); however, when body weight or carcass weight was used instead of length as an estimate of size, the growth curve for males from Site 2 was lower than that at Site 1, and the size at a given age of males from Site 4 was lower than that at Site 2 (Table 9.37). In 1999, the relationship between fork length (or any other estimate of size) and age of trout-perch was extremely variable and poor and could, therefore, not be compared among sites.

As in 1999, male and female trout-perch from Site 4 had a lower condition factor (i.e., they weighed less for a given length and were, therefore, thinner or less robust) relative to fish collected at reference Site 2 (Table 9.37). The same situation was observed with female fish from Site 5. Male trout-perch from Site 2 may be responding to an increase in productivity in the river below the Fort McMurray sewage treatment plant (STP); this population had a higher mean condition factor and relative liver size as identified by the liver-somatic index (LSI) than male fish at reference Site 1. The female trout-perch population at Site 2 displayed the same response, though the differences were only marginally significant (condition $P = 0.026$ and liver $P = 0.024$). LSIs in both females and males from Site 4 were lower than those at Site 2 and, together with the lower condition factors, may reflect characteristics of a site with lower overall productivity. Similar results were obtained in 1999.

Relative gonad weight in females as determined by the gonad somatic index (GSI) were not significantly different among trout-perch populations from reference and exposure sites, though the higher GSI at Site 5 relative to Site 2 was marginally significant ($P = 0.014$). In contrast, male GSI were higher in all three exposure populations and increased with each downstream site (Table 9.37). The highest GSI for both males and females was at Site 5. In contrast to the observations made in 1999, fecundity of female trout-perch was lower at Sites 3 and 4 compared to that at reference Site 2. Fecundity at Site 5 was similar to that at Site 2.

Figure 9.20 Plot of Fork Lengths vs. Age for Trout-Perch, Athabasca River, Fall 2002



Overall, there were some differences in characteristics of trout-perch populations among the five study sites; however, those differences were generally not consistent between males and females. As illustrated in 1999, male and female trout-perch downstream of the Muskeg River (Site 4) showed some evidence of reduced levels of energy storage (e.g., reduced condition and liver size; Gibbons and Munkittrick 1994). This evidence, coupled with smaller body weights in males (and marginally significant smaller weights and smaller gonads in females [*P* = 0.025 and 0.014, respectively]) and lower fecundity provides some evidence for a biologically significant difference. The significantly larger gonad weights in males at this site, however, complicate the interpretation. In contrast to the fish population from Site 4, responses in fish downstream of the Fort McMurray STP indicate that these fish may have higher levels of energy storage. These responses in fish inhabiting rivers exposed to treated municipal sewage have been observed elsewhere (Golder 2000c; Stantec and Golder 2000)

The response of trout-perch collected at the potentially "exposed" sites in 2002 was, for the most part, inconsistent with results documented for trout-perch in 1999 and for longnose sucker in 1998 (Table 9.38). As described in Golder (1999), there are reasons why the discrepancy in responses between trout-perch and longnose sucker may exist, including species differences in life history, longevity, habitat preferences and resource utilization. Moreover, there were differences in habitat and reference locations for both species. The differences in response observed in trout-perch populations between 1999 and 2002 may, however, simply illustrate the natural annual variability that can occur in fish populations. The one consistent observation among years and species was the lower levels of energy storage at Site 4 in both 1999 and 2002.

Golder (1999) discussed the need to understand exposure-response relationships for fishes within the Oil Sands Region. There is limited information that describes the movement of trout-perch within the Oil Sands Region. As such, it is difficult to rule out the possibility that the inconsistent responses of trout-perch are related to their ability to move among sites. The consistent responses that were observed, together with other differences among populations indicate that the populations do remain isolated from one another; however, there may be a need to evaluate the assumption of mobility of trout-perch within the Oil Sands Region.

Table 9.38 Summary of Changes in Whole-Organism Characteristics of Longnose Sucker (fall 1998) and Trout-Perch (fall 1999 and 2002), Athabasca River

Parameter	Longnose Sucker 1998[a]	Trout-Perch	
		1999[b]	2002[c]
age	0[d]	0 / 0	- [e]/ 0 / -
fork length	+	0 / 0	0 / 0 / 0
body weight	+	0 / 0	- / - / -
condition	-	0 / -	0 / - / -
liver size	-	0 / - [f]	0 / - / 0
gonad size	0	0 / 0	+ [e]/ + [e]/ +
fecundity	-	0 / 0	- / - / 0

[a] Data from Golder (1999).
[b] Separate responses for two exposure sites.
[c] Separate responses for three exposure sites (sites 3 / 4 / 5).
[d] + signifies an increase relative to reference data; - signifies a decrease; 0 signifies no change.
[e] In males only.
[f] In females only.

Sample Size Considerations

The number of fish needed to detect a 20, 30 and 50% change (i.e., effect size or δ) in each fish parameter between sites is summarized in Table 9.39. The final results indicated that the minimum number of fish needed from each site was approximately 26 females and 25 males to detect a 20% difference between sites; 11 females and 11 males to detect a 30% difference; and 4 females and 4 males to detect a 50% difference. For a given effect size, the estimated sample size is related to the amount of variability observed in a particular parameter within and between study sites. From these analyses, it is apparent that estimates of age are the most variable and require greater sample sizes relative to other measurements. The observed variability in age of adult fish is common (and real), particularly when using capture techniques that are only moderately size selective. However, improved ageing techniques may also contribute to reducing some of the observed variability. These sample size estimates are considerably lower than those made in 1999 and reflect the overall larger sample size obtained across the five sites in 2002.

Table 9.39 Number of Trout-Perch per Site Needed to Detect Parameter Decreases of 20, 30 and 50% Between Sites

Parameter	Sex	Estimated Sample Size (# fish/site)[a]		
		ES=20%	ES=30%	ES=50%
fork length	Female	4	<3	<3
	male	3	<3	<3
body weight	female	17	8	3
	male	11	5	3
condition	female	3	2	<2
	male	3	2	<2
age	female	26	11	4
	male	25	11	4
gonad weight	female	7	4	2
	male	15	7	3
fecundity	female	7	4	2
liver weight	female	8	2	3
	male	8	4	3

[a] Calculations were done using $\log_{10}$ transformed data, power=0.80 and α=0.05.
ES = effect size or δ.

For both female and male trout-perch, sufficient sample sizes were collected in 2002 from each site to detect at least a 20% difference among sites. Furthermore, sample sizes of trout-perch were more than adequate to detect the recommended effects criterion of ±25% gonad weight used for the pulp and paper Environmental Effects Monitoring (EEM) program (Environment Canada 1997b).

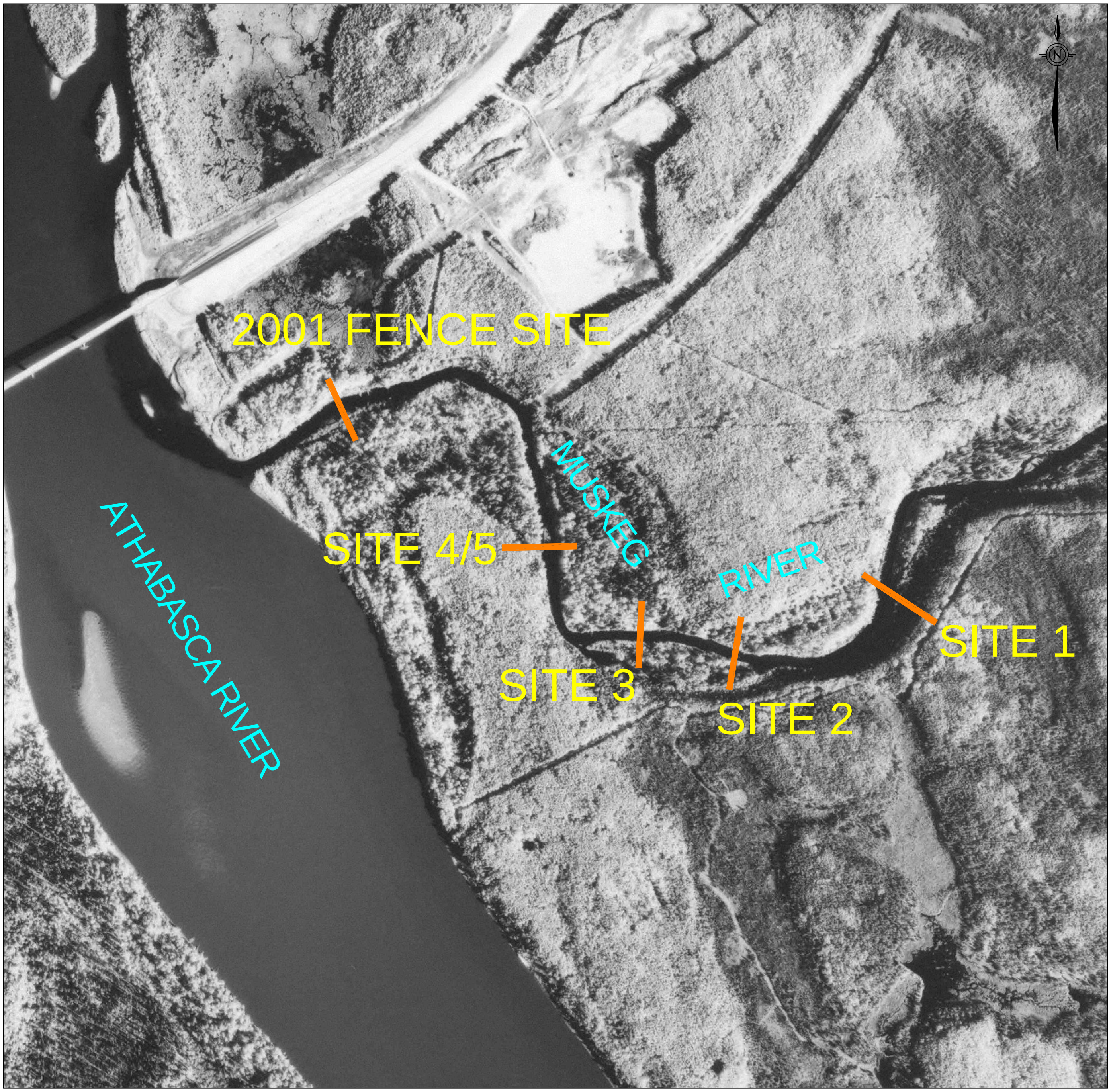
9.4 MUSKEG RIVER FISH FENCE RECONNAISSANCE

The lower 1.5 km of the Muskeg River was examined on two separate occasions in 2002 for potential sites to place the RAMP fish fence (scheduled for deployment in spring 2003). Five candidate sites were located that appeared to have suitable cross-sectional depth profiles and hydraulic conditions (Figure 9.21). The UTM coordinates of the sites are presented in Table 9.40, with the exception of Site 5, which was located only a few metres downstream of Site 4. The fish fence site used in the 2001 RAMP study is presented in Figure 9.21 for comparison; the 2001 fence site was not considered a candidate site for fence deployment in 2003.

Table 9.40 UTM Coordinates for Candidate Fish Fence Sites, Lower Muskeg River, 2002

Candidate Site #	UTM Coordinates (NAD 83)
1	4464373 E / 6332365 N
2	464041 E / 6332278 N
3	463965 E / 6332277 N
4	463815 E / 6332405 N
5	-

The depth and velocity profiles for each candidate site at a river discharge of 5.5 m^3/s are presented in Figures 9.22 and 9.23. All profiles begin on the left-downstream bank of the river. The following is a brief description of each candidate site.



REFERENCE
AIR PHOTOGRAPH OBTAINED FROM AIR PHOTO SERVICES
PROJECT P97-197 AS4883 LINE 05 PHOTO 146
ORIGINAL SCALE 1:15,000

PROJECT

RAMP 2002

TITLE

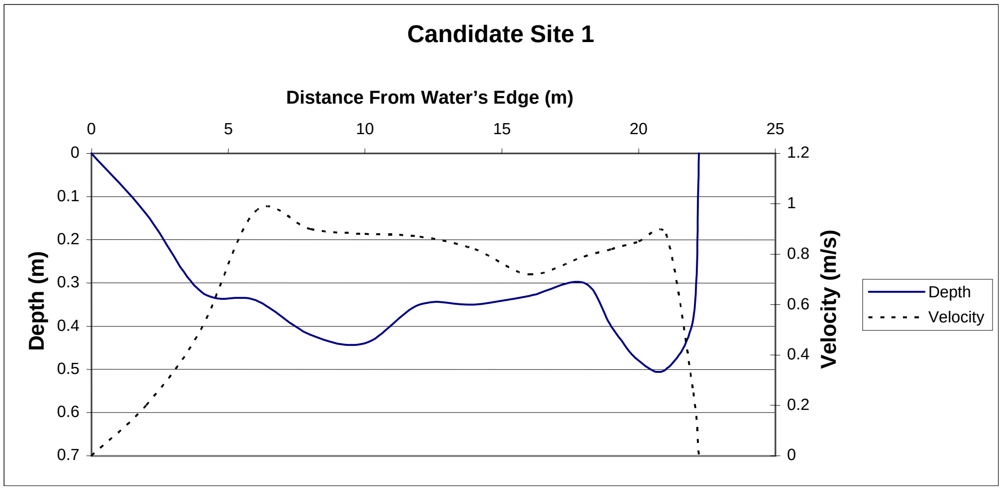
LOCATION OF CANDIDATE FISH FENCE SITES, LOWER MUSKEG RIVER, 2002

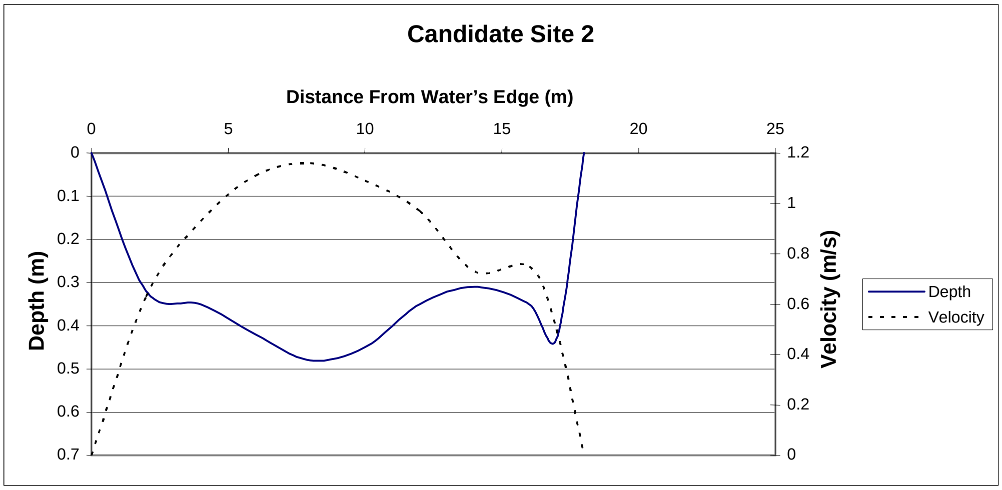
Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.6460			FILE No. Transect Locations
DESIGN	CB	20/02/03	SCALE AS SHOWN REV. 0
CADD	PSR	20/02/03	**FIGURE: 9.21**
CHECK	CB	11/03/03	
REVIEW			

R:\CAD\2300\022-2301\6460\ Drawing file: TRANSECT LOCATIONS.dwg Mar 17, 2003 - 10:15am

Figure 9.22 Depth and Velocity Profiles for Candidate Fish Fence Sites 1, 2 and 3, Muskeg River, 2002





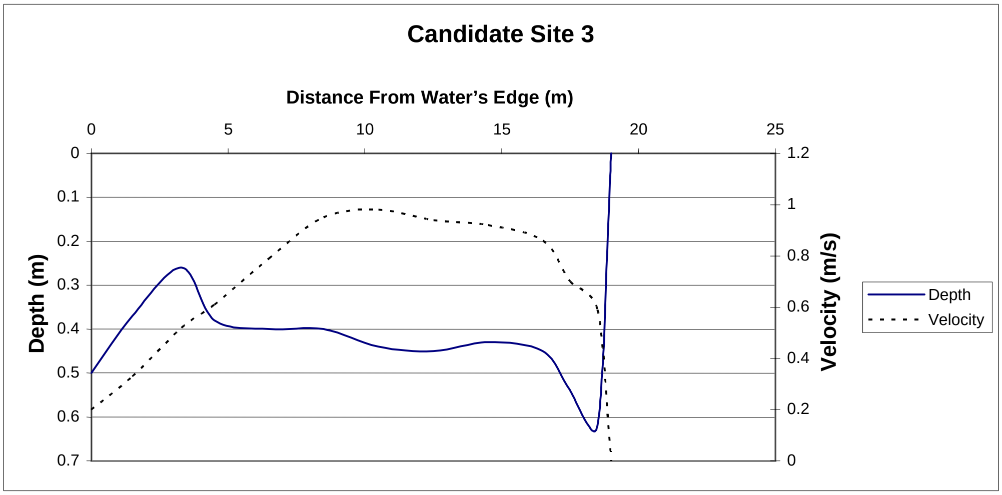
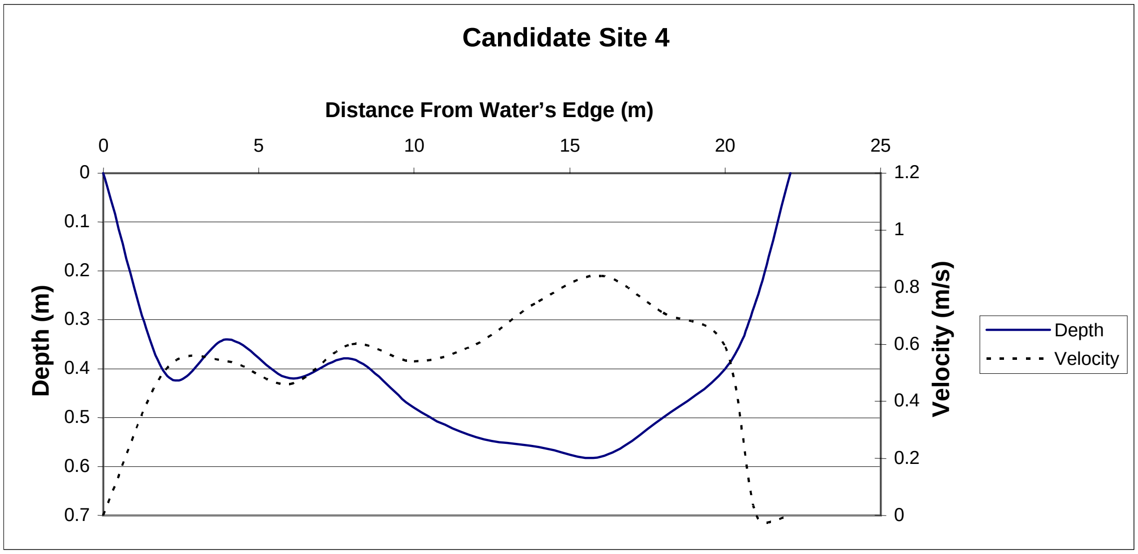
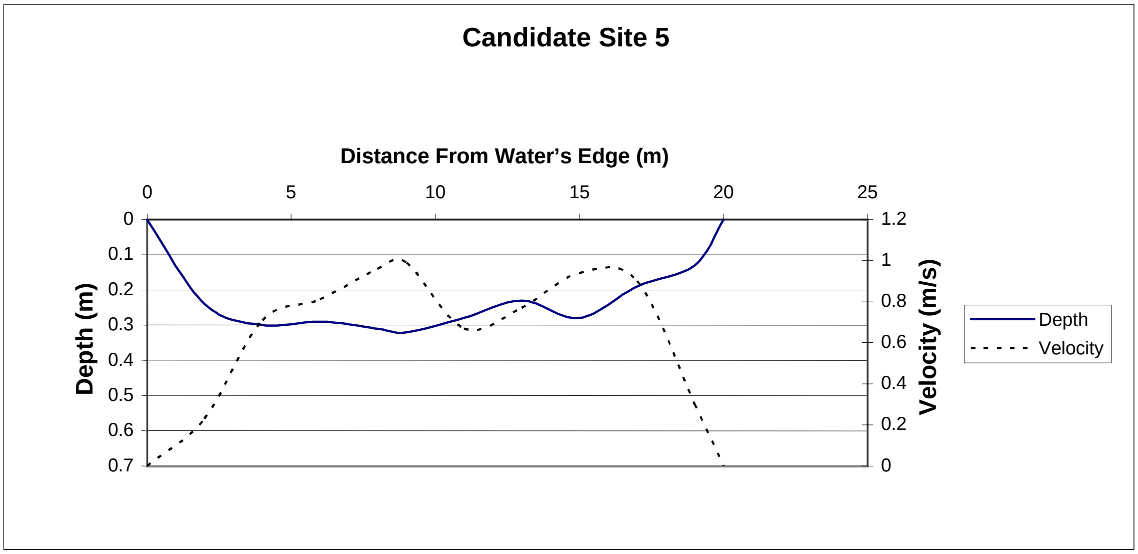


Figure 9.23 Depth and Velocity Profiles for Candidate Fish Fence Sites 4 and 5, Muskeg River, 2002





Candidate Site 1 had a maximum depth that occurred along the right-downstream bank where there was also a slight undercut bank. However, there was a small velocity shelter in this area because of a protrusion on the bank further upstream that may provide some protection from high velocities and possible scouring. At the higher discharge encountered during the second site visit, velocities near the left-downstream bank appeared to be too swift for deployment of a trap box. There was heavy shrub cover lining both banks so there was no good working/staging area. The substrate was gravel/sand, which would make fence installation relatively easy, but erosion/scouring would be a concern.

Candidate Site 2 was located in a riffle area, so it was generally shallow and swift. The site remained shallow (<0.5 m) during the higher discharge associated with the second site visit, but it appeared that velocities near the left-downstream bank were too high for easy deployment of a fence or trap box. There was a small working area on the left-downstream bank, whereas the right-downstream bank was a cliff face. The substrate was coarser than Site 1, consisting of gravel/cobble, but was soft with sand underneath creating potential for erosion/scour problems.

Candidate Site 3 was located in shallow run habitat. The site had a good profile and uniform substrate. During the higher discharge associated with the second site visit, the highest velocities were at mid-channel, with potential trap box locations near each bank in slower water. The substrate was primarily gravel with some cobble-sized material but appeared to be soft and easily eroded. There were shrubs on both banks of the river with no real working/staging area. There was an old, overgrown cutline that crossed the river a short distance upstream of the site. Access along the cutline would require travel by OHV and would likely be difficult due to the variable terrain and the probable need to move fallen timber.

Candidate Site 4 was located in a shallow run immediately upstream of an island/riffle area. The maximum depth at this site was deeper than at the other candidate sites, with the deepest, fastest water along the right-downstream bank. The substrate was gravel/cobble with some boulder-sized particles but was soft and easily penetrated. There was a very small working area on the left-downstream bank.

Candidate Site 5 was located in the riffle crest at the top of the island immediately below Site 4. The island split the river flow approximately in half. The profile data presented in Figure 9.21 is for the east half of the channel only, from the left-downstream bank to the island. The west half of the channel was observed to be deeper and swifter than the east half. Using this site would require a fence on each side of the island but the site provides shallow water and coarse substrate. The substrate was gravel/cobble with some boulder and appeared to be less susceptible to erosion than the previous sites. However, the riffle occurred on a diagonal and would require a fairly long fence to block the channel. In addition, the higher water level during the second site visit showed that the island had a low profile and could become inundated at higher flows.

Overall, there are several sites in the lower Muskeg River with suitable profiles for a counting fence. Although specific profiles were identified and measured at each site, the same general profile characteristics occur for a distance upstream and downstream at each site, providing similar conditions over a length of channel. Therefore, the fence could be placed within a short distance upstream or downstream of any of the sites identified in Figure 9.21. All candidate sites have a mobile substrate, poor access and small working/staging areas. Although the substrates are generally rocky, they are soft with underlying sand and/or bitumen. The biggest challenge for fence deployment will be the erodable nature of the substrate, a general condition for the entire length of river examined.

The recommended site, based on both site inspections would be Site 3. The discharge during the second site visit was higher than the initial visit and, although profile measurements were not conducted on the second visit, the increase in depth and velocity was observed to be the least at Site 3. Site 3 is also in close proximity to the fish fence site used for historical AOSERP studies (Bond and Machniak 1977, 1979).

9.5 MUSKEG RIVER TRIBUTARY FYKE NET MONITORING

9.5.1 Muskeg Creek

Table 9.41 presents the numbers of fish captured during each day of fyke net sampling in Muskeg Creek, by season (i.e., direction of travel). The total number of fish captured moving upstream in Muskeg Creek during the spring sampling period was 71, consisting of five species. The catch consisted primarily of three small-bodied forage species (94% of the catch), with small numbers of longnose sucker (4%) and northern pike (2%). Pearl dace was the most abundant of the small-bodied species, followed by brook stickleback and lake chub. All longnose sucker captured were juvenile fish, while the one northern pike captured was an adult. Most of the spring upstream movement occurred shortly after ice-out, with 85% of the fish captured prior to May 28. Fish measurement data for Muskeg Creek is presented in Appendix XVIII.

Table 9.41 Fyke Net Sampling Results, Muskeg Creek, Spring and Fall 2002

Date	Species							Total
	Brook Stickleback	Lake Chub	Longnose Sucker	Northern Pike	Pearl Dace	Spoonhead Sculpin	White Sucker	
Spring Upstream Movement								
May 24	0	0	0	0	0	0	0	**0**
May 25	1	0	2	1	28	0	0	**32**
May 26	2	0	0	0	1	0	0	**3**
May 27	5	2	0	0	18	0	0	**25**
May 28	1	0	1	0	1	0	0	**3**
May 29	0	2	0	0	0	0	0	**2**
May 30	2	0	0	0	3	0	0	**5**
May 31	1	0	0	0	0	0	0	**1**
June 1	0	0	0	0	0	0	0	0
Total	**12**	**4**	**3**	**1**	**51**	**0**	**0**	**71**
Fall Downstream Movement								
Oct 3	0	0	0	0	0	0	0	**0**
Oct 4	1	0	0	0	2	0	0	**3**
Oct 5	0	0	0	0	0	0	0	**0**
Oct 6	2	0	0	0	1	0	1	**4**
Oct 7	2	3	0	0	1	0	0	**6**
Oct 8	2	0	0	0	0	0	3	**5**
Oct 9	2	0	0	0	5	0	2	**9**
Oct 10	4	0	0	0	6	1	1	**12**
Oct 11	7	1	0	0	5	0	0	**13**
Oct 12	1	1	0	0	6	0	0	**8**
Total	**21**	**5**	**0**	**0**	**26**	**1**	**7**	**60**

The total number of fish captured moving downstream at the fyke net site in the fall was 60, consisting of five species (Table 9.41); this included two species not recorded in the spring. The catch was again dominated by small-bodied forage species (88%), with a small number of white sucker (12%). The dominant species in the fall were pearl dace and brook stickleback. White sucker was the only large-bodied species captured and all fish were either young-of-the-year or juvenile. Most of the downstream movement (78 % of captured fish) occurred during the later half of the sampling period (i.e., October 8 to 12).

Backpack electrofishing and minnow trap sets were used to augment fyke net sampling. The total number of fish captured and catch-per-unit-effort (CPUE) in the spring and fall are presented in Table 9.42 for electrofishing and Table 9.43 for minnow trap sets. Similar to the fyke net results, pearl dace was the most abundant species in the spring in both electrofishing and minnow trap catches.

Lake chub were also captured by electrofishing, as was one juvenile white sucker, a species not recorded in the spring fyke net study. The fall results were also similar to the fyke net results, with a lower abundance of pearl dace and an increase in brook stickleback numbers. Lake chub were also present, as was a small number of juvenile white sucker.

Table 9.42 Backpack Electrofishing Results, Muskeg Creek, Spring and Fall 2002

Season	Species	Number of Fish		Effort (s)	CPUE[(a)] (No./100 s)
		Captured	Captured and Observed		
spring	lake chub	6	6	3606	0.17
	pearl dace	43	43		1.19
	white sucker	1	1		0.03
fall	brook stickleback	0	3	948	0.32
	lake chub	2	2		0.21
	pearl dace	4	4		0.42
	white sucker	2	2		0.21
Total		**58**	**61**	**4554**	**1.34**

(a) Calculated using captured plus observed fish.

Table 9.43 Minnow Trap Sampling Results, Muskeg Creek, Spring and Fall 2002

Season	Species	Number Captured	Effort (hr)	CPUE (No./hr)
spring	pearl dace	9	18.0	0.50
fall	brook stickleback	1	144.0	<0.01
Total		**10**	**162.0**	**0.06**

Overall, seven fish species were captured in Muskeg Creek (all seasons and sampling techniques) and this included four small-bodied species, two sucker species and one sport species. Small-bodied species dominated the fish community. Three juvenile longnose sucker and one adult pike were captured in the spring. A few white sucker were captured consisting of juvenile fish in the spring and young-of-the-year and juvenile fish in the fall. In general, fish abundance was lower in the fall than the spring, with lower numbers in the fyke net and lower CPUE for electrofishing (1.39 fish/100 s in the spring versus 1.16 fish/100 s in the fall) and minnow trap sets (0.5 fish/hr in the spring versus <0.01 fish/hr in the fall).

Analysis of historical fish data for Muskeg Creek (Golder 2003b) shows seven species reported from this watercourse prior to the RAMP study. The only difference between the species previously reported and those captured during the present study was that fathead minnow were not captured in 2002, and northern pike were not previously recorded in Muskeg Creek. Northern pike have been reported from Kearl Lake and Muskeg Creek would provide a potential route between the lake and the Muskeg River. The single adult northern pike captured in the spring fyke net set may represent a low level of use of Muskeg Creek by this species or that fish may have been destined for Kearl Lake. Fish passage in Muskeg Creek has been reported to be affected by beaver activity and it is not known if fish movement between Kearl Lake and the Muskeg River was possible in 2002.

The historical data (Golder 2003b) indicate that Muskeg Creek provides potential spawning habitat for sucker species, with white sucker spawning activity documented in the upper portion of the creek near the Kearl Lake outlet. The spring fyke net results do not indicate a spawning run for either longnose or white suckers in this watercourse in 2002.

The total number of fish captured in the fyke net in spring was relatively small, indicating that fish migration had either not yet occurred, or fish had already moved upstream. Low numbers may also indicate that fish abundance in this watercourse is generally low. Electrofishing and minnow trapping effort did not show that large numbers of fish were upstream or downstream of the fyke net. At the time of fyke net installation, 80% of Muskeg Creek in the vicinity of the net site was covered with ice, and fish movement upstream may not have yet occurred. However, the fact that most fish recorded in the spring fyke net were captured shortly after net installation suggests some upstream movement occurred as the ice was clearing.

Fall fish movement in Muskeg Creek also consisted of small numbers of fish, which may indicate that the fyke net was installed before or after fish moved downstream. The number of fish captured by fyke net was lower in the fall than in the spring. In addition, fall CPUE for electrofishing and minnow trapping were lower in the fall, indicating fewer fish were present during the fall fyke netting period.

Environmental conditions over the period of the fyke net study are presented in Table 9.44 for each day of sampling to show how conditions changed over the length of the sampling period. Maximum water temperatures during spring monitoring ranged from 6°C to 12°C and minimum temperatures ranged from 3.5 to 6°C. In general, there was no increase in water temperatures over the length of the spring fyke netting period. Water temperatures decreased during fall from

5.5 to 3.0 °C for maximum temperature and from 3.9 to 2.0°C for minimum temperature.

Table 9.44 Water Quality and Discharge Measurements, Muskeg Creek, Spring and Fall 2002

Date	Discharge (m^3/s)	Water Temperature (°C)		Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)
		Minimum	Maximum			
Spring						
24-May-02	-	4.2	10.0	10.63	8.20	189
25-May-02	-	4.7	12.0	10.50	8.09	230
26-May-02	-	4.0	8.0	10.76	8.12	218
27-May-02	-	4.0	6.0	10.86	7.89	215
28-May-02	0.052	3.5	7.0	9.46	7.79	222
29-May-02	-	4.0	11.0	9.68	7.89	223
30-May-02	-	6.0	8.5	-	-	-
31-May-02	-	5.0	9.0	9.58	7.88	219
1-Jun-02	-	-	-	9.68	7.80	223
Fall						
3-Oct-02	-	3.9	5.5	12.82	7.70	180
4-Oct-02	2.135	3.9	5.0	13.02	7.80	174
5-Oct-02	-	3.0	4.0	12.85	6.00	94
6-Oct-02	-	2.0	4.5	12.17	6.69	89
7-Oct-02	-	3.0	3.0	11.86	6.82	-
8-Oct-02	-	2.0	3.0	12.03	6.39	94
9-Oct-02	-	2.0	3.0	12.46	6.68	93
10-Oct-02	-	2.0	3.0	11.54	7.44	93
11-Oct-02	-	-	-	13.44	7.95	130
12-Oct-02	2.041	-	-	12.82	8.15	169

Note: "-" = Measurement not completed.

The dissolved oxygen concentration of Muskeg Creek was high and remained fairly constant during the spring and fall studies, ranging from 9.46 to 10.86 mg/L in spring and 11.54 to 13.02 mg/L in fall. Conductivity of the water remained constant in the spring (189 to 230 µS/cm) but fluctuated in the fall (89 to 180 µS/cm). The pH stayed relatively constant in the spring (7.79 to 8.2), while in the fall it was generally lower and more variable (6 to 8.15).

The stream discharge was relatively low during the spring fyke netting period (0.052 m^3/s), but was higher during the fall sampling period (2.135 to 2.041 m^3/s). Based on data from the Water Survey of Canada Muskeg River monitoring station, low spring flows and high fall flows were typical in the basin in 2002.

9.5.2 Wapasu Creek

Table 9.45 presents the numbers of fish captured during each day of fyke net operation in Wapasu Creek, by season (i.e., direction of travel). The total number of fish captured moving upstream in the spring was 19, consisting of three species. The catch consisted almost entirely of small-bodied fish (pearl dace and lake chub), with one juvenile longnose sucker also captured. Pearl dace was the most abundant species recorded. Most of the fish movement occurred on May 28, with the capture of 15 pearl dace. Fish measurement data are presented in Appendix XVIII.

Table 9.45 Fyke Net Sampling Results, Wapasu Creek, Spring and Fall 2002

Date	Species					Total
	Brook Stickleback	Lake Chub	Longnose Sucker	Pearl Dace	White Sucker	
Spring Upstream Movement						
May 18	0	0	0	0	0	**0**
May 19	0	0	0	0	0	**0**
May 20	0	0	0	0	0	**0**
May 21	0	0	0	0	0	**0**
May 22	0	0	0	0	0	**0**
May 23	0	0	0	0	0	**0**
May 24	0	0	0	0	0	**0**
May 25	0	0	0	0	0	**0**
May 26	0	0	0	1	0	**1**
May 27	0	0	0	0	0	**0**
May 28	0	0	0	15	0	**15**
May 29	0	0	0	0	0	**0**
May 30	0	0	0	0	0	**0**
May 31	0	2	1	0	0	**3**
Total	**0**	**2**	**1**	**16**	**0**	**19**
Fall Downstream Movement						
Oct 3	0	0	0	0	0	**0**
Oct 4	1	0	0	20	8	**29**
Oct 5	1	0	0	1	0	**2**
Oct 6	3	0	2	4	0	**9**
Oct 7	4	0	1	21	0	**26**
Oct 8	1	0	0	0	3	**4**
Oct 9	2	0	0	6	8	**16**
Oct 10	0	0	0	3	0	**3**
Oct 11	1	0	0	0	0	**1**
Oct 12	7	0	0	2	0	**9**
Total	**20**	**0**	**3**	**57**	**19**	**99**

A larger number of fish (99) was captured moving downstream during the fall monitoring period (Table 9.45), consisting of four fish species, including two species not recorded in the spring. Two small-bodied species were captured in the fall (pearl dace and brook stickleback) and comprised 78% of the catch. The remaining species included young-of-the-year and juvenile white sucker (19%) and juvenile longnose sucker (3%). The downstream movement was spread out over the length of the sampling period.

Backpack electrofishing and minnow trap sets were used to augment fyke net sampling. The total number of fish captured and CPUE in the spring and fall are presented in Table 9.46 for electrofishing and Table 9.47 for minnow trap sets. Although not captured in the spring fyke netting, brook stickleback was captured in minnow traps and by electrofishing in the spring. Overall, fish abundance was low in the spring, with only one fish captured while electrofishing. Catch rates for minnow trapping were also low, with small numbers of pearl dace, brook stickleback and lake chub captured. Similar to the fyke netting results, the other sampling techniques showed that fish abundance was higher in the fall than in the spring. Three species were captured electrofishing in the fall (brook stickleback, pearl dace and white sucker) and the CPUE increased from 0.03 to 1.69 fish/100 s. The minnow trapping CPUE also increased in the fall compared to the spring (from 0.07 to 0.24 fish/hr), with brook stickleback and pearl dace captured.

Table 9.46 Backpack Electrofishing Results, Wapasu Creek, Spring and Fall 2002

Season	Species	Number of Fish		Effort (s)	CPUE[a] (No./100 s)
		Captured	Captured and Observed		
spring	brook stickleback	1	1	2890	0.03
fall	brook stickleback	20	26	2133	1.22
	pearl dace	6	7		0.33
	white sucker	3	3		0.14
Total		**30**	**37**	**5023**	**0.74**

(a) Calculated using captured plus observed fish.

Table 9.47 Minnow Trap Sampling Results, Wapasu Creek, Spring and Fall 2002

Season	Species	Number Captured	Effort (hr)	CPUE (No./hr)
spring	brook stickleback	9	318.0	0.03
	lake chub	2		<0.01
	pearl dace	11		0.03
fall	brook stickleback	48	209.2	0.23
	pearl dace	3		0.01
Total		**73**	**527.2**	**0.14**

Overall, five fish species were recorded in Wapasu Creek for all seasons and sampling techniques combined. These five fish species included three small-bodied species and two sucker species (Table 9.45). The fish community in Wapasu Creek was dominated by small-bodied species, although a small number of juvenile longnose sucker and young-of-the-year and juvenile white suckers were present. Fish abundance was generally low in both the spring and fall. In comparison to historical fish data (Golder 2003b), the number of species recorded in 2002 was higher than previously reported. Brook stickleback, pearl dace and white sucker were known to be in this watercourse, but lake chub and longnose sucker were not found historically. Both of the new species are known to be common and widely distributed in the Muskeg River watershed. The fact that they were not previously reported would be due to the small number of fisheries investigations conducted for Wapasu Creek.

The small numbers of fish captured in the fyke net in spring may indicate that fish migration had either not yet occurred, or fish had already moved upstream. Low numbers may also be an indication that fish abundance is generally low in Wapasu Creek. Downstream fish movement in Wapasu Creek in the fall consisted of larger numbers of fish than were recorded moving upstream in the spring, although the total number of fish was still fairly low. It is difficult to determine if the spring and fall fyke net sampling periods missed the timing of migrations or if the fish movements recorded represent a typical low level of fish movement in this watercourse. In addition to fyke net catches being higher in the fall, the CPUE values for the other sampling techniques were also higher in the fall than in the spring. This suggests that downstream movements were not likely complete by the time the fall fyke net was installed.

Groups of dead and decayed lake chub and brook stickleback were observed in Wapasu Creek during electrofishing efforts in spring 2002. These dead fish may indicate that habitat conditions were unsuitable for over-wintering. As it appears that some small-bodied fish attempt to overwinter in this watercourse, the fall CPUE results may include fish that would not migrate out of the creek.

Environmental conditions over the period of the fyke net study are presented in Table 9.48 for each day of sampling to show how conditions changed over the length of the sampling period. Water temperatures increased over the duration of the spring study period, with maximum water temperatures ranging from 3.0 to 12.0°C and minimum temperatures ranging from 2.0 to 8.0°C. Water temperatures decreased during fall monitoring; from 5.0 to 2.0°C for maximum temperature and from 4.0 to 1.0°C for minimum temperature.

Table 9.48 Water Quality and Discharge Measurements, Wapasu Creek, Spring and Fall 2002

Date	Discharge (m^3/s)	Water Temperature (^oC)		Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)
		Minimum	Maximum			
Spring						
18-May-02	-	2.0	3.0	10.86	7.59	191
19-May-02	0.045	2.5	3.0	10.87	8.46	208
20-May-02	-	2.5	3.0	11.62	8.46	207
21-May-02	-	3.0	3.0	11.30	7.77	208
22-May-02	-	3.0	4.0	11.84	8.56	218
23-May-02	-	3.0	6.0	11.86	8.24	223
24-May-02	0.039	3.0	7.0	11.18	7.70	228
25-May-02	-	5.0	8.0	11.30	8.49	230
26-May-02	-	7.0	8.0	10.56	8.39	227
27-May-02	-	-	-	-	-	-
28-May-02	-	5.0	12.0	10.60	8.30	223
29-May-02	-	-	-	-	-	-
30-May-02	-	-	-	-	-	-
31-May-02	-	8.0	12.0	9.11	8.12	211
Fall						
3-Oct-02	-	-	-		7.78	170
4-Oct-02	-	4.0	5.0	12.08	7.80	176
5-Oct-02	0.765	3.0	4.0	12.18	6.68	95
6-Oct-02	-	2.0	3.0	13.12	7.02	92
7-Oct-02	-	3.0	4.0	12.62	6.80	94
8-Oct-02	-	3.0	4.0	12.46	6.92	94
9-Oct-02	-	3.0	4.0	12.26	6.82	93
10-Oct-02	0.635	-	-	12.43	7.18	95
11-Oct-02	-	2.0	3.0	12.86	8.04	163
12-Oct-02	-	1.0	2.0	11.73	8.03	171

Note: "-" = Measurement not completed.

The dissolved oxygen concentrations in Wapasu Creek were high and remained fairly constant during the spring and fall studies, ranging from 9.11 to 11.86 mg/L in spring and 11.73 to 13.12 mg/L in fall. Conductivity in the spring remained constant (191 to 230 µS/cm), while in the fall conductivity was lower and more variable (92 to 171 µS/cm). The pH in the spring ranged from 7.59 to 8.56 and was somewhat lower in the fall (6.68 to 8.04).

The stream discharge was relatively low during the spring fyke netting period (0.039 to 0.045 m^3/s). Stream discharge was much higher during the fall monitoring period (0.635 to 0.765 m^3/s), as was typical for the watershed in 2002.

9.6 ATHABASCA RIVER INDEX OF BIOTIC INTEGRITY TEST

****This section is to be provided by Alberta Pacific Forest Industries Inc. (AlPac).****

10 ACID SENSITIVE LAKES

10.1 BACKGROUND INFORMATION

10.1.1 General Information

The objective of the acidification monitoring network is to monitor the water chemistry of acid sensitive lakes in northeastern Alberta and identify any changes caused by acidic deposition. A total of 49 lakes were monitored in 2002, including 32 lakes monitored prior to 2002 and 17 new lakes located near the area of heaviest oil sands development.

Information in this section of the report includes a discussion of Potential Acid Input (PAI) and critical loads estimated for the lakes sampled in the 2002 monitoring program. It also includes a summary and analysis of water chemistry data for the monitored lakes, including parameters such as pH, alkalinity, major ions, colour, dissolved organic carbon, suspended solids and nutrients. Information relating to each lake's trophic status is also provided based on chlorophyll *a* concentrations.

10.1.2 Potential Acid Input and Critical Loads

The most useful variable in assessing the effects of acid deposition in standing waters is the modelled PAI, in units of keq H^+/ha/yr. PAI is a measure of the total acidifying potential of atmospheric deposition, including wet and dry deposition of sulphur and nitrogen compounds from sources within the area being evaluated and from background sources. PAI modelling also accounts for the mitigating effect of base cations.

The estimated PAI values for acid sensitive lakes monitored by RAMP are shown in Table 10.1. These estimated PAI values were modelled as part of a number of recent Environmental Impact Assessments (EIAs) for developments in the Oil Sands Region (Petro-Canada 2001; OPTI/Nexen 2002; Shell 2002; CNRL 2002). At this time, PAI values are not available for the 17 new lakes monitored in 2002, or for lakes in the comparison regions.

Table 10.1 Modelled Acid Deposition Rates and Critical Loads for Acid Sensitive Lakes Monitored by RAMP

Lake	Modelled PAI (Baseline) (keq H+/ha/yr)				Modelled PAI (CEA) CNRL Horizon (June 2002)	Critical Load PAI (keq H+/ha/yr)	Critical Load Data Source
	Petro-Canada Meadow Creek(a) (December 2001)	OPTI Long Lake EIA Update(b) (July 2002)	Shell Jackpine Phase 1(c) (May 2002)	CNRL Horizon(d) (June 2002)			
Oil Sands Sub-Regions							
1. North East of Fort McMurray							
L4 (A-170)	0.130	0.133	0.134	0.134	0.213	0.247	WRS (2000)
L7	0.120	0.124	0.125	0.125	0.195	0.403	P-C (2001)
L8	0.116	0.121	0.122	0.122	0.185	0.608	P-C (2001)
L39 (A-150)	0.055	0.055	0.055	0.055	0.081	0.271	WRS (2000)
E15 (268)	0.224	0.224	0.226	0.226	0.325	0.656	WRS (2000)
182 (P23)	na	na	na	na	na	0.462	WRS (2001)
185 (P27)	na	na	na	na	na	0.307	WRS (2001)
209 (P7)	na	na	na	na	na	0.387	WRS (2001)
270	na	na	na	na	na	1.129	WRS (2000)
271	na	na	na	na	na	0.887	WRS (2000)
2. Stony Mountains							
A21	**0.136**[e]	**0.132**	**0.132**	**0.132**	**0.188**	0.132	WRS (2001)
A24	**0.135**	**0.131**	**0.131**	**0.131**	**0.179**	0.036	WRS (2001)
A26	**0.137**	**0.133**	**0.133**	**0.133**	**0.188**	0.025	WRS (2001)
A29	**0.126**	**0.123**	**0.124**	**0.124**	**0.163**	0.057	WRS (2001)
A86	**0.093**	**0.090**	**0.090**	**0.090**	**0.106**	0.069	WRS (2001)
287	na	na	na	na	na	0.031	WRS (2000)
289	na	na	na	na	na	0.112	WRS (2000)
290	na	na	na	na	na	0.130	WRS (2000)
342	na	na	na	na	na	0.164	WRS (2000)
354	na	na	na	na	na	0.319	WRS (2000)
3. West of Fort McMurray							
A42	0.096	0.096	0.097	0.097	0.109	0.374	WRS (2001)
A47	**0.095**	**0.095**	**0.095**	**0.095**	**0.107**	0.035	WRS (2001)
A59	0.095	0.095	0.095	0.095	0.107	0.297	WRS (2001)
223 (P94)	na	na	na	na	na	1.030	WRS (2001)
225 (P96)	na	na	na	na	na	0.582	WRS (2001)
226 (P97)	na	na	na	na	na	0.365	WRS (2001)
227 (P98)	na	na	na	na	na	0.942	WRS (2001)
267	na	na	na	na	na	0.726	WRS (2000)
4. Birch Mountains							
L18 (Namur)	0.097	0.096	0.096	0.096	0.122	0.223	P-C (2001)

Table 10.1 Modelled Acid Deposition Rates and Critical Loads for Acid Sensitive Lakes Monitored by RAMP (continued)

Lake	Modelled PAI (Baseline) (keq H+/ha/yr)				Modelled PAI (CEA) CNRL Horizon (June 2002)	Critical Load PAI (keq H+/ha/yr)	Critical Load Data Source
	Petro-Canada Meadow Creek(a) (December 2001)	OPTI Long Lake EIA Update(b) (July 2002)	Shell Jackpine Phase 1(c) (May 2002)	CNRL Horizon(d) (June 2002)			
L23 (Otasan)	**0.072**	**0.072**	**0.072**	**0.072**	**0.101**	0.049	P-C (2001)
L25 (Legend)	**0.117**	**0.115**	**0.116**	**0.116**	**0.161**	0.112	D. Andrews (pers. comm.)
L28	0.065	0.065	0.065	0.065	0.082	0.096	D. Andrews (pers. comm.)
L29 (Clayton)	**0.069**	**0.069**	**0.069**	**0.069**	**0.093**	0.015	WRS (2001)
L46 (Bayard)	0.067	0.067	0.067	0.067	0.093	0.327	P-C (2001)
L47	0.095	0.095	0.095	0.095	0.107	0.261	D. Andrews (pers. comm.)
L49	0.072	0.066	0.067	0.067	0.090	0.361	D. Andrews (pers. comm.)
L60	0.081	0.076	0.077	0.077	0.103	0.421	P-C (2001)
175 (P13)	na	na	na	na	na	0.860	WRS (2001)
199 (P49)	na	na	na	na	na	0.329	WRS (2001)
Comparison Regions							
1. Caribou Mountains							
E52 (Fleming)	na	na	na	na	na	0.018	WRS (2001)
E59 (Rocky Island)	na	na	na	na	na	0.029	WRS (2001)
E68 (Whitesand)	na	na	na	na	na	0.024	WRS (2001)
O1 (Unnamed #6) (E55)	na	na	na	na	na	0.016	WRS (2001)
O2 (Unnamed #9) (E67)	na	na	na	na	na	0.033	WRS (2001)
2. Canadian Shield							
A301	na	na	na	na	na	na	na
L107 (Weekes)	na	na	na	na	na	0.099	WRS (2001)
L109 (Fletcher)	na	na	na	na	na	0.471	WRS (2001)
O10	na	na	na	na	na	0.352	WRS (2001)
R1	na	na	na	na	na	0.370	WRS (2001)

Notes: na = Data not available.
P-C = Petro-Canada.
WRS = Western Resource Solutions.
(a) Petro-Canada (2001).
(b) OPTI/Nexen (2002).
(c) Shell (2002).
(d) CNRL (2002).
(e) Shaded and bolded text identifies PAI values above the critical load.

PAI values in Table 10.1 represent combined acid deposition from all existing and approved oil sands developments at the time the above EIAs were submitted (i.e., the baseline case) and from existing, approved and planned oil sands developments (i.e., the cumulative effects assessment [CEA] case) from the most recently submitted EIA. All projects were considered “fully developed” during modelling, suggesting that baseline acid deposition rates to these lakes may be higher than the current rate. Therefore, for the purpose of this document, the baseline PAI values are considered to represent potential “near-future” deposition rates. The CEA case PAI values provide an indication of future acid deposition rates if all approved and planned projects are built.

Critical load is defined as the highest load that will not cause chemical changes leading to long-term harmful effects on the most sensitive ecological systems. It is one of several guidelines established by the Target Loading Subgroup of the Clean Air Strategic Alliance (CASA) to evaluate the likelihood of soil and lake acidification in Alberta (CASA 1996, 1999). The critical load was set at 0.25 keq H^+/ha/yr for highly sensitive soils in Alberta and was subsequently extended to sensitive aquatic systems based on a review by Schindler (1996). It is applicable at the spatial resolution of 1^o latitude by 1^o longitude cells and is not intended for evaluating the effects of acid deposition on individual lakes.

Recent oil sands EIAs adopted the use of the lake-specific critical load, calculated based on the Henriksen steady state model (Henriksen et al. 1992; Rhim 1995). The lake-specific critical load takes into account the buffering capacity of the lake being evaluated and inputs of base cations from the drainage basin. It represents the amount of acid deposition below which acid neutralizing capacity (ANC) or pH remain above a specified threshold value. The ANC threshold value is referred to as the ANC_{lim} and has been set at 75 µeq/L (i.e., the value suggested for the Oil Sands Region by the NO_X and SO_X Management Working Group [NSMWG]). This value corresponds to a pH of 6, based on information presented by Western Resource Solutions (2000).

Comparison of critical loads and modelled PAI values for individual lakes can be used to identify which lakes are at greatest risk of acidification. More specifically, when the PAI value exceeds the critical load for a given lake, this suggests that acidic deposition may be a concern and highlights the need for water quality monitoring for such a lake. In this way, critical load and PAI values can be used to direct more specific investigations, to intensify monitoring, or target specific research questions.

Critical loads of acidity have been calculated for all 49 lakes monitored by RAMP in 2002 and are presented in Table 10.1. The critical loads available for the 49 RAMP lakes range from 0.015 to 1.129 keq H^+/ha/yr. The modelled baseline and CEA PAI values exceed the critical loads in five lakes in the Stony Mountain sub-region (A21, A24, A26, A29 and A86), three lakes in the Birch Mountain sub-region (L23, L25 and L30) and one lake west of Fort McMurray (A47). These results suggest that there is already some concern regarding potential acidification in the Oil Sands Region.

10.2 PH, ALKALINITY AND ACID SENSITIVITY

Monitoring the pH of lake water over time allows for the detection of changes in acidity, while alkalinity serves as an indicator of changes in acid sensitivity. Generally, when the pH of a lake falls below 4 or 5, species diversity becomes restricted (Goldman and Horne 1983), with effects beginning at a pH of 6 (Environment Canada 1997a). At typical lake pH levels of 6 to 8, bicarbonate is the most abundant carbon form relative to carbon dioxide and carbonate and it acts to maintain pH within the normal range (Goldman and Horne 1983; Brower et al. 1989).

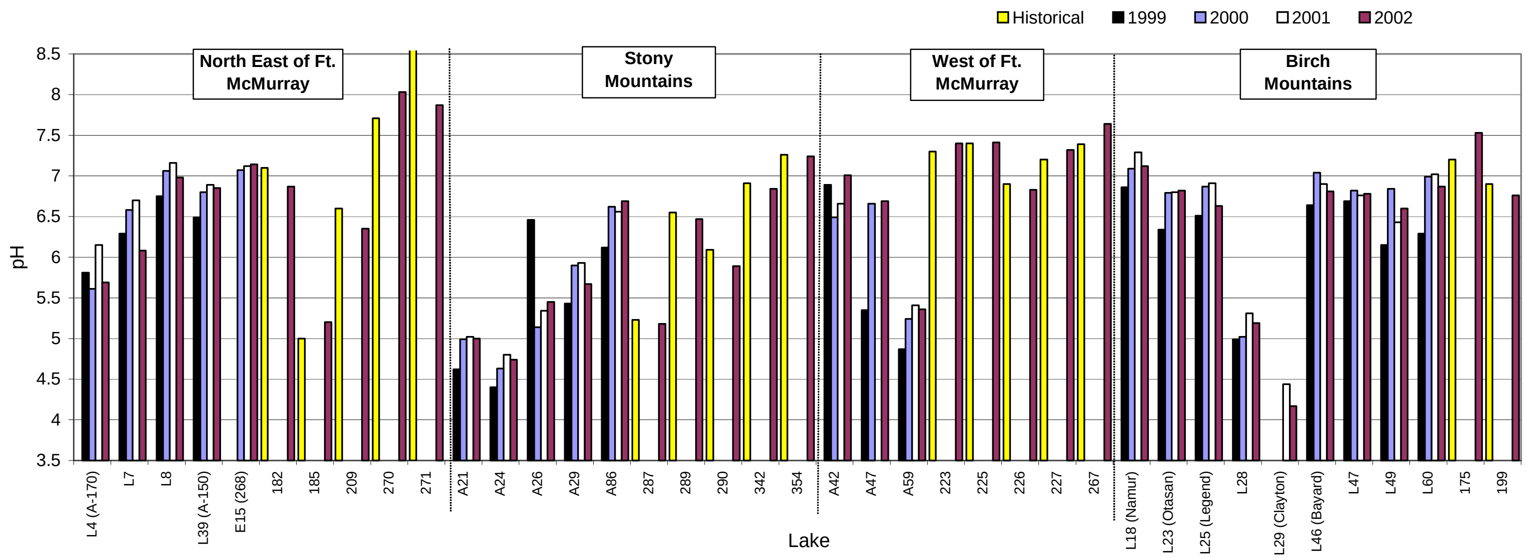
Alkalinity refers to the total bicarbonate (HCO_3^-), carbonate (CO_3^{2-}) and hydroxide (OH^-) that neutralize an acid and represents the buffering capacity of a lake (Brower et al. 1989). Low alkalinity indicates a smaller buffering capacity and greater acid sensitivity compared to higher alkalinity values. More specifically, alkalinity concentrations between 0 to 10 mg/L are indicative of lakes that are highly sensitive to acidic deposition (Saffran and Trew 1996). Lakes with alkalinity from >10 to 20 mg/L are moderately sensitive, while lakes with alkalinity >20 mg/L show only low sensitivity.

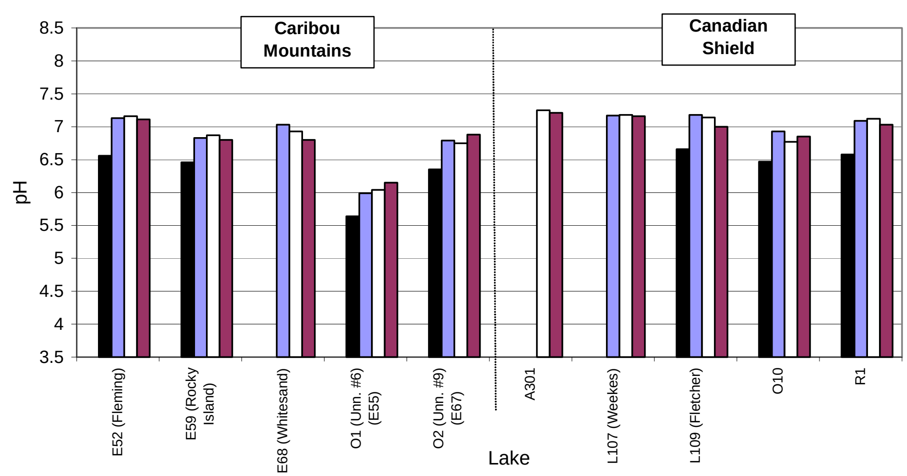
Both pH and alkalinity were measured in the 49 lakes in 2002. For comparison purposes, historical pH and alkalinity data for the new lakes were obtained from WRS (2000) and WRS (2001).

pH

For the 49 lakes monitored in 2002, lab pH ranged between 4.2 and 8.0, with 11 of the lakes having pH values less than 6 (Figure 10.1; the entire 2002 data set is presented in Appendix XIX). However, variation in pH among years was relatively low (i.e., 0.4 units calculated as the average of the difference between minimum and maximum values for each lake). Lake 271 had the greatest difference over time (decline=1.5 units; n=2). Although 21 lakes exhibited declines in pH between 2001 and 2002, L7 was the only lake that had a decline greater than 0.5 units. Seven of the ten lakes in the comparison regions also showed slight declines in pH.

Figure 10.1 Variation in pH Among Years in the Lakes Sampled in 2002





Progressive declines in pH were generally not observed in the lakes monitored for more than two years, with the exception of E68 in the Caribou Mountains (a reference lake), which had a total decline of 0.23 pH units over three consecutive years (Figure 10.1). Visual comparison of the box and whisker plots of pH by sub-region based on data for the 26 lakes sampled in all four years of monitoring also showed no decline over time (Figure 10.2). As well, pH was fairly similar among the two comparison sub-regions and the oil sands sub-regions, with the exception of the Stony Mountains sub-region (Figures 10.1 and 10.2). Several sites in the Stony Mountains (A21, A24, A26 and 287) had pH values <5.5 over the monitoring period, which tended to lower the median pH for this sub-region compared to the others.

Alkalinity

Total alkalinity varied from 0 to 84.5 mg/L as $CaCO_3$ among lakes in 2002 (Figure 10.3). Using the sensitivity categories described by Saffran and Trew (1996), 22 of the 49 lakes were highly sensitive to acidic deposition (alkalinity of 0 to 10 mg/L as $CaCO_3$), 14 lakes were moderately sensitive (alkalinity of >10 to 20 mg/L) and 13 lakes showed a low sensitivity (alkalinity >20 mg/L). Lakes in the Stony Mountain sub-region were generally lower in alkalinity than lakes in other regions, with 5 of the 10 lakes in this sub-region (A21, A24, A26, A29 and 290) having alkalinity values <5 mg/L (Figures 10.3 and 10.4). Other lakes with alkalinity values <5 mg/L included A59 (West of Fort McMurray), L28 (Birch Mountains) and O1 (Caribou Mountains).

Eight of the 13 lakes with low acid sensitivity (i.e., alkalinity >20 mg/L) in 2002 were new lakes (175, 223, 225, 227, 267, 270, 271 and 354). This raises the concern that some of the new lakes monitored in 2002 may not conform to the original objectives of the monitoring network, which included monitoring lakes of moderate to high sensitivity to acid deposition.

The magnitude of year-to-year variation in alkalinity was different among lakes. Of the 48 lakes with more than one year’s data (including historical data), the difference between the minimum and maximum alkalinity values was >5 mg/L for 20 lakes, between 2 and 5 mg/L for 12 lakes and <2 mg/L for 16 lakes. Two-fold or greater variation in alkalinity among years were observed for nine lakes (L4, A21, A24, A26, A42, A47, L28, L46 and L47). The variation in alkalinity among years may partly reflect seasonal changes (i.e., samples were not collected at the exact same time each year) and year-to-year differences in hydrology.

Figure 10.2 Box and Whisker Plots of pH by Sub-region (1999 to 2002)

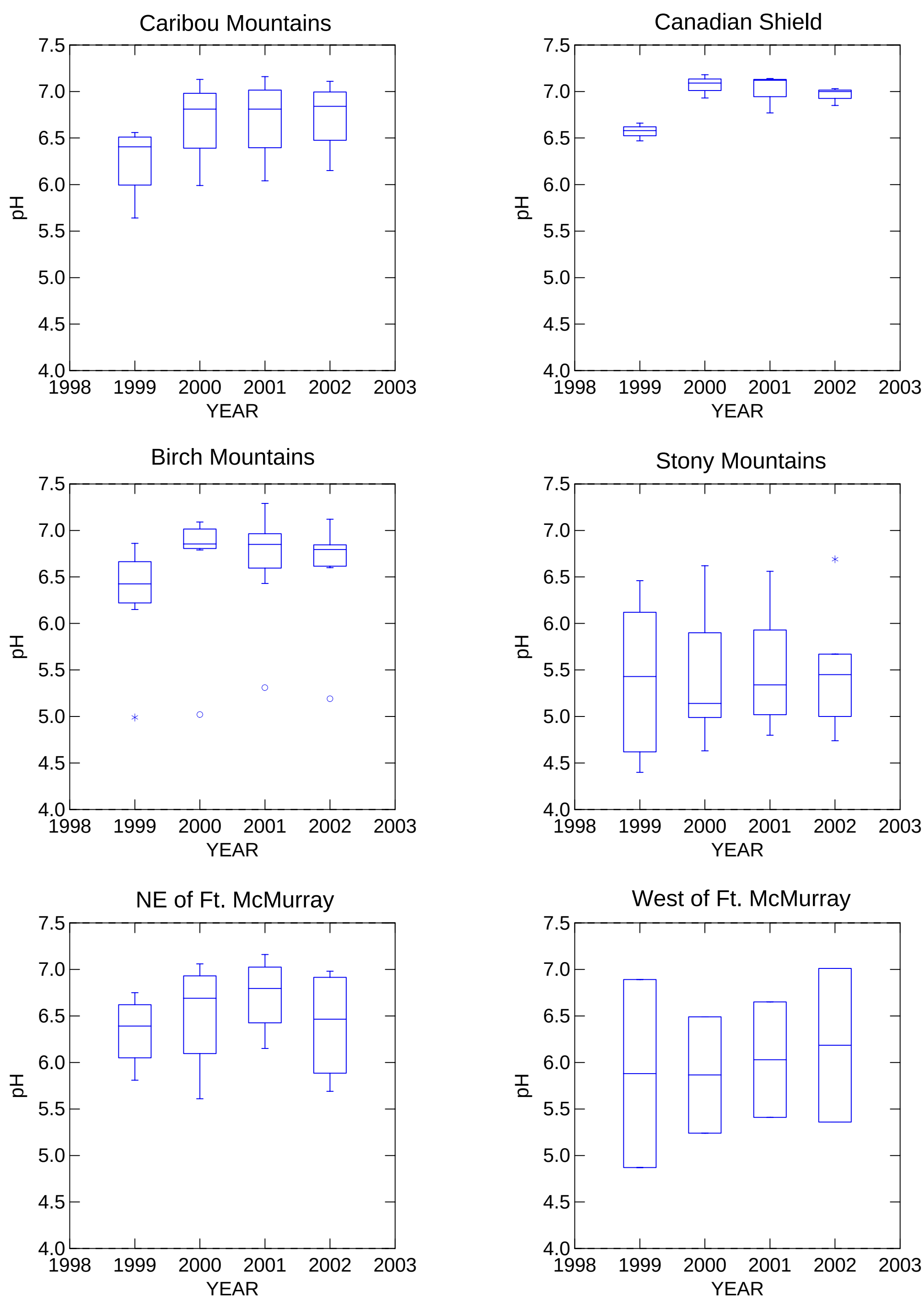
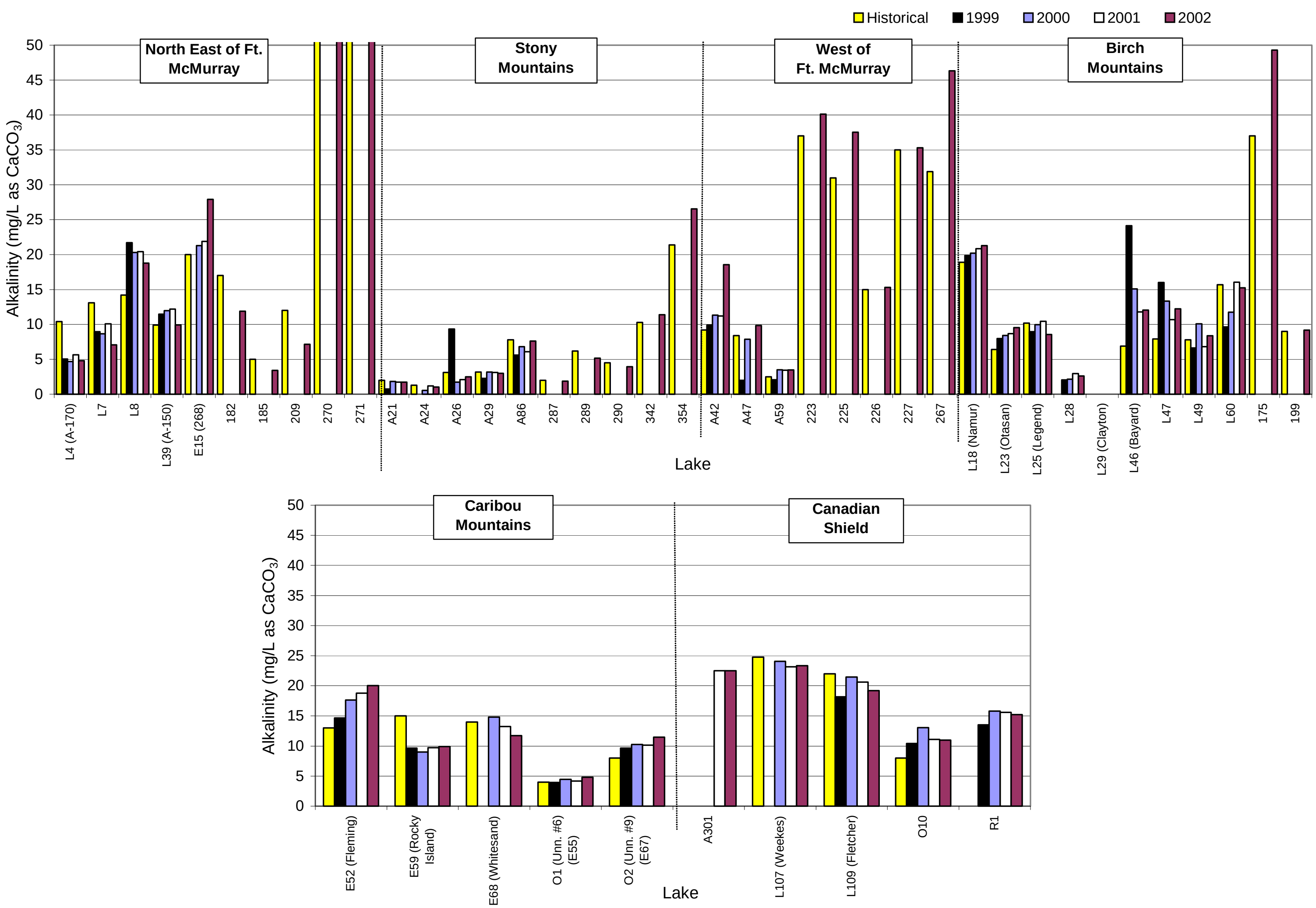
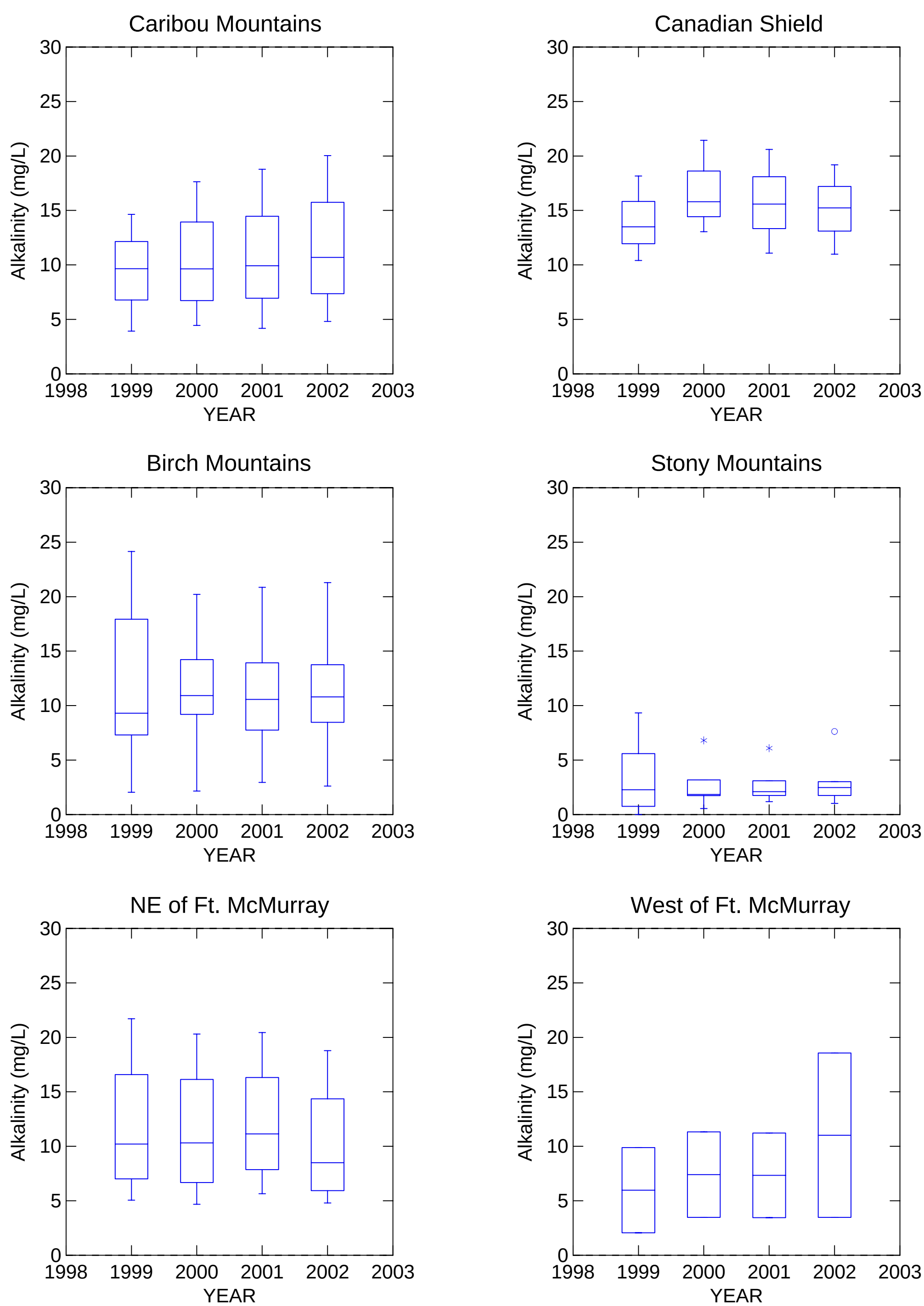


Figure 10.3 Variation in Alkalinity Among Years in the Lakes Sampled in 2002



Notes: Alkalinity was measured as 0 mg/L CaCO3 for Lake A24 in 1999, L28 in the historical data and L29 in both 2001 and 2002.

Figure 10.4 Box and Whisker Plots of Alkalinity by Sub-region (1999 to 2002)



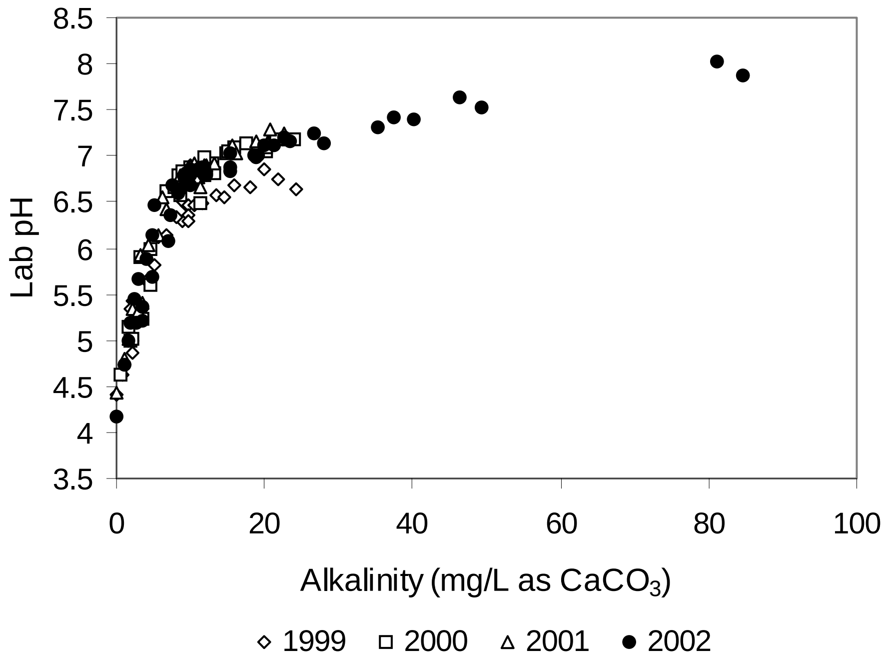
Although the available data are insufficient for a trend analysis, visual examination of the alkalinity data revealed no consistent declines in alkalinity in most of the lakes monitored (Figure 10.3). However, considering only the RAMP data collected from 1999 to 2002 (i.e., not historical data) four lakes in the oil sands sub-regions (L7, L8, L46 and L47) and Lake E68 in the Caribou Mountains showed a slight tendency for declining alkalinity. Conversely, increases in alkalinity were apparent in four lakes in the oil sands sub-regions (E15, A42, L18 and L23) and three lakes in the Caribou Mountains (E52, O1 and O2), while the remaining lakes showed no apparent trend.

The box and whisker plot of alkalinity by sub-region based on data for the 26 lakes sampled in all four years of monitoring also indicated no appreciable change in alkalinity over time within sub-regions (Figure 10.4). Interpretation of the box and whisker plots should include the fact that the new lakes with relatively high alkalinities were not included in the plots. As a result, the alkalinities for each sub-region in the box and whisker plots are lower than would be suggested by alkalinities shown in Figure 10.3. Furthermore, the alkalinities shown in these plots represent alkalinity levels over time for the more acid sensitive lakes in the monitoring network.

There was a strong, non-linear relationship between alkalinity and pH in the data from 1999 to 2002 (Figure 10.5). The “steepest” part of the curve was consistently below the alkalinity value of 10 mg/L as $CaCO_3$. The lakes in this category are particularly susceptible to acidification, because even small changes in alkalinity will result in rapid changes in pH.

Alkalinity in 2002 was significantly correlated with critical load (Pearson correlation, r=0.83, P<0.001; Figure 10.6 shows the mean of available alkalinity data for each lake). However, critical loads suggest a slightly different acid sensitivity compared to alkalinity alone. This difference arises from the fact that critical loads are not entirely based on existing water chemistry, but rather incorporate runoff volume in an attempt to account for the supply of base cations from the drainage basin. For example, if two lakes have similar alkalinity but one has a considerably larger drainage area (and hence receives more runoff annually), the lake with the larger drainage area would have a higher critical load (i.e., it would be less acid sensitive) because it has a greater annual supply of buffering chemicals.

Figure 10.5 The Relationship Between pH and Total Alkalinity (1999 to 2002)

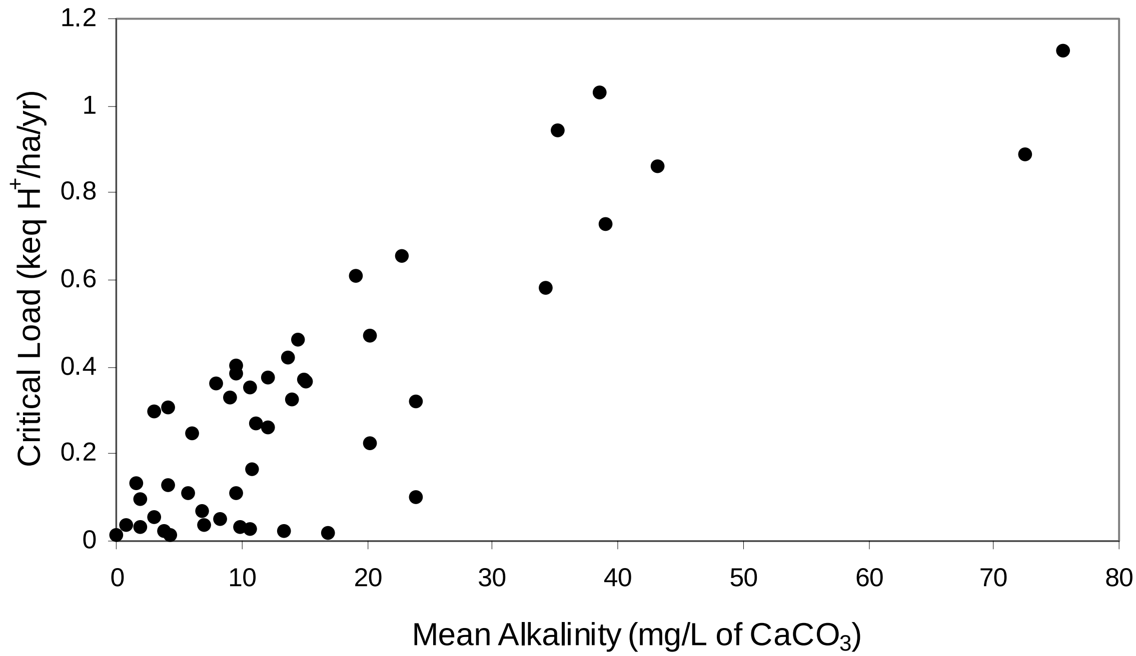


Acid Sensitivity

Nine lakes (A21, A24, A26, A29, A86, A47, L23, L25 and L29/L30 [Clayton Lake]) with alkalinities generally below 10 mg/L for the monitoring time period also had critical loads below the modelled PAI values (Figure 10.3 and Table 10.1). Therefore, these nine lakes have the potential to be the most sensitive to acidification at deposition rates (both baseline and CEA) predicted for the Oil Sands Region. Conversely, lakes L4, L7, L28, L39, L49 and A59 had alkalinities below 10 mg/L in 2002, but their critical loads were greater than the predicted deposition rates. These lakes are most likely not sensitive to acidification at the predicted deposition rates. Several other lakes with alkalinity values <10 mg/L in 2002 included lakes 185, 199, 209, 287, 289, 290 and E59; however, PAI values were not available for these lakes.

The monitoring data collected by the Acid Sensitive Lakes program consist of single samples collected during the fall; therefore, it is important to ascertain that fall data provide a reliable indication of acid sensitivity and lake water chemistry in general. A cursory investigation in the RAMP 2001 annual report (Golder 2002c) suggested that fall data may underestimate acid-sensitivity. Although a more detailed examination of seasonal fluctuations in water chemistry was not conducted in 2002, plans are being made to include the assessment in future monitoring (P. McEachern, AENV, pers. comm.).

Figure 10.6 Critical Load Versus Mean Alkalinity for the Lakes Sampled in 2002



10.3 MAJOR IONS, COLOUR AND DOC

Lake water generally contains a vast array of inorganic and organic compounds present as dissolved solids and gases (Goldman and Horne 1983). In this section, levels of general indicators of dissolved compounds (total dissolved solids [TDS], dissolved organic carbon [DOC], colour) and major ions (e.g., calcium, sulphate) are described for the 49 lakes monitored in 2002. Various ratios are also presented as indices of change (ion balance, ratio of sulphate to sum of base cations; ratio of bicarbonate to divalent cations). Ion balance is the ratio of the sum of cations (calcium, magnesium, sodium, potassium and ammonium) to the sum of anions (bicarbonate, chloride, sulphate, nitrite and nitrate) in lake water. Base cations include calcium, magnesium, sodium and potassium. Divalent cations include calcium and magnesium.

Monitoring of these water quality parameters is important for several reasons. Sulphur is a major component of acid deposition. DOC is an indicator of organic compounds in surface waters and becomes increasingly important in the ion balance of natural waters once DOC exceeds 5 mg/L (Sullivan 2000; Clair et al. 2000). Colour largely depends on the dissolved organic compounds in water and can change significantly from changes in pH and temperature via their effects on the solubility and stability of dissolved and particulate material in water (CCME 1999).

In 2002, TDS and concentrations of most dissolved ions were generally low to moderate in the monitored lakes and varied without obvious groupings of lakes (Figures 10.7 and 10.8; Appendix XIX). Exceptions included elevated calcium and sum of base cations in lakes 270 and 271, which also exhibited elevated pH, alkalinity, bicarbonate, conductivity, TDS and dissolved inorganic carbon compared to other lakes (Appendix XIX).

The sum of base cations was significantly related to alkalinity (linear regression, r^2=0.91, P<0.00001, Figure 10.9). In lakes with low DOC content, a 1:1 relationship would be expected between these variables (Sullivan 2000). In the case of the RAMP lakes (characterized by elevated DOC; Figure 10.7), the deviation from this relationship may be due to the presence of organic acids, which tend to lower acid neutralizing capacity relative to base cation concentrations (Sullivan 2000). There was a significant but weak relationship between DOC and the residuals from the regression line shown in Figure 10.9 (linear regression, r^2=0.18, P=0.003), suggesting the variation in alkalinity was at least partly related to the presence of organic acids.

Colour and DOC

Colour and DOC spanned wide ranges in the lakes monitored in 2002 (Figure 10.7). When considering the data for all 49 lakes, there was no correlation between colour and DOC (Pearson correlation, r=0.25, P>0.05; Figure 10.10). However, careful inspection of the data leads to the identification of two distinct groups of lakes with different relationships between DOC and colour.

"Group A" includes 13 lakes (175, 223, 225, 226, 227, 267, 270, 271, 342, 354 E15, A42 and O10), 10 of which were new to the monitoring network in 2002. This group exhibited a relatively high DOC range of 22.4 to 55.5 mg/L over a relatively narrow range of colour (19 to 154 TCU). DOC was significantly correlated with colour for Group A lakes (Pearson correlation, r=0.64, P<0.02). "Group B" includes the remaining 36 lakes. This group had a narrower range of DOC (8.4 to 31.5 mg/L) over a wider range of colour (11 to 422 TCU). There was also a strong correlation between DOC and colour among Group B lakes (Pearson correlation, r=0.87, P<0.001).

Figure 10.7 Total Dissolved Solids (TDS), Dissolved Organic Carbon (DOC) and Colour in the Lakes Sampled in 2002

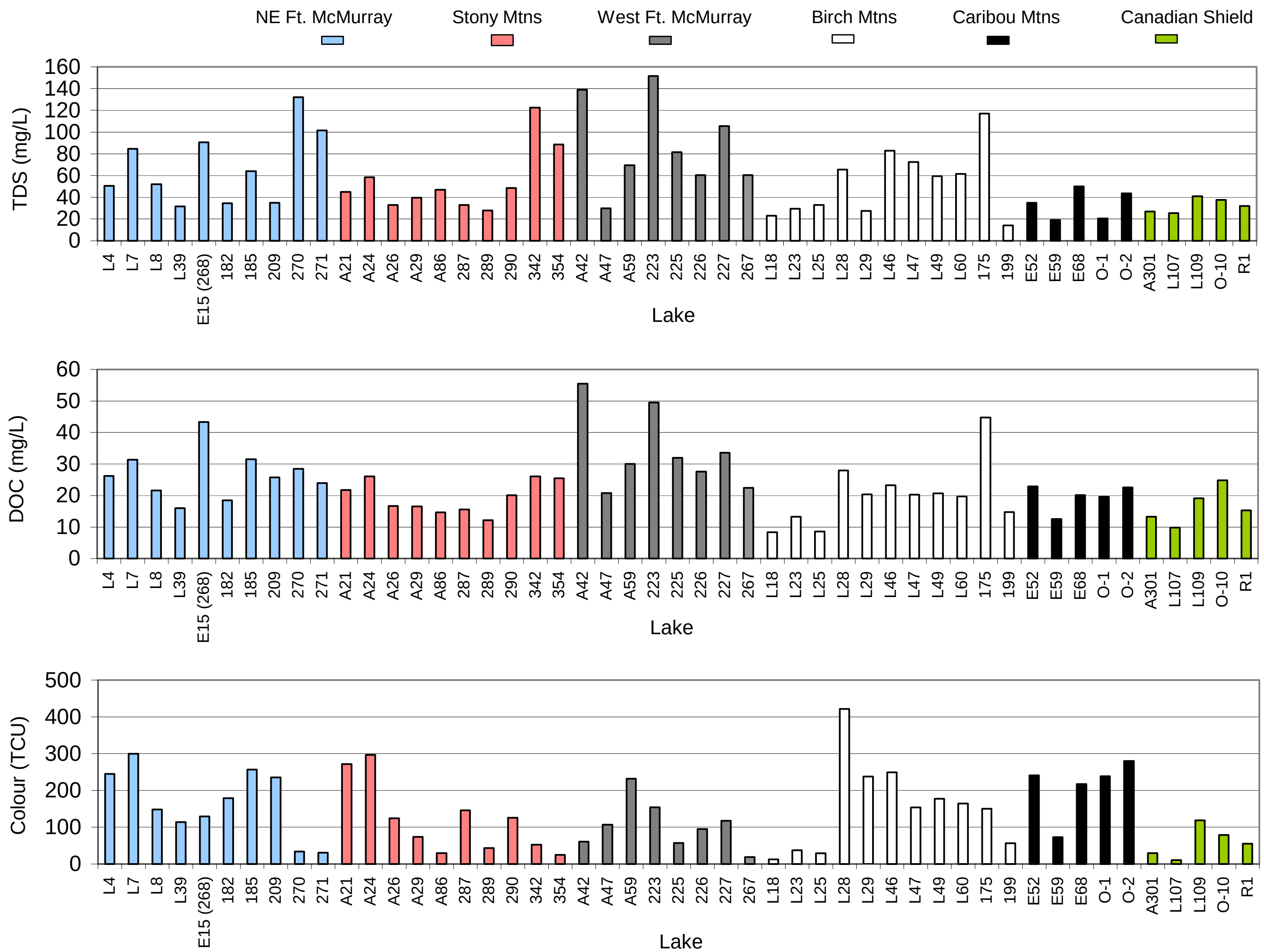


Figure 10.8 Calcium and the Sum of Base Cations in the Lakes Sampled in 2002

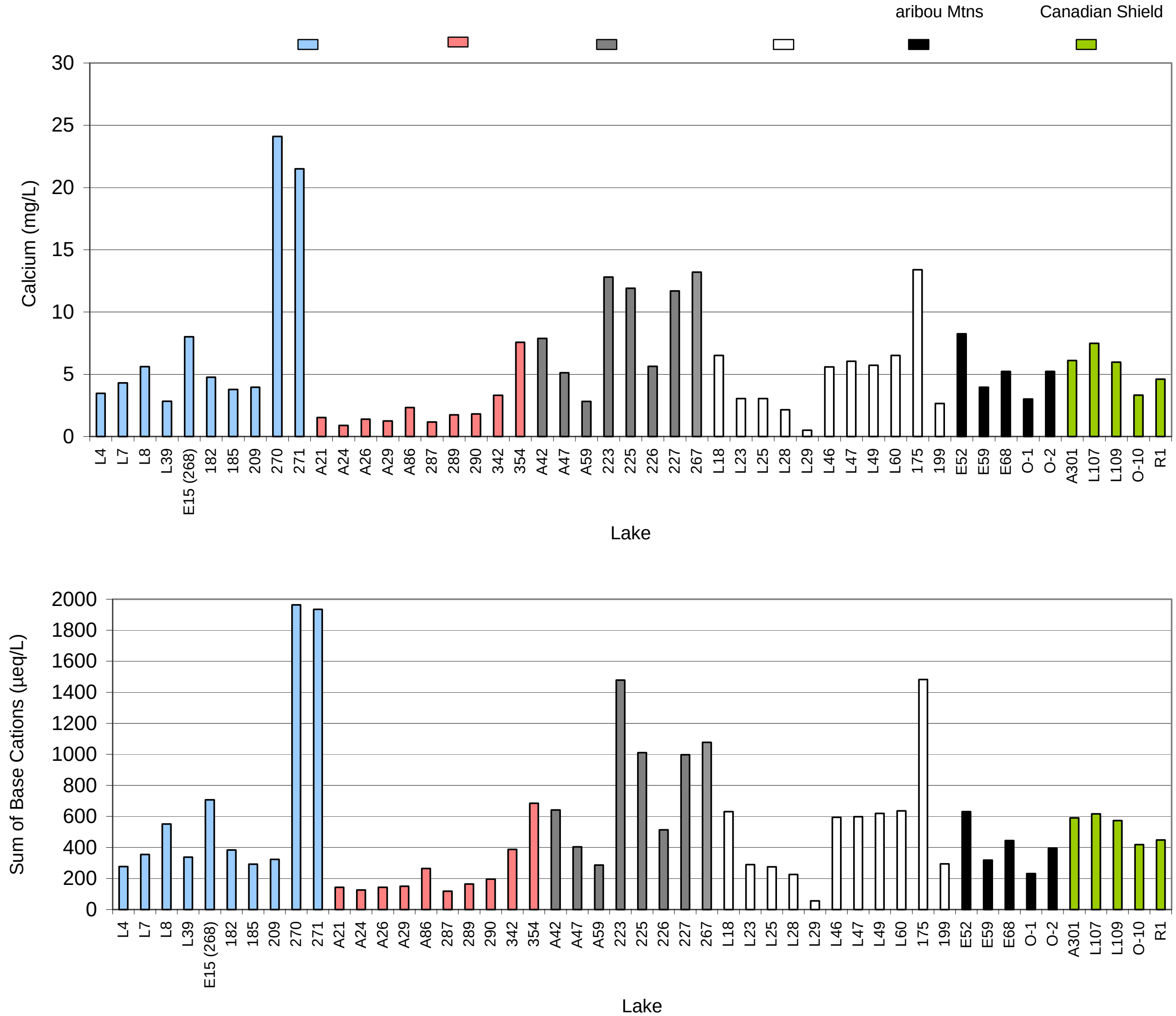
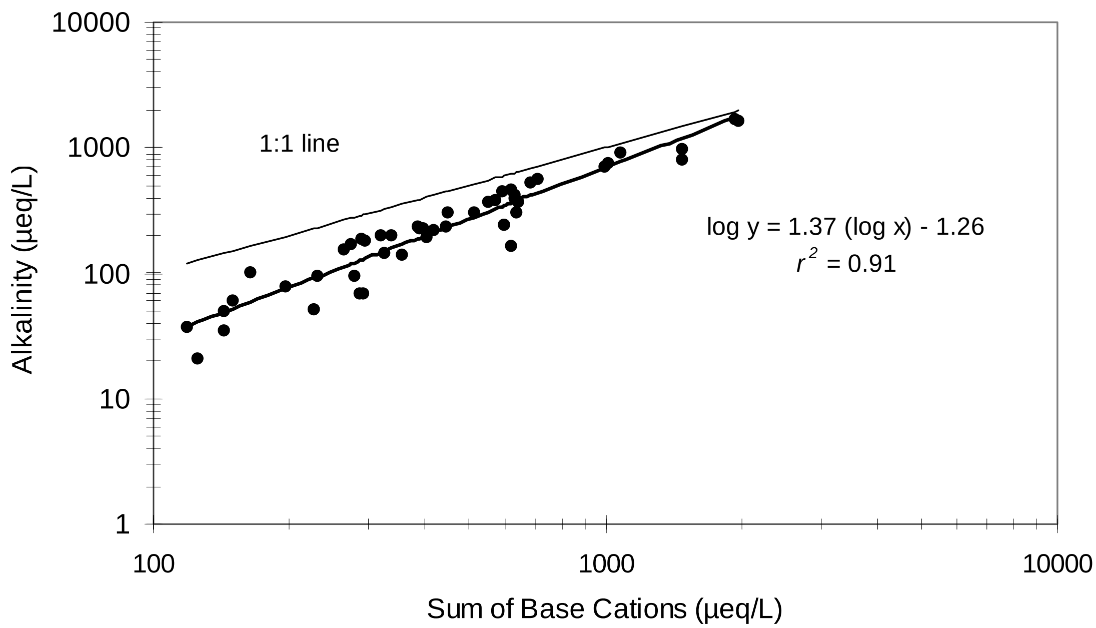


Figure 10.9 The Relationship Between Alkalinity and the Sum of Base Cations in the 2002 Data Set



Several additional differences in water chemistry between lakes in groups A and B identify Group A as a collection of productive lakes that have lower acid sensitivity than Group B lakes (Table 10.2). For example, Group A lakes, on average, had higher levels of alkalinity, bicarbonate, sum of base cations, chlorophyll *a*, conductivity, TDS, TSS, dissolved inorganic carbon (DIC) and various forms of nitrogen (including total nitrogen [TN], total dissolved nitrogen [TDN], TKN and ammonium). In addition, the average critical load for Group A lakes was 0.645 keq $H^{+/}$ha/yr, while the average for Group B lakes was 0.196 keq $H^{+/}$ha/yr. As well, the mean pH of Group B lakes was lower than that of Group A.

These groupings partly highlight the relaxation in 2002 of the original project objective of monitoring only lakes with moderate to high sensitivity to acid deposition. Addition of new lakes with relatively high alkalinity and critical loads (i.e., lakes 175, 223, 225, 227, 267, 270, 271 and 354, all of which are in Group A) to the monitoring program may need to be re-evaluated on the basis that water chemistry data collected from these lakes may not help to identify changes caused by acid deposition in the Oil Sands Region.

Table 10.2 Water Chemistry Summary for Group A and Group B Lakes Based on the 2002 Data Set

Parameter	Units	Group A				Group B			
		Mean	Minimum	Maximum	*n*	Mean	Minimum	Maximum	*n*
Colour	(TCU)	77.1	19.0	154.4	13	159.2	10.7	421.6	36
DOC	(mg/L)	33.6	22.4	55.5	13	19.4	8.3	31.5	36
pH (lab)	-	7.3	6.8	8.0	13	6.3	4.2	7.2	36
Alkalinity	(mg/L as $CaCO_3$)	37.3	11.0	84.5	13	9.5	0	23.3	36
Bicarbonate	(mg/L)	45.5	13.4	103.1	13	11.5	0	28.5	36
Chlorophyll *a*	(µg/L)	24.2	2.7	144.0	13	7.2	1.3	28.5	36
Sum of base cations	(µeq/L)	1023	387	1963	13	360	55	635	36
Conductivity	(µS/cm)	86.8	32.9	172.3	13	33.5	13.5	63.7	36
TDS	(mg/L)	99.1	37.5	151.5	13	43.0	14.0	84.5	36
Turbidity	(NTU)	3.7	1.0	18.0	13	2.6	0.5	20.0	36
TSS	(mg/L)	16.5	1.4	122.5	13	4.7	0.3	17.5	36
DIC	(mg/L)	7.4	1.9	18.7	13	1.7	0.2	5.0	36
Iron	(mg/L)	0.06	0.02	0.14	7	0.48	0.03	2.20	32
TN	(mg/L)	2.273	1.165	5.664	13	0.777	0.341	1.929	36
TDN	(mg/L)	1.747	0.953	2.689	13	0.669	0.324	1.924	36
TKN	(mg/L)	2.259	1.164	5.663	13	0.722	0.336	1.385	36
Ammonium	(mg/L)	0.203	0.006	1.509	13	0.021	0.001	0.076	36
Nitrite + Nitrate	(mg/L)	0.015	0.0004	0.092	13	0.055	0.0004	0.733	36
TP	(mg/L)	0.061	0.019	0.210	13	0.045	0.007	0.190	36
TDP	(mg/L)	0.014	0.005	0.035	13	0.021	0.003	0.097	36
Sulphate	(mg/L)	2.33	0.25	13.74	13	2.75	0.34	16.71	36

Sulphate

In lake ecosystems, sulphur is an important component of proteins in aquatic organisms and rarely directly limits the growth or distribution of aquatic biota (Goldman and Horne 1983). However, sulphur dioxide emissions from industrial sources react chemically with hydrogen in the atmosphere to produce sulphuric acid, one of the main constituents of acid rain.

Sulphate is often used as a measure of acidifying deposition (Schindler 1996). Concentrations of sulphate in lakes of the monitoring network were generally below 4 mg/L over the four years of monitoring (including historical data) (Figure 10.11). Exceptions included a cluster of lakes in the Birch Mountains (lakes L18, L46, L47, L49, L60 and 175) and Lake 223, that had sulphate concentrations consistently >6 mg/L.

Visual examination of the sulphate data for sites monitored from 1999 to 2002 (i.e., not including historical data), revealed a slight tendency for increasing sulphate in L18, E52 and E68. Considering the same data set, tendencies toward declining sulphate were observed in lakes L4, L7, L8, A21, A24, A29, L23, L28, L46, L49 and L60 in the oil sands sub-regions and lakes O1, O2, L109, O10 and R1 in the comparison regions (Figure 10.11). Due to the small sample sizes, trend analysis could not be conducted to verify if these increasing and decreasing tendencies were statistically significant or simply within the range of natural variation. In terms of the magnitudes of the year-to-year changes, none were large enough to be of concern regarding acidification.

Indices of Change

The ion balance is the ratio of total cations to total anions and in the 2002 data set it ranged from 1.1 to 5.6 on an equivalent basis (Figure 10.12). As well, 19 of the 49 lakes had ion balance values >1.5. The fact that the ion balance was greater than one for all lakes indicates general anion deficits, which appear related to the presence of organic anions associated with DOC. As stated earlier, DOC is an indicator of organic compounds in surface waters and becomes increasingly important in the ion balance of natural waters once DOC exceeds 5 mg/L (Sullivan 2000; Clair et al. 2000). All 49 lakes in the monitoring region had DOC >5 mg/L. Furthermore, the difference between total cations and total anions was significantly related to DOC (linear regression, r^2=0.74, P<0.00001; Figure 10.13), suggesting that excess cations were balanced by organic anions.

Another index of change is the ratio of sulphate to the sum of base cations. This ratio ranged from 0.004 to 0.56 among the monitored lakes in 2002 (Figure 10.12). High sulphate concentration is generally only associated with biologically significant changes in water chemistry where the sum of base cations is low (Sullivan 2000). Therefore, when the ratio of sulphate to base cations is greater than 1, water is acidic because of high sulphate concentration, irrespective of organic acid anion concentration (Sullivan 2000). Since the ratio was less than one for all 49 lakes, acidification due to sulphate is not indicated.

The ratio of bicarbonate to divalent cations was also calculated for each lake monitored by RAMP. This ratio is expected to equal one under pristine conditions, unless organic acids are present in elevated concentrations or the lakes being evaluated are located in unusual geological settings (Schindler 1996). Both of these conditions may apply to the RAMP lakes, since DOC is elevated in most lakes and elevated sodium concentration is common. Acidification causes a decline in bicarbonate and an increase in divalent cations by increased leaching from soils and lake sediments. As a result, the ratio is more sensitive to acidification than either the numerator or the denominator and a declining ratio over time may indicate progressive acidification.

The ratio of bicarbonate to divalent cations was <1 for all lakes (Table 10.2) based on the 1999 to 2002 RAMP data sets. At this time, available data are insufficient to statistically evaluate trends over time using this approach for most RAMP lakes. Of the 25 lakes with four years of data, no lake showed a decline in the ratio with each consecutive year. Lake L46 had a decline for the first three years followed by no change between 2001 and 2002. Lake L46 is not, however, subject to predicted exceedances of the critical load (Table 10.1).

Five lakes (A59, L23, L29, E52 and O2) showed an increase in the bicarbonate to divalent cation ratio and the remaining 19 showed no consistent trend over time. The absolute changes in the ratios for these lakes are small and within the year-to-year variation documented by Schindler (1996) for Lakes L4, L7, L18 and L25. Visual comparison of the box and whisker plot of the bicarbonate to divalent cation ratio by sub-region based on data for the 26 lakes sampled in all four years of monitoring also indicated no decline in the ratio (Figure 10.14).

Table 10.3 Ratios of Bicarbonate/Divalent Cations for the Acid Sensitive Lakes Monitored by RAMP in 1999 to 2002

Lake	$HCO_3^- / (Ca^{2+}+Mg^{2+})$ (Equivalents)			
	1999	2000	2001	2002
Oil Sands Sub-Regions				
North East of Fort McMurray				
L4 (A-170)	0.39	0.34	0.45	0.38
L7	0.56	0.45	0.54	0.44
L8	0.84	0.8	0.79	0.82
L39 (A-150)	0.82	0.86	0.92	0.82
E15 (268)	-[(a)]	0.70	0.72	1.02
182	-	-	-	0.69
185	-	-	-	0.25
209	-	-	-	0.49
270	-	-	-	0.87
271	-	-	-	1.04
Stony Mountains				
A21	0.12	0.30	0.27	0.31
A24	-	0.16	0.29	0.28
A26	0.64	0.40	0.48	0.45
A29	0.46	0.63	0.53	0.56

Table 10.3 Ratios of Bicarbonate/Divalent Cations for the Acid Sensitive Lakes Monitored by RAMP in 1999 to 2002 (continued)

Lake	$HCO_3^- / (Ca^{2+}+Mg^{2+})$ (Equivalents)			
	1999	2000	2001	2002
A86	0.67	0.76	0.70	0.79
287	-	-	-	0.42
289	-	-	-	0.81
290	-	-	-	0.48
342	-	-	-	0.77
354	-	-	-	0.89
West of Fort McMurray				
A42	0.58	0.60	0.59	0.70
A47	0.39	0.57	-	0.56
A59	0.20	0.30	0.32	0.33
223	-	-	-	0.71
225	-	-	-	0.80
226	-	-	-	0.69
227	-	-	-	0.77
267	-	-	-	0.93
Birch Mountains				
L18 (Namur)	0.84	0.83	0.86	0.86
L23 (Otasan)	0.67	0.72	0.75	0.79
L25 (Legend)	0.75	0.77	0.80	0.77
L28	0.25	0.26	0.37	0.32
L29 (Clayton)	-	-	0.00	0.00
L46 (Bayard)	0.77	0.57	0.55	0.55
L47	0.57	0.56	0.49	0.54
L49	0.31	0.42	0.35	0.38
L60	0.47	0.46	0.63	0.61
175	-	-	-	0.91
199	-	-	-	0.75
Caribou Mountains				
E52 (Fleming)	0.59	0.65	0.68	0.71
E59 (Rocky Island)	0.64	0.66	0.66	0.69
E68 (Whitesand)	-	0.59	0.57	0.60
O1 (Unnamed #6) (E55)	0.35	0.41	0.40	0.46
O2 (Unnamed #9) (E67)	0.50	0.51	0.54	0.62
Canadian Shield				
A301	-	-	0.88	0.90
L107 (Weekes)	-	0.93	0.92	0.93
L109 (Fletcher)	0.75	0.84	0.83	0.81
O10	0.66	0.80	0.78	0.76
R1	0.76	0.84	0.82	0.84

(a) No data.

Figure 10.10 Dissolved Organic Carbon (DOC) Versus Colour for the Lakes Sampled in 2002

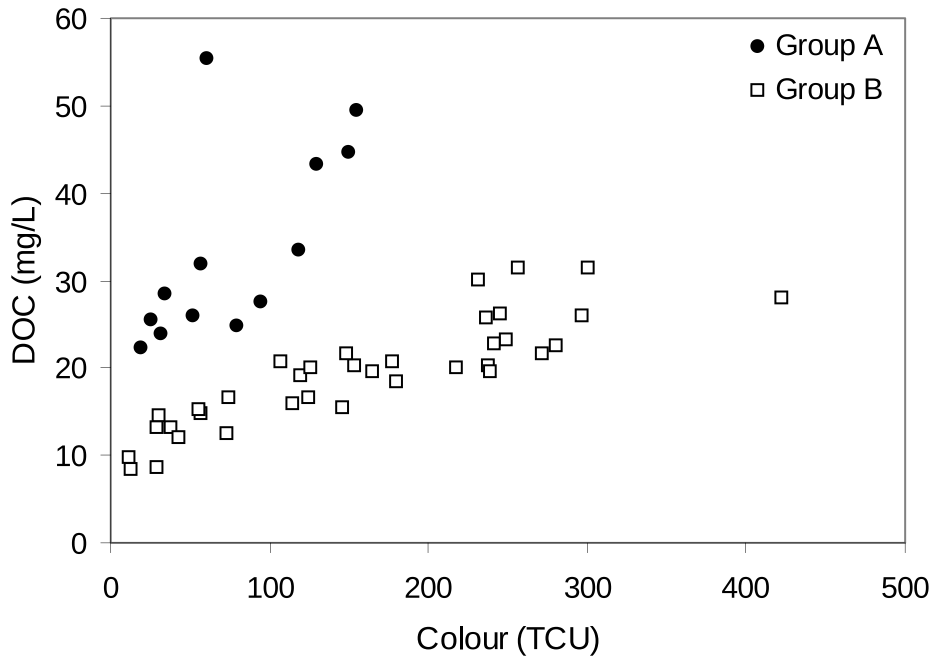


Figure 10.11 Variation in Sulphate Among Years for the Lakes Sampled in 2002

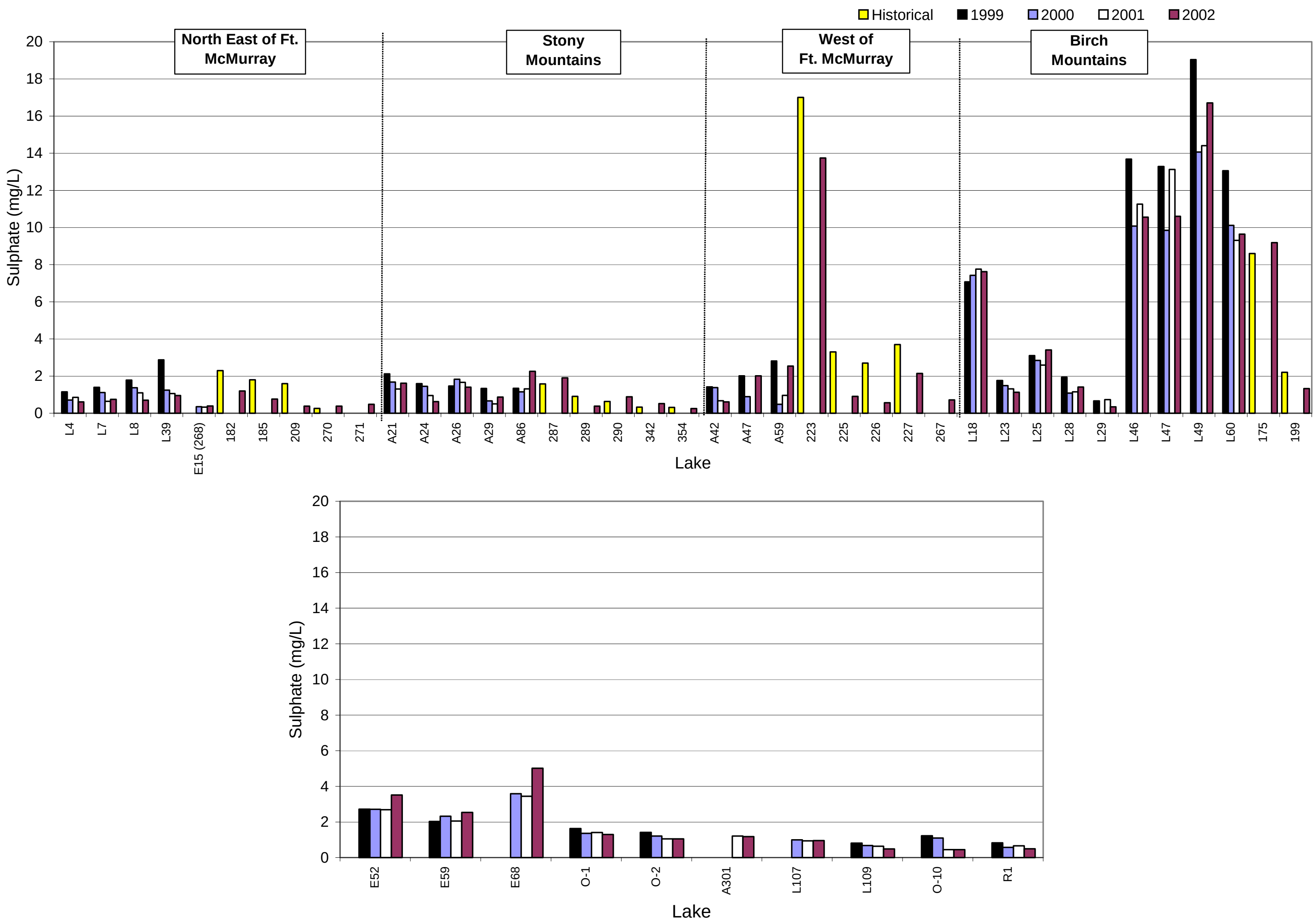


Figure 10.12 Ion Balance (Sum of Cations/Sum of Anions) and Ratio of Sulphate to Sum of Base Cations in the Lakes Sampled in 2002

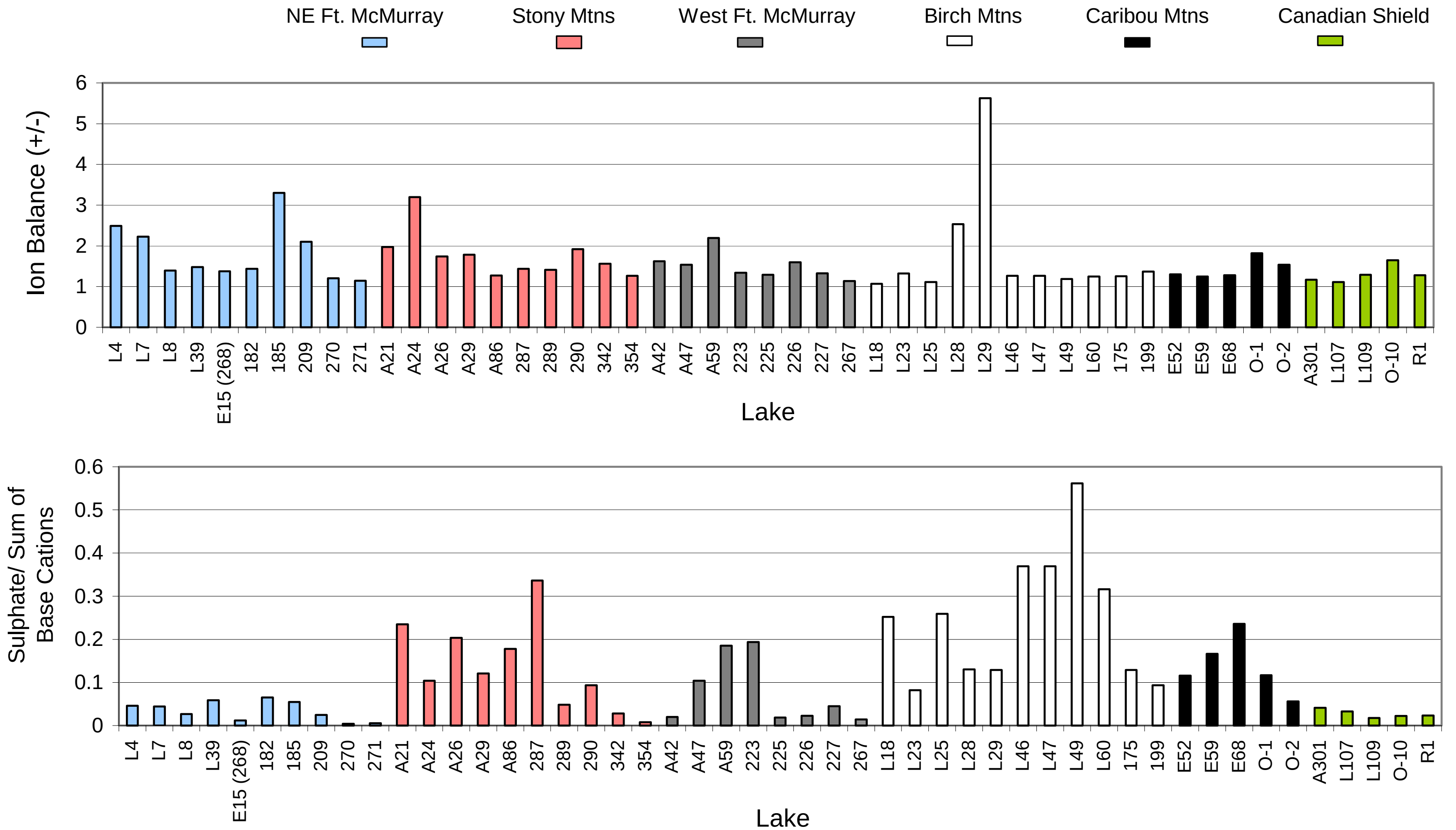


Figure 10.13 The Relationship between (Sum of Cations – Sum of Anions) and Dissolved Organic Carbon (DOC) in the 2002 Data Set

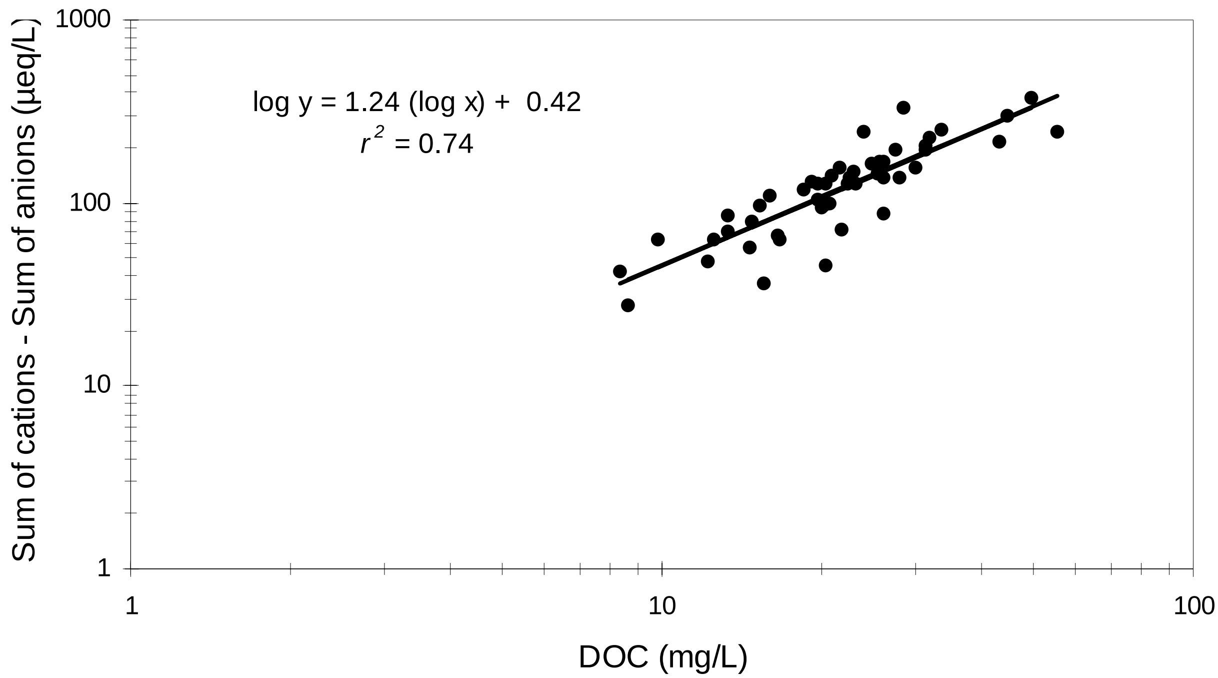
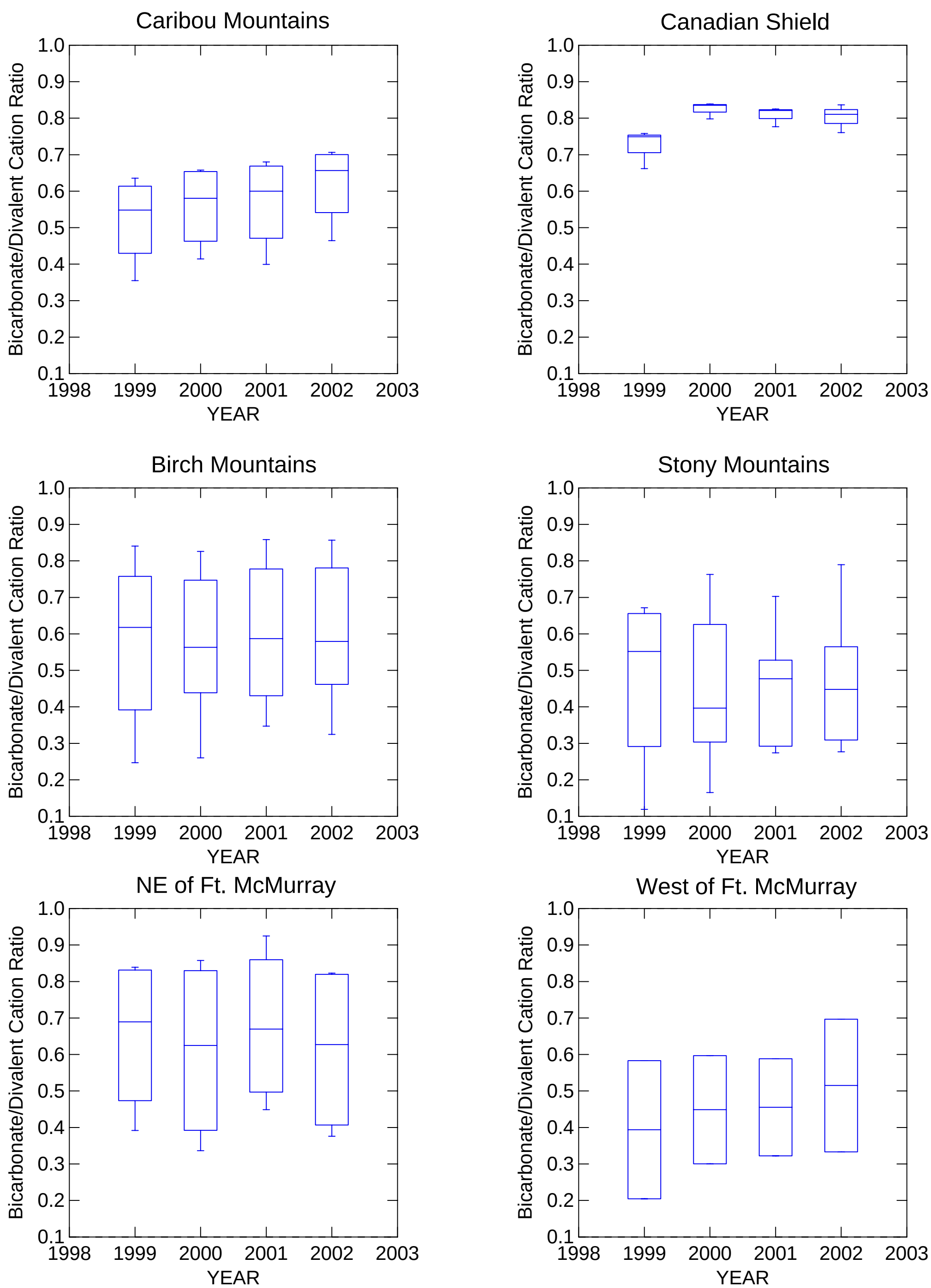


Figure 10.14 Box and Whisker Plots of Bicarbonate/Divalent Cations Ratios by Sub-region (1999 to 2002)



10.4 SUSPENDED SOLIDS, NUTRIENTS AND TROPHIC STATUS

In addition to major ions and other dissolved substances, lake water also contains solid materials (living and non-living) and various nutrients. Total suspended solids (TSS) is the fraction of solids that will not pass through a 0.45-µm pore diameter filter and can include inorganic sediment, fine particles of organic and inorganic matter, plankton and other microscopic organisms (CCME 1999). Chlorophyll *a* is a plant pigment and is used as an indicator of a lake's productivity or trophic status (Goldman and Horne 1983). Major nutrients include various forms of nitrogen (total nitrogen [TN], nitrite [NO_2^-], nitrate [NO_3^-], ammonium [NH_4^+]) and phosphorus (e.g., total phosphorus [TP]), which often limit productivity in lakes. It is important to note that nitrogen compounds (i.e., NO_X) are found in acid deposition.

NO_X emissions react with hydrogen in the atmosphere to produce nitric acid, a component of acid rain. Recent investigations have identified a phenomenon referred to as "nitrogen saturation" that involves declining rates of nitrogen removal by terrestrial ecosystems due to excess loading of nitrogen from industrial sources. Declining rates of nitrogen removal result in increasing nitrogen concentrations in surface waters in affected areas, which may then contribute to acidification (Schindler 1996). The potential for nitrogen saturation of a system highlights the importance of monitoring nitrogen in aquatic ecosystems experiencing extra loadings of nitrogen, such as those associated with acid deposition.

Total Suspended Solids

In 2002, TSS values were below 25.0 mg/L (Figure 10.15) with the exception of one outlier (Lake A42; TSS=122.5 mg/L). As with the 2001 data set, higher TSS levels were associated with lakes that had depths <2 m. The most likely reason for this observation is wind-induced mixing in the shallower lakes. It should be noted that depth data were not available for the 17 new lakes in 2002, so they were not included in the above assessment of TSS versus maximum depth.

Nutrients and Chlorophyll a

Concentrations of nutrients (e.g., TP=0.007 to 0.210 mg/L; TN=0.3 to 5.7 mg/L) and chlorophyll *a* (1.3 to 144.0 ug/L) varied widely among lakes (Figures 10.15 and 11.16). As well, there were significant correlations between TSS and TP (r=0.65), TN (r=0.75) and TKN (r=0.77) (Pearson correlations, P<0.001 for all tests; scatter-plots in Figure 10.17). There was also a significant correlation between TSS and chlorophyll *a* (Figure 10.18; Pearson correlation, r=0.96, P<0.001) in the 2002 data set.

The trophic status of a lake is often defined by chlorophyll *a* concentration. For example, the trophic status of a lake can be related to chlorophyll *a* (chl *a*) concentration as follows (from Mitchell and Prepas 1990):

- hyper-eutrophic or very highly productive lakes have >25 µg/L chl *a*;
- eutrophic lakes with high productivity have 8 to 25 µg/L chl *a*;
- mesotrophic lakes with moderate productivity have 2.5 to 8 µg/L chl *a*; and
- oligotrophic lakes or low productivity lakes have <2.5 µg/L chl *a*.

Based on chlorophyll *a* concentration for the lakes sampled in 2002, 7 lakes were oligotrophic, 19 lakes were mesotrophic, 19 lakes were eutrophic and 4 lakes were hyper-eutrophic.

As in previous years, there was a relationship between TP and chlorophyll *a*, although this relationship was stronger in 2002 than in the past (Figure 10.19; Pearson correlation, r=0.62, P<0.001). Concentrations of phosphorus and nitrogen variables were significantly intercorrelated (Pearson correlations; P<0.001) with the exception of TDP and nitrite + nitrate.

Nitrite + nitrate concentrations were generally below 0.1 mg/L for the lakes in the monitoring network (Figure 10.20). Exceptions included three lakes in the Birch Mountains (L46, L47 and L49), two lakes West of Fort McMurray (A42 and A47) and Lake E68 in the Caribou Mountains. Year-to-year variation was high for nitrite + nitrate, with several lakes (L4, L8, 271, A26, A47, L46, L47 and L60) experiencing elevated concentrations in 2002 compared to past values.

Since this RAMP component is focused on acidification, additional analysis and interpretation of the nutrient and chlorophyll *a* data was not warranted.

Figure 10.15 Total Suspended Solids (TSS), Total Phosphorus (TP) and Chlorophyll *a* in the Lakes Sampled in 2002

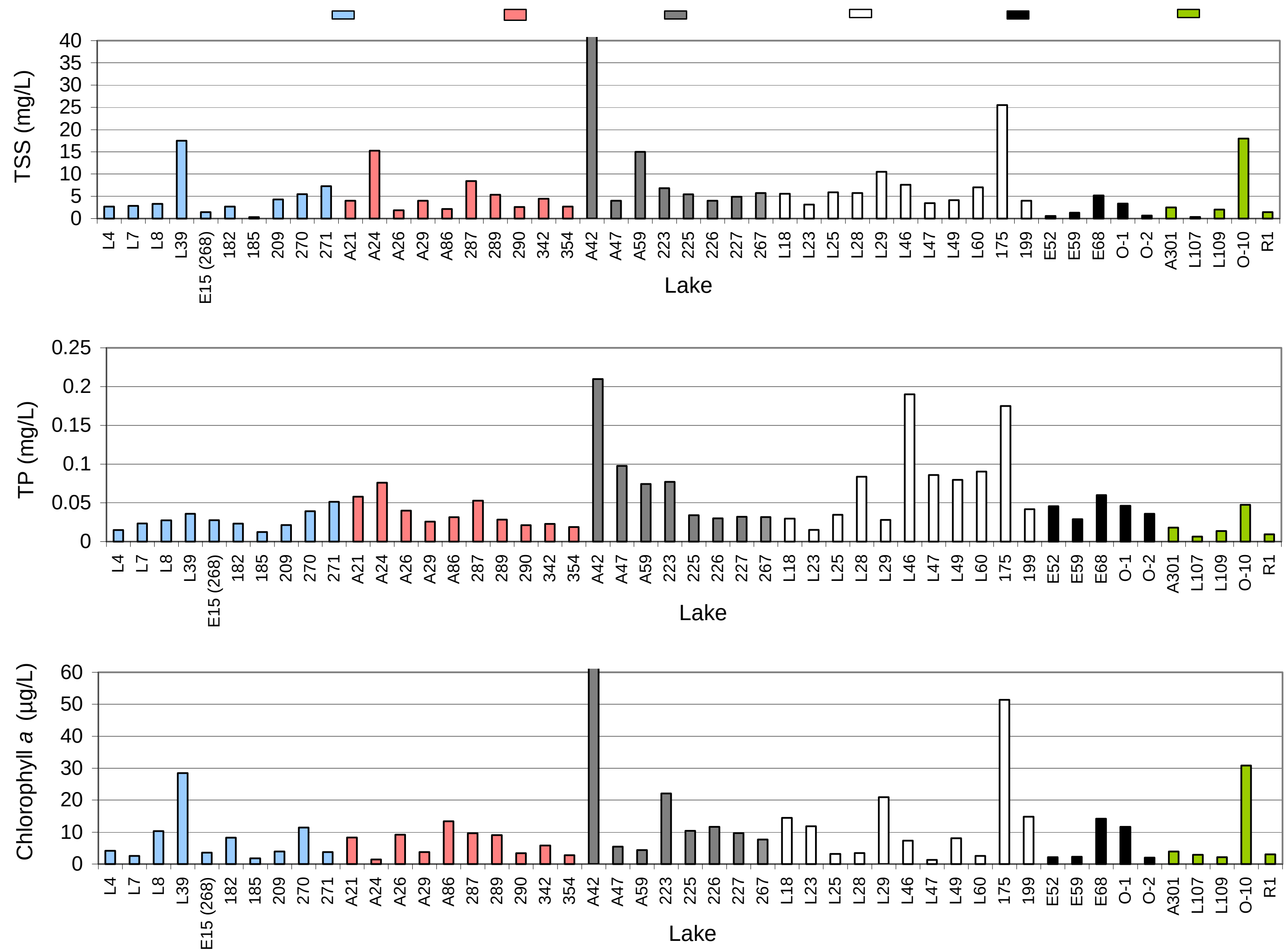


Figure 10.16 Total Nitrogen (TN), Total Kjeldahl Nitrogen (TKN), Nitrate + Nitrite (NO_2+NO_3) and Ammonium (NH_4^+) in the Lakes Sampled in 2002

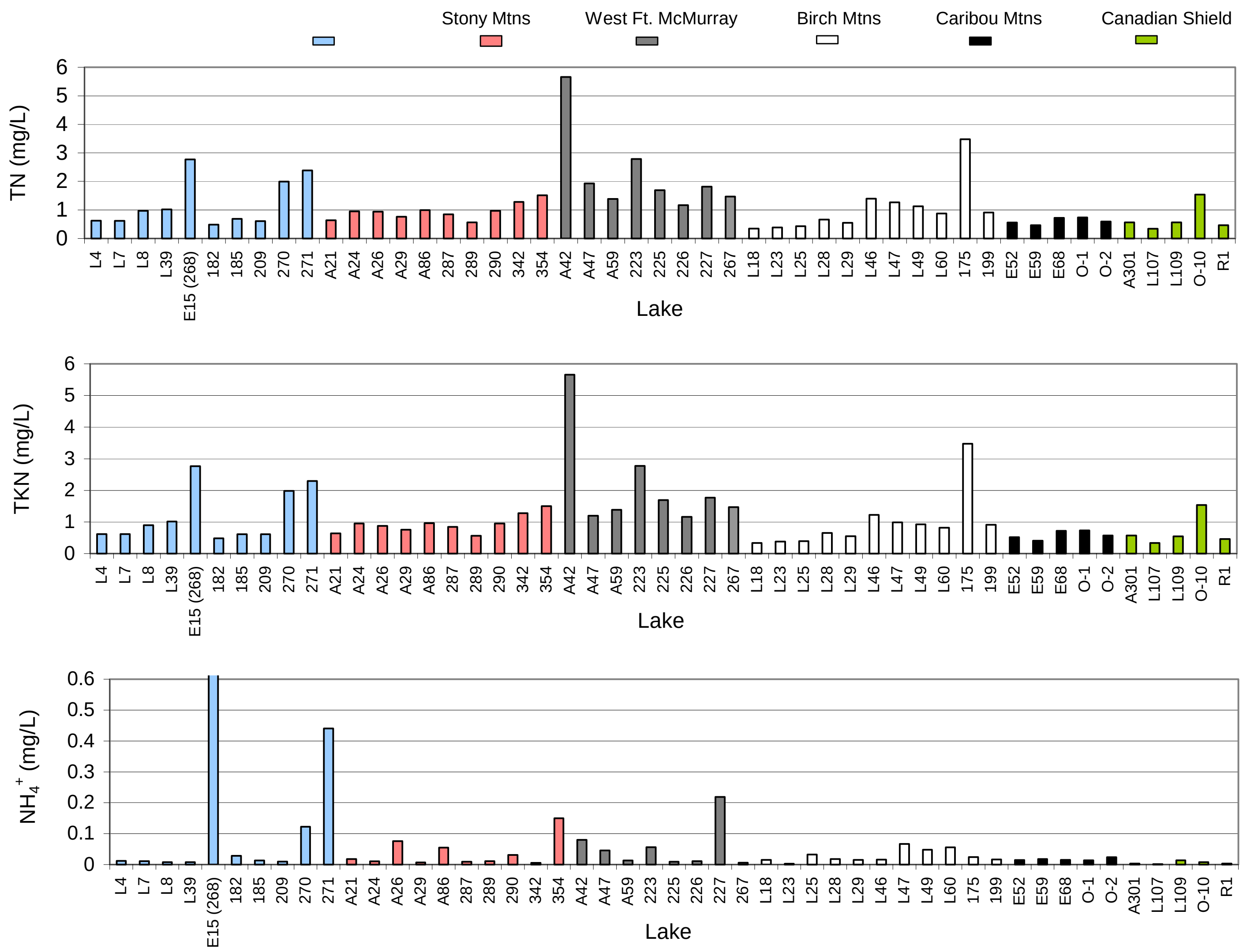


Figure 10.17 Plot of Nutrient Concentrations Versus TSS for the Lakes Sampled in 2002

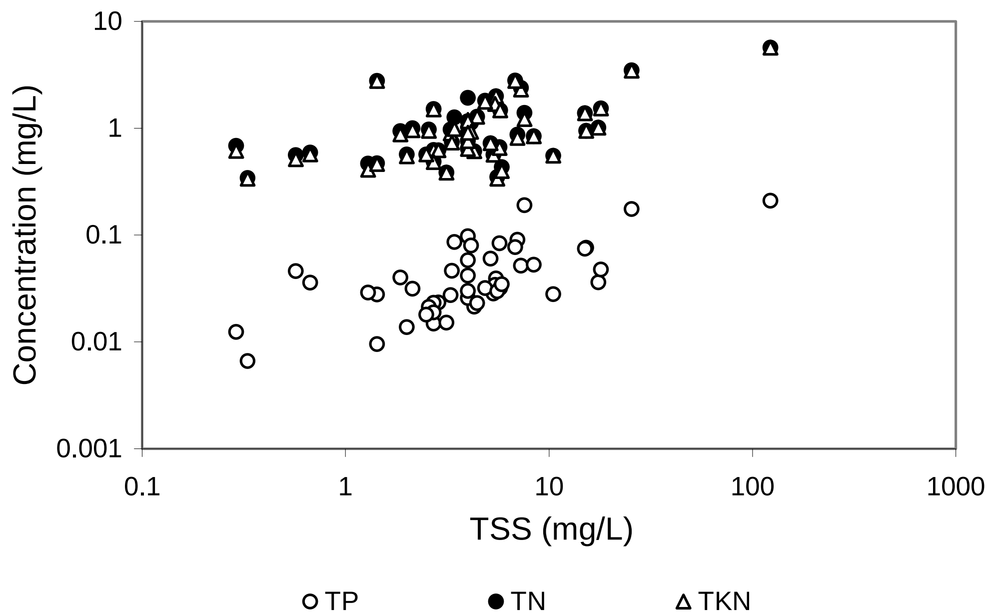


Figure 10.18 Plot of Chlorophyll *a* Versus TSS for the Lakes Sampled in 2002

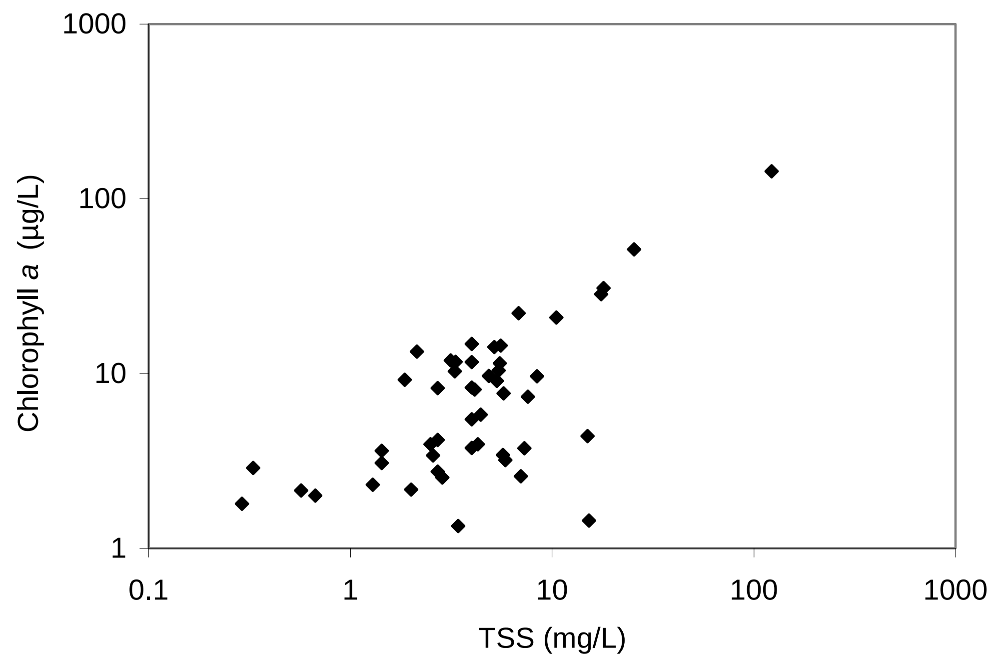


Figure 10.19 Plot of Chlorophyll *a* versus TP for the Lakes Sampled in 2002

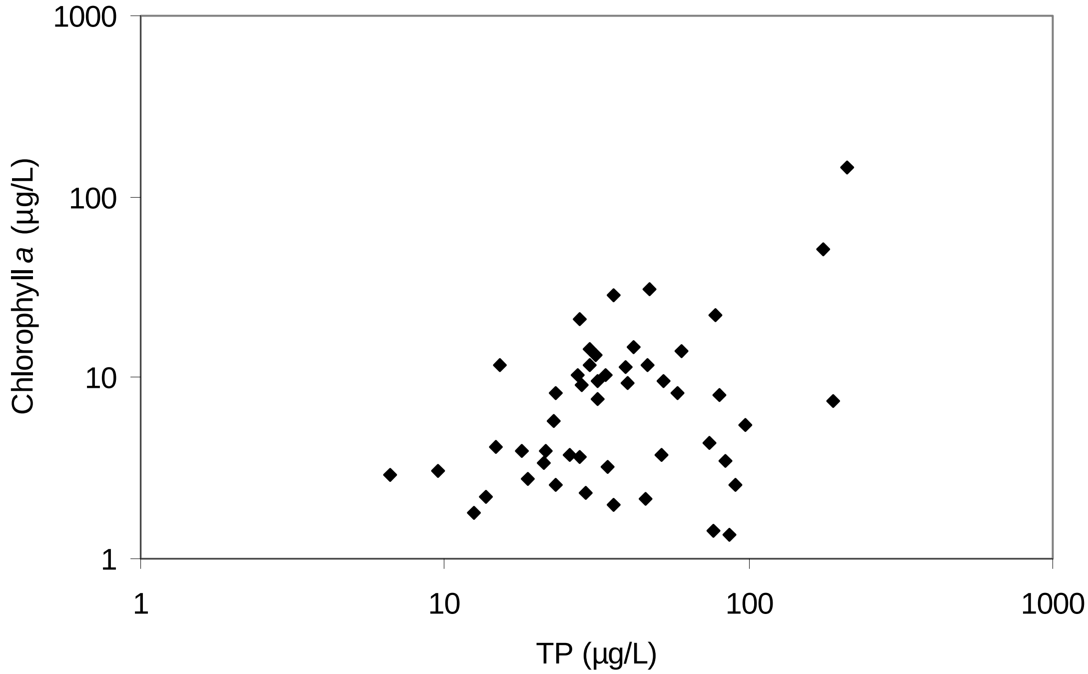
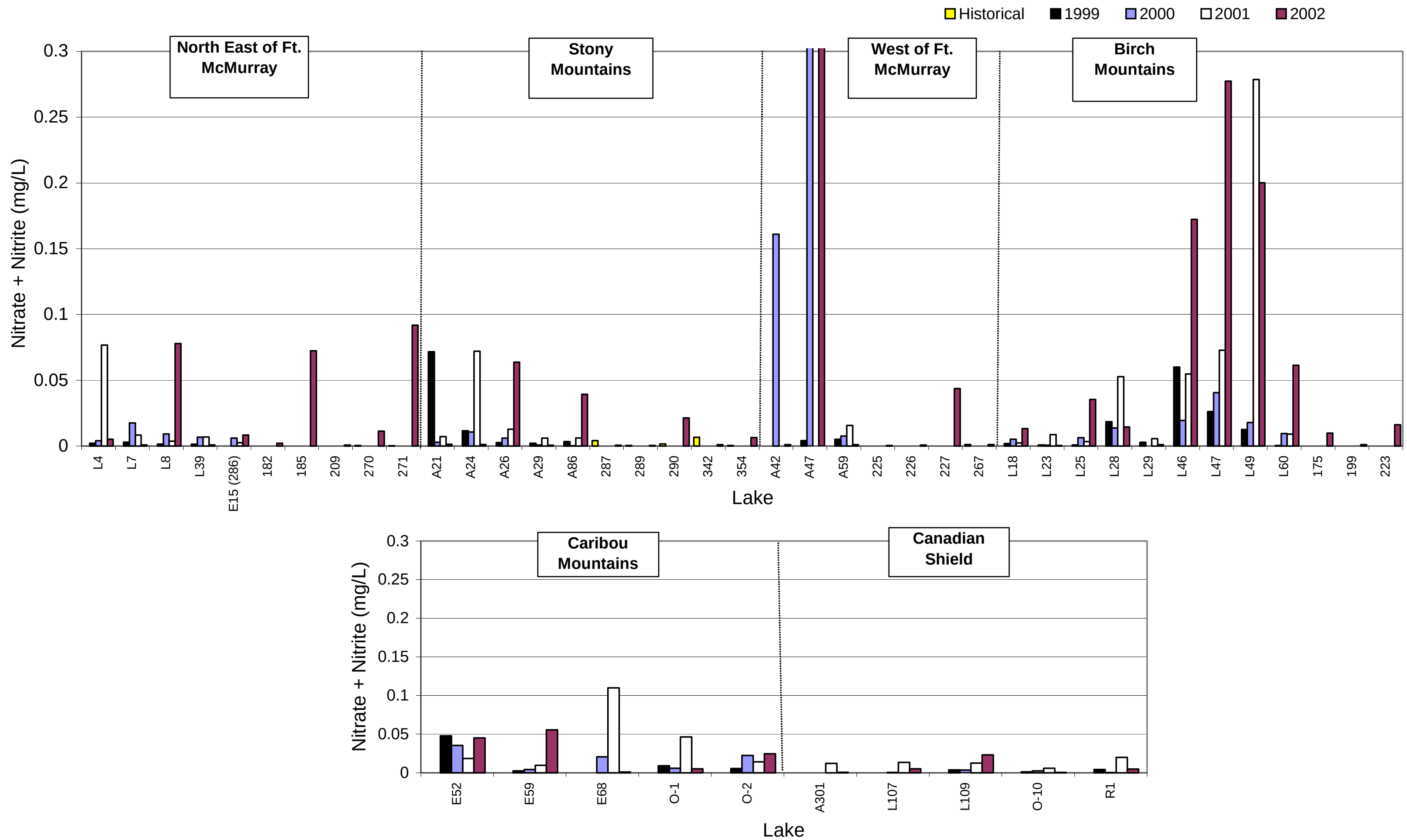


Figure 10.20 Variation in Nitrite + Nitrate Among Years for the Lakes Sampled in 2002



11 AQUATIC VEGETATION

Aquatic vegetation was monitored through the comparison of a series of aerial photographs. Wetlands were originally identified from black and white or true colour aerial photographs. More recent photograph interpretation includes false colour infrared images when possible. The lake boundaries and surrounding wetlands polygons were interpreted and digitized onto a scanned coverage of the aerial photograph. Qualitative visual examinations and area analysis of wetlands types were performed using AUTOCAD programs.

The approach used to analyze aquatic communities in the RAMP program is outlined in Section 2.1.6. A description of the methods of analysis is presented in Section 3.7.

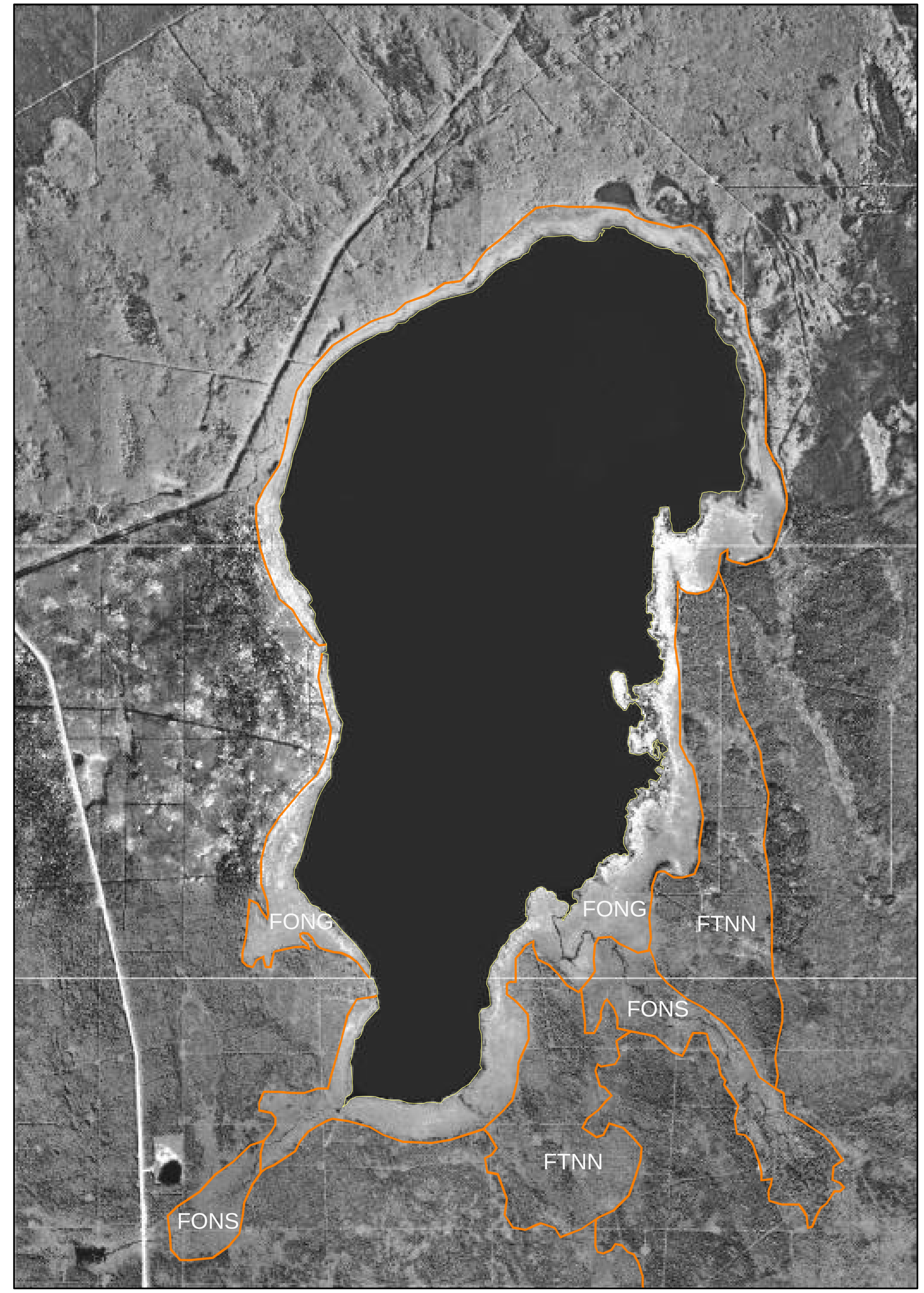
11.1.1 Kearl Lake

Kearl Lake does not appear to have any change in the lake boundary between 1997 and 2001 (Figure 11.1). The lake is immediately surrounded by graminoid fen (FONG) and shrubby fen (FONS) complexes in the 1997 photograph. In the 2001 photograph, the graminoid fen (FONG) wetlands type immediately surrounded the lake. This difference does not appear to be due to any change in the landscape but due to individual interpretation and the quality of the 1997 photograph (Table 11.1).

Table 11.1 Area of Aquatic and Wetlands Polygons for Kearl Lake, 1997 and 2001

Wetlands Type		Area (ha)	
		1997	2001
NWL	Kearl Lake	547	536
FONG	graminoid fen	162	172
FTNN	wooded fen	107	133
FONS	shrubby fen	138	52

1997



2001

250 0 250
SCALE METRES

REFERENCE

1997 THE ORTHOPSHOP (PHOTO DTE 1997)
THE FORESTRY CORP.

REFERENCE

2002 ORTHOPHOTO IMAGE BOTTOM PORTION KEARL LAKE. COURTESY OF SHELL CANADA LTD.,
ALBERTA PACIFIC LTD. FLOWN 2001
ORTHOPHOTO IMAGE UPPER PORTION KEARL LAKE. FROM ORTHOSHOP, FLOWN 1998.
COURTESY OF MOBIL.

PROJECT

RAMP 2002

TITLE

VEGETATION COMMUNITIES OF KEARL LAKE, 1997 AND 2001

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No.	Kearl 1997-2001
DESIGN	HS	07/01/03	SCALE 1:12500	REV. 1
CADD	BGM	24/01/03		
CHECK			**FIGURE: 11.1**	
REVIEW				

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Kearl Wetlands.dwg Mar 15, 2003 - 5:30pm

11.1.2 Shipyard Lake

Shipyard Lake is surrounded entirely by a graminoid marsh (MONG) wetlands type with shallow open water (WONN) and wooded swamp (STNN) patches occurring in the eastern half (Figure 11.2). Changes have varied year to year; however, there appears to have been a gradual increase in the size of the lake from 1997 to 2002 (Table 11.2). This is especially obvious along the northern and western shore where the open water area is expanding into cattail edge. However, due to beaver activity the channel that connects the shrubby swamp (SONS) and the graminoid marsh (MONG) in the north appears to be receding and filling in from the 1997 photo to the 2002 photo.

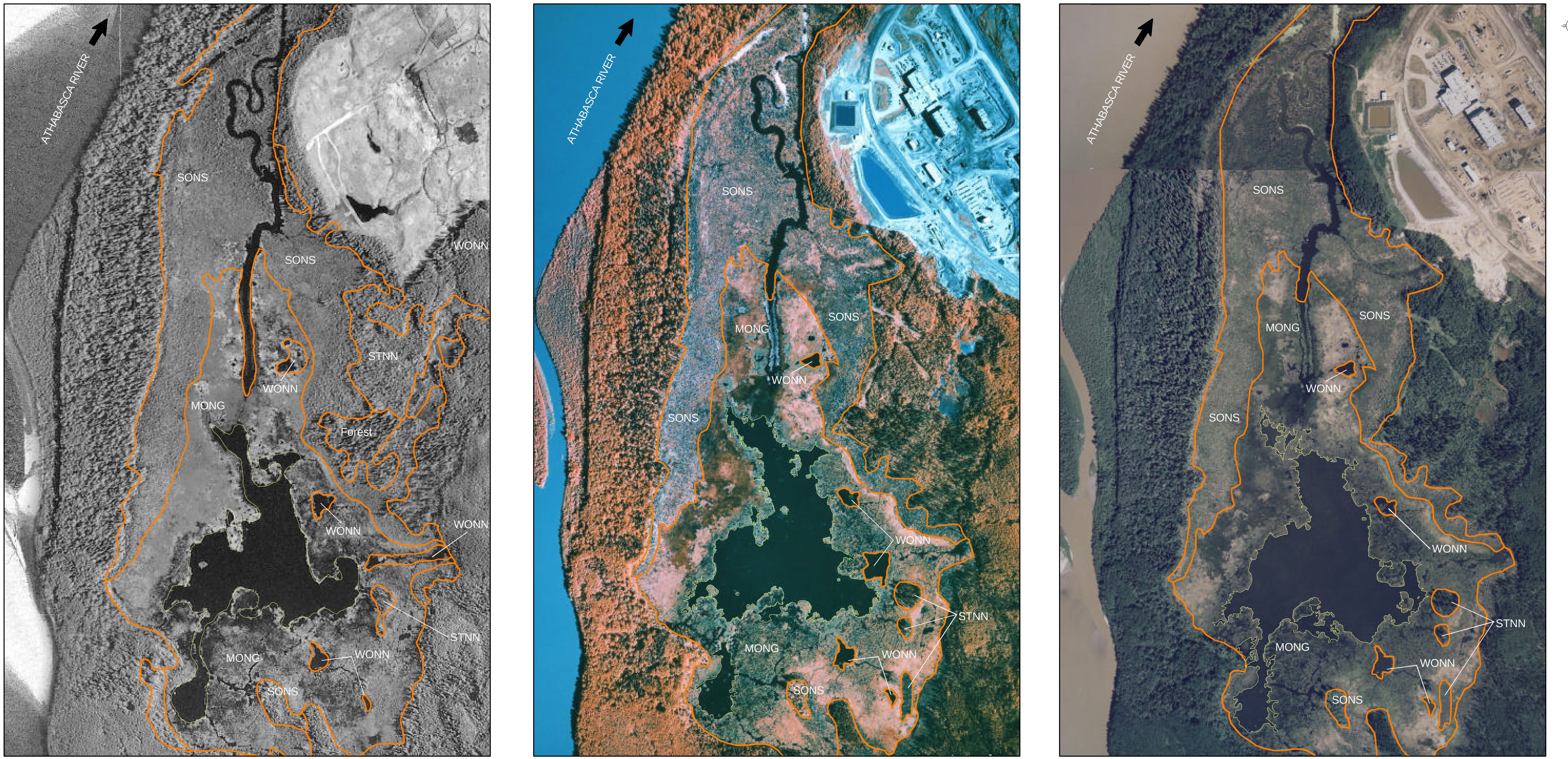
Table 11.2 Area of Aquatic and Wetlands Polygons for Shipyard Lake, 1997 to 2002

Wetlands Type		Area (ha)		
		1997	2001	2002
NWL	Shipyard Lake	17	19	21
SONS	shrubby swamp	60	52	53
MONG	graminoid marsh	67	66	65
WONN	shallow open water	2	2	1
STNN	wooded swamp	8	1	1

11.1.3 Isadore's Lake

Isadore's Lake is surrounded by a series of fens and swamps, specifically FONS, FONG and SONS wetlands types (Figure 11.3). Visual examination shows some reduction in the size of the northern channel of Isadore's Lake. The FONG wetland on the north edge of the lake has enlarged as the WONN located in the 1997 photo has receded. All other wetlands polygons bordering the lake do not appear to have undergone any noteworthy change to their boundaries (Table 11.3).

With the false colour infra-red photo; aquatic vegetation is also visible within the lake boundaries allowing for future comparisons. This was not possible with the true colour photos in 1997.



1997 | 2001 | 2002

250 0 250
SCALE METRES

REFERENCE

1997 THE ORTHOSHOP (PHOTO DATE 1997)
THE FORESTRY CORP.

REFERENCE

2001 PHOTO IMAGES SUPPLIED BY AMEC, PHOTO FFC01045 L-9A PHOTO 284, FLOWN 1:10,000, 01/08/01. COURTESY OF TEEM.

REFERENCE

2002 PHOTO IMAGES GEOGRAPHIC AIR SURVEY LTD., PHOTO UMA 2011-1-022 AND UMA 2011-1-024, FLOWN 1:10,000, 07/07/02. COURTESY OF SUNCOR ENERGY INC.

PROJECT

RAMP 2002

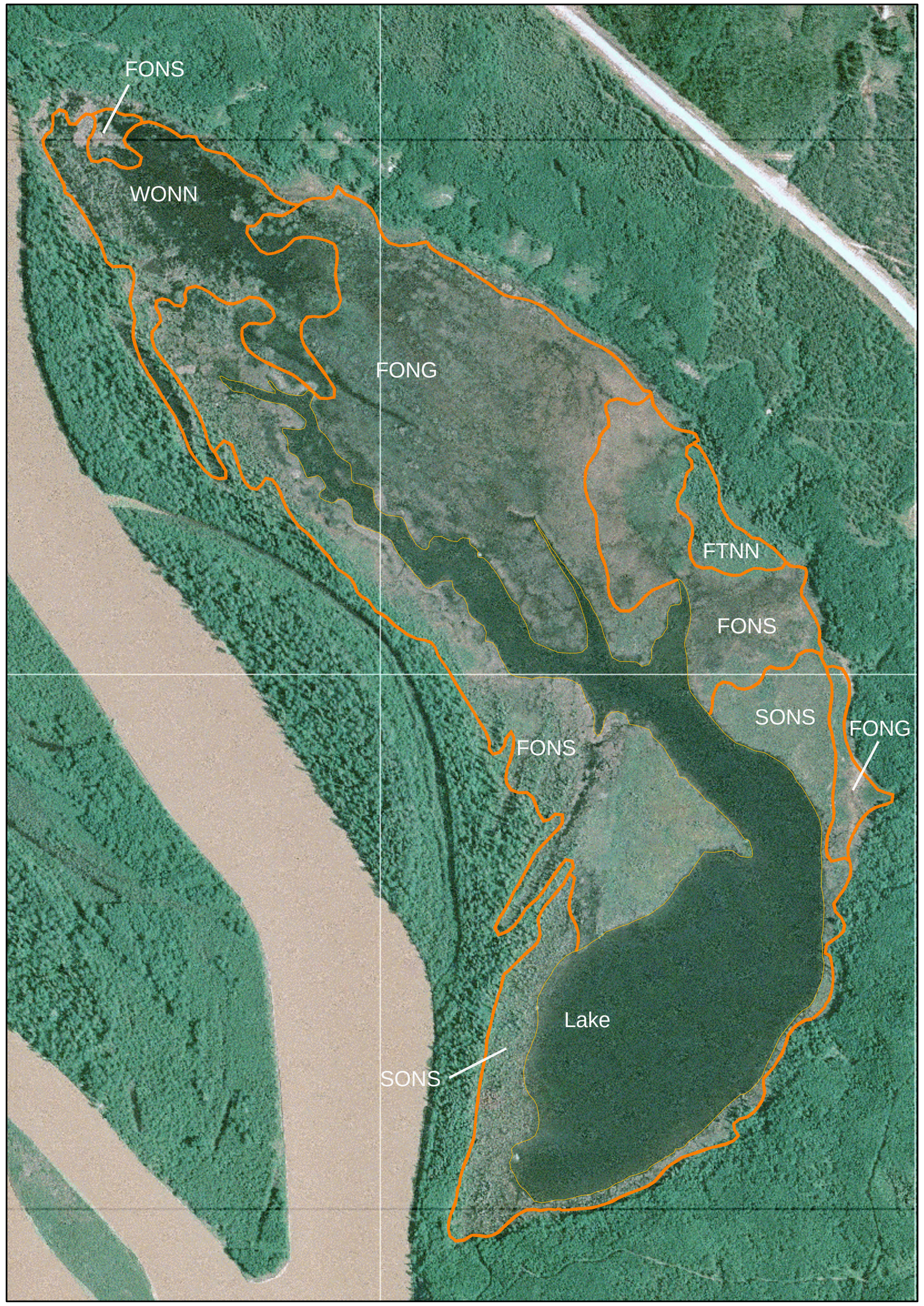
TITLE

VEGETATION COMMUNITIES OF SHIPYARD LAKE, 1997, 2001 AND 2002

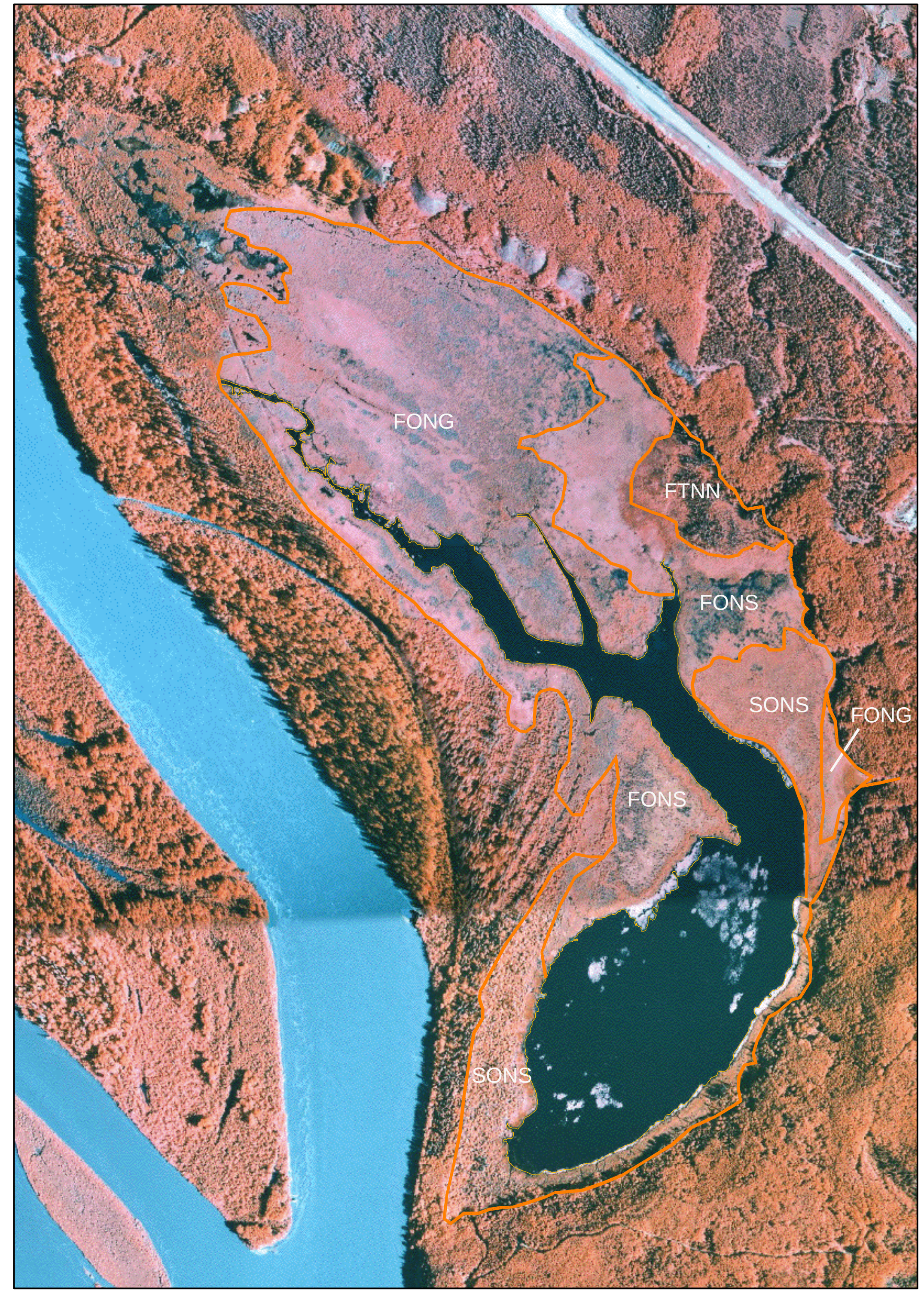
Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. ShipyardWetlands2002	
DESIGN	HS	07/01/03	SCALE 1:12500	REV. 1
CADD	BGM	24/01/03	**FIGURE: 11.2**	
CHECK				
REVIEW				

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Shipyard Wetlands 2002.dwg Mar 15, 2003 - 5:31pm



1997



2001

250 0 250
SCALE METRES

REFERENCE

1997 PHOTO IMAGE
THE ORTHOSHOP (PHOTO DATE 1997)
THE FORESTRY CORP.

REFERENCE

2002 PHOTO IMAGES SUPPLIED BY AMEC,
PHOTOS FFC01046 L-28 PHOTOS 362 AND 369,
FLOWN 1:10,000 02/08/01. COURTESY OF TEEM.

PROJECT

RAMP 2002

TITLE

VEGETATION COMMUNITIES OF ISADORE'S LAKE, 1997 AND 2001

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No.		Kearl 1997-2001	
DESIGN	HS	07/01/03	SCALE	1:12500	REV.	1
CADD	BGM	24/01/03				
CHECK						
REVIEW						

FIGURE: 11.3

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Isadore Wetlands.dwg Mar 15, 2003 - 5:36pm

Table 11.3 Area of Aquatic and Wetlands Polygons for Isadore's Lake, 1997 and 2001

Wetlands Type		Area (ha)	
		1997	2001
NWL	Isadore's Lake	38	31
FONG	graminoid fen	34	36
FTNN	wooded fen	2	4
FONS[a]	shrubby fen	29	27
SONS	shrubby swamp	13	16

[a] In the 1997 calculation the FONS in the NW section was included; in the 2001 calculation this FONS was not included.

11.1.4 McClelland Lake

Only a 1994 photo was available for McClelland Lake making it impossible to compare changes between years (Figure 11.4). The northern shore of McClelland Lake is composed of a combination of wetlands and uplands ecosite phases while the southern shore is primarily uplands. The eastern and western shores of the lake are made up of a series of wetlands types, primarily MONG, SONS, STNN and FONS.

1994 Area = 30510861.85 m²

REFERENCE

1994 PHOTO IMAGES SUPPLIED BY AIR PHOTO SERVICES
FLOWN 1:40,000, OCT 12–18, 1994 (WET YEAR)
IMAGES COURTESY OF TRUENORTH ENERGY

WETLANDS WERE DIGITIZED FROM TOPOGRAPHIC MAPS
74 E/6 (1974) AND 74 E/11 (1974) NAD 27, ZONE 12,
NATURAL RESOURCES CANADA.

500 0 500
SCALE METRES

PROJECT

RAMP 2002

TITLE

VEGETATION COMMUNITIES OF McCLELLAND LAKE, 1994

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. McClellandWetland		
DESIGN	HS	07/01/03	SCALE 1:30000	REV. 0	
CADD	BGM	24/01/03	**FIGURE: 11.4**		
CHECK					
REVIEW					

12 SUMMARY AND CONCLUSIONS

12.1 SUMMARY

12.1.1 Climate and Hydrology

The 2002 RAMP Climate and Hydrology monitoring component, has fulfilled it's monitoring objectives and resulted in an expansion of the climatic and hydrologic database for the Oil Sands Region, particularly for the Muskeg River basin, Birch Mountains east slope basins and Fort Hills basins. The specific contributions of the 2002 monitoring program are summarized below.

- Continuing operation of the Aurora Climate Station contributed to expansion of the regional climatic database and provided required climatic information for interpreting the hydrologic monitoring results. Continuing operation of the precipitation and temperature sensors at the Calumet River site initiated collection of climatic data to extend the regional coverage to the north and west. Installation of rain gauges at the Christina River, Tar River Lowland and McClelland Lake sites and continued operation of the rain gauge at the Iyinimin Creek site resulted in a denser rain gauge network in the Oil Sands Region than in the past.
- A second year of snow course survey for various terrain types in the Birch Mountains east slope basins expanded the snowpack database necessary for determining the snowfall undercatch correction factor and providing required input to calibrate and verify a snowmelt runoff model. The snow course survey should be continued in the Birch Mountains east slope basins in 2003.
- The 2002 program resulted in installation of new water level monitoring stations on the Susan Lake Outlet (S25), MacKay River (S26), Firebag River (S27) and Christina River (S29). Operation of the Petro-Canada stations on the Hangingstone River (S30), Hangingstone Creek (S31) and Surmont Creek (S32) were incorporated by RAMP in 2002.
- The 2002 streamflow measurements and monitoring were conducted to meet regulatory requirements and contributed to an expansion of the existing streamflow database that is required to develop reliable stage-discharge rating curves and discharge hydrographs at the monitoring stations.
- The 2002 water level monitoring at McClelland Lake (L1) was conducted to meet regulatory requirements and contributed to an expansion of the hydrologic database for assessing the effects of the regional oil sands developments on the lake.

- The 2002 TSS measurements contributed to an expansion of the existing TSS database required to monitor watershed and channel erosion and streamflow water quality and to develop more reliable predictive tools to correlate TSS concentrations with streamflows. Sufficient data have been acquired for long-term stations such that TSS measurements need only be undertaken during high discharges, supplemented with a limited number of low discharge measurements. Regular measurements should continue to be undertaken for stations established since 2000.
- Ongoing operations of the monitoring stations provided a basis for identifying the maintenance needs and developing recommendations for the upcoming 2003 monitoring program.
- The 2002 program has resulted in development of a regional climatic and hydrologic database updated to the end of 2002. This database is stored on a compact disc for easy access by users.

It is recommended that the collection of climatic and hydrologic data at the existing monitoring stations be continued and that the monitoring should cover the entire year including snowmelt flows, summer flows and winter low flows, where possible. Continuation of the monitoring program is required for development of an improved hydrologic database, which will allow updating of previous hydrologic analyses and modelling based on site-specific data. The continuation will also provide the hydrologic data necessary for monitoring any potential effects of the oil sands projects as required by regulatory agencies. The specific recommendations for the 2003 monitoring program, which were identified during the 2002 program, are summarized below.

- The operations and maintenance of the climatic and hydrologic monitoring stations, and the relevant data collection should be continued.
- A snow course survey in the Birch Mountains east slope basins should be conducted in early March 2003 to collect a third year of snowpack data to supplement data acquired during the CNRL Horizon Project baseline studies.
- Consideration should be given to further extending the regional rain gauge network, beyond those installed at the selected streamflow stations in 2002.
- Surveys should be performed to tie all permanent benchmarks to the geodetic datum.
- Consideration should be given to retrofitting streamflow and lake level monitoring stations, where budgets allow, to allow remote data retrieval.
- Consideration should be given to visiting all RAMP stations periodically over the winter months, and undertaking manual stream

discharge measurements if possible. Most of the RAMP stations on smaller watersheds are not operated during the winter months, since they typically freeze to the bottom and cease to flow over the winter, and do not lend themselves to continuous year-round flow monitoring. However, most recent monitoring was undertaken during relatively dry conditions relative to the available record of precipitation, and it is possible that wetter conditions may result in higher winter flows.

- It is recommended that year-round hydrologic monitoring be undertaken at a small watershed in conjunction with intensive rainfall and snowfall monitoring. A natural watershed should be examined to measure the temporal variation of stream discharge. These measurements would be used with detailed precipitation data to allow more detailed analysis of watershed response to rainfall and snowfall.

12.1.2 Water Quality

The RAMP Five Year Report (Golder 2003a) discussed both spatial and temporal water quality trends in the lower Athabasca River watershed. The investigation of spatial trends included comparisons among the waterbodies sampled by RAMP, as well as specific "upstream - downstream" comparisons in the Athabasca and Muskeg rivers. Temporal trend analyses were focused on two long-term (i.e., 1976 to 2001) monitoring sites in the Athabasca River located upstream of Fort McMurray and near Old Fort, and two shorter-term (i.e., 1997 to 2001) reaches positioned in the Muskeg River upstream of Muskeg Creek and in the lower section of the Muskeg River between Jackpine Creek and the river mouth. In both cases, selected sites were situated upstream and downstream, respectively, of current oil sands development in their respective watersheds.

To be efficient and avoid repetition, the examination of water quality data within this report will be limited to temporal trend analysis involving waterbodies that were not examined in Golder (2003a), where oil sands development by member companies is actively occurring within their respective watersheds and sufficient data are available to meet the minimum requirements of the relevant statistical test. Waterbodies meeting these three criteria included the following:

- the Steepbank, Firebag and MacKay rivers;
- McLean, Fort, Jackpine and Poplar creeks; and
- Shipyard Lake.

For each waterbody, the Mann-Kendall test for trend in combination with Sen's slope estimation procedure (Gilbert 1987) was used to determine both the magnitude and potential significance of apparent temporal trends. In rivers and creeks, the analysis was completed using fall data collected from the mouth of each waterbody. Fall was selected, because, for many of these streams, sufficient data (i.e., sample size >5) were only available for this season. Similarly, the analysis considered only the mouth of each river or creek, because upstream sites on a given stream are not currently included in RAMP or insufficient data were available from these areas to perform the Mann-Kendall test for trend.

With respect to Shipyard Lake, the analysis was focused on temporal trends in summer, as this was the only season for which more than five samples were available. The parameters considered in this investigation were limited to the following 11 indicators discussed in the RAMP Five Year Report (Golder 2003a):

- dissolved organic carbon (DOC)
- pH
- total alkalinity
- total dissolved solids (TDS)
- total suspended solids (TSS)
- sulphate
- total Kjeldahl nitrogen (TKN)
- total phosphorus
- total aluminum
- total boron
- total chromium

The presence of significant temporal trends with respect to sulphate and boron concentrations in Shipyard Lake suggests that water quality in this wetland may have been affected by human activities within its watershed.

With respect to the other waterbodies included in this study, the absence of significant temporal variations in in-stream water quality suggests that oil sands activities occurring within their respective watersheds are having limited impact on receiving water quality.

12.1.3 Sediment Quality

A spatial analysis of sediment quality in the lower Athabasca River watershed was recently completed as part of the RAMP Five Year Report (Golder 2003a). Temporal trends in the Athabasca River and Muskeg River sediment quality were also discussed therein. Although temporal trend analysis in other waterbodies sampled by RAMP was considered for the 2002 annual RAMP report, sample sizes for these areas did not yet meet the minimum input requirements for the Mann-Kendall test procedure. Sufficient data were also not yet available from these locations to complete "before and after development" type of testing.

The analysis of sediment quality discussed herein was, therefore, confined to an investigation of how sediment composition (i.e., sand, silt and clay content), metal content and/or polycyclic aromatic hydrocarbon (PAH) content correlate to observed sediment toxicity within the lower Athabasca River watershed. As was done in Golder (2003a), Principal Component Analysis (PCA) was used to reduce the number of parameters included in this investigation. Input data were included for available historical information described in Golder (2003a), as well as all of the 2002 sample data available as of January 20, 2003.

Based on the results discussed in Section 7.1, the following conclusions can be drawn from the sediment toxicity - sediment chemistry and composition analysis:

- toxic responses exhibited by *C. tentans*, *H. azteca* and *L. variegatus* have been observed in 21, 23 and 35% of the sediment samples tested to date, respectively;
- the distribution of sediments eliciting toxic responses in one or more of the three test organisms includes both areas downstream of active oil sands development (e.g., Athabasca Delta) and areas without active development within their respective watersheds (e.g., the Ells River, Fort Creek and Isadore's Lake);
- the variability observed in the response of *C. tentans* and *H. azteca* to sample sediments from the lower Athabasca River watershed does not appear to be related to sediment composition, metal content or PAH concentrations; and
- the survival and growth of *L. variegatus* is strongly influenced by sediment composition, with significant negative correlations to sand content.

The significant, positive correlation observed between *L. variegatus* growth and PAH PC2 also suggests that growth rates for *L. variegatus* increase as the concentrations of naphthalene and C1 substituted naphthalene increase. However, this relationship may result from the relative nature of the *L. variegatus* test results, which are expressed as a percentage of the observed performance of *L. variegatus* in control sediments. Given the importance of the sediment used for the control samples, it is recommended that the RAMP Water and Sediment Subgroup of the Technical Subcommittee consider the following:

- submitting several samples of the control sediments used by HydroQual for analysis to determine how their chemical and physical composition compares to sediments collected from the lower Athabasca River watershed; and

- identifying an area within the Athabasca River watershed where reference sediment could be collected to ensure that the control samples used in the toxicity tests are appropriate.

12.1.4 Benthic Invertebrate Community

Benthic invertebrate data collected in 2002 was summarized for the Athabasca River Delta, the MacKay, Muskeg and Steepbank rivers, Fort Creek, and Kearl and Shipyard lakes. Other waterbodies sampled in 2002 are in the baseline phase and available data at this time are insufficient to illustrate baseline variability or time trends.

The sites located in the Fletcher Channel and the Goose Island Channel of the Athabasca River Delta were selected for analysis of benthic invertebrate samples based on the 2001 sediment toxicity results. The Fletcher Channel supported a community of lower total abundance and richness compared to the community in the Goose Island Channel. Community composition at the major group level was also more diverse in the Goose Island Channel. There was no indication of effects related to sediment toxicity. Rather, the greater abundance and richness in the Goose Island Channel may have been a reflection of the presence of macrophytes at that site.

Erosional reaches were sampled in the lower MacKay, Muskeg and Steepbank Rivers, and in the upper MacKay River. Total benthic invertebrate abundance was lowest in the Steepbank River, intermediate in the Muskeg River and highest in the MacKay River. In particular, the upper reach in the MacKay River, which also had the highest benthic algal biomass based on the chlorophyll *a* data, supported the highest numbers of invertebrates. Total abundance varied without an apparent trend over time in all three rivers.

As in previous years of monitoring, the Muskeg River supported the most diverse benthic fauna of these three rivers, with over 80 taxa in the lower erosional reach. Richness was slightly lower in the MacKay and Steepbank rivers. Apparent increasing trends in richness over time in these rivers were artifacts of changes in sampling design over time.

There were some consistent differences among rivers in community composition. The benthic faunas of the MacKay and Steepbank rivers were usually dominated by midges, bristle worms and mayflies, with a generally higher percentage of mayflies in the Steepbank River. Erosional benthic communities in the Muskeg River were more diverse than those in the MacKay and Steepbank rivers.

There were few significant correlations between local habitat variables and erosional benthic community variables, reflecting the similarity in habitat sampled within each river. Declining trends in total abundance were apparent with increasing flow in all thee rivers, suggesting the build-up of algae and lack of scouring in low flow years may allow the development of communities with greater abundances.

Two depositional reaches were also sampled in the Muskeg River, one in the lower reach and one in the upper reach. Compared to the lower erosional reach, total benthic invertebrate abundance was higher in the lower depositional reach in all years of monitoring. The upper depositional reach supported a community with a considerably lower total abundance and richness. Benthic communities were dominated by chironomid midges in depositional reaches in all years. Other common groups included bristle worms, fingernail clams, roundworms and ostracods. There were no significant correlations between habitat variables and benthic community variables.

Fort Creek was sampled at its mouth. Total benthic invertebrate abundance was considerably higher in 2002 than in 2001, but richness was similar in both years. The benthic community was dominated by midges in both years. There were no significant correlations between habitat variables and benthic community variables.

Benthic communities in Kearl and Shipyard lakes were characterized by variable total abundance, with a nearly ten-fold variation among years without apparent trends over time. Richness was slightly higher in Shipyard Lake. There were no trends over time in richness. Samples collected from Kearl Lake were dominated by amphipods and midges. Midge dominance was less pronounced in Shipyard Lake, where amphipods, ostracods, fingernail clams, snails and mayflies were also abundant. Compared to previous years' data, long term trends in community composition were not apparent. There were very few significant correlations between the benthic invertebrate data and habitat data in lakes.

12.1.5 Fish Populations

In general, concentrations of inorganic chemicals (trace metals) and organic compounds (tainting compounds) in fish tissue samples from the Athabasca River, Muskeg River and Gregoire Lake were below levels that would affect fish health, the suitability of the fish for human consumption, or fish flavour. The exception was mercury concentrations in fish tissues from the Athabasca River and Gregoire Lake in relation to established consumption guidelines for the protection of human health. Mercury concentrations in fish tissues from the Muskeg River were difficult to evaluate due to the small sample size collected in

2002 (the highest concentration measured in 2002 was equal to the guideline for subsistence consumers).

For the Athabasca River, fillets from a few lake whitefish (28% of fish sampled) and several walleye (64% of fish sampled) had mercury concentrations higher than the guideline for subsistence consumers, and a few of these walleye (24% of fish sampled) had concentrations that were also higher than the guideline for occasional consumers. Although mercury concentrations in tissue from some fish, particularly walleye, were above consumption guidelines, mercury levels do not appear to be increasing and are representative of naturally high concentrations documented historically from the Athabasca River Oil Sands Area and beyond (i.e., upstream and downstream).

For Gregoire Lake, mercury concentrations in all lake whitefish tissue samples were below the two consumption guidelines, while a few of the walleye (20%) and northern pike (16%) samples were higher than the guideline for subsistence consumers and one northern pike was higher than the guideline for occasional consumers.

For the Athabasca and Muskeg rivers, there were no trends in tissue concentrations for any of the inorganic chemicals that have been measured in more than one year, with the possible exception of strontium in Athabasca River fish, which appears to have declined from higher levels recorded in 1998.

With respect to analysis of fish tissues for organic tainting compounds, development of an appropriate methodology, including an appropriate list of parameters to be examined, is warranted. At present, CONRAD has undertaken a process to address this concern and provide to RAMP a recommended methodology.

Inventory sampling in the Athabasca River determined that walleye, goldeye, white sucker, longnose sucker and northern pike were the most abundant large-bodied species in the Oil Sands Region in the spring of 2002. These results were found to be typical for the region for sampling that does not include the fall period; lake whitefish are typically the most abundant species in the fall. Comparisons of relative abundance (boat electrofishing CPUE) to previous inventory data indicated that, other than northern pike, the main large-bodied species appear to have declined in abundance in recent years (1997 to 2002). For walleye, goldeye and white sucker, CPUE in 2002 was comparable to 1995 estimates and was, therefore, within the known range of abundance for the region. For longnose sucker, the 2002 CPUE was the lowest yet recorded.

Potential trends in Athabasca River fish abundance identified in the RAMP Five Year Report (Golder 2003a) included a possible decline in abundance for walleye and lake whitefish. The 2002 results showed an increase in walleye CPUE in 2002 relative to 2001. The spring inventory data was not able to provide an assessment of lake whitefish abundance in 2002.

The Athabasca River inventory data showed that length frequency distribution, condition factor and pathology index for the main large-bodied species were variable among years, with some differences being statistically significant. However, there were no systematic changes in any of these variables that would indicate a change over time.

The inventory data from the Muskeg River basin indicated that the summer fish community in both the lower Muskeg River and lower Jackpine Creek were dominated by suckers and small-bodied species. A small number of sport fish were present in the watershed (goldeye, northern pike, mountain whitefish and walleye), most of which were juvenile fish. There were some differences in relative abundance for some species compared to previous RAMP data and historical reports. The most significant difference was the lack of Arctic grayling in both watercourses in 2002, suggesting that this species may not have used the Muskeg River watershed for spawning, rearing or feeding activities in 2002.

The results for Athabasca River sentinel species sampling identified some differences for the five trout-perch populations examined; however, the differences were generally not consistent between males and females. In comparing Site 1 (upstream of the Fort McMurray STP) to Site 2 (between the STP and the oil sands area), significant differences were found only for condition factor and relative liver size (LSI) in male fish, indicating that this sex may be responding to increased productivity below the STP. Site 2 was used as the reference site for the three oil sands exposure sites, because all four of these sites are below the STP discharge. Compared to the reference site, adult trout-perch at some of the oil sands sites had significantly lower age, weight, condition factor, LSI and fecundity, and significantly higher relative gonad size (GSI). However, in most cases, these differences did not occur at all three exposure sites and were not consistent for both sexes at the sites where they did occur. The only consistent differences were lower condition factor and LSI for males and females at Site 4, providing some evidence of reduced levels of energy storage at this site, a result consistent with 1999 data.

The responses of adult trout-perch at the oil sands sites relative to the reference site were inconsistent between the 1999 and 2002 sentinel species studies (with the exception of lower condition factor and LSI at Site 4). The differences in response observed in trout-perch populations between 1999 and 2002 may illustrate the natural annual variability that can occur for this species. Because of the inconsistent responses observed in 1999 and 2002, it is possible that the populations at the different sampling sites are not isolated. This suggests there may be a need to evaluate the mobility of trout-perch in the Oil Sands Region relative to the assumption that trout-perch do not move among sites.

In the examination of the lower 1.5 km of the Muskeg River, five sites were found that had depth and velocity profiles suitable for fish fence deployment. However, all sites have a soft, mobile substrate, poor access and poor working/staging areas. This was observed to be the general condition for the entire length of river examined. Of the candidate sites, Site 3 was recommended based on its velocity profile and proximity to the historical AOSERP fence site.

Spring and fall fyke net monitoring and inventory sampling in upper tributaries of the Muskeg River (Muskeg and Wapasu creeks) indicated that the fish communities in these watercourses were dominated by small-bodied species, along with small numbers of young-of-the-year or juvenile suckers. One adult northern pike was also captured in Muskeg Creek. Small upstream (spring) and downstream (fall) fish movements were recorded in both of these watercourses, suggesting that either the fyke net monitoring periods did not coincide with the main migrations, or that migrations within these watercourses are small scale. Groups of dead forage fish observed in Wapasu Creek after ice-out indicated that some fish attempted to overwinter in this watercourse and that conditions were not suitable.

12.1.6 Acid Sensitive Lakes

The RAMP long-term acidification monitoring network was established in 1999. The objective of the network is to monitor the water chemistry of acid sensitive lakes in northeastern Alberta and identify any changes caused by acidic deposition. Lake water chemistry is evaluated annually, with special attention to indicators of acidification.

The objective of the network in 2002 was to continue collecting water chemistry data from lakes sampled in the past, and to enhance the network by adding new lakes near the area of heaviest oil sands development. As a result, 49 lakes were monitored in 2002, including 32 lakes monitored prior to 2002 and 17 new lakes.

The most recent estimates of acid deposition rates and critical loads were summarized for the lakes in the network to provide an indication of which lakes are at the greatest potential risk of acidification. The modelled baseline and CEA PAI values for lakes in the monitoring network exceeded corresponding critical loads in five lakes in the Stony Mountain sub-region (A21, A24, A26, A29 and A86), three lakes in the Birch Mountain sub-region (L23, L25 and L29/L30 [Clayton lakes]), and one lake West of Fort McMurray (A47). These nine lakes also had alkalinity values generally below 10 mg/L over the monitoring period. Modelled PAI values greater than critical loads coupled with low alkalinities suggest that these lakes have the potential to be sensitive to acidification at predicted deposition rates (both baseline and CEA) for the Oil Sands Region. Conversely, L4, L7, L28, L39, L49 and A59 had alkalinity values below 10 mg/L in 2002, but their critical loads were greater than the predicted PAI rates. Therefore, these lakes are most likely not sensitive to acidification at the predicted deposition rates. Several other lakes with alkalinity values <10 mg/L in 2002 included lakes 185, 199, 209, 287, 289, 290 and E59; however, PAI values were not available for these lakes.

Acidity-related variables (pH, alkalinity) generally showed no indication of changes signaling acidification in 2002 compared to data from previous years. Visual comparison of data collected from 1999 to 2002 identified lakes L7, L8, L46 and L47 in the Oil Sands Region, and E68 in the Caribou Mountains as showing slight tendencies for declining alkalinity. However, seven other lakes (E15, A42, L18, L23, E52, O1 and O2) showed increasing alkalinity and there were no consistent changes in the remaining lakes with more than two years of data.

Concentrations of most dissolved ions were low to moderate in 2002. Ion balance calculations revealed anion deficits in all lakes, which appeared related to the presence of organic anions. TSS values were generally below 25.0 mg/L. As in 2001, higher TSS levels were associated with the shallower lakes. Nutrients and chlorophyll *a* concentrations varied widely among lakes. Based on the 2002 chlorophyll *a* data, 7 lakes were oligotrophic, 19 lakes were mesotrophic, 19 lakes were eutrophic and 4 lakes were hyper-eutrophic.

Concentrations of sulphate in lakes of the monitoring network were generally below 4 mg/L over the four years of monitoring (including historical data). Exceptions included a cluster of lakes in the Birch Mountains (L18, L46, L47, L49, L60 and 175) and Lake 223 that had sulphate concentrations consistently >6 mg/L.

Nitrite + nitrate concentrations were generally below 0.1 mg/L for the lakes in the monitoring network. Exceptions included three lakes in the Birch Mountains (L46, L47 and L49), two lakes West of Fort McMurray (A42 and A47) and Lake E68 in the Caribou Mountains. Year-to-year variation was high for nitrite + nitrate, with several lakes (L4, L8, 271, A26, A47, L46, L47 and L60) experiencing elevated concentrations in 2002 compared to past values.

Several indices were used to determine if water chemistry was changing due to acidification. As in the past, the ratio of bicarbonate to divalent cations for all lakes in 2002 was <1, most likely due to the presence of organic anions. Of the lakes with four years of RAMP data, no lake showed a decline in this ratio with each consecutive year. Another index of change is the ratio of sulphate to the sum of base cations. Since the ratio was less than one for all 49 lakes, acidification due to sulphate was not indicated.

Colour and DOC spanned wide ranges and the relationship between these two parameters resulted in the identification of two different groups of lakes within the monitoring network. One group consisted of 13 lakes, 10 of which were new; the remaining 36 lakes belonged to the other group. The group of 13 lakes had relatively high DOC concentrations over a narrow range of colour, and upon more careful inspection of water chemistry and critical loads of these lakes, it was determined that the group consisted of a collection of productive lakes that had low acid sensitivity compared to the other group. These groupings highlight the relaxation in 2002 of the original project objective of monitoring only lakes with moderate to high sensitivity to acid deposition. Re-evaluation of the relevance to the monitoring program may be warranted for new lakes 175, 223, 225, 227, 267, 270, 271 and 354, which have relatively high alkalinities and critical loads,. Water chemistry data collected from these lakes may not help to identify changes caused by acid deposition in the Oil Sands Region.

The data collected during the fourth year of acid sensitive lake monitoring indicated that relative to past data, changes related to acidification have not occurred. However, modelled PAI values in excess of critical loads and low alkalinities for some lakes indicated that there is the potential for sensitivity to acid deposition at the predicted deposition rates. Potential future changes to the program include re-evaluation of new lakes added to the monitoring network and directing research towards issues related to seasonal changes in lake chemistry in relation to time of sampling.

12.1.7 Aquatic Vegetation

Kearl Lake did not appear to undergo any changes to the lake boundary or the size of wetlands polygons surrounding the lake. Any differences to the lake boundary or wetlands polygons are attributable to the difference in quality of the 1997 photograph compared to the 2001 photograph and to the different individuals who interpreted the polygons boundaries.

Shipyard Lake appears to have increased in size from a visual examination of the 1997 and 2002 photographs with the greatest amount of change occurring on the western and northern shores. Additionally, there has been recession and in-filling of the channel that flows from the open shrubby swamp (SONS) wetland into the open, non-patterned graminoid marsh (MONG) wetland in the centre of the photograph.

The northern channel of Isadore's Lake appears to have receded from 1997 to 2001. Additionally, there appears to have been a reduction in the shallow open water (WONN) polygon to the north of the lake. This decrease has resulted in an increase to the area of the adjacent open, non-patterned graminoid fen (FONG) wetlands type. With the use of false colour infra-red photograph, vegetation within the lake is now visible for future analysis.

The northern shore of McClelland Lake is composed of a combination of wetlands and uplands ecosite phases while the southern shore is primarily uplands. The eastern and western shores of the lake are made up of a series of wetlands types, primarily MONG, SONS, open treed swamp (STNN) and open, non-patterned shrubby fens (FONS).

12.2 CONCLUSIONS

The 2002 RAMP program is the sixth year of monitoring and the first year after the completion of the Five Year Report (1997 to 2001). Therefore, 2002 is the beginning of a new five-year period. It also provides an opportunity to use one more year of data to check on the trends that seemed to be emerging in the first five years. The results of the 2002 Annual Program have identified some new findings that may require further investigation (e.g., water quality in Shipyard Lake) and further support and clarification of previous findings (e.g., potential toxicity of Athabasca Delta sediments, effect of low flows in the Muskeg River, mercury in fish tissues from the Athabasca and Muskeg rivers). Each of these issues is discussed below.

Increasing sulphate and boron in Shipyard Lake. Based on summer water quality data, sulphate and boron concentrations in Shipyard Lake appear to be increasing exponentially. Concentrations appear to be doubling every 2.6 years. The rate at which these changes are occurring suggests that the changes in water quality in this wetland may go beyond natural variation. The monitoring program was able to identify an effect, but the potential causes of this effect require further investigation.

Although the benthic invertebrate community in Shipyard Lake has been highly variable, no temporal trends in abundance or richness of the benthic community have been apparent. Species richness was slightly higher in Shipyard Lake than Kearl Lake. It has a diverse and abundant fauna of midges, amphipods, ostracods, fingernail clams, snails and mayflies. There has been no indication that the current increase in sulphate and boron are affecting the benthic invertebrate community.

Shipyard Lake appears to have increased in size, based on a visual examination of the 1997 and 2002 photographs of this wetland as part of the aquatic vegetation monitoring. The greatest amount of change appears to be occurring on the western and northern shores. However, in 2002, this watershed received very little snowfall resulting in very low spring runoff. Rainfall has been average.

It is recommended that Suncor consider further study of Shipyard Lake to identify the probable source of the sulphate and boron, and establish if natural occurrences (e.g., changes in inflow from the Athabasca River, basal aquifer water) or human activity within the Shipyard Lake watershed are responsible for the observed change.

Potential toxicity of Athabasca Delta sediments. In 2001, reduced growth and survival of *Lumbriculus variegatus* was observed in Athabasca Delta sediment collected from Fletcher Channel. Survival and growth of *L. variegatus* can be significantly affected by the physical characteristics of sediment, as opposed to chemical content. The benthic invertebrate communities in Fletcher Channel and Goose Island Channel of the Athabasca Delta were selected in 2002 to provide further information related to sediment toxicity. The Fletcher Channel supported a community of lower total abundance and richness of the two. However, the greater abundance and richness in the Goose Island Channel may have been a reflection of the presence of macrophytes at that site, but not the other site.

The results of the analysis comparing sediment toxicity to sediment chemistry and composition showed that the survival and growth of *L. variegatus* is strongly influenced by sediment composition; it is negatively correlated to sand content. The significant positive correlation observed between *L. variegatus* growth and the second principal component from the PAH principal components analysis suggested that growth rates for *L. variegatus* increase as the concentrations of naphthalene and Cl-substituted naphthalene increase. This unexpected finding may be related to other characteristics of the sediment samples. This information has to be used in context; sediment toxicity data represent only one line of evidence.

The lowest total flow ever recorded for the Athabasca River occurred in 2002, based on preliminary streamflow data from Environment Canada. Under these extreme low flow conditions, the water quality component did not find significant temporal variations in in-stream water quality in the Athabasca River. This suggests that oil sands activities are having limited, or no impact on receiving water quality in the Athabasca River Delta, even under extreme low flows.

Looking at results from the different components, the 2002 RAMP monitoring program continues to show the potential for a slight effect limited to the sediments. However, the results may simply reflect variations in the general condition. It is recommended that the properties of the sediments used as controls in the laboratory also be investigated, as the effect of the delta sediments are reported relative to the effect of the control sediments.

Effects of low to average tributary flows. Visual examination of the relationship between river discharge and benthic community variables in the MacKay, Muskeg and Steepbank rivers suggested that flow may influence total abundance but not richness. Declining trends in total abundance were apparent with increasing flow in all three rivers, suggesting the build-up of algae and lack of scouring in low flow years may allow the development of communities with greater abundance. Very little snow fall was recorded at the Aurora Climate Station in 2002 resulting in a very low spring runoff. Rainfall during the rest of 2002 was average and similar to 2001. Recent years have not had the high flows to scour the river substrates. The fish species composition for the Muskeg River in 2002 was also similar to that observed in 2001. Both show a greater species diversity than in 1997. However, 1997 was the only year that Arctic grayling were captured in the Muskeg River. Arctic grayling were not recorded in the Muskeg River watershed during any of the sampling activities conducted for RAMP in 2002. This species was not captured in the RAMP inventory in 2001 either, but it was reported by an angler. It has been suggested in earlier reports that the increase in beaver activity in this area (due to their effect on spawning habitat and access to spawning areas) may be the cause, at least in part, of the absence of Arctic grayling. Taken together, these findings suggest that significant effects identified in the biological components of the Muskeg River are likely related to hydrologic conditions that continued in 2002.

Flow conditions have influenced water quality in the Athabasca and Muskeg rivers as demonstrated in the RAMP Five Year Report (Golder 2003a). Temporal trends for parameters such as total suspended solids, total alkalinity, sulphate and total dissolved solids were significantly affected by flow conditions in the Athabasca River, and trends in total phosphorus and dissolved organic carbon were affected in the Muskeg River.

Mercury in fish tissues in the Oil Sands Region. Since mercury concentrations in fish from the Athabasca River exceeded consumption guidelines previously, a more thorough investigation was completed in 2002. Mercury analysis of individual tissue samples from 25 walleye and 25 lake whitefish were analyzed in 2002, which allowed comparisons of mercury content versus age or length to be made. Previously, fish tissues had been combined into composite samples before analysis.

Health Canada recommends two fish consumption guidelines: 0.5 mg/kg for occasional consumption and 0.2 mg/kg for subsistence consumption. Most of the walleye and seven of the lake whitefish from the Athabasca River had concentrations that exceeded the subsistence guideline. Tissue from six walleye also exceeded the occasional consumption guideline. This study investigated whether mercury concentrations that exceeded guidelines were associated with a specific size range of fish. Generally, no relationships between concentrations and age or fork length were found. Although there was an increasing trend of mercury concentration and age for male walleye, there was considerable variability in the results for larger and older walleye. Based on published toxicological data, it is unlikely that the mercury concentrations would affect fish health. The results of the more detailed study in 2002, which analyzed individual tissue samples, confirmed that the results from previous studies, which used composite samples, were valid.

Mercury concentrations in northern pike tissue from the Muskeg River were lower than walleye results with mercury concentration from only one fish equal to the subsistence guideline. Trends with increasing fork length and age were apparent, but they may be an artifact of the size distribution in the sample.

Generally, the more detailed study in 2002 produced data similar to 2001. The average concentrations of mercury in walleye fillets in 2002 were similar to 2001 results, although they were slightly higher than 2001 concentrations for males. Average concentrations in northern pike were also slightly higher in 2002 when compared to results for 2001. The data appear to be consistent with regional and historical data.

13 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

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15 GLOSSARY AND LIST OF ACRONYMS

15.1 GLOSSARY

Acute	Acute refers to a stimulus severe enough to rapidly induce an effect; in aquatic toxicity tests, an effect observed in 96 hours or less is typically considered acute. When referring to aquatic toxicology or human health, an acute effect is not always measured in terms of lethality.
Ageing Structures	Parts of the fish which are taken for ageing analyzes. These structures contain bands for each year of growth or maturity which can be counted. Some examples of these structures are scales, fin rays, otoliths and opercula. Most ageing structures can be taken with minimal effect on the fish and vary according to fish species
ANOVA	Analysis of Variance. A statistical test of whether 2 or more sample means could have been obtained from populations with the same parametric (true, absolute) mean.
Baseline	A surveyed condition which serves as a reference point to which later surveys are compared.
Benthic Invertebrates	Invertebrate organisms living on the bottom of lakes, ponds and streams. Examples of benthic invertebrates include the aquatic insects such as caddisfly larvae, which spend at least part of their life on or in bottom sediments. Many benthic invertebrates are major food sources for fish.
Biological Indicator (Bioindicator)	Any biological parameter used to indicate the response of individuals, populations or ecosystems to environmental stress. For example, growth is a biological indicator.
Biomonitoring	The use of living organisms as indicators of the quality and integrity of aquatic or terrestrial systems in which they reside.
Catch-Per-Unit-Effort (CPUE)	A measure which relates to the catch of fish, with a particular type of gear, per unit of time (number of fish/hour). Results can be given for a particular species or the entire catch. The results can reflect both the density and/or the vulnerability of the gear utilized, of a species in a particular system.

Chronic	Defines a stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span or more. Chronic should be considered a relative term depending on the life span of the organism. The measurement of a chronic effect can be reduced growth, reduce reproduction, etc., in addition to lethality.
Community	Plant or animal species living in close association in a defined location (e.g., fish community of a lake).
Concentration	Quantifiable amount of a chemical in environmental medium, expressed as mass of a substance per unit volume (e.g., mg/L), or per unit sample mass (e.g., mg/g).
Condition Factor	A measure of the relative "fitness" of an individual or population of fishes by examining the mathematical relationship between length and weight. The values calculated show the relationship between growth in length relative to growth in weight. In populations where increases in length are matched by increases in weight, the growth is said to be isometric. Allometric growth, the most common situation in wild populations, occurs when increases in either length or weight are disproportionate.
Conductivity	A measure of a water's capacity to conduct an electrical current. It is the reciprocal of resistance. This measurement provides an estimate of the total concentration of dissolved ions in the water.
Detection Limit (DL)	The lowest concentration at which individual measurement results for a specific analyte are statistically different from a blank (that may be zero) with a specified confidence level for a given method and representative matrix.
Discharge	In a stream or river, the volume of water that flows past a given point in a unit of time (i.e., m^3/s).
Diversity	The variety, distribution and abundance of different plant and animal communities and species within an area.
Ecological Indicator	Any ecological parameter used to indicate the response of individuals, populations or ecosystems to environmental stress.

Environmental Impact Assessment (EIA)	A review of the effects that a proposed development will have on the local and regional environment.
Fauna	A term referring to an association of animals living in a particular place or at a particular time.
Fecundity Index	The most common measure of reproductive potential in fishes. It is the number of eggs in the ovary of a female fish. It is most commonly measured in gravid fish. Fecundity increases with the size of the female.
Gonad Somatic Index (GSI)	The proportion of reproductive tissue in the body of a fish. It is calculated by dividing the total gonad weight by the carcass weight and multiplying the result by 100. It is used as an index of the proportion of growth allocated to reproductive tissues in relation to somatic growth.
GPS	Global Positioning System. This system is based on a constellation of satellites which orbit the earth every 24 hours. GPS provides exact position in standard geographic grid (e.g., UTM).
Lethal	Causing death by direct action.
Liver Somatic Index (LSI)	Ratio of liver versus total body weight. Expressed as a percentage of carcass weight.
m^3/s	Cubic metres per second. The standard measure of water flow in rivers; i.e., the volume of water in cubic metres that passes a given point in one second.
Microtox®	A toxicity test that includes an assay of light production by a strain of luminescent bacteria (*Photobacterium phosphoreum*).
Oil Sands	A sand deposit containing a heavy hydrocarbon (bitumen) in the intergranular pore space of sands and fine grained particles. Typical oil sands comprise approximately 10 wt% bitumen, 85% coarse sand (>44 µm) and a fines (<44 µm) fraction, consisting of silts and clays.

Organics	Chemical compounds, naturally occurring or otherwise, which contain carbon, with the exception of carbon dioxide (CO_2) and carbonates (e.g., $CaCo_3$).
Pathological Index (PI)	A quantitative summary of pathology where variables examined are assigned numerical values (either 0, 10, 20 or 30) to indicate normal or abnormal condition. In this system, variables that exhibit an increasing degree of pathology are assigned higher values. The PI is calculated by summing the index values for each variable. The PI value increases as the number and severity of abnormalities increases. Based on the Health Assessment Index (HAI) developed by Adams *et al.* (1993).
Pathology	The science which deals with the cause and nature of disease or diseased tissues.
PAH	Polycyclic Aromatic Hydrocarbon. A chemical by-product of petroleum-related industry and combustion of organic materials. PAHs are composed of at least two fused benzene rings. Toxicity increases with molecular size and degree of alkylation.
PEL	Probable Effect Level. Concentration of a chemical in sediment above which adverse effects on an aquatic organism are likely.
QA/QC	Quality Assurance and Quality Control refers to a set of practices that ensure the quality of a product or a result. For example, “Good Laboratory Practice” is part of QA/QC in analytical laboratories and involves proper instrument calibration, meticulous glassware cleaning and an accurate sample information system.
Reach	A comparatively short length of river, stream channel or shore. The length of the reach is defined by the purpose of the study.
Receptor	The person or organism subjected to exposure to chemicals or physical agents.
Relative Abundance	The proportional representation of a species in a sample or a community.
Riffle Habitat	Shallow rapids where the water flows swiftly over completely or partially submerged materials to produce surface agitation.

Run Habitat	Areas of swiftly flowing water, without surface waves, that approximates uniform flow and in which the slope of water surface is roughly parallel to the overall gradient of the stream reach.
Sediments	Solid fragments of inorganic or organic material that fall out of suspension in water, wastewater, or other liquid.
Shannon-Weiner Diversity Index	A calculation used to estimate species diversity using both species richness and relative abundance. A basic count of the number of species present in a community represents species richness. The number of individuals of each species occurring in a community is the species relative abundance.
Spawning Habitat	A particular type of area where a fish species chooses to reproduce. Preferred habitat (substrate, water flow, temperature) varies from species to species.
Species	A group of organisms that actually or potentially interbreed and are reproductively isolated from all other such groups; a taxonomic grouping of genetically and morphologically similar individuals; the category below genus.
Sport/Game Fish	Large fish that are caught for food or sport (e.g., northern pike, trout).
Stressor	An agent, a condition, or another stimulus that causes stress to an organism.
Transect	A line drawn perpendicular to the flow in a channel along which measurements are taken.
Toxic	A substance, dose, or concentration that is harmful to a living organism.
Toxicity	The inherent potential or capacity of a material to cause adverse effects in a living organism.

Wetlands	Term for a broad group of wet habitats. Wetlands are transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands include features that are permanently wet, or intermittently water-covered such as swamps, marshes, bogs, muskeg, potholes, swales, glades, slashes and overflow land of river valleys.

15.2 ACRONYMS

AENV	Alberta Environment
AEP	Alberta Environmental Protection
AES	Atmospheric Environment Services
Albian	Albian Sands Energy Inc.
Al-Pac	Alberta–Pacific Forest Industries Inc.
ANC	Acid Neutralizing Capacity
ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
ARC-Vegreville	Alberta Research Council located in Vegreville
ASRD	Alberta Sustainable Resource Development
AXYS	AXYS Analytical Services Ltd.
benthos	Benthic invertebrate
BOD	Bological Oxygen Demand
CAEAL	Canadian Association for Environmental Analytical Laboratories
CCME	Canadian Council of Ministers of the Environment
CEA	Cumulative effects assessment
CEMA	Cumulative Environmental Management Association
CIR	False-colour infrared
CL	Critical load
CNRL	Canadian Natural Resources Limited
CPUE	Catch-per-unit-effort
Devon	Devon Canada Corporation
DFO	Fisheries and Oceans Canada
DIC	Dissolved inorganic carbon

DL	Detection limit
DO	Dissolved oxygen
DOC	Dissolved organic carbon
D/S	Downstream
EEM	Environmental effects monitoring
EIA	Environmental Impact Assessment
EPEA	*Environment Protection & Enhancement Act*
EPI	External pathological index
ETL	Enviro-Test Laboratories
Exxon	ExxonMobil Canada Ltd.
GPS	Global Positioning System
GSI	Gonad Somatic Index
HAI	Health Assessment Index
Hydroqual	Hydroqual Laboratories
IBI	Index of Biotic Integrity
ISQG	Interim Freshwater Sediment Quality Guidelines
JACOS	Japan Canada Oil Sands Limited
KIR	Key Indicator Resource
KP	Kilometre Posts
LCS	Laboratory Control Sample
LSI	Liver Somatic Index
MDL	Method Detection Limit
MS-222	Tricaine methane sulfonate
MSE	Mean squared error
Nexen	Nexen Canada Ltd.
NIWA	Norwegian Institute for Water Research
NSMWG	NO_x and SO_x Management Working Group
NWRI	National Water Research Institute
OPTI	OPTI Canada Inc.
PAH	Polycyclic aromatic hydrocarbon
PAI	Potential Acid Input

PC	Principal Component
PCA	Principal Component Analysis
Petro-Canada	Petro-Canada Oil and Gas
PI	Pathology index
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAP	Quality Assurance Plan
QC	Quality Control
RAMP	Regional Aquatics Monitoring Program
RBC	Risk-based concentration
Shell	Shell Canada Limited
SPSS	Statistical software Systat
STP	Sewage treatment plant
Suncor	Suncor Energy Inc., Oil Sands Group
SWE	Snow water equivalent
SWI	Specific Work Instructions
Syncrude	Syncrude Canada Ltd.
TCU	Total colour units
TDN	Total dissolved nitrogen
TDP	Total dissolved phosphorus
TDS	Total dissolved solids
TKN	Total Kjeldahl nitrogen
TOC	Total organic carbon
TN	Total nitrogen
TP	Total phosphorus
TRH	Total recoverable hydrogen
TrueNorth	TrueNorth Energy L.P.
TSS	Total suspended solids
TVH	Total volatile hydrocarbon
U/S	Upstream
U.S. EPA	United States Environmental Protection Agency

UTM	Universal Transverse Mercator
WAI	Weighted Average Index
WBEA	Wood Buffalo Environmental Association
WWG	Water Working Group (CEMA)
Yr	Year

APPENDIX I

2002 DAILY CLIMATIC DATA
AT AURORA CLIMATE STATION AND
OTHER RAMP CLIMATE STATIONS

Table I.1 Climatic Data Recorded at Aurora Climate Station, January – December, 2002

Year	Month	Day	Temperature Minimum (°C)	Temperature Mean (°C)	Temperature Maximum (°C)	Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation ($kW·h/m^2$)	Wind Speed and Direction: Mean Daily Wind Speed (km/h)	Mean Daily Wind Direction (degrees)	Maximum Sustained Gusts 5 Second (km/h)	Maximum Sustained Gusts 2 Minute (km/h)	Maximum Sustained Gusts 10 Minute (km/h)
2002	January	1	-25.1	-20.8	-16.5	0.0	0.0	84.9	0.4	2.8	198.3	13.1	8.0	5.6
2002	January	2	-20.4	-19.5	-17.6	0.0	0.0	86.1	0.2	3.1	154.7	16.2	12.4	8.0
2002	January	3	-18.6	-10.5	-6.3	0.0	0.8	92.3	0.4	4.4	180.7	17.3	9.8	7.1
2002	January	4	-12.1	-10.6	-7.6	0.0	1.0	91.0	0.1	2.9	90.1	15.3	10.0	8.2
2002	January	5	-13.0	-11.7	-9.4	0.0	0.0	93.5	0.1	3.8	162.3	18.4	10.4	7.4
2002	January	6	-13.6	-7.0	-0.5	0.0	1.0	94.2	0.2	3.9	216.9	18.6	9.1	7.8
2002	January	7	-4.9	-1.2	3.3	0.0	1.5	95.1	0.7	4.1	194.7	18.8	8.2	7.0
2002	January	8	-5.7	0.9	5.0	0.0	1.3	87.5	0.4	3.8	246.8	23.8	11.6	9.4
2002	January	9	-13.3	-6.5	-0.6	0.0	0.0	90.7	0.7	3.2	199.0	12.7	6.5	5.0
2002	January	10	-10.7	-2.8	2.8	0.0	0.0	84.7	0.5	4.0	203.6	18.1	9.2	6.8
2002	January	11	-9.5	-2.6	2.0	0.0	1.8	70.1	0.7	4.1	232.3	22.9	13.6	11.6
2002	January	12	-13.0	-6.6	-1.2	0.0	0.5	91.7	0.2	3.1	228.0	12.9	8.4	6.9
2002	January	13	-9.2	-4.7	-0.8	0.0	1.0	87.2	0.3	7.2	217.0	31.7	21.8	16.2
2002	January	14	-13.4	-10.8	-8.3	0.0	0.0	89.4	0.5	4.4	155.5	19.7	12.8	10.0
2002	January	15	-17.2	-11.3	-8.9	0.0	0.0	90.6	0.4	1.5	190.2	10.3	7.5	5.5
2002	January	16	-24.5	-16.7	-13.5	0.0	0.0	88.9	0.3	4.1	75.0	17.7	11.1	8.7
2002	January	17	-28.3	-24.0	-19.4	0.0	0.0	81.6	0.6	2.8	169.4	12.3	7.5	6.1
2002	January	18	-23.8	-17.0	-11.2	0.0	0.0	87.6	0.2	5.9	96.3	24.2	15.1	11.4
2002	January	19	-31.9	-26.8	-21.8	0.0	0.0	77.6	0.5	2.0	128.5	13.2	7.7	5.7
2002	January	20	-33.0	-29.3	-25.4	0.0	0.0	74.2	0.5	4.6	45.6	18.0	11.0	8.5
2002	January	21	-33.0	-30.6	-28.3	0.0	0.0	71.3	0.5	3.5	43.8	14.3	8.7	6.8
2002	January	22	-39.8	-34.8	-29.5	0.0	0.0	66.9	0.6	1.8	110.9	10.4	8.8	5.9
2002	January	23	-39.5	-32.7	-23.8	0.0	0.0	69.3	0.6	2.9	185.3	13.4	7.8	6.2
2002	January	24	-39.8	-33.7	-27.5	0.0	0.0	69.1	0.6	2.9	107.4	19.8	12.0	10.1
2002	January	25	-39.9	-34.5	-26.7	0.0	0.0	67.1	0.7	2.8	161.3	21.9	12.9	10.4
2002	January	26	-39.1	-32.3	-24.3	0.0	0.0	70.1	0.5	2.7	155.2	14.8	11.2	7.5
2002	January	27	-39.9	-36.3	-27.1	0.0	0.0	63.8	0.6	3.2	180.5	12.0	7.1	6.6
2002	January	28	-39.9	-32.6	-21.4	0.0	0.0	68.2	0.7	3.0	189.2	15.7	10.1	7.2
2002	January	29	-39.9	-35.0	-26.1	0.0	0.0	67.3	0.7	1.7	151.3	14.0	8.6	5.7
2002	January	30	-39.8	-33.3	-20.4	0.0	0.0	66.7	0.9	2.1	222.4	9.6	7.6	6.8
2002	January	31	-35.3	-23.0	-13.2	0.0	0.5	77.5	0.4	2.4	235.1	14.3	8.9	5.9

Year	Month	Day	Temperature Minimum (°C)	Temperature Mean (°C)	Temperature Maximum (°C)	Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation ($kW·h/m^2$)	Wind Speed and Direction: Mean Daily Wind Speed (km/h)	Mean Daily Wind Direction (degrees)	Maximum Sustained Gusts 5 Second (km/h)	Maximum Sustained Gusts 2 Minute (km/h)	Maximum Sustained Gusts 10 Minute (km/h)
2002	February	1	-16.4	-12.0	-8.3	0.0	1.8	83.8	0.8	2.7	179.7	14.3	8.2	6.4
2002	February	2	-14.9	-9.9	-5.3	0.0	0.5	88.0	0.9	4.9	186.9	21.6	11.5	9.8
2002	February	3	-14.5	-6.8	-1.3	0.0	0.5	82.2	0.9	6.3	187.8	36.3	20.4	17.7
2002	February	4	-28.6	-18.6	-13.4	0.0	0.0	72.3	1.3	4.2	138.4	27.7	16.9	13.2
2002	February	5	-23.0	-16.7	-12.8	0.0	0.0	86.6	0.6	3.4	98.4	17.0	11.3	8.2
2002	February	6	-22.1	-16.6	-12.1	0.0	3.8	85.2	0.4	3.9	102.8	17.3	10.8	9.6
2002	February	7	-23.6	-18.0	-13.2	0.0	0.0	87.4	0.4	3.2	88.3	13.5	7.5	6.4
2002	February	8	-20.6	-15.5	-12.0	0.0	0.3	89.4	0.5	2.8	174.9	12.4	7.4	5.9
2002	February	9	-24.5	-18.6	-16.0	0.0	0.0	86.8	0.4	2.7	62.6	13.6	8.5	6.0
2002	February	10	-16.9	-11.0	-3.3	0.0	1.3	91.9	0.4	1.9	234.2	16.7	8.7	6.3
2002	February	11	-20.4	-11.6	-7.2	0.0	0.3	89.8	0.9	4.0	58.7	20.0	12.9	10.7
2002	February	12	-19.6	-8.8	0.6	0.0	0.3	88.9	0.5	3.6	201.4	18.6	9.6	7.0
2002	February	13	-4.6	0.5	5.4	0.0	1.3	73.3	1.3	4.5	198.4	20.4	12.7	11.5
2002	February	14	-10.5	-2.3	7.2	0.0	0.3	70.0	1.8	4.6	202.5	27.8	15.9	10.8
2002	February	15	-9.2	0.0	7.2	0.0	0.0	66.9	1.8	5.0	267.4	29.1	18.4	15.6
2002	February	16	-11.8	-3.9	6.2	0.0	0.0	76.3	1.7	4.7	184.7	18.1	11.2	7.7
2002	February	17	-15.4	-3.5	3.0	0.0	0.0	67.6	1.8	8.5	218.6	48.1	29.5	22.3
2002	February	18	-26.7	-16.5	-7.1	0.0	0.0	71.5	1.8	2.2	183.9	15.6	9.3	8.1
2002	February	19	-16.6	-5.0	2.5	0.0	0.0	73.3	2.0	6.5	189.1	28.4	15.7	13.8
2002	February	20	-2.2	0.3	4.8	0.0	0.0	69.4	1.1	6.3	230.2	34.3	21.0	17.2
2002	February	21	-11.2	-3.2	3.3	0.0	0.0	57.8	2.4	3.7	242.1	25.4	12.9	10.7
2002	February	22	-17.9	-13.3	-6.6	0.0	0.0	76.5	0.9	5.4	44.5	30.5	17.8	15.3
2002	February	23	-27.6	-19.3	-15.8	0.0	0.0	71.5	1.5	4.7	131.1	20.3	13.8	10.2
2002	February	24	-28.8	-23.4	-17.8	0.0	0.0	73.7	1.3	2.9	151.4	16.7	10.9	7.8
2002	February	25	-29.7	-18.4	-9.0	0.0	0.0	66.5	2.5	5.1	198.7	24.6	13.1	10.2
2002	February	26	-18.6	-10.9	-3.1	0.0	0.0	58.9	1.8	5.5	133.9	21.4	12.7	10.6
2002	February	27	-28.1	-20.1	-14.6	0.0	0.0	65.8	2.6	6.8	43.1	24.7	14.0	11.7
2002	February	28	-37.3	-26.9	-15.9	0.0	0.0	56.9	2.9	2.5	86.5	17.7	9.7	7.4

Table I.1 Climatic Data Recorded at Aurora Climate Station, January – December, 2002 (continued)

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m^2)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	March	1	-37.4	-25.7	-11.0	0.0	0.0	52.6	2.9	3.1	173.4	15.5	8.4	6.7
2002	March	2	-34.3	-18.6	-5.3	0.0	0.0	49.5	2.9	4.8	183.7	20.7	12.5	9.0
2002	March	3	-11.2	-6.3	-2.0	0.0	0.0	73.4	0.9	7.1	105.5	36.3	17.6	12.4
2002	March	4	-23.2	-15.0	-11.2	0.0	0.0	67.0	2.4	7.5	84.9	35.0	20.6	14.7
2002	March	5	-31.9	-23.4	-16.1	0.0	0.0	62.0	2.9	4.7	270.0	24.5	14.3	12.2
2002	March	6	-33.3	-24.9	-15.7	0.0	0.0	62.4	3.0	2.9	220.0	16.9	11.7	8.7
2002	March	7	-35.1	-23.6	-10.0	0.0	0.0	59.4	3.2	2.8	200.6	12.2	9.8	7.0
2002	March	8	-33.5	-22.2	-11.1	0.0	0.0	64.8	3.1	2.9	203.1	15.4	9.6	7.6
2002	March	9	-30.1	-20.9	-9.7	0.0	0.0	66.2	3.3	3.1	165.5	15.4	11.4	7.5
2002	March	10	-31.4	-24.6	-17.6	0.0	0.0	72.5	2.0	4.7	78.2	24.1	14.0	11.7
2002	March	11	-36.1	-21.4	-7.7	0.0	0.0	64.3	2.9	3.9	158.4	21.5	15.2	11.3
2002	March	12	-24.5	-14.7	-10.4	0.0	0.0	75.1	2.9	5.5	42.8	23.5	15.8	11.6
2002	March	13	-27.1	-20.6	-13.0	0.0	0.0	60.7	3.1	3.2	64.8	15.6	10.5	8.5
2002	March	14	-30.3	-19.3	-7.6	0.0	0.0	62.1	2.9	3.4	92.4	18.4	11.8	10.0
2002	March	15	-28.7	-17.8	-9.4	0.0	0.0	62.8	3.7	4.6	134.8	24.8	14.7	10.7
2002	March	16	-31.4	-21.8	-13.4	0.0	0.0	61.7	3.9	2.9	184.4	18.1	13.7	8.0
2002	March	17	-31.7	-20.9	-10.6	0.0	0.0	63.6	3.1	3.3	166.6	13.8	8.7	6.5
2002	March	18	-29.5	-21.8	-14.6	0.0	0.0	68.3	3.7	5.1	52.1	25.5	15.7	12.5
2002	March	19	-33.2	-23.1	-13.1	0.0	0.0	60.6	4.1	3.7	151.9	18.3	12.3	8.1
2002	March	20	-34.1	-21.3	-10.4	0.0	0.0	54.7	4.2	3.8	222.4	20.5	13.6	9.2
2002	March	21	-21.1	-8.5	3.9	0.0	0.0	42.2	4.4	5.7	246.9	30.9	20.9	17.0
2002	March	22	-21.0	-7.3	4.8	0.0	0.0	54.2	4.5	4.6	150.9	23.8	15.1	13.3
2002	March	23	-19.4	-6.7	3.0	0.0	0.0	62.6	4.1	4.4	164.9	20.0	13.7	9.5
2002	March	24	-6.8	-1.0	4.8	0.0	0.0	51.4	3.0	8.0	178.9	28.3	16.9	14.0
2002	March	25	-5.5	-1.8	0.4	0.0	0.0	70.2	1.6	4.3	110.4	19.0	11.4	9.6
2002	March	26	-10.2	0.3	8.0	0.0	0.0	66.0	3.7	8.5	175.2	32.3	17.4	13.2
2002	March	27	0.0	3.5	10.4	0.0	0.0	67.2	3.2	6.0	205.0	22.4	16.9	12.7
2002	March	28	-10.2	-1.3	2.9	0.0	0.0	75.7	2.2	6.1	63.7	28.1	15.4	12.8
2002	March	29	-15.4	-11.9	-7.0	0.0	0.0	62.1	4.4	7.9	33.1	34.3	17.5	15.4
2002	March	30	-20.6	-14.3	-6.9	0.0	0.0	54.6	5.0	7.7	36.3	32.5	15.9	12.6
2002	March	31	-25.4	-16.6	-8.6	0.0	0.0	67.2	3.6	6.9	86.2	33.6	16.9	14.7

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m^2)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	April	1	-19.0	-16.3	-12.1	0.0	0.0	66.4	3.9	7.8	23.7	28.9	16.2	12.0
2002	April	2	-26.6	-15.5	-6.5	0.0	0.0	58.0	5.2	3.3	137.0	15.0	10.3	6.9
2002	April	3	-21.4	-10.5	-0.6	0.0	0.0	54.9	4.8	2.3	204.9	16.7	11.9	8.6
2002	April	4	-18.4	-9.8	-2.6	0.0	0.0	60.2	4.6	5.0	69.2	25.0	14.5	11.0
2002	April	5	-24.5	-11.9	-1.8	0.0	0.0	54.6	4.3	3.7	145.4	20.1	12.1	10.5
2002	April	6	-12.9	-7.5	-0.9	0.0	0.0	77.1	2.8	4.8	59.0	15.1	9.9	8.1
2002	April	7	-13.4	-6.1	-0.1	0.0	0.0	67.1	4.2	4.6	60.7	23.2	16.1	12.5
2002	April	8	-23.6	-9.1	0.8	0.0	0.0	58.8	4.8	4.9	182.9	27.7	18.6	13.0
2002	April	9	-23.1	-7.7	2.5	0.0	0.0	44.9	5.8	5.2	178.3	24.5	16.3	11.5
2002	April	10	-7.3	0.1	7.7	0.0	0.0	59.4	2.7	7.9	180.1	26.5	16.9	13.9
2002	April	11	-4.2	5.9	11.7	0.0	0.0	53.0	5.7	9.7	238.4	48.4	29.1	22.5
2002	April	12	-6.8	2.9	12.5	0.0	0.0	65.9	2.9	5.7	134.0	39.7	20.0	15.8
2002	April	13	-4.0	0.5	4.3	0.0	0.0	82.0	2.8	7.0	60.2	31.5	19.1	13.6
2002	April	14	-6.4	0.4	8.0	0.0	0.0	60.0	5.3	8.3	70.4	31.5	19.0	15.8
2002	April	15	-8.1	-2.7	2.6	0.0	0.0	47.1	4.9	9.6	75.0	30.5	19.3	15.4
2002	April	16	-13.3	-4.9	1.4	0.0	0.0	61.7	4.5	3.8	167.7	16.8	11.7	8.9
2002	April	17	-6.2	-2.2	2.8	0.0	0.0	58.5	4.7	7.1	77.6	32.1	18.8	13.5
2002	April	18	-10.2	-2.7	5.2	0.0	0.0	55.1	6.3	5.0	163.7	23.4	14.1	11.0
2002	April	19	-11.6	1.8	12.5	0.0	0.0	43.5	6.2	5.2	188.6	21.5	14.3	9.9
2002	April	20	-0.8	9.0	18.0	0.0	0.0	34.6	5.7	7.1	206.1	26.3	14.8	9.9
2002	April	21	-1.4	7.9	15.7	0.4	0.0	59.1	4.0	5.8	200.6	28.1	14.2	11.0
2002	April	22	-9.6	-1.0	3.8	1.0	0.0	88.3	1.8	7.5	89.2	37.8	21.8	15.1
2002	April	23	-11.5	-9.1	-5.6	0.0	0.0	72.1	3.7	8.7	142.2	32.9	16.3	12.7
2002	April	24	-13.0	-7.8	-1.3	0.4	0.0	49.0	6.4	7.1	87.1	29.4	19.3	12.5
2002	April	25	-18.2	-4.5	7.0	0.0	0.0	55.4	5.4	5.9	159.7	29.1	17.4	14.5
2002	April	26	-11.6	-2.7	5.1	0.0	0.0	57.2	6.2	4.2	158.3	21.0	13.2	11.2
2002	April	27	-9.1	3.0	11.4	0.0	0.0	38.8	5.5	7.1	234.0	39.1	21.8	13.0
2002	April	28	-1.8	4.1	9.6	0.4	0.0	62.1	3.8	7.2	263.1	36.3	23.9	16.5
2002	April	29	-4.3	2.5	8.2	0.0	0.0	60.7	5.0	7.3	231.8	32.2	18.2	14.6
2002	April	30	-7.8	-2.0	1.6	0.0	0.0	44.0	7.0	9.5	61.8	33.3	20.3	16.1

Table I.1 Climatic Data Recorded at Aurora Climate Station, January – December, 2002 (continued)

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m^2)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	May	1	-8.5	0.6	7.6	0.0	0.0	44.3	6.1	7.7	174.2	38.2	21.9	18.3
2002	May	2	-7.2	0.1	3.7	1.4	0.0	67.7	1.6	12.9	261.3	39.3	25.1	19.4
2002	May	3	-13.7	-7.4	-2.8	0.0	0.0	51.0	4.7	9.8	322.6	33.6	22.9	19.1
2002	May	4	-19.2	-6.4	2.8	0.0	0.0	48.3	7.4	5.4	202.6	30.1	15.7	10.6
2002	May	5	-13.1	-3.7	3.2	0.0	0.0	45.3	7.3	7.1	44.4	31.5	16.6	12.3
2002	May	6	-13.1	-3.1	5.5	0.0	0.0	50.5	7.0	5.0	63.4	22.4	14.2	11.9
2002	May	7	-11.8	0.6	10.6	0.0	0.0	44.2	6.9	4.1	177.6	21.0	14.2	10.9
2002	May	8	-9.2	3.7	13.6	0.0	0.0	36.8	7.3	5.4	114.7	28.7	17.4	12.8
2002	May	9	-9.9	4.5	15.8	0.0	0.0	31.3	7.2	4.2	196.7	31.3	18.7	13.6
2002	May	10	-0.3	8.2	16.5	0.0	0.0	33.9	6.6	4.6	133.0	21.5	15.2	10.1
2002	May	11	-3.1	6.7	16.5	0.6	0.0	60.4	4.3	4.8	193.0	25.5	18.9	14.2
2002	May	12	-1.0	10.4	18.4	0.4	0.0	52.0	7.5	4.7	229.1	20.4	13.0	10.0
2002	May	13	3.5	14.3	22.5	0.0	0.0	37.7	6.9	6.8	121.1	29.2	19.5	13.7
2002	May	14	0.2	7.7	14.1	0.0	0.0	52.8	7.9	9.6	46.7	33.9	22.9	16.3
2002	May	15	-5.6	6.8	17.0	0.0	0.0	52.4	8.0	4.6	133.1	20.4	12.4	9.3
2002	May	16	-1.6	11.9	21.2	0.0	0.0	33.0	8.0	8.2	172.2	30.6	20.1	15.5
2002	May	17	5.9	14.6	21.5	0.0	0.0	22.5	7.0	11.1	166.2	40.6	25.1	18.8
2002	May	18	8.4	16.2	23.1	0.0	0.0	19.4	7.2	11.7	162.5	41.1	25.2	19.6
2002	May	19	7.8	12.4	16.5	0.0	0.0	39.5	1.9	10.6	185.0	42.6	25.5	19.4
2002	May	20	3.1	9.0	13.5	0.6	0.0	76.8	1.7	4.2	85.5	26.5	14.2	12.5
2002	May	21	-2.8	5.0	9.7	0.0	0.0	43.2	8.0	10.9	51.0	37.2	22.2	17.2
2002	May	22	-6.0	1.7	8.8	0.0	0.0	41.9	8.1	7.4	61.6	34.4	21.6	16.4
2002	May	23	-9.9	4.0	13.3	0.0	0.0	37.9	7.3	3.5	203.6	20.3	13.6	9.7
2002	May	24	-1.1	9.4	17.0	0.0	0.0	34.4	5.9	4.8	240.2	26.1	20.4	14.0
2002	May	25	-0.7	7.4	12.8	0.6	0.0	53.8	6.0	6.0	239.5	34.5	21.9	15.7
2002	May	26	-0.7	13.4	23.7	0.0	0.0	36.3	6.5	6.9	155.2	41.0	23.0	18.0
2002	May	27	1.2	9.4	15.8	0.0	0.0	43.8	7.3	10.4	53.0	35.8	23.4	17.9
2002	May	28	1.8	13.7	23.7	0.0	0.0	42.7	6.9	6.3	96.9	26.1	14.6	11.9
2002	May	29	7.9	13.7	21.2	9.6	0.0	76.0	2.7	3.4	236.3	26.2	18.3	12.9
2002	May	30	6.3	12.0	18.0	4.4	0.0	80.4	4.6	5.3	167.3	36.7	22.9	19.2
2002	May	31	0.2	8.3	14.6	6.4	0.0	89.2	3.8	4.0	163.0	24.8	13.2	11.6

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m^2)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	June	1	-1.4	10.0	19.7	0.2	0.0	69.8	6.8	3.9	116.3	20.0	11.8	9.0
2002	June	2	0.3	13.1	22.7	0.0	0.0	57.5	7.1	3.9	66.3	32.7	20.9	13.6
2002	June	3	0.9	14.6	25.3	0.0	0.0	54.0	6.1	4.4	166.8	32.0	17.4	14.7
2002	June	4	6.4	18.1	26.9	0.0	0.0	48.4	7.2	5.3	181.6	23.1	15.5	9.5
2002	June	5	9.7	18.5	28.8	1.2	0.0	53.0	5.8	5.4	190.2	42.3	21.0	11.2
2002	June	6	8.5	10.4	12.0	22.2	0.0	98.6	0.9	2.0	172.9	12.6	7.2	5.8
2002	June	7	8.3	14.5	23.3	6.2	0.0	75.7	6.1	4.7	159.6	26.9	15.6	12.7
2002	June	8	3.8	15.4	26.1	0.0	0.0	58.1	8.5	4.9	140.1	27.8	15.8	11.1
2002	June	9	4.7	16.6	25.5	0.0	0.0	50.9	8.4	4.6	85.3	37.7	15.5	10.9
2002	June	10	3.5	17.5	27.3	0.0	0.0	43.6	8.7	3.7	163.1	23.0	15.6	10.3
2002	June	11	2.4	17.0	28.0	0.0	0.0	40.5	8.2	3.4	169.5	23.9	11.4	8.9
2002	June	12	3.7	19.0	30.3	0.0	0.0	39.1	7.2	4.4	186.9	24.3	14.2	12.1
2002	June	13	9.5	18.1	24.3	0.0	0.0	42.9	8.6	5.7	68.8	26.8	16.5	12.2
2002	June	14	2.7	13.9	23.9	0.0	0.0	56.4	6.6	2.8	161.1	21.8	14.1	10.0
2002	June	15	3.8	14.4	24.6	1.0	0.0	61.8	4.7	2.4	99.9	14.8	8.6	6.6
2002	June	16	6.9	12.7	20.4	0.6	0.0	73.4	4.3	4.5	70.9	26.7	16.2	12.9
2002	June	17	2.8	10.4	18.2	0.8	0.0	73.0	4.3	3.2	57.5	21.0	12.9	8.5
2002	June	18	-1.9	12.6	22.2	0.0	0.0	52.9	7.3	2.9	130.5	16.9	10.5	8.0
2002	June	19	1.3	11.3	17.9	3.4	0.0	70.0	4.3	4.8	231.9	34.4	23.6	18.3
2002	June	20	-0.8	14.3	26.0	0.4	0.0	60.4	7.2	5.0	229.0	34.2	18.9	13.6
2002	June	21	4.6	16.1	28.4	0.2	0.0	63.6	7.6	5.1	174.3	36.1	17.2	14.4
2002	June	22	1.3	18.1	29.8	0.0	0.0	53.3	8.0	4.0	180.3	25.3	16.6	10.8
2002	June	23	10.9	23.0	34.7	0.2	0.0	46.5	6.4	5.4	153.1	30.1	17.2	13.5
2002	June	24	14.2	20.4	28.1	0.0	0.0	62.9	4.6	3.6	242.3	25.2	13.9	8.8
2002	June	25	6.9	20.0	29.1	0.0	0.0	49.4	8.0	5.0	254.6	38.7	17.6	13.7
2002	June	26	10.1	22.4	33.2	0.0	0.0	55.5	6.3	2.8	206.7	19.1	12.2	7.5
2002	June	27	11.3	24.1	36.0	0.0	0.0	54.4	6.8	4.1	245.1	30.0	15.9	13.0
2002	June	28	14.0	19.0	29.0	3.6	0.0	72.2	3.7	2.6	191.6	17.8	10.7	7.7
2002	June	29	12.0	19.1	27.6	0.6	0.0	72.2	6.2	3.3	193.5	25.7	13.3	9.4
2002	June	30	10.8	14.1	15.7	24.0	0.0	96.7	1.8	3.3	289.0	22.8	10.6	9.0

Table I.1 Climatic Data Recorded at Aurora Climate Station, January – December, 2002 (continued)

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation ($kW \cdot h/m^2$)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	July	1	9.9	11.5	12.7	27.4	0.0	96.4	1.6	3.3	246.8	27.8	10.7	7.7
2002	July	2	7.8	12.1	18.7	2.6	0.0	80.4	5.1	3.5	93.6	15.5	9.0	6.6
2002	July	3	4.0	15.0	24.3	0.0	0.0	65.3	7.3	4.2	189.8	24.3	13.5	7.7
2002	July	4	10.2	14.2	19.6	5.4	0.0	87.4	2.0	4.1	176.3	30.8	15.9	11.2
2002	July	5	5.5	13.2	18.7	0.4	0.0	70.3	5.9	5.2	235.8	27.8	14.5	10.9
2002	July	6	8.1	15.8	22.9	0.2	0.0	70.6	5.3	4.3	273.5	22.2	13.2	9.3
2002	July	7	3.6	16.5	27.6	0.0	0.0	63.1	7.8	3.0	217.7	18.6	15.4	7.4
2002	July	8	5.9	20.4	31.9	0.0	0.0	56.2	7.4	2.9	198.1	21.5	14.4	9.5
2002	July	9	12.0	22.8	29.2	0.0	0.0	41.9	6.5	5.3	180.1	25.1	15.2	10.1
2002	July	10	11.8	23.2	32.6	0.0	0.0	45.5	8.4	4.9	226.5	31.5	16.1	10.7
2002	July	11	11.3	21.4	32.3	0.0	0.0	59.5	5.8	2.4	157.9	18.3	8.8	6.4
2002	July	12	13.0	22.5	31.1	0.0	0.0	57.8	6.1	4.1	264.5	27.5	16.8	13.1
2002	July	13	9.8	19.5	26.7	0.0	0.0	59.0	7.0	3.8	77.5	20.7	12.3	9.1
2002	July	14	10.7	17.7	22.0	2.0	0.0	77.0	3.1	3.8	199.2	24.3	12.5	9.8
2002	July	15	10.7	15.8	21.0	0.0	0.0	57.4	6.0	8.2	288.1	38.2	20.6	17.4
2002	July	16	6.2	15.0	22.5	0.0	0.0	67.0	7.3	4.0	175.6	19.8	11.1	9.1
2002	July	17	7.0	17.6	27.7	0.0	0.0	66.5	4.5	3.2	117.1	19.2	10.9	7.8
2002	July	18	11.6	16.4	22.5	5.8	0.0	89.5	2.9	3.9	178.6	17.2	12.3	8.8
2002	July	19	12.9	15.6	20.2	0.2	0.0	85.5	3.8	3.2	186.0	17.6	10.4	7.7
2002	July	20	12.0	13.5	14.3	34.0	0.0	96.9	0.8	5.5	144.0	39.3	15.7	11.7
2002	July	21	8.4	16.0	23.8	0.2	0.0	70.9	7.9	4.0	141.1	20.8	12.0	8.0
2002	July	22	4.0	17.4	28.6	0.0	0.0	65.3	7.8	3.1	206.7	20.9	12.6	8.4
2002	July	23	12.8	18.1	26.0	1.2	0.0	78.3	4.3	3.1	176.0	21.4	13.1	8.9
2002	July	24	8.2	19.8	29.8	0.2	0.0	68.0	7.5	3.6	208.0	29.7	17.2	14.0
2002	July	25	11.8	20.9	30.5	1.0	0.0	71.9	4.5	3.5	226.8	37.2	18.7	10.4
2002	July	26	11.7	18.3	25.4	0.8	0.0	81.1	4.3	2.9	234.6	15.5	9.4	7.3
2002	July	27	13.1	15.9	21.1	9.6	0.0	88.1	3.5	3.0	233.0	25.9	16.6	15.1
2002	July	28	10.9	17.1	23.2	6.2	0.0	72.9	6.2	5.2	276.8	30.5	16.5	13.5
2002	July	29	6.4	14.8	21.1	0.0	0.0	62.3	6.1	5.3	270.6	29.3	16.3	12.7
2002	July	30	7.4	9.6	12.3	28.0	0.0	92.7	1.5	4.9	282.9	20.5	10.0	8.6
2002	July	31	7.6	8.8	11.7	5.6	0.0	92.2	1.6	8.3	207.5	35.5	17.4	14.2

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation ($kW \cdot h/m^2$)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	August	1	4.2	9.2	14.5	0.2	0.0	69.4	5.1	7.3	294.5	30.7	15.6	13.0
2002	August	2	1.0	7.1	13.5	0.0	0.0	77.3	5.2	4.5	219.6	27.0	15.2	10.9
2002	August	3	3.8	8.8	14.0	0.2	0.0	78.4	3.7	2.2	242.7	17.1	10.6	7.3
2002	August	4	-1.3	10.3	19.2	0.0	0.0	72.1	5.5	2.0	160.8	13.1	8.7	6.4
2002	August	5	6.0	9.8	12.5	9.2	0.0	93.1	0.9	2.6	143.7	13.9	7.9	5.9
2002	August	6	6.6	13.7	22.6	0.2	0.0	74.5	6.5	4.1	208.5	21.0	11.6	7.6
2002	August	7	4.5	16.0	26.8	1.2	0.0	68.1	6.5	4.0	190.3	20.3	10.6	7.3
2002	August	8	7.2	18.2	28.4	0.2	0.0	64.0	6.6	4.3	209.9	24.7	11.8	8.9
2002	August	9	8.4	17.1	27.2	0.0	0.0	69.8	5.0	4.7	222.0	43.0	24.4	18.6
2002	August	10	6.7	14.9	22.2	0.4	0.0	73.4	4.9	5.3	260.1	34.0	18.8	15.9
2002	August	11	7.4	14.9	23.5	0.0	0.0	74.6	5.6	3.4	262.1	26.4	18.8	13.4
2002	August	12	6.2	14.8	21.9	0.0	0.0	74.8	3.8	3.7	232.0	29.1	17.2	12.6
2002	August	13	12.4	15.6	24.8	5.4	0.0	87.2	3.2	4.0	230.0	37.5	21.3	17.1
2002	August	14	11.5	12.9	14.9	6.0	0.0	95.0	1.5	3.8	221.1	29.4	14.8	12.2
2002	August	15	7.1	11.5	17.9	7.8	0.0	88.8	3.8	4.0	232.8	25.8	11.6	9.0
2002	August	16	1.6	8.4	15.4	4.8	0.0	81.1	5.2	4.5	232.2	21.0	11.5	8.9
2002	August	17	-0.4	6.2	15.5	1.2	0.0	90.6	2.8	2.7	191.9	14.5	8.9	6.9
2002	August	18	-0.7	9.9	22.5	0.2	0.0	82.4	4.3	4.0	204.3	25.5	13.2	9.9
2002	August	19	3.4	9.2	14.4	7.6	0.0	86.3	3.8	3.9	129.6	28.8	15.4	10.5
2002	August	20	2.7	10.6	20.0	0.0	0.0	74.5	6.0	3.0	222.7	18.7	10.4	8.0
2002	August	21	4.8	15.7	26.2	0.0	0.0	70.0	5.5	3.6	183.2	21.2	10.5	7.9
2002	August	22	11.2	18.4	26.7	0.0	0.0	64.9	5.0	3.5	245.3	24.7	12.7	11.0
2002	August	23	8.1	18.2	28.6	0.0	0.0	70.4	5.5	3.5	205.3	17.6	9.7	6.6
2002	August	24	9.8	19.2	27.3	0.0	0.0	65.1	5.8	3.8	254.6	24.1	15.8	12.0
2002	August	25	4.3	12.6	19.1	0.2	0.0	86.9	2.1	1.9	170.7	13.4	7.6	6.3
2002	August	26	11.5	16.8	25.0	3.0	0.0	88.6	3.8	2.0	206.3	14.3	8.5	6.1
2002	August	27	10.0	18.5	28.5	0.0	0.0	79.6	5.2	2.7	157.6	13.1	8.8	4.9
2002	August	28	12.1	20.4	30.8	0.0	0.0	70.3	4.5	3.8	195.8	20.3	10.5	7.2
2002	August	29	11.3	21.1	31.4	0.0	0.0	64.5	5.4	4.3	168.8	25.9	11.2	9.3
2002	August	30	11.9	15.3	18.3	0.8	0.0	89.6	1.1	2.3	190.8	20.7	9.8	7.1
2002	August	31	5.9	15.5	24.6	0.0	0.0	75.1	4.9	3.3	181.2	18.9	10.3	7.4

Table I.1 Climatic Data Recorded at Aurora Climate Station, January – December, 2002 (continued)

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m²)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	September	1	9.0	14.9	22.6	1.6	0.0	78.3	4.4	4.2	233.8	28.4	17.0	13.7
2002	September	2	8.4	12.2	16.2	3.0	0.0	86.0	2.0	3.8	215.6	20.2	12.1	10.3
2002	September	3	8.4	11.6	15.2	2.4	0.0	89.1	1.8	2.1	179.6	11.9	7.0	6.0
2002	September	4	10.2	12.1	15.5	22.6	0.0	96.4	1.7	3.8	205.3	16.9	10.1	7.7
2002	September	5	6.9	10.1	15.1	2.6	0.0	90.0	2.4	4.1	237.8	19.6	12.0	8.3
2002	September	6	4.3	9.2	14.5	0.8	0.0	90.6	2.2	1.3	204.8	9.4	5.7	4.5
2002	September	7	2.5	10.3	18.7	0.2	0.0	78.3	4.1	4.1	180.0	23.2	11.5	8.1
2002	September	8	4.8	11.4	19.6	0.2	0.0	76.7	4.1	3.9	209.2	23.0	11.4	7.8
2002	September	9	2.5	11.3	20.6	0.2	0.0	75.2	4.9	4.1	218.4	24.8	12.5	9.2
2002	September	10	4.8	13.9	23.7	0.6	0.0	70.5	4.4	3.8	219.2	33.5	13.6	10.0
2002	September	11	4.7	12.1	20.8	0.2	0.0	73.8	4.7	3.8	256.4	29.1	18.3	13.0
2002	September	12	0.8	9.9	19.6	0.0	0.0	77.5	3.9	2.9	195.7	16.9	7.3	5.9
2002	September	13	1.3	11.5	19.0	1.2	0.0	73.7	4.2	4.2	264.9	33.4	18.1	13.7
2002	September	14	-0.9	10.2	21.6	0.0	0.0	76.8	4.0	3.7	188.1	25.5	12.3	8.5
2002	September	15	6.6	13.7	22.2	0.0	0.0	73.6	4.4	3.5	246.1	16.0	9.6	8.6
2002	September	16	5.4	12.7	21.3	0.4	0.0	82.1	2.0	2.9	185.4	21.2	13.5	10.6
2002	September	17	3.8	11.2	20.0	0.0	0.0	74.9	4.3	3.2	239.9	18.9	13.8	9.9
2002	September	18	-0.9	9.5	18.7	0.0	0.0	69.1	4.2	4.2	211.1	22.1	15.3	9.8
2002	September	19	6.8	10.4	15.5	3.4	0.0	77.3	2.5	5.2	283.5	25.0	15.8	13.3
2002	September	20	5.6	7.5	10.4	1.0	0.0	84.8	1.6	8.8	319.1	39.7	24.8	18.6
2002	September	21	0.6	5.4	9.9	0.6	0.0	78.9	2.3	6.7	324.0	38.3	23.4	16.0
2002	September	22	-4.1	3.1	8.9	0.0	0.0	83.5	2.7	3.9	213.8	33.1	15.3	12.5
2002	September	23	-4.1	2.1	11.1	0.2	0.0	79.6	2.4	4.5	234.4	34.4	20.4	14.3
2002	September	24	-7.8	-1.8	5.4	0.0	0.0	71.4	3.5	4.2	290.6	29.5	16.4	12.5
2002	September	25	-9.8	-1.5	8.8	0.0	0.0	68.7	4.0	3.2	249.2	28.0	14.0	9.9
2002	September	26	-8.4	-1.4	5.9	0.0	0.0	79.8	2.3	2.9	188.8	22.5	11.9	8.7
2002	September	27	-2.0	2.2	8.1	0.0	0.0	66.6	2.7	4.7	170.5	21.8	13.4	9.9
2002	September	28	3.2	8.2	14.1	6.0	0.0	71.3	1.6	5.3	162.6	22.2	11.5	9.5
2002	September	29	2.1	6.7	11.5	1.4	0.0	88.6	2.5	3.0	222.0	16.1	11.2	7.7
2002	September	30	-5.2	1.2	7.9	0.0	0.0	87.3	2.1	2.0	152.8	20.5	14.3	11.3

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m²)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	October	1	-7.3	0.6	10.1	0.0	0.0	85.6	2.2	3.0	183.5	16.2	9.0	7.4
2002	October	2	3.2	6.9	13.1	4.0	0.0	79.4	1.9	5.5	241.2	42.1	21.3	15.7
2002	October	3	-0.5	3.7	7.5	3.0	0.0	85.0	1.3	6.8	230.9	33.2	18.2	15.6
2002	October	4	-3.7	-0.9	2.7	0.0	0.0	85.4	1.9	2.5	138.0	13.2	8.1	6.0
2002	October	5	-4.4	-1.3	1.9	0.8	0.0	94.7	1.2	2.0	108.0	14.2	8.7	4.9
2002	October	6	-4.4	1.5	6.7	0.0	0.0	84.6	2.3	3.7	180.9	15.0	8.2	6.0
2002	October	7	-2.9	3.4	9.3	0.0	0.0	71.6	2.9	4.2	206.9	24.0	12.5	9.4
2002	October	8	-0.9	6.0	14.7	0.0	0.0	71.6	1.5	4.2	193.1	20.5	12.2	9.3
2002	October	9	-1.6	3.6	10.0	0.0	0.0	82.9	1.3	3.6	210.7	24.2	17.1	13.7
2002	October	10	-4.5	0.1	4.2	0.0	0.0	85.6	1.2	4.9	127.7	28.2	13.7	10.3
2002	October	11	-3.4	-1.1	2.5	0.0	0.0	55.5	2.7	6.5	286.6	32.5	16.4	13.1
2002	October	12	-6.2	-3.2	0.7	0.0	0.0	67.7	2.1	3.0	170.0	13.6	9.8	6.9
2002	October	13	-1.2	1.2	5.1	3.8	0.0	86.8	0.7	4.5	146.8	25.7	14.2	8.6
2002	October	14	-11.5	-3.7	-0.5	0.0	0.0	79.0	1.8	4.6	98.6	27.5	16.4	13.4
2002	October	15	-12.0	-3.9	1.7	3.8	0.0	89.8	1.0	2.7	162.5	12.4	8.6	6.4
2002	October	16	-3.8	-2.5	-1.0	0.6	0.0	86.0	0.9	5.2	115.1	23.8	13.7	10.4
2002	October	17	-4.9	-3.1	-1.4	0.0	0.0	97.6	0.2	4.3	120.3	22.1	13.9	10.3
2002	October	18	-7.0	-4.5	-2.1	0.0	1.0	88.3	0.9	2.9	201.4	12.6	8.1	6.5
2002	October	19	-12.6	-5.1	0.7	0.0	0.3	87.6	2.1	1.9	138.4	11.3	8.0	6.1
2002	October	20	-19.9	-10.6	0.3	0.0	1.8	84.1	2.2	2.4	199.7	11.4	7.8	6.0
2002	October	21	-13.4	-4.6	0.1	0.0	0.0	82.5	1.2	2.6	209.6	16.1	9.6	7.3
2002	October	22	-10.4	-2.8	3.3	0.0	0.0	71.2	2.2	6.4	185.3	23.2	13.3	11.1
2002	October	23	-5.9	-1.8	4.6	0.0	0.0	78.7	1.7	5.2	192.0	21.5	13.0	10.4
2002	October	24	-3.5	-0.6	3.3	0.0	1.5	91.5	0.6	3.2	192.2	16.5	9.2	7.2
2002	October	25	-5.5	-2.9	-1.0	0.0	4.1	91.4	0.8	5.6	78.6	19.9	10.9	9.0
2002	October	26	-6.9	-5.6	-4.0	0.0	0.0	87.5	0.5	2.5	147.5	9.2	6.0	4.8
2002	October	27	-11.3	-5.4	-0.5	0.0	0.0	82.9	1.5	3.6	102.1	15.1	9.0	7.0
2002	October	28	-18.7	-8.4	-4.0	0.0	0.0	72.9	1.8	3.5	83.1	15.4	9.5	7.1
2002	October	29	-22.3	-13.2	-2.5	0.0	0.0	76.7	1.8	4.3	188.2	21.7	10.4	8.2
2002	October	30	-15.7	-8.0	-1.0	0.0	0.0	73.3	1.3	4.9	190.1	17.6	10.9	9.0
2002	October	31	-14.0	-6.5	2.3	0.0	0.0	73.6	1.6	4.4	182.5	18.4	10.9	9.5

Table I.1 Climatic Data Recorded at Aurora Climate Station, January – December, 2002 (continued)

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m^2)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	November	1	-15.9	-8.5	-3.7	0.0	0.0	92.1	0.6	2.7	132.1	14.2	9.2	7.0
2002	November	2	-8.1	-5.7	-3.8	0.0	0.0	90.8	0.9	2.4	167.3	14.4	8.2	6.3
2002	November	3	-4.7	-2.4	-0.1	0.0	0.0	87.4	0.4	1.4	208.9	8.5	6.2	4.3
2002	November	4	-2.8	-0.9	2.0	0.0	0.0	89.4	0.6	2.8	198.5	17.8	8.2	6.7
2002	November	5	-17.1	-7.8	-1.1	0.0	0.0	86.4	0.6	5.7	71.4	32.7	19.4	15.1
2002	November	6	-16.7	-11.0	-6.6	0.0	0.0	82.9	0.5	4.0	164.4	16.4	9.4	7.3
2002	November	7	-18.5	-12.7	-9.6	0.0	0.0	87.5	0.8	5.0	46.8	24.7	13.5	11.0
2002	November	8	-16.5	-13.9	-11.4	0.0	0.0	85.6	0.7	4.6	43.7	18.7	11.5	8.5
2002	November	9	-14.6	-13.0	-11.4	0.0	0.0	88.7	0.4	3.7	45.2	14.6	10.3	6.6
2002	November	10	-20.8	-13.8	-9.5	0.0	0.0	87.3	0.3	2.1	213.0	13.9	7.5	4.2
2002	November	11	-18.1	-13.5	-10.1	0.0	0.0	87.1	0.2	1.5	206.1	9.8	4.8	3.9
2002	November	12	-25.2	-18.7	-9.9	0.0	0.0	83.2	0.5	2.0	190.9	10.4	6.2	5.4
2002	November	13	-28.0	-22.1	-15.2	0.0	0.0	83.5	0.3	1.3	151.2	7.1	5.8	4.0
2002	November	14	-22.7	-18.4	-14.3	0.0	0.0	86.6	0.4	1.8	173.2	9.6	6.9	5.7
2002	November	15	-18.5	-9.8	-2.7	0.0	0.0	92.8	0.4	4.0	199.1	16.9	8.6	6.7
2002	November	16	-11.3	-6.8	-2.1	0.0	0.0	96.4	0.4	1.7	288.7	10.4	6.0	4.8
2002	November	17	-6.6	-1.0	1.1	0.0	0.0	94.5	0.1	4.1	227.2	24.4	13.8	10.4
2002	November	18	-10.2	-6.1	1.2	0.0	0.0	93.3	0.8	3.5	200.4	16.4	8.7	6.9
2002	November	19	-14.6	-9.8	-5.4	0.0	0.0	94.9	0.3	1.8	147.6	9.8	5.9	5.2
2002	November	20	-8.1	-4.2	1.6	0.0	0.0	97.9	0.6	2.8	209.4	11.7	7.3	6.4
2002	November	21	-9.9	-3.5	2.5	0.0	0.0	97.1	0.7	3.1	221.4	17.8	10.8	8.3
2002	November	22	-7.2	-2.1	3.1	0.0	0.3	78.3	0.4	12.1	219.9	41.6	29.5	23.1
2002	November	23	-15.2	-11.1	-7.2	0.0	0.0	89.2	0.3	4.7	152.5	30.3	16.4	11.9
2002	November	24	-14.9	-8.7	-3.5	0.0	0.0	84.4	0.4	6.6	159.5	35.7	19.6	16.5
2002	November	25	-15.8	-11.4	-7.9	0.0	0.0	85.2	0.8	5.2	178.9	22.4	12.9	10.5
2002	November	26	-14.0	-9.6	-2.4	0.0	0.0	92.1	0.5	3.1	164.3	12.6	7.2	6.1
2002	November	27	-12.0	-0.8	6.8	0.0	0.0	87.4	0.6	5.7	193.8	22.4	10.0	8.2
2002	November	28	3.2	7.1	10.0	0.0	0.0	51.9	0.6	14.6	302.5	60.7	36.6	29.4
2002	November	29	-3.4	-1.4	5.0	0.0	0.0	79.0	0.4	5.5	147.9	40.0	22.7	18.2
2002	November	30	-4.5	-2.3	1.6	0.0	0.0	85.0	0.7	3.0	170.2	11.0	7.3	6.5

Year	Month	Day	Temperature			Total Rainfall (mm)	Total Snowfall (cm)	Mean Relative Humidity (%)	Total Global Solar Radiation (kW·h/m^2)	Wind Speed and Direction				
										Mean Daily Wind		Maximum Sustained Gusts		
			Minimum (°C)	Mean (°C)	Maximum (°C)					Speed (km/h)	Direction (degrees)	5 Second (km/h)	2 Minute (km/h)	10 Minute (km/h)
2002	December	1	-10.7	-5.9	-1.9	0.0	0.0	89.1	0.1	4.3	132.6	18.3	11.8	9.6
2002	December	2	-28.8	-20.1	-10.7	0.0	0.0	83.6	0.7	3.7	117.2	16.7	8.8	7.1
2002	December	3	-27.8	-19.6	-13.4	0.0	0.0	85.7	0.3	5.2	188.0	18.8	9.5	7.1
2002	December	4	-13.4	-9.7	-7.1	0.0	0.0	92.9	0.2	2.6	176.8	15.6	8.0	6.6
2002	December	5	-14.3	-10.5	-6.9	0.0	0.0	91.6	0.5	2.5	196.1	14.5	8.1	7.1
2002	December	6	-26.0	-12.5	-7.8	0.0	0.0	87.1	0.4	2.5	188.4	18.7	13.0	8.7
2002	December	7	-27.4	-17.2	-11.6	0.0	0.0	86.0	0.4	2.9	182.8	18.8	8.9	7.5
2002	December	8	-14.0	-5.3	1.0	0.0	0.0	90.9	0.6	4.7	208.5	24.1	10.6	8.4
2002	December	9	-7.4	-4.2	-0.1	0.0	0.0	96.9	0.5	4.3	193.2	17.3	9.1	8.2
2002	December	10	-11.9	-6.6	-3.3	0.0	0.0	96.6	0.2	1.5	173.4	9.5	6.3	4.4
2002	December	11	-7.6	-4.7	-3.6	0.0	0.0	96.5	0.1	0.0	0.0	0.0	0.0	0.0
2002	December	12	-11.9	-8.0	-6.2	0.0	0.0	96.1	0.1	0.0	0.0	0.0	0.0	0.0
2002	December	13	-10.1	-6.0	-1.2	0.0	0.0	95.1	0.3	2.3	123.8	17.8	9.1	7.6
2002	December	14	-13.8	-6.4	1.5	0.0	0.0	92.2	0.4	5.1	199.3	23.3	13.3	11.9
2002	December	15	-8.7	-3.8	-1.6	0.0	0.0	95.4	0.1	2.7	220.0	18.1	12.1	8.8
2002	December	16	-5.2	-2.3	-0.5	0.0	0.0	98.9	0.1	3.0	178.2	16.2	10.1	7.3
2002	December	17	-3.1	-1.4	-0.2	0.0	0.0	95.9	0.1	5.4	185.0	22.5	12.0	10.1
2002	December	18	-10.7	-5.4	-0.8	0.0	0.0	95.0	0.2	2.0	254.8	19.8	14.6	12.2
2002	December	19	-20.0	-12.5	-7.3	0.0	0.0	92.6	0.1	1.6	215.1	11.9	6.6	4.4
2002	December	20	-23.5	-16.7	-13.3	0.0	0.0	89.2	0.2	0.6	192.4	5.2	3.7	3.2
2002	December	21	-22.1	-19.2	-16.4	0.0	0.0	86.4	0.2	1.1	220.0	7.5	4.1	3.2
2002	December	22	-25.5	-20.4	-15.8	0.0	0.0	85.2	0.2	2.6	208.6	12.6	6.6	5.2
2002	December	23	-20.1	-15.2	-10.7	0.0	0.0	89.3	0.2	4.1	196.7	17.5	7.8	6.5
2002	December	24	-12.3	-9.3	-5.9	0.0	0.0	93.4	0.2	4.3	191.4	13.3	8.2	6.5
2002	December	25	-11.4	-9.9	-7.4	0.0	0.0	91.9	0.3	4.8	194.0	15.9	9.5	8.0
2002	December	26	-13.3	-8.0	-4.4	0.0	0.0	92.5	0.1	3.7	216.1	18.2	9.7	7.7
2002	December	27	-14.2	-11.4	-9.5	0.0	0.0	93.7	0.1	2.2	157.5	13.5	8.3	7.0
2002	December	28	-15.8	-14.1	-12.5	0.0	0.0	90.2	0.1	2.4	70.4	14.0	9.3	6.8
2002	December	29	-15.7	-13.7	-11.8	0.0	0.0	90.3	0.0	0.6	269.3	7.3	4.3	2.9
2002	December	30	-14.4	-12.9	-10.2	0.0	0.0	89.3	0.1	4.9	200.9	22.9	13.6	10.2
2002	December	31	-16.2	-10.8	-9.6	0.0	0.0	89.5	0.3	4.2	203.7	17.6	9.3	7.2

Table I.2 Climatic Data Recorded at Other RAMP Climate Stations, January – December, 2002

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	January	1	-26.2	-22.8	-18.7	0.0	0.0					
2002	January	2	-21.8	-19.2	-16.6	0.0	0.0					
2002	January	3	-18.1	-10.6	-6.8	0.0	1.5					
2002	January	4	-10.6	-9.9	-8.3	0.0	0.3					
2002	January	5	-11.9	-10.5	-8.8	0.0	0.0					
2002	January	6	-16.0	-10.3	-4.6	0.0	0.5					
2002	January	7	-9.9	-3.8	1.1	0.0	1.5					
2002	January	8	-5.9	-0.8	2.7	0.0	0.8					
2002	January	9	-14.9	-9.4	-3.7	0.0	0.0					
2002	January	10	-14.7	-7.4	2.4	0.0	0.0					
2002	January	11	-11.6	-0.5	4.8	0.0	0.0					
2002	January	12	-16.0	-8.2	-2.9	0.0	0.0					
2002	January	13	-15.6	-5.2	-0.6	0.0	0.3					
2002	January	14	-14.0	-11.4	-7.9	0.0	0.0					
2002	January	15	-20.6	-12.7	-8.7	0.0	0.0					
2002	January	16	-21.3	-15.9	-13.3	0.0	0.0					
2002	January	17	-25.5	-22.6	-19.9	0.0	0.0					
2002	January	18	-21.9	-17.1	-12.6	0.0	0.0					
2002	January	19	-30.9	-26.4	-21.4	0.0	0.0					
2002	January	20	-32.2	-29.2	-26.3	0.0	0.0					
2002	January	21	-32.3	-30.4	-28.5	0.0	0.0					
2002	January	22	-40.5	-34.9	-29.9	0.0	0.0					
2002	January	23	-40.3	-34.7	-26.2	0.0	0.0					
2002	January	24	-41.9	-34.9	-27.9	0.0	0.0					
2002	January	25	-41.0	-35.5	-28.3	0.0	0.0					
2002	January	26	-41.1	-33.4	-22.9	0.0	0.0					
2002	January	27	-44.7	-39.1	-28.8	0.0	0.0					
2002	January	28	-43.5	-36.6	-25.4	0.0	0.0					
2002	January	29	-41.8	-36.3	-26.5	0.0	0.0					
2002	January	30	-42.0	-35.4	-23.3	0.0	14.0					
2002	January	31	-37.1	-24.2	-14.3	0.0	0.0					

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	February	1	-16.9	-12.3	-8.3	0.0	0.0					
2002	February	2	-20.7	-10.5	-3.5	0.0	0.0					
2002	February	3	-20.1	-8.7	-2.3	0.0	0.0					
2002	February	4	-30.0	-19.2	-13.7	0.0	0.0					
2002	February	5	-24.1	-16.8	-12.2	0.0	0.0					
2002	February	6	-26.6	-17.1	-11.8	0.0	0.0					
2002	February	7	-26.6	-18.4	-12.6	0.0	0.0					
2002	February	8	-26.1	-16.1	-11.0	0.0	0.0					
2002	February	9	-28.2	-19.7	-14.6	0.0	0.0					
2002	February	10	-15.7	-11.1	-4.5	0.0	0.0					
2002	February	11	-17.8	-10.9	-7.5	0.0	0.0					
2002	February	12	-22.2	-12.0	0.1	0.0	0.0					
2002	February	13	-7.8	-3.1	6.4	0.0	0.0					
2002	February	14	-12.8	-3.8	6.9	0.0	0.0					
2002	February	15	-9.6	-0.2	9.0	0.0	0.0					
2002	February	16	-15.2	-6.7	6.8	0.0	0.0					
2002	February	17	-15.1	-7.2	4.2	0.0	0.0					
2002	February	18	-27.1	-16.8	-7.0	0.0	0.0					
2002	February	19	-15.3	-5.9	3.4	0.0	0.0					
2002	February	20	-2.9	0.1	5.4	0.0	0.0					
2002	February	21	-14.1	-4.7	5.6	0.0	0.0					
2002	February	22	-18.4	-12.2	-6.9	0.0	0.0					
2002	February	23	-27.6	-18.7	-13.9	0.0	0.0					
2002	February	24	-29.6	-23.1	-15.2	0.0	0.0					
2002	February	25	-29.6	-18.2	-5.5	0.0	0.0					
2002	February	26	-17.7	-10.7	-2.1	0.0	0.0					
2002	February	27	-26.6	-18.8	-13.0	0.0	0.0					
2002	February	28	-36.7	-26.3	-12.7	0.0	0.0					

Table I.2 Climatic Data Recorded at Other RAMP Climate Stations, January – December, 2002 (continued)

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	March	1	-36.9	-25.2	-9.2	0.0	0.0					
2002	March	2	-34.5	-20.0	-3.9	0.0	0.0					
2002	March	3	-12.8	-5.8	-0.3	0.0	0.0					
2002	March	4	-26.0	-13.8	-9.8	0.0	0.0					
2002	March	5	-33.4	-23.4	-13.1	0.0	0.0					
2002	March	6	-31.5	-23.3	-11.6	0.0	0.0					
2002	March	7	-35.2	-23.3	-7.4	0.0	0.0					
2002	March	8	-31.9	-21.8	-8.7	0.0	0.0					
2002	March	9	-30.5	-20.1	-6.1	0.0	0.0					
2002	March	10	-31.1	-23.0	-16.6	0.0	0.0					
2002	March	11	-35.4	-20.8	-8.4	0.0	0.0					
2002	March	12	-21.6	-12.9	-7.9	0.0	0.0					
2002	March	13	-25.9	-18.5	-10.5	0.0	0.0					
2002	March	14	-27.7	-17.9	-6.1	0.6	0.0					
2002	March	15	-26.3	-17.5	-8.5	0.0	0.0					
2002	March	16	-30.3	-20.3	-11.0	0.0	0.0					99.6
2002	March	17	-30.3	-19.5	-10.0	0.0	0.0					99.5
2002	March	18	-30.1	-20.6	-12.2	0.0	0.0					99.8
2002	March	19	-32.3	-21.7	-10.9	0.0	0.0					99.9
2002	March	20	-34.0	-20.5	-7.0	0.0	0.0					100.6
2002	March	21	-25.7	-10.0	5.6	0.7	0.0					99.8
2002	March	22	-21.0	-6.9	7.0	0.9	0.0					98.8
2002	March	23	-19.1	-6.8	4.7	0.0	0.0					98.7
2002	March	24	-12.8	-3.3	5.3	0.0	0.0					98.4
2002	March	25	-3.3	-1.1	0.8	0.0	0.0					98.3
2002	March	26	-14.2	-1.3	8.5	0.0	0.0					97.1
2002	March	27	-0.5	3.5	11.5	0.0	0.0					96.1
2002	March	28	-8.5	-1.0	2.4	0.1	0.0					96.9
2002	March	29	-13.5	-9.7	-3.8	0.0	0.0					98.5
2002	March	30	-22.7	-13.1	-4.8	0.0	0.0					99.2
2002	March	31	-23.9	-15.3	-7.4	0.0	0.0					98.8

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	April	1	-17.3	-13.9	-9.4	0.0	0.0					100.1
2002	April	2	-26.0	-14.8	-4.2	0.1	0.0					100.5
2002	April	3	-20.3	-9.8	0.9	0.1	0.0					99.6
2002	April	4	-18.2	-8.9	-3.5	0.0	0.0					99.7
2002	April	5	-24.7	-11.6	-1.3	0.0	0.0					99.6
2002	April	6	-11.8	-6.4	2.3	1.7	0.0					98.1
2002	April	7	-13.8	-5.8	1.6	0.1	0.0					98.2
2002	April	8	-24.6	-9.0	4.6	0.0	0.0					98.4
2002	April	9	-24.4	-7.2	6.2	0.0	0.0					98.6
2002	April	10	-11.7	-0.8	8.7	0.0	0.0					97.5
2002	April	11	-4.5	3.0	11.4	0.0	0.0					97.1
2002	April	12	-6.3	2.6	12.5	0.0	0.0					97.4
2002	April	13	-3.3	0.9	4.4	0.0	0.0					97.0
2002	April	14	-5.0	0.7	7.8	0.0	0.0					96.9
2002	April	15	-6.8	-1.7	4.6	0.0	0.0					96.8
2002	April	16	-11.8	-4.2	2.3	0.0	0.0					97.6
2002	April	17	-5.0	-1.5	3.8	0.0	0.0					98.3
2002	April	18	-12.4	-2.6	6.1	0.0	0.0					99.4
2002	April	19	-12.8	0.0	13.1	0.0	0.0					99.0
2002	April	20	-3.3	6.6	17.6	0.0	0.0					97.8
2002	April	21	-3.0	5.0	15.7	0.0	0.0					96.8
2002	April	22	-8.2	-0.9	2.1	2.5	0.0					96.9
2002	April	23	-10.2	-7.3	-3.3	0.1	0.0					98.6
2002	April	24	-13.9	-6.6	0.3	0.0	0.0					99.6
2002	April	25	-18.6	-4.8	7.9	0.0	0.0					99.3
2002	April	26	-12.8	-2.4	7.1	0.0	0.0					98.8
2002	April	27	-12.5	1.2	11.5	0.0	0.0	0.0				97.7
2002	April	28	-2.9	3.3	10.0	0.0	0.0	0.0				97.5
2002	April	29	-5.4	1.6	7.6	0.0	0.0	0.0				98.2
2002	April	30	-6.8	-1.1	2.6	0.0	0.0	0.0				98.9

Table I.2 Climatic Data Recorded at Other RAMP Climate Stations, January – December, 2002 (continued)

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	May	1	-7.5	1.0	7.5	0.0	0.0	0.0				98.0
2002	May	2	-6.7	0.2	3.7	0.7	0.0	1.3				96.3
2002	May	3	-13.5	-6.5	-0.8	0.0	0.0	0.0				98.2
2002	May	4	-19.7	-6.4	3.3	0.0	0.0	0.0				98.7
2002	May	5	-12.6	-3.4	3.8	0.0	0.0	1.3				99.4
2002	May	6	-13.6	-2.7	6.2	0.0	0.0	0.0				99.6
2002	May	7	-12.5	0.1	10.8	0.0	0.0	0.0				99.0
2002	May	8	-10.6	2.8	14.1	0.0	0.0	0.0				98.6
2002	May	9	-11.1	3.7	16.8	0.0	0.0	0.0				98.2
2002	May	10	-2.1	6.9	16.8	0.0	0.0	0.0				97.7
2002	May	11	-3.8	5.5	16.5	6.4	0.0	0.0				97.9
2002	May	12	-2.9	8.5	19.3	0.1	0.0	0.0				98.8
2002	May	13	-1.6	11.1	22.5	0.0	0.0	0.0				98.2
2002	May	14	0.1	7.1	13.8	0.0	0.0	0.0				98.1
2002	May	15	-4.6	6.3	17.9	0.0	0.0	1.5				98.7
2002	May	16	-6.3	9.9	23.1	0.0	0.0	0.0				98.9
2002	May	17	-3.6	11.9	23.9	0.0	0.0	0.0				98.8
2002	May	18	-2.2	13.3	24.7	0.0	0.0	0.0				98.9
2002	May	19	4.5	10.2	15.0	1.5	0.0	0.3				98.7
2002	May	20	0.9	7.7	12.3	0.9	0.0	0.0				98.4
2002	May	21	-3.0	5.4	11.7	0.0	0.0	0.0				98.8
2002	May	22	-4.9	2.5	9.6	0.0	0.0	0.0				99.1
2002	May	23	-10.2	4.1	15.2	0.0	0.0	0.0				98.8
2002	May	24	-2.6	8.9	18.2	0.0	0.0	0.0				97.8
2002	May	25	-2.7	7.6	14.8	0.0	0.0	2.8				97.4
2002	May	26	-3.3	12.3	25.6	0.0	0.0	0.0				96.8
2002	May	27	-1.7	8.5	15.5	0.0	0.0	0.0				97.1
2002	May	28	2.5	12.8	24.7	0.0	0.0	0.0				97.3
2002	May	29	4.9	12.3	21.2	5.8	0.0	9.1				96.4
2002	May	30	2.5	10.3	20.7	0.5	0.0	2.0				96.9
2002	May	31	-1.1	7.4	13.9	2.5	0.0	1.0				97.5

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperatur e (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	June	1	-1.9	8.9	19.5	0.9	0.0	0.5				98.0
2002	June	2	-1.5	11.9	23.9	0.0	0.0	0.0				98.0
2002	June	3	-1.1	12.5	25.1	0.0	0.0	0.0				98.0
2002	June	4	2.1	15.9	28.6	0.0	0.0	1.0				97.6
2002	June	5	3.8	16.0	30.8	1.2	0.0	0.3				97.0
2002	June	6	7.8	10.9	12.1	12.2	0.0	13.7				97.1
2002	June	7	7.8	15.5	25.8	4.0	0.0	3.6				97.6
2002	June	8	0.0	14.9	27.2	0.0	0.0	0.0				98.8
2002	June	9	1.6	16.0	27.4	0.0	0.0	0.0				99.1
2002	June	10	-0.2	16.1	29.5	0.0	0.0	0.0				98.6
2002	June	11	-1.7	15.4	29.6	0.0	0.0	0.0				98.0
2002	June	12	-1.8	17.0	32.0	0.0	0.0	0.0				98.1
2002	June	13	7.6	18.8	26.7	0.0	0.0	0.0				98.8
2002	June	14	1.6	13.7	26.0	0.1	0.0	0.0	0.0			98.7
2002	June	15	2.0	13.4	25.0	1.2	0.0	0.5	0.2			98.1
2002	June	16	8.8	12.3	16.6	0.2	0.0	0.3	0.2			97.8
2002	June	17	2.3	11.6	20.3	0.0	0.0	0.0	0.0			97.5
2002	June	18	-2.7	12.1	24.4	0.0	0.0	0.0	0.0			97.3
2002	June	19	-2.6	10.1	20.3	0.4	0.0	2.5	0.7			97.4
2002	June	20	-3.7	13.3	27.7	0.4	0.0	0.3	0.2			97.6
2002	June	21	3.9	16.0	29.9	0.0	0.0	0.0	0.2			97.7
2002	June	22	-1.1	16.9	31.7	0.0	0.0	0.0	0.0			98.0
2002	June	23	5.2	19.4	35.0	1.4	0.0	1.8	1.0			97.6
2002	June	24	10.0	19.8	29.1	0.4	0.0	0.0	0.7			97.5
2002	June	25	1.6	18.5	31.2	0.0	0.0	0.0	0.0			97.8
2002	June	26	7.3	21.2	34.9	0.0	0.0	0.0	0.0			97.6
2002	June	27	8.0	23.0	37.9	0.0	0.0	0.0	0.0			96.8
2002	June	28	13.6	18.7	27.8	2.2	0.0	3.3	2.5			96.7
2002	June	29	14.1	20.1	28.3	0.6	0.0	0.8	0.7			96.5
2002	June	30	10.3	14.3	17.5	14.7	0.0	10.9	17.4			96.5

Table I.2 Climatic Data Recorded at Other RAMP Climate Stations, January – December, 2002 (continued)

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	July	1	9.7	11.8	13.9	16.3	0.0	16.3	24.3			96.7
2002	July	2	5.0	12.7	20.4	2.3	0.0	1.3	1.5			97.7
2002	July	3	0.5	15.1	26.7	0.0	0.0	0.0	0.0			98.1
2002	July	4	7.9	13.0	18.7	6.4	0.0	2.0	5.6			97.2
2002	July	5	3.0	12.1	19.8	0.1	0.0	0.3	0.5			97.1
2002	July	6	8.1	16.4	26.1	1.0	0.0	0.0	0.0			98.0
2002	July	7	0.3	15.5	29.7	0.1	0.0	0.0	0.0			98.6
2002	July	8	2.4	19.4	34.9	0.0	0.0	0.0	0.0	0.0		98.8
2002	July	9	10.1	21.0	31.8	0.0	0.0	0.0	0.0	0.0		98.8
2002	July	10	3.7	20.6	34.1	0.0	0.0	0.0	0.0	0.0		98.5
2002	July	11	8.5	20.5	33.8	0.1	0.0	0.0	0.2	0.0		98.0
2002	July	12	9.9	21.3	32.9	0.0	0.0	0.0	0.0	1.4		97.9
2002	July	13	7.9	19.5	28.2	0.0	0.0	0.0	0.0	0.0		98.1
2002	July	14	7.3	16.7	21.5	7.0	0.0	5.3	6.1	4.4		97.0
2002	July	15	-0.1	12.6	21.3	0.1	0.0	0.0	0.2	0.0		97.3
2002	July	16	2.3	14.1	24.9	0.0	0.0	0.0	0.0	0.0		98.4
2002	July	17	3.4	14.1	25.9	0.0	0.0	0.0	0.0	0.1		98.3
2002	July	18	9.4	14.8	18.1	5.8	0.0	4.6	5.1	12.9		97.9
2002	July	19	12.3	15.7	20.9	0.3	0.0	0.3	0.2	0.1		97.9
2002	July	20	11.6	13.7	15.0	26.5	0.0	29.2	20.8	33.7		97.6
2002	July	21	6.9	16.4	26.3	0.0	0.0	1.0	0.0	4.6		98.7
2002	July	22	0.8	16.8	31.0	0.0	0.0	0.0	0.0	0.0		98.5
2002	July	23	9.7	17.2	29.5	4.7	0.0	2.5	2.2	0.6		97.9
2002	July	24	5.3	19.1	32.2	0.0	0.0	0.0	0.0	1.4		97.6
2002	July	25	9.1	20.4	32.9	0.2	0.0	0.3	0.5	0.0		97.1
2002	July	26	9.9	17.6	26.5	28.5	0.0	0.8	0.5	0.0		97.0
2002	July	27	11.9	16.0	23.1	9.8	0.0	9.1	12.3	0.0		96.9
2002	July	28	7.7	17.1	25.2	6.3	0.0	2.0	6.6	0.0		96.6
2002	July	29	1.3	13.4	23.2	0.0	0.0	0.0	0.5	0.0		97.0
2002	July	30	6.2	10.5	12.8	20.6	0.0	26.2	20.6	0.0		97.3
2002	July	31	8.2	10.1	12.2	1.8	0.0	5.3	2.2	0.0		98.0

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	August	1	0.6	9.1	17.1	0.2	0.0	0.0	0.0	0.0		98.9
2002	August	2	-2.8	7.0	16.0	0.1	0.0	0.8	0.2	0.0		99.0
2002	August	3	3.6	9.1	15.0	0.0	0.0	0.0	0.0	0.0		99.1
2002	August	4	-2.5	10.1	21.2	0.0	0.0	0.0	0.0	0.0		99.2
2002	August	5	5.2	9.6	12.6	8.1	0.0	6.3	7.8	0.0		98.7
2002	August	6	5.6	14.1	25.2	0.0	0.0		0.0	0.0		98.0
2002	August	7	1.1	15.2	29.3	0.0	0.0		0.0	2.3		98.2
2002	August	8	1.4	16.2	30.2	0.0	0.0		0.0	0.1		98.1
2002	August	9	4.2	15.8	29.2	0.0	0.0		0.0	0.0	0.0	97.6
2002	August	10	3.2	13.7	22.1	0.0	0.0		0.0	0.0	0.1	97.5
2002	August	11	5.5	14.8	26.0	0.0	0.0		0.0	0.0	0.0	97.9
2002	August	12	3.4	14.5	24.4	0.0	0.0		4.4	0.0	0.0	97.8
2002	August	13	11.9	15.7	27.1	3.8	0.0		1.5	0.0	2.2	96.7
2002	August	14	10.6	12.8	15.5	1.5	0.0		2.2	8.8	6.7	97.1
2002	August	15	7.0	11.2	18.0	17.8	0.0		10.8	38.9	7.9	97.9
2002	August	16	-0.7	8.4	18.6	2.6	0.0		2.4	4.5	4.0	98.1
2002	August	17	-2.6	5.8	18.2	0.3	0.0		0.5	0.0	0.5	97.9
2002	August	18	-2.3	9.5	24.6	0.0	0.0		2.0	0.1	0.0	97.4
2002	August	19	2.4	8.9	15.8	4.9	0.0		6.6	1.4	4.6	97.4
2002	August	20	1.7	10.0	23.3	0.0	0.0		0.0	0.0	0.0	97.8
2002	August	21	2.0	14.3	28.3	0.0	0.0		0.0	0.0	0.0	97.5
2002	August	22	7.2	17.4	28.8	0.0	0.0		0.0	0.0	0.0	97.4
2002	August	23	3.7	17.2	30.4	0.0	0.0		0.0	0.0	0.0	97.7
2002	August	24	7.0	17.4	29.7	0.0	0.0		0.0	0.0	0.0	98.0
2002	August	25	1.3	11.6	19.6	1.9	0.0		1.2	1.0	0.8	98.4
2002	August	26	10.9	17.0	27.7	2.1	0.0		2.0	0.4	0.8	98.3
2002	August	27	7.9	17.6	29.9	0.0	0.0		0.0	0.0	0.0	98.4
2002	August	28	7.9	18.7	32.6	0.0	0.0		0.0	0.0	0.0	97.9
2002	August	29	7.3	19.6	32.6	0.0	0.0		0.0	0.0	0.0	97.4
2002	August	30	9.0	15.6	20.3	2.7	0.0		1.5	3.9	3.1	97.8
2002	August	31	2.9	13.8	26.7	1.4	0.0		0.0	0.2	0.8	97.6

Table I.2 Climatic Data Recorded at Other RAMP Climate Stations, January – December, 2002 (continued)

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	September	1	6.2	14.1	24.2	4.0	0.0		0.2	1.0	1.0	96.8
2002	September	2	6.9	12.3	18.1	0.9	0.0		0.5	0.0	1.7	97.2
2002	September	3	6.2	11.2	15.9	0.1	0.0		0.0	15.2	0.0	97.8
2002	September	4	10.2	12.4	17.2	17.6	0.0		16.9	4.9	33.9	97.9
2002	September	5	6.6	10.8	17.0	0.2	0.0		0.5	0.0	0.0	98.4
2002	September	6	3.3	9.9	18.6	0.4	0.0		0.5	0.0	0.0	98.3
2002	September	7	0.5	9.3	21.7	1.9	0.0		0.7	0.0	0.0	97.6
2002	September	8	1.0	10.6	22.5	0.1	0.0		0.0	0.0	2.3	97.2
2002	September	9	2.1	10.9	23.4	0.0	0.0		0.0	0.1	0.1	97.6
2002	September	10	1.2	12.3	25.9	0.0	0.0		0.0	0.0		97.8
2002	September	11	-0.4	10.6	23.6	0.0	0.0	0.0	0.0	0.0		97.9
2002	September	12	-2.2	8.7	21.9	0.0	0.0	1.5	0.0	1.2		98.0
2002	September	13	-1.1	11.2	21.7	3.5	0.0	4.1	1.2	7.0		97.7
2002	September	14	-3.9	8.0	24.0	0.0	0.0	0.0	0.0	0.0		97.5
2002	September	15	3.5	12.1	24.8	0.0	0.0	0.0	0.2	0.0		97.1
2002	September	16	-0.2	9.1	20.1	0.3	0.0	0.0	0.2	0.0		96.8
2002	September	17	-0.5	9.5	22.9	0.0	0.0	0.0	0.0	0.0		96.8
2002	September	18	-3.1	7.6	21.9	0.0	0.0	0.0	0.0	0.1		96.9
2002	September	19	5.0	10.1	18.0	2.8	0.0	3.3	1.7	0.0		95.8
2002	September	20	3.7	7.4	11.8	0.3	0.0	5.1	0.0	1.5		96.9
2002	September	21	-1.3	5.3	13.6	0.4	0.0	1.3	0.0	0.1		98.4
2002	September	22	-4.5	3.2	12.1	0.0	0.0	0.8	0.2	2.4		98.8
2002	September	23	-7.4	1.2	13.6	0.0	0.0	0.0	0.0	0.5		98.4
2002	September	24	-9.4	-2.6	7.8	0.0	0.0	0.0	0.0	0.1		98.6
2002	September	25	-13.8	-2.8	12.4	0.0	0.0	0.0	0.0	0.0		98.4
2002	September	26	-10.4	-1.4	10.0	0.0	0.0	0.0	0.0	0.0		98.4
2002	September	27	-2.2	2.3	11.8	0.0	0.0	0.0	0.0	0.0		98.3
2002	September	28	-3.2	5.7	13.7	4.4	0.0	3.6	3.2	0.4		96.4
2002	September	29	-1.6	7.4	16.6	0.5	0.0	2.5	0.7	0.0		97.0
2002	September	30	-5.8	0.4	9.2	0.1	0.0	0.0	0.0	0.0		98.1

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperatur e (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	October	1	-9.2	-0.6	13.1	0.0	0.0	0.0	0.0	0.5		98.4
2002	October	2	-5.0	3.5	14.1	2.4	0.0	2.3	2.4	1.8		96.7
2002	October	3	-0.7	4.6	10.3	2.4	0.0	1.5	2.0	0.4		97.6
2002	October	4	-4.5	-0.3	6.7	0.0	0.0	0.3	0.0	1.4		98.3
2002	October	5	-7.4	-1.1	3.7	0.3	0.0	0.0	0.2	1.7		98.1
2002	October	6	-7.3	-0.2	8.2	0.0	0.0	0.3	0.0	0.1		97.8
2002	October	7	-5.9	2.7	12.5	0.0	0.0	0.0	0.0	0.1		97.8
2002	October	8	-5.9	3.9	17.7	0.0	0.0	0.3	0.0	0.1		97.1
2002	October	9	-4.1	1.3	11.4	1.9	0.0	0.0	0.0	0.6		96.7
2002	October	10	-5.0	0.3	5.5	0.0	0.0	0.0	0.0	1.4		97.3
2002	October	11	-2.9	-0.4	5.2	0.1	0.0	0.0	0.0	0.3		98.6
2002	October	12	-5.3	-2.1	5.2	0.0	0.0	0.0	0.0	0.7		98.8
2002	October	13	-2.3	0.8	6.2	1.2	0.0	1.0	1.5	1.3		97.6
2002	October	14	-12.1	-2.6	3.2	0.0	0.0	0.0	0.0	0.1		98.9
2002	October	15	-12.8	-4.0	1.6	4.1	0.0	1.0	0.2	1.9		98.7
2002	October	16	-3.2	-2.0	-0.2	0.1	0.0	0.3	0.0	0.0		98.5
2002	October	17	-4.4	-2.6	-0.7	0.0	0.0	0.0	0.0	4.1		97.4
2002	October	18	-5.9	-3.5	-0.5	0.0	0.0	0.0	0.0	0.0		98.4
2002	October	19	-12.2	-4.1	2.8	0.0	1.5	0.0	0.2	0.0		98.6
2002	October	20	-21.9	-12.0	3.2	0.0	1.4	0.0	1.5	0.6		98.9
2002	October	21	-17.7	-6.4	0.7	0.0	0.1	0.0	0.0	0.0		99.7
2002	October	22	-18.2	-7.3	4.2	0.0	0.9	0.0		2.4		99.7
2002	October	23	-13.3	-4.8	4.9	0.0	1.5	0.0				98.5
2002	October	24	-6.8	-1.3	3.2	0.0	1.5	0.0				98.0
2002	October	25	-4.7	-2.1	-0.5	0.0	0.0	0.0				98.8
2002	October	26	-12.9	-5.3	-3.1	0.0	0.0	0.0				99.1
2002	October	27	-20.2	-9.9	0.0	0.0	0.3					98.7
2002	October	28	-20.3	-8.6	-1.8	0.0	0.0					100.0
2002	October	29	-25.2	-15.4	-1.4	0.0	0.0					100.3
2002	October	30	-17.5	-8.9	-0.5	0.0	0.0					99.2
2002	October	31	-18.8	-9.4	1.9	0.0	0.0					98.7

Table I.2 Climatic Data Recorded at Other RAMP Climate Stations, January – December, 2002 (continued)

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	November	1	-17.6	-9.5	-2.9	0.0	0.0					98.6
2002	November	2	-9.8	-4.7	-2.7	0.0	0.0					98.3
2002	November	3	-4.8	-2.0	1.3	0.3	0.0					98.4
2002	November	4	-2.5	-0.7	3.0	0.6	0.0					97.3
2002	November	5	-16.1	-6.8	-0.9	0.0	0.0					97.8
2002	November	6	-15.5	-10.7	-7.4	0.0	0.0					97.5
2002	November	7	-18.4	-11.8	-9.7	0.0	0.0					97.2
2002	November	8	-16.7	-13.3	-10.8	0.0	0.0					97.2
2002	November	9	-13.6	-11.9	-9.8	0.0	0.0					97.4
2002	November	10	-20.3	-13.4	-8.0	0.0	0.0					98.0
2002	November	11	-22.0	-14.5	-8.6	0.0	0.0					98.2
2002	November	12	-28.9	-21.8	-13.6	0.0	0.0					98.5
2002	November	13	-29.2	-22.4	-16.1	0.0	0.0					98.3
2002	November	14	-22.6	-17.3	-14.2	0.0	0.0					98.7
2002	November	15	-17.9	-11.4	-4.9	0.0	0.0					98.0
2002	November	16	-12.7	-8.1	-3.5	0.0	0.0					97.0
2002	November	17	-9.8	-2.6	1.4	0.0	0.0					95.9
2002	November	18	-15.5	-8.2	0.1	0.0	0.0					96.9
2002	November	19	-15.7	-9.1	-5.5	0.0	0.0					97.6
2002	November	20	-12.3	-6.8	0.0	0.0	0.0					98.1
2002	November	21	-14.5	-6.7	1.1	0.0	0.0					97.7
2002	November	22	-10.3	-2.8	1.7	0.0	0.0					98.1
2002	November	23	-13.0	-9.6	-5.9	0.0	0.0					99.8
2002	November	24	-18.2	-9.7	-4.1	0.0	0.0					98.6
2002	November	25	-24.5	-17.9	-10.3	0.0	0.0					99.3
2002	November	26	-18.1	-13.7	-5.4	0.0	0.0					98.6
2002	November	27	-15.7	-4.6	2.5	0.0	0.0					97.6
2002	November	28	-2.1	5.9	9.5	0.0	0.0					96.8
2002	November	29	-3.6	-0.9	4.9	0.0	0.0					98.8
2002	November	30	-6.5	-3.7	0.8	0.0	0.0					98.0

Year	Month	Day	RAMP Station S16 Calumet River					RAMP Station S3 Iyinimin Creek	RAMP Station S19 Tar River Lowland	RAMP Station S29 Christina RIver	RAMP Station L1 McClellan d Lake	RAMP Station S5A Muskeg River Aurora
			Minimum Temperatur e (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Total Rainfall (mm)	Total Snowfall (mm SWE)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Total Rainfall (mm)	Mean Barometric Pressure (kPa)
2002	December	1	-9.9	-6.5	-3.1	0.0	0.0					97.8
2002	December	2	-30.3	-20.4	-9.9	0.0	0.0					99.8
2002	December	3	-31.6	-22.0	-12.9	0.0	0.0					99.8
2002	December	4	-13.1	-9.4	-7.2	0.0	0.0					98.9
2002	December	5	-15.4	-10.8	-6.7	0.0	0.0					98.0
2002	December	6	-27.4	-13.6	-7.7	0.0	0.0					98.2
2002	December	7	-28.4	-18.8	-12.2	0.0	0.0					98.7
2002	December	8	-12.6	-7.6	-2.1	0.0	0.0					97.7
2002	December	9	-14.7	-10.9	-4.7	0.0	0.0					97.1
2002	December	10	-14.3	-8.5	-3.9	0.0	0.0					96.6
2002	December	11	-7.2	-4.6	-3.4	0.0	0.0					96.8
2002	December	12	-12.3	-8.2	-6.0	0.0	0.0					96.9
2002	December	13	-18.0	-9.9	-4.7	0.0	0.0					96.2
2002	December	14	-20.6	-13.9	-3.9	0.0	0.0					96.4
2002	December	15	-15.2	-6.0	-2.3	0.0	0.0					95.9
2002	December	16	-3.0	-1.6	-0.7	0.0	0.0					95.6
2002	December	17	-2.9	-1.7	-0.4	0.0	0.0					95.8
2002	December	18	-14.6	-7.6	-1.9	0.0	0.0					97.1
2002	December	19	-22.5	-14.4	-9.2	0.0	0.0					98.3
2002	December	20	-24.3	-16.1	-10.9	0.0	0.0					98.8
2002	December	21	-25.9	-21.3	-16.3	0.0	0.0					98.8
2002	December	22	-26.5	-23.3	-18.5	0.0	0.0					98.9
2002	December	23	-22.1	-17.1	-12.8	0.0	0.0					98.3
2002	December	24	-18.2	-13.8	-8.9	0.0	0.0					97.3
2002	December	25	-41.0	-35.5	-28.3	0.0	0.0					96.8
2002	December	26	-41.1	-33.4	-22.9	0.0	0.0					96.2
2002	December	27	-44.7	-39.1	-28.8	0.0	0.0					97.2
2002	December	28	-43.5	-36.6	-25.4	0.0	0.0					97.9
2002	December	29	-41.8	-36.3	-26.5	0.0	0.0					97.6
2002	December	30	-42.0	-35.4	-23.3	0.0	0.0					97.4
2002	December	31	-37.1	-24.2	-14.3	0.0	0.0					97.0

APPENDIX II

UPDATED CLIMATIC AND HYDROLOGIC DATABASE

The 2002 RAMP Climate and Hydrology Program included the important task of updating the regional climatic and hydrologic database. The updated database is stored in a compact disc (CD) for ease of data access. Development and continuing updates of this database are required to protect the monitoring investments and to provide readily-accessible data for future water management studies, characterize baseline conditions and comply with permit conditions.

The database CD included in this appendix contains data from local monitoring programs and regional data collected by Environment Canada, including climatic data collected by Meteorological Services Canada (MSC) and hydrologic data collected by the Water Survey of Canada (WSC). Data included in the database CD are summarized in Table II.1. Tables II.2, II.3, II.4 and II.5 present descriptions of site locations and available data for local hydrologic stations, local climatic stations, regional hydrologic stations, and regional climatic stations, respectively. The directory structure of the CD is detailed in Table II.6.

Table II.1 Contents of RAMP Climate and Hydrology Database CD

RAMP Data		Environment Canada Data	
Hydrology	**Climate**	**Hydrology**	**Climate**
North of Fort McMurray	North of Fort McMurray	North of Fort McMurray	North of Fort McMurray
Alsands Drain (S1)	Aurora Climate Station	Athabasca River (WSC 07DA001)	Birch Mountain. Lookout (MSC 3060700)
Jackpine Creek (S2)	Iyinimin Creek Station	Beaver River (WSC 07DA005)	Bitumont Lookout (MSC 3060705)
Iyinimin Creek (S3)	Calumet River Station	Steepbank River (WSC 07DA006)	Buckton Lookout (MSC 3060922)
Blackfly Creek (S4)	Tar River Lowland Station	Poplar Creek (WSC 07DA007)	Ells Lookout (MSC 3062300)
Muskeg River Aurora (S5/S5A)	McClelland Lake Station	Muskeg River (WSC 07DA008)	Fort McMurray Airport (MSC 3062693)
Mills Creek (S6)	Snow Course Survey in the Muskeg River Basin	Jackpine Creek (WSC 07DA009)	Johnson Lake Lookout (MSC 3063563)
Muskeg River WSC (S7)	Snow Course Survey in the Fort Creek Basin	Ells River (WSC 07DA010)	Legend Lookout (MSC 3073792)
Stanley Creek (S8)	Snow Course Survey in the Birch Mountains East Slope	Unnamed Creek (WSC 07DA011)	Mildred Lake (MSC 3064531 and MSC 3064528)
Kearl Lake Outlet (S9)	South of Fort McMurray	Asphalt Creek (WSC 07DA012)	Muskeg Lookout (MSC 3064740)
Wapasu Creek (S10)	Christina River Station	Pierre River (WSC 07DA013)	Richardson Lookout (MSC 3065492)
Poplar Creek (S11)		Calumet River (WSC 07DA014)	Tar Island (MSC 3066364)
Fort Creek (S12)		Tar River (WSC 07DA015)	Thickwood Lookout (MSC 3066380)
Alsands Pond #3 (S13)		Joslyn Creek (WSC 07DA016)	South of Fort McMurray
Ells River (S14)		Ells River (WSC 07DA017)	Algar Lookout (MSC 3060110)
Tar River (S15)		Beaver River (WSC 07DA018)	Christina Lookout (MSC 3061580)
Calumet River (S16)		Tar River (WSC 07DA019)	Conklin Lookout (MSC 3061800)
Upland Tar River (S17)		MacKay River (WSC 07DB001)	Cowpar Lookout (MSC 3061930)
Upland Calumet River (S18/S18A)		Dover River (WSC 07DB002)	Gordon Lake Lookout (MSC 3062889)
Lowland Tar River (S19)		Dunkirk River (WSC 07DB003)	Heart Lake Lookout (MSC 3063120)
Upland Muskeg River (S20)		Thickwood Creek (WSC 07DB004)	Round Hill Lookout (MSC 3065560)
Shelley Creek (S21)		MacKay River (WSC 07DB005)	Stoney Mountain Lookout (MSC 3066160)
Muskeg Creek (S22)		Firebag River (WSC 07DC001)	Winefred Lookout (MSC 3067590)
Aurora Boundary Weir (S23)		Lost Creek (WSC 07DC002)	
Athabasca River (S24)		South of Fort McMurray	
Susan Lake Outlet (S25)		Horse River (WSC 07CC001)	
MacKay River WSC (S26)		Clearwater River at Draper (WSC 07D001)	
Firebag River WSC (S27)		Hangingstone River (WSC 07CD004)	
Khahago Creek (S28)		Clearwater River above Christina River (WSC 07CD005)	
McClelland Lake (L1)		Gregoire Lake (WSC 07CE001)	
Kearl Lake (L2)		Christina River (WSC 07CE002)	
Isadore's Lake (L3)		Pony Creek (WSC 07CE003)	
South of Fort McMurray		Robert Creek (WSC 07CE004)	
Christina River (S29)		Jackfish River (WSC 07CE005)	
Hangingstone River (S30)		Birch Creek (WSC 07CE006)	
Hangingstone Creek (S31)			
Surmont Creek (S32)			

Table II.2 RAMP Hydrologic Data

Station	Location		Basin Characteristics		Period of Record
	North	West	Drainage Area	Elevation	
Alsands Drain (S1)	57° 15’ 12”	111° 29’ 52”	15.8 km^2	280 – 300 m	1995 – 2002
Jackpine Creek (S2)	57° 15’ 31”	111° 27’ 55”	358 km^2	270 – 490 m	1995 – 2002
Iyinimin Creek (S3)	57° 15’ 00”	111° 10’ 27”	32.3 km^2	340 – 560 m	1995 – 1999; 2001 – 2002
Blackfly Creek (S4)	57° 12’ 20”	111° 15’ 22”	31.1 km^2	345 – 540 m	1995 – 1998
Muskeg River Aurora (S5/S5A)	57° 18’ 30”	111° 23’ 43”	552 km^2	280 – 560 m	1995 – 2002
Mills Creek (S6)	57° 14’ 44”	111° 35’ 57”	23.8 km^2	280 – 300 m	1997 – 2002
Muskeg River WSC (S7)	57° 11’ 29”	111° 34’ 10”	1,460 km^2	260 – 560 m	1998 – 2002
Stanley Creek (S8)	57° 21’ 06”	111° 22’ 26”	71.8 km^2	290 – 360 m	1999 – 2002
Kearl Lake Outlet (S9)	57° 15’ 57”	111° 15’ 57”	73.6 km^2	330 – 560 m	1998 – 1999; 2001 – 2002
Wapasu Creek (S10)	57° 20’ 35”	111° 09’ 40”	90.7 km^2	320 – 560 m	1998 – 1999; 2001 – 2002
Poplar Creek (S11)	56° 54’ 46”	111° 27’ 44”	422 km^2	240 – 510 m	1995 – 2002
Fort Creek (S12)	57° 24’ 48”	111° 37’ 18”	35.5 km^2	250 – 360 m	2000 – 2002
Alsands Pond #3 (S13)	57° 14’ 47”	111° 30’ 58”	disturbed area	gauge at 279 m	2000 – 2002
Ells River (S14)	57° 17’ 10”	111° 42’ 30”	2,450 km^2	235 – 730 m	2001 – 2002
Tar River (S15)	57° 21’ 12”	111° 45’ 25”	301 km^2	285 – 810 m	2001 – 2002
Calumet River (S16)	57° 23’ 46”	111° 41’ 47”	182 km^2	265 – 750 m	2001 – 2002
Upland Tar River (S17)	57° 21’ 35”	111° 55’ 22”	13.8 km^2	365 – 650 m	2001 – 2002
Upland Calumet River (S18)	57° 26’ 40”	111° 47’ 17”	48 km^2	308 – 750 m	2001 – 2002
Lowland Tar River (S19)	57° 19’ 00”	111° 42’ 30”	11.5 km^2	270 – 300 m	2001 – 2002
Upland Muskeg (S20)	57° 20’ 09”	111° 07’ 48”	157 km^2	335 – 560 m	2001 – 2002
Shelley Creek (S21)	57° 16’ 26”	111° 23’ 28”	16 km^2	295 – 327 m	2001 – 2002
Muskeg Creek (S22)	57° 16’ 56”	111° 18’ 52”	345 km^2	308 – 540 m	2001 – 2002
Aurora Boundary Weir (S23)	57° 17’ 30”	111° 29’ 33”	disturbed	gauge at 295 m	2001 – 2002
Athabasca River (S24)	57° 29’ 46”	111° 33’ 43”	146,000 km^2	230 – 1490 m	2001 – 2002
Susan Lake Outlet (S25)	57° 27’ 28”	111° 35’ 31”	13.6 km^2	305 – 230 m	2002
MacKay River WSC (S26)	57° 12’ 39”	111° 41’ 41”	5,570 km^2	240 – 520 m	2002
Firebag River WSC (S27)	57° 38’ 26”	111° 11’ 22”	5,990 km^2	270 – 640 m	2002
Khahago Creek (S28)	57° 13’ 21”	111° 19’ 23”	13.6 km^2	325 – 540 m	2001 – 2002
Christina River WSC (S29)	56° 26’ 30”	111° 05’ 10”	4,860 km^2	476 – 732 m	2002
Hangingstone River (S30)	56° 25’ 04”	111° 22’ 26”	520 km^2	500 – 720 m	2001 – 2002
Hangingstone Creek (S31)	56° 16’ 07”	111° 29’ 21”	160 km^2	660 – 720 m	2001 – 2002
Surmont Creek (S32)	56° 26’ 06”	111° 09’ 29”	92 km^2	500 – 700 m	2000 – 2002
McClelland Lake (L1)	57° 29’ 30”	111° 16’ 37”	191 km^2	295 – 350 m	1997-2002
Kearl Lake (L2)	57° 18’ 15”	111° 14’ 40”	72.6 km^2	330 – 560 m	1999-2002
Isadore’s Lake (L3)	57° 13’ 15”	111° 36’ 24”	28.0 km^2	240 – 300 m	2000-2002
TSS Data	all local hydrologic monitoring stations				1997 – 2002
Ice thickness data	all local hydrologic monitoring stations				1997 – 2001

Note: Locations of these hydrometric monitoring sites are shown on Figures 3.1 and 3.2.

Table II.3 RAMP Climatic Data

Station	Location	Daily Mean Data	Hourly Data
Aurora Climate Station (RAMP Station C1)	57° 14' 16" North 111° 24' 27" West 310 m elevation	mean daily temperature maximum daily temperature minimum daily temperature total daily rainfall total daily snowfall mean relative humidity total global solar radiation mean daily wind speed mean daily wind direction 5 second gust wind speed 5 second gust wind direction 2 minute gust wind speed 10 minute gust wind speed	air temperature relative humidity mean wind speed mean wind vector magnitude mean wind vector direction sigma theta wind speed standard deviation peak 5 second wind speed peak wind speed time peak wind speed direction maximum 2 minute wind speed TBRG precipitation instantaneous TBRG precipitation hourly accumulation snow depth mean wind speed minute 50-60 mean wind vector magnitude minute 50-60 mean wind vector direction minute 50-60 sigma theta minute 50-60 peak 5 second wind speed minute 50-60 maximum 10 minute wind speed temperature relative humidity mean wind speed 1 hour mean wind vector magnitude 1 hour mean wind vector direction 1 hour sigma theta maximum 1 minute air temperature minimum 1 minute air temperature global solar radiation
Iyinimin Creek Station (RAMP Station S3)	57° 15' 00" North 111° 10' 27" West 340 m elevation	TBRG rainfall instantaneous TBRG rainfall hourly accumulation 1999, 2001-2002	
Calumet River Station (RAMP Station S16)	57° 23' 46" North 111° 41' 47" West 265 m elevation	TBRG rainfall and snowfall instantaneous TBRG rainfall and snowfall hourly accumulation Air temperature 15-minute interval 2001-2002	
Tar River Lowland Station (RAMP Station S19)	57° 15' 00" North 111° 42' 30" West 270 m elevation	TBRG rainfall instantaneous TBRG rainfall hourly accumulation 2002	
Christina River Station (RAMP Station S29)	56° 26' 30" North 111° 05' 10" West *** m elevation	TBRG rainfall instantaneous TBRG rainfall hourly accumulation 2002	
McClelland Lake Station (RAMP Station L1)	57° 29' 30" North 111° 16' 37" West 295 m elevation	TBRG rainfall instantaneous TBRG rainfall hourly accumulation 2002	
Kearl Lake Outlet Station	57° 15' 57" North 111° 15' 57" West 330 m elevation	atmospheric pressure 1999 monitored in 2000-2001 at Aurora Climate Station monitored in 2002 at Muskeg River Aurora (RAMP Station S5A)	
Snow course survey in the Muskeg River Basin	Centred on 57° 15' North 111° 30' West	snow survey data March 1997, March 1998, March 1999, March 2000, March 2001	
Snow course survey in the Fort Creek Basin	Centred on 57° 20' North 111° 35' West	snow survey data March 2000	
Snow course survey in the Birch Mountains East Slope	Centred on 57° 20' North 111° 45' West	snow survey data March 2001, March 2002	

Note: Locations of these climatic monitoring sites are shown on Figures 3.1, 3.2 and 3.3.

Table II.4 Environment Canada (WSC) Hydrologic Data

Station	Location		Basin Characteristics		Period of Record
	North	West	Drainage Area	Elevation	
Horse River (WSC Station 07CC001)	56° 42' 29"	111° 23' 40"	2,130 km^2	250 – 738 m	1976 – 1979
Clearwater River at Draper (WSC Station 07CD001)	56° 41' 07"	111° 15' 15"	30,800 km^2	245 – 550 m	1957 – 2002
Hangingstone River (WSC Station 07CD004)	56° 42' 18"	111° 21' 20"	959 km^2	250 – 720 m	1965 – 2002
Clearwater River above Christina River (WSC Station 07CD005)	56° 39' 40"	110° 55' 40"	17,000 km^2	250 – 550 m	1966 – 2002
Gregoire Lake (WSC Station 07CE001)	56° 26' 30"	111° 05' 10"	263 km^2	472 – 750 m	1969 – 2002
Christina River[1] (WSC Station 07CE002)	55° 50' 20"	110° 52' 00"	4,860 km^2	476 – 732 m	1982 – 2002
Pony Creek (WSC Station 07CE003)	55° 52' 11"	110° 55' 00"	278 km^2	518 – 701 m	1982 – 2002
Robert Creek (WSC Station 07CE004)	56° 23' 01"	111° 01' 42"	54.1 km^2	470 – 740 m	1982 – 1995
Jackfish River (WSC Station 07CE005)	55° 40' 25"	111° 06' 00"	1,290 km^2	549 – 637 m	1982 – 1995
Birch Creek (WSC Station 07CE006)	55° 37' 07"	111° 05' 09"	232 km^2	560 – 655 m	1984 – 1995
Athabasca River (WSC Station 07DA001)	56° 46' 50"	111° 24' 00"	133,000 km^2	240 – 1490 m	1957 – 2002
Beaver River (WSC Station 07DA005)	57° 06' 00"	111° 38' 00"	454 km^2	270 – 530 m	1961 – 1966 1972 – 1975
Steepbank River (WSC Station 07DA006)	57° 00' 14"	111° 24' 53"	1,320 km^2	300 – 580 m	1972 – 2002
Poplar Creek (WSC Station 07DA007)	56° 54' 50"	111° 27' 35"	151 km^2	270 – 460 m	1972 – 1986
Muskeg River[1] (WSC Station 07DA008)	57° 11' 30"	111° 34' 05"	1,460 km^2	260 – 560 m	1974 – 2002
Jackpine Creek[2] (WSC Station 07DA009)	57° 15' 34"	111° 27' 53"	358 km^2	270 – 490 m	1975 – 1993
Ells River[2] (WSC Station 07DA010)	57° 22' 30"	112° 33' 40"	1,380 km^2	640 – 730 m	1975 – 1979
Unnamed Creek (WSC Station 07DA011)	57° 39' 41"	111° 31' 11"	274 km^2	270 – 760 m	1975 – 1993
Asphalt Creek (WSC Station 07DA012)	57° 32' 20"	111° 40' 36"	148 km^2	290 – 850 m	1975 – 1977
Pierre River (WSC Station 07DA013)	57° 27' 55"	111° 39' 14"	123 km^2	270 – 820 m	1975 – 1977
Calumet River[2] (WSC Station 07DA014)	57° 24' 12"	111° 40' 57"	183 km^2	250 – 610 m	1975 – 1977
Tar River[2] (WSC Station 07DA015)	57° 21' 14"	111° 45' 29"	301 km^2	270 – 810 m	1975 – 1977
Joslyn Creek (WSC Station 07DA016)	57° 16' 27"	111° 44' 30"	257 km^2	270 – 760 m	1975 – 1993
Ells River (WSC Station 07DA017)	57° 16' 04"	111° 42' 51"	2,450 km^2	270 – 730 m	1975 - 1986
Beaver River (WSC Station 07DA018)	56° 56' 29"	111° 33' 54"	165 km^2	320 – 530 m	1975 – 2002
Tar River (WSC Station 07DA019)	57° 29' 05"	112° 01' 10"	103 km^2	620 – 810 m	1976 – 1977

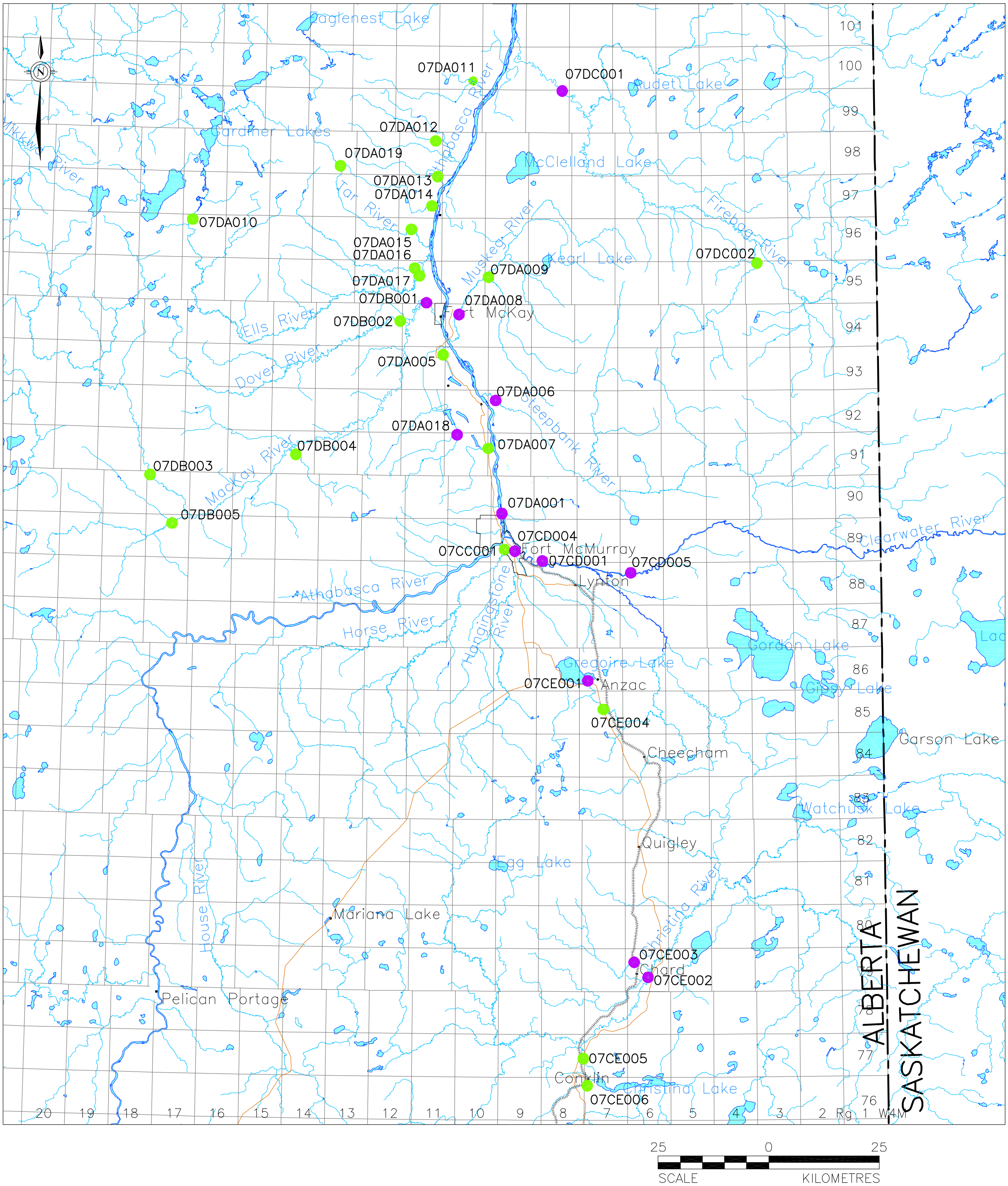
Table II.4 Environment Canada (WSC) Hydrologic Data (continued)

Station	Location		Basin Characteristics		Period of Record
	North	West	Drainage Area	Elevation	
MacKay River[1] (WSC Station 07DB001)	57° 12' 38"	111° 41' 36"	5,570 km^2	240 – 520 m	1972 – 2002
Dover River (WSC Station 07DB002)	57° 10' 12"	111° 47' 38"	963 km^2	290 – 580 m	1975 – 1977
Dunkirk River (WSC Station 07DB003)	56° 51' 20"	112° 42' 40"	1,570 km^2	490 – 820 m	1975 – 1979
Thickwood Creek (WSC Station 07DB004)	56° 53' 55"	112° 10' 15"	176 km^2	460 – 520 m	1976 – 1977
MacKay River (WSC Station 07DB005)	56° 45' 35"	112 ° 36' 50"	1,010 km^2	470 – 520 m	1983 – 1991
Firebag River[1] (WSC Station 07DC001)	57° 38' 30"	111° 10' 30"	5,990 km^2	270 – 580 m	1971 – 2002
Lost Creek (WSC Station 07DC002)	57° 17' 20"	110° 27' 50"	418 km^2	470 – 640 m	1976 – 1977

1 – This site is now monitored in winter months as part of the current program.

2 – This site is now monitored in open water months as part of the current program.

Note: Locations of these hydrometric monitoring sites are shown on Figure II.1.



LEGEND

- ROADWAYS
- RIVERS AND STREAMS
- ACTIVE HYDROMETRIC MONITORING STATIONS
- DISCONTINUED HYDROMETRIC MONITORING STATIONS

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUG. 2001. NAD 83 ZONE 12. SHEETS 74D, E AND L IN NAD 27, ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG, 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83, UTM ZONE 12.

PROJECT

RAMP 2002

TITLE

REGIONAL ENVIRONMENT CANADA (WSC) HYDROLOGIC MONITORING STATIONS

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Region-WSC-Station	
DESIGN	CS	19/02/03	SCALE AS SHOWN	REV. 0
CADD	AS	06/03/03		
CHECK			FIGURE: II.1	
REVIEW				

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Region-WSC-Stations.dwg Mar 15, 2003 - 4:31pm

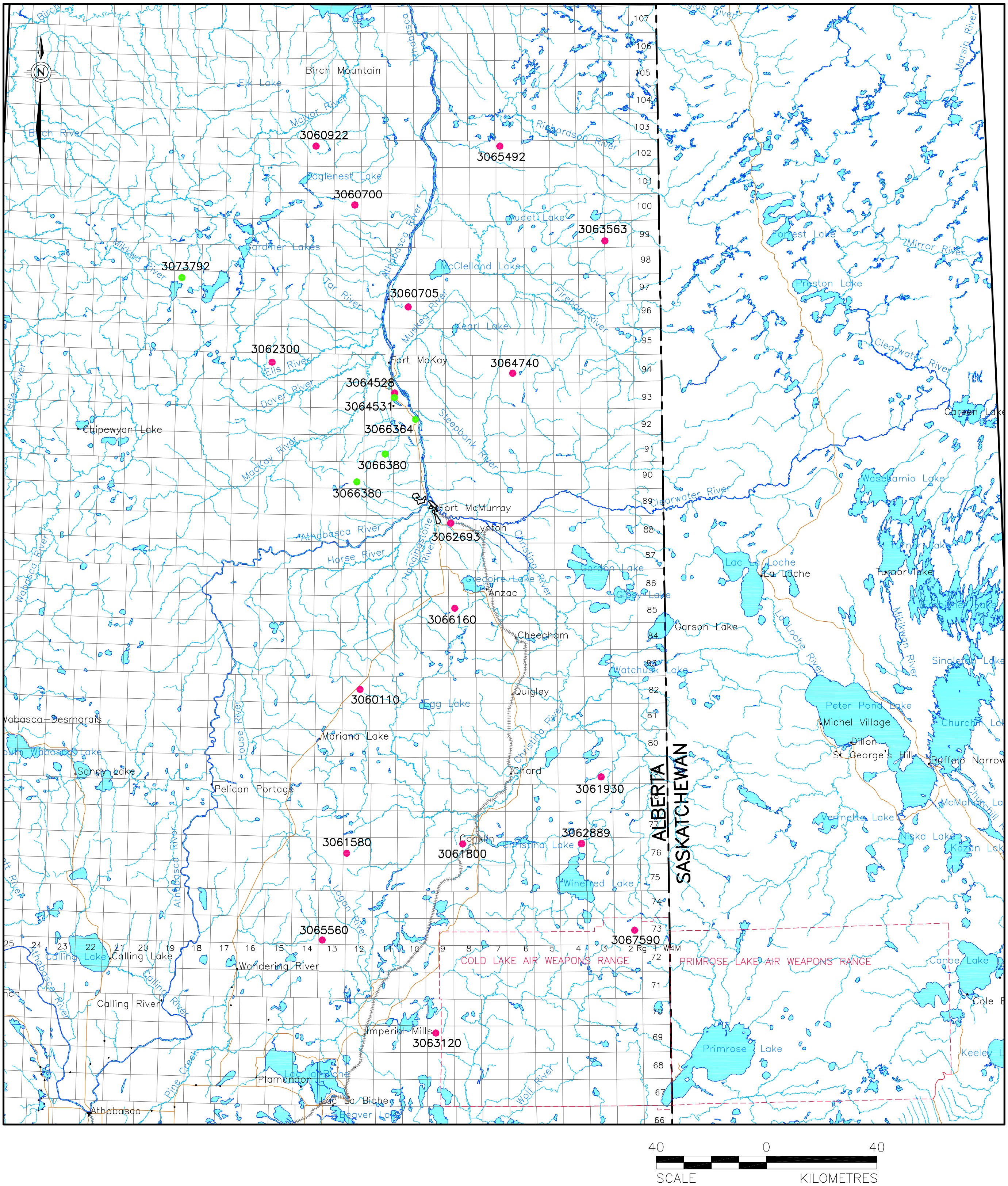
Table II.5 Environment Canada (MSC) Climatic Data

Station	Location		Elevation	Daily Mean Data	Hourly Data
	North	West			
Algar Lookout (MSC Station 3060110)	56° 07'	111° 47'	780 m	rainfall 1957 – 2002[1] temperature 1965 – 2002[1]	
Birch Mountain Lookout (MSC Station 3060700)	57° 43'	111° 51'	853 m	rainfall 1960 – 2002[1] temperature 1966 – 2002[1]	
Bitumont Lookout (MSC Station 3060705)	57° 22'	111° 32'	349 m	rainfall 1962 – 2002[1] temperature 1962 – 2002[1]	
Buckton Lookout (MSC Station 3060922)	57° 52'	112° 06'	793 m	rainfall 1965 – 2002[1] temperature 1965 – 2002[1]	
Christina Lookout (MSC Station 3061580)	55° 35'	111° 51'	823 m	rainfall 1967 – 2002[1] temperature 1967 – 2002[1]	
Conklin Lookout (MSC Station 3061800)	55° 37'	111° 11'	671 m	rainfall 1954 – 2002[1] temperature 1965 – 2002[1]	
Cowpar Lookout (MSC Station 3061930)	55° 50'	110° 23'	563 m	rainfall 1957 – 2002[1] temperature 1965 – 2002[1]	
Ells Lookout (MSC Station 3062300)	57° 11'	112° 20'	610 m	rainfall 1961 – 2002[1] temperature 1964 – 2002[1]	
Fort McMurray Airport (MSC Station 3062693)	56° 39'	111° 13'	369 m	rainfall 1944 – 2002 snowfall 1944 – 2002 precipitation 1944 – 2002 temperature 1944 – 2002	atmospheric pressure 1953 – 2002 dew point temperature 1953 – 2002 dry bulb temperature 1953 – 2002 wind speed 1953 – 2002 wind direction 1959 – 2002
Gordon Lake Lookout (MSC Station 3062889)	55° 37'	110° 30'	488 m	rainfall 1964 – 2002[1] temperature 1964 – 2002[1]	
Heart Lake Lookout (MSC Station 3063120)	55° 00'	111° 20'	887 m	rainfall 1947– 2002[1] temperature 1965 – 2002[1]	
Johnson Lake Lookout (MSC Station 3063563)	57° 35'	110° 20'	549 m	rainfall 1965 – 2002[1] temperature 1965 – 2002[1]	
Legend Lookout (MSC Station 3073792)	57° 27'	112° 53'	911 m	rainfall 1962 – 1995[1] temperature 1962 – 1995[1]	

Table II.5 Environment Canada (MSC) Climatic Data (continued)

Station	Location		Elevation	Daily Mean Data		Hourly Data	
	North	West					
Mildred Lake (MSC Station 3064531 and MSC Station 3064528)	57° 05'	111° 36'	310 m	rainfall snowfall precipitation temperature	1973 – 1982, 1993 – 2002 1973 – 1982, 1993 – 2002 1973 – 1982, 1993 – 2002 1973 – 1982, 1993 – 2002	temperature dew point temperature wind speed rainfall snow by weight snow on ground	1994 – 2002 1994 – 2002 1994 – 2002 1995 – 1996 1995 – 1996 1995 – 1996
Muskeg Lookout (MSC Station 3064740)	57° 08'	110° 54'	652 m	rainfall temperature	1965 – 2002[1] 1965 – 2002[1]		
Richardson Lookout (MSC Station 3065492)	57° 55'	110° 58'	305 m	rainfall temperature	1960 – 2002[1] 1964 – 2002[1]		
Round Hill Lookout (MSC Station 3065560)	55° 18'	111° 59'	750 m	rainfall temperature	1952 – 2002[1] 1951 – 2002[1]		
Stoney Mountain Lookout (MSC Station 3066160)	56° 23'	111° 14'	762 m	rainfall temperature	1954 – 2002[1] 1964 – 2002[1]		
Tar Island (MSC Station 3066364)	56° 59'	111° 28'	240 m	rainfall	1970 – 1984[1]		
Thickwood Lookout (MSC Station 3066380)	56° 53'	111° 39'	604 m	rainfall snowfall precipitation temperature	1957 – 1994[1] 1957 – 1991[1] 1957 – 1991[1] 1957 – 1992[1]		
Winefred Lookout (MSC Station 3067590)	55° 20'	110° 12'	744 m	rainfall temperature	1957 – 2002[1] 1965 – 2002[1]		

Notes: 1 – Seasonal values only.
Locations of these climatic monitoring sites are shown on Figure II.2.



LEGEND

ROADWAYS
RIVERS AND STREAMS
ACTIVE CLIMATE MONITORING STATIONS
DISCONTINUED CLIMATE MONITORING STATIONS

REFERENCE

ALBERTA NTDB DATA SUPPLIED BY GEOMATICS CANADA, AUG. 2001. NAD 83 ZONE 12. SHEETS 74D, E AND L IN NAD 27, ZONE 12. SASKATCHEWAN NTDB DATA SUPPLIED BY ISC, AUG, 2001. NAD 83 ZONE 13. ALL DATA CONVERTED TO NAD 83, UTM ZONE 12.

PROJECT

RAMP 2002

TITLE

REGIONAL ENVIRONMENT CANADA (MSC) CLIMATE MONITORING STATIONS

Golder Associates
Calgary, Alberta

PROJECT No. 022-2301.5300			FILE No. Region-MSC-Station	
DESIGN	CS	19/02/03	SCALE AS SHOWN	REV. 0
CADD	AS	06/03/03		
CHECK			**FIGURE: II.2**	
REVIEW				

R:\CAD\2300\022-2301\5300\Final 2002 Annual Report\ Drawing file: Region-MSC-Stations.dwg Mar 15, 2003 - 4:38pm

Table II.6 Directory Structure of Database CD

DATABASE_CD			
RAMP Data		**Environment Canada Data**	
Hydrology	**Climate**	**Hydrology**	**Climate**
<u>Stream Gauging Data</u> S1-Alsands Drain-95to02.xls S2-Jackpine Creek-95to02.xls S3-Iyinimin Creek-95to02.xls S4-Blackfly Creek-95to98.xls S5A-Muskeg River Aurora-95to02.xls S6-Mills Creek-96to02.xls S7-Muskeg River WSC-98to02.xls S8-Stanley Creek-99to02.xls S9-Kearl Lake Outlet-98to02.xls S10-Wapasu Creek-98to02.xls S11-Poplar Creek-95to02.xls S12-Fort Creek-00to02.xls S13-Albian Pond #3-00to02.xls S14-Ells River-01to02.xls S15-Tar River-01to02.xls S16-Calumet River-01to02.xls S17-Upland Tar River-01to02.xls S18A-Upland Calumet River-01to02.xls S19-Lowland Tar River-01to02.xls S20-Upland Muskeg River-01to02.xls S21-Shelley Creek-01to02.xls S22-Muskeg Creek-01to02.xls S23-Aurora Boundary-01to02.xls S24-Athabasca River-01to02.xls S25-Susan Lake Outlet-02.xls S26-MacKay River WSC-02.xls S27-Firebag River WSC-02.xls S28-Khahago Creek-01to02.xls S29-Christina River-02.xls S30-Hangingstone River-01to02.xls S31-Hangingstone Creek-01to02.xls S32-Surmont Creek-00to02.xls L1-McClelland Lake-97to02.xls L2-Kearl Lake-99to02.xls L3-Isadore's Lake-00to02.xls <u>Other Data</u> Muskeg-Ice Observations-97to02.xls Muskeg-TSS Observations-97to01.xls	<u>Aurora Climate Station</u> Aurora-Climate-95to02.xls Aurora-Raw Data-95to02.xls Aurora-Wind Roses-95to01.xls <u>Other Climatic Data</u> Iyinimin-TBRG-99to02.xls Kearl-Barometer-99to02.xls Calumet-Climatic-01to02.xls Tar Lowland-TBRG-02.xls Christina-TBRG-02.xls McClelland-TBRG-02.xls <u>Snow Survey Data</u> Muskeg-Snow Survey-97.xls Muskeg-Snow Survey-98.xls Muskeg-Snow Survey-99.xls Muskeg-Snow Survey-00.xls Muskeg-Snow Survey-01.xls Fort Hills-Snow Survey-00.xls Birch-Snow Survey-01.xls Birch-Snow Survey-02.xls	<u>Daily Mean WSC Data</u> Regional-Daily Discharges-02 Update.xls	<u>Daily MSC Data</u> Regional-Daily Climate-02 Update.xls <u>Hourly MSC Data</u> Ft McMurray A-Hourly Temperature-53to02.xls Ft McMurray A-Hourly Wind-53to02.xls Ft McMurray A-Hourly Pressure-53to02.xls Mildred Lake-Hourly Climate-85to02.xls

APPENDIX III

SUMMARY OF 2001-2002
BIRCH MOUNTAINS EAST SLOPE
SNOW COURSE SURVEY DATA

Table III.1 Summary of 2001 Birch Mountains East Slope Snow Course Survey Data

Terrain Type	Survey Plot No	Date of Survey	GPS Location	Snow Density (g/cm^3)	Snow Depth (cm)	Snow Water Equivalent (mm)	Description of Vegetation	Snow Cover Appearance
flat low lying	FL-01-1	14-Mar-01	6360676 N 455598 E	0.156	34.9	54.3	- young black spruce - 95%, ht. 5m, dia. 5cm tamarack - 5%, ht. 20m, dia. 10cm Labrador tea and young spruce <1m tall	- crust on top 0 - 2 cm clean, wet, sticky, compacted, needles, medium coarse grained
	FL-01-2	14-Mar-01	6359393 N 455449 E	0.123	33.9	41.8	- willow (2.5m tall) 90%, grass - 10% surrounded by white and black spruce	- crust on top 0 - 4 cm clean, wet, sticky, compacted, leaves
	FL-01-3	15-Mar-01	6354379 N 454245 E	0.158	35.2	55.8	- willow (<2.5m tall) 95%, grass (<0.5m tall) 5%	- crust on top 0 - 2 cm clean, wet, sticky, medium coarse grained
	FL-01-4	16-Mar-01	6364545 N 450795 E	0.140	31.7	44.4	- willow (3m tall) 95%, young spruce - 5%, ht. 6m, dia. 5cm grass and dogwood	- crust on top 0 - 3 cm clean, dry, compacted, coarse grained ice bottom
open land	OP-01-1	14-Mar-01	6362131 N 455610 E	0.155	36.7	57.0	- young spruce and aspen, dead trees, wild rose, buffalo berry, grass surrounded by aspen and spruce	- crust on top 0 - 4 cm clean, dry, compacted, medium coarse grained
	OP-01-2	15-Mar-01	6355475 N 449523 E	0.190	30.8	58.7	- grass surrounded by aspen and spruce,* beaver dam at east side of the open area	- crust on top 0 - 5 cm clean, wet, sticky compacted, medium coarse grained
open lake	OP-01-3	16-Mar-01	6359210 N 450705 E	0.151	30.1	45.4	- surrounded by aspen, spruce, alders and dead trees along the shoreline	- crust on top 0 - 4 cm clean, dry, compacted, ice bottom
	OP-01-4	16-Mar-01	6357988 N 452810 E	0.140	31.7	44.4	- cattails and grass surrounded by aspen and spruce	- crust on top 0 - 5 cm clean, wet, sticky, compacted, coarse grained ice bottom
mixed deciduous	MD-01-1	14-Mar-01	6362686 N 455626 E	0.156	32.5	50.7	- canopy 30%, aspen - 60%, ht. 25m, dia. 11cm white spruce - 40%, ht. 30m, dia. 35cm understory - young spruce, cransberry, birch, dead trees and labrador tea	- crust on top 0 - 2 cm clean, dry, compacted, needles medium coarse grained
	MD-01-2	14-Mar-01	6353287 N 454220 E	0.183	28.5	52.2	- canopy 50%, aspen - 90%, ht. 25m, dia. 10cm white spruce - 10%, ht. 20m, dia. 10cm understorey - alders, labrador tea and dead trees	- crust on top 0 - 3 cm clean, wet, sticky, needles medium coarse grained
	MD-01-3	15-Mar-01	6362244 N 458905 E	0.108	31.4	33.9	- canopy 60%, aspen - 80%, ht.22m, dia. 14cm black/white spruce-20%, ht. 18m dia. 10cm understory - wild rose , cranberry and buffalo berry	- crust on top 0 - 0.6 cm clean, dry, compacted medium coarse grained
	MD-01-4	15-Mar-01	6355845 N 449862 E	0.152	32.1	48.7	- canopy 50%, aspen - 90%, ht. 25m, dia. 12cm black spruce - 10%, ht. 15m, dia. 10cm understory - buffalo berry, cranberry, young spruce and dead trees	- crust on top 0- 3 cm clean, wet, sticky, compacted, medium coarse grained
	MD-01-5	16-Mar-01	6366752 N 450790 E	0.213	25.3	54.0	- canopy 70%, aspen - 60%, ht. 30m, dia. 26cm white spruce - 40%, ht. 25m, dia. 17cm understory - wild rose, cranberry young spruce	- crust on top 0- 4 cm clean, dry, compacted, needles, leaves, coarse grained
jack pine	JP-01-1	14-Mar-01	6352488 N 455355 E	0.159	30.1	48.0	- canopy 40%, jack pine - 100%, ht. 20m, dia. 12cm understory - alders, buffalo berry and dead trees	- crust on top 0 - 1.5 cm clean, dry compacted, medium coarse grained
	JP-01-2	14-Mar-01	6360159 N 455585 E	0.160	31.7	50.7	- canopy 40%, jack pine - 95%, av. ht. 25m, dia.15cm black spruce 5%, ht. 20m, dia. 10cm understory - young spruce, alders and labrador tea	- crust on top 0 - 2 cm clean, wet, sticky, compacted, needles, medium coarse grained
	JP-01-3	16-Mar-01	6357816 N 454514 E	0.183	26.7	48.9	- canopy 60%, jack pine - 99%, ht. 22m, dia. 15cm white spruce - 1%, ht. 15m, dia. 6cm understorey - Labrador tea, alders and buffalo berry	- crust on top 0 - 3 cm clean, wet, sticky, compacted, needles
	JP-01-4	16-Mar-01	6354457 N 453380 E	0.144	26.7	38.5	- canopy 65% jackpine - 100%, ht. 25m, dia. 25cm understory - alders	- crust on top 0 - 3 cm clean, wet, sticky, compacted, needles

Table III.2 Summary of 2002 Birch Mountains East Slope Snow Course Survey Data

Terrain Type	Survey Plot No	Date of Survey	GPS Location	Snow Density (g/cm^3)	Snow Depth (cm)	Snow Water Equivalent (mm)	Description of Vegetation	Snow Cover Appearance
flat low lying	FL-02-1	12-Mar-02	6358050 N 456679 E	0.070	31.9	22.4	- tamarack - 7m max high 5% young spruce 10%, alders - 85%, grass	- crust at 3 - 7 cm clean, dry, compacted fine at surface to coarse grained with depth
	FL-02-2	12-Mar-02	6359616 N 455377 E	0.159	28	44.7	- alders - 5m high 90% willows -10%, grass surrounded by white spruce	- clean, dry, compacted fine at surface to coarse grained with depth.ice bottom
	FL-02-3	13-Mar-02	6360330 N 450625 E	0.133	29.5	39.1	- alders - 6m high 80% willows - 3m high 20%, grass	- clean, dry, compacted fine at surface to coarse grained with depth ice bottom
	FL-02-4	13-Mar-02	6354992 N 453949 E	0.129	30.1	38.8	- willows - 4m high 80%, young spruce - 10m high 10%, tamarack - 7m high - 10% grass	- crust at 3.5 - 5 cm clean, dry, compacted fine at surface to coarse grained with depth ice bottom
open land	OP-02-1	12-Mar-02	6358033 N 456815 E	0.086	31	26.7	- low willows - 5% of area grass surrounded by black spruce	- crust at 4 - 6 cm clean, dry, compacted fine at surface to medium coarse grained with depth
	OP-02-2	12-Mar-02	6363764 N 455618 E	0.152	29.1	44.2	- willows/young spruce grass/dead falls surrounded by tamarack and black spruce	- crust at 10 - 13 cm clean, dry, compacted fine at surface to coarse grained with depth ice bottom
open lake	OP-02-3	13-Mar-02	6358111 N 452803 E	0.154	28.9	44.5	- surrounded by cattail, white spruce, poplar, wild rose	- crust at 3 - 8 cm clean, dry, compacted slight windswept, coarse grained, ice bottom
	OP-02-4	13-Mar-02	6359477 N 450609 E	0.144	31.7	45.7	- surrounded by white spruce, cattail, grass and dead falls	- crust at 3 - 7 cm clean, dry, compacted fine at surface to coarse grained with depth ice bottom
mixed deciduous	MD-02-1	12-Mar-02	6356786 N 455016 E	0.122	27.1	33.2	- canopy 50% white spruce - 50%, ht. 17m, dia. 20cm poplar - 50%, ht. 20m, dia. 17cm understory - alder, Labrador tea, young spruce and fireweed	- crust on top 0 - 4 cm clean, wet, compacted, leaves medium to coarse grained
	MD-02-2	12-Mar-02	6361553 N 458445 E	0.135	26	35.1	- canopy 50% poplar - 70%, ht. 22m, dia. 25cm white spruce - 30%, ht. 17m, dia. 15cm understory - young spruce, fireweed, and low bush cranberry	- clean, dry, compacted, fine at surface to coarse grained with depth
	MD-02-3	12-Mar-02	6362358 N 458077 E	0.189	23.1	43.7	- canopy 40% white spruce - 50%, ht. 20m, dia. 15cm poplar - 50%, ht. 20m, dia. 15cm understory - wild rose, buffalo berry, young spruce, cranberry and fireweed.	- clean, dry, compacted, fine at surface to medium coarse grained with depth leaves
	MD-02-4	13-Mar-02	6358089 N 452239 E	0.155	29.9	46.3	- canopy 40% poplar - 90%, ht. 20m, dia. 10cm white spruce - 10%, ht. 12m, dia. 6cm understory - alder, buffalo berry, wild rose, fireweed and dead falls	- clean, dry, compacted, fine at surface to coarse grained with depth
jack pine	JP-02-1	12-Mar-02	6354544 N 454526 E	0.144	26.7	38.3	- canopy 40% jack pine - 100%, ht. 17m, dia. 10cm understory - dead falls, moss, low bush cranberry, lichen, wild rose	- clean, dry, compacted, needles, coarse grained with depth
	JP-02-2	12-Mar-02	6359600 N 457771 E	0.141	24.0	33.8	- canopy 60% jack pine - 100%, av. ht. 20m, dia.15cm understory - young spruce - 5m ht., alders, Labrador tea, fireweed, buffalo berry	- clean, slightly wet, compacted, needles, coarse grained with depth
	JP-02-3	13-Mar-02	6358046 N 454422 E	0.175	26.0	45.5	- canopy 70% jack pine - 99%, ht. 20m, dia. 15cm poplar - 1%, ht. 19m, dia. 6cm understory - buffalo berry, young spruce and dead falls	- crust at 10 - 11 cm clean, dry, compacted, needles, fine to coarse grained with depth
	JP-02-4	13-Mar-02	6356081 N 453996 E	0.143	24.6	35.0	- canopy 50% jackpine - 100%, ht. 22m, dia. 20cm understory - low bush cranberry and dead falls	- crust at 2 - 8 cm clean, dry, compacted, needles, fine to coarse grained with depth

APPENDIX IV

CLIMATIC AND HYDROLOGIC MONITORING STATION FACTSHEETS FOR NEW STATIONS

CHRISTINA RIVER HYDROMETRIC STATION

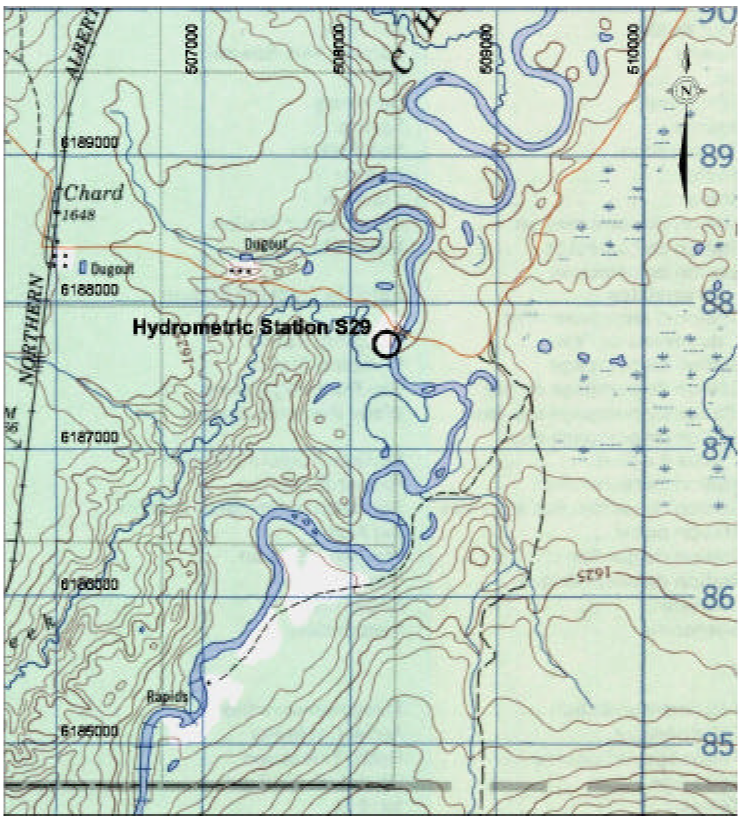
S29

FACTSHEET

LOCATION AND PURPOSE

Established to monitor winter discharge on Christina River just downstream of Environment Canada hydrometric station 07CE002. The Environment Canada hydrometric station has operated from 1982 to 2002.

Period of Record:	January 2002 to Present		
Access:	2WD access on Hwy 881		
Benchmark:	T-bar in PVC housing, elevation 99.076 m (local)		
Drainage Area:	4860 km^2		
Coordinates:	UTM: 476998 E, 6252434 N	Lat/Long: 55°50'20" N, 110°52'00" W	
	LSD: SE-16-79-6-W4	NTS Map: 73M/15	



EQUIPMENT

Component	Function	Serial No.
Optimum DD 128 Datalogger	Record data	0104170268
Keller 5 psi Pressure Transducer	Measure water levels	0205463
Tipping bucket rain gauge (metric)	Measure rainfall	30496-402

HANGINGSTONE RIVER HYDROMETRIC STATION

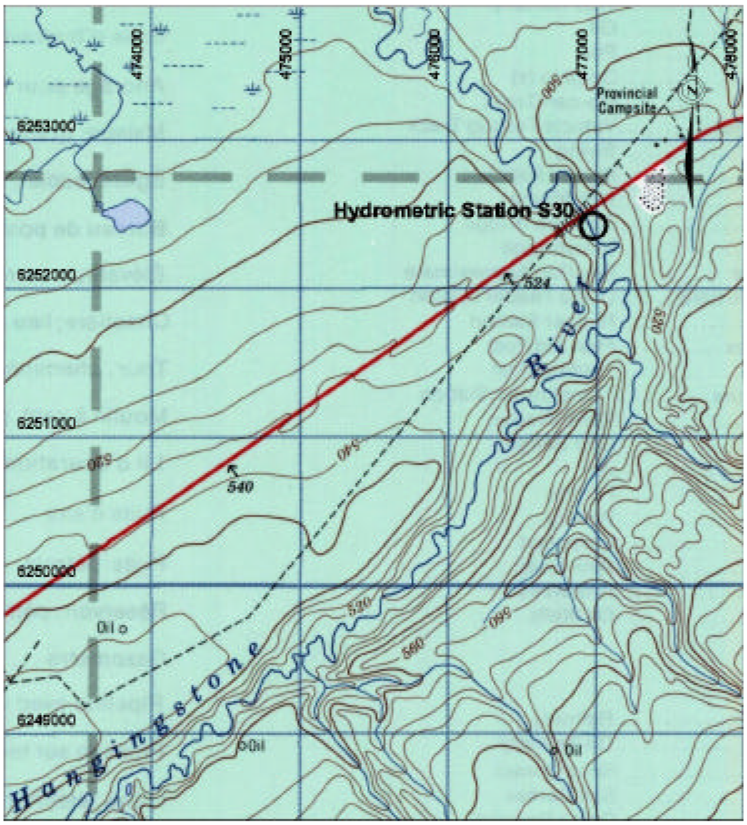
S30

FACTSHEET

LOCATION AND PURPOSE

Established to monitor discharge on Hangingstone River upstream of the Athabasca River.

Period of Record:	May 2001 to Present		
Access:	2WD access on Hwy 63, south of Ft. McMurray		
Benchmark:	Temporary nail in tree 100.00 m (local)		
Drainage Area:	520 km^2		
Coordinates:	UTM: 476933 E, 6252647 N	Lat/Long:	56°25'04" N, 111°22'26" W
	LSD: NE-32-85-9-4	NTS Map:	74D/6



EQUIPMENT

Component	Function	Serial No.
Lakewood UltraLogger RX-1A	Record data	206095
Keller 8363K 10 psi Pressure Transducer	Measure water levels	971332

HANGINGSTONE CREEK HYDROMETRIC STATION

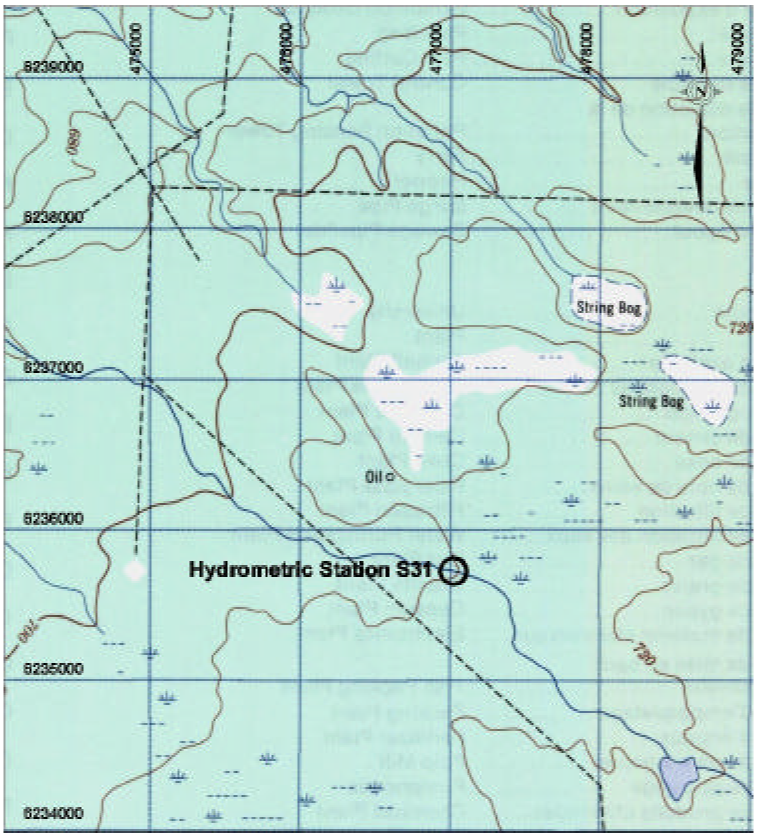
S31

FACTSHEET

LOCATION AND PURPOSE

Established to monitor discharge on a typical tributary upstream of the Hangingstone River.

Period of Record:	May 2001 to Present	
Access:	2WD access from Hwy 63 to North Star Lease road	
Benchmark:	Temporary nail in tree 100.00 m (local)	
Drainage Area:	160 km^2	
Coordinates:	UTM: 4769698 E, 6236095 N	Lat/Long: 56°16'08" N, 111°29'21" W
	LSD: NW-10-84-10-4	NTS Map: 74D/6



EQUIPMENT

Component	Function	Serial No.
Lakewood UltraLogger RX-1A	Record data	95185-03
Keller 8363K 3 psi Pressure Transducer	Measure water levels	3498

FACT-S11-01.DOC

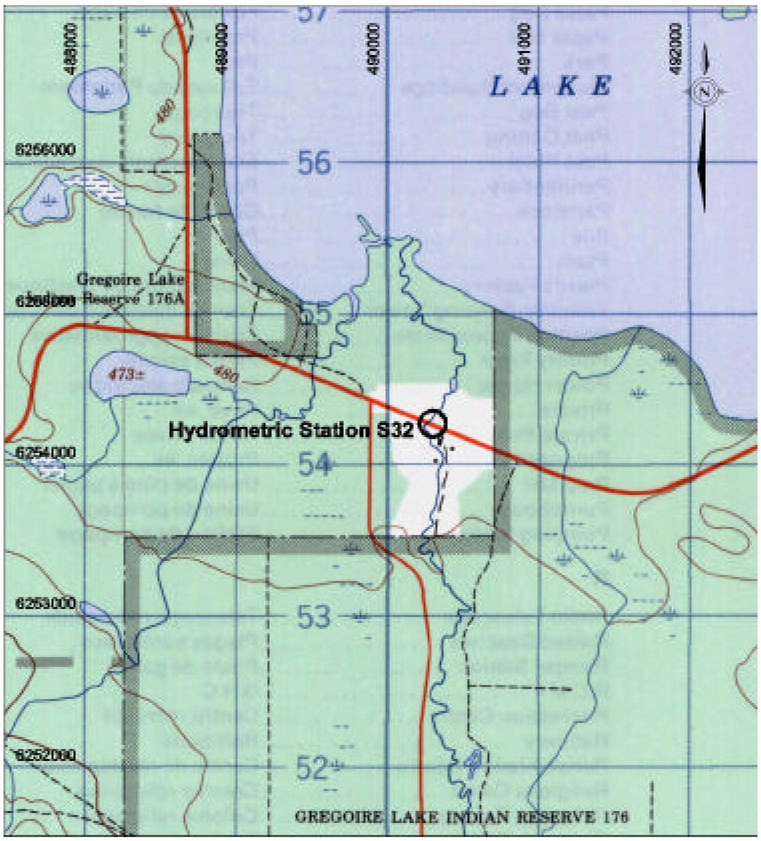
SURMONT CREEK HYDROMETRIC STATION

S32 FACTSHEET

LOCATION AND PURPOSE

Established to monitor discharge on Surmont Creek upstream of Gregoire Lake.

Period of Record:	May 2001 to Present.		
Access:	2WD access on Hwy 881		
Benchmark:	Temporary nail by LHS downstream abutment, elevation 97.942 m (local)		
Drainage Area:	158 km^2		
Coordinates:	UTM: 490252 E, 6254511N	Lat/Long: 56°26’06” N, 111°9’29” W	
	LSD: NE-3-86-8-4	NTS Map: 74D/6	



EQUIPMENT

Component	Function	Serial No.
Lakewood UltraLogger RX-1A	Record data	203149
Keller 8363K 6 psi Pressure Transducer	Measure water levels	971889

APPENDIX V

2002 MANUAL DISCHARGE MEASUREMENTS FOR DEVELOPING STAGE-DISCHARGE RATING CURVES AT HYDROLOGIC STATIONS

Table V.1 Summary of 2002 Manual Discharge Measurements

Station No.	Stream Name	Winter Discharge (m^3/s)	Date	Snowmelt Discharge (m^3/s)	Date	Summer Discharge (m^3/s)	Date
S1	Alsands Drain	0.097 0.000	Jan 11 Feb 7	0.000 0.000 0.111	Mar 15 Apr 9 Apr 24	*	Jun 9
S2	Jackpine Creek	No Flow	Jan 16	* 0.110 0.257	Apr 8 Apr 23 May 14	0.974 1.990 * 3.464 1.416	Jun 11 Jul 11 Aug 11 Sep 13 Oct 25
S3	Iyinimin Creek					0.063 0.864 0.493 0.203	Jun 10 Aug 9 Sep 12 Oct 26
S4	Blackfly Creek	station not operational in 2001					
S5A	Muskeg River Aurora	0.217 0.206 * 0.151 0.491 0.263	Jan 12 Feb 8 Feb 24 Mar 15 Nov 28 Jan 7/03	* * 0.266	Apr 9 Apr 25 May 14	*	Oct 21
S6	Mills Creek	0.008	Jan 15	0.011 0.010 0.012 0.010	Mar 13 Apr 9 Apr 23 May 14	0.026 0.019 0.017 0.021	Jun 9 Jul 8 Aug 10 Oct 21
S7	Muskeg River WSC	0.313 0.178 0.267 1.868 0.670	Jan 10 Feb 5 Mar 15 Nov 28 Jan 7/03	0.315 * 1.146	Apr 8 Apr 25 May 14		
S8	Stanley Creek			WL only WL only	Apr 28 May 16	WL only WL only	Aug 9 Oct 26
S9	Kearl Lake Outlet			0.000 0.000 0.000 0.069	Apr 8 Apr 23 Apr 25 May 15	0.000 0.004 0.701 0.467	Jun 9 Jul 1 Sep 13 Oct 25
S10	Wapasu Creek			0.000 0.035 0.012	Apr 8 Apr 23 May 15	0.165 0.587 * 1.812 0.845 0.375	Jun 9 Jul 11 Jul 31 Aug 11 Sep 13 Oct 25
S11	Poplar Creek			0.157 0.366 0.022	Apr 10 Apr 23 May 18	0.294 0.055 0.930 0.675	Jun 13 Jul 9 Aug 11 Oct 29
S12	Fort Creek			0.000	May 14	0.093 0.079 0.096 0.034	Jun 9 Jul 8 Aug 10 Oct 23
S13	Albian Pond #3			0.000 0.000	Apr 9 Apr 24	0.000 0.000	Jun 9 Aug 8
S14	Ells River			* * 6.234	Apr 11 Apr 28 May 16	4.242 * 7.924 *	Jul 10 Aug 9 Sep 12 Oct 27

Table V.1 Summary of 2002 Manual Discharge Measurements (continued)

Station No.	Stream Name	Winter Discharge (m^3/s)	Date	Snowmelt Discharge (m^3/s)	Date	Summer Discharge (m^3/s)	Date
S15	Tar River	0.072	Jan 11	* 0.613	Apr 24 May 16	0.580 0.901 0.621 0.319	Jul 8 Aug 10 Sep 12 Oct 21
S16	Calumet River	0.021 0.004	Jan 14 Feb 25	0.066	May 16	0.345 0.116 0.058	Aug 9 Sep 12 Oct 27
S17	Upland Tar River			0.000 0.023	Apr 28 May 16	0.001 0.000	Sep 12 Oct 27
S18A	Upland Calumet River					0.008 0.006 0.024 0.011 0.005	Jun 10 Jul 10 Aug 9 Sep 12 Oct 27
S19	Lowland Tar River			0.000 0.011	Apr 24 May 18	0.017 0.027 0.025 0.019 0.007	Jun 13 Jul 8 Aug 10 Sep 11 Oct 21
S20	Upland Muskeg River			0.203 0.155	Apr 25 May 15	0.239 0.581 * 1.723 1.113 0.536	Jun 9 Jul 11 Jul 31 Aug 11 Sep 13 Oct 25
S21	Shelley Creek			*	May 16	0.000 0.035 *	Jun 10 Aug 9 Oct 26
S22	Muskeg Creek	0.010	Jan 11	0.059 * *	Apr 8 Apr 23 May 15	0.352 0.760 * 3.019 1.403	Jun 9 Jul 11 Aug 11 Sep 13 Oct 25
S23	Aurora Boundary Weir	* * * *	Jan 12 Feb 8 Feb 24 Mar 15	* * 0.063	Apr 8 Apr 25 May 14	* *	Jun 9 Oct 21
S24	Athabasca River	103.2 90.8	Feb 5 Mar 22	719.3	May 31		
S25	Susan Lake Outlet					0.057 0.073 0.051	Jun 11 Aug 10 Sep 11
S26	MacKay River WSC	0.536 0.051 0.000 1.012 0.577	Jan 15 Feb 8 Mar 18 Nov 27 Jan 8/03			*	Oct 24
S27	Firebag River WSC	9.186 7.693 6.412 14.685 10.970	Jan 14 Feb 7 Mar 16 Dec 3 Jan 7/03	6.466 *	Apr 9 May 14	*	Oct 23

Table V.1 Summary of 2002 Manual Discharge Measurements (continued)

Station No.	Stream Name	Winter Discharge (m^3/s)	Date	Snowmelt Discharge (m^3/s)	Date	Summer Discharge (m^3/s)	Date
S28	Khahago Creek			*	May 14	0.544 2.777 1.979	Jul 10 Aug 9 Sep 12
S29	Christina River WSC	2.462 2.144 1.777 4.844 2.513	Jan 13 Feb 4 Mar 17 Nov 29 Jan 6/03	2.063	Apr 10	* *	Sep 11 Oct 22
S30	Hangingstone River			* 1.073	Apr 22 May 13	1.069 * 0.712 4.026 0.496	Jun 8 Jul 8 Jul 9 Aug 7 Oct 22
S31	Hangingstone Creek			0.101 0.261	Apr 10 Apr 22	0.203 0.120 0.367 1.671 0.263	May 13 Jun 8 Jul 8 Aug 7 Oct 22
S32	Surmont Creek			0.288 0.319 0.306	May 18 Jun 8 Jul 8	2.152 0.709 0.386	Aug 7 Sep 11 Oct 22
L1	McClelland Lake	0.000	Jan 14	* *	Apr 28 May 16	* * * *	Jun 10 Jul 10 Aug 9 Sep 12
L2	Kearl Lake	WL only WL only WL only WL only WL only	Jan 11 Feb 7 Mar 13 Dec 3 Jan 7/03	WL only WL only	Apr 8 May 15	WL only |WL only WL only WL only WL only	Jun 9 Jul 11 Aug 11 Sep 13 Oct 25
L3	Isadore's Lake	WL only WL only	Jan 11 Jan 8/03			WL only WL only WL only	Aug 8 Oct 27 Oct 29

* Site visited but manual streamflow measurement was not performed (generally due to thin ice, blocked access, equipment malfunction or well-developed rating curve).

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S1
STREAM NAME: Alsands Drain
COORDINATES: 6345533.7N/470006.2E

MEASUREMENT DATE: 11 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1140 hrs.
MEASUREMENT END TIME: 1148 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.06			0.040	0.20	0.000
2	0.40		0.15			0.030	0.20	0.001
3	0.60		0.16			0.460	0.20	0.015
4	0.80		0.08			0.560	0.20	0.009
5	1.00		0.08			0.770	0.20	0.012
6	1.20		0.08			1.130	0.20	0.018
7	1.40		0.12			0.780	0.20	0.019
8	1.60		0.12			0.820	0.20	0.020
9	1.80		0.12			0.130	0.20	0.003
10	2.00		0.04			0.050	0.20	0.000
RDB	2.20		0.00			0.000	0.10	0.000
								0.097

Notes: 1. Water elevation 279.574m, top of ice elevation 279.614m (1136hrs)
2. No ice built-up at the discharge section

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S1
STREAM NAME: Alsands Drain
COORDINATES: 6345533.7N/470006.2E

MEASUREMENT DATE: 7 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. No discharge observed; frozen conditions

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S1
STREAM NAME: Alsands Drain
COORDINATES: 6345533.7N/470006.2E

MEASUREMENT DATE: 15 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. No discharge observed; frozen conditions

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S1
STREAM NAME: Alsands Drain
COORDINATES: 6345533.7N/470006.2E

MEASUREMENT DATE: 9 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. No discharge observed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S1
STREAM NAME: Alsands Drain
COORDINATES: 6345533.7N/470006.2E
MEASUREMENT DATE: 24 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0953 hrs.
MEASUREMENT END TIME: 1000 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.12			0.360	0.20	0.009
2	0.40		0.12			0.540	0.20	0.013
3	0.60		0.10			0.520	0.20	0.010
4	0.80		0.12			0.510	0.20	0.012
5	1.00		0.08			0.610	0.20	0.010
6	1.20		0.08			0.360	0.20	0.006
7	1.40		0.11			0.790	0.20	0.017
8	1.60		0.10			0.800	0.20	0.016
9	1.80		0.10			0.620	0.29	0.018
RDB	2.17		0.00			0.000	0.19	0.000
								0.111

Notes:
1. Water elevation 279.564m (1003 hrs)
2. Open water at the discharge section

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S1
STREAM NAME: Alsands Drain
COORDINATES: 6345533.7N/470006.2E

MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Notes: 1. Water elevation 279.342m (1257 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E

MEASUREMENT DATE: 8 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								
1								*
RDB								*
								*

Notes: 1. Water elevation 279.137m, top of ice elevation 297.102m (1533 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E

MEASUREMENT DATE: 23 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1420 hrs.
MEASUREMENT END TIME: 1430 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	5.20		0.00			0.000	0.25	0.000
1	5.70		0.08			0.010	0.40	0.000
2	6.00		0.13			0.000	0.25	0.000
3	6.20		0.15			0.110	0.25	0.004
4	6.50		0.15			-0.010	0.40	-0.001
5	7.00		0.14			0.210	0.50	0.015
6	7.50		0.17			0.050	0.50	0.004
7	8.00		0.22			0.120	0.50	0.013
8	8.50		0.20			0.110	0.50	0.011
9	9.00		0.25			0.320	0.50	0.040
10	9.50		0.18			0.180	0.50	0.016
11	10.00		0.11			0.090	0.50	0.005
12	10.50		0.10			0.060	0.40	0.002
13	10.80		0.13			-0.010	0.30	0.000
RDB	11.10		0.00			0.000	0.15	0.000
								0.110

Note: 1. Water elevation 296.862m (1450 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E

MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1610 hrs.
MEASUREMENT END TIME: 1615 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	3.70		0.00			0.000	0.15	0.000
1	4.00		0.04			-0.020	0.40	0.000
2	4.50		0.04			0.040	0.50	0.001
3	5.00		0.06			0.030	0.50	0.001
4	5.50		0.07			0.110	0.50	0.004
5	6.00		0.10			0.200	0.50	0.010
6	6.50		0.08			0.290	0.50	0.012
7	7.00		0.11			0.150	0.50	0.008
8	7.50		0.11			0.380	0.50	0.021
9	8.00		0.13			0.270	0.50	0.018
10	8.50		0.14			0.480	0.50	0.034
11	9.00		0.14			0.680	0.50	0.048
12	9.50		0.17			0.560	0.50	0.048
13	10.00		0.19			0.420	0.50	0.040
14	10.50		0.16			0.020	0.50	0.002
15	11.00		0.09			0.170	0.50	0.008
16	11.50		0.07			0.150	0.55	0.006
RDB	12.10		0.00			0.000	0.30	0.000
								0.257

Notes:
1. Water elevation 296.807m (1608 hrs) at the temporary installation location
2. At 1635 hrs transducer moved to permanent burial conduit location – Water elevation 296.871m (1635 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E

MEASUREMENT DATE: 11 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1630 hrs.
MEASUREMENT END TIME: 1635 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.40		0.00			0.000	0.55	0.000
1	2.50		0.03			0.010	0.80	0.000
2	3.00		0.06			0.120	0.50	0.004
3	3.50		0.03			0.140	0.50	0.002
4	4.00		0.09			0.310	0.50	0.014
5	4.50		0.10			0.260	0.50	0.013
6	5.00		0.12			0.240	0.50	0.014
7	5.50		0.14			0.300	0.50	0.021
8	6.00		0.18			0.370	0.50	0.033
9	6.50		0.14			0.590	0.50	0.041
10	7.00		0.23			0.620	0.50	0.071
11	7.50		0.28			0.740	0.50	0.104
12	8.00		0.28			0.660	0.50	0.092
13	8.50		0.32			0.370	0.50	0.059
14	9.00		0.36			0.660	0.50	0.119
15	9.50		0.37			0.490	0.50	0.091
16	10.00		0.35			0.690	0.50	0.121
17	10.50		0.36			0.410	0.50	0.074
18	11.00		0.20			0.450	0.50	0.045
19	11.50		0.17			0.390	0.50	0.033
20	12.00		0.10			0.400	0.55	0.022
RDB	12.60		0.00			0.000	0.30	0.000
								0.974

Note: 1. Water elevation 296.954m (1635 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E
MEASUREMENT DATE: 11 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1614 hrs.
MEASUREMENT END TIME: 1625 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.30		0.00			0.000	0.35	0.000
1	1.00		0.12			0.250	0.60	0.018
2	1.50		0.10			0.370	0.50	0.019
3	2.00		0.14			0.420	0.50	0.029
4	2.50		0.14			0.280	0.50	0.020
5	3.00		0.15			0.510	0.50	0.038
6	3.50		0.20			0.370	0.50	0.037
7	4.00		0.20			0.460	0.50	0.046
8	4.50		0.24			0.460	0.50	0.055
9	5.00		0.26			0.740	0.50	0.096
10	5.50		0.26			0.800	0.50	0.104
11	6.00		0.28			0.850	0.50	0.119
12	6.50		0.38			0.520	0.50	0.099
13	7.00		0.38			0.660	0.50	0.125
14	7.50		0.38			0.660	0.50	0.125
15	8.00		0.44			0.830	0.50	0.183
16	8.50		0.44			0.690	0.50	0.152
17	9.00		0.44			0.880	0.50	0.194
18	9.50		0.38			0.950	0.50	0.181
19	10.00		0.34			0.850	0.50	0.145
20	10.50		0.32			0.440	0.50	0.070
21	11.00		0.22			0.950	0.50	0.105
22	11.50		0.16			0.440	0.45	0.032
RDB	11.90		0.00			0.000	0.20	0.000
								1.990

Note: 1. Water elevation 297.049m (1630 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E
MEASUREMENT DATE: 11 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 279.292m (1120 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E

MEASUREMENT DATE: 13 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1621 hrs.
MEASUREMENT END TIME: 1632 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.21			0.300	0.50	0.032
2	1.00		0.23			0.520	0.50	0.060
3	1.50		0.26			0.590	0.50	0.077
4	2.00		0.32			0.600	0.75	0.144
5	3.00		0.32			0.420	1.00	0.134
6	4.00		0.20			0.620	0.75	0.093
7	4.50		0.29			0.250	0.50	0.036
8	5.00		0.33			0.480	0.50	0.079
9	5.50		0.33			0.450	0.50	0.074
10	6.00		0.36			0.850	0.50	0.153
11	6.50		0.40			0.980	0.50	0.196
12	7.00		0.42			1.330	0.50	0.279
13	7.50		0.41			1.210	0.50	0.248
14	8.00		0.41			1.090	0.50	0.223
15	8.50		0.41			1.250	0.50	0.256
16	9.00		0.41			1.130	0.50	0.232
17	9.50		0.40			1.110	0.50	0.222
18	10.00		0.36			1.230	0.50	0.221
19	10.50		0.37			1.090	0.50	0.202
20	11.00		0.36			1.140	0.50	0.205
21	11.50		0.33			0.950	0.50	0.157
22	12.00		0.23			0.950	0.50	0.109
23	12.50		0.25			0.350	0.35	0.031
RDB	12.70		0.00			0.000	0.10	0.000
								3.464

Note: 1. Water elevation 297.112m (1635 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S2
STREAM NAME: Jackpine Creek
COORDINATES: 6343902N/475067E

MEASUREMENT DATE: 25 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1452 hrs.
MEASUREMENT END TIME: 1503 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.18			0.020	0.50	0.002
2	1.00		0.19			0.340	0.50	0.032
3	1.50		0.20			0.140	0.45	0.013
4	1.90		0.23			0.550	0.65	0.082
5	2.80		0.22			0.180	0.55	0.022
6	3.00		0.14			0.640	0.35	0.031
7	3.50		0.15			0.590	0.50	0.044
8	4.00		0.17			0.580	0.50	0.049
9	4.50		0.17			1.030	0.40	0.070
10	4.80		0.14			0.440	0.58	0.035
11	5.65		0.20			-0.030	0.60	-0.004
12	6.00		0.20			0.530	0.43	0.045
13	6.50		0.20			0.870	0.50	0.087
14	7.00		0.26			0.220	0.50	0.029
15	7.50		0.33			0.120	0.50	0.020
16	8.00		0.38			0.680	0.50	0.129
17	8.50		0.40			0.430	0.50	0.086
18	9.00		0.49			0.250	0.50	0.061
19	9.50		0.49			0.560	0.50	0.137
20	10.00		0.40			0.390	0.50	0.078
21	10.50		0.33			-0.010	0.50	-0.002
22	11.00		0.28			0.580	0.50	0.081
23	11.50		0.33			0.640	0.50	0.106
24	12.00		0.29			0.500	0.50	0.073
25	12.50		0.26			0.620	0.50	0.081
26	13.00		0.22			0.190	0.50	0.021
27	13.50		0.18			0.090	0.43	0.007
RDB	13.85		0.00			0.000	0.18	0.000
								1.416

Notes:
1. Water elevation 297.000m (1450 hrs)
2. Logger/transducer were removed for the season
3. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S3
STREAM NAME: Iyinmin Creek
COORDINATES: 6345028.7N/489490.6E

MEASUREMENT DATE: 10 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1415 hrs.
MEASUREMENT END TIME: 1430 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.20	0.000
1	0.40		0.08			0.240	0.40	0.008
2	0.80		0.04			0.460	0.35	0.006
3	1.10		0.18			0.300	0.25	0.014
4	1.30		0.13			0.490	0.20	0.013
5	1.50		0.12			0.410	0.20	0.010
6	1.70		0.10			-0.090	0.20	-0.002
7	1.90		0.12			-0.110	0.20	-0.003
8	2.10		0.13			0.130	0.20	0.003
9	2.30		0.18			0.010	0.20	0.000
10	2.50		0.20			0.120	0.20	0.005
11	2.70		0.15			0.030	0.20	0.001
12	2.90		0.11			0.420	0.18	0.008
13	3.05		0.00			0.000	0.23	0.000
14	3.35		0.00			0.000	0.23	0.000
15	3.50		0.04			-0.170	0.20	-0.001
16	3.75		0.00			0.000	0.20	0.000
17	3.90		0.06			0.140	0.18	0.001
RDB	4.10		0.00			0.000	0.10	0.000
								0.063

Notes:
1. Water elevation 358.913m (1412 hrs)
2. Installed transducer s/n 996022-5psi

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S3
STREAM NAME: Iyinmin Creek
COORDINATES: 6345028.7N/489490.6E

MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0825 hrs.
MEASUREMENT END TIME: 0844 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.30		0.00			0.000	0.20	0.000
1	0.70		0.17			-0.110	0.30	-0.006
2	0.90		0.27			-0.110	0.20	-0.006
3	1.10		0.36			-0.060	0.20	-0.004
4	1.30		0.44			-0.080	0.20	-0.007
5	1.50		0.48			0.080	0.20	0.008
6	1.70		0.52			0.020	0.20	0.002
7	1.90		0.58			0.300	0.20	0.035
8	2.10		0.56			0.520	0.20	0.058
9	2.30		0.62			0.580	0.20	0.072
10	2.50		0.70			0.730	0.20	0.102
11	2.70		0.62			0.820	0.20	0.102
12	2.90		0.66			0.880	0.15	0.087
13	3.00		0.56			0.850	0.25	0.119
14	3.40		0.66			0.810	0.30	0.160
15	3.60		0.62			0.710	0.20	0.088
16	3.80		0.28			0.320	0.20	0.018
17	4.00		0.24			0.430	0.20	0.021
18	4.20		0.28			0.250	0.20	0.014
19	4.40		0.30			0.020	0.23	0.001
RDB	4.65		0.00			0.000	0.13	0.000
								0.864

Note: 1. Water elevation 359.248m (0825 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S3
STREAM NAME: Iyinmin Creek
COORDINATES: 6345028.7N/489490.6E

MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1555 hrs.
MEASUREMENT END TIME: 1605 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.25		0.00			0.000	0.08	0.000
1	0.40		0.38			0.000	0.18	0.000
2	0.60		0.51			0.020	0.20	0.002
3	0.80		0.40			0.210	0.20	0.017
4	1.00		0.54			1.010	0.20	0.109
5	1.20		0.54			0.640	0.20	0.069
6	1.40		0.58			0.490	0.20	0.057
7	1.60		0.58			0.410	0.20	0.048
8	1.80		0.56			0.420	0.20	0.047
9	2.00		0.56			0.340	0.20	0.038
10	2.20		0.54			0.260	0.20	0.028
11	2.40		0.49			0.200	0.20	0.020
12	2.60		0.42			0.230	0.20	0.019
13	2.80		0.30			0.280	0.20	0.017
14	3.00		0.30			0.190	0.20	0.011
15	3.20		0.26			0.130	0.20	0.007
16	3.40		0.18			0.090	0.20	0.003
17	3.60		0.10			0.050	0.25	0.001
RDB	3.90		0.00			0.000	0.15	0.000
								0.493

Notes:
1. Water elevation 359.111m (1555 hrs)
2. Rain gauge was slightly bent - disturbed by wild life. Repaired and photographs taken

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S3
STREAM NAME: Iyinmin Creek
COORDINATES: 6345028.7N/489490.6E

MEASUREMENT DATE: 26 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1242 hrs.
MEASUREMENT END TIME: 1245 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.11	0.000
1	0.22		0.40			0.140	0.25	0.014
2	0.50		0.40			0.310	0.34	0.042
3	0.90		0.55			0.460	0.30	0.076
4	1.10		0.64			0.300	0.35	0.067
5	1.60		0.24			0.050	0.40	0.005
6	1.90		0.25			-0.010	0.25	-0.001
7	2.10		0.16			-0.010	0.29	0.000
RDB	2.47		0.00			0.000	0.19	0.000
								0.203

Notes:
1. Water elevation 359.02m, top of ice elevation 359.165m (1248 hrs)
2. The ice covered was broke off, open water discharge measurement
3. TSS collected
4. The average ice thickness at shore was 2 inches
5. Logger and transducer were removed for the season, rain gauge was left on site

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River **MEASUREMENT DATE: 12 Jan 2002**
COORDINATES: 6351833N/476052E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/PM **MEASUREMENT START TIME: 1120 hrs.**
COMPUTATIONS BY: LL/NS **MEASUREMENT END TIME: 1145 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.90	0.45	0.00			0.000	0.30	0.000
1	1.50	0.45	0.16			0.020	0.80	0.002
2	2.50	0.44	0.69			0.050	1.05	0.033
3	3.60	0.41	1.07	0.05	0.06	0.055	1.05	0.062
4	4.60	0.37	1.25	0.06	0.07	0.065	0.98	0.080
5	5.56	0.37	1.24	0.05	0.06	0.055	0.95	0.065
6	6.50	0.38	1.11	0.05	0.04	0.045	0.95	0.047
7	7.45	0.47	1.05	0.02	0.02	0.020	0.93	0.019
8	8.35	0.51	0.95	0.01	0.02	0.015	1.03	0.015
9	9.50	0.51	0.65			0.010	1.05	0.006
10	10.45	0.56	0.41			-0.110	1.15	-0.048
11	11.80	0.72	0.20			-0.360	0.98	-0.065
RDB	12.40	0.72	0.00			0.000	0.30	0.000
								0.217

Note: 1. Water elevation 281.061m, top of ice elevation 281.082m (1148 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River **MEASUREMENT DATE: 08 Feb 2002**
COORDINATES: 6351833N/476052E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/JE **MEASUREMENT START TIME: 1455 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1520 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.40	0.00			0.000	0.58	0.000
1	1.15	0.40	0.64			0.010	1.08	0.006
2	2.15	0.45	0.91	0.01	0.03	0.020	1.08	0.019
3	3.30	0.45	1.12	0.05	0.05	0.050	1.08	0.060
4	4.30	0.45	1.19	0.03	0.05	0.040	1.10	0.052
5	5.50	0.46	1.20	0.01	0.03	0.020	1.38	0.033
6	7.05	0.48	1.15	0.04	0.00	0.020	1.50	0.035
7	8.50	0.49	0.89	0.00	0.00	0.000	1.48	0.000
8	10.00	0.46	0.54			0.000	1.30	0.000
RDB	11.10	0.46	0.00			0.000	0.55	0.000
								0.206

Notes:
1. Water elevation 281.041m, top of ice elevation 281.140m (1521 hrs)
2. The internal battery of Dolphin Logger was replaced
3. Due to a short transducer cable, a temporary transducer s/n -2psi with Lakewood Logger were installed as existing transducer might be faulty

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 24 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 281.014m, top of ice elevation 281.175m (1126 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 15 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1700 hrs.
MEASUREMENT END TIME: 1740 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.48	0.00			0.000	0.90	0.000
1	1.80	0.48	0.67			0.050	1.55	0.048
2	3.10	0.60	1.10			0.020	1.45	0.029
3	4.70	0.58	0.89			0.040	1.65	0.054
4	6.40	0.58	0.47			0.030	1.50	0.019
5	7.70	0.60	0.30			0.000	1.35	0.000
6	9.10	0.56	0.11			0.000	0.90	0.000
RDB	9.50	0.56	0.00			0.000	0.20	0.000
								0.151

Note: 1. Water elevation 281.105m, top of ice elevation 281.164m (1737hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 09 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 281.261m, top of ice elevation 281.034m (1215 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 25 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 281.002m (1044 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1407 hrs.
MEASUREMENT END TIME: 1436 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.50		0.00			0.000	0.40	0.000
1	2.30		0.48			0.010	0.75	0.004
2	3.00		0.90	0.01	0.02	0.015	0.85	0.011
3	4.00		1.20	0.01	0.02	0.015	1.00	0.018
4	5.00		1.40	0.05	0.00	0.025	1.00	0.035
5	6.00		1.30	0.06	0.04	0.050	1.00	0.065
6	7.00		1.30	0.08	0.03	0.055	1.00	0.072
7	8.00		1.30	0.04	0.05	0.045	1.00	0.059
8	9.00		1.12	0.06	-0.03	0.015	1.00	0.017
9	10.00		1.00	0.00	-0.01	-0.005	1.00	-0.005
10	11.00		0.80	-0.01	0.00	-0.005	1.00	-0.004
11	12.00		0.55			-0.010	0.90	-0.005
RDB	12.80		0.00			0.000	0.40	0.000
								0.266

Notes:
1. Water elevation 281.08m (1340 hrs)
2. Installed thermistor string to the Dolphin Logger - Input #15
3. Was not able to install transducer inside the burial pipe as it was still frozen

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 21 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes:
1. Water elevation 281.603m (1305 hrs)
2. Installed transducer s/n 0104640-5psi

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 28 Nov 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1050 hrs.
MEASUREMENT END TIME: 1116 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.20	0.00			0.000	0.10	0.000
1	0.20	0.20	0.83	-0.01	0.02	0.005	0.60	0.002
2	1.20	0.22	1.02	0.04	0.01	0.025	1.05	0.027
3	2.30	0.23	1.33	0.03	0.03	0.030	1.10	0.044
4	3.40	0.23	1.50	0.07	0.04	0.055	1.10	0.091
5	4.50	0.24	1.52	0.08	0.08	0.080	1.20	0.146
6	5.80	0.25	1.50	0.07	0.04	0.055	1.20	0.099
7	6.90	0.22	1.46	0.04	0.04	0.040	1.15	0.067
8	8.10	0.22	1.48	0.00	0.01	0.005	1.30	0.010
9	9.50	0.25	1.16	0.02	0.00	0.010	1.20	0.014
10	10.50	0.25	0.88	-0.01	-0.01	-0.010	0.95	-0.008
RDB	11.40	0.25	0.00			0.000	0.45	0.000
								0.491

Note: 1. Water elevation 281.205m, top of ice elevation 281.331m (1116 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S5A
STREAM NAME: Muskeg River
COORDINATES: 6351833N/476052E
MEASUREMENT DATE: 07 Jan 2003
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1150 hrs.
MEASUREMENT END TIME: 1208 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.44	0.00			0.000	0.60	0.000
1	1.20	0.44	0.13			0.000	1.20	0.000
2	2.40	0.37	0.63			0.020	1.30	0.015
3	3.80	0.37	1.09	0.00	0.02	0.010	1.43	0.016
4	5.25	0.39	1.32	0.03	0.06	0.045	1.43	0.085
5	6.65	0.38	1.14	0.05	0.04	0.045	1.43	0.073
6	8.10	0.35	0.91	0.04	0.07	0.055	1.38	0.069
7	9.40	0.35	0.49			0.010	1.40	0.006
8	10.90	0.35	0.35			0.000	1.15	0.000
RDB	11.70	0.35	0.00			0.000	0.40	0.000
								0.263

Note: 1. Water elevation 281.156m, top of ice elevation 281.206m (1212 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 15 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1310 hrs.
MEASUREMENT END TIME: 1319 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.04	0.00			0.000	0.10	0.000
1	0.20	0.04	0.06			0.040	0.20	0.000
2	0.40	0.04	0.10			0.060	0.20	0.001
3	0.60	0.04	0.12			0.090	0.20	0.002
4	0.80	0.04	0.12			0.090	0.20	0.002
5	1.00	0.04	0.09			-0.060	0.20	-0.001
6	1.20	0.04	0.13			0.090	0.20	0.002
7	1.40	0.04	0.16			0.050	0.20	0.002
8	1.60	0.04	0.12			-0.010	0.20	0.000
9	1.80	0.04	0.10			-0.030	0.20	-0.001
RDB	2.00	0.04	0.00			0.000	0.10	0.000
								0.008

Notes: 1. Water elevation 272.072m, top of ice elevation 272.103 (1324 hrs)
2. The channel was opened at the discharge section - no correction of discharge calculation required

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 13 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JG
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1215 hrs.
MEASUREMENT END TIME: 1217 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.07	0.00			0.000	0.15	0.000
1	0.30	0.07	0.12			0.080	0.20	0.002
2	0.40	0.07	0.10			0.090	0.15	0.001
3	0.60	0.07	0.11			0.050	0.20	0.001
4	0.80	0.07	0.11			0.100	0.20	0.002
5	1.00	0.07	0.12			0.120	0.20	0.003
6	1.20	0.07	0.12			0.120	0.18	0.002
RDB	1.35	0.07	0.00			0.000	0.08	0.000
								0.011

Notes: 1. Surveyed the old weir elevation and new proposed weir location (2m d/s of existing)
2. Water level not surveyed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 09 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1316 hrs.
MEASUREMENT END TIME: 1325 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.02			0.000	0.20	0.000
2	0.40		0.13			0.040	0.20	0.001
3	0.60		0.16			0.040	0.20	0.001
4	0.80		0.18			0.040	0.20	0.001
5	1.00		0.20			0.050	0.20	0.002
6	1.20		0.14			0.040	0.20	0.001
7	1.40		0.17			0.050	0.20	0.002
8	1.60		0.13			0.030	0.25	0.001
RDB	1.90		0.00			0.000	0.15	0.000
								0.010

Notes:
1. Water elevation 272.029m (1312 hrs)
2. The channel was opened at the discharge section - no correction of discharge calculation required
3. Elevation 271.9m, top of V-notch weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 23 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1500 hrs.
MEASUREMENT END TIME: 1520 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.04			0.010	0.20	0.000
2	0.40		0.08			0.010	0.20	0.000
3	0.60		0.12			0.050	0.20	0.001
4	0.80		0.14			0.070	0.20	0.002
5	1.00		0.17			0.070	0.20	0.002
6	1.20		0.18			0.100	0.20	0.004
7	1.40		0.16			0.070	0.24	0.003
RDB	1.68		0.00			0.000	0.14	0.000
								0.012

Notes:
1. Water elevation 272.035m (1520 hrs)
2. The channel was opened at the discharge section - no correction of discharge calculation required
3. Elevation 271.906m, top of V-notch weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1525 hrs.
MEASUREMENT END TIME: 1529 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.20	0.000
1	0.40		0.06			-0.020	0.30	0.000
2	0.60		0.10			0.010	0.20	0.000
3	0.80		0.11			0.070	0.20	0.002
4	1.00		0.11			0.090	0.20	0.002
5	1.20		0.11			0.110	0.20	0.002
6	1.40		0.08			0.130	0.20	0.002
7	1.60		0.08			0.120	0.20	0.002
8	1.80		0.06			0.040	0.25	0.001
RDB	2.10		0.00			0.000	0.15	0.000
								0.010

Notes: 1. Water elevation 272.037m (1524 hrs)
2. Elevation 271.910m, top of V-notch weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1216 hrs.
MEASUREMENT END TIME: 1224 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.05			0.220	0.20	0.002
2	0.40		0.07			0.240	0.10	0.002
3	0.50		0.12			0.240	0.10	0.003
4	0.60		0.14			0.260	0.10	0.004
5	0.70		0.14			0.270	0.10	0.004
6	0.80		0.14			0.280	0.10	0.004
7	0.90		0.15			0.280	0.10	0.004
8	1.00		0.11			0.250	0.10	0.003
9	1.10		0.07			0.150	0.10	0.001
RDB	1.20		0.00			0.000	0.05	0.000
								0.026

Notes: 1. Water elevation 272.093m (1224 hrs)
2. Elevation 271.910m, top of V-notch weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 08 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1407 hrs.
MEASUREMENT END TIME: 1414 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.04			0.020	0.20	0.000
2	0.40		0.05			0.100	0.15	0.001
3	0.50		0.08			0.080	0.10	0.001
4	0.60		0.12			0.220	0.10	0.003
5	0.70		0.14			0.250	0.10	0.004
6	0.80		0.12			0.250	0.10	0.003
7	0.90		0.12			0.260	0.10	0.003
8	1.00		0.11			0.260	0.10	0.003
9	1.10		0.08			0.230	0.13	0.002
RDB	1.25		0.00			0.000	0.08	0.000
								0.019

Note: 1. Water elevation 272.114m (1422 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E
MEASUREMENT DATE: 10 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1237 hrs.
MEASUREMENT END TIME: 1241 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.30		0.00			0.000	0.05	0.000
1	0.40		0.02			-0.020	0.10	0.000
2	0.50		0.03			0.060	0.10	0.000
3	0.60		0.08			0.120	0.10	0.001
4	0.70		0.11			0.220	0.10	0.002
5	0.80		0.13			0.240	0.10	0.003
6	0.90		0.09			0.340	0.10	0.003
7	1.00		0.11			0.210	0.10	0.002
8	1.10		0.10			0.300	0.10	0.003
9	1.20		0.08			0.190	0.10	0.002
10	1.30		0.04			0.110	0.15	0.001
RDB	1.50		0.00			0.000	0.10	0.000
								0.017

Note: 1. Water elevation 272.091m (1234 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S6
STREAM NAME: Mills Creek
COORDINATES: 6344743.3N/463828.7E

MEASUREMENT DATE: 21 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1331 hrs.
MEASUREMENT END TIME: 1333 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.20		0.00			0.000	0.05	0.000
1	0.30		0.04			0.230	0.10	0.001
2	0.40		0.06			0.300	0.10	0.002
3	0.50		0.07			0.270	0.10	0.002
4	0.60		0.08			0.310	0.10	0.002
5	0.70		0.11			0.360	0.10	0.004
6	0.80		0.11			0.340	0.10	0.004
7	0.90		0.10			0.340	0.10	0.003
8	1.00		0.08			0.230	0.10	0.002
9	1.10		0.05			0.070	0.14	0.000
RDB	1.28		0.00			0.000	0.09	0.000
								0.021

Notes:
1. Surveyed the water level el.=272.083m @1338 hrs.
2. Elevation 271.907m, V-notch weir
3. TSS collected
4. No ice cover when discharge measurement taken
5. Instruments were removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 10 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1510 hrs.
MEASUREMENT END TIME: 1528 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.90	0.23	0.00			0.000	0.20	0.000
1	2.30	0.23	0.25			0.020	0.83	0.004
2	3.55	0.25	0.30			0.040	1.20	0.013
3	4.70	0.31	0.36			0.060	1.13	0.022
4	5.80	0.24	0.40			0.060	1.15	0.025
5	7.00	0.23	0.35			0.070	1.13	0.025
6	8.05	0.20	0.45			0.080	1.15	0.038
7	9.30	0.19	0.44			0.060	1.23	0.029
8	10.50	0.24	0.43			0.070	1.20	0.033
9	11.70	0.21	0.46			0.090	1.15	0.043
10	12.80	0.21	0.44			0.080	1.48	0.048
11	14.65	0.23	0.35			0.050	1.50	0.024
12	15.80	0.25	0.34			0.030	0.83	0.008
RDB	16.30	0.25	0.00			0.000	0.25	0.000
								0.313

Note: 1. Water elevation 271.962m, top of ice elevation 271.963m (1525 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 05 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1615 hrs.
MEASUREMENT END TIME: 1635 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.60	0.35	0.00			0.000	0.35	0.000
1	1.30	0.35	0.21			0.000	1.20	0.000
2	3.00	0.39	0.25			0.050	1.80	0.021
3	4.90	0.30	0.35			0.050	1.95	0.031
4	6.90	0.27	0.38			0.060	2.15	0.045
5	9.20	0.27	0.44			0.050	2.03	0.041
6	10.95	0.29	0.40			0.040	1.65	0.024
7	12.50	0.27	0.29			0.040	1.53	0.016
RDB	14.00	0.27	0.00			0.000	0.75	0.000
								0.178

Note: 1. Water elevation 271.975m, top of ice elevation 271.960m (1644 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 15 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1415 hrs.
MEASUREMENT END TIME: 1435 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.76	0.00			0.000	0.33	0.000
1	0.65	0.76	0.16			0.020	1.03	0.003
2	2.05	0.78	0.22			0.020	1.60	0.006
3	3.85	0.80	0.37			0.030	1.95	0.020
4	5.95	0.64	0.55			0.050	2.00	0.050
5	7.84	0.61	0.64			0.050	1.98	0.058
6	9.90	0.64	0.56			0.050	1.76	0.045
7	11.35	0.63	0.51			0.050	1.58	0.037
8	13.05	0.65	0.43			0.050	1.78	0.035
9	14.90	0.73	0.37			0.020	1.73	0.012
RDB	16.50	0.73	0.00			0.000	0.80	0.000
								0.267

Note: 1. Water elevation 272.418m, top of ice elevation 272.418m (1536 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 08 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1515 hrs.
MEASUREMENT END TIME: 1535 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.76	0.00			0.000	0.70	0.000
1	1.40	0.76	0.19			0.000	1.70	0.000
2	3.40	0.73	0.43			0.050	1.88	0.037
3	5.15	0.65	0.54			0.050	1.88	0.047
4	7.15	0.67	0.56			0.030	1.83	0.028
5	8.80	0.68	0.64			0.100	1.63	0.096
6	10.40	0.78	0.32			0.110	1.35	0.043
7	11.50	0.82	0.35			0.110	1.25	0.044
8	12.90	0.87	0.27			0.060	1.35	0.020
RDB	14.20	0.87	0.00			0.000	0.65	0.000
								0.315

Note: 1. Water elevation 272.50m, top of ice elevation 272.513m (1545 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 25 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 272.417m (1443 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1732 hrs.
MEASUREMENT END TIME: 1743 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	3.70		0.00			0.000	0.15	0.000
1	4.00		0.04			0.180	0.40	0.003
2	4.50		0.05			0.150	0.50	0.004
3	5.00		0.09			0.230	0.50	0.010
4	5.50		0.11			0.550	0.50	0.030
5	6.00		0.15			0.670	0.50	0.050
6	6.50		0.19			0.600	0.50	0.057
7	7.00		0.21			0.820	0.50	0.086
8	7.50		0.23			0.900	0.50	0.104
9	8.00		0.24			0.930	0.50	0.112
10	8.50		0.24			0.850	0.50	0.102
11	9.00		0.22			0.810	0.50	0.089
12	9.50		0.20			0.900	0.50	0.090
13	10.00		0.24			1.100	0.50	0.132
14	10.50		0.22			0.820	0.50	0.090
15	11.00		0.16			0.790	0.50	0.063
16	11.50		0.16			0.490	0.50	0.039
17	12.00		0.14			0.610	0.50	0.043
18	12.50		0.12			0.460	0.50	0.028
19	13.00		0.08			0.340	0.50	0.014
20	13.50		0.06			0.010	0.55	0.000
RDB	14.10		0.00			0.000	0.30	0.000
								1.146

Note: 1. Water elevation 271.974m (1724 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 28 Nov 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1429 hrs.
MEASUREMENT END TIME: 1434 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	7.40		0.00			0.000	0.30	0.000
1	8.00		0.20			0.790	0.80	0.126
2	9.00		0.27			0.870	1.00	0.235
3	10.00		0.32			0.810	1.00	0.259
4	11.00		0.28			0.960	1.00	0.269
5	12.00		0.33			1.020	1.00	0.337
6	13.00		0.29			0.830	1.00	0.241
7	14.00		0.22			0.940	1.00	0.207
8	15.00		0.22			0.790	1.00	0.174
9	16.00		0.12			0.250	0.70	0.021
RDB	16.40		0.00			0.000	0.20	0.000
								1.868

Notes: 1. Water elevation 272.044m, top of ice elevation 272.067m (1440 hrs)
2. The discharge was measurement downstream of the gauging station, open water, no correction for ice cover

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S7
STREAM NAME: Muskeg River
COORDINATES: 6338944N/465408E
MEASUREMENT DATE: 07 Jan 2003
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1410 hrs.
MEASUREMENT END TIME: 1418 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.31	0.00			0.000	0.60	0.000
1	1.20	0.31	0.33			0.040	1.53	0.019
2	3.05	0.37	0.42			0.100	1.90	0.073
3	5.00	0.32	0.50			0.160	2.00	0.147
4	7.05	0.30	0.53			0.130	1.90	0.120
5	8.80	0.23	0.57			0.130	1.88	0.128
6	10.80	0.27	0.55			0.140	1.90	0.135
7	12.60	0.37	0.33			0.100	1.48	0.045
8	13.75	0.31	0.07			0.040	1.15	0.003
RDB	14.90	0.31	0.00			0.000	0.58	0.000
								0.670

Note: 1. Water elevation 272.143m, top of ice elevation 272.123m (1420hrs) - Water level is above top of ice

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S8
STREAM NAME: Stanley Creek
COORDINATES: 6356450N/477500E
MEASUREMENT DATE: 28 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elev ation 289.983m (1206 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S8
STREAM NAME: Stanley Creek
COORDINATES: 6356450N/477500E
MEASUREMENT DATE: 16 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 289.829m (1531 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S8
STREAM NAME: Stanley Creek
COORDINATES: 6356450N/477500E
MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 289.780m (1050 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S8
STREAM NAME: Stanley Creek
COORDINATES: 6356450N/477500E
MEASUREMENT DATE: 26 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 289.732m, top of ice elevation 289.765m (1310 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet
COORDINATES: 6346750N/483980E
MEASUREMENT DATE: 8 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Note: 1. Ice conditions; no flow observed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet
COORDINATES: 6346750N/483980E
MEASUREMENT DATE: 23 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Note: 1. Ice conditions; no flow observed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet
COORDINATES: 6346750N/483980E
MEASUREMENT DATE: 25 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Note: 1. Ice conditions; no flow observed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet **MEASUREMENT DATE: 15 May 2002**
COORDINATES: 6346750N/483980E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/ME **MEASUREMENT START TIME: 1105 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1110 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.71			0.030	0.30	0.006
2	0.60		0.71			0.040	0.30	0.009
3	0.90		0.70			0.050	0.30	0.011
4	1.20		0.61			0.020	0.30	0.004
5	1.50		0.58			0.010	0.30	0.002
6	1.80		0.56			0.000	0.30	0.000
7	2.10		0.51			0.060	0.30	0.009
8	2.40		0.56			0.060	0.30	0.010
9	2.70		0.59			0.050	0.30	0.009
10	3.00		0.62			0.030	0.30	0.006
11	3.30		0.59			0.010	0.30	0.002
12	3.60		0.54			0.010	0.45	0.002
RDB	4.20		0.00			0.000	0.30	0.000
								0.069

Notes: 1. Water elevation 329.381m (1111 hrs)
2. Temporary transducer was installed s/n 981354-2psi

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet **MEASUREMENT DATE: 09 Jun 2002**
COORDINATES: 6346750N/483980E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/PM **MEASUREMENT START TIME: 1620 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1624 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.10		0.00			0.000	0.20	0.000
1	0.50		0.40			-0.010	0.45	-0.002
2	1.00		0.42			0.000	0.50	0.000
3	1.50		0.42			0.010	0.35	0.001
4	1.70		0.36			0.000	0.35	0.000
5	2.20		0.36			-0.020	0.50	-0.004
6	2.70		0.31			0.010	0.40	0.001
7	3.00		0.35			0.000	0.45	0.000
8	3.60		0.36			-0.010	0.63	-0.002
RDB	4.25		0.00			0.000	0.33	0.000
								-0.005

Note: 1. Water elevation 329.176m (1629 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet
COORDINATES: 6346750N/483980E

MEASUREMENT DATE: 11 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1405 hrs.
MEASUREMENT END TIME: 1415 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.20		0.00			0.000	0.05	0.000
1	0.30		0.20			0.000	0.10	0.000
2	0.40		0.24			0.000	0.10	0.000
3	0.50		0.42			0.000	0.10	0.000
4	0.60		0.46			0.010	0.10	0.000
5	0.70		0.48			0.010	0.10	0.000
6	0.80		0.38			0.010	0.10	0.000
7	0.90		0.38			0.010	0.10	0.000
8	1.00		0.41			0.000	0.10	0.000
9	1.10		0.48			0.000	0.10	0.000
10	1.20		0.24			0.020	0.10	0.000
11	1.30		0.30			0.020	0.10	0.001
12	1.40		0.30			0.010	0.10	0.000
13	1.50		0.20			0.000	0.10	0.000
14	1.60		0.20			0.000	0.10	0.000
15	1.70		0.18			0.000	0.10	0.000
16	1.80		0.18			0.010	0.25	0.000
RDB	2.20		0.00			0.000	0.20	0.000
								0.004

Note: 1. Water elevation 329.160m (1430 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet
COORDINATES: 6346750N/483980E

MEASUREMENT DATE: 13 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1443 hrs.
MEASUREMENT END TIME: 1458 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.50		0.00			0.000	0.25	0.000
1	2.00		0.46			0.010	0.50	0.002
2	2.50		0.48			0.040	0.50	0.010
3	3.00		0.49			0.080	0.50	0.020
4	3.50		0.57			0.180	0.50	0.051
5	4.00		0.55			0.250	0.50	0.069
6	4.50		0.60			0.350	0.50	0.105
7	5.00		0.60			0.310	0.50	0.093
8	5.50		0.62			0.350	0.50	0.109
9	6.00		0.64			0.270	0.50	0.086
10	6.50		0.65			0.140	0.50	0.046
11	7.00		0.86			0.150	0.50	0.065
12	7.50		0.70			0.060	0.50	0.021
13	8.00		0.55			0.060	0.50	0.017
14	8.50		0.54			0.040	0.40	0.009
RDB	8.80		0.00			0.000	0.15	0.000
								0.701

Note: 1. Water elevation 329.672m (1443 hrs)
2. The discharge was carried out d/s of the gauging station (approximately 20m d/s of the access road culvert)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S9
STREAM NAME: Kearl Lake Outlet
COORDINATES: 6346750N/483980E

MEASUREMENT DATE: 25 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1105 hrs.
MEASUREMENT END TIME: 1115 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.40		0.00			0.000	0.45	0.000
1	1.30		0.29			0.000	0.55	0.000
2	1.50		0.48			0.020	0.35	0.003
3	2.00		0.36			0.120	0.50	0.022
4	2.50		0.43			0.350	0.50	0.075
5	3.00		0.50			0.290	0.50	0.073
6	3.50		0.55			0.290	0.50	0.080
7	4.00		0.56			0.320	0.50	0.090
8	4.50		0.58			0.110	0.50	0.032
9	5.00		0.64			0.060	0.50	0.019
10	5.50		0.60			0.130	0.50	0.039
11	6.00		0.58			0.050	0.50	0.015
12	6.50		0.53			0.070	0.50	0.019
13	7.00		0.41			0.010	0.50	0.002
14	7.50		0.35			0.000	0.45	0.000
RDB	7.90		0.00			0.000	0.20	0.000
								0.467

Note:
1. Water elevation 329.596m, top of ice elevation 329.605m (1119 hrs)
2. The discharge was carried out d/s of the gauging station (approximately 20m d/s of the access road culvert)
3. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E

MEASUREMENT DATE: 8 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. Ice covered conditions; no flow

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E

MEASUREMENT DATE: 23 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1230 hrs.
MEASUREMENT END TIME: 1236 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.08	0.000
1	0.15		0.08			0.050	0.18	0.001
2	0.35		0.12			0.220	0.20	0.005
3	0.55		0.14			0.290	0.20	0.008
4	0.75		0.13			0.210	0.20	0.005
5	0.95		0.14			0.130	0.20	0.004
6	1.15		0.14			0.090	0.20	0.003
7	1.35		0.12			0.140	0.20	0.003
8	1.55		0.20			0.130	0.20	0.005
9	1.75		0.12			0.020	0.18	0.000
RDB	1.90		0.00			0.000	0.08	0.000
								0.035

Notes: 1. Water elevation 320.004m (1252 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E

MEASUREMENT DATE: 15 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0928 hrs.
MEASUREMENT END TIME: 0940 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.10			-0.010	0.30	0.000
2	0.60		0.28			-0.020	0.30	-0.002
3	0.90		0.42			-0.020	0.30	-0.003
4	1.20		0.58			0.020	0.30	0.003
5	1.50		0.60			0.020	0.30	0.004
6	1.80		0.64			0.000	0.30	0.000
7	2.10		0.62			0.020	0.30	0.004
8	2.40		0.64			0.000	0.30	0.000
9	2.70		0.63			0.000	0.30	0.000
10	3.00		0.60			0.030	0.30	0.005
11	3.30		0.52			-0.010	0.30	-0.002
12	3.60		0.50			0.010	0.30	0.002
13	3.90		0.22			0.010	0.30	0.001
14	4.20		0.38			0.000	0.35	0.000
RDB	4.60		0.00			0.000	0.20	0.000
								0.012

Notes: 1. Water elevation 319.509m (0941 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E

MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1500 hrs.
MEASUREMENT END TIME: 1510 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.60		0.00			0.000	0.10	0.000
1	0.80		0.13			0.100	0.15	0.002
2	0.90		0.20			0.190	0.10	0.004
3	1.00		0.24			0.330	0.10	0.008
4	1.10		0.26			0.440	0.10	0.011
5	1.20		0.25			0.570	0.10	0.014
6	1.30		0.25			0.670	0.10	0.017
7	1.40		0.25			0.730	0.10	0.018
8	1.50		0.26			0.790	0.10	0.021
9	1.60		0.26			0.810	0.10	0.021
10	1.70		0.27			0.760	0.10	0.021
11	1.80		0.26			0.150	0.10	0.004
12	1.90		0.26			0.560	0.10	0.015
13	2.00		0.24			0.370	0.10	0.009
14	2.10		0.24			0.150	0.10	0.004
15	2.20		0.22			-0.020	0.10	0.000
16	2.30		0.19			-0.010	0.15	0.000
17	2.50		0.20			-0.030	0.30	-0.002
RDB	2.90		0.00			0.000	0.20	0.000
								0.165

Notes: 1. Water elevation 319.666m (1511 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E
MEASUREMENT DATE: 11 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1155 hrs.
MEASUREMENT END TIME: 1207 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.20	0.000
1	0.40		0.10			0.100	0.35	0.004
2	0.70		0.08			0.350	0.30	0.008
3	1.00		0.08			0.350	0.30	0.008
4	1.30		0.46			0.510	0.25	0.059
5	1.50		0.48			0.570	0.20	0.055
6	1.70		0.46			0.610	0.20	0.056
7	1.90		0.46			0.640	0.20	0.059
8	2.10		0.46			0.620	0.20	0.057
9	2.30		0.45			0.610	0.20	0.055
10	2.50		0.46			0.530	0.20	0.049
11	2.70		0.45			0.490	0.20	0.044
12	2.90		0.44			0.430	0.20	0.038
13	3.10		0.44			0.450	0.20	0.040
14	3.30		0.39			0.480	0.20	0.037
15	3.50		0.38			0.220	0.20	0.017
16	3.70		0.38			0.030	0.15	0.002
RDB	3.80		0.00			0.000	0.05	0.000
								0.587

Notes: 1. Water elevation 320.136m (1207hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E
MEASUREMENT DATE: 31 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes: 1. Water elevation 320.442m (0920hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek
COORDINATES: 6355942N/490272E

MEASUREMENT DATE: 11 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0914 hrs.
MEASUREMENT END TIME: 0920 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.30		0.00			0.000	0.85	0.000
1	2.00		0.12			0.010	1.10	0.001
2	2.50		0.08			0.030	0.50	0.001
3	3.00		0.16			0.010	0.50	0.001
4	3.50		0.11			0.040	0.50	0.002
5	4.00		0.60			0.120	0.50	0.036
6	4.50		0.75			0.500	0.50	0.188
7	5.00		0.80			0.750	0.50	0.300
8	5.50		0.80			0.810	0.50	0.324
9	6.00		0.75			0.710	0.50	0.266
10	6.50		0.56			0.810	0.50	0.227
11	7.00		0.50			0.840	0.50	0.210
12	7.50		0.46			0.680	0.50	0.156
13	8.00		0.31			0.480	0.50	0.074
14	8.50		0.24			0.140	0.50	0.017
15	9.00		0.16			0.100	0.50	0.008
16	9.50		0.08			0.010	0.50	0.000
17	10.00		0.14			0.000	0.65	0.000
RDB	10.80		0.00			0.000	0.40	0.000
								1.812

Notes: 1. Water elevation 320.289m (0927 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek **MEASUREMENT DATE: 13 Sep 2002**
COORDINATES: 6355942N/490272E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/NS **MEASUREMENT START TIME: 1405 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1411 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	3.30		0.00			0.000	0.10	0.000
1	3.50		0.42			0.030	0.35	0.004
2	4.00		0.37			0.340	0.50	0.063
3	4.50		0.52			0.570	0.50	0.148
4	5.00		0.58			0.590	0.50	0.171
5	5.50		0.62			0.630	0.50	0.195
6	6.00		0.50			0.430	0.50	0.108
7	6.50		0.40			0.400	0.50	0.080
8	7.00		0.33			0.390	0.50	0.064
9	7.50		0.28			0.060	0.50	0.008
10	8.00		0.22			0.030	0.50	0.003
11	8.50		0.16			0.000	0.75	0.000
RDB	9.50		0.00			0.000	0.50	0.000
								0.845

Notes:
1. Water elevation 320.045m (1417 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S10
STREAM NAME: Wapasu Creek **MEASUREMENT DATE: 25 Oct 2002**
COORDINATES: 6355942N/490272E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/TC **MEASUREMENT START TIME: 1302 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1307 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.31			0.000	0.50	0.000
2	1.00		0.34			-0.030	0.50	-0.005
3	1.50		0.38			0.250	0.50	0.048
4	2.00		0.46			0.340	0.50	0.078
5	2.50		0.57			0.320	0.50	0.091
6	3.00		0.57			0.280	0.50	0.080
7	3.50		0.55			0.210	0.40	0.046
8	3.80		0.49			0.150	0.35	0.026
9	4.20		0.44			0.060	0.43	0.011
RDB	4.65		0.00			0.000	0.23	0.000
								0.375

Notes:
1. Water elevation 319.852m (1313 hrs)
2. TSS collected
3. Transducer/temperature probes were removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E
MEASUREMENT DATE: 10 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1503 hrs.
MEASUREMENT END TIME: 1511 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.13			-0.020	0.20	-0.001
2	0.40		0.19			0.310	0.10	0.006
3	0.50		0.23			0.720	0.10	0.017
4	0.60		0.26			0.680	0.10	0.018
5	0.70		0.28			0.970	0.10	0.027
6	0.80		0.32			1.020	0.10	0.033
7	0.90		0.29			1.140	0.10	0.033
8	1.00		0.26			0.860	0.10	0.022
9	1.10		0.20			0.170	0.10	0.003
10	1.20		0.10			-0.090	0.15	-0.001
RDB	1.40		0.00			0.000	0.10	0.000
								0.157

Notes:
1. Water elevation 241.589m, top of ice elevation 241.623m (1437 hrs)
2. Water was flowing in a channel on top of the ice

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E
MEASUREMENT DATE: 23 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1645 hrs.
MEASUREMENT END TIME: 1655 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.55		0.00			0.000	0.23	0.000
1	1.00		0.26			0.030	0.48	0.004
2	1.50		0.26			0.240	0.50	0.031
3	2.00		0.24			0.240	0.50	0.029
4	2.50		0.24			0.250	0.50	0.030
5	3.00		0.38			0.300	0.50	0.057
6	3.50		0.36			0.260	0.50	0.047
7	4.00		0.34			0.280	0.50	0.048
8	4.50		0.32			0.290	0.50	0.046
9	5.00		0.33			0.210	0.50	0.035
10	5.50		0.26			0.170	0.50	0.022
11	6.00		0.28			0.070	0.50	0.010
12	6.50		0.18			0.070	0.50	0.006
13	7.00		0.14			0.020	0.60	0.002
RDB	7.70		0.00			0.000	0.35	0.000
								0.366

Notes:
1. Water elevation 240.985m (1700 hrs)
2. Discharge measurement done at the open section of creek

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E

MEASUREMENT DATE: 18 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1004 hrs.
MEASUREMENT END TIME: 1011 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.20		0.00			0.000	0.10	0.000
1	0.40		0.16			0.000	0.15	0.000
2	0.50		0.13			0.000	0.10	0.000
3	0.60		0.22			0.030	0.10	0.001
4	0.70		0.24			0.040	0.10	0.001
5	0.80		0.26			0.060	0.10	0.002
6	0.90		0.30			0.060	0.10	0.002
7	1.00		0.35			0.060	0.10	0.002
8	1.10		0.33			0.070	0.10	0.002
9	1.20		0.36			0.050	0.10	0.002
10	1.30		0.37			0.060	0.10	0.002
11	1.40		0.35			0.050	0.10	0.002
12	1.50		0.37			0.040	0.10	0.001
13	1.60		0.20			0.060	0.10	0.001
14	1.70		0.22			0.050	0.10	0.001
15	1.80		0.33			0.040	0.10	0.001
16	1.90		0.13			0.050	0.10	0.001
17	2.00		0.11			0.040	0.10	0.000
18	2.10		0.14			0.030	0.10	0.000
19	2.20		0.16			0.010	0.10	0.000
20	2.30		0.04			0.010	0.10	0.000
21	2.40		0.18			0.020	0.12	0.000
RDB	2.54		0.00			0.000	0.07	0.000
								0.022

Notes: 1. Water elevation 240.829m (1015 hrs)
2. Water level in the creek is very low

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E
MEASUREMENT DATE: 13 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1308 hrs.
MEASUREMENT END TIME: 1314 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.11			0.250	0.40	0.011
2	0.80		0.17			0.100	0.30	0.005
3	1.10		0.09			0.090	0.30	0.002
4	1.40		0.16			0.350	0.33	0.018
5	1.75		0.26			0.600	0.30	0.047
6	2.00		0.28			0.330	0.28	0.025
7	2.30		0.26			0.840	0.30	0.066
8	2.60		0.30			0.470	0.30	0.042
9	2.90		0.20			0.410	0.30	0.025
10	3.20		0.23			0.580	0.30	0.040
11	3.50		0.09			0.290	0.30	0.008
12	3.80		0.10			0.150	0.33	0.005
13	4.15		0.04			0.030	0.26	0.000
RDB	4.32		0.00			0.000	0.09	0.000
								0.294

Note: 1. Water elevation 240.953m (1317 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E
MEASUREMENT DATE: 09 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1349 hrs.
MEASUREMENT END TIME: 1401 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.60		0.00			0.000	0.05	0.000
1	0.70		0.05			0.240	0.15	0.002
2	0.90		0.00			0.000	0.18	0.000
3	1.05		0.07			0.090	0.20	0.001
4	1.30		0.05			0.390	0.23	0.004
5	1.50		0.06			0.520	0.20	0.006
6	1.70		0.07			0.280	0.20	0.004
7	1.90		0.06			0.490	0.20	0.006
8	2.10		0.09			0.170	0.20	0.003
9	2.30		0.10			0.190	0.20	0.004
10	2.50		0.14			0.500	0.20	0.014
11	2.70		0.13			0.030	0.20	0.001
12	2.90		0.14			0.150	0.20	0.004
13	3.10		0.11			0.230	0.20	0.005
14	3.30		0.07			0.070	0.18	0.001
RDB	3.45		0.00			0.000	0.08	0.000
								0.055

Note: 1. Water elevation 240.924m (1440 hrs July 8th, 2002)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E

MEASUREMENT DATE: 11 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1424 hrs.
MEASUREMENT END TIME: 1430 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.60	0.000
1	1.20		0.22			0.060	1.10	0.015
2	2.20		0.28			0.180	1.00	0.050
3	3.20		0.28			0.310	1.00	0.087
4	4.20		0.34			0.250	1.00	0.085
5	5.20		0.22			0.180	1.00	0.040
6	6.20		0.26			0.190	1.00	0.049
7	7.20		0.21			0.200	1.00	0.042
8	8.20		0.25			0.170	1.00	0.043
9	9.20		0.25			0.180	1.00	0.045
10	10.20		0.22			0.290	1.00	0.064
11	11.20		0.27			0.290	1.00	0.078
12	12.20		0.28			0.220	1.00	0.062
13	13.20		0.26			0.260	1.00	0.068
14	14.20		0.35			0.250	1.00	0.088
15	15.20		0.32			0.170	1.00	0.054
16	16.20		0.30			0.040	1.00	0.012
17	17.20		0.26			0.110	1.00	0.029
18	18.20		0.14			0.170	0.90	0.021
RDB	19.00		0.00			0.000	0.40	0.000
								0.930

Note: 1. Water elevation 241.071m (1433 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S11
STREAM NAME: Poplar Creek
COORDINATES: 6307667N/471998E

MEASUREMENT DATE: 29 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: TC/JE
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1422 hrs.
MEASUREMENT END TIME: 1443 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.05	0.000
1	0.10		0.14			-0.010	0.30	0.000
2	0.60		0.22			0.060	0.50	0.007
3	1.10		0.19			0.110	0.50	0.010
4	1.60		0.20			0.140	0.50	0.014
5	2.10		0.25			0.160	0.50	0.020
6	2.60		0.26			0.090	0.50	0.012
7	3.10		0.33			0.210	0.50	0.035
8	3.60		0.38			0.070	0.50	0.013
9	4.10		0.38			0.120	0.50	0.023
10	4.60		0.38			0.130	0.50	0.025
11	5.10		0.36			0.060	0.50	0.011
12	5.60		0.25			0.110	0.50	0.014
13	6.10		0.34			0.140	0.50	0.024
14	6.60		0.26			0.170	0.50	0.022
15	7.10		0.21			0.180	0.50	0.019
16	7.60		0.21			0.180	0.50	0.019
17	8.10		0.21			0.170	0.50	0.018
18	8.60		0.26			0.140	0.50	0.018
19	9.10		0.26			0.150	0.50	0.020
20	9.60		0.25			0.160	0.50	0.020
21	10.10		0.24			0.180	0.50	0.022
22	10.60		0.19			0.170	0.50	0.016
23	11.10		0.19			0.190	0.50	0.018
24	11.60		0.26			0.170	0.50	0.022
25	12.10		0.30			0.160	0.50	0.024
26	12.60		0.27			0.170	0.50	0.023
27	13.10		0.26			0.180	0.50	0.023
28	13.60		0.26			0.170	0.50	0.022
29	14.10		0.33			0.150	0.50	0.025
30	14.60		0.29			0.190	0.50	0.028
31	15.10		0.29			0.160	0.50	0.023
32	15.60		0.26			0.170	0.50	0.022
33	16.10		0.24			0.170	0.50	0.020
34	16.60		0.21			0.110	0.50	0.012
35	17.10		0.26			0.110	0.50	0.014
36	17.60		0.19			0.130	0.50	0.012
37	18.10		0.13			0.080	0.65	0.007
RDB	18.90		0.00			0.000	0.40	0.000
								0.675

Notes:
1. Water elevation 241.055m (1413 hrs)
2. Poplar Reservoir gate was not totally shut down due to debris jammed underneath

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S12
STREAM NAME: Fort Creek
COORDINATES: 6363545N/462641E
MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0942 hrs.
MEASUREMENT END TIME: 1003 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.10			0.070	0.15	0.001
2	0.30		0.14			0.150	0.10	0.002
3	0.40		0.14			0.280	0.10	0.004
4	0.50		0.19			0.320	0.10	0.006
5	0.60		0.20			0.340	0.10	0.007
6	0.70		0.22			0.430	0.10	0.009
7	0.80		0.22			0.440	0.10	0.010
8	0.90		0.22			0.510	0.10	0.011
9	1.00		0.19			0.560	0.10	0.011
10	1.10		0.19			0.440	0.10	0.008
11	1.20		0.20			0.350	0.10	0.007
12	1.30		0.19			0.370	0.10	0.007
13	1.40		0.16			0.290	0.10	0.005
14	1.50		0.15			0.240	0.10	0.004
15	1.60		0.13			0.060	0.10	0.001
16	1.70		0.04			0.050	0.15	0.000
RDB	1.90		0.00			0.000	0.10	0.000
								0.093

Notes:
1. Water elev ation 251.019m (1010 hrs)
2. TSS collected
3. Installed the temporary transducer in the creek
4. Installed the thermistor string, as per request by Aquatics Group

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S12
STREAM NAME: Fort Creek
COORDINATES: 6363545N/462641E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes:
1. Culvert upstream of station was blocked by ice

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S12
STREAM NAME: Fort Creek
COORDINATES: 6363545N/462641E

MEASUREMENT DATE: 08 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1228 hrs.
MEASUREMENT END TIME: 1302 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.04			0.200	0.15	0.001
2	0.30		0.15			0.300	0.10	0.005
3	0.40		0.13			0.120	0.10	0.002
4	0.50		0.12			0.490	0.10	0.006
5	0.60		0.11			0.450	0.10	0.005
6	0.70		0.12			0.500	0.10	0.006
7	0.80		0.12			0.540	0.10	0.006
8	0.90		0.14			0.380	0.10	0.005
9	1.00		0.14			0.470	0.10	0.007
10	1.10		0.14			0.460	0.10	0.006
11	1.20		0.12			0.430	0.10	0.005
12	1.30		0.14			0.360	0.10	0.005
13	1.40		0.20			0.500	0.10	0.010
14	1.50		0.08			0.460	0.10	0.004
15	1.60		0.08			0.340	0.10	0.003
16	1.70		0.07			0.270	0.10	0.002
17	1.80		0.06			0.200	0.10	0.001
18	1.90		0.07			0.020	0.10	0.000
RDB	2.00		0.00			0.000	0.05	0.000
								0.079

Notes:
1. Water elevation 250.988m (1310 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S12
STREAM NAME: Fort Creek
COORDINATES: 6363545N/462641E

MEASUREMENT DATE: 10 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1322 hrs.
MEASUREMENT END TIME: 1326 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.20		0.00			0.000	0.10	0.000
1	0.40		0.10			0.610	0.20	0.012
2	0.60		0.12			0.450	0.15	0.008
3	0.70		0.16			0.430	0.10	0.007
4	0.80		0.13			0.560	0.10	0.007
5	0.90		0.16			0.570	0.10	0.009
6	1.00		0.12			0.580	0.10	0.007
7	1.10		0.16			0.630	0.10	0.010
8	1.20		0.14			0.520	0.10	0.007
9	1.30		0.14			0.560	0.10	0.008
10	1.40		0.14			0.530	0.10	0.007
11	1.50		0.12			0.460	0.10	0.006
12	1.60		0.10			0.390	0.10	0.004
13	1.70		0.06			0.310	0.18	0.003
RDB	1.95		0.00			0.000	0.13	0.000
								0.096

Notes:
1. Water elevation 250.683m (1333 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S12
STREAM NAME: Fort Creek
COORDINATES: 6363545N/462641E

MEASUREMENT DATE: 23 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1335 hrs.
MEASUREMENT END TIME: 1348 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.20		0.00			0.000	0.05	0.000
1	0.30		0.08			0.100	0.10	0.001
2	0.40		0.10			0.150	0.10	0.002
3	0.50		0.10			0.180	0.10	0.002
4	0.60		0.12			0.190	0.10	0.002
5	0.70		0.15			0.150	0.10	0.002
6	0.80		0.16			0.320	0.10	0.005
7	0.90		0.16			0.150	0.10	0.002
8	1.00		0.14			0.370	0.10	0.005
9	1.10		0.16			0.270	0.10	0.004
10	1.20		0.14			0.240	0.10	0.003
11	1.30		0.13			0.220	0.10	0.003
12	1.40		0.12			0.140	0.10	0.002
13	1.50		0.10			0.070	0.10	0.001
14	1.60		0.08			0.010	0.10	0.000
15	1.70		0.04			-0.020	0.08	0.000
RDB	1.75		0.00			0.000	0.03	0.000
								0.034

Notes:
1. Water elevation 250.958m (1350 hrs)
2. TSS collected
3. Transducer and temperature probes were removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S13
STREAM NAME: Albian Pond #3
COORDINATES: 6344688N/468854E
MEASUREMENT DATE: 9 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. No flow observed over weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S13
STREAM NAME: Albian Pond #3
COORDINATES: 6344688N/468854E
MEASUREMENT DATE: 24 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. No flow observed over weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S13
STREAM NAME: Albian Pond #3
COORDINATES: 6344688N/468854E
MEASUREMENT DATE: 9 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. No flow observed over weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S13
STREAM NAME: Albian Pond #3
COORDINATES: 6344688N/468854E

MEASUREMENT DATE: 08 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								0.000
1								0.000
RDB								0.000
								0.000

Notes: 1. Water elevation 278.516m (1426 hrs)
2. Elevation 278.907m, top of V-notch weir

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S14
STREAM NAME: Ells River
COORDINATES: 6349466N/457310E
MEASUREMENT DATE: 28 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 234.283m (1809 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S14
STREAM NAME: Ells River
COORDINATES: 6349466N/457310E
MEASUREMENT DATE: 16 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1055 hrs.
MEASUREMENT END TIME: 1117 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	1.15	0.000
1	2.30		0.34			0.960	2.15	0.702
2	4.30		0.33			0.860	2.00	0.568
3	6.30		0.28			1.010	2.00	0.566
4	8.30		0.32			1.050	2.00	0.672
5	10.30		0.22			0.960	2.00	0.422
6	12.30		0.28			0.760	2.00	0.426
7	14.30		0.30			0.540	2.00	0.324
8	16.30		0.28			0.530	2.00	0.297
9	18.30		0.24			1.120	2.00	0.538
10	20.30		0.32			0.860	2.00	0.550
11	22.30		0.38			1.030	2.50	0.979
12	25.30		0.24			0.320	2.50	0.192
RDB	27.30		0.00			0.000	1.00	0.000
								6.234

Note: 1. Water elevation 233.729m (1055 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S14
STREAM NAME: Ells River
COORDINATES: 6349466N/457310E
MEASUREMENT DATE: 10 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: PM/RS
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1053 hrs.
MEASUREMENT END TIME: 1104 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.50	0.000
1	1.00		0.18			0.480	1.00	0.086
2	2.00		0.30			0.660	1.00	0.198
3	3.00		0.42			0.470	1.00	0.197
4	4.00		0.38			0.730	1.00	0.277
5	5.00		0.44			0.800	1.00	0.352
6	6.00		0.52			0.720	1.00	0.374
7	7.00		0.52			0.770	1.00	0.400
8	8.00		0.50			0.710	1.00	0.355
9	9.00		0.48			0.740	1.00	0.355
10	10.00		0.50			0.600	1.00	0.300
11	11.00		0.50			0.640	1.00	0.320
12	12.00		0.50			0.570	1.00	0.285
13	13.00		0.40			0.500	1.00	0.200
14	14.00		0.33			0.590	1.00	0.195
15	15.00		0.29			0.460	1.00	0.133
16	16.00		0.28			0.470	1.00	0.132
17	17.00		0.20			0.330	1.00	0.066
18	18.00		0.11			0.140	1.00	0.015
RDB	19.00		0.00			0.000	0.50	0.000
								4.242

Note: 1. Water elevation 233.689m (1110 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S14
STREAM NAME: Ells River
COORDINATES: 6349466N/457310E
MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 233.979m (1451 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S14
STREAM NAME: Ells River
COORDINATES: 6349466N/457310E
MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: NS/LL
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0855 hrs.
MEASUREMENT END TIME: 0910 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.30		0.00			0.000	0.15	0.000
1	0.60		0.26			-0.050	0.35	-0.005
2	1.00		0.39			0.050	0.45	0.009
3	1.50		0.42			0.530	0.50	0.111
4	2.00		0.43			0.320	0.75	0.103
5	3.00		0.42			0.910	1.00	0.382
6	4.00		0.49			0.860	1.00	0.421
7	5.00		0.66			0.870	1.00	0.574
8	6.00		0.70			1.000	1.00	0.700
9	7.00		0.72			0.950	1.00	0.684
10	8.00		0.70			0.790	1.00	0.553
11	9.00		0.73			0.810	1.00	0.591
12	10.00		0.70			0.770	1.00	0.539
13	11.00		0.71			0.820	1.00	0.582
14	12.00		0.64			0.820	1.00	0.525
15	13.00		0.57			0.810	1.00	0.462
16	14.00		0.52			0.830	1.00	0.432
17	15.00		0.43			0.830	1.00	0.357
18	16.00		0.40			0.840	1.00	0.336
19	17.00		0.37			0.770	1.00	0.285
20	18.00		0.30			0.530	0.75	0.119
21	18.50		0.36			0.490	0.50	0.088
22	19.00		0.28			0.400	0.50	0.056
23	19.50		0.18			0.310	0.50	0.028
24	20.00		0.10			-0.200	0.45	-0.009
RDB	20.40		0.00			0.000	0.20	0.000
								7.924

Note: 1. Water elevation 233.807m (0918 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S14
STREAM NAME: Ells River
COORDINATES: 6349466N/457310E
MEASUREMENT DATE: 27Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes: 1. Water elevation 234.092m (1133 hrs)
2. Transducer was removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E
MEASUREMENT DATE: 10 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1320 hrs.
MEASUREMENT END TIME: 1331 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.00	0.58	0.00			0.000	0.15	0.000
1	1.30	0.58	0.05			0.000	0.55	0.000
2	2.10	0.54	0.15			0.220	0.90	0.027
3	3.10	0.49	0.11			0.230	0.93	0.022
4	3.95	0.50	0.18			0.140	0.97	0.022
5	5.03	0.55	0.15			0.010	0.83	0.001
RDB	5.60	0.55	0.00			0.000	0.29	0.000
								0.072

Note: 1. Water elevation 282.846m, top of ice elevation 282.965m, ice thickness 58 cm (1335 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E
MEASUREMENT DATE: 24 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 283.301m (1240 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E

MEASUREMENT DATE: 16 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1125 hrs.
MEASUREMENT END TIME: 1150 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.15			0.060	0.50	0.005
2	1.00		0.36			0.130	0.50	0.023
3	1.50		0.38			0.180	0.50	0.034
4	2.00		0.46			0.300	0.50	0.069
5	2.50		0.56			0.330	0.50	0.092
6	3.00		0.58			0.320	0.50	0.093
7	3.50		0.55			0.220	0.50	0.061
8	4.00		0.58			0.200	0.50	0.058
9	4.50		0.56			0.150	0.50	0.042
10	5.00		0.52			0.170	0.50	0.044
11	5.50		0.56			0.180	0.50	0.050
12	6.00		0.58			0.150	0.48	0.041
RDB	6.45		0.00			0.000	0.23	0.000
								0.613

Notes:
1. Water elevation 282.901m (1152 hrs)
2. The transducer was lowered deeper

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E

MEASUREMENT DATE: 08 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: PM/RS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1557 hrs.
MEASUREMENT END TIME: 1620 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.80		0.00			0.000	0.10	0.000
1	1.00		0.05			0.060	0.35	0.001
2	1.50		0.32			0.120	0.50	0.019
3	2.00		0.38			0.200	0.50	0.038
4	2.50		0.42			0.270	0.40	0.045
5	2.80		0.46			0.310	0.30	0.043
6	3.10		0.51			0.300	0.30	0.046
7	3.40		0.53			0.300	0.30	0.048
8	3.70		0.52			0.280	0.30	0.044
9	4.00		0.52			0.210	0.30	0.033
10	4.30		0.53			0.210	0.30	0.033
11	4.60		0.52			0.210	0.30	0.033
12	4.90		0.54			0.160	0.30	0.026
13	5.20		0.53			0.150	0.30	0.024
14	5.50		0.53			0.130	0.30	0.021
15	5.80		0.50			0.160	0.30	0.024
16	6.10		0.51			0.190	0.30	0.029
17	6.40		0.56			0.220	0.30	0.037
18	6.70		0.60			0.150	0.30	0.027
19	7.00		0.48			0.080	0.25	0.010
RDB	7.20		0.00			0.000	0.10	0.000
								0.580

Note: 1. Water elevation 282.843m (1630 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E
MEASUREMENT DATE: 10 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1117 hrs.
MEASUREMENT END TIME: 1122 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.32			0.030	0.50	0.005
2	1.00		0.42			0.180	0.50	0.038
3	1.50		0.47			0.280	0.50	0.066
4	2.00		0.52			0.370	0.50	0.096
5	2.50		0.56			0.400	0.50	0.112
6	3.00		0.60			0.350	0.50	0.105
7	3.50		0.61			0.230	0.50	0.070
8	4.00		0.48			0.280	0.50	0.067
9	4.50		0.42			0.250	0.50	0.053
10	5.00		0.54			0.240	0.50	0.065
11	5.50		0.72			0.250	0.50	0.090
12	6.00		0.72			0.250	0.75	0.135
RDB	7.00		0.00			0.000	0.50	0.000
								0.901

Note: 1. Water elevation 282.882m (1236 hrs August 11th, 2002)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E
MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0955 hrs.
MEASUREMENT END TIME: 1003 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.20			0.030	0.25	0.002
2	0.50		0.55			0.060	0.35	0.012
3	1.00		0.60			0.230	0.50	0.069
4	1.50		0.58			0.220	0.50	0.064
5	2.00		0.55			0.280	0.50	0.077
6	2.50		0.52			0.300	0.50	0.078
7	3.00		0.46			0.290	0.50	0.067
8	3.50		0.40			0.290	0.50	0.058
9	4.00		0.34			0.310	0.50	0.053
10	4.50		0.26			0.310	0.50	0.040
11	5.00		0.23			0.280	0.50	0.032
12	5.50		0.20			0.310	0.50	0.031
13	6.00		0.19			0.280	0.50	0.027
14	6.50		0.14			0.140	0.50	0.010
15	7.00		0.11			0.060	0.45	0.003
RDB	7.40		0.00			0.000	0.20	0.000
								0.621

Note: 1. Water elevation 282.875m (1005 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S15
STREAM NAME: Tar River
COORDINATES: 6356983N/454453E

MEASUREMENT DATE: 21 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1530 hrs.
MEASUREMENT END TIME: 1535 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.15	0.03	0.00			0.000	0.18	0.000
1	1.50	0.03	0.16			0.040	0.43	0.003
2	2.00	0.03	0.32			0.080	0.50	0.012
3	2.50	0.03	0.38			0.120	0.50	0.021
4	3.00	0.03	0.44			0.140	0.50	0.028
5	3.50	0.03	0.49			0.160	0.50	0.036
6	4.00	0.03	0.55			0.140	0.50	0.035
7	4.50	0.03	0.59			0.120	0.50	0.033
8	5.00	0.03	0.53			0.110	0.50	0.027
9	5.50	0.03	0.38			0.100	0.50	0.017
10	6.00	0.03	0.43			0.070	0.50	0.014
11	6.50	0.03	0.52			0.110	0.50	0.026
12	7.00	0.03	0.57			0.140	0.50	0.037
13	7.50	0.03	0.50			0.110	0.40	0.020
14	7.80	0.03	0.40			0.090	0.30	0.010
RDB	8.10	0.03	0.00			0.000	0.15	0.000
								0.319

Note:
1. Water elevation 282.785m (1513 hrs)
2. Ice covered across the creek
3. TSS collected
4. Transducer was removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S16
STREAM NAME: Calumet River
COORDINATES: 6361908N/458087E
MEASUREMENT DATE: 14 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1452 hrs.
MEASUREMENT END TIME: 1530 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.40	0.31	0.00			0.000	0.33	0.000
1	1.05	0.31	0.28			0.040	0.63	0.006
2	1.65	0.31	0.27			0.080	0.60	0.012
3	2.25	0.30	0.24			0.040	0.60	0.005
4	2.85	0.30	0.08			-0.060	0.58	-0.003
RDB	3.40	0.30	0.00			0.000	0.28	0.000
								0.021

Note: 1. No survey of water/ice level elevations as the survey rod was left behind at the last station

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S16
STREAM NAME: Calumet River
COORDINATES: 6361908N/458087E
MEASUREMENT DATE: 25 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: NS/JB
MEASUREMENT START TIME: 1127 hrs.
MEASUREMENT END TIME: 1148 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.50	0.00			0.000	0.28	0.000
1	0.55	0.50	0.07			0.020	0.60	0.001
2	1.20	0.47	0.02			0.020	0.78	0.000
3	2.10	0.40	0.05			0.000	0.95	0.000
4	3.10	0.40	0.04			0.060	0.85	0.002
5	3.80	0.39	0.03			0.040	0.70	0.001
6	4.50	0.39	0.03			0.010	0.75	0.000
7	5.30	0.39	0.03			0.010	0.95	0.000
8	6.40	0.51	0.02			0.000	0.95	0.000
9	7.20	0.53	0.00			0.000	0.60	0.000
RDB	7.60	0.53	0.00			0.000	0.20	0.000
								0.004

Note: 1. Water elevation 264.673m, top of ice elevation 264.622m (1149 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S16
STREAM NAME: Calumet River
COORDINATES: 6361908N/458087E

MEASUREMENT DATE: 16 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: NS/JB

MEASUREMENT START TIME: 1402 hrs.
MEASUREMENT END TIME: 1405 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.70		0.00			0.000	0.10	0.000
1	0.90		0.14			-0.050	0.25	-0.002
2	1.20		0.26			-0.030	0.25	-0.002
3	1.40		0.27			0.020	0.20	0.001
4	1.60		0.26			0.390	0.20	0.020
5	1.80		0.22			0.630	0.20	0.028
6	2.00		0.18			0.050	0.20	0.002
7	2.20		0.15			0.400	0.20	0.012
8	2.40		0.13			0.080	0.20	0.002
9	2.60		0.10			-0.040	0.20	-0.001
10	2.80		0.08			-0.050	0.20	-0.001
11	3.00		0.10			0.180	0.35	0.006
RDB	3.50		0.00			0.000	0.25	0.000
								0.066

Notes: 1. Water elevation 264.040m, (1402 hrs)
2. Ice at the edge of the river when discharge was carried out

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S16
STREAM NAME: Calumet River
COORDINATES: 6361908N/458087E

MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1328 hrs.
MEASUREMENT END TIME: 1334 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.16			0.010	0.25	0.000
2	0.50		0.22			0.060	0.20	0.003
3	0.70		0.22			0.140	0.20	0.006
4	0.90		0.22			0.110	0.20	0.005
5	1.10		0.22			0.170	0.20	0.007
6	1.30		0.24			0.430	0.20	0.021
7	1.50		0.18			0.610	0.20	0.022
8	1.70		0.24			0.340	0.20	0.016
9	1.90		0.26			0.550	0.20	0.029
10	2.10		0.26			0.560	0.20	0.029
11	2.30		0.30			0.480	0.20	0.029
12	2.50		0.30			0.850	0.20	0.051
13	2.70		0.23			0.770	0.20	0.035
14	2.90		0.24			0.650	0.20	0.031
15	3.10		0.20			0.700	0.20	0.028
16	3.30		0.20			0.730	0.20	0.029
17	3.50		0.20			0.080	0.20	0.003
RDB	3.70		0.00			0.000	0.10	0.000
								0.345

Note: 1. Water elevation 264.158m, (1339 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S16
STREAM NAME: Calumet River
COORDINATES: 6361908N/458087E

MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1242 hrs.
MEASUREMENT END TIME: 1251 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	6.20		0.00			0.000	0.03	0.000
1	6.25		0.18			0.090	0.15	0.002
2	6.50		0.20			0.130	0.28	0.007
3	6.80		0.20			0.090	0.30	0.005
4	7.10		0.23			0.100	0.30	0.007
5	7.40		0.25			0.140	0.30	0.011
6	7.70		0.29			0.130	0.30	0.011
7	8.00		0.30			0.120	0.30	0.011
8	8.30		0.34			0.100	0.30	0.010
9	8.60		0.28			0.090	0.30	0.008
10	8.90		0.36			0.110	0.30	0.012
11	9.20		0.32			0.110	0.30	0.011
12	9.50		0.30			0.120	0.30	0.011
13	9.80		0.18			0.110	0.30	0.006
14	10.10		0.02			0.080	0.30	0.000
15	10.40		0.18			0.060	0.30	0.003
16	10.70		0.14			0.020	0.30	0.001
17	11.00		0.12			0.010	0.40	0.000
RDB	11.50		0.00			0.000	0.25	0.000
								0.116

Notes:
1. Water elevation 264.078m (1252 hrs)
2. After discharge measurement, break beaver dam u/s (approx. 30m) from the gauging station
3. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S16
STREAM NAME: Calumet River
COORDINATES: 6361908N/458087E

MEASUREMENT DATE: 27 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1308 hrs.
MEASUREMENT END TIME: 1311 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.50		0.00			0.000	0.15	0.000
1	1.80		0.07			0.050	0.25	0.001
2	2.00		0.08			0.010	0.35	0.000
3	2.50		0.08			0.190	0.40	0.006
4	2.80		0.06			0.120	0.35	0.003
5	3.20		0.06			0.250	0.35	0.005
6	3.50		0.12			0.290	0.30	0.010
7	3.80		0.18			0.330	0.35	0.021
8	4.20		0.08			0.300	0.35	0.008
9	4.50		0.04			0.220	0.25	0.002
10	4.70		0.04			0.130	0.23	0.001
RDB	4.95		0.00			0.000	0.13	0.000
								0.058

Notes:
1. Water elevation 264.034m, top of ice elevation 264.057m (1340 hrs)
2. No beaver dam noted
3. TSS collected
4. Snow adapter was installed
5. Ice covered was broken up at discharge section, no flow correction required

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S17
STREAM NAME: CNRL Upland Tar
COORDINATES: 6358143N/444474E

MEASUREMENT DATE: 28 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								0.000

Notes: 1. Creek frozen to bottom

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S17
STREAM NAME: CNRL Upland Tar
COORDINATES: 6358143N/444474E

MEASUREMENT DATE: 16 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1235 hrs.
MEASUREMENT END TIME: 1240 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.28			-0.030	0.20	-0.002
2	0.40		0.22			-0.010	0.20	0.000
3	0.60		0.32			0.110	0.20	0.007
4	0.80		0.32			0.080	0.20	0.005
5	1.00		0.28			0.160	0.20	0.009
6	1.20		0.20			0.040	0.20	0.002
7	1.40		0.18			0.080	0.20	0.003
8	1.60		0.16			0.010	0.20	0.000
9	1.80		0.11			-0.050	0.20	-0.001
RDB	2.00		0.00			0.000	0.10	0.000
								0.023

Notes: 1. Water elevation 364.276 (1243 hrs)
2. Ice at the shore bank; bottom was not frozen

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S17
STREAM NAME: CNRL Upland Tar
COORDINATES: 6358143N/444474E
MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								0.000
1								0.000
RDB								0.000
								0.000

Notes:
1. Water elevation 363.925 (1120 hrs)
2. Transducer was above water level
3. No discharge measurement due to very low flow (approx. 1 litre per sec., according to Nathan's estimate)
4. Transducer was reinstalled deeper into pool of water; water level reading from the logger was 0.236088m (1115 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S17
STREAM NAME: CNRL Upland Tar
COORDINATES: 6358143N/444474E
MEASUREMENT DATE: 27 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								0.000
1								0.000
RDB								0.000
								0.000

Notes:
1. Water elevation 364.008m, top of ice elevation 364.040m (1206 hrs)
2. Transducer was removed for the season
3. No discharge measurement due to no flow and iced across the creek

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S18A
STREAM NAME: Calumet River Upland
COORDINATES: 6363488N/450662E

MEASUREMENT DATE: 10 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1754 hrs.
MEASUREMENT END TIME: 1758 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.05	0.000
1	0.10		0.08			0.000	0.10	0.000
2	0.20		0.12			0.010	0.10	0.000
3	0.30		0.16			0.220	0.10	0.004
4	0.40		0.16			0.120	0.10	0.002
5	0.50		0.14			0.030	0.10	0.000
6	0.60		0.10			0.020	0.10	0.000
7	0.70		0.10			0.060	0.10	0.001
8	0.80		0.08			0.070	0.10	0.001
9	0.90		0.08			0.050	0.10	0.000
10	1.00		0.06			0.030	0.10	0.000
11	1.10		0.04			0.030	0.10	0.000
RDB	1.20		0.00			0.000	0.05	0.000
								0.008

Notes: 1. Water elevation 97.414m (1804 hrs)
2.Transducer s/n 0201991 and logger 621 were installed near Grandjambe's trapline cabin

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S18A
STREAM NAME: Calumet River Upland
COORDINATES: 6363488N/450662E
MEASUREMENT DATE: 10 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1248 hrs.
MEASUREMENT END TIME: 1304 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	1.00		0.00			0.000	0.10	0.000
1	1.20		0.14			0.000	0.15	0.000
2	1.30		0.18			0.070	0.10	0.001
3	1.40		0.19			0.170	0.10	0.003
4	1.50		0.18			0.070	0.10	0.001
5	1.60		0.13			0.010	0.10	0.000
6	1.70		0.14			0.000	0.10	0.000
7	1.80		0.14			0.010	0.10	0.000
8	1.90		0.12			0.010	0.10	0.000
9	2.00		0.10			0.000	0.10	0.000
10	2.10		0.10			0.000	0.38	0.000
RDB	2.75		0.00			0.000	0.33	0.000
								0.006

Note: 1. Water elevation 97.374m (1315 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S18A
STREAM NAME: Calumet River Upland
COORDINATES: 6363488N/450662E

MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1400 hrs.
MEASUREMENT END TIME: 1413 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.20		0.00			0.000	0.05	0.000
1	0.30		0.12			0.010	0.10	0.000
2	0.40		0.17			0.010	0.10	0.000
3	0.50		0.18			0.030	0.10	0.001
4	0.60		0.22			0.080	0.10	0.002
5	0.70		0.25			0.070	0.10	0.002
6	0.80		0.27			0.070	0.10	0.002
7	0.90		0.30			0.050	0.10	0.002
8	1.00		0.24			0.050	0.10	0.001
9	1.10		0.26			0.180	0.10	0.005
10	1.20		0.26			0.080	0.10	0.002
11	1.30		0.26			0.100	0.10	0.003
12	1.40		0.24			0.120	0.10	0.003
13	1.50		0.14			0.040	0.10	0.001
14	1.60		0.20			0.050	0.10	0.001
15	1.70		0.14			0.040	0.10	0.001
16	1.80		0.06			0.030	0.10	0.000
17	1.90		0.06			0.010	0.10	0.000
RDB	2.00		0.00			0.000	0.05	0.000
								0.024

Note: 1. Water elevation 97.496m (1357 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S18A
STREAM NAME: Calumet River Upland
COORDINATES: 6363488N/450662E
MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1155 hrs.
MEASUREMENT END TIME: 1159 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.40		0.00			0.000	0.05	0.000
1	0.50		0.28			0.030	0.10	0.001
2	0.60		0.38			0.180	0.08	0.005
3	0.65		0.38			0.180	0.05	0.003
4	0.70		0.36			0.040	0.08	0.001
5	0.80		0.22			0.010	0.10	0.000
6	0.90		0.01			0.000	0.10	0.000
RDB	1.00		0.00			0.000	0.05	0.000
								0.011

Note: 1. Water elevation 97.496m (1206 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S18A
STREAM NAME: Calumet River Upland
COORDINATES: 6363488N/450662E
MEASUREMENT DATE: 27 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1241 hrs.
MEASUREMENT END TIME: 1244 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.01	0.00			0.000	0.05	0.000
1	0.10	0.01	0.40			0.060	0.10	0.002
2	0.20	0.01	0.44			0.040	0.10	0.002
3	0.30	0.01	0.38			0.020	0.10	0.001
4	0.40	0.01	0.28			0.040	0.10	0.001
5	0.50	0.01	0.27			-0.010	0.10	0.000
6	0.60	0.01	0.24			-0.010	0.10	0.000
7	0.70	0.01	0.22			-0.010	0.10	0.000
8	0.80	0.01	0.16			-0.010	0.15	0.000
RDB	1.00	0.01	0.00			0.000	0.10	0.000
								0.005

Note: 1. Water elevation 97.443m, top of ice elevation 97.449m (1245 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E
MEASUREMENT DATE: 24 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								0.000
1								0.000
RDB								0.000
								0.000

Notes: 1. Water elevation 100.724m (1418 hrs)
2. No flow; frozen to bottom

PROJECT NAME: RAMP/Climate & Hydrology/ Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E
MEASUREMENT DATE: 18 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1111 hrs.
MEASUREMENT END TIME: 1114 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.05		0.00			0.000	0.03	0.000
1	0.10		0.10			-0.010	0.08	0.000
2	0.20		0.12			-0.010	0.10	0.000
3	0.30		0.14			0.000	0.10	0.000
4	0.40		0.12			0.030	0.10	0.000
5	0.50		0.10			0.140	0.10	0.001
6	0.60		0.12			0.230	0.10	0.003
7	0.70		0.11			0.250	0.10	0.003
8	0.80		0.10			0.220	0.10	0.002
9	0.90		0.12			0.080	0.10	0.001
10	1.00		0.08			0.060	0.15	0.001
RDB	1.19		0.00			0.000	0.10	0.000
								0.011

Notes: 1. Water elevation 100.392m (1115 hrs)
2. Temporary transducer was lowered deeper into water

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E

MEASUREMENT DATE: 13 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0935 hrs.
MEASUREMENT END TIME: 0945 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.10		0.00			0.000	0.05	0.000
1	0.20		0.16			0.010	0.10	0.000
2	0.30		0.16			0.080	0.10	0.001
3	0.40		0.12			0.070	0.10	0.001
4	0.50		0.11			0.080	0.10	0.001
5	0.60		0.13			0.190	0.10	0.002
6	0.70		0.12			0.230	0.10	0.003
7	0.80		0.14			0.280	0.10	0.004
8	0.90		0.12			0.240	0.10	0.003
9	1.00		0.10			0.100	0.10	0.001
10	1.10		0.07			0.100	0.10	0.001
11	1.20		0.04			0.060	0.10	0.000
RDB	1.30		0.00			0.000	0.05	0.000
								0.017

Notes:
1. Water elevation 100.377m (0950 hrs)
2. Exchanged logger with a stroke input/installed rain gauge

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E
MEASUREMENT DATE: 08 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1722 hrs.
MEASUREMENT END TIME: 1730 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.80		0.00			0.000	0.10	0.000
1	1.00		0.16			0.000	0.15	0.000
2	1.10		0.30			0.000	0.10	0.000
3	1.20		0.48			0.040	0.10	0.002
4	1.30		0.50			0.050	0.10	0.003
5	1.40		0.51			0.060	0.10	0.003
6	1.50		0.50			0.070	0.10	0.004
7	1.60		0.46			0.070	0.10	0.003
8	1.70		0.45			0.060	0.10	0.003
9	1.80		0.44			0.070	0.10	0.003
10	1.90		0.40			0.070	0.10	0.003
11	2.00		0.41			0.070	0.10	0.003
12	2.10		0.40			0.050	0.10	0.002
13	2.20		0.37			0.000	0.10	0.000
14	2.30		0.37			0.000	0.10	0.000
15	2.40		0.30			-0.010	0.10	0.000
16	2.50		0.30			0.000	0.10	0.000
17	2.60		0.18			0.000	0.20	0.000
RDB	2.90		0.00			0.000	0.15	0.000
								0.027

Note: 1. Water elevation 100.728m (1738 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E
MEASUREMENT DATE: 10 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1005 hrs.
MEASUREMENT END TIME: 1009 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.14			0.010	0.35	0.000
2	0.70		0.26			0.010	0.20	0.001
3	0.90		0.32			0.020	0.20	0.001
4	1.10		0.38			0.020	0.20	0.002
5	1.30		0.40			0.050	0.20	0.004
6	1.50		0.40			0.050	0.20	0.004
7	1.70		0.41			0.060	0.20	0.005
8	1.90		0.41			0.080	0.20	0.007
9	2.10		0.40			0.020	0.20	0.002
10	2.30		0.20			0.010	0.20	0.000
11	2.50		0.14			0.000	0.30	0.000
RDB	2.90		0.00			0.000	0.20	0.000

Note: 1. Water elevation 100.810m (1002 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E
MEASUREMENT DATE: 11 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1221 hrs.
MEASUREMENT END TIME: 1231 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.50		0.00			0.000	0.10	0.000
1	0.70		0.14			0.000	0.15	0.000
2	0.80		0.24			0.000	0.10	0.000
3	0.90		0.30			0.020	0.10	0.001
4	1.00		0.30			0.050	0.10	0.002
5	1.10		0.32			0.050	0.10	0.002
6	1.20		0.28			0.050	0.10	0.001
7	1.30		0.32			0.080	0.10	0.003
8	1.40		0.32			0.080	0.10	0.003
9	1.50		0.31			0.080	0.10	0.002
10	1.60		0.28			0.050	0.10	0.001
11	1.70		0.27			0.060	0.10	0.002
12	1.80		0.26			0.050	0.10	0.001
13	1.90		0.24			0.030	0.10	0.001
14	2.00		0.22			0.020	0.10	0.000
15	2.10		0.22			0.010	0.10	0.000
16	2.20		0.20			0.010	0.10	0.000
17	2.30		0.12			0.000	0.10	0.000
18	2.40		0.08			-0.010	0.10	0.000
RDB	2.50		0.00			0.000	0.05	0.000
								0.019

Note: 1. Water elevation 100.693m (1233 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S19
STREAM NAME: CNRL Lowland Tar
COORDINATES: 6352848N/457324E
MEASUREMENT DATE: 21 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1623 hrs.
MEASUREMENT END TIME: 1626 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.10		0.00			0.000	0.05	0.000
1	1.20		0.16			0.000	0.10	0.000
2	1.30		0.14			0.000	0.10	0.000
3	1.40		0.10			0.030	0.10	0.000
4	1.50		0.10			0.030	0.10	0.000
5	1.60		0.12			0.040	0.10	0.000
6	1.70		0.12			0.100	0.10	0.001
7	1.80		0.13			0.110	0.10	0.001
8	1.90		0.14			0.100	0.10	0.001
9	2.00		0.14			0.070	0.15	0.001
RDB	2.20		0.00			0.000	0.10	0.000
								0.007

Note: 1. Water elevation 100.506m (1634 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E
MEASUREMENT DATE: 25 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1420 hrs.
MEASUREMENT END TIME: 1430 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.65		0.00			0.000	0.03	0.000
1	0.70		0.20			0.070	0.18	0.002
2	1.00		0.29			0.100	0.40	0.012
3	1.50		0.41			0.130	0.50	0.027
4	2.00		0.58			0.190	0.50	0.055
5	2.50		0.58			0.140	0.50	0.041
6	3.00		0.68			0.110	0.50	0.037
7	3.50		0.74			0.080	0.50	0.030
RDB	4.00		0.00			0.000	0.25	0.000
								0.203

Notes: 1. Water elevation 98.736m (1347 hrs)
2. New location (downstream of the year 2001 station location)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E
MEASUREMENT DATE: 15 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0850 hrs.
MEASUREMENT END TIME: 0900 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	2.20		0.00			0.000	0.20	0.000
1	2.60		0.10			0.000	0.40	0.000
2	3.00		0.20			0.050	0.35	0.004
3	3.30		0.38			0.050	0.30	0.006
4	3.60		0.42			0.110	0.30	0.014
5	3.90		0.46			0.100	0.30	0.014
6	4.20		0.49			0.110	0.30	0.016
7	4.50		0.50			0.130	0.30	0.020
8	4.80		0.56			0.120	0.30	0.020
9	5.10		0.58			0.110	0.30	0.019
10	5.40		0.63			0.080	0.30	0.015
11	5.70		0.67			0.070	0.30	0.014
12	6.00		0.62			0.040	0.30	0.007
13	6.30		0.56			0.050	0.30	0.008
14	6.60		0.46			0.010	0.30	0.001
15	6.90		0.36			-0.020	0.50	-0.004
RDB	7.60		0.00			0.000	0.35	0.000
								0.155

Note: 1. Water elevation 98.662m (0904 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E

MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1357 hrs.
MEASUREMENT END TIME: 1415 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.30		0.00			0.000	0.20	0.000
1	1.70		0.10			0.000	0.35	0.000
2	2.00		0.16			0.010	0.30	0.000
3	2.30		0.32			0.060	0.25	0.005
4	2.50		0.48			0.090	0.25	0.011
5	2.80		0.55			0.060	0.30	0.010
6	3.10		0.56			0.090	0.30	0.015
7	3.40		0.60			0.130	0.30	0.023
8	3.70		0.64			0.140	0.30	0.027
9	4.00		0.68			0.120	0.30	0.024
10	4.30		0.67			0.110	0.30	0.022
11	4.60		0.73			0.090	0.30	0.020
12	4.90		0.72			0.090	0.30	0.019
13	5.20		0.70			0.060	0.30	0.013
14	5.50		0.63			0.110	0.30	0.021
15	5.80		0.61			0.060	0.30	0.011
16	6.10		0.55			0.110	0.30	0.018
17	6.40		0.48			0.010	0.30	0.001
18	6.70		0.36			-0.010	0.30	-0.001
19	7.00		0.18			-0.010	0.30	-0.001
20	7.30		0.11			0.000	0.30	0.000
21	7.60		0.08			0.000	0.40	0.000
RDB	8.10		0.00			0.000	0.25	0.000
								0.239

Note: 1. Water elevation 98.820m (1420 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E
MEASUREMENT DATE: 11 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1054 hrs.
MEASUREMENT END TIME: 1106 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.30		0.00			0.000	0.10	0.000
1	0.50		0.16			-0.020	0.35	-0.001
2	1.00		0.24			-0.010	0.50	-0.001
3	1.50		0.40			0.020	0.50	0.004
4	2.00		0.56			0.120	0.50	0.034
5	2.50		0.67			0.140	0.50	0.047
6	3.00		0.80	0.15	0.27	0.210	0.50	0.084
7	3.50		0.82	0.18	0.28	0.230	0.50	0.094
8	4.00		0.82	0.23	0.27	0.250	0.50	0.103
9	4.50		0.68			0.230	0.50	0.078
10	5.00		0.64			0.230	0.50	0.074
11	5.50		0.50			0.200	0.50	0.050
12	6.00		0.30			0.100	0.45	0.014
13	6.40		0.18			0.030	0.50	0.003
RDB	7.00		0.00			0.000	0.30	0.000
								0.581

Notes:
1. Water elevation 98.925m (1116 hrs)
2. Logger was burnt due to recent forest fire

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E
MEASUREMENT DATE: 31 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes:
1. Water elevation 99.474m (0757 hrs)
2. Reinstalled logger with probe; no discharge was measured as water level was too high

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E

MEASUREMENT DATE: 11 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0815 hrs.
MEASUREMENT END TIME: 0821 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.34			0.060	0.35	0.007
2	0.70		0.38			0.180	0.50	0.034
3	1.20		0.42			0.220	0.50	0.046
4	1.70		0.58			0.300	0.50	0.087
5	2.20		0.68			0.470	0.50	0.160
6	2.70		0.84			0.340	0.50	0.143
7	3.20		1.04			0.360	0.50	0.187
8	3.70		1.00			0.410	0.50	0.205
9	4.20		0.94			0.510	0.50	0.240
10	4.70		0.90			0.350	0.50	0.158
11	5.20		0.86			0.420	0.50	0.181
12	5.70		0.72			0.370	0.50	0.133
13	6.20		0.60			0.370	0.50	0.111
14	6.70		0.51			0.120	0.50	0.031
15	7.20		0.32			0.010	0.30	0.001
RDB	7.30		0.00			0.000	0.05	0.000
								1.723

Notes: 1. Water elevation 99.181m (0826 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S20
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E

MEASUREMENT DATE: 13 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1220 hrs.
MEASUREMENT END TIME: 1228 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	2.50		0.00			0.000	0.25	0.000
1	3.00		0.49			0.220	0.50	0.054
2	3.50		0.56			0.240	0.50	0.067
3	4.00		0.66			0.310	0.50	0.102
4	4.50		0.78			0.400	0.50	0.156
5	5.00		0.80			0.410	0.50	0.164
6	5.50		0.88			0.340	0.50	0.150
7	6.00		0.88			0.290	0.50	0.128
8	6.50		0.87			0.140	0.50	0.061
9	7.00		0.70			0.140	0.50	0.049
10	7.50		0.63			0.290	0.50	0.091
11	8.00		0.47			0.270	0.50	0.063
12	8.50		0.30			0.100	0.50	0.015
13	9.00		0.23			0.100	0.50	0.012
14	9.50		0.23			0.010	0.35	0.001
RDB	9.70		0.00			0.000	0.10	0.000
								1.113

Note:
1. Water elevation 99.090m (1233 hrs)
2. Beaver dam by the steel bridge was removed before discharge measurement carried out (1100 hrs)
3. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S20 (D/S of Steel Bridge)
STREAM NAME: Muskeg River Upland
COORDINATES: 6355709N/492106E

MEASUREMENT DATE: 25 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1221 hrs.
MEASUREMENT END TIME: 1227 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.35		0.00			0.000	0.15	0.000
1	0.65		0.28			0.170	0.63	0.030
2	1.60		0.30			0.300	0.68	0.061
3	2.00		0.29			0.520	0.45	0.068
4	2.50		0.24			0.540	0.50	0.065
5	3.00		0.17			0.570	0.50	0.048
6	3.50		0.12			0.560	0.50	0.034
7	4.00		0.06			0.300	0.50	0.009
8	4.50		0.07			0.290	0.50	0.010
9	5.00		0.17			0.490	0.50	0.042
10	5.50		0.25			0.400	0.50	0.050
11	6.00		0.32			0.380	0.50	0.061
12	6.50		0.24			0.350	0.50	0.042
13	7.00		0.20			0.110	0.33	0.007
RDB	7.15		0.00			0.000	0.08	0.000
								0.526

Notes:
1. Water elevation 99.702m, top of ice elevation 99.709m (1213 hrs)
2. Beaver dam by the steel bridge which had been removed on Sep 13 was built up again
3. TSS collected
4. Not possible to perform a discharge measurement at transducer due to ice and large water depth; discharge measurement was performed d/s of the steel bridge where open water conditions prevailed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S21
STREAM NAME: Shelley Creek
COORDINATES: 6347933N/476419E
MEASUREMENT DATE: 16 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 295.184m (1600 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S21
STREAM NAME: Shelley Creek
COORDINATES: 6347933N/476419E
MEASUREMENT DATE: 10 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								0.000
1								0.000
RDB								0.000
								0.000

Notes: 1. Water elevation 295.459m (1550 hrs)
2. No flow detected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S21
STREAM NAME: Shelley Creek
COORDINATES: 6347933N/476419E
MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1010 hrs.
MEASUREMENT END TIME: 1023 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.25	0.000
1	0.50		0.24			0.010	0.40	0.001
2	0.80		0.38			0.010	0.30	0.001
3	1.10		0.46			0.010	0.30	0.001
4	1.40		0.58			0.010	0.30	0.002
5	1.70		0.74			0.010	0.30	0.002
6	2.00		0.76			0.050	0.30	0.011
7	2.30		0.76			0.030	0.30	0.007
8	2.60		0.58			0.010	0.30	0.002
9	2.90		0.48			0.000	0.30	0.000
10	3.20		0.40			0.010	0.30	0.001
11	3.50		0.34			0.020	0.30	0.002
12	3.80		0.36			0.010	0.30	0.001
13	4.10		0.30			0.000	0.30	0.000
14	4.40		0.30			0.010	0.30	0.001
15	4.70		0.24			0.010	0.30	0.001
16	5.00		0.20			0.010	0.30	0.001
17	5.30		0.20			0.010	0.25	0.001
18	5.50		0.12			0.010	0.35	0.000
RDB	6.00		0.00			0.000	0.25	0.000
								0.035

Notes: 1. Water elevation 295.587m (1026 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S21
STREAM NAME: Shelley Creek
COORDINATES: 6347933N/476419E
MEASUREMENT DATE: 26 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 295.549m, top of ice elevation 295.559m (1337 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E
MEASUREMENT DATE: 11 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1328 hrs.
MEASUREMENT END TIME: 1349 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.10	0.17	0.00			0.000	0.15	0.000
1	0.40	0.17	0.14			-0.010	0.25	0.000
2	0.60	0.17	0.18			-0.030	0.20	-0.001
3	0.80	0.19	0.19			-0.010	0.20	0.000
4	1.00	0.19	0.19			0.280	0.20	0.010
5	1.20	0.19	0.18			0.080	0.20	0.003
6	1.40	0.19	0.13			0.030	0.20	0.001
7	1.60	0.19	0.11			0.000	0.20	0.000
8	1.80	0.17	0.24			-0.010	0.20	0.000
9	2.00	0.17	0.21			-0.010	0.20	0.000
10	2.20	0.17	0.12			-0.010	0.20	0.000
11	2.40	0.17	0.08			0.000	0.15	0.000
RDB	2.50	0.17	0.00			0.000	0.05	0.000
								0.010

Notes: 1. Water elevation 303.458m, top of ice elevation 303.479m (1442 hrs)
2. At the discharge section, water was bubbling and flowing underneath the ice cover

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E
MEASUREMENT DATE: 08 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1215 hrs.
MEASUREMENT END TIME: 1225 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.29	0.00			0.000	0.35	0.000
1	0.70	0.29	0.05			0.070	0.80	0.003
2	1.60	0.29	0.08			0.020	0.95	0.001
3	2.60	0.27	0.11			0.120	0.93	0.011
4	3.45	0.26	0.12			0.110	0.85	0.010
5	4.30	0.26	0.14			0.150	0.98	0.018
6	5.40	0.25	0.14			0.090	1.40	0.016
RDB	7.10	0.25	0.00			0.000	0.85	0.000
								0.059

Notes: 1. Water elevation 304.628m, top of ice elevation 304.661m (1320 hrs)
2. At the discharge section, water was bubbling and flowing underneath the ice cover

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E
MEASUREMENT DATE: 23 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 304.465m (1341 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E
MEASUREMENT DATE: 15 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 303.970m (1451 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E

MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1745 hrs.
MEASUREMENT END TIME: 1753 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.30		0.00			0.000	0.20	0.000
1	1.70		0.11			0.060	0.35	0.002
2	2.00		0.09			0.020	0.30	0.001
3	2.30		0.09			0.210	0.30	0.006
4	2.60		0.08			0.140	0.30	0.003
5	2.90		0.06			0.320	0.30	0.006
6	3.20		0.12			0.450	0.30	0.016
7	3.50		0.17			0.370	0.30	0.019
8	3.80		0.18			0.280	0.30	0.015
9	4.10		0.24			0.590	0.20	0.028
10	4.20		0.28			0.620	0.15	0.026
11	4.40		0.32			0.570	0.25	0.046
12	4.70		0.33			0.620	0.30	0.061
13	5.00		0.24			0.810	0.30	0.058
14	5.30		0.18			0.470	0.30	0.025
15	5.60		0.16			0.420	0.30	0.020
16	5.90		0.16			0.370	0.30	0.018
17	6.20		0.06			0.090	0.35	0.002
18	6.60		0.06			-0.030	0.45	-0.001
RDB	7.10		0.00			0.000	0.25	0.000
								0.352

Notes:
1. Water elevation 303.577m (1755 hrs)
2. TSS collected
3. Transducer was moved deeper into the water. The buried conduit was still too frozen to install the probe

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E
MEASUREMENT DATE: 11 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1514 hrs.
MEASUREMENT END TIME: 1524 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.25		0.00			0.000	0.13	0.000
1	0.50		0.08			0.150	0.28	0.003
2	0.80		0.14			0.330	0.30	0.014
3	1.10		0.18			0.440	0.30	0.024
4	1.40		0.22			0.500	0.30	0.033
5	1.70		0.27			0.070	0.30	0.006
6	2.00		0.28			0.420	0.30	0.035
7	2.30		0.30			0.600	0.30	0.054
8	2.60		0.28			0.710	0.30	0.060
9	2.90		0.38			0.710	0.30	0.081
10	3.20		0.36			0.730	0.30	0.079
11	3.50		0.42			0.640	0.30	0.081
12	3.80		0.42			0.470	0.30	0.059
13	4.10		0.42			0.560	0.30	0.071
14	4.40		0.42			0.530	0.30	0.067
15	4.70		0.38			0.260	0.30	0.030
16	5.00		0.34			0.080	0.30	0.008
17	5.30		0.32			0.080	0.30	0.008
18	5.60		0.40			0.180	0.30	0.022
19	5.90		0.37			0.260	0.25	0.024
20	6.10		0.10			0.180	0.20	0.004
RDB	6.30		0.00			0.000	0.10	0.000
								0.760

Notes: 1. Water elevation 303.689m (1533 hrs)
2. TSS collected
3. Transducer was moved inside the buried conduit

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E
MEASUREMENT DATE: 11 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 304.182m (1040 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E

MEASUREMENT DATE: 13 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1542 hrs.
MEASUREMENT END TIME: 1553 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.50		0.00			0.000	0.15	0.000
1	1.80		0.47			0.180	0.25	0.021
2	2.00		0.54			0.260	0.35	0.049
3	2.50		0.52			0.370	0.50	0.096
4	3.00		0.55			0.420	0.50	0.116
5	3.50		0.64			0.620	0.50	0.198
6	4.00		0.66			0.680	0.50	0.224
7	4.50		0.72			0.720	0.40	0.207
8	4.80		0.72			0.700	0.30	0.151
9	5.10		0.90			0.790	0.35	0.249
10	5.50		0.85			0.920	0.45	0.352
11	6.00		0.85			0.930	0.50	0.395
12	6.50		0.82			0.910	0.50	0.373
13	7.00		0.72			0.780	0.50	0.281
14	7.50		0.61			0.860	0.50	0.262
15	8.00		0.17			0.730	0.35	0.043
RDB	8.20		0.00			0.000	0.10	0.000
								3.019

Note: 1. Water elevation 304.118m (1555 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S22
STREAM NAME: Muskeg Creek
COORDINATES: 6348856N/481036E

MEASUREMENT DATE: 25 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1337 hrs.
MEASUREMENT END TIME: 1347 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.08	0.000
1	0.15		0.51			0.140	0.33	0.023
2	0.65		0.48			0.200	0.50	0.048
3	1.15		0.48			0.240	0.50	0.058
4	1.65		0.41			0.330	0.50	0.068
5	2.15		0.35			0.450	0.50	0.079
6	2.65		0.31			0.690	0.50	0.107
7	3.15		0.29			0.700	0.50	0.102
8	3.65		0.59			0.690	0.50	0.204
9	4.15		0.57			0.780	0.50	0.222
10	4.65		0.52			0.850	0.50	0.221
11	5.15		0.49			0.290	0.50	0.071
12	5.65		0.34			0.710	0.50	0.121
13	6.15		0.34			0.290	0.50	0.049
14	6.65		0.23			0.280	0.50	0.032
15	7.15		0.12			-0.010	0.50	-0.001
RDB	7.65		0.00			0.000	0.25	0.000
								1.403

Note:
1. Water elevation 303.795m (1350 hrs)
2. TSS collected
3. Downloaded all data from logger
4. Transducer/temperature probes removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S23
STREAM NAME: Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 12 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 292.360m, top of ice elevation 292.366m (1235 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S23
STREAM NAME: Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 8 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 292.437m, top of ice elevation 292.466m (1225 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S23
STREAM NAME: Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 24 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 292.423m, top of ice elevation 292.482m (1150 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S23
STREAM NAME:Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 15 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 292.311m, top of ice elevation 292.502m (1807 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S23
STREAM NAME:Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 08 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 292.307m, top of ice elevation 292.470m (1134 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S23
STREAM NAME:Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 25 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 292.444m (1022 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S23
STREAM NAME: Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1145 hrs.
MEASUREMENT END TIME: 1203 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.80		0.00			0.000	0.25	0.000
1	2.30		0.56			-0.010	0.50	-0.003
2	2.80		0.74			-0.010	0.45	-0.003
3	3.20		0.90			0.000	0.60	0.000
4	4.00		1.02			0.000	0.75	0.000
5	4.70		1.12	-0.02	0.01	-0.005	0.75	-0.004
6	5.50		1.10	0.00	0.02	0.010	0.85	0.009
7	6.40		0.94	0.01	0.03	0.020	0.75	0.014
8	7.00		0.75			0.030	0.70	0.016
9	7.80		0.62			0.070	0.55	0.024
10	8.10		0.48			0.050	0.30	0.007
11	8.40		0.34			0.020	0.40	0.003
RDB	8.90		0.00			0.000	0.25	0.000
								0.063

Note: 1. Water elevation 292.544m (1127 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S23
STREAM NAME: Boundary Weir
COORDINATES: 6350171N/470255E
MEASUREMENT DATE: 09 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 292.453m (1146 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S24
STREAM NAME: Athabasca River
COORDINATES: 6372760N/466313E
MEASUREMENT DATE: 05 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/NS
MEASUREMENT START TIME: 1130 hrs.
MEASUREMENT END TIME: 1330 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.35	0.00			0.000	9.48	0.000
1	18.95	0.35	0.75			0.260	15.10	2.709
2	30.20	0.47	0.72			0.310	13.18	2.705
3	45.30	0.40	0.99	0.34	0.22	0.280	12.33	3.416
4	54.85	0.29	1.19	0.25	0.16	0.205	11.20	2.732
5	67.70	0.36	1.03	0.29	0.18	0.235	11.63	2.814
6	78.10	0.34	1.16	0.32	0.24	0.280	10.80	3.508
7	89.30	0.40	1.07	0.45	0.25	0.350	10.35	3.876
8	98.80	0.41	1.34	0.40	0.21	0.305	10.65	4.353
9	110.60	0.38	1.55	0.34	0.40	0.370	11.50	6.595
10	121.80	0.38	1.46	0.39	0.19	0.290	10.65	4.509
11	131.90	0.39	1.68	0.48	0.43	0.455	8.50	6.497
12	138.80	0.40	1.83	0.45	0.31	0.380	7.18	4.989
13	146.25	0.40	1.87	0.42	0.38	0.400	7.85	5.872
14	154.50	0.39	1.90	0.48	0.41	0.445	9.38	7.927
15	165.00	0.41	1.99	0.32	0.37	0.345	10.95	7.518
16	176.40	0.36	2.00	0.41	0.24	0.325	10.65	6.923
17	186.30	0.39	1.52	0.35	0.28	0.315	11.05	5.291
18	198.50	0.38	1.50	0.37	0.29	0.330	12.45	6.163
19	211.20	0.42	1.40	0.31	0.31	0.310	12.25	5.317
20	223.00	0.46	1.08	0.27	0.33	0.300	10.90	3.532
21	233.00	0.31	1.07	0.19	0.28	0.235	10.25	2.577
22	243.50	0.31	0.90	0.23	0.20	0.215	10.10	1.954
23	253.20	0.47	0.62			0.140	10.00	0.799
24	263.50	0.47	0.49			0.150	9.85	0.666
25	272.90	0.46	0.30			0.000	8.75	0.000
RDB	281.00	0.46	0.00			0.000	4.05	0.000
								103.2

Note: 1. Water elevation 225.678m, top of ice elevation 225.708m (1330 hrs); measurements referenced from T-bar 231.347m (geodetic)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S24
STREAM NAME: Athabasca River
COORDINATES: 6372760N/466313E
MEASUREMENT DATE: 22 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: TC/PM
COMPUTATIONS BY: LL/JG
MEASUREMENT START TIME: 1530 hrs.
MEASUREMENT END TIME: 1545 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00	0.46	0.00			0.000	0.75	0.000
1	1.50	0.46	0.14			0.150	3.50	0.068
2	7.00	0.51	0.52			0.240	6.70	0.769
3	14.90	0.54	0.64			0.260	7.68	1.175
4	22.35	0.63	0.62			0.250	7.80	1.112
5	30.50	0.74	0.40			0.220	8.13	0.658
6	38.60	0.68	0.45			0.260	7.90	0.850
7	46.30	0.61	0.77	0.38	0.27	0.325	7.38	1.846
8	53.35	0.50	0.76	0.34	0.27	0.305	7.15	1.657
9	60.60	0.54	0.76	0.32	0.20	0.260	7.48	1.477
10	68.30	0.57	0.99	0.33	0.17	0.250	7.95	1.968
11	76.50	0.55	0.93	0.41	0.31	0.360	7.85	2.628
12	84.00	0.52	0.97	0.43	0.31	0.370	7.55	2.710
13	91.60	0.52	1.10	0.43	0.30	0.365	7.68	3.082
14	99.35	0.51	1.21	0.42	0.30	0.360	7.47	3.252
15	106.53	0.48	1.26	0.45	0.34	0.395	7.11	3.539
16	113.57	0.49	1.19	0.44	0.42	0.430	7.34	3.753
17	121.20	0.52	1.23	0.48	0.32	0.400	7.22	3.550
18	128.00	0.54	1.54	0.41	0.31	0.360	7.35	4.075
19	135.90	0.59	1.60	0.45	0.32	0.385	7.83	4.820
20	143.65	0.60	1.49	0.35	0.32	0.335	8.00	3.993
21	151.90	0.62	1.49	0.43	0.44	0.435	7.45	4.829
22	158.55	0.56	1.44	0.42	0.35	0.385	7.65	4.241
23	167.20	0.54	1.68	0.43	0.28	0.355	8.10	4.831
24	174.75	0.53	1.75	0.42	0.40	0.410	7.25	5.202
25	181.70	0.57	1.56	0.44	0.41	0.425	7.33	4.856
26	189.40	0.54	1.46	0.35	0.34	0.345	7.63	3.841
27	196.95	0.52	1.43	0.31	0.18	0.245	7.70	2.698
28	204.80	0.50	1.23	0.34	0.25	0.295	7.88	2.857
29	212.70	0.57	1.14	0.30	0.32	0.310	8.13	2.871
30	221.05	0.62	1.11	0.28	0.12	0.200	8.48	1.881
31	229.65	0.52	1.00	0.24	0.20	0.220	8.38	1.843
32	237.80	0.51	0.77	0.28	0.20	0.240	8.68	1.603
33	247.00	0.50	0.62			0.200	8.72	0.995
34	255.25	0.58	0.48			0.180	8.68	0.690
35	264.35	0.55	0.39			0.140	8.82	0.443
36	272.90	0.55	0.20			0.110	8.07	0.163
37	280.50	0.55	0.08			0.050	6.30	0.023
RDB	285.50	0.55	0.00			0.000	2.50	0.000
								90.8

Note: 1. Water elevation 225.544m, top of ice elevation 226.025m (1600hrs); measurement referenced from T-bar 231.347m (geodetic)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S24
STREAM NAME: Athabasca River
COORDINATES: 6372760N/466313E

MEASUREMENT DATE: 31 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: JB/CD
COMPUTATIONS BY: LL/JG

MEASUREMENT START TIME: 1025 hrs.
MEASUREMENT END TIME: 1250 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	1.50	0.000
1	3.00		1.00	0.65	0.44	0.545	6.00	3.270
2	12.00		1.00	0.69	0.62	0.655	14.50	9.498
3	32.00		0.95	0.65	0.64	0.645	23.50	14.400
4	59.00		1.05	0.69	0.57	0.630	24.00	15.876
5	80.00		1.20	0.68	0.64	0.660	22.50	17.820
6	104.00		1.25	0.57	0.35	0.460	23.50	13.513
7	127.00		1.25	0.51	0.25	0.380	24.50	11.638
8	153.00		1.80	0.36	0.26	0.310	20.50	11.439
9	168.00		2.25	0.46	0.40	0.430	15.50	14.996
10	184.00		2.40	0.49	0.42	0.455	17.00	18.564
11	202.00		2.57	0.51	0.35	0.430	21.50	23.760
12	227.00		2.37	0.53	0.47	0.500	20.50	24.293
13	243.00		2.22	0.68	0.57	0.625	17.50	24.281
14	262.00		2.37	0.64	0.58	0.610	22.00	31.805
15	287.00		2.60	0.93	0.71	0.820	26.00	55.432
16	314.00		2.70	1.05	0.81	0.930	31.00	77.841
17	349.00		2.80	1.04	0.85	0.945	29.00	76.734
18	372.00		2.50	1.10	0.78	0.940	22.00	51.700
19	393.00		2.15	1.09	0.92	1.005	17.50	37.813
20	407.00		2.12	0.96	0.80	0.880	25.00	46.640
21	443.00		1.95	0.96	0.76	0.860	38.50	64.565
22	484.00		1.45	0.86	0.66	0.760	36.00	39.672
23	515.00		1.25	0.74	0.66	0.700	22.00	19.250
24	528.00		1.15	0.54	0.48	0.510	20.00	11.730
25	555.00		0.60			0.280	16.50	2.772
26	561.00		0.00			0.000	10.50	0.000
27	576.00		0.00			0.000	10.00	0.000
28	581.00		0.40			-0.010	11.00	-0.044
29	598.00		0.60			0.000	17.50	0.000
30	616.00		1.10			0.000	12.50	0.000
RDB	623.00		0.00			0.000	3.50	0.000
								719.3

Note: 1. Water elevation 226.735m (1300hrs); measurements referenced from T-bar 231.347m (geodetic)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S24
STREAM NAME: Athabasca River
COORDINATES: 6372760N/466313E
MEASUREMENT DATE: 11 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 226.491m (1040 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S25
STREAM NAME: Susan Lake Outlet
COORDINATES: 6368595N/464455E
MEASUREMENT DATE: 11 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1310 hrs.
MEASUREMENT END TIME: 1320 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.14			0.230	0.20	0.006
2	0.40		0.14			0.140	0.10	0.002
3	0.50		0.14			0.490	0.10	0.007
4	0.60		0.14			0.500	0.10	0.007
5	0.70		0.14			0.590	0.10	0.008
6	0.80		0.16			0.690	0.10	0.011
7	0.90		0.14			0.520	0.10	0.007
8	1.00		0.10			0.470	0.10	0.005
9	1.10		0.10			0.290	0.10	0.003
10	1.20		0.08			0.220	0.10	0.002
11	1.30		0.04			0.140	0.10	0.001
12	1.40		0.04			0.150	0.10	0.001
13	1.50		0.02			-0.320	0.35	-0.002
RDB	2.10		0.00			0.000	0.30	0.000
								0.057

Notes:
1. Water elevation 228.264m (1322 hrs)
2. Installed the transducer and Lakewood logger

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S25
STREAM NAME: Susan Lake Outlet
COORDINATES: 6368595N/464455E
MEASUREMENT DATE: 10 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0845 hrs.
MEASUREMENT END TIME: 0850 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.15	0.000
1	0.30		0.06			0.090	0.25	0.001
2	0.50		0.04			0.120	0.20	0.001
3	0.70		0.12			0.270	0.20	0.006
4	0.90		0.16			0.560	0.20	0.018
5	1.10		0.22			0.520	0.20	0.023
6	1.30		0.24			0.260	0.20	0.012
7	1.50		0.20			0.240	0.20	0.010
8	1.70		0.06			0.150	0.15	0.001
RDB	1.80		0.00			0.000	0.05	0.000
								0.073

Note:
1. Water elevation 228.267m (0853 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S25
STREAM NAME: Susan Lake Outlet
COORDINATES: 6368595N/464455E

MEASUREMENT DATE: 11 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0903 hrs.
MEASUREMENT END TIME: 0910 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.10	0.000
1	0.20		0.14			0.060	0.15	0.001
2	0.30		0.22			0.150	0.10	0.003
3	0.40		0.26			0.080	0.10	0.002
4	0.50		0.22			0.140	0.10	0.003
5	0.60		0.23			0.290	0.10	0.007
6	0.70		0.23			0.490	0.10	0.011
7	0.80		0.17			0.370	0.10	0.006
8	0.90		0.16			0.460	0.10	0.007
9	1.00		0.16			0.280	0.10	0.004
10	1.10		0.15			0.220	0.10	0.003
11	1.20		0.10			0.120	0.10	0.001
12	1.30		0.06			0.060	0.10	0.000
13	1.40		0.06			0.020	0.10	0.000
14	1.50		0.05			-0.010	0.16	0.000
RDB	1.72		0.00			0.000	0.11	0.000
								0.051

Notes:
1. Water elevation 228.264m (1003 hrs)
2. Installed a new BM at the new proposed gauging station site (u/s of existing station); BM elevation 232.550m and water elevation 231.603m (0952 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S26
STREAM NAME: Mackay River WSC
COORDINATES: 6341078N/458031E
MEASUREMENT DATE: 15 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1225 hrs.
MEASUREMENT END TIME: 1250 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.50	0.00			0.000	0.60	0.000
1	1.20	0.50	0.17			0.130	1.05	0.021
2	2.10	0.38	0.26			0.200	1.15	0.055
3	3.50	0.42	0.17			0.220	1.33	0.046
4	4.76	0.39	0.30			0.290	1.13	0.090
5	5.75	0.32	0.33			0.180	1.22	0.067
6	7.20	0.27	0.30			0.290	1.33	0.106
7	8.40	0.27	0.31			0.270	1.13	0.087
8	9.45	0.28	0.26			0.170	1.15	0.047
9	10.70	0.31	0.14			0.120	1.18	0.018
RDB	11.80	0.27	0.00			0.000	0.55	0.000
								0.536

Notes:
1. This discharge measurement was conducted at the Fort Mackay Bridge (downstream of the WSC station); measurement was not conducted at the WSC station because equipment was not hauled down by access trail
2. Water elevation 97.295m, top of ice elevation 97.405m (1053 hrs) (surveyed at the WSC station)
3. TSS sample was taken from the WSC station

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S26
STREAM NAME: Mackay River WSC
COORDINATES: 6341078N/458031E
MEASUREMENT DATE: 08 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1020 hrs.
MEASUREMENT END TIME: 1023 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.40	0.24	0.00			0.000	0.18	0.000
1	0.75	0.24	0.07			0.210	0.38	0.005
2	1.15	0.19	0.17			0.380	0.35	0.021
3	1.45	0.17	0.14			0.410	0.29	0.015
4	1.73	0.21	0.10			0.300	0.35	0.010
5	2.15	0.24	0.00			0.000	0.49	0.000
RDB	2.70	0.24	0.00			0.000	0.28	0.000
								0.051

Notes:
1. Water elevation (surveyed at the transducer) 97.390m, top of ice elevation 97.277m (0945 hrs)
2. TSS sample was taken from the WSC station

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S26
STREAM NAME: Mackay River WSC
COORDINATES: 6341078N/458031E

MEASUREMENT DATE: 18 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1530 hrs.
MEASUREMENT END TIME: 1550 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.22	0.00			0.000	0.20	0.000
1	0.40	0.22	0.00			0.000	0.53	0.000
2	1.05	0.22	0.00			0.000	0.45	0.000
RDB	1.30	0.22	0.00			0.000	0.13	0.000
								0.000

Note: 1. Water elevation (surveyed at the transducer) 97.113m, top of ice elevation 97.327m (1502 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S26
STREAM NAME: Mackay River WSC
COORDINATES: 6341078N/458031E

MEASUREMENT DATE: 24 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 97.630m (1327 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S26
STREAM NAME: Mackay River WSC
COORDINATES: 6341078N/458031E
MEASUREMENT DATE: 27 Nov 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1534 hrs.
MEASUREMENT END TIME: 1539 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00	0.23	0.00			0.000	0.90	0.000
1	1.80	0.23	0.26			0.230	2.03	0.111
2	4.05	0.27	0.11			0.160	2.23	0.036
3	6.25	0.29	0.35			0.350	2.25	0.254
4	8.55	0.30	0.47			0.340	2.18	0.320
5	10.60	0.32	0.38			0.270	2.35	0.222
6	13.25	0.26	0.22			0.130	2.58	0.068
7	15.75	0.26	0.06			0.020	1.38	0.002
RDB	16.00	0.26	0.00			0.000	0.13	0.000
								1.012

Notes: 1. Water elevation (surveyed at the transducer) 97.325m, top of ice elevation 97.460m (1600 hrs)
2. TSS sample was taken from the WSC station

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S26
STREAM NAME: Mackay River WSC
COORDINATES: 6341078N/458031E
MEASUREMENT DATE: 08 Jan 2003
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/TC
COMPUTATIONS BY: LL/NS
MEASUREMENT START TIME: 1137 hrs.
MEASUREMENT END TIME: 1142 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	9.00	0.50	0.00			0.000	0.45	0.000
1	9.90	0.50	0.11			0.000	1.15	0.000
2	11.30	0.38	0.37			0.240	1.15	0.094
3	12.20	0.38	0.39			0.270	0.95	0.092
4	13.20	0.41	0.36			0.350	0.95	0.110
5	14.10	0.40	0.30			0.240	0.90	0.060
6	15.00	0.37	0.23			0.310	1.05	0.069
7	16.20	0.35	0.26			0.260	1.10	0.068
8	17.20	0.35	0.21			0.220	1.00	0.043
9	18.20	0.36	0.23			0.160	1.00	0.034
10	19.20	0.42	0.12			0.070	1.00	0.008
11	20.20	0.45	0.00			0.000	1.00	0.000
RDB	21.20	0.36	0.00			0.000	0.50	0.000
								0.577

Note: 1. Water elevation (surveyed at the transducer) 97.385m, top of ice elevation 97.467m (1600 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River
COORDINATES: 63887706N/488685E

MEASUREMENT DATE: 14 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/NS

MEASUREMENT START TIME: 1238 hrs.
MEASUREMENT END TIME: 1255 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00	0.47	0.00			0.000	0.50	0.000
1	1.00	0.47	0.11			0.120	2.40	0.029
2	4.80	0.41	0.28			0.460	3.95	0.468
3	8.90	0.56	0.23			0.220	4.25	0.195
4	13.30	0.54	0.24			0.470	4.28	0.444
5	17.45	0.53	0.20			0.020	4.58	0.017
6	22.45	0.51	0.12			0.080	4.73	0.042
7	26.90	0.44	0.14			0.030	4.58	0.018
8	31.60	0.47	0.25			0.270	4.80	0.298
9	36.50	0.49	0.34			0.580	4.90	0.876
10	41.40	0.43	0.38			0.510	5.00	0.891
11	46.50	0.36	0.49			0.620	5.00	1.397
12	51.40	0.39	0.63			0.730	4.70	1.976
13	55.90	0.19	0.55			0.850	3.65	1.581
14	58.70	0.36	0.70			0.520	2.30	0.765
15	60.50	0.51	0.49			0.300	1.40	0.189
RDB	61.50	0.51	0.49			0.000	0.50	0.000
								9.186

Note: 1. Water elevation 97.507m, top of ice elevation 97.507m (1309 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River
COORDINATES: 63887706N/488685E
MEASUREMENT DATE: 07 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1416 hrs.
MEASUREMENT END TIME: 1451 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.60	0.45	0.00			-0.030	1.83	0.000
1	5.25	0.51	0.27			0.260	3.65	0.237
2	8.90	0.59	0.34			0.150	3.68	0.170
3	12.60	0.59	0.18			0.200	4.10	0.136
4	17.10	0.60	0.12			0.130	4.00	0.057
5	20.60	0.59	0.08			-0.010	2.55	-0.002
6	22.20	0.59	0.00			0.000	3.05	0.000
7	26.70	0.59	0.00			0.000	3.55	0.000
8	29.30	0.55	0.10			0.170	3.40	0.053
9	33.50	0.55	0.17			0.400	3.90	0.245
10	37.10	0.53	0.26			0.520	3.80	0.464
11	41.10	0.43	0.34			0.530	4.00	0.663
12	45.10	0.42	0.42			0.600	3.75	0.859
13	48.60	0.24	0.68			0.800	3.90	1.938
14	52.90	0.23	0.51			0.790	4.00	1.483
15	56.60	0.20	0.63			0.660	3.00	1.148
16	58.90	0.36	0.58			0.270	1.70	0.243
RDB	60.00	0.36	0.00			0.000	0.55	0.000
								7.693

Note: 1. Water elevation 97.507m, top of ice elevation 97.529m (1500 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River
COORDINATES: 63887706N/488685E
MEASUREMENT DATE: 16 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0910 hrs.
MEASUREMENT END TIME: 0943 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.70	0.72	0.00			0.000	0.95	0.000
1	2.60	0.72	0.06			0.330	2.75	0.050
2	6.20	0.68	0.25			0.390	4.45	0.399
3	11.50	0.64	0.22			0.430	4.85	0.422
4	15.90	0.54	0.46			0.510	3.65	0.788
5	18.80	0.46	0.71			0.760	2.80	1.390
6	21.50	0.52	0.59			0.830	2.40	1.081
7	23.60	0.20	0.86	0.88	0.59	0.735	1.95	1.233
8	25.40	0.16	0.80	0.82	0.54	0.680	1.90	1.034
9	27.40	0.60	0.45			0.020	1.80	0.015
RDB	29.00	0.60	0.00			0.000	0.80	0.000
								6.412

Note: 1. Water elevation 97.582m, top of ice elevation 97.651m (0955 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River
COORDINATES: 63887706N/488685E
MEASUREMENT DATE: 09 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0905 hrs.
MEASUREMENT END TIME: 0915 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.74	0.00			0.000	2.10	0.000
1	4.20	0.74	0.26			0.180	4.80	0.207
2	9.60	0.69	0.37			0.480	5.35	0.862
3	14.90	0.59	0.66			0.630	4.95	1.894
4	19.50	0.49	0.64			0.880	3.73	1.924
5	22.35	0.11	0.93	0.73	0.40	0.565	2.65	1.389
6	24.80	0.49	0.49			0.220	1.93	0.190
RDB	26.20	0.49	0.00			0.000	0.70	0.000
								6.466

Note: 1. Water elevation 97.655m, top of ice elevation 97.708m (0927 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River
COORDINATES: 63887706N/488685E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 97.507m (0841 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River
COORDINATES: 63887706N/488685E
MEASUREMENT DATE: 23 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*

Note: 1. Water elevation 97.470m (1241 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River **MEASUREMENT DATE: 03 Dec 2002**
COORDINATES: 63887706N/488685E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/JE **MEASUREMENT START TIME: 1000 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1030 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.43	0.00			0.000	1.00	0.000
1	2.00	0.43	0.80	0.01	0.32	0.165	3.30	0.436
2	6.60	0.35	0.75			0.420	5.35	1.550
3	12.70	0.33	0.49			0.430	6.25	1.212
4	19.10	0.33	0.58			0.370	6.10	1.204
5	24.90	0.33	0.47			0.540	5.65	1.319
6	30.40	0.30	0.39			0.580	5.50	1.145
7	35.90	0.31	0.30			0.260	4.90	0.352
8	40.20	0.32	0.20			0.120	5.15	0.114
9	46.20	0.43	0.69			0.290	5.25	0.966
10	50.70	0.34	0.84	0.43	0.38	0.405	4.35	1.480
11	54.90	0.36	0.91	0.57	0.48	0.525	4.10	1.959
12	58.90	0.31	1.20	0.60	0.48	0.540	4.55	2.948
RDB	64.00	0.31	0.00			0.000	2.55	0.000
								14.685

Notes:
1. Water elevation 97.624m, top of ice elevation 97.763m (1000 hrs)
2. Installed non-telemetry Data Dolphin logger on 23 Oct 2002
3. Key 3892 for the metal housing

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S27
STREAM NAME: Firebag River **MEASUREMENT DATE: 07 Jan 2003**
COORDINATES: 63887706N/488685E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/PM **MEASUREMENT START TIME: 0842 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 0903 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.51	0.00			0.000	1.40	0.000
1	2.80	0.51	0.18			0.390	4.45	0.287
2	8.90	0.47	0.61			0.350	6.75	1.326
3	16.30	0.46	0.62			0.430	7.40	1.815
4	23.70	0.44	0.27			0.290	6.40	0.461
5	29.10	0.38	0.27			0.370	6.35	0.584
6	36.40	0.43	0.07			0.000	6.70	0.000
7	42.50	0.41	0.34			0.430	5.70	0.767
8	47.80	0.42	0.53			0.750	5.25	1.920
9	53.00	0.43	0.65			0.750	4.70	2.108
10	57.20	0.49	0.43			0.580	4.35	0.998
11	61.70	0.55	0.64			0.380	3.15	0.705
RDB	63.50	0.55	0.00			0.000	0.90	0.000

Notes:
1. Water elevation 97.644m, top of ice elevation 97.711m (0907 hrs)
2. Downloaded data for year end 2002

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S28
STREAM NAME: Khahago Creek
COORDINATES: 6342185N/480489E
MEASUREMENT DATE: 14 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 323.807m (1645 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S28
STREAM NAME: Khahago Creek
COORDINATES: 6342185N/480489E
MEASUREMENT DATE: 10 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: RS/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1655 hrs.
MEASUREMENT END TIME: 1730 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.40	0.000
1	0.80		1.20	0.09	0.11	0.100	0.65	0.078
2	1.30		1.20	0.12	0.14	0.130	0.50	0.078
3	1.80		1.30	0.12	0.16	0.140	0.50	0.091
4	2.30		1.20	0.03	0.14	0.085	0.50	0.051
5	2.80		1.25	0.13	0.13	0.130	0.50	0.081
6	3.30		1.00	0.08	0.12	0.100	0.50	0.050
7	3.80		0.90	0.02	0.09	0.055	0.50	0.025
8	4.30		1.20	0.08	0.07	0.075	0.50	0.045
9	4.80		0.98	0.04	0.06	0.050	0.50	0.025
10	5.30		0.82	0.01	0.06	0.035	0.50	0.014
11	5.80		0.51	0.01	0.04	0.025	0.50	0.006
RDB	6.30		0.00			0.000	0.25	0.000
								0.544

Notes: 1. Water elevation 324.104m (1738 hrs)
2. First discharge measurement at this site

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S28
STREAM NAME: Khahago Creek
COORDINATES: 6342185N/480489E
MEASUREMENT DATE: 09 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0855 hrs.
MEASUREMENT END TIME: 0948 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.55	0.000
1	1.10		0.91	-0.02	0.00	-0.010	0.80	-0.007
2	1.60		1.22	0.18	0.18	0.180	0.50	0.110
3	2.10		1.34	0.17	0.16	0.165	0.50	0.111
4	2.60		1.52	0.21	0.18	0.195	0.50	0.148
5	3.10		1.60	0.23	0.37	0.300	0.50	0.240
6	3.60		1.85	0.18	0.30	0.240	0.50	0.222
7	4.10		1.88	0.34	0.27	0.305	0.50	0.287
8	4.60		2.12	0.30	0.08	0.190	0.50	0.201
9	5.10		2.12	0.36	0.05	0.205	0.50	0.217
10	5.60		2.05	0.34	0.10	0.220	0.50	0.226
11	6.10		1.95	0.41	0.41	0.410	0.50	0.400
12	6.60		1.85	0.35	0.28	0.315	0.50	0.291
13	7.10		1.70	0.37	0.23	0.300	0.65	0.332
RDB	7.90		0.00			0.000	0.40	0.000
								2.777

Note: 1. Water level not surveyed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S28
STREAM NAME: Khahago Creek
COORDINATES: 6342185N/480489E

MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1453 hrs.
MEASUREMENT END TIME: 1525 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	4.00		0.00			0.000	0.25	0.000
1	4.50		0.24			0.000	0.50	0.000
2	5.00		0.62			0.030	0.50	0.009
3	5.50		0.96	0.08	0.13	0.105	0.50	0.050
4	6.00		1.10	0.17	0.12	0.145	0.50	0.080
5	6.50		1.35	0.16	0.18	0.170	0.50	0.115
6	7.00		1.50	0.21	0.15	0.180	0.50	0.135
7	7.50		1.62	0.20	0.17	0.185	0.50	0.150
8	8.00		1.81	0.23	0.22	0.225	0.50	0.204
9	8.50		1.90	0.22	0.23	0.225	0.50	0.214
10	9.00		1.85	0.24	0.22	0.230	0.50	0.213
11	9.50		1.80	0.24	0.22	0.230	0.50	0.207
12	10.00		1.72	0.24	0.25	0.245	0.50	0.211
13	10.50		1.58	0.25	0.15	0.200	0.50	0.158
14	11.00		1.47	0.27	0.22	0.245	0.50	0.180
15	11.50		1.00	0.21	0.06	0.135	0.40	0.054
RDB	11.80		0.00			0.000	0.15	0.000
								1.979

Note: 1. Water elevation 324.245m (1533 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC
COORDINATES: 6187926N/508195E

MEASUREMENT DATE: 13 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1145 hrs.
MEASUREMENT END TIME: 1220 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.10	0.39	0.00			0.000	0.25	0.000
1	1.60	0.39	0.27			0.110	0.68	0.018
2	2.45	0.35	0.42			0.230	1.18	0.104
3	3.95	0.32	0.51			0.280	1.83	0.239
4	6.10	0.21	0.64			0.340	3.08	0.616
5	10.10	0.17	0.59			0.390	3.70	0.786
6	13.50	0.25	0.46			0.360	2.70	0.410
7	15.50	0.35	0.32			0.280	1.95	0.158
8	17.40	0.40	0.21			0.140	2.50	0.068
9	20.50	0.40	0.05			0.000	2.15	0.000
10	21.70	0.37	0.00			0.000	2.68	0.000
11	25.85	0.36	0.06			0.000	4.35	0.000
12	30.40	0.35	0.11			0.080	2.98	0.024
13	31.80	0.25	0.17			0.150	1.33	0.030
14	33.05	0.21	0.19			0.060	0.75	0.008
RDB	33.30	0.25	0.00			0.000	0.13	0.000
								2.462

Notes:
1. Water elevation 94.925m; top of ice elevation 95.01m (1310 hrs) (referenced to WSC BM pin elevation 100.00m)
2. Temporary Logger/Transducer s/n 2025-5psi was installed at left bank approximately 40m upstream of WSC
3. TSS sample was collected
4. No hand held cellular coverage; but cov erage should be alright with remote antenna and solar panel

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC **MEASUREMENT DATE: 04 Feb 2002**
COORDINATES: 6187926N/508195E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/PM **MEASUREMENT START TIME: 1120 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1142 hrs.**

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	1.20	0.51	0.00			0.000	0.60	0.000
1	2.40	0.51	0.20			0.230	1.45	0.063
2	4.10	0.50	0.36			0.270	1.83	0.165
3	6.05	0.43	0.52			0.300	1.93	0.276
4	7.95	0.40	0.55			0.360	1.70	0.311
5	9.45	0.37	0.54			0.380	1.93	0.363
6	11.80	0.35	0.55			0.390	2.68	0.523
7	14.80	0.43	0.38			0.300	2.83	0.296
8	17.45	0.48	0.24			0.160	2.80	0.099
9	20.40	0.46	0.10			0.040	3.28	0.012
10	24.00	0.43	0.06			-0.060	3.38	-0.012
11	27.15	0.38	0.08			0.010	3.08	0.002
12	30.15	0.40	0.04			0.000	2.93	0.000
13	33.00	0.16	0.28			0.100	1.78	0.045
RDB	33.70	0.16	0.00			0.000	0.35	0.000
								2.144

Notes:
1. Water elevation 95.034m; top of ice elevation 95.023m (1152 hrs) (referenced to WSC BM pin elevation 100.00m)
2. Temporary Logger/Transducer s/n 2025-5psi was chewed by rabbit and a new transducer s/n 971889-6psi was installed at the same location
3. TSS sample was collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC **MEASUREMENT DATE: 17 Mar 2002**
COORDINATES: 6187926N/508195E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/ME **MEASUREMENT START TIME: 0945 hrs.**
COMPUTATIONS BY: LL/JB **MEASUREMENT END TIME: 1015 hrs.**

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.50	0.59	0.00			0.000	1.40	0.000
1	3.30	0.59	0.35			0.180	3.00	0.174
2	6.50	0.56	0.43			0.260	3.70	0.381
3	10.70	0.40	0.87	0.26	0.22	0.240	4.30	0.898
4	15.10	0.54	0.42			0.190	3.80	0.279
5	18.30	0.66	0.13			0.120	3.20	0.046
RDB	21.50	0.66	0.00			0.000	1.60	0.000
								1.777

Notes:
1. Water elevation 95.75m; top of ice elevation 95.706m (1006 hrs) (referenced to WSC BM pin elevation 100.00m)
2. TSS sample was collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC
COORDINATES: 6187926N/508195E
MEASUREMENT DATE: 10 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0830 hrs.
MEASUREMENT END TIME: 0855 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00	0.69	0.00			0.000	0.70	0.000
1	1.40	0.69	0.35			0.360	2.13	0.246
2	4.25	0.58	0.48			0.480	2.70	0.572
3	6.80	0.62	0.49			0.450	2.55	0.517
4	9.35	0.64	0.43			0.460	2.08	0.378
5	10.95	0.64	0.40			0.420	1.83	0.282
6	13.00	0.71	0.18			0.260	1.58	0.068
RDB	14.10	0.71	0.00			0.000	0.55	0.000
								2.063

Notes:
1. Water elevation 95.198m; top of ice elevation 95.240m (0840 hrs)
(referenced to WSC BM pin elevation 100.00m / Nail by tree 99.594m)
2. TSS sample was collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC
COORDINATES: 6187926N/508195E
MEASUREMENT DATE: 11 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes:
1. Water elevation 95.006m (1638 hrs)
2. Installed BM (pin) and tied into Nail by tree; elevation of BM (pin) 99.076m

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC
COORDINATES: 6187926N/508195E

MEASUREMENT DATE: 22 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes:
1. Water elevation 94.769m (1510 hrs)
2. Non telemetry Data Dolphin logger #268 installed
3. Removed the raingauge/Lakewood logger

PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC
COORDINATES: 6187926N/508195E

MEASUREMENT DATE: 29 Nov 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JE
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1413 hrs.
MEASUREMENT END TIME: 1438 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.80	0.21	0.00			0.000	0.50	0.000
1	1.80	0.21	0.56			0.350	1.25	0.225
2	3.30	0.34	0.57			0.530	1.50	0.417
3	4.80	0.34	0.67			0.510	1.70	0.534
4	6.70	0.37	0.69			0.520	2.00	0.660
5	8.80	0.34	0.66			0.550	2.20	0.735
6	11.10	0.23	0.72			0.530	2.30	0.807
7	13.40	0.31	0.58			0.600	1.90	0.608
8	14.90	0.40	0.46			0.090	2.25	0.086
9	17.90	0.34	0.52			0.120	2.50	0.144
10	19.90	0.35	0.36			0.320	2.45	0.260
11	22.80	0.32	0.22			0.190	2.90	0.112
12	25.70	0.33	0.25			0.130	2.90	0.087
13	28.60	0.37	0.19			0.140	2.50	0.061
14	30.70	0.41	0.19			0.160	1.95	0.055
15	32.50	0.37	0.19			0.200	1.55	0.054
RDB	33.80	0.37	0.00			0.000	0.65	0.000
								4.844

Note:
1. Water elevation 95.972m, top of ice elevation 95.020m (1413 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: S29
STREAM NAME: Christina River WSC
COORDINATES: 6187926N/508195E

MEASUREMENT DATE: 06 Jan 2003
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1235 hrs.
MEASUREMENT END TIME: 1244 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.80	0.52	0.00			0.000	0.55	0.000
1	2.90	0.52	0.02			0.010	2.10	0.000
2	6.00	0.53	0.04			0.030	3.80	0.004
3	10.50	0.54	0.02			0.050	4.40	0.004
4	14.80	0.50	0.11			0.210	4.30	0.091
5	19.10	0.56	0.25			0.310	4.00	0.285
6	22.80	0.49	0.57			0.390	4.50	0.920
7	28.10	0.46	0.42			0.480	5.00	0.927
8	32.80	0.54	0.26			0.340	3.45	0.281
RDB	35.00	0.54	0.00			0.000	1.10	0.000
								2.513

Note: 1. Water elevation 95.094m, top of ice elevation 95.146m (1250 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E
MEASUREMENT DATE: 22 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY			WIDTH (m)	DISCHARGE (m^3/sec)
				0.2 Depth (m/sec)	0.8 Depth (m/sec)	0.6 Depth (m/sec)		
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 99.09m (1237 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E
MEASUREMENT DATE: 13 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1217 hrs.
MEASUREMENT END TIME: 1223 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY			WIDTH (m)	DISCHARGE (m^3/sec)
				0.2 Depth (m/sec)	0.8 Depth (m/sec)	0.6 Depth (m/sec)		
LDB	0.00		0.00			0.000	0.46	0.000
1	0.92		0.14			0.210	0.81	0.024
2	1.62		0.16			0.570	0.55	0.050
3	2.02		0.36			0.500	0.50	0.090
4	2.62		0.42			1.010	0.45	0.191
5	2.92		0.38			0.990	0.40	0.150
6	3.42		0.38			0.870	0.35	0.116
7	3.62		0.54			0.900	0.20	0.097
8	3.82		0.54			0.860	0.20	0.093
9	4.02		0.58			0.800	0.20	0.093
10	4.22		0.56			0.740	0.20	0.083
11	4.42		0.52			0.520	0.25	0.068
12	4.72		0.12			0.360	0.43	0.018
RDB	5.27		0.00			0.000	0.28	0.000
								1.073

Notes:
1. Water elevation 98.370m (1240 hrs)
2. Discharge measurement was carried out where there was only a short section of bottom ice
3. TSS collected
4. Transducer that was installed 22 April 02 was above water - reinstalled May 13 2002

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E
MEASUREMENT DATE: 08 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1105 hrs.
MEASUREMENT END TIME: 1115 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	4.20		0.00			0.000	0.15	0.000
1	4.50		0.08			0.130	0.40	0.004
2	5.00		0.16			0.640	0.50	0.051
3	5.50		0.20			0.700	0.50	0.070
4	6.00		0.25			0.700	0.50	0.088
5	6.50		0.15			0.840	0.50	0.063
6	7.00		0.14			0.920	0.50	0.064
7	7.50		0.14			0.940	0.50	0.066
8	8.00		0.20			0.950	0.50	0.095
9	8.50		0.25			0.910	0.50	0.114
10	9.00		0.20			0.800	0.50	0.080
11	9.50		0.28			0.710	0.50	0.099
12	10.00		0.22			0.650	0.50	0.072
13	10.50		0.26			0.560	0.50	0.073
14	11.00		0.31			0.460	0.50	0.071
15	11.50		0.30			0.240	0.50	0.036
16	12.00		0.20			0.160	0.50	0.016
17	12.50		0.07			0.160	0.50	0.006
18	13.00		0.06			0.060	0.40	0.001
RDB	13.30		0.00			0.000	0.15	0.000
								1.069

Notes: 1. Water elevation 98.125m (1129 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E
MEASUREMENT DATE: 08 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Notes: 1. Water elevation 98.159m (1446 hrs)
2. Transducer was removed as it was not working

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E
MEASUREMENT DATE: 09 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1455 hrs.
MEASUREMENT END TIME: 1501 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.30	0.000
1	0.60		0.25			0.000	0.55	0.000
2	1.10		0.27			0.160	0.50	0.022
3	1.60		0.25			0.570	0.50	0.071
4	2.10		0.23			0.380	0.50	0.044
5	2.60		0.22			0.390	0.50	0.043
6	3.10		0.20			0.470	0.50	0.047
7	3.60		0.25			0.470	0.50	0.059
8	4.10		0.27			0.550	0.50	0.074
9	4.60		0.29			0.630	0.50	0.091
10	5.10		0.30			0.600	0.50	0.090
11	5.60		0.27			0.550	0.50	0.074
12	6.10		0.25			0.380	0.50	0.048
13	6.60		0.26			0.360	0.53	0.049
RDB	7.15		0.00			0.000	0.28	0.000
								0.712

Notes:
1. Water elevation 98.109m (1507 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E
MEASUREMENT DATE: 07 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1343 hrs.
MEASUREMENT END TIME: 1349 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.30	0.000
1	0.60		0.50			0.770	0.65	0.250
2	1.30		0.44			0.760	0.85	0.284
3	2.30		0.48			0.820	1.00	0.394
4	3.30		0.38			0.910	1.00	0.346
5	4.30		0.50			0.790	1.00	0.395
6	5.30		0.68			0.920	1.00	0.626
7	6.30		0.58			0.990	1.00	0.574
8	7.30		0.52			1.080	1.00	0.562
9	8.30		0.52			0.680	1.00	0.354
10	9.30		0.32			0.840	0.90	0.242
RDB	10.10		0.00			0.000	0.40	0.000
								4.026

Notes:
1. Water level not surveyed
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S30
STREAM NAME: Hangingstone River
COORDINATES: 6252647N/476933E

MEASUREMENT DATE: 22 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1057 hrs.
MEASUREMENT END TIME: 1105 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	2.30		0.00			0.000	0.10	0.000
1	2.50		0.30			0.160	0.35	0.017
2	3.00		0.27			0.260	0.50	0.035
3	3.50		0.26			0.160	0.50	0.021
4	4.00		0.28			0.290	0.50	0.041
5	4.50		0.23			0.330	0.50	0.038
6	5.00		0.20			0.360	0.50	0.036
7	5.50		0.21			0.310	0.50	0.033
8	6.00		0.22			0.360	0.50	0.040
9	6.50		0.28			0.020	0.50	0.003
10	7.00		0.38			0.340	0.50	0.065
11	7.50		0.42			0.290	0.50	0.061
12	8.00		0.46			0.200	0.50	0.046
13	8.50		0.44			0.120	0.50	0.026
14	9.00		0.40			0.040	0.50	0.008
15	9.50		0.38			0.130	0.50	0.025
16	10.00		0.27			0.050	0.50	0.007
17	10.50		0.31			0.000	0.50	0.000
18	11.00		0.26			-0.020	0.65	-0.003
RDB	11.80		0.00			0.000	0.40	0.000
								0.496

Notes:
1. Water elevation 98.314m (1110 hrs)
2. TSS collected
3. Partial ice was broken up for open water measurement
4. Transducer and logger were removed for the season

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E

MEASUREMENT DATE: 10 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1135 hrs.
MEASUREMENT END TIME: 1145 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.30		0.00			0.000	0.05	0.000
1	0.40		0.10			0.030	0.15	0.000
2	0.60		0.10			0.010	0.20	0.000
3	0.80		0.10			0.250	0.20	0.005
4	1.00		0.12			0.250	0.20	0.006
5	1.20		0.14			0.210	0.20	0.006
6	1.40		0.14			0.330	0.20	0.009
7	1.60		0.11			0.350	0.20	0.008
8	1.80		0.16			0.310	0.20	0.010
9	2.00		0.16			0.310	0.20	0.010
10	2.20		0.12			0.310	0.20	0.007
11	2.40		0.13			0.350	0.20	0.009
12	2.60		0.14			0.340	0.20	0.010
13	2.80		0.16			0.270	0.20	0.009
14	3.00		0.20			0.230	0.20	0.009
15	3.20		0.08			0.130	0.25	0.003
RDB	3.50		0.00			0.000	0.15	0.000
								0.101

Notes:
1. Water elevation 98.209m (1150 hrs)
2. Creek was opened (no ice cover)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E
MEASUREMENT DATE: 22 Apr 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/ME
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1047 hrs.
MEASUREMENT END TIME: 1100 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	2.40		0.00			0.000	0.30	0.000
1	3.00		0.23			0.070	0.55	0.009
2	3.50		0.26			0.150	0.50	0.020
3	4.00		0.34			0.180	0.50	0.031
4	4.50		0.36			0.130	0.50	0.023
5	5.00		0.39			0.120	0.50	0.023
6	5.50		0.48			0.140	0.50	0.034
7	6.00		0.47			0.120	0.50	0.028
8	6.50		0.46			0.090	0.50	0.021
9	7.00		0.49			0.100	0.50	0.025
10	7.50		0.47			0.100	0.50	0.024
11	8.00		0.40			0.070	0.50	0.014
12	8.50		0.24			0.070	0.63	0.011
RDB	9.25		0.00			0.000	0.38	0.000
								0.261

Notes: 1. Water elevation 98.290m (1059 hrs)
2. Creek was opened (no ice cover)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E
MEASUREMENT DATE: 13 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/JK
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1035 hrs.
MEASUREMENT END TIME: 1042 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.60		0.00			0.000	0.20	0.000
1	2.00		0.10			0.030	0.45	0.001
2	2.50		0.27			0.170	0.50	0.023
3	3.00		0.30			0.180	0.50	0.027
4	3.50		0.32			0.140	0.50	0.022
5	4.00		0.31			0.160	0.50	0.025
6	4.50		0.31			0.150	0.50	0.023
7	5.00		0.32			0.130	0.50	0.021
8	5.50		0.32			0.140	0.50	0.022
9	6.00		0.33			0.100	0.50	0.017
10	6.50		0.29			0.090	0.50	0.013
11	7.00		0.20			0.070	0.50	0.007
12	7.50		0.18			0.030	0.50	0.003
13	8.00		0.08			-0.020	0.53	-0.001
RDB	8.55		0.00			0.000	0.28	0.000
								0.203

Note: 1. Water elevation 98.264m (1046 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E
MEASUREMENT DATE: 08 Jun 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0955 hrs.
MEASUREMENT END TIME: 1003 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.10		0.00			0.000	0.20	0.000
1	1.50		0.08			0.000	0.45	0.000
2	2.00		0.24			0.030	0.50	0.004
3	2.50		0.27			0.100	0.50	0.014
4	3.00		0.30			0.110	0.50	0.017
5	3.50		0.34			0.100	0.50	0.017
6	4.00		0.26			0.130	0.50	0.017
7	4.50		0.28			0.090	0.50	0.013
8	5.00		0.27			0.100	0.50	0.014
9	5.50		0.33			0.090	0.50	0.015
10	6.00		0.30			0.060	0.50	0.009
11	6.50		0.28			0.020	0.50	0.003
12	7.00		0.18			0.000	0.65	0.000
RDB	7.80		0.00			0.000	0.40	0.000
								0.120

Note: 1. Water elevation 98.239m (1007 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E
MEASUREMENT DATE: 08 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1337 hrs.
MEASUREMENT END TIME: 1346 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	3.65		0.00			0.000	0.18	0.000
1	4.00		0.06			0.000	0.43	0.000
2	4.50		0.17			0.160	0.50	0.014
3	5.00		0.26			0.230	0.50	0.030
4	5.50		0.38			0.200	0.50	0.038
5	6.00		0.51			0.150	0.50	0.038
6	6.50		0.56			0.170	0.50	0.048
7	7.00		0.57			0.190	0.50	0.054
8	7.50		0.55			0.190	0.50	0.052
9	8.00		0.54			0.100	0.50	0.027
10	8.50		0.47			0.140	0.50	0.033
11	9.00		0.46			0.110	0.50	0.025
12	9.50		0.57			0.020	0.50	0.006
13	10.00		0.45			0.010	0.50	0.002
14	10.50		0.28			0.000	0.65	0.000
RDB	11.30		0.00			0.000	0.40	0.000
								0.367

Note: 1. Water elevation 98.387m (1348 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E
MEASUREMENT DATE: 07 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 1245 hrs.
MEASUREMENT END TIME: 13096 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.50	0.000
1	1.00		0.54			0.350	1.00	0.189
2	2.00		0.92			0.210	1.00	0.193
3	3.00		1.00			0.440	1.00	0.440
4	4.00		0.94			0.290	1.00	0.273
5	5.00		0.92			0.220	1.00	0.202
6	6.00		0.92			0.220	1.00	0.202
7	7.00		0.90			0.120	1.00	0.108
8	8.00		0.56			0.120	0.95	0.064
RDB	8.90		0.00			0.000	0.45	0.000
								1.671

Note: 1. Water level not surveyed

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S31
STREAM NAME: Hangingstone Creek
COORDINATES: 6236095N/469698E
MEASUREMENT DATE: 22 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB
MEASUREMENT START TIME: 0940 hrs.
MEASUREMENT END TIME: 0946 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	0.00		0.00			0.000	0.30	0.000
1	0.60		0.17			-0.010	0.55	-0.001
2	1.10		0.33			0.030	0.50	0.005
3	1.60		0.48			0.060	0.50	0.014
4	2.10		0.56			0.060	0.50	0.017
5	2.60		0.60			0.100	0.50	0.030
6	3.10		0.60			0.110	0.50	0.033
7	3.60		0.60			0.120	0.50	0.036
8	4.10		0.56			0.100	0.50	0.028
9	4.60		0.52			0.130	0.50	0.034
10	5.10		0.54			0.070	0.50	0.019
11	5.60		0.54			0.080	0.50	0.022
12	6.10		0.58			0.040	0.50	0.012
13	6.60		0.60			0.020	0.50	0.006
14	7.10		0.52			0.020	0.50	0.005
15	7.60		0.37			0.000	0.50	0.000
16	8.10		0.24			0.030	0.50	0.004
RDB	8.60		0.00			0.000	0.25	0.000
								0.263

Notes:
1. Water elevation 98.439m (0950 hrs)
2. Transducer and datalogger were removed for the season
3. Average ice cover was 0.06m; ice cover was broken so that it did not affect the discharge measurement

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S32
STREAM NAME: Surmont Creek
COORDINATES: 6254511N/490252E

MEASUREMENT DATE: 18 May 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 0850 hrs.
MEASUREMENT END TIME: 0855 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.35	0.000
1	0.70		0.21			0.190	0.45	0.018
2	0.90		0.21			0.220	0.20	0.009
3	1.10		0.21			0.310	0.20	0.013
4	1.30		0.23			0.380	0.20	0.017
5	1.50		0.24			0.380	0.20	0.018
6	1.70		0.26			0.330	0.20	0.017
7	1.90		0.26			0.290	0.20	0.015
8	2.10		0.26			0.380	0.20	0.020
9	2.30		0.24			0.470	0.20	0.023
10	2.50		0.19			0.360	0.20	0.014
11	2.70		0.17			0.470	0.20	0.016
12	2.90		0.17			0.330	0.20	0.011
13	3.10		0.20			0.360	0.20	0.014
14	3.30		0.24			0.370	0.20	0.018
15	3.50		0.21			0.320	0.20	0.013
16	3.70		0.20			0.260	0.20	0.010
17	3.90		0.20			0.280	0.20	0.011
18	4.10		0.17			0.290	0.20	0.010
19	4.30		0.16			0.200	0.20	0.006
20	4.50		0.16			0.190	0.20	0.006
21	4.70		0.15			0.220	0.22	0.007
RDB	4.94		0.00			0.000	0.12	0.000
								0.288

Notes:
1. Water elevation 96.676m (0857 hrs); surveyed at the transducer
2. Installed transducer and logger approximately 15m downstream of 2001 location
3. Surveyed new BM elevation 97.942m (referenced to nail by abutment)
4. Ice present on both sides of the creek; at the location of the discharge measurement channel not ice covered

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: S32
STREAM NAME: Surmont Creek | **MEASUREMENT DATE: 08 Jun 2002**
COORDINATES: 6254511N/490252E | **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/PM | **MEASUREMENT START TIME: 1156 hrs.**
COMPUTATIONS BY: LL/JB | **MEASUREMENT END TIME: 1201 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	6.30		0.00			0.000	0.35	0.000
1	7.00		0.17			0.020	0.60	0.002
2	7.50		0.38			0.120	0.35	0.016
3	7.70		0.50			0.200	0.25	0.025
4	8.00		0.52			0.400	0.25	0.052
5	8.20		0.54			0.480	0.20	0.052
6	8.40		0.54			0.450	0.20	0.049
7	8.60		0.55			0.380	0.20	0.042
8	8.80		0.52			0.310	0.20	0.032
9	9.00		0.46			0.250	0.20	0.023
10	9.20		0.39			0.130	0.25	0.013
11	9.50		0.27			0.180	0.40	0.019
12	10.00		0.30			0.000	0.50	0.000
13	10.50		0.13			-0.070	0.65	-0.006
RDB	11.30		0.00			0.000	0.40	0.000
								0.319

Notes: 1. Water elevation 96.641m (1210 hrs); surveyed at the transducer
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S32
STREAM NAME: Surmont Creek | **MEASUREMENT DATE: 08 Jul 2002**
COORDINATES: 6254511N/490252E | **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: LL/PM | **MEASUREMENT START TIME: 1220 hrs.**
COMPUTATIONS BY: LL/JB | **MEASUREMENT END TIME: 1240 hrs.**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	2.57		0.00			0.000	0.22	0.000
1	3.00		0.06			0.070	0.47	0.002
2	3.50		0.20			0.050	0.40	0.004
3	3.80		0.35			0.090	0.35	0.011
4	4.20		0.50			0.260	0.35	0.046
5	4.50		0.53			0.450	0.30	0.072
6	4.80		0.45			0.330	0.35	0.052
7	5.20		0.36			0.360	0.35	0.045
8	5.50		0.32			0.290	0.40	0.037
9	6.00		0.25			0.150	0.50	0.019
10	6.50		0.16			0.120	0.55	0.011
11	7.10		0.10			0.130	0.63	0.008
RDB	7.75		0.00			0.000	0.33	0.000
								0.306

Notes: 1. Water elevation 96.673m (1243 hrs); surveyed at the transducer
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S32
STREAM NAME: Surmont Creek
COORDINATES: 6254511N/490252E

MEASUREMENT DATE: 07 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/PM
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1425 hrs.
MEASUREMENT END TIME: 1432 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	0.00		0.00			0.000	0.20	0.000
1	0.40		0.43			0.230	0.70	0.069
2	1.40		0.54			0.050	0.75	0.020
3	1.90		0.78			0.360	0.50	0.140
4	2.40		0.86			0.570	0.50	0.245
5	2.90		0.82			0.570	0.50	0.234
6	3.40		0.78			0.620	0.50	0.242
7	3.90		0.78			0.570	0.50	0.222
8	4.40		0.82			0.470	0.50	0.193
9	4.90		0.80			0.460	0.50	0.184
10	5.40		0.82			0.260	0.50	0.107
11	5.90		0.90			0.510	0.50	0.230
12	6.40		0.79			0.320	0.50	0.126
13	6.90		0.63			0.230	0.50	0.072
14	7.40		0.50			0.260	0.50	0.065
15	7.90		0.20			0.030	0.50	0.003
RDB	8.40		0.00			0.000	0.25	0.000
								2.152

Notes:
1. Water level not surveyed
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S32
STREAM NAME: Surmont Creek
COORDINATES: 6254511N/490252E

MEASUREMENT DATE: 11 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1748 hrs.
MEASUREMENT END TIME: 1800 hrs.

STATION	DISTANCE FROM LDB	ICE THICKNESS	DEPTH	VELOCITY			WIDTH	DISCHARGE
				0.2 Depth	0.8 Depth	0.6 Depth		
	(m)	(m)	(m)	(m/sec)	(m/sec)	(m/sec)	(m)	(m^3/sec)
LDB	4.60		0.00			0.000	0.20	0.000
1	5.00		0.10			-0.010	0.30	0.000
2	5.20		0.20			-0.010	0.20	0.000
3	5.40		0.28			0.080	0.20	0.004
4	5.60		0.30			0.080	0.25	0.006
5	5.90		0.40			0.370	0.30	0.044
6	6.20		0.50			0.320	0.30	0.048
7	6.50		0.55			0.340	0.30	0.056
8	6.80		0.54			0.240	0.30	0.039
9	7.10		0.59			0.410	0.30	0.073
10	7.40		0.51			0.320	0.30	0.049
11	7.70		0.58			0.440	0.30	0.077
12	8.00		0.53			0.310	0.30	0.049
13	8.30		0.43			0.250	0.30	0.032
14	8.60		0.28			0.200	0.30	0.017
15	8.90		0.29			0.330	0.30	0.029
16	9.20		0.35			0.370	0.30	0.039
17	9.50		0.43			0.340	0.30	0.044
18	9.80		0.37			0.310	0.30	0.034
19	10.10		0.34			0.390	0.30	0.040
20	10.40		0.24			0.380	0.30	0.027
21	10.70		0.08			0.110	0.31	0.003
RDB	11.01		0.00			0.000	0.16	0.000
								0.709

Notes:
1. Water elevation 96.856m (1804 hrs)
2. TSS collected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: S32
STREAM NAME: Surmont Creek
COORDINATES: 6254511N/490252E

MEASUREMENT DATE: 22 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY: LL/NS
COMPUTATIONS BY: LL/JB

MEASUREMENT START TIME: 1620 hrs.
MEASUREMENT END TIME: 1632 hrs.

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB	1.60	0.02	0.00			0.000	0.20	0.000
1	2.00	0.02	0.10			-0.020	0.45	-0.001
2	2.50	0.02	0.15			0.000	0.50	0.000
3	3.00	0.02	0.27			0.020	0.50	0.002
4	3.50	0.02	0.26			0.350	0.50	0.042
5	4.00	0.02	0.47			0.110	0.50	0.024
6	4.50	0.02	0.50			0.350	0.50	0.081
7	5.00	0.02	0.44			0.320	0.50	0.065
8	5.50	0.02	0.27			0.330	0.50	0.041
9	6.00	0.02	0.32			0.270	0.50	0.040
10	6.50	0.02	0.34			0.100	0.50	0.016
11	7.00	0.02	0.20			0.240	0.50	0.022
12	7.50	0.02	0.42			0.160	0.50	0.031
13	8.00	0.02	0.45			0.100	0.50	0.021
14	8.50	0.02	0.30			0.030	0.50	0.004
15	9.00	0.02	0.14			-0.010	0.45	-0.001
RDB	9.40	0.02	0.00			0.000	0.20	0.000
								0.386

Notes:
1. Water elevation 96.970m (1635 hrs)
2. TSS collected
3. Instruments were removed for the season
4. Ice covered across creek

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake **MEASUREMENT DATE: 14 Jan 2002**
COORDINATES: 6371950N/483430E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								0.000
1								0.000
RDB								0.000
								0.000

Note: 1. Water elevation 294.417m; top of ice elevation 294.417m; ice thickness 29cm (1133 hrs); no flow detected

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake **MEASUREMENT DATE: 28 Apr 2002**
COORDINATES: 6371950N/483430E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 294.437m (1206 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake **MEASUREMENT DATE: 16 May 2002**
COORDINATES: 6371950N/483430E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*****

Note: 1. Water elevation 294.429m (1504 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake **MEASUREMENT DATE: 10 Jun 2002**
COORDINATES: 6371950N/483430E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Notes: 1. Water elevation 294.392m (1030 hrs)
2. Installed telemetry and removed temporary logger from Suncor

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake **MEASUREMENT DATE: 10 Jul 2002**
COORDINATES: 6371950N/483430E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 294.319m (1520 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake **MEASUREMENT DATE: 09 Aug 2002**
COORDINATES: 6371950N/483430E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Notes: 1. Water elevation 294.420m (1300 hrs)
2. Old logger 276 was removed and replaced with logger 607

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L1
STREAM NAME: McClelland Lake
COORDINATES: 6371950N/483430E
MEASUREMENT DATE: 12 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Notes: 1. Water elevation 294.454m (1350 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 11 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.147m; top of ice elevation 332.147m; ice thickness 31.2cm (1248 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 07 Feb 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.104m; top of ice elevation 332.107m; ice thickness 38cm (1143 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 13 Mar 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.058m; top of ice elevation 332.058m; ice thickness 47cm (1322 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake **MEASUREMENT DATE: 08 Apr 2002**
COORDINATES: 6351050N/485250E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.096m; top of ice elevation 332.175m (1106 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake **MEASUREMENT DATE: 15 May 2002**
COORDINATES: 6351050N/485250E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 331.865m (1304 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7030
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake **MEASUREMENT DATE: 09 Jun 2002**
COORDINATES: 6351050N/485250E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 331.848m (1542 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 11 Jul 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 331.823m (1340 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 11 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.247m (1025 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 13 Sep 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.271m (1516 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 25 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.197m; top of ice elevation 332.219m (1039 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 03 Dec 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.092m; top of ice elevation 332.116m; ice thickness 28cm (1257 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L2
STREAM NAME: Kearl Lake
COORDINATES: 6351050N/485250E
MEASUREMENT DATE: 07 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:
MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 332.044m; top of ice elevation 332.057m; ice thickness 40cm (1322 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L3
STREAM NAME: Isadore's Lake
COORDINATES: 6343250N/463400E

MEASUREMENT DATE: 11 Jan 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 233.745m; top of ice elevation 233.767m; ice thickness 32cm (1543 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L3
STREAM NAME: Isadore's Lake
COORDINATES: 6343250N/463400E

MEASUREMENT DATE: 08 Aug 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 233.792m (1150 hrs)
2. Installed new BM (Rebar) ; elevation 234.506m

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L3
STREAM NAME: Isadore's Lake
COORDINATES: 6343250N/463400E

MEASUREMENT DATE: 27 Oct 2002
METER NUMBER: Marsh-McBirney Flo-Mate 2000

MEASUREMENT BY:
COMPUTATIONS BY:

MEASUREMENT START TIME:
MEASUREMENT END TIME:

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	VELOCITY 0.8 Depth (m/sec)	VELOCITY 0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 233.735m; top of ice elevation 233.763m (1023 hrs)
2. Transducer 971024-8psi not working (was pulled out)
3. Reinstalled Solinst logger

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7050
DISCHARGE DATA

LOCATION: L3
STREAM NAME: Isadore's Lake **MEASUREMENT DATE: 29 Oct 2002**
COORDINATES: 6343250N/463400E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	0.8 Depth (m/sec)	0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 233.786m; top of ice elevation 233.820m (1210 hrs)

PROJECT NAME: RAMP/Climate & Hydrology/Ft. McMurray
PROJECT NO.: 022-2301-7010
DISCHARGE DATA

LOCATION: L3
STREAM NAME: Isadore's Lake **MEASUREMENT DATE: 08 Jan 2003**
COORDINATES: 6343250N/463400E **METER NUMBER: Marsh-McBirney Flo-Mate 2000**

MEASUREMENT BY: **MEASUREMENT START TIME:**
COMPUTATIONS BY: **MEASUREMENT END TIME:**

STATION	DISTANCE FROM LDB (m)	ICE THICKNESS (m)	DEPTH (m)	VELOCITY 0.2 Depth (m/sec)	0.8 Depth (m/sec)	0.6 Depth (m/sec)	WIDTH (m)	DISCHARGE (m^3/sec)
LDB								*
1								*
RDB								*
								*

Note: 1. Water elevation 233.687m; top of ice elevation 233.687m (0937 hrs)
2. Downloaded data for end of year 2002

APPENDIX VI

2002 STAGE-DISCHARGE RATING CURVES

Figure VI.1 Stage-Discharge Rating Curve for RAMP Station S1

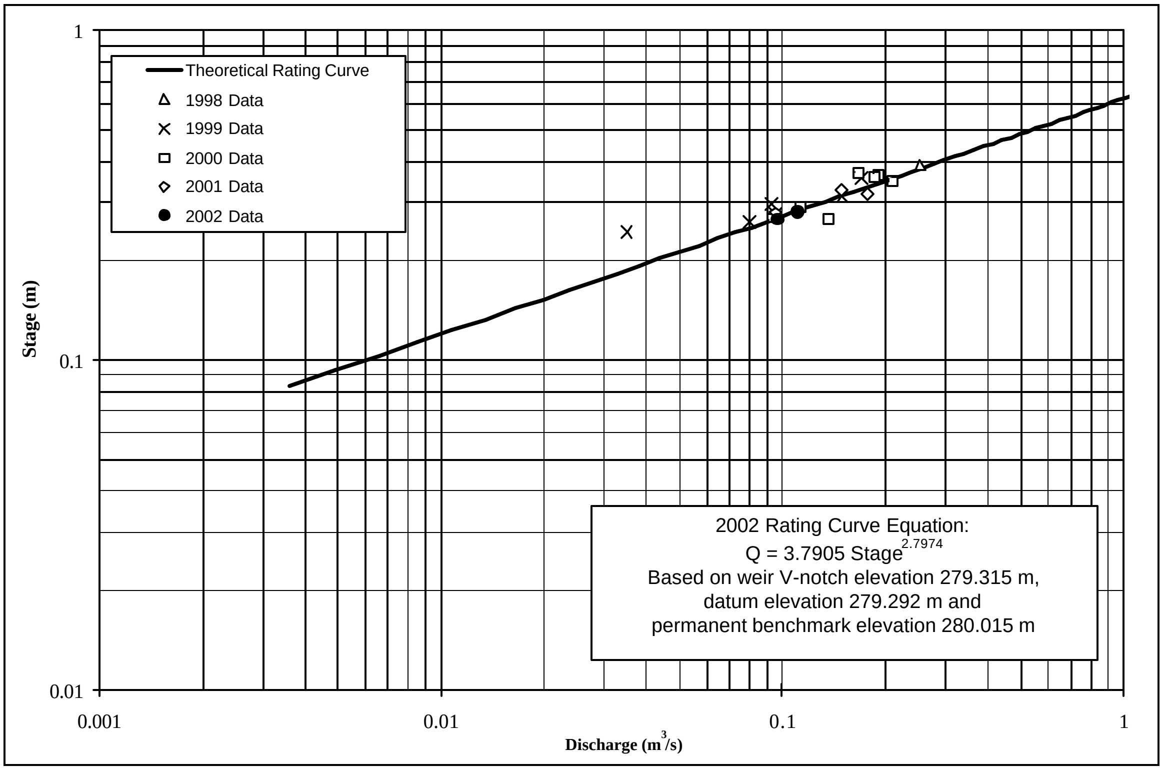


Table VI.1 Stage-Discharge Data for RAMP Station S1

Year	Date	Stage (m)	Discharge (m^3/s)
1998	26-Oct	0.388	0.253
1999	7-Apr	0.358	0.17
	29-Apr	0.316	0.15
	4-Jun	0.2785	0.096
	23-Jul	0.262	0.08
	13-Sep	0.245	0.035
	26-Oct	0.298	0.093
2000	2-Apr	0.271	0.135
	14-Jun	0.367	0.191
	2-Jul	0.371	0.166
	14-Aug	0.359	0.186
	11-Sep	0.351	0.209
	17-Oct	0.271	0.093
	8-Nov	0.292	0.113
2001	16-Jan	0.279	0.095
	20-Apr	0.319	0.178
	15-May	0.327	0.149
2002	11-Jan	0.282	0.111
	24-Apr	0.267	0.097

Figure VI.2 Stage-Discharge Rating Curve for RAMP Station S2

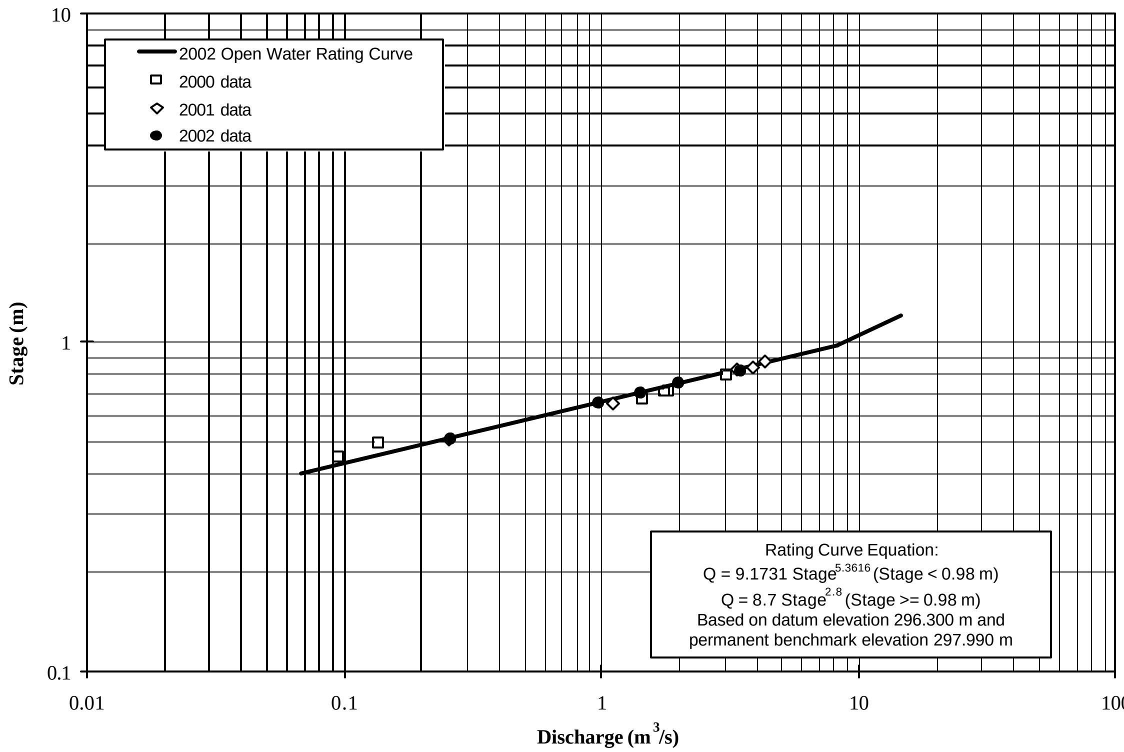


Table VI.2 Stage-Discharge Data for RAMP Station S2

Year	Date	Stage (m)	Discharge (m^3/s)
2000	20-Apr	0.448	0.096
	16-May	0.493	0.137
	14-Jun	0.672	1.450
	25-Jun	1.085	8.000
	14-Aug	0.705	1.84
	12-Sep	0.796	3.069
	17-Oct	0.703	1.754
2001	11-May	0.877	4.320
	12-Jun	0.838	3.882
	8-Jul	0.822	3.363
	6-Aug	0.651	1.113
	27-Oct	0.509	0.256
2002	14-May	0.507	0.258
	11-Jun	0.654	0.974
	11-Jul	0.749	1.990
	13-Sep	0.812	3.464
	25-Oct	0.700	1.416

Figure VI.3 Stage-Discharge Rating Curve for RAMP Station S3

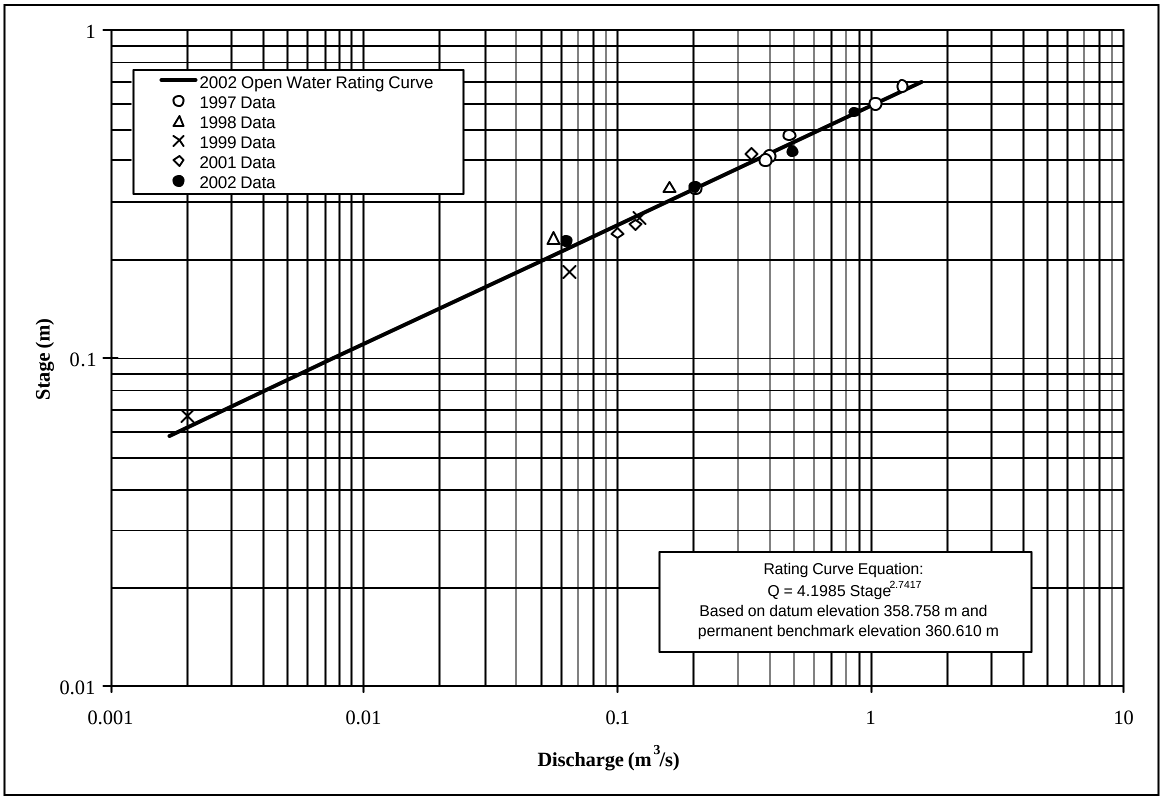


Table VI.3 Stage-Discharge Data for RAMP Station S3

Year	Date	Stage (m)	Discharge (m^3/s)
1997	8-May	0.479	0.478
	3-Jun	0.412	0.4
	21-Jun	0.329	0.204
	20-Aug	0.675	1.338
	3-Oct	0.598	1.05
	24-Oct	0.401	0.386
1998	17-May	0.333	0.162
	27-Jul	0.233	0.056
1999	5-Jun	0.268	0.122
	24-Jul	0.182	0.065
	14-Sep	0.067	0.002
2001	12-Jun	0.421	0.342
	10-Jul	0.255	0.118
	25-Oct	0.241	0.1
2002	10-Jun	0.228	0.063
	9-Aug	0.563	0.864
	12-Sep	0.426	0.493
	26-Oct	0.335	0.203

Figure VI.4 Stage-Discharge Rating Curve for RAMP Station S4

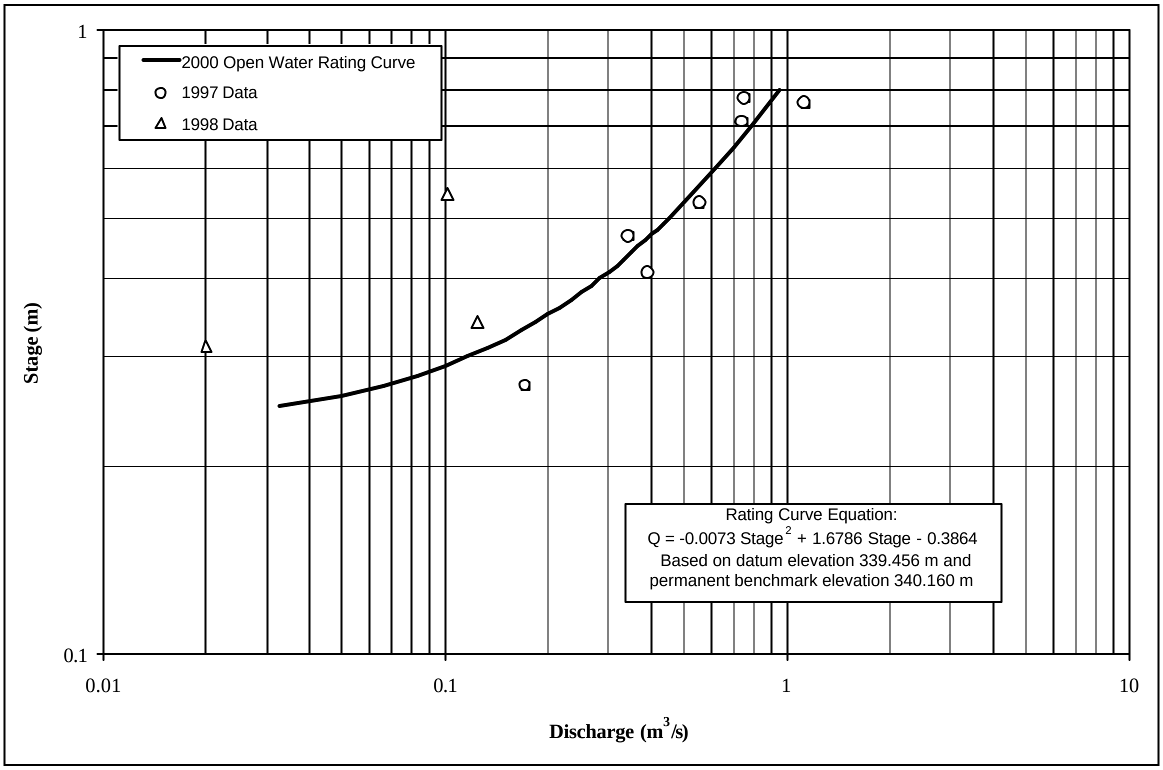


Table VI.4 Stage-Discharge Data for RAMP Station S4

Year	Date	Stage (m)	Discharge (m^3/s)
1997	25-Apr	0.780	0.750
	8-May	0.529	0.553
	3-Jun	0.409	0.390
	23-Jul	0.270	0.171
	20-Aug	0.765	1.121
	3-Oct	0.715	0.737
	24-Oct	0.469	0.342
1998	17-May	0.341	0.124
	27-Jul	0.312	0.020

Figure VI.5 Stage-Discharge Rating Curve for RAMP Station S5A

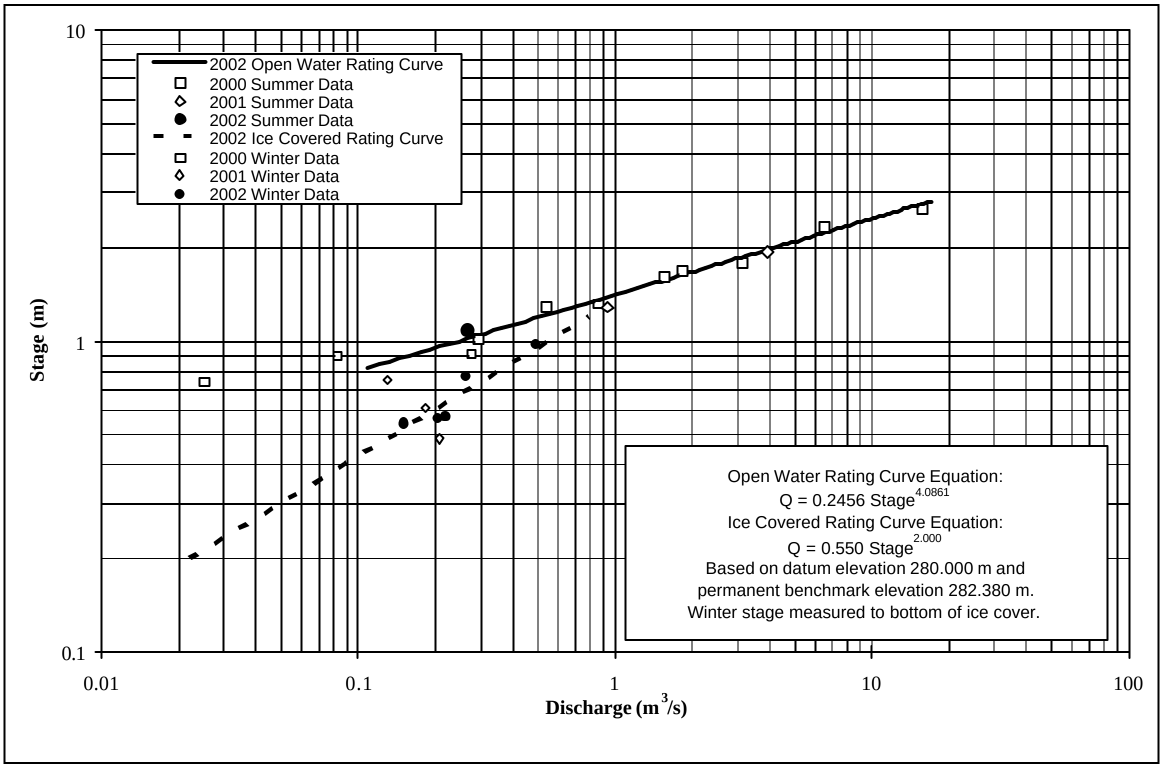


Table VI.5 Stage-Discharge Data for RAMP Station S5A

Year	Date	Stage (m)	Discharge (m^3/s)
Open-Water Data			
2000	20-Apr-00	1.301	0.537
	14-Jun-00	1.790	3.124
	14-Aug-00	1.324	0.854
	12-Sep-00	1.691	1.823
	17-Oct-00	1.625	1.554
	30-May-00	2.340	6.458
	28-Jun-00	2.660	15.750
2001	13-Jun-01	1.947	3.932
	7-Aug-01	1.287	0.930
2002	14-May-02	1.080	0.266
Ice-Covered Data			
2000	3-Jan-00	1.021	0.292
	11-Jan-00	0.909	0.276
	21-Feb-00	0.746	0.025
	19-Dec-00	0.902	0.082
2001	17-Jan-01	0.607	0.182
	16-Feb-01	0.485	0.208
	5-Dec-01	0.752	0.129
2002	12-Jan-02	0.571	0.217
	8-Feb-02	0.564	0.204
	15-Mar-02	0.545	0.151
	28-Nov-02	0.975	0.491
2003	1-Jan-03	0.776	0.263

Figure VI.6 Stage-Discharge Rating Curve for RAMP Station S6

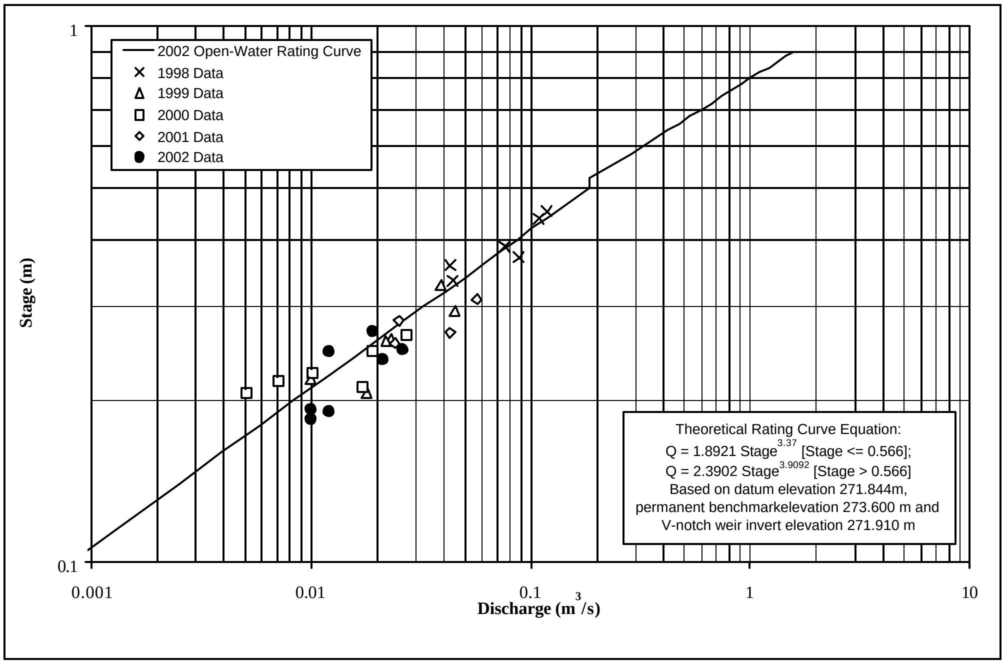


Table VI.6 Stage-Discharge Data for RAMP Station S6

Year	Date	Stage (m)	Discharge (m^3/s)
1998	29-Mar	0.370	0.088
	13-Apr	0.452	0.119
	20-Apr	0.438	0.109
	18-May	0.388	0.076
	24-Jul	0.358	0.043
	26-Oct	0.336	0.044
1999	8-Apr	0.330	0.039
	29-Apr	0.293	0.045
	4-Jun	0.262	0.023
	6-Jul	0.258	0.022
	23-Jul	0.208	0.018
	14-Sep	0.220	0.01
2000	2-Apr	0.267	0.027
	20-Apr	0.208	0.005
	17-May	0.248	0.019
	2-Jul	0.219	0.007
	14-Aug	0.226	0.01
	12-Sep	0.213	0.017
2001	20-Apr	0.217	0.024
	11-May	0.244	0.025
	13-Jun	0.271	0.057
	8-Jul	0.229	0.043
2002	9-Apr	0.185	0.010
	23-Apr	0.191	0.012
	14-May	0.193	0.010
	9-Jun	0.249	0.026
	8-Jul	0.270	0.019
	10-Aug	0.247	0.012
	21-Oct	0.239	0.021

Figure VI.7 Stage-Discharge Rating Curve for RAMP Station S7

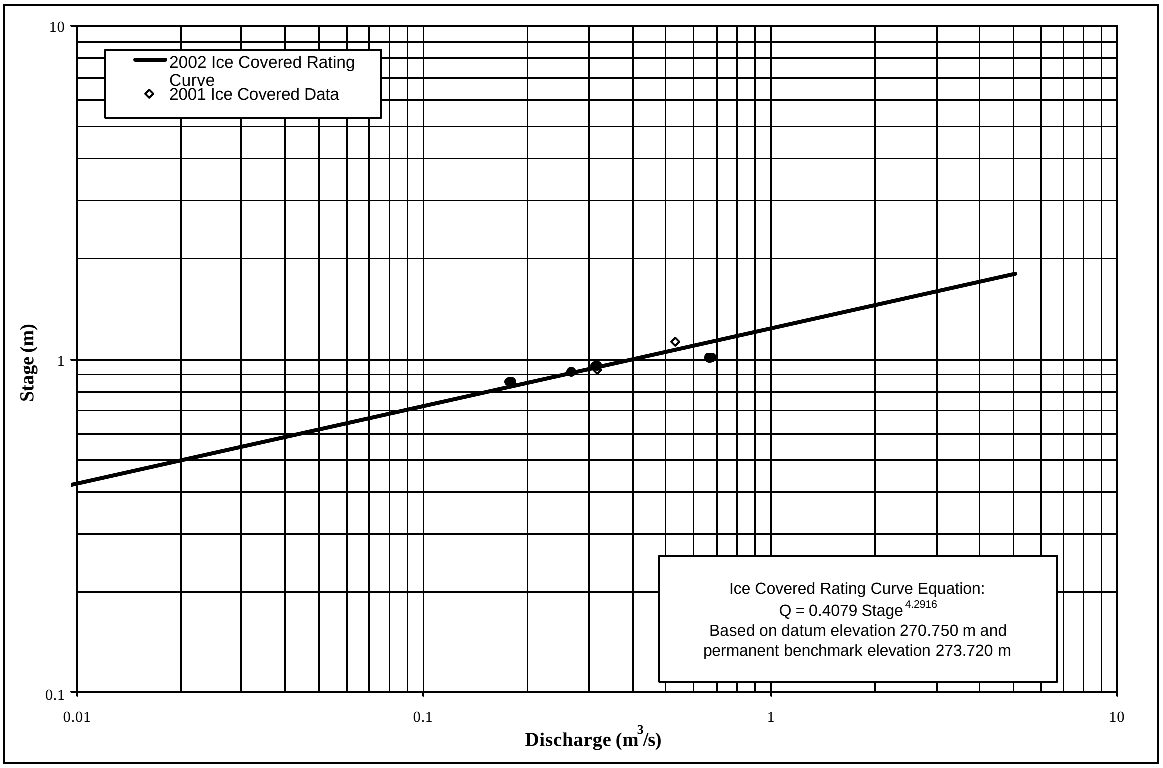


Table VI.7 Stage-Discharge Data for RAMP Station S7

Year	Date	Stage (m)	Discharge (m^3/s)
2001	6-Dec	1.129	0.533
2002	10-Jan	0.932	0.318
	5-Feb	0.850	0.178
	15-Mar	0.918	0.267
	8-Apr	0.953	0.315
2003	7-Jan	1.013	0.670

Figure VI.8 Stage-Discharge Rating Curve for RAMP Station S9

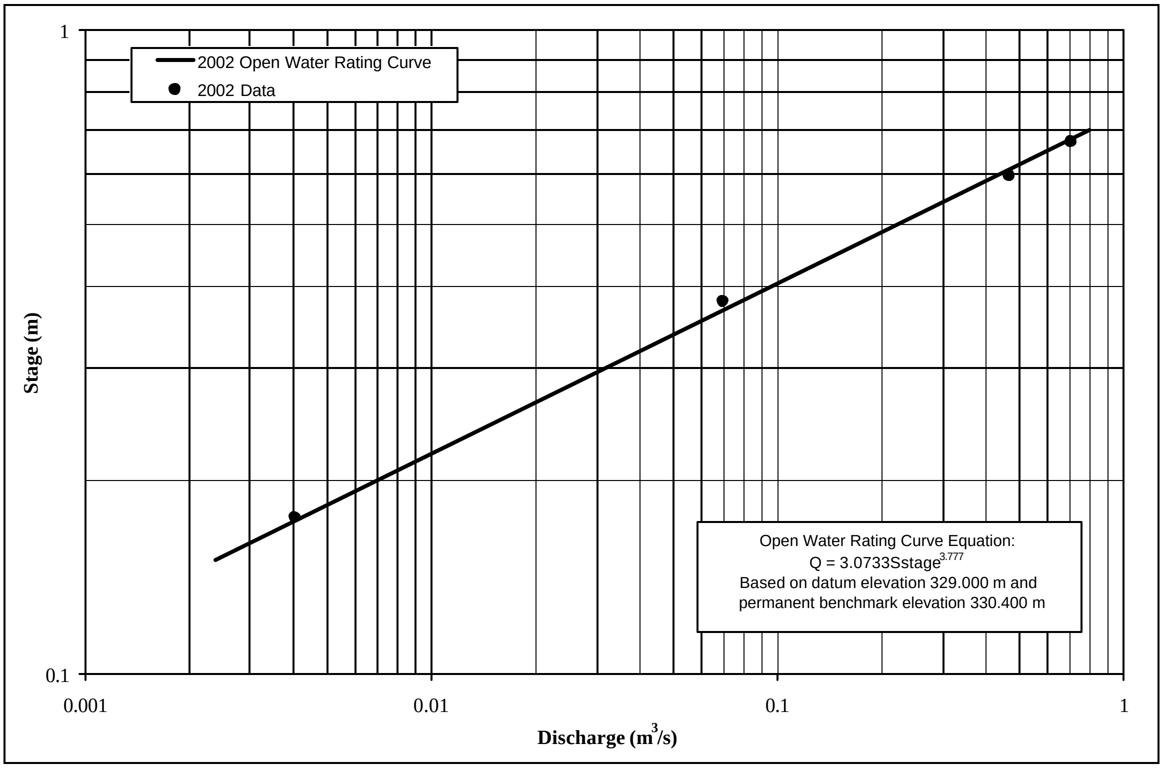


Table VI.8 Stage-Discharge Data for RAMP Station S9

Year	Date	Stage (m)	Discharge (m^3/s)
2002	15-May	0.381	0.069
	11-Jul	0.176	0.004
	13-Sep	0.672	0.701
	25-Oct	0.596	0.467

Note: Pre-2002 data discarded due to very low flows at Kearl Lake Outlet

Figure VI.9 Stage-Discharge Rating Curve for RAMP Station S10

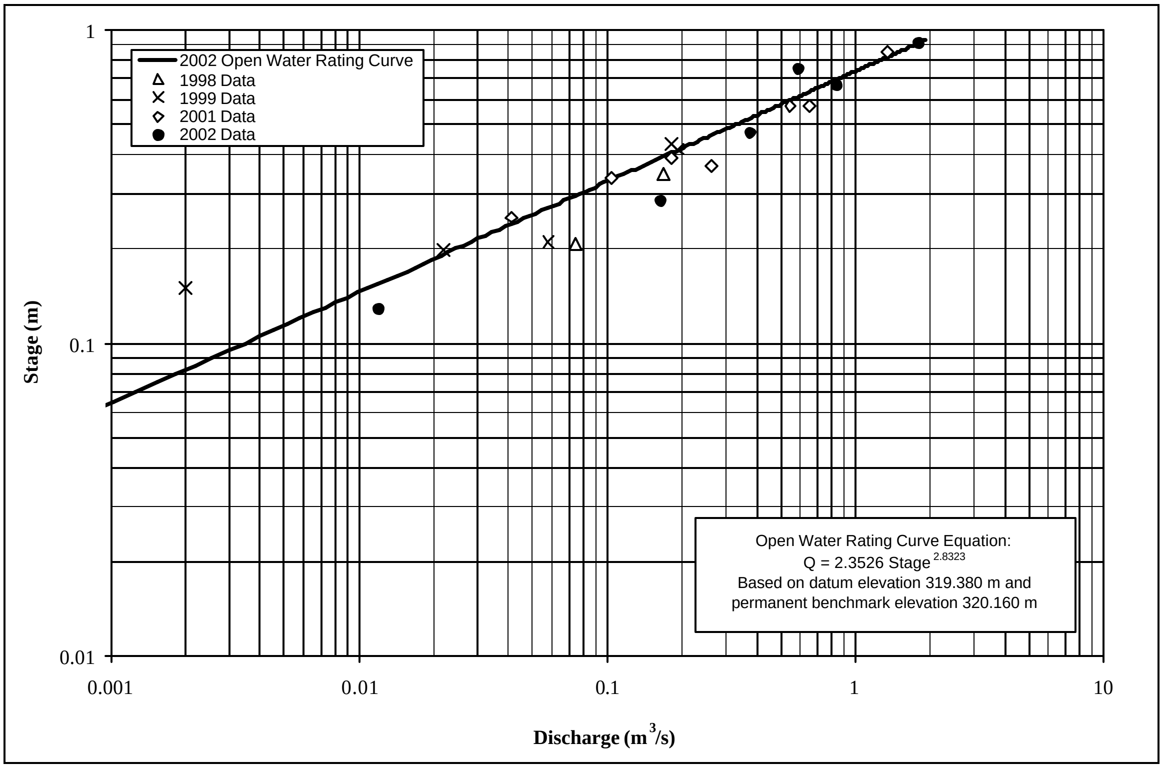


Table VI.9 Stage-Discharge Data for RAMP Station S10

Year	Date	Stage (m)	Discharge (m^3/s)
1998	24-Jun	0.207	0.075
	25-Jul	0.348	0.168
	15-Sep	0.008	0.0001
	26-Oct	0.004	0.0001
1999	4-Jun	0.434	0.181
	5-Jul	0.417	0.192
	23-Jul	0.212	0.058
	13-Sep	0.150	0.002
	26-Oct	0.200	0.022
2001	20-Apr	0.369	0.265
	11-May	0.847	1.351
	10-Jun	0.576	0.548
	8-Jul	0.574	0.650
	6-Aug	0.388	0.181
	19-Sep	0.337	0.104
	27-Oct	0.253	0.041
2002	15-May	0.129	0.012
	9-Jun	0.286	0.165
	11-Jul	0.756	0.587
	11-Aug	0.909	1.812
	13-Sep	0.665	0.845
	25-Oct	0.472	0.375

Figure VI.10 Stage-Discharge Rating Curve for RAMP Station S11

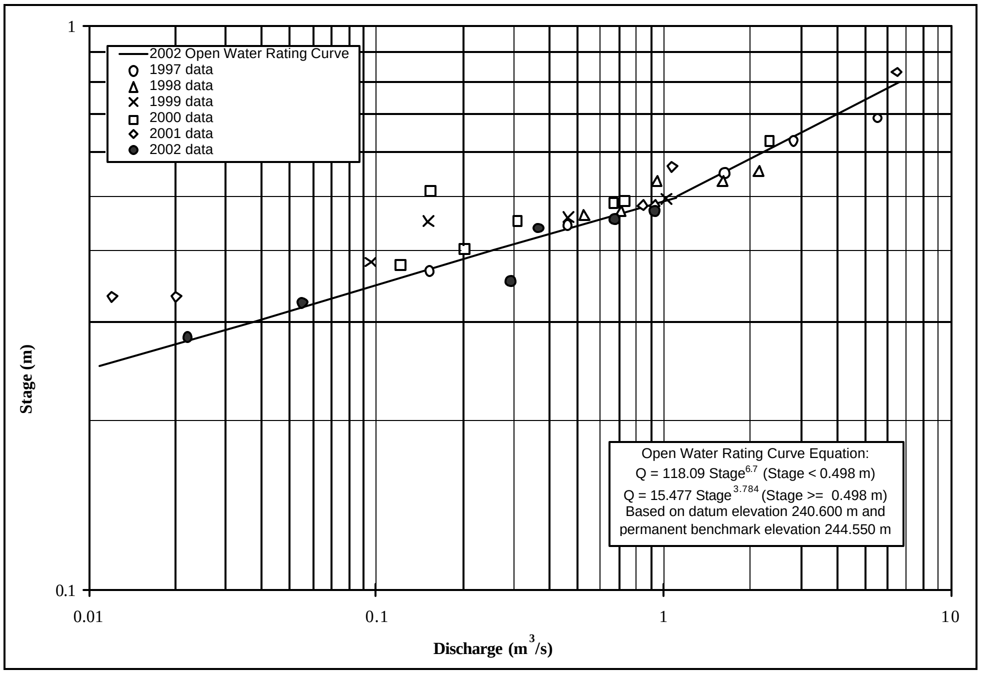


Table VI.10 Stage-Discharge Data for RAMP Station S11

Year	Date	Stage (m)	Discharge (m^3/s)
1997	21-Jun	0.548	1.638
	23-Jul	0.368	0.153
	20-Aug	0.443	0.462
	23-Sep	0.688	5.549
	25-Oct	0.628	2.830
1998	13-Apr	0.552	2.148
	20-Apr	0.533	1.602
	20-May	0.471	0.709
	26-Jul	0.531	0.947
	26-Oct	0.463	0.530
1999	8-Apr	0.451	0.151
	29-Apr	0.382	0.096
	4-Jun	0.458	0.464
	24-Jul	0.495	1.020
2000	2-Apr	0.453	0.308
	20-Apr	0.405	0.201
	17-May	0.489	0.665
	14-Jun	0.492	0.725
	2-Jul	0.629	2.320
	15-Aug	0.511	0.154
	14-Sep	0.378	0.121
2001	24-Apr	0.564	1.072
	11-May	0.830	6.499
	13-Jun	0.481	0.845
	9-Jul	0.481	0.936
	12-Sep	0.332	0.012
	27-Oct	0.332	0.020
2002	23-Apr	0.439	0.366
	18-May	0.281	0.022
	13-Jun	0.353	0.294
	9-Jul	0.324	0.055
	11-Aug	0.471	0.93
	29-Oct	0.455	0.675

Figure VI.11 Stage-Discharge Rating Curve for RAMP Station S12

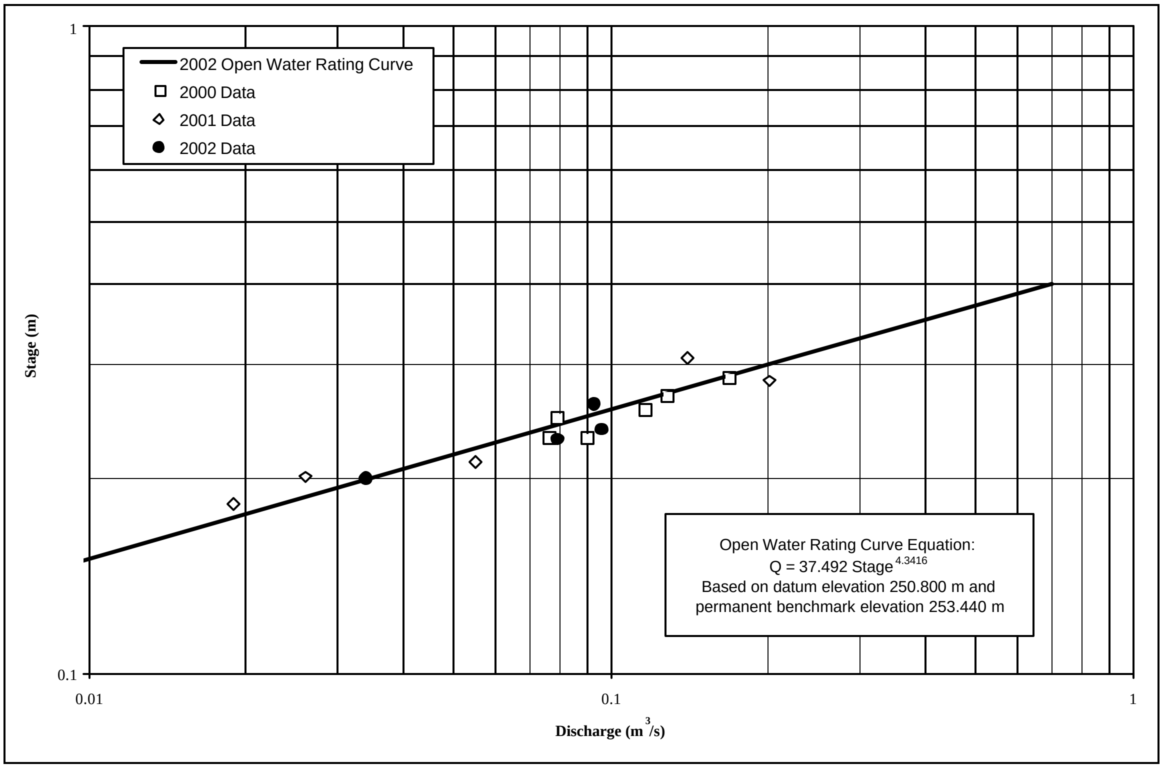


Table VI.11 Stage-Discharge Data for RAMP Station S12

Year	Date	Stage (m)	Discharge (m^3/s)
2000	14-Jun	0.287	0.168
	2-Apr	0.268	0.128
	3-Jul	0.256	0.116
	14-Aug	0.248	0.079
	13-Sep	0.232	0.076
	19-Oct	0.232	0.090
2001	11-May	0.307	0.140
	13-Jun	0.283	0.201
	9-Jul	0.212	0.055
	7-Aug	0.201	0.026
	10-Sep	0.182	0.019
2002	9-Jun	0.261	0.093
	8-Jul	0.230	0.079
	10-Aug	0.238	0.096
	23-Oct	0.200	0.034

Figure VI.12 Stage-Discharge Rating Curve for RAMP Station S13

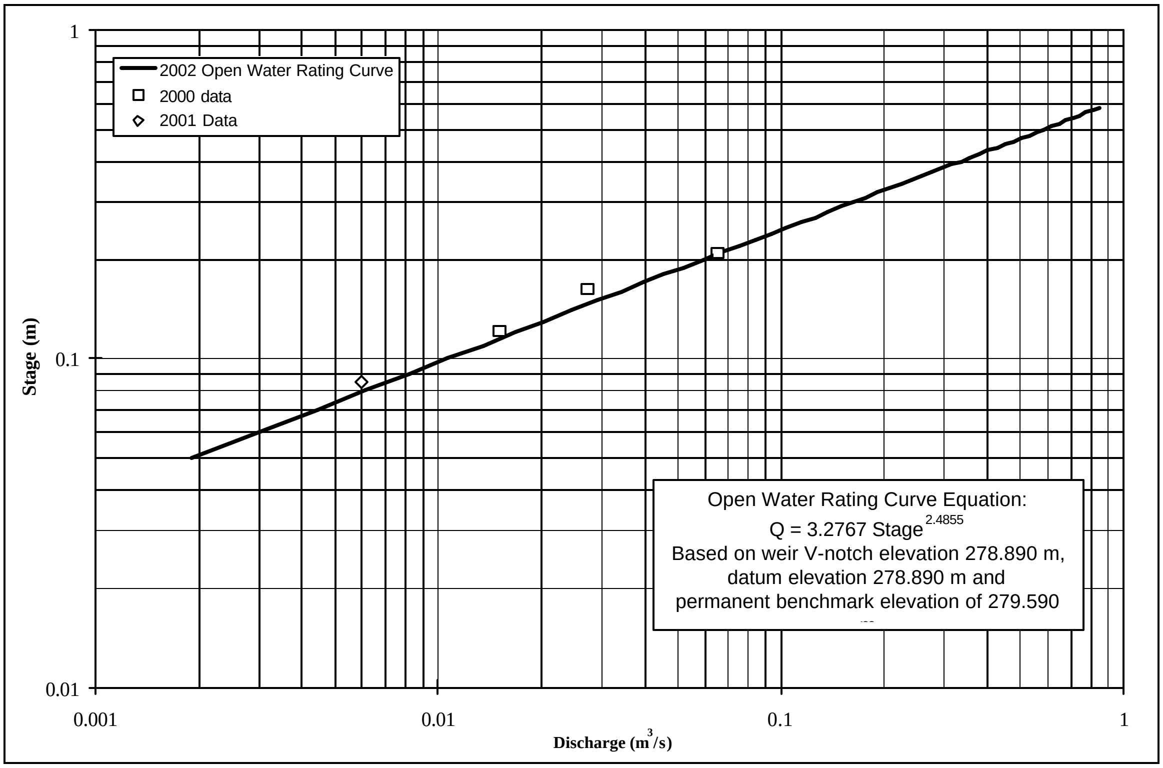


Table VI.12 Stage-Discharge Data for RAMP Station S13

Year	Date	Stage (m)	Discharge (m^3/s)
2000	14-Jun	0.065	0.211
	14-Aug	0.027	0.164
	11-Sep	0.015	0.122
2001	12-Sep	0.006	0.085

Figure VI.13 Stage-Discharge Rating Curve for RAMP Station S14

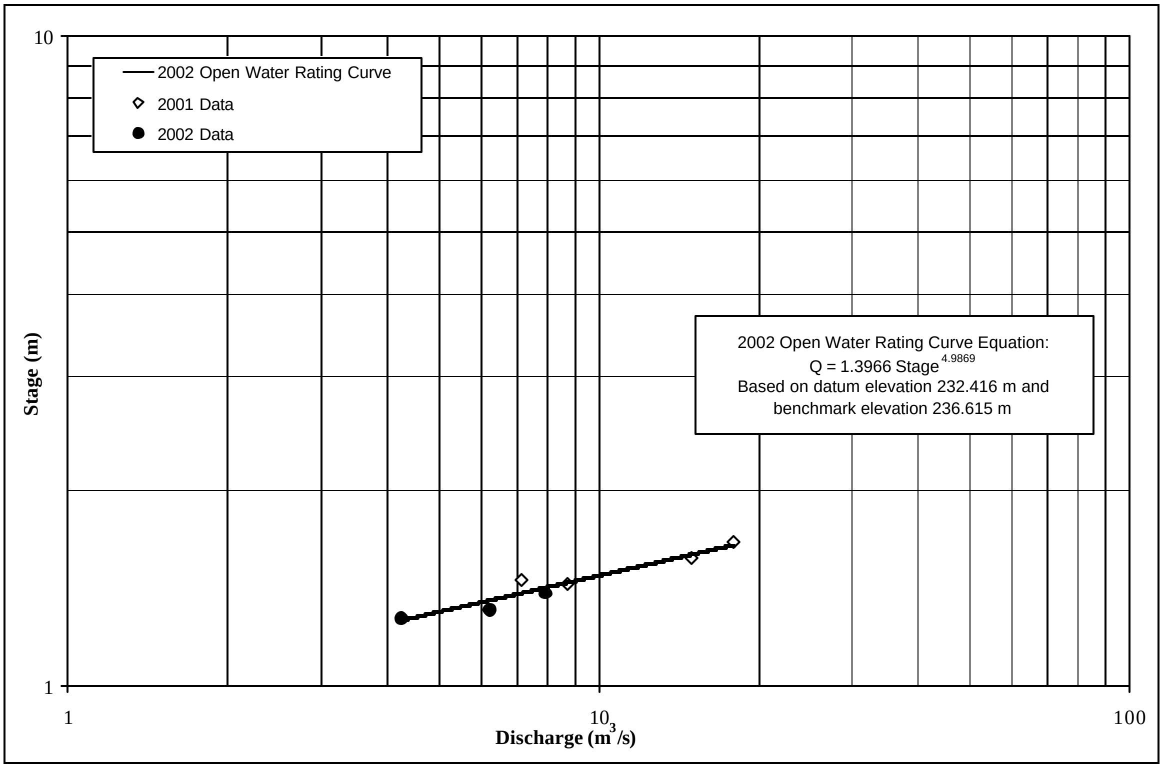


Table VI.13 Stage-Discharge Data for RAMP Station S14

Year	Date	Stage (m)	Discharge (m^3/s)
2001	13-May	1.666	17.916
	21-Jun	1.462	7.129
	9-Aug	1.581	14.889
	15-Sep	1.433	8.741
2002	16-May	1.313	6.234
	10-Jul	1.273	4.242
	12-Sep	1.391	7.924

Figure VI.14 Stage-Discharge Rating Curve for RAMP Station S15

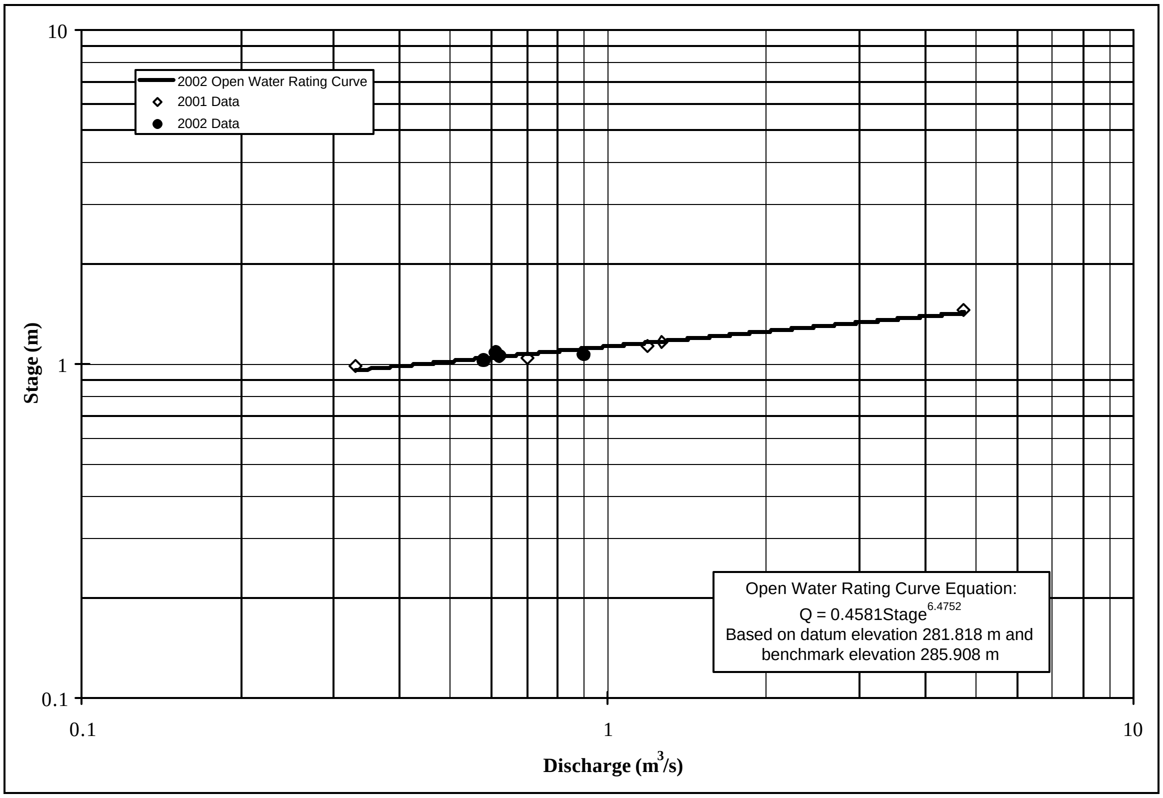


Table VI.14 Stage-Discharge Data for RAMP Station S15

Year	Date	Stage (m)	Discharge (m^3/s)
2001	9-May	1.457	4.754
	11-Jun	1.163	1.269
	8-Jul	1.046	0.704
	6-Aug	1.127	1.191
	11-Sep	0.990	0.330
2002	16-May	1.083	0.613
	8-Jul	1.025	0.58
	11-Aug	1.064	0.901
	12-Sep	1.057	0.621

Figure VI.15 Stage-Discharge Rating Curve for RAMP Station S16

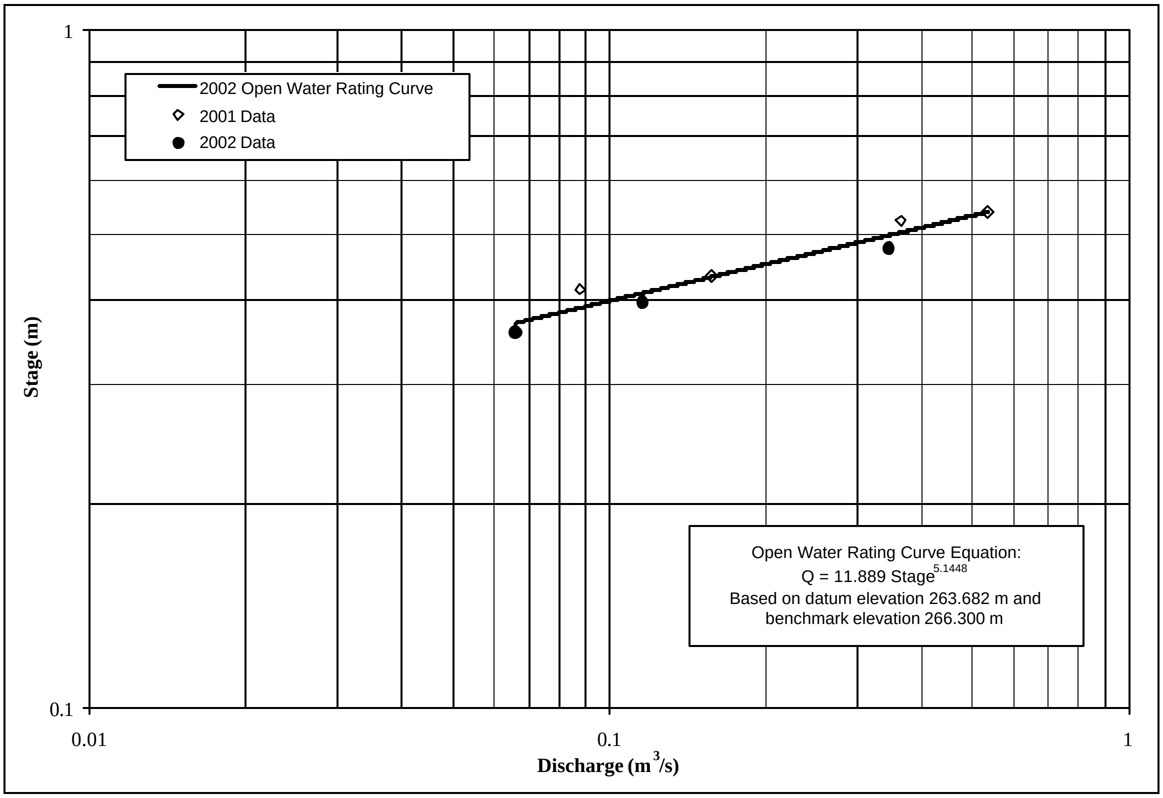


Table VI.15 Stage-Discharge Data for RAMP Station S16

Year	Date	Stage (m)	Discharge (m^3/s)
2001	11-Jun	0.540	0.536
	10-Jul	0.435	0.157
	9-Aug	0.523	0.364
	15-Sep	0.415	0.088
2002	16-May	0.358	0.066
	9-Aug	0.476	0.345
	12-Sep	0.396	0.116

Figure VI.16 Stage-Discharge Rating Curve for RAMP Station S17

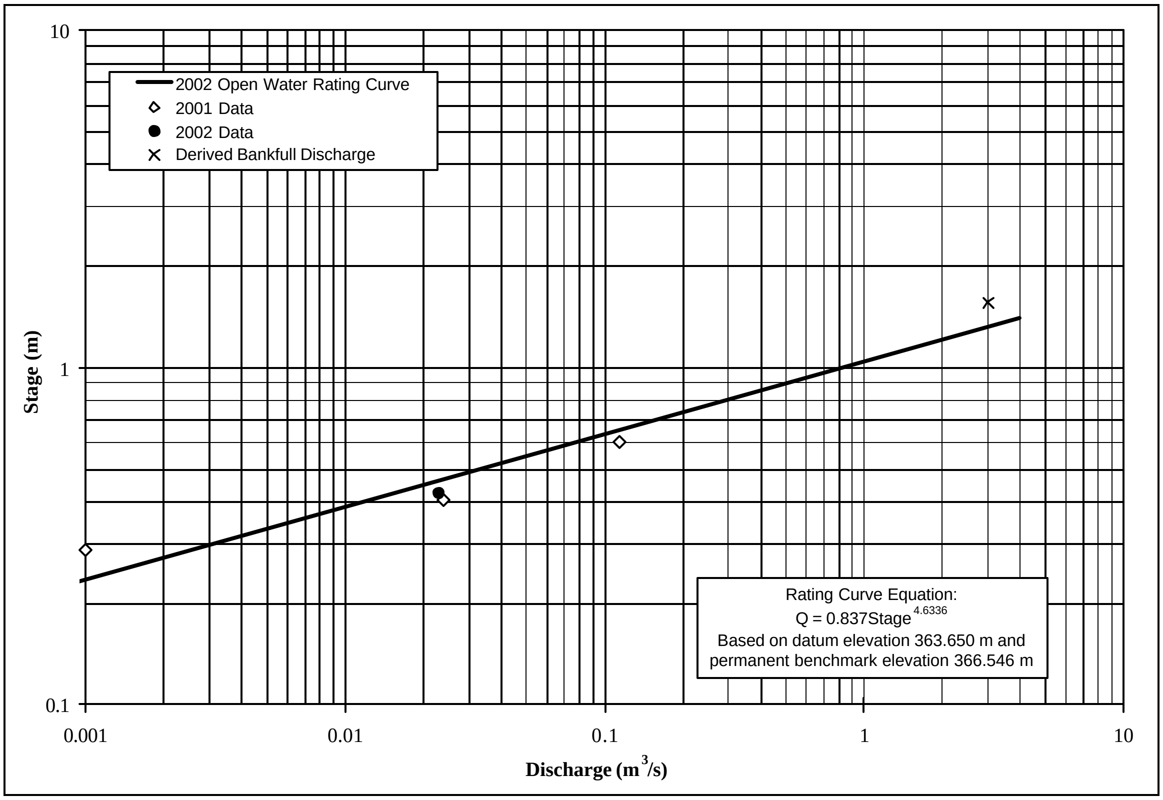


Table VI.16 Stage-Discharge Data for RAMP Station S17

Year	Date	Stage (m)	Discharge (m^3/s)
2001	12-May	0.604	0.114
	11-Jun	0.403	0.024
	9-Aug	0.288	0.001
2002	18-May	0.426	0.023
	Derived Bankfull	1.561	2.99

Figure VI.17 Stage-Discharge Rating Curve for RAMP Station S18A

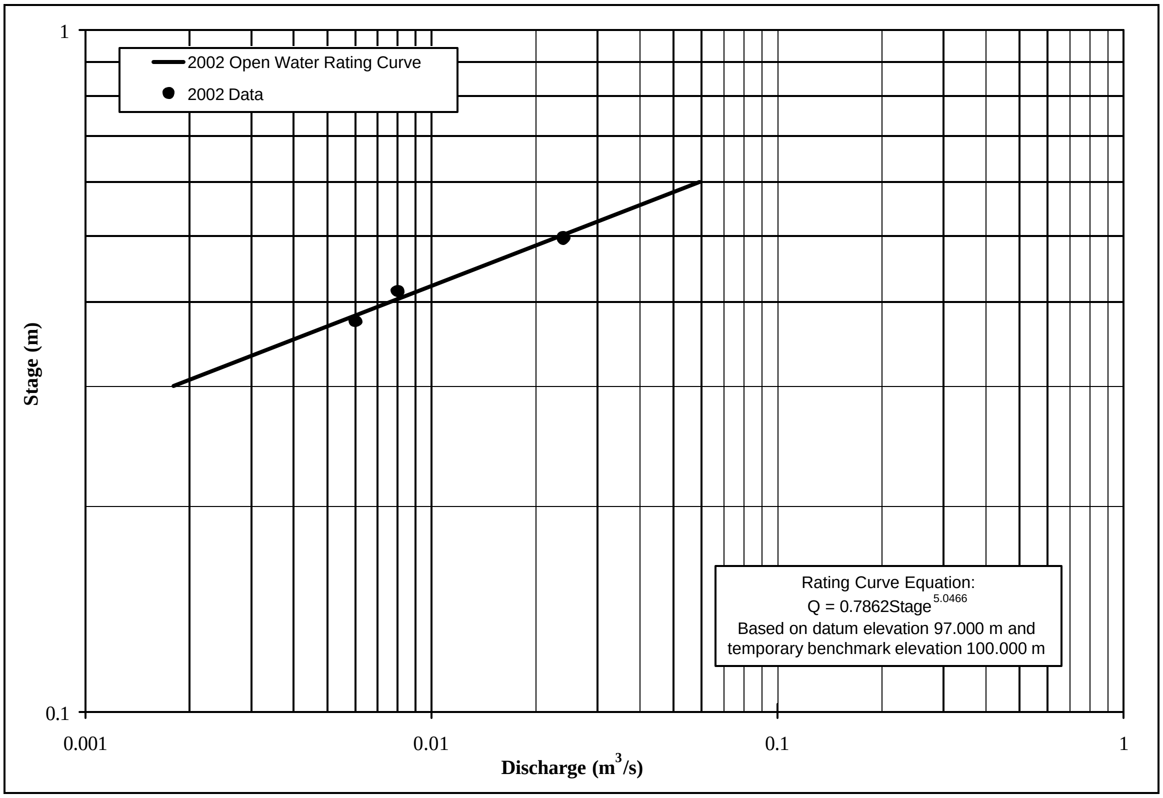


Table VI.17 Stage-Discharge Data for RAMP Station S18A

Year	Date	Stage (m)	Discharge (m^3/s)
2002	10-Jun	0.414	0.008
	10-Jul	0.374	0.006
	9-Aug	0.496	0.024

Figure VI.18 Stage-Discharge Rating Curve for RAMP Station S19

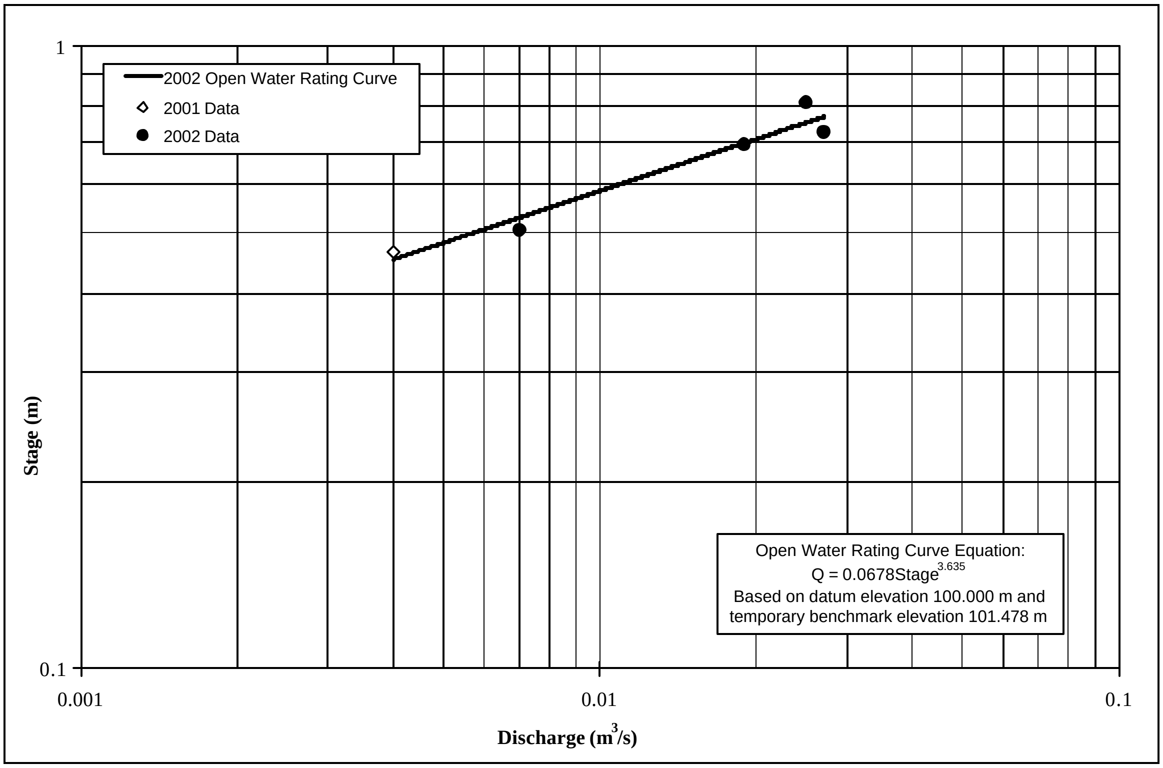


Table VI.18 Stage-Discharge Data for RAMP Station S19

Year	Date	Stage (m)	Discharge (m^3/s)
2001	11-Sep	0.467	0.004
2002	8-Jul	0.728	0.027
	10-Aug	0.810	0.025
	11-Sep	0.693	0.019
	21-Oct	0.506	0.007

Figure VI.19 Stage-Discharge Rating Curve for RAMP Station S20

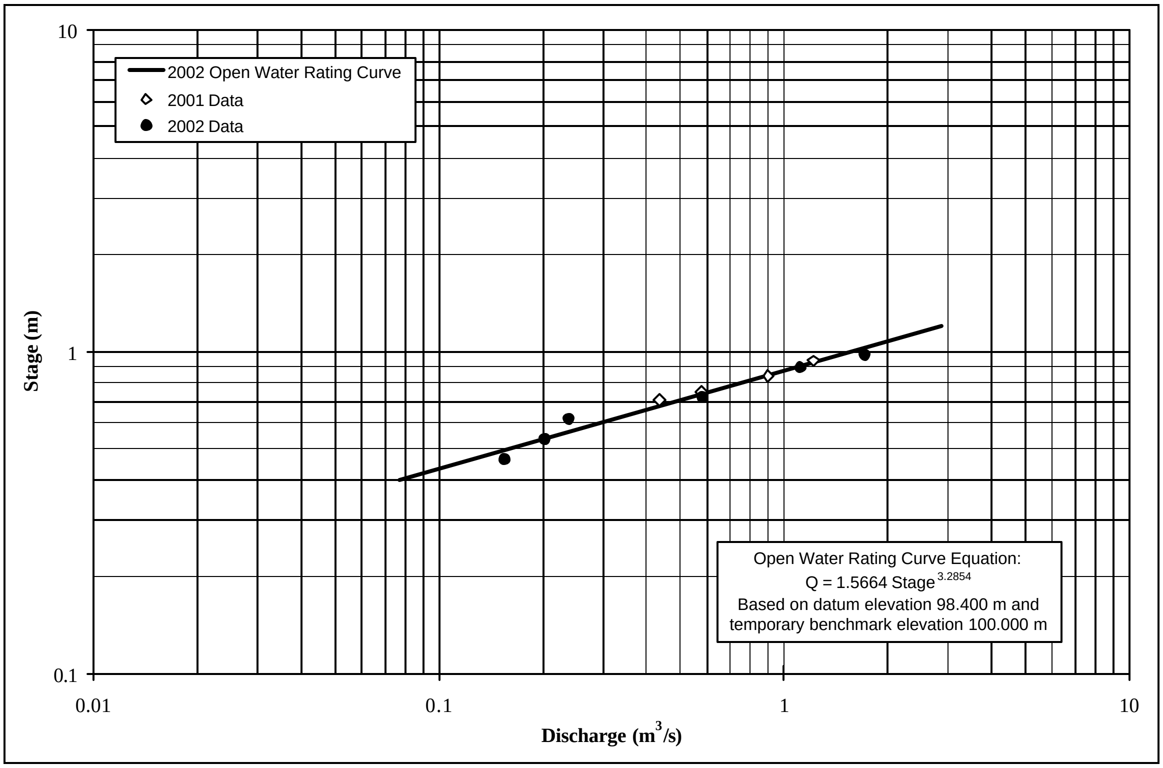


Table VI.19 Stage-Discharge Data for RAMP Station S20

Year	Date	Stage (m)	Discharge (m^3/s)
2001	8-May	0.936	1.218
	10-Jun	0.749	0.575
	8-Jul	0.838	0.904
	6-Aug	0.704	0.435
2002	25-Apr	0.536	0.203
	15-May	0.462	0.155
	9-Jun	0.620	0.239
	11-Jul	0.725	0.581
	11-Aug	0.981	1.723
	13-Sep	0.890	1.113

Figure VI.20 Stage-Discharge Rating Curve for RAMP Station S22

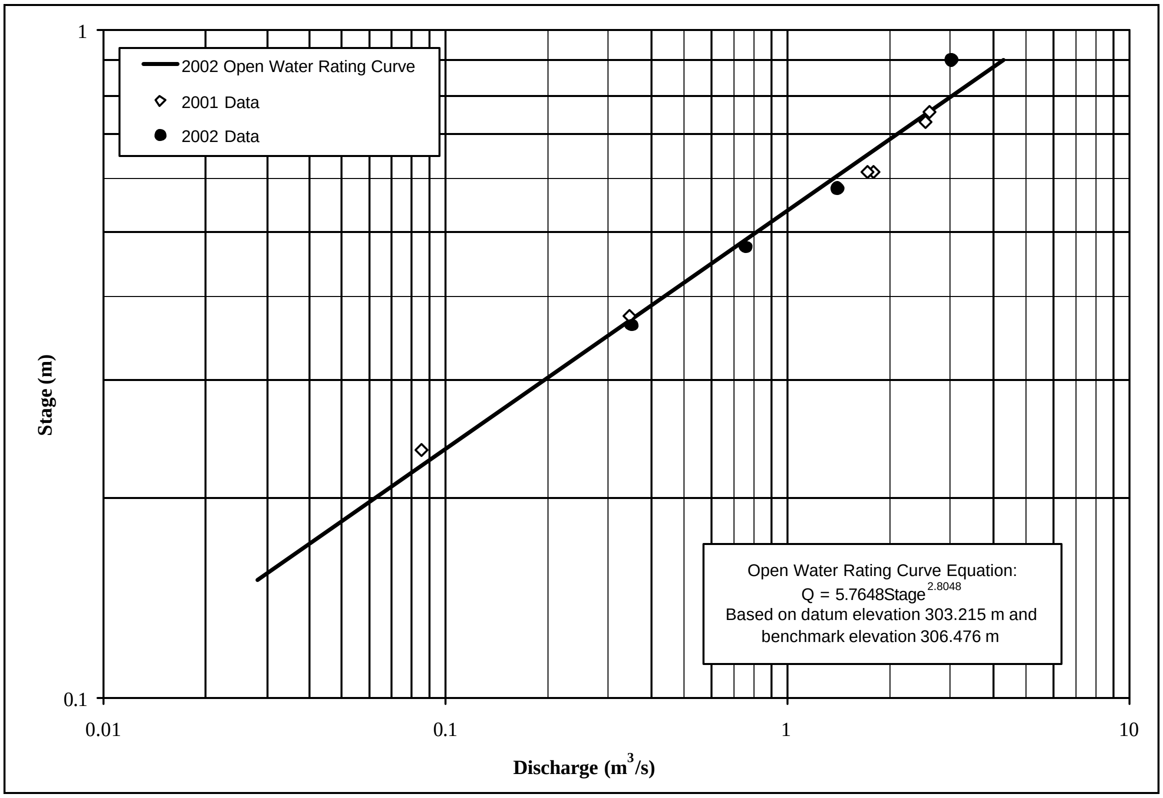


Table VI.20 Stage-Discharge Data for RAMP Station S22

Year	Date	Stage (m)	Discharge (m^3/s)
2001	8-May	0.754	2.623
	6-Jun	0.614	1.785
	12-Jun	0.728	2.542
	8-Jul	0.613	1.730
	10-Sep	0.373	0.346
	27-Oct	0.235	0.085
2002	9-Jun	0.362	0.352
	11-Jul	0.474	0.760
	13-Sep	0.903	3.019
	25-Oct	0.580	1.403

Figure VI.21 Stage-Discharge Rating Curve for RAMP Station S23

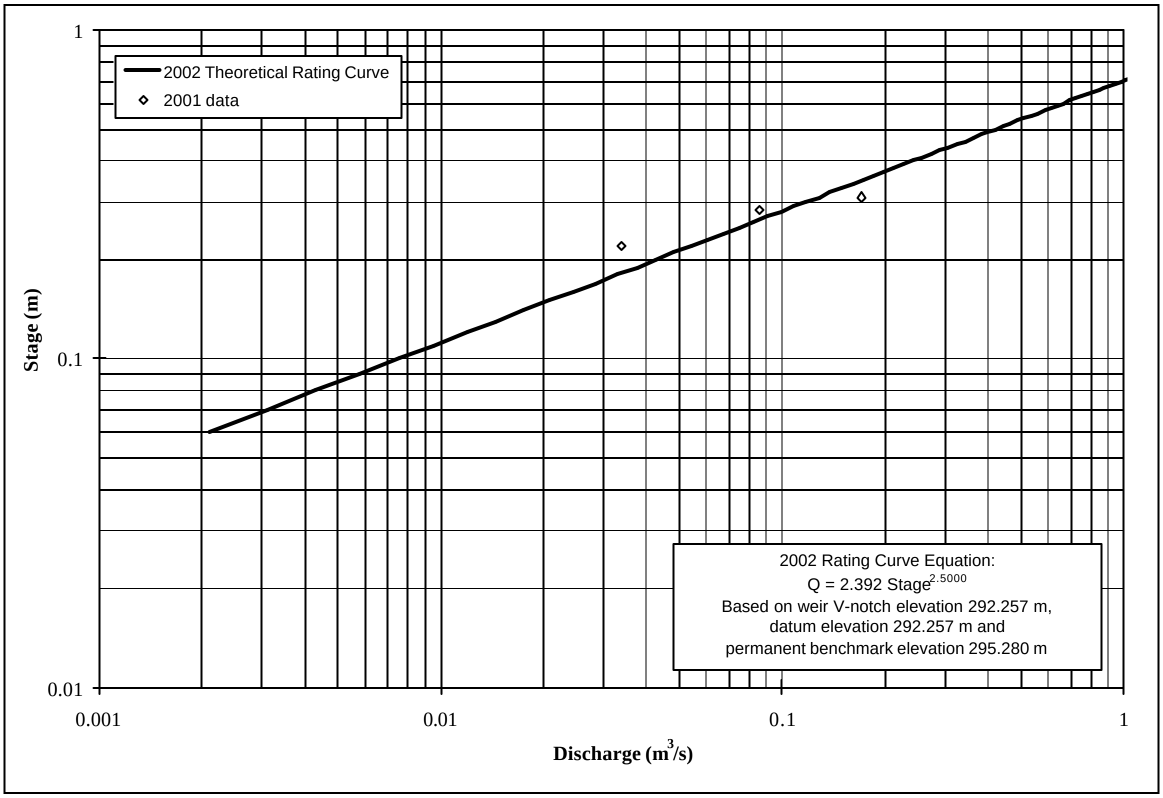


Table VI.21 Stage-Discharge Data for RAMP Station S23

Year	Date	Stage (m)	Discharge (m^3/s)
2001	18-Mar	0.220	0.034
	15-May	0.282	0.086
	13-Jun	0.310	0.170

Figure VI.22 Stage-Discharge Rating Curve for RAMP Station S24

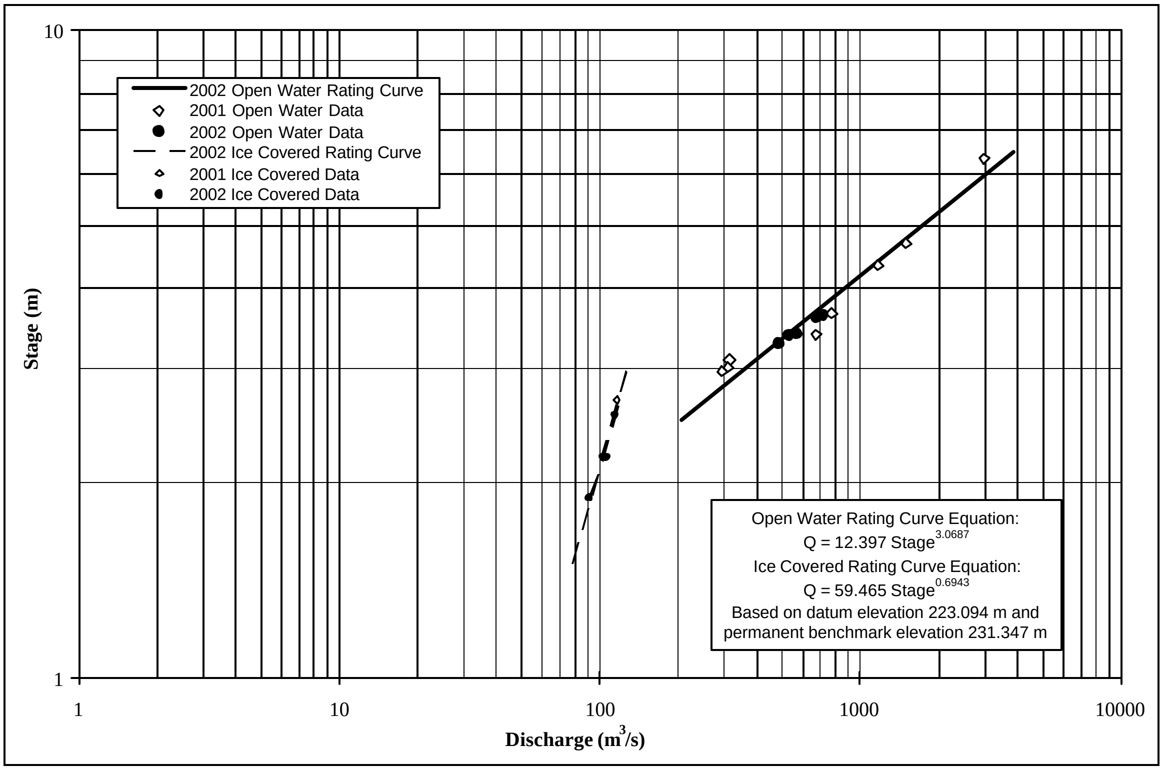


Table VI.22 Stage-Discharge Data for RAMP Station S24

Year	Date	Stage (m)	Discharge (m^3/s)
Open Water Data			
2001	20-Jun	3.649	774.6
	4-Jul	4.339	1168.6
	30-Jul	6.339	2980.0
	11-Aug	4.683	1496.9
	31-Aug	3.394	676.0
	12-Oct	3.096	314.3
	21-Oct	3.013	309.6
	27-Oct	2.976	294.3
2002	31-May	3.641	719.3
	15-Jun	3.397	567.7
	15-Jul	3.598	673.4
	15-Aug	3.281	482.1
	11-Sep	3.395	532.5
Ice Covered Data			
2001	18-Dec	2.682	116.0
2002	9-Jan	2.550	114.0
	5-Feb	2.194	103.2
	22-Mar	1.900	90.8

Figure VI.23 Stage-Discharge Rating Curve for RAMP Station S25

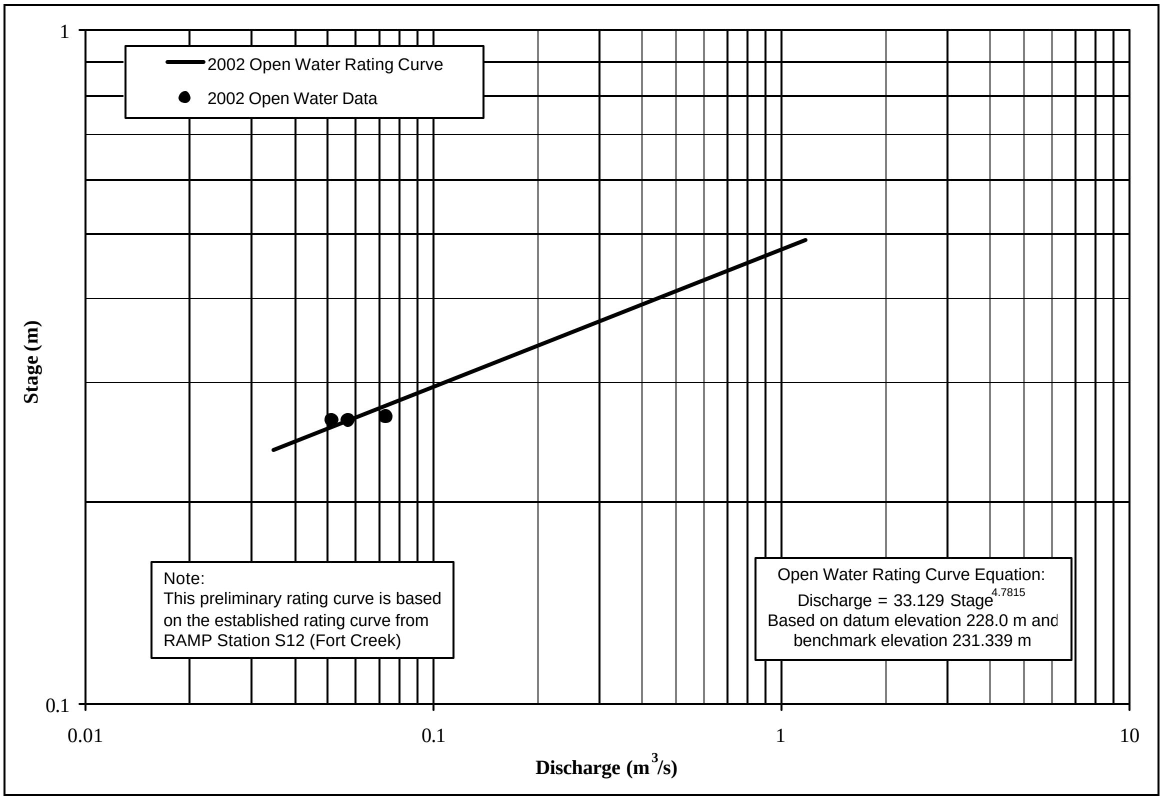


Table VI.23 Stage-Discharge Data for RAMP Station S25

Year	Date	Stage (m)	Discharge (m^3/s)
2002	11-Jun	0.264	0.057
	10-Aug	0.267	0.073
	11-Sep	0.264	0.051

Figure VI.24 Stage-Discharge Rating Curve for RAMP Station S26

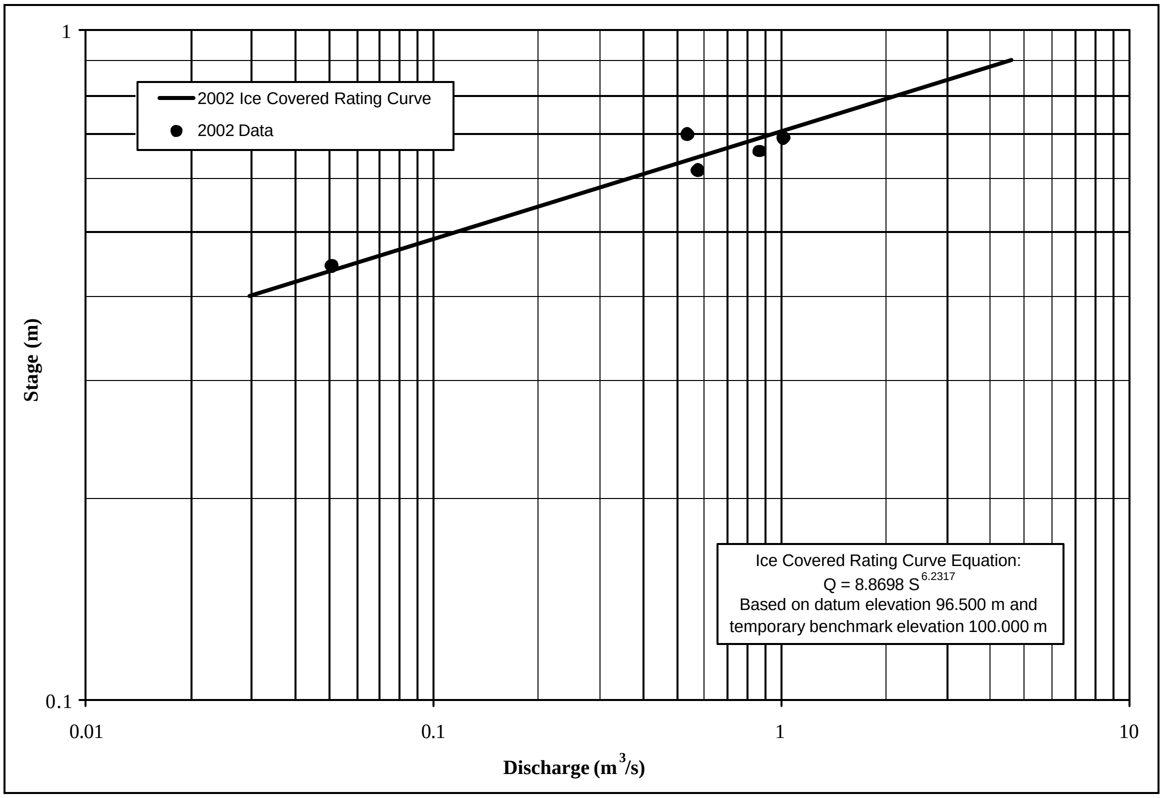


Table VI.24   Stage-Discharge Data for RAMP Station S26

Year	Date	Stage (m)	Discharge (m^3/s)
2001	7-Dec	0.659	0.866
2002	15-Jan	0.698	0.536
	8-Feb	0.445	0.051
	27-Nov	0.691	1.012
2003	8-Jan	0.617	0.577

Figure VI.25 Stage-Discharge Rating Curve for RAMP Station S27

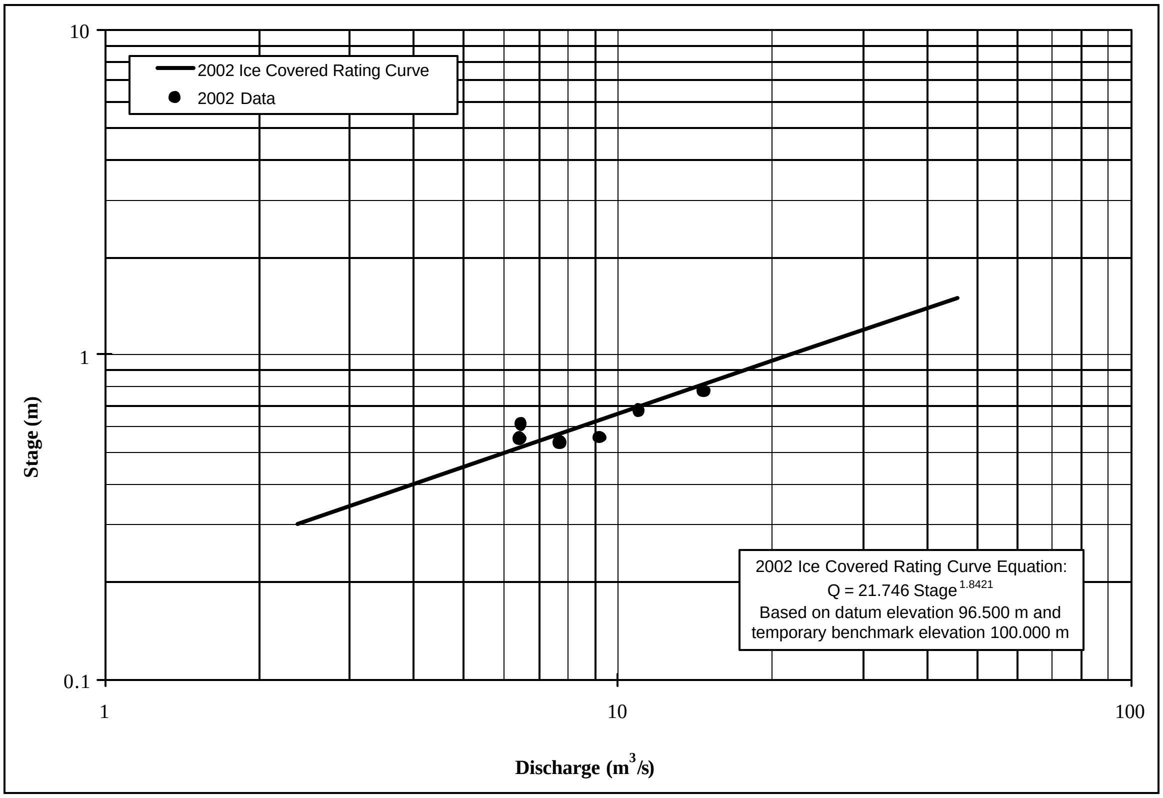


Table VI.25   Stage-Discharge Data for RAMP Station S27

Year	Date	Stage (m)	Discharge (m^3/s)
2002	14-Jan	0.557	9.186
	7-Feb	0.537	7.693
	16-Mar	0.552	6.412
	9-Apr	0.615	6.466
	3-Dec	0.774	14.685
2003	7-Jan	0.674	10.970

Figure VI.26 Stage-Discharge Rating Curve for RAMP Station S28

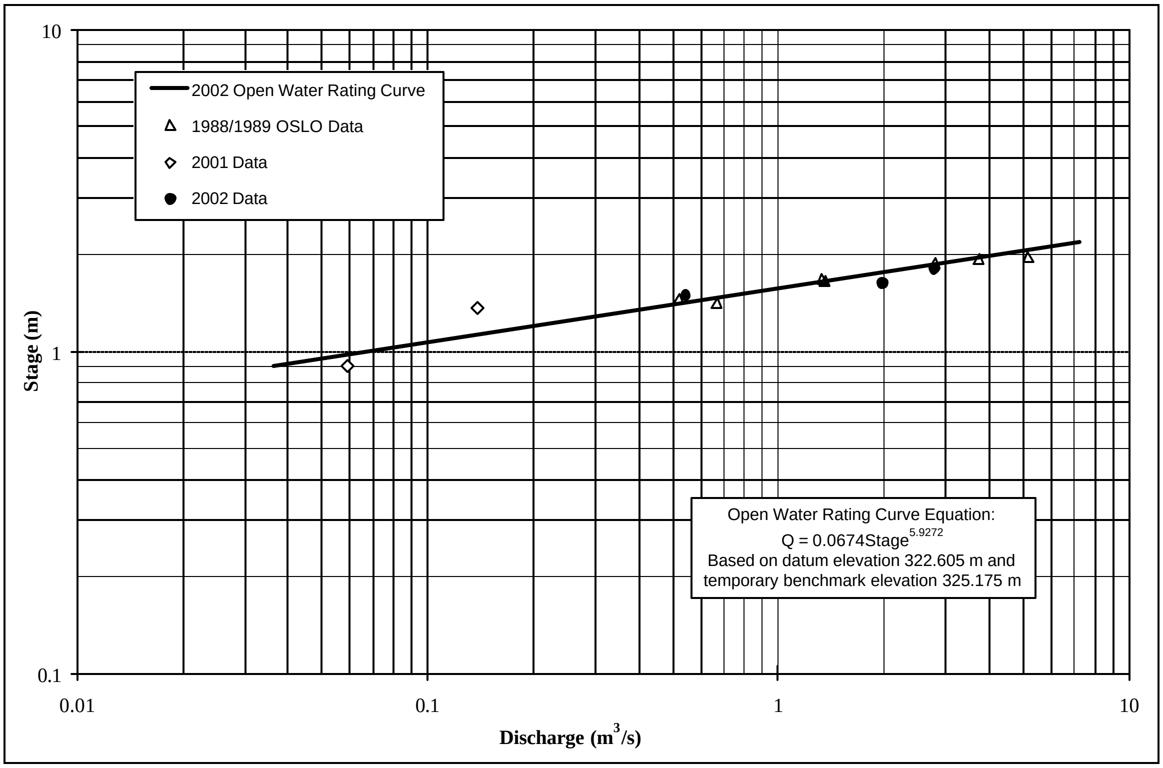


Table VI.26 Stage-Discharge Data for RAMP Station S28

Year	Date	Stage (m)	Discharge (m^3/s)
1988	14-Jul	1.893	2.800
	13-Sep	1.677	1.334
1989	11-May	1.977	5.160
	30-May	1.945	3.740
	28-Jun	1.655	1.360
	30-Aug	1.416	0.669
	26-Oct	1.450	0.522
2001	19-Sep	1.368	0.139
	1-Nov	0.900	0.059
2002	10-Jul	1.499	0.544
	9-Aug	1.819	2.777
	12-Sep	1.640	1.979

Figure VI.27 Stage-Discharge Rating Curve for RAMP Station S29

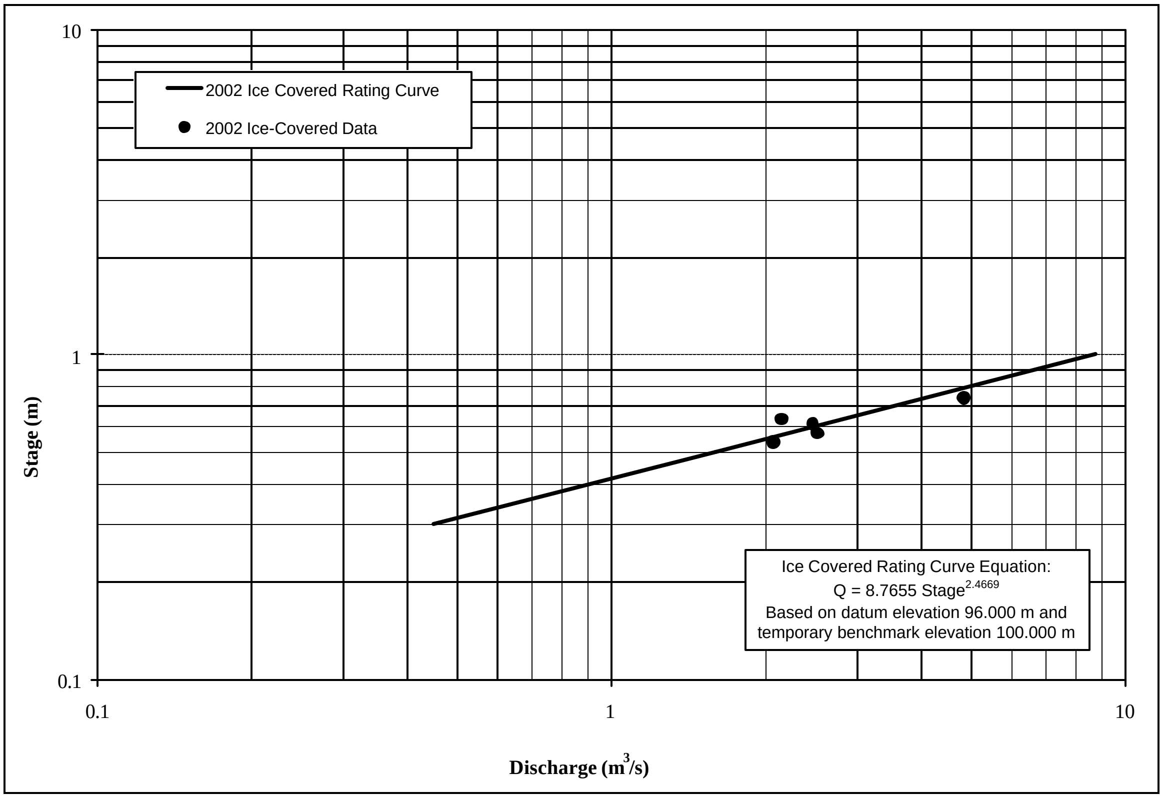


Table VI.27   Stage-Discharge Data for RAMP Station S29

Year	Date	Stage (m)	Discharge (m^3/s)
2002	13-Jan	0.615	2.462
	4-Feb	0.634	2.144
	10-Apr	0.538	2.063
	29-Nov	0.739	4.844
2003	6-Jan	0.574	2.513

Figure VI.28 Stage-Discharge Rating Curve for RAMP Station S30

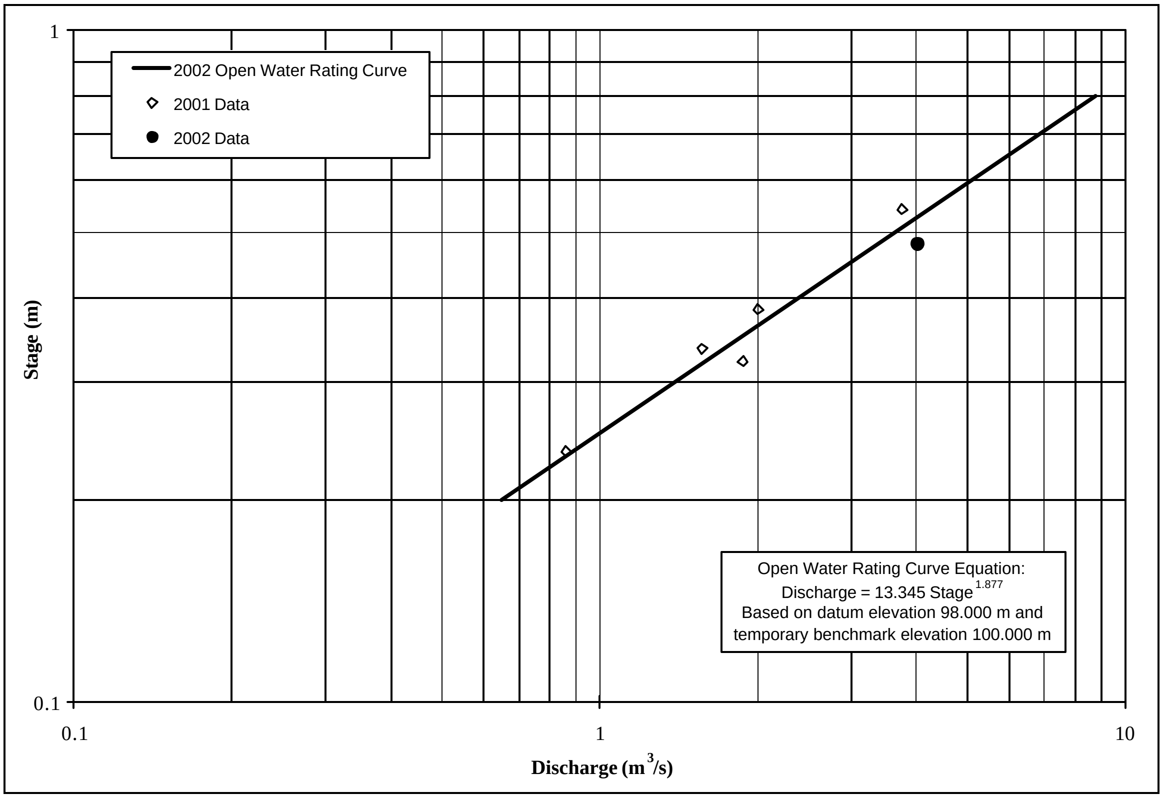


Table VI.28 Stage-Discharge Data for RAMP Station S30

Year	Date	Stage (m)	Discharge (m^3/s)
2001	15-May	0.540	3.750
	15-Jun	0.321	1.869
	9-Jul	0.335	1.565
	10-Aug	0.385	2.002
	20-Sep	0.236	0.861
2002	7-Aug	0.481	4.026

Figure VI.29 Stage-Discharge Rating Curve for RAMP Station S31

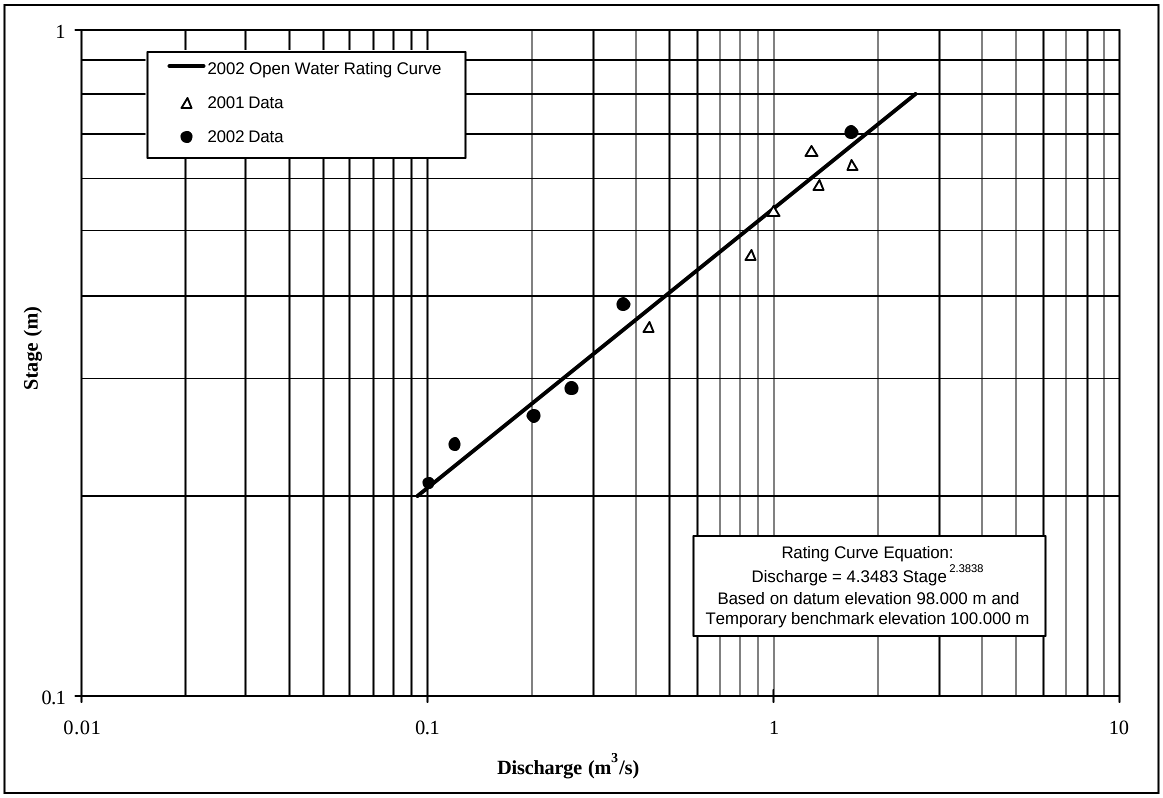


Table VI.29 Stage-Discharge Data for RAMP Station S31

Year	Date	Stage (m)	Discharge (m^3/s)
2001	26-Apr	0.661	1.285
	15-May	0.627	1.685
	15-Jun	0.461	0.858
	9-Jul	0.534	0.998
	10-Aug	0.585	1.348
	20-Sep	0.357	0.437
2002	10-Apr	0.209	0.101
	22-Apr	0.290	0.261
	13-May	0.264	0.203
	8-Jun	0.239	0.120
	8-Jul	0.387	0.367
	7-Aug	0.703	1.671

Figure VI.30 Stage-Discharge Rating Curve for RAMP Station S32

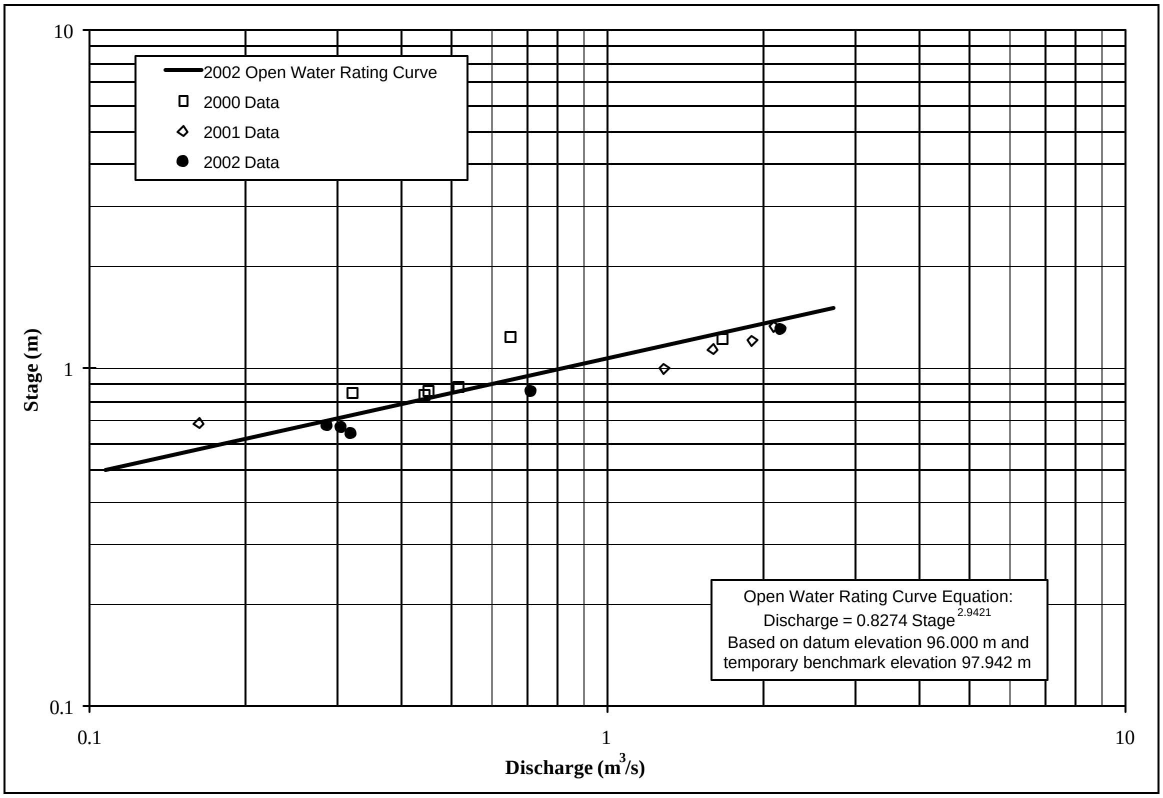


Table VI.30 Stage-Discharge Data for RAMP Station S32

Year	Date	Stage (m)	Discharge (m^3/s)
2000	18-May	0.840	0.442
	15-Jun	1.245	0.650
	2-Jul	1.233	1.665
	15-Aug	0.883	0.515
	14-Sep	0.865	0.451
	17-Oct	0.849	0.322
2001	16-May	1.331	2.094
	15-Jun	1.001	1.285
	9-Jul	1.136	1.597
	10-Aug	1.207	1.901
	19-Sep	0.685	0.163
2002	18-May	0.676	0.288
	8-Jun	0.641	0.319
	8-Jul	0.673	0.306
	7-Aug	1.307	2.152
	11-Sep	0.856	0.709

Figure VI.31 Stage-Discharge Rating Curve for RAMP Station L1

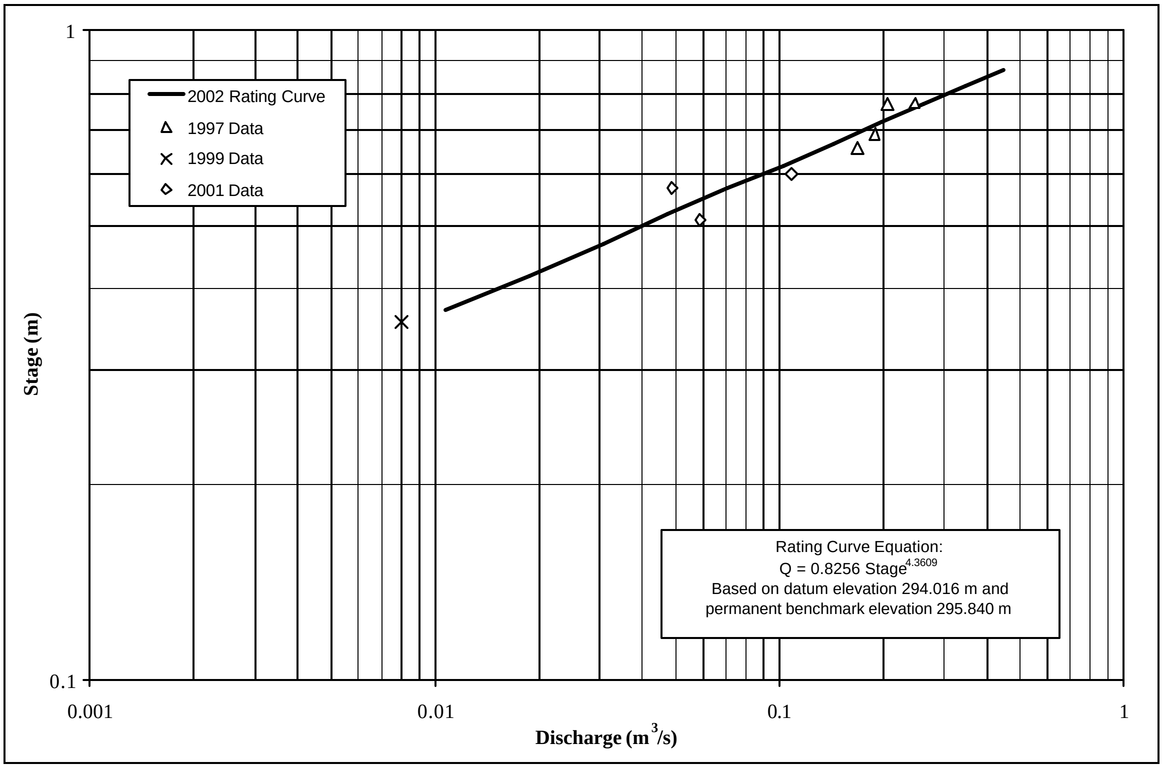


Table VI.31 Stage-Discharge Data for RAMP Station L1

Year	Date	Stage (m)	Discharge (m^3/s)
1997	22-Jun	0.694	0.189
	25-Jul	0.658	0.168
	3-Oct	0.768	0.207
	24-Oct	0.773	0.247
1999	30-Apr	0.356	0.008
2001	14-May	0.602	0.108
	12-Jun	0.571	0.049
	10-Jul	0.510	0.059

APPENDIX VII

2002 MEAN DAILY WATER LEVELS AND DISCHARGES

Table VII.1 S1 Alsands Drain Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	0.000	0.000	0.000	0.000	0.051	0.001	0.000	0.055	0.027	0.000	0.000	0.000
2	0.028	0.000	0.000	0.000	0.095	0.000	0.058	0.007	0.000	0.000	0.000	0.015
3	0.000	0.000	0.000	0.000	0.093	0.005	0.092	0.000	0.036	0.000	0.000	0.027
4	0.000	0.000	0.000	0.000	0.094	0.000	0.090	0.000	0.023	0.000	0.000	0.019
5	0.000	0.000	0.000	0.000	0.094	0.000	0.041	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.095	0.035	0.000	0.044	0.041	0.000	0.000	0.006
7	0.043	0.000	0.000	0.000	0.096	0.091	0.000	0.076	0.073	0.011	0.000	0.000
8	0.000	0.000	0.000	0.000	0.097	0.090	0.000	0.032	0.060	0.000	0.000	0.000
9	0.023	0.000	0.000	0.000	0.099	0.032	0.000	0.016	0.000	0.005	0.000	0.000
10	0.000	0.000	0.000	0.000	0.102	0.001	0.000	0.000	0.000	0.000	0.000	0.000
11	0.010	0.000	0.000	0.000	0.105	0.000	0.000	0.053	0.000	0.014	0.000	0.000
12	0.000	0.000	0.000	0.000	0.047	0.000	0.061	0.057	0.000	0.023	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.098	0.083	0.000	0.014	0.007	0.000
14	0.027	0.000	0.000	0.000	0.000	0.000	0.135	0.083	0.000	0.000	0.020	0.000
15	0.000	0.000	0.000	0.000	0.012	0.000	0.148	0.082	0.000	0.002	0.011	0.000
16	0.043	0.000	0.000	0.000	0.005	0.000	0.145	0.079	0.015	0.012	0.000	0.000
17	0.000	0.000	0.000	0.000	0.014	0.000	0.146	0.076	0.000	0.009	0.000	0.000
18	0.000	0.000	0.000	0.000	0.048	0.000	0.148	0.095	0.021	0.010	0.000	0.000
19	0.000	0.000	0.000	0.000	0.051	0.000	0.147	0.093	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.118	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.047	0.000	0.140	0.118	0.013	0.011	0.000	0.000
22	0.000	0.000	0.000	0.062	0.061	0.000	0.142	0.124	0.051	0.020	0.000	0.000
23	0.000	0.000	0.000	0.095	0.000	0.000	0.147	0.128	0.055	0.015	0.000	0.000
24	0.000	0.000	0.000	0.071	0.046	0.000	0.130	0.131	0.017	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.101	0.000	0.145	0.129	0.003	0.012	0.000	0.000
26	0.000	0.000	0.000	0.000	0.116	0.000	0.052	0.064	0.000	0.013	0.000	0.000
27	0.000	0.000	0.000	0.000	0.044	0.000	0.001	0.000	0.008	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.081	0.000	0.001	0.000	0.000	0.000	0.000	0.000
29	0.000	-	0.000	0.000	0.076	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	-	0.000	0.000	0.001	0.000	0.000	0.056	0.000	0.000	0.000	0.000
31	0.000	-	0.000	-	0.027	-	0.046	0.054	-	0.000	-	0.000
min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
mean	0.006	0.000	0.000	0.008	0.058	0.008	0.073	0.060	0.015	0.006	0.001	0.002
max	0.043	0.000	0.000	0.095	0.116	0.091	0.148	0.131	0.073	0.023	0.020	0.027

Notes: P - Partial daily average.

Table VII.2 S1 Alsands Drain Mean Daily Water Levels (m) Based on Permanent Benchmark el. 280.015 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	279.069	278.987	-	-	279.448	279.335	279.076	279.487	279.401	279.252	279.173	279.161
2	279.284	278.978	-	-	279.560	279.323	279.396	279.337	279.319	279.251	279.149	279.316
3	279.292	278.970	-	-	279.558	279.342	279.556	279.309	279.397	279.251	279.145	279.462
4	279.165	278.965	-	-	279.558	279.326	279.554	279.306	279.389	279.239	279.169	279.404
5	279.086	278.958	-	-	279.559	279.325	279.439	279.308	279.312	279.227	279.219	279.229
6	279.054	278.951	-	-	279.560	279.415	279.328	279.441	279.431	279.218	279.189	279.307
7	279.342	278.948	-	-	279.560	279.555	279.325	279.539	279.536	279.305	279.155	279.227
8	279.406	278.943	-	-	279.561	279.554	279.325	279.423	279.501	279.261	279.115	279.210
9	279.426	278.938	-	-	279.564	279.418	279.319	279.372	279.307	279.317	279.103	279.180
10	279.387	278.933	-	-	279.566	279.333	279.303	279.320	279.305	279.286	279.095	279.141
11	279.388	278.929	-	-	279.569	279.330	279.286	279.466	279.307	279.382	279.083	279.151
12	279.295	278.924	-	-	279.456	279.324	279.453	279.495	279.297	279.453	279.196	279.127
13	279.138	278.920	-	-	279.299	279.313	279.562	279.547	279.295	279.386	279.330	279.105
14	279.324	278.916	-	-	279.308	279.294	279.593	279.547	279.278	279.248	279.445	279.102
15	279.405	278.913	-	-	279.358	279.278	279.606	279.546	279.275	279.303	279.362	279.106
16	279.496	278.909	-	-	279.336	279.262	279.603	279.542	279.340	279.368	279.236	279.100
17	279.498	278.906	-	-	279.371	279.241	279.604	279.539	279.304	279.344	279.234	279.089
18	279.358	278.902	-	-	279.462	279.227	279.605	279.557	279.383	279.352	279.228	279.075
19	279.300	278.898	-	-	279.483	279.213	279.605	279.553	279.300	279.247	279.215	279.053
20	279.256	278.894	-	-	279.314	279.203	279.602	279.581	279.290	279.244	279.196	279.031
21	279.214	278.891	-	-	279.454	279.191	279.600	279.581	279.339	279.349	279.174	279.013
22	279.177	278.888	-	-	279.507	279.173	279.601	279.586	279.506	279.444	279.162	278.987
23	279.147	278.883	-	-	279.324	279.158	279.605	279.590	279.512	279.403	279.126	278.960
24	279.123	278.881	-	279.476	279.450	279.138	279.589	279.592	279.365	279.253	279.100	278.938
25	279.102	-	-	279.328	279.563	279.119	279.602	279.590	279.307	279.367	279.079	278.918
26	279.082	-	-	279.326	279.563	279.102	279.448	279.479	279.265	279.385	279.056	278.899
27	279.063	-	-	279.328	279.461	279.085	279.335	279.329	279.323	279.243	279.036	278.882
28	279.044	-	-	279.332	279.544	279.063	279.333	279.330	279.265	279.239	279.131	278.864
29	279.027	-	-	279.331	279.533	279.051	279.326	279.329	279.271	279.231	279.227	278.848
30	279.009	-	-	279.328	279.340	279.051	279.317	279.469	279.263	279.216	279.200	-
31	278.996	-	-	-	279.408	-	279.451	279.474	-	279.199	-	-
min	278.996	278.881	-	279.326	279.299	279.051	279.076	279.306	279.263	279.199	279.036	278.848
mean	279.224	278.926	-	279.350	279.471	279.258	279.463	279.470	279.346	279.299	279.178	279.100
max	279.498	278.987	-	279.476	279.569	279.555	279.606	279.592	279.536	279.453	279.445	279.462

Notes: P - Partial daily average.

Table VII.3 S2 Jackpine Creek Mean Daily Discharges (m^3/s), 2002

DATE	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	-	-	-	-	0.304	0.497	0.657	11.199	2.020	1.740	-	-
2	-	-	-	-	0.193	0.577	1.614	13.607	1.902	1.730	-	-
3	-	-	-	-	0.252	0.559	2.021	14.350	1.829	1.828	-	-
4	-	-	-	-	0.296	0.540	2.325	13.826	2.129	2.037	-	-
5	-	-	-	-	0.264	0.523	2.608	12.898	3.298	2.253	-	-
6	-	-	-	-	0.220	0.569	2.870	12.720	4.428	2.225	-	-
7	-	-	-	-	0.191	0.926	2.994	12.192	5.423	2.178	-	-
8	-	-	-	-	0.193	1.106	2.772	11.476	5.387	2.122	-	-
9	-	-	-	-	0.174	1.082	2.541	10.375	4.947	2.066	-	-
10	-	-	-	-	0.132	1.055	2.184	9.277	4.376	1.990	-	-
11	-	-	-	-	0.142	1.036	1.934	8.180	3.825	1.863	-	-
12	-	-	-	-	0.158	1.022	1.705	6.676	3.353	1.727	-	-
13	-	-	-	-	0.164	0.974	1.486	5.496	3.028	1.653	-	-
14	-	-	-	-	0.289	0.907	1.313	4.885	2.842	1.667	-	-
15	-	-	-	-	0.478	0.853	1.244	5.075	2.629	1.832	-	-
16	-	-	-	-	0.472	0.790	1.115	6.246	2.384	1.443	-	-
17	-	-	-	-	0.473	0.751	0.979	7.754	2.197	1.465	-	-
18	-	-	-	-	0.469	0.746	0.991	8.447	1.990	1.691	-	-
19	-	-	-	-	0.445	0.752	1.283	8.199	1.848	1.650	-	-
20	-	-	-	-	0.436	0.771	1.394	7.428	1.773	1.943	-	-
21	-	-	-	-	0.417	0.703	3.152	6.384	1.703	-	-	-
22	-	-	-	-	0.407	0.653	4.752	5.363	1.628	-	-	-
23	-	-	-	-	0.407	0.618	5.765	4.433	1.579	-	-	-
24	-	-	-	-	0.392	0.558	5.938	3.689	1.505	-	-	-
25	-	-	-	-	0.367	0.529	5.739	2.984	1.421	-	-	-
26	-	-	-	-	0.346	0.498	5.337	2.786	1.365	-	-	-
27	-	-	-	0.243	0.346	0.472	5.005	3.094	1.328	-	-	-
28	-	-	-	0.221	0.329	0.451	5.924	2.885	1.326	-	-	-
29	-	-	-	0.216	0.341	0.440	7.010	2.545	1.479	-	-	-
30	-	-	-	0.268	0.355	0.497	7.764	2.225	1.735	-	-	-
31	-	-	-	-	0.376	-	9.363	2.104	-	-	-	-
min	-	-	-	0.216	0.132	0.440	0.657	2.104	1.326	1.443	-	-
mean	-	-	-	0.237	0.317	0.715	3.283	7.381	2.556	1.855	-	-
max	-	-	-	0.268	0.478	1.106	9.363	14.350	5.423	2.253	-	-

NOTES: P - Partial daily average.
A - Manual discharge measurement.

Table VII.4 S2 Jackpine Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 297.990 m (geodetic), 2002

DATE	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	-	-	-	-	296.825	296.880	296.909	297.394	297.054	297.033	-	-
2	-	-	-	-	296.787	296.897	297.021	297.473	297.046	297.033	-	-
3	-	-	-	-	296.809	296.893	297.054	297.496	297.040	297.040	-	-
4	-	-	-	-	296.821	296.890	297.074	297.480	297.061	297.055	-	-
5	-	-	-	-	296.810	296.886	297.091	297.451	297.126	297.070	-	-
6	-	-	-	-	296.793	296.895	297.105	297.445	297.173	297.068	-	-
7	-	-	-	-	296.781	296.951	297.112	297.428	297.207	297.065	-	-
8	-	-	-	297.126	296.779	296.974	297.100	297.404	297.205	297.061	-	-
9	-	-	-	297.145	296.772	296.971	297.087	297.365	297.191	297.057	-	-
10	-	-	-	297.117	296.753	296.968	297.065	297.323	297.171	297.052	-	-
11	-	-	-	297.122	296.760	296.966	297.048	297.281	297.149	297.043	-	-
12	-	-	-	297.101	296.769	296.964	297.031	297.242	297.129	297.032	-	-
13	-	-	-	297.107	296.772	296.958	297.012	297.209	297.113	297.026	-	-
14	-	-	-	297.106	296.820	296.949	296.996	297.189	297.104	297.028	-	-
15	-	-	-	297.071	296.876	296.942	296.989	297.195	297.092	297.039	-	-
16	-	-	-	297.000	296.875	296.933	296.975	297.230	297.078	297.008	-	-
17	-	-	-	297.001	296.875	296.927	296.959	297.269	297.066	297.010	-	-
18	-	-	-	297.020	296.874	296.926	296.960	297.290	297.052	297.029	-	-
19	-	-	-	296.961	296.869	296.927	296.993	297.280	297.042	297.026	-	-
20	-	-	-	296.854	296.867	296.930	297.003	297.261	297.036	297.096	-	-
21	-	-	-	296.846	296.862	296.919	297.116	297.234	297.030	297.167	-	-
22	-	-	-	296.837	296.859	296.911	297.184	297.205	297.024	297.142	-	-
23	-	-	-	296.935	296.859	296.905	297.217	297.173	297.020	297.142	-	-
24	-	-	-	297.100	296.856	296.893	297.222	297.144	297.014	297.026	-	-
25	-	-	-	296.948	296.849	296.887	297.216	297.111	297.006	0.000	-	-
26	-	-	-	296.853	296.843	296.881	297.204	297.101	297.001	-	-	-
27	-	-	-	296.823	296.843	296.875	297.193	297.117	296.997	-	-	-
28	-	-	-	296.799	296.837	296.870	297.221	297.106	296.997	-	-	-
29	-	-	-	296.797	296.841	296.867	297.251	297.087	297.011	-	-	-
30	-	-	-	296.815	296.845	296.880	297.270	297.068	297.033	-	-	-
31	-	-	-	-	296.851	-	297.326	297.060	-	-	-	-
Min	-	-	-	296.797	296.753	296.867	296.909	297.060	296.997	0.000	-	-
Mean	-	-	-	296.978	296.827	296.917	297.097	297.262	297.076	285.174	-	-
Max	-	-	-	297.145	296.876	296.974	297.326	297.496	297.207	297.167	-	-

NOTES: P - Partial daily average.

Table VII.5 S3 Iyinimin Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	0.180	1.695	0.266	0.440	-	-
2	-	-	-	-	-	-	0.458	1.425	0.258	0.439	-	-
3	-	-	-	-	-	-	0.458	1.253	0.256	0.457	-	-
4	-	-	-	-	-	-	0.483	1.090	0.401	0.476	-	-
5	-	-	-	-	-	-	0.474	1.008	0.594	0.460	-	-
6	-	-	-	-	-	-	0.454	1.035	0.618	0.440	-	-
7	-	-	-	-	-	-	0.428	0.947	0.595	0.427	-	-
8	-	-	-	-	-	-	0.391	0.847	0.551	0.411	-	-
9	-	-	-	-	-	-	0.354	0.749	0.499	0.399	-	-
10	-	-	-	-	-	0.103 P	0.319	0.662	0.451	0.380	-	-
11	-	-	-	-	-	0.091	0.284	0.608	0.425	0.359	-	-
12	-	-	-	-	-	0.069	0.255	0.542	0.394	0.334	-	-
13	-	-	-	-	-	0.060	0.223	0.505	0.391	0.324	-	-
14	-	-	-	-	-	0.054	0.202	0.531	0.415	0.300	-	-
15	-	-	-	-	-	0.048	0.184	0.621	0.384	0.278	-	-
16	-	-	-	-	-	0.045	0.159	0.686	0.356	0.307	-	-
17	-	-	-	-	-	0.041	0.144	0.652	0.332	0.288	-	-
18	-	-	-	-	-	0.040	0.160	0.597	0.305	0.278	-	-
19	-	-	-	-	-	0.044	0.152	0.582	0.289	0.263	-	-
20	-	-	-	-	-	0.033	0.244	0.560	0.323	-	-	-
21	-	-	-	-	-	0.026	0.976	0.506	0.446	-	-	-
22	-	-	-	-	-	0.022	1.031	0.462	0.481	-	-	-
23	-	-	-	-	-	0.031	1.019	0.419	0.483	0.224	-	-
24	-	-	-	-	-	0.021	0.955	0.382	0.467	0.219	-	-
25	-	-	-	-	-	0.018	0.841	0.341	0.438	0.216	-	-
26	-	-	-	-	-	0.016	0.761	0.339	0.415	0.208 P	-	-
27	-	-	-	-	-	0.013	0.702	0.331	0.399	-	-	-
28	-	-	-	-	-	0.010	0.754	0.305	0.389	-	-	-
29	-	-	-	-	-	0.013	0.703	0.278	0.447	-	-	-
30	-	-	-	-	-	0.039	0.740	0.274	0.462	-	-	-
31	-	-	-	-	-	-	1.422	0.277	-	-	-	-
min	-	-	-	-	-	0.010	0.144	0.274	0.256	0.208	-	-
mean	-	-	-	-	-	0.040	0.513	0.662	0.423	0.340	-	-
max	-	-	-	-	-	0.103	1.422	1.695	0.618	0.476	-	-

Notes: P - Partial daily average.

Table VII.6 S3 Iyinimin Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 360.610 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	359.066	359.476	359.124	359.197	-	-
2	-	-	-	-	-	-	359.203	359.432	359.119	359.197	-	-
3	-	-	-	-	-	-	359.204	359.401	359.118	359.203	-	-
4	-	-	-	-	-	-	359.212	359.369	359.180	359.210	-	-
5	-	-	-	-	-	-	359.209	359.352	359.248	359.204	-	-
6	-	-	-	-	-	-	359.202	359.358	359.255	359.197	-	-
7	-	-	-	-	-	-	359.193	359.339	359.248	359.192	-	-
8	-	-	-	-	-	-	359.179	359.316	359.235	359.186	-	-
9	-	-	-	-	-	-	359.164	359.291	359.218	359.182	-	-
10	-	-	-	-	-	359.017 P	359.149	359.268	359.201	359.174	-	-
11	-	-	-	-	-	359.004	359.132	359.252	359.192	359.166	-	-
12	-	-	-	-	-	358.982	359.118	359.232	359.180	359.155	-	-
13	-	-	-	-	-	358.971	359.101	359.220	359.179	359.151	-	-
14	-	-	-	-	-	358.963	359.089	359.229	359.188	359.139	-	-
15	-	-	-	-	-	358.953	359.078	359.256	359.176	359.176	-	-
16	-	-	-	-	-	358.949	359.061	359.274	359.165	359.147	-	-
17	-	-	-	-	-	358.942	359.050	359.265	359.154	359.134	-	-
18	-	-	-	-	-	358.941	359.061	359.249	359.142	359.129	-	-
19	-	-	-	-	-	358.947	359.056	359.244	359.135	359.131	-	-
20	-	-	-	-	-	358.929	359.103	359.238	359.150	359.174	-	-
21	-	-	-	-	-	358.914	359.344	359.220	359.199	359.231	-	-
22	-	-	-	-	-	358.905	359.357	359.205	359.212	359.192	-	-
23	-	-	-	-	-	358.924	359.355	359.190	359.212	359.153	-	-
24	-	-	-	-	-	358.903	359.341	359.175	359.207	359.099	-	-
25	-	-	-	-	-	358.896	359.314	359.158	359.196	359.097	-	-
26	-	-	-	-	-	358.890	359.294	359.157	359.188	359.092 P	-	-
27	-	-	-	-	-	358.881	359.279	359.154	359.182	-	-	-
28	-	-	-	-	-	358.867	359.293	359.142	359.178	-	-	-
29	-	-	-	-	-	358.878	359.279	359.129	359.200	-	-	-
30	-	-	-	-	-	358.933	359.287	359.128	359.205	-	-	-
31	-	-	-	-	-	-	359.431	359.129	-	-	-	-
min	-	-	-	-	-	358.867	359.050	359.128	359.118	359.092	-	-
mean	-	-	-	-	-	358.933	359.200	359.253	359.188	359.165	-	-
max	-	-	-	-	-	359.017	359.431	359.476	359.255	359.231	-	-

Notes: P - Partial daily average.

Table VII.7 S5A Muskeg River Aurora Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	281.042 B	281.031 B	281.080 B	280.997 B	281.055	281.135	281.242	282.196 X	281.804	281.753	281.331 B	281.203 B
2	281.049 B	281.030 B	281.102 B	281.024 B	280.992	281.137	281.394	282.222 X	281.769	281.758	281.318 B	281.193 B
3	281.059 B	281.029 B	281.152 B	281.057 B	281.106	281.136	281.402	282.237 X	281.742	281.793	281.308 B	281.173 B
4	281.052 B	281.028 B	281.086 B	281.050 B	280.982	281.133	281.404	282.244 X	281.849	281.809	281.309 B	281.168 B
5	281.047 B	281.027 B	281.039 B	281.044 B	280.970	281.138	281.451	282.257 X	282.092	281.808	281.314 B	281.178 B
6	281.065 B	281.026 B	281.049 B	281.090 B	280.964	281.149	281.475	282.272 X	282.126 X	281.805	281.299 B	281.173 B
7	281.065 B	281.025 B	281.079 B	281.093 B	280.965	281.220	281.483	282.276 X	282.145 X	281.802	281.306 B	281.159 B
8	281.052 B	281.024 B	281.105 B	281.075 B	280.967	281.243	281.470	282.277 X	282.156 X	281.794	281.299 B	281.157 B
9	281.038 B	281.023 B	281.109 B	281.068 B	280.971	281.229	281.447	282.274 X	282.157 X	281.783	281.291 B	281.164 B
10	281.037 B	281.022 B	281.110 B	281.099 B	280.979	281.223	281.417	282.267 X	282.154 X	281.767	281.291 B	281.161 B
11	281.039 B	281.021 B	281.134 B	281.138 B	280.998	281.217	281.388	282.257 X	282.146 X	281.740	281.284 B	281.167 B
12	281.059 B	281.020 B	281.180 B	281.147 B	281.023	281.209	281.365	282.251 X	282.130 X	281.705	281.277 B	281.167 B
13	281.053 B	281.019 B	281.133 B	281.149 B	281.057	281.200	281.338	282.252 X	282.117	281.679	281.262 B	281.170 B
14	281.047 B	281.018 B	281.101 B	281.127 B	281.081	281.189	281.319	282.255 X	282.092	281.699	281.250 B	281.160 B
15	281.044 B	281.017 B	281.104 B	281.076 B	281.099	281.181	281.312	282.243 X	282.037	281.659	281.242 B	281.159 B
16	281.043 B	281.015 B	281.076 B	281.029 B	281.107	281.183	281.289	282.238 X	281.981	281.626	281.239 B	281.176 B
17	281.044 B	281.014 B	281.093 B	281.003 B	281.112	281.181	281.264	282.237 X	281.918	281.639	281.250 B	281.172 B
18	281.060 B	281.013 B	281.092 B	280.990 B	281.111	281.168	281.261	282.238 X	281.842	281.698 B	281.245 B	281.164 B
19	281.046 B	281.012 B	281.085 B	280.985 B	281.095	281.151	281.282	282.238 X	281.771	281.664 B	281.232 B	281.153 B
20	281.043 B	281.011 B	281.081 B	281.001 B	281.101	281.144	281.313	282.237 X	281.754	281.660 B	281.228 B	281.148 B
21	281.037 B	281.010 B	281.124 B	281.052 B	281.109	281.147	281.603	282.229 X	281.781	281.598 B	281.221 B	281.142 B
22	281.040 B	281.009 B	281.154 B	281.119 B	281.100	281.123	281.700	282.218 X	281.804	281.548 B	281.226 B	281.136 B
23	281.041 B	281.008 B	281.142 B	281.177 B	281.080	281.096	281.747	282.207 X	281.785	281.517 B	281.213 B	281.135 B
24	281.039 B	281.008 B	281.140 B	281.058 B	281.073	281.122	281.876	282.195 X	281.765	281.503 B	281.213 B	281.149 B
25	281.038 B	281.018 B	281.130 B	281.008 B	281.074	281.151	281.975	282.169 X	281.744	281.501 B	281.208 B	281.152 B
26	281.037 B	281.063 B	281.153 B	280.985 B	281.068	281.121	282.014	282.136 X	281.726	281.488 B	281.203 B	281.154 B
27	281.036 B	281.028 B	281.233 B	280.987 B	281.055	281.095	282.030	282.097	281.711	281.472 B	281.199 B	281.140 B
28	281.035 B	281.025 B	281.241 B	280.992	281.050	281.071	282.078	282.047	281.702	281.454 B	281.211 B	281.133 B
29	281.034 B	-	281.101 B	281.043	281.067	281.072	282.109	281.990	281.735	281.402 B	281.208 B	281.134 B
30	281.033 B	-	281.019 B	281.054	281.100	281.104	282.119	281.924	281.764	281.361 B	281.204 B	281.133 B
31	281.032 B	-	281.012 B	-	281.122	-	282.158 X	281.864	-	281.349 B	-	281.136 B
min	281.032	281.008	281.012	280.985	280.964	281.071	281.242	281.864	281.702	281.349	281.199	281.133
mean	281.045	281.021	281.111	281.057	281.053	281.156	281.572	282.195	281.910	281.640	281.256	281.158
max	281.065	281.063	281.241	281.177	281.122	281.243	282.158	282.277	282.157	281.809	281.331	281.203

Notes: P - Partial daily average.
B - Ice effects.
X - Estimated based on values at downstream SCL station.

Table VII.8 S5A Muskeg River Aurora Mean Daily Water Levels (m) Based on Permanent Benchmark el. 282.380 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	0.212 B	0.182 B	0.103 B	0.052 B	0.241	0.412	0.600	6.112 X	2.740	2.437	0.815 B	0.509 B
2	0.213 B	0.182 B	0.116 B	0.060 B	0.236	0.416	0.957	6.409 X	2.526	2.465	0.792 B	0.494 B
3	0.217 B	0.182 B	0.146 B	0.068 B	0.236	0.414	0.977	6.588 X	2.370	2.668	0.774 B	0.470 B
4	0.209 B	0.182 B	0.114 B	0.063 B	0.228	0.408	0.982	6.676 X	3.068	2.767	0.769 B	0.461 B
5	0.203 B	0.182 B	0.095 B	0.058 B	0.217	0.417	1.125	6.830 X	5.024	2.759	0.770 B	0.467 B
6	0.212 B	0.181 B	0.103 B	0.073 B	0.211	0.434	1.202	7.023 X	5.350 X	2.745	0.745 B	0.459 B
7	0.209 B	0.181 B	0.121 B	0.071 B	0.212	0.554	1.227	7.074 X	5.554 X	2.725	0.748 B	0.441 B
8	0.198 B	0.180 B	0.137 B	0.061 B	0.214	0.597	1.185	7.090 X	5.668 X	2.675	0.734 B	0.435 B
9	0.185 B	0.173 B	0.143 B	0.057 B	0.218	0.570	1.111	7.044 X	5.684 X	2.610	0.719 B	0.438 B
10	0.182 B	0.163 B	0.147 B	0.071 B	0.225	0.559	1.019	6.956 X	5.644 X	2.514	0.712 B	0.432 B
11	0.181 B	0.154 B	0.165 B	0.093 B	0.243	0.549	0.939	6.841 X	5.561 X	2.361	0.699 B	0.434 B
12	0.191 B	0.145 B	0.198 B	0.102 B	0.270	0.533	0.876	6.764 X	5.396 X	2.171	0.684 B	0.430 B
13	0.188 B	0.136 B	0.172 B	0.107 B	0.309	0.517	0.808	6.779 X	5.264	2.039	0.661 B	0.430 B
14	0.184 B	0.128 B	0.157 B	0.102 B	0.337	0.498	0.761	6.805 X	5.014	2.140	0.642 B	0.417 B
15	0.182 B	0.120 B	0.158 B	0.084 B	0.361	0.485	0.745	6.669 X	4.498	1.947	0.627 B	0.412 B
16	0.183 B	0.112 B	0.143 B	0.069 B	0.373	0.488	0.694	6.608 X	4.010	1.792	0.619 B	0.425 B
17	0.184 B	0.105 B	0.148 B	0.063 B	0.379	0.485	0.640	6.595 X	3.514	1.599	0.627 B	0.417 B
18	0.194 B	0.097 B	0.144 B	0.063 B	0.378	0.464	0.633	6.602 X	2.985	1.488 B	0.616 B	0.406 B
19	0.186 B	0.090 B	0.136 B	0.065 B	0.356	0.436	0.679	6.604 X	2.539	1.420 B	0.596 B	0.392 B
20	0.184 B	0.083 B	0.129 B	0.076 B	0.364	0.425	0.750	6.591 X	2.440	1.406 B	0.587 B	0.384 B
21	0.181 B	0.077 B	0.149 B	0.103 B	0.375	0.430	1.716	6.494 X	2.597	1.291 B	0.573 B	0.375 B
22	0.183 B	0.071 B	0.162 B	0.144 B	0.363	0.394	2.147	6.367 X	2.740	1.201 B	0.574 B	0.366 B
23	0.184 B	0.065 B	0.150 B	0.194 B	0.337	0.357	2.400	6.240 X	2.619	1.144 B	0.555 B	0.362 B
24	0.184 B	0.060 B	0.145 B	0.161 B	0.327	0.394	3.225	6.099 X	2.502	1.116 B	0.551 B	0.372 B
25	0.184 B	0.065 B	0.135 B	0.173 B	0.329	0.436	3.963	5.806 X	2.386	1.105 B	0.540 B	0.370 B
26	0.184 B	0.086 B	0.144 B	0.202 B	0.322	0.392	4.289	5.464 X	2.283	1.078 B	0.530 B	0.369 B
27	0.183 B	0.074 B	0.187 B	0.249 B	0.306	0.356	4.434	5.062	2.205	1.048 B	0.521 B	0.354 B
28	0.183 B	0.075 B	0.188 B	0.253	0.300	0.325	4.876	4.587	2.159	1.014 B	0.529 B	0.343 B
29	0.183 B	-	0.105 B	0.247	0.320	0.326	5.186	4.091	2.334	0.932 B	0.522 B	0.341 B
30	0.183 B	-	0.066 B	0.245	0.363	0.369	5.282	3.561	2.495	0.868 B	0.514 B	0.337 B
31	0.183 B	-	0.060 B	-	0.393	-	5.691 X	3.128	-	0.845 B	-	0.337 B
min	0.181	0.060	0.060	0.052	0.211	0.325	0.600	3.128	2.159	0.845	0.514	0.337
mean	0.191	0.126	0.138	0.114	0.301	0.448	1.972	6.179	3.639	1.818	0.645	0.409
max	0.217	0.182	0.198	0.253	0.393	0.597	5.691	7.090	5.684	2.767	0.815	0.509

Notes: P - Partial daily average.
B - Ice effects.
X - Estimated based on values at downstream SCL station.

Table VII.9 S6 Mills Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	272.032	272.066	272.146	272.151	272.120	272.119	-	-
2	-	-	-	-	272.031	272.063	272.157	272.132	272.118	272.121	-	-
3	-	-	-	-	272.030	272.062	272.131	272.121	272.117	272.123	-	-
4	-	-	-	-	272.030	272.063	272.124	272.113	272.178	272.122	-	-
5	-	-	-	-	272.031	272.065	272.117	272.124	272.176	272.118	-	-
6	-	-	-	-	272.032	272.084	272.106	272.130	272.169	272.115	-	-
7	-	-	-	-	272.033	272.118	272.099	272.120	272.160	272.115	-	-
8	-	-	-	-	272.034	272.104	272.092	272.117	272.154	272.111	-	-
9	-	-	-	272.018 P	272.034	272.096	272.086	272.112	272.147	272.111	-	-
10	-	-	-	-	272.036	272.090	272.081	272.109	272.140	272.107	-	-
11	-	-	-	272.046	272.036	272.085	272.078	272.109	272.137	272.103	-	-
12	-	-	-	272.026	272.039	272.081	272.076	272.108	272.130	272.099	-	-
13	-	-	-	272.024	272.040	272.078	272.073	272.115	272.130	272.103	-	-
14	-	-	-	272.029	272.040	272.076	272.085	272.118	272.124	272.103	-	-
15	-	-	-	272.025	272.039	272.074	272.081	272.133	272.124	272.098	-	-
16	-	-	-	272.024	272.040	272.076	272.075	272.173	272.122	272.099	-	-
17	-	-	-	272.025	272.040	272.073	272.073	272.154	272.122	272.103	-	-
18	-	-	-	272.028	272.041	272.071	272.088	272.150	272.118	272.101	-	-
19	-	-	-	272.032	272.041	272.072	272.082	272.171	272.119	272.100	-	-
20	-	-	-	272.037	272.042	272.071	272.127	272.168	272.124	272.095	-	-
21	-	-	-	272.041	272.043	272.070	272.133	272.162	272.119	272.093 P	-	-
22	-	-	-	272.038	272.042	272.068	272.113	272.160	272.118	-	-	-
23	-	-	-	272.033	272.042	272.067	272.105	272.157	272.114	-	-	-
24	-	-	-	272.031	272.044	272.068	272.099	272.148	272.110	-	-	-
25	-	-	-	272.030	272.045	272.067	272.091	272.135	272.106	-	-	-
26	-	-	-	272.030	272.045	272.066	272.089	272.137	272.106	-	-	-
27	-	-	-	272.032	272.045	272.065	272.092	272.135	272.109	-	-	-
28	-	-	-	272.032	272.046	272.065	272.127	272.133	272.114	-	-	-
29	-	-	-	272.032	272.054	272.067	272.105	272.128	272.131	-	-	-
30	-	-	-	272.032	272.058	272.095	272.145	272.126	272.125	-	-	-
31	-	-	-	-	272.064	-	272.176	272.121	-	-	-	-
min	-	-	-	272.018	272.030	272.062	272.073	272.108	272.106	272.093	-	-
mean	-	-	-	272.031	272.040	272.075	272.105	272.135	272.129	272.108	-	-
max	-	-	-	272.046	272.064	272.118	272.176	272.173	272.178	272.123	-	-

Notes: P - Partial daily average.

Table VII.10 S6 Mills Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 273.600 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.007	0.012	0.037	0.035	0.025	0.024	-	-
2	-	-	-	-	0.007	0.011	0.038	0.028	0.024	0.025	-	-
3	-	-	-	-	0.006	0.011	0.028	0.025	0.024	0.026	-	-
4	-	-	-	-	0.007	0.011	0.026	0.023	0.048	0.025	-	-
5	-	-	-	-	0.007	0.012	0.024	0.026	0.046	0.024	-	-
6	-	-	-	-	0.007	0.016	0.021	0.028	0.043	0.023	-	-
7	-	-	-	-	0.007	0.024	0.019	0.025	0.039	0.023	-	-
8	-	-	-	-	0.007	0.020	0.017	0.024	0.037	0.022	-	-
9	-	-	-	0.005 P	0.007	0.018	0.016	0.022	0.034	0.022	-	-
10	-	-	-	-	0.007	0.017	0.015	0.022	0.031	0.021	-	-
11	-	-	-	0.010	0.007	0.016	0.014	0.022	0.030	0.020	-	-
12	-	-	-	0.006	0.008	0.015	0.014	0.021	0.028	0.019	-	-
13	-	-	-	0.006	0.008	0.014	0.013	0.023	0.028	0.020	-	-
14	-	-	-	0.007	0.008	0.014	0.016	0.024	0.026	0.020	-	-
15	-	-	-	0.006	0.008	0.013	0.015	0.029	0.026	0.019	-	-
16	-	-	-	0.006	0.008	0.014	0.014	0.045	0.025	0.019	-	-
17	-	-	-	0.006	0.008	0.013	0.013	0.037	0.025	0.020	-	-
18	-	-	-	0.006	0.008	0.013	0.016	0.035	0.024	0.019	-	-
19	-	-	-	0.007	0.008	0.013	0.015	0.044	0.024	0.019	-	-
20	-	-	-	0.008	0.008	0.013	0.029	0.042	0.026	0.018	-	-
21	-	-	-	0.008	0.008	0.013	0.029	0.040	0.025	0.017 P	-	-
22	-	-	-	0.008	0.008	0.012	0.023	0.039	0.024	-	-	-
23	-	-	-	0.007	0.008	0.012	0.020	0.038	0.023	-	-	-
24	-	-	-	0.007	0.008	0.012	0.019	0.034	0.022	-	-	-
25	-	-	-	0.007	0.008	0.012	0.017	0.030	0.021	-	-	-
26	-	-	-	0.007	0.008	0.012	0.016	0.030	0.021	-	-	-
27	-	-	-	0.007	0.009	0.012	0.017	0.030	0.022	-	-	-
28	-	-	-	0.007	0.009	0.012	0.027	0.029	0.023	-	-	-
29	-	-	-	0.007	0.010	0.012	0.021	0.027	0.028	-	-	-
30	-	-	-	0.007	0.010	0.018	0.035	0.027	0.026	-	-	-
31	-	-	-	-	0.012	-	0.046	0.025	-	-	-	-
min	-	-	-	0.005	0.006	0.011	0.013	0.021	0.021	0.017	-	-
mean	-	-	-	0.007	0.008	0.014	0.022	0.030	0.028	0.021	-	-
max	-	-	-	0.010	0.012	0.024	0.046	0.045	0.048	0.026	-	-

Notes: P - Partial daily average.

Table VII.11 S7 Muskeg River WSC Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	271.988 B	271.954 B	272.218 B	272.444 B	272.094 B	271.949	271.951	272.499	272.364	272.287	272.261	272.066
2	271.988 B	271.942 B	272.304 B	272.436 B	272.100 B	271.963	271.968	272.543	272.341	272.296	272.194	272.066 B
3	271.994 B	271.940 B	272.325 B	272.466 B	272.065 B	271.975	272.067	272.600	272.323	272.296	272.150	272.064 B
4	271.991 B	271.940 B	272.246 B	272.484 B	272.042 B	271.971	272.200	272.672	272.310	272.300	272.124	272.070 B
5	271.984 B	271.943 B	272.193 B	272.489 B	272.032 B	271.966	272.218	272.734	272.316	272.309	272.116	272.066 B
6	271.980 B	271.978 B	272.139 B	272.495 B	272.015 B	271.968	272.232	272.774	272.362	272.322	272.112	272.053 B
7	271.980 B	272.007 B	272.077 B	272.500 B	272.004 B	272.009	272.253	272.800	272.418	272.325	272.109	272.054 B
8	271.981 B	272.032 B	272.044 B	272.504 B	272.000 B	272.070	272.267	272.824	272.473	272.325	272.112	272.051 B
9	271.974 B	272.050 B	272.052 B	272.509 B	271.995 B	272.086	272.266	272.846	272.511	272.323	272.109	272.046 B
10	271.966 B	272.059 B	272.117 B	272.514 B	271.996 B	272.077	272.253	272.859	272.524	272.320	272.105	272.047 B
11	271.962 B	272.036 B	272.198 B	272.497 B	272.000 B	272.074	272.235	272.849	272.521	272.315	272.104	272.049 B
12	271.961 B	272.003 B	272.304 B	272.490 B	271.995	272.069	272.213	272.813	272.509	272.308	272.100	272.050 B
13	271.960 B	271.984 B	272.391 B	272.500 B	271.984	272.057	272.196	272.764	272.488	272.300	272.097	272.048 B
14	271.957 B	271.976 B	272.427 B	272.513 B	271.983	272.043	272.178	272.711	272.465	272.290	272.095	272.050 B
15	271.964 B	271.971 B	272.409 B	272.522 B	271.994	272.031	272.157	272.660	272.444	272.283	272.096 B	272.049 B
16	271.955 B	271.973 B	272.436 B	272.524 B	271.995	272.020	272.141	272.620	272.424	272.279	272.092 B	272.050 B
17	271.981 B	271.974 B	272.476 B	272.502 B	271.989	272.012	272.128	272.607	272.403	272.273	272.085 B	272.057 B
18	271.987 B	271.979 B	272.494 B	272.458 B	271.988	272.009	272.106	272.614	272.382	272.264 B	272.086 B	272.063 B
19	271.956 B	271.988 B	272.507 B	272.415 B	271.988	272.007	272.092	272.631	272.360	272.253 B	272.085 B	272.056 B
20	271.953 B	271.986 B	272.484 B	272.388 B	271.979	272.003	272.097	272.648	272.335	272.279 B	272.082 B	272.048 B
21	271.949 B	271.980 B	272.448 B	272.390 B	271.972	271.997	272.124	272.649	272.314	272.317 B	272.077 B	272.045 B
22	271.947 B	271.990 B	272.435 B	272.413 B	271.969	271.989	272.175	272.637	272.304	272.345 B	272.074 B	272.048 B
23	271.947 B	272.016 B	272.464 B	272.448 B	271.960	271.980	272.295	272.616	272.304	272.275 B	272.074 B	272.056 B
24	271.949 B	272.039 B	272.487 B	272.472 B	271.954	271.971	272.345	272.586	272.305	272.266 B	272.071 B	272.070 B
25	271.946 B	272.064 B	272.494 B	272.436 B	271.956	271.962	272.366	272.550	272.298	272.223 B	272.070 B	272.085 B
26	271.945 B	272.103 B	272.493 B	272.410 B	271.955	271.967	272.385	272.512	272.288	272.212 B	272.069 B	272.097 B
27	271.943 B	272.130 B	272.461 B	272.325 B	271.946	271.962	272.397	272.476	272.279	272.209 B	272.069	272.109 B
28	271.948 B	272.154 B	272.446 B	272.237 B	271.941	271.954	272.397	272.452	272.273	272.262 B	272.068	272.110 B
29	271.946 B	-	272.459 B	272.181 B	271.943	271.945	272.413	272.435	272.270	272.295 B	272.070	272.105 B
30	271.946 B	-	272.487 B	272.135 B	271.939	271.948	272.436	272.411	272.273	272.328 B	272.070	272.102 B
31	271.950 B	-	272.505 B	-	271.937	-	272.461	272.385	-	272.351 B	-	272.100 B
min	271.943	271.940	272.044	272.135	271.937	271.945	271.951	272.385	272.270	272.209	272.068	272.045
mean	271.964	272.007	272.355	272.437	271.991	272.001	272.226	272.638	272.373	272.291	272.101	272.066
max	271.994	272.154	272.507	272.524	272.100	272.086	272.461	272.859	272.524	272.351	272.261	272.110

Notes: All data collected at RAMP station S7. B - Ice effects.
E - Estimated. A - Manual reading.

Table VII.12 S7 Muskeg River WSC Mean Daily Water Levels (m) Based on Permanent Benchmark el. 273.720 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	0.416 B	0.210 B	0.190 B	0.273 B	1.550 B	0.839	1.014	14.529	7.861	6.906	2.664	1.059 E
2	0.407 B	0.195 B	0.190 B	0.300 B	1.470 B	0.989	2.272	16.214	7.384	6.890	1.738	0.924 B
3	0.408 B	0.190 B	0.191 B	0.300 B	1.380 B	1.093	4.448	18.327	7.053	6.999	0.931	0.922 B
4	0.395 B	0.187 B	0.191 B	0.350 B	1.300 B	1.055	4.895	20.098	7.272	7.266	0.452	0.886 B
5	0.373 B	0.186 B	0.192 B	0.400 B	1.270 B	1.000	5.293	21.113	8.606	7.616	0.317	0.824 B
6	0.359 B	0.213 B	0.192 B	0.500 B	1.200 B	1.032	5.834	21.741	10.147	7.743	0.749	0.805 B
7	0.352 B	0.234 B	0.192 B	0.600 B	1.180 B	1.481	6.117	22.328	11.635	7.742	0.824	0.775 B
8	0.346 B	0.251 B	0.193 B	0.750 B	1.170 B	2.207	6.067	22.932	12.694	7.671	0.897 A	0.743 B
9	0.327 B	0.260 B	0.193 B	0.800 B	1.190 B	2.368	5.699	23.245	13.070	7.582	0.810 E	0.726 B
10	0.308 B	0.259 B	0.193 B	0.900 B	1.200 B	2.240	5.193	22.840	12.996	7.442	0.633 E	0.710 B
11	0.298 B	0.220 B	0.194 B	1.100 B	1.250 B	2.184	4.626	21.685	12.576	7.247	0.456 E	0.696 B
12	0.292 B	0.177 B	0.194 B	1.390 B	1.280 E	2.104	4.169	20.182	11.999	7.040	0.367 A	0.672 B
13	0.287 B	0.151 B	0.195 B	1.500 B	1.500 E	1.947	3.816	18.573	11.462	6.782	0.552	0.659 B
14	0.279 B	0.137 B	0.195 B	1.400 B	1.500 E	1.786	3.460	17.037	10.859	6.614	0.943 A	0.638 B
15	0.284 B	0.126 B	0.200 B	1.200 B	1.460 E	1.631	3.225	15.945	10.272	6.531	0.977 BE	0.623 B
16	0.268 B	0.120 B	0.200 B	1.150 B	1.266 A	1.515	3.026	15.590	9.694	6.379	1.044 BE	0.624 B
17	0.299 B	0.114 B	0.200 B	1.100 B	1.244	1.414	2.716	15.790	9.135	6.161	1.111 BE	0.620 B
18	0.302 B	0.110 B	0.200 B	1.000 B	1.233	1.377	2.524	16.256	8.527	5.713 B	1.178 BE	0.587 B
19	0.258 B	0.109 B	0.200 B	1.000 B	1.240	1.350	2.635	16.750	7.838	5.748 B	1.245 BE	0.553 B
20	0.251 B	0.102 B	0.200 B	1.000 B	1.154	1.304	3.048	16.758	7.282	5.372 B	1.312 BE	0.530 B
21	0.243 B	0.092 B	0.220 B	1.100 B	1.096	1.251	4.079	16.347	7.020	5.712 B	1.379 BE	0.522 B
22	0.236 B	0.092 B	0.230 B	1.700 B	1.075	1.163	7.135	15.730	7.057	5.131 B	1.446 BE	0.524 B
23	0.233 B	0.102 B	0.230 B	1.800 B	0.980	1.071	8.470	14.754	7.079	5.286 B	1.513 BE	0.538 B
24	0.232 B	0.109 B	0.230 B	1.700 B	0.915	1.001	9.107	13.704	6.914	4.839 B	1.580 BE	0.557 B
25	0.225 B	0.119 B	0.240 B	1.500 B	0.931	0.925	9.646	12.640	6.664	4.741 B	1.647 BE	0.568 B
26	0.221 B	0.140 B	0.240 B	1.000 B	0.906	0.954	10.206	11.627	6.474	4.536 B	1.714 BE	0.579 B
27	0.215 B	0.153 B	0.240 B	1.300 B	0.813	0.917	10.370	10.977	6.319	4.679 B	1.781 E	0.564 B
28	0.217 B	0.165 B	0.233 B	1.800 B	0.779	0.842	10.550	10.485	6.218	4.214 B	1.822 A	0.538 B
29	0.211 B	-	0.234 B	1.720 B	0.790	0.774	11.424	9.817	6.308	4.423 B	1.610 E	0.515 B
30	0.209 B	-	0.237 B	1.630 B	0.748	0.800	12.509	9.068	6.691	4.832 B	1.334 E	0.498 B
31	0.209 B	-	0.254 B	-	0.747	-	13.594	8.478	-	3.923 B	-	0.487 B
min	0.209	0.092	0.190	0.273	0.747	0.774	1.014	8.478	6.218	3.923	0.317	0.487
mean	0.289	0.162	0.209	1.075	1.155	1.354	6.038	16.502	8.837	6.121	1.167	0.660
max	0.416	0.260	0.254	1.800	1.550	2.368	13.594	23.245	13.070	7.743	2.664	1.059

Notes: data for period 1 Mar - 8 Nov AND 12 Nov - 14 Nov from Environment Canada Station 07DA008.
E – Estimated. B - Ice effects.
A - Manual reading.

Table VII.13 S8 Mills Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 292.150 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	289.957	289.742	289.826	-	289.761	289.810	-	-
2	-	-	-	-	289.948	289.739	289.856	-	289.764	289.814	-	-
3	-	-	-	-	289.938	289.735	289.853	-	289.768	289.815	-	-
4	-	-	-	-	289.925	289.740	289.842	-	289.803	289.816	-	-
5	-	-	-	-	289.914	289.764	289.834	-	289.815	289.814	-	-
6	-	-	-	-	289.910	289.813	289.827	-	289.821	289.813	-	-
7	-	-	-	-	289.909	289.908	289.819	-	289.819	289.813	-	-
8	-	-	-	-	289.912	289.929	289.810	-	289.810	289.812	-	-
9	-	-	-	-	289.917	289.902	289.801	289.799 P	289.804	289.810	-	-
10	-	-	-	-	289.924	289.870	289.792	289.796	289.800	289.811	-	-
11	-	-	-	-	289.925	289.846	289.785	289.785	289.796	289.808	-	-
12	-	-	-	-	289.929	289.828	289.780	289.778	289.790	289.806	-	-
13	-	-	-	-	289.920	289.808	289.778	289.775	289.788	289.810	-	-
14	-	-	-	-	289.899	289.776	289.781	289.779	289.788	289.812	-	-
15	-	-	-	-	289.883	289.752	289.784	289.784	289.789	289.810	-	-
16	-	-	-	-	289.840	289.753	289.786	289.803	289.789	289.809	-	-
17	-	-	-	-	289.806	289.758	289.785	289.812	289.787	289.811	-	-
18	-	-	-	-	289.791	289.758	289.787	289.819	289.785	289.808	-	-
19	-	-	-	-	289.791	289.758	289.794	289.823	289.791	289.810	-	-
20	-	-	-	-	289.792	289.761	289.814	289.823	289.801	289.808	-	-
21	-	-	-	-	289.773	289.768	289.840	289.819	289.803	289.808	-	-
22	-	-	-	-	289.743	289.767	289.852	289.810	289.803	289.808	-	-
23	-	-	-	-	289.689	289.772	289.841 P	289.801	289.803	289.807	-	-
24	-	-	-	-	289.650	289.792	-	289.791	289.799	289.807	-	-
25	-	-	-	-	289.632	289.794	-	289.785	289.802	289.809 P	-	-
26	-	-	-	-	289.642	289.782	-	289.777	289.803	-	-	-
27	-	-	-	-	289.670	289.775	-	289.775	289.802	-	-	-
28	-	-	-	289.969 P	289.663	289.773	-	289.773	289.806	-	-	-
29	-	-	-	289.968	289.678	289.778	-	289.769	289.807	-	-	-
30	-	-	-	289.964	289.724	289.798	-	289.765	289.807	-	-	-
31	-	-	-	-	289.744	-	-	289.761	-	-	-	-
min	-	-	-	289.964	289.632	289.735	289.778	289.761	289.761	289.806	-	-
mean	-	-	-	289.967	289.821	289.791	289.812	289.791	289.797	289.810	-	-
max	-	-	-	289.969	289.957	289.929	289.856	289.823	289.821	289.816	-	-

Notes: P - Partial daily average.

Table VII.14 S9 Mills Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	0.006	0.031	0.532	0.555	-	-
2	-	-	-	-	-	-	0.007	0.052	0.548	0.558	-	-
3	-	-	-	-	-	-	0.004	0.098	0.521	0.606	-	-
4	-	-	-	-	-	-	0.003	0.174	0.630	0.604	-	-
5	-	-	-	-	-	-	0.003	0.268	0.699	0.595	-	-
6	-	-	-	-	-	-	0.002	0.357	0.690	0.579	-	-
7	-	-	-	-	-	-	0.002	0.431	0.675	0.600	-	-
8	-	-	-	-	-	-	0.001	0.486	0.674	0.573	-	-
9	-	-	-	-	-	-	0.001	0.520	0.673	0.574	-	-
10	-	-	-	-	-	-	0.001	0.547	0.675	0.592	-	-
11	-	-	-	-	-	0.000 P	0.001	0.573	0.683	0.576	-	-
12	-	-	-	-	-	0.000	0.001	0.574	0.676	0.537	-	-
13	-	-	-	-	-	0.000	0.000	0.586	0.677	0.528	-	-
14	-	-	-	-	-	0.000	0.000	0.652	0.656	0.559	-	-
15	-	-	-	-	-	0.000	0.000	0.698	0.630	0.524	-	-
16	-	-	-	-	-	0.000	0.001	0.773	0.615	0.519	-	-
17	-	-	-	-	-	0.000	0.001	0.766	0.588	0.542	-	-
18	-	-	-	-	-	0.000	0.001	0.766	0.558	0.537	-	-
19	-	-	-	-	-	0.001	0.001	0.839	0.559	0.525	-	-
20	-	-	-	-	-	0.001	0.006	0.818	0.579	0.501	-	-
21	-	-	-	-	-	0.000	0.010	0.793	0.597	0.483	-	-
22	-	-	-	-	-	0.000	0.005	0.786	0.581	0.466	-	-
23	-	-	-	-	-	0.000	0.003	0.782	0.561	0.446	-	-
24	-	-	-	-	-	0.000	0.003	0.770	0.547	0.436	-	-
25	-	-	-	-	-	0.000	0.002	0.765	0.533	0.438 P	-	-
26	-	-	-	-	-	0.000	0.002	0.754	0.537	-	-	-
27	-	-	-	-	-	0.000	0.003	0.733	0.517	-	-	-
28	-	-	-	-	-	0.000	0.008	0.662	0.501	-	-	-
29	-	-	-	-	-	0.001	0.006	0.609	0.570	-	-	-
30	-	-	-	-	-	0.002	0.011	0.606	0.579	-	-	-
31	-	-	-	-	-	-	0.028	0.562	-	-	-	-
min	-	-	-	-	-	0.000	0.000	0.031	0.501	0.436	-	-
mean	-	-	-	-	-	0.000	0.004	0.575	0.602	0.538	-	-
max	-	-	-	-	-	0.002	0.028	0.839	0.699	0.606	-	-

Notes: P - Partial daily average.

Table VII.15 S9 Mills Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 330.400 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	329.180	329.297	329.629	329.635	-	-
2	-	-	-	-	-	-	329.195	329.338	329.634	329.636	-	-
3	-	-	-	-	-	-	329.165	329.400	329.625	329.650	-	-
4	-	-	-	-	-	-	329.156	329.467	329.657	329.650	-	-
5	-	-	-	-	-	-	329.152	329.523	329.676	329.647	-	-
6	-	-	-	-	-	-	329.143	329.565	329.673	329.643	-	-
7	-	-	-	-	-	-	329.141	329.594	329.669	329.649	-	-
8	-	-	-	-	-	-	329.127	329.613	329.669	329.641	-	-
9	-	-	-	-	-	-	329.117	329.625	329.669	329.641	-	-
10	-	-	-	-	-	-	329.108	329.633	329.669	329.647	-	-
11	-	-	-	-	-	329.075 P	329.109	329.641	329.672	329.642	-	-
12	-	-	-	-	-	329.088	329.103	329.641	329.670	329.630	-	-
13	-	-	-	-	-	329.086	329.097	329.645	329.670	329.627	-	-
14	-	-	-	-	-	329.084	329.096	329.663	329.664	329.637	-	-
15	-	-	-	-	-	329.084	329.097	329.675	329.657	329.626	-	-
16	-	-	-	-	-	329.087	329.107	329.694	329.653	329.625	-	-
17	-	-	-	-	-	329.098	329.109	329.692	329.645	329.632	-	-
18	-	-	-	-	-	329.095	329.114	329.692	329.636	329.630	-	-
19	-	-	-	-	-	329.102	329.111	329.709	329.637	329.626	-	-
20	-	-	-	-	-	329.096	329.170	329.704	329.643	329.619	-	-
21	-	-	-	-	-	329.085	329.219	329.698	329.648	329.613	-	-
22	-	-	-	-	-	329.090	329.179	329.697	329.643	329.607	-	-
23	-	-	-	-	-	329.089	329.161	329.696	329.637	329.600	-	-
24	-	-	-	-	-	329.091	329.153	329.693	329.633	329.596	-	-
25	-	-	-	-	-	329.086	329.145	329.692	329.629	329.597 P	-	-
26	-	-	-	-	-	329.079	329.141	329.689	329.630	-	-	-
27	-	-	-	-	-	329.075	329.162	329.684	329.624	-	-	-
28	-	-	-	-	-	329.087	329.209	329.666	329.619	-	-	-
29	-	-	-	-	-	329.099	329.190	329.651	329.640	-	-	-
30	-	-	-	-	-	329.133	329.217	329.650	329.643	-	-	-
31	-	-	-	-	-	-	329.288	329.638	-	-	-	-
min	-	-	-	-	-	329.075	329.096	329.297	329.619	329.596	-	-
mean	-	-	-	-	-	329.091	329.150	329.622	329.649	329.630	-	-
max	-	-	-	-	-	329.133	329.288	329.709	329.676	329.650	-	-

Notes: P - Partial daily average.

Table VII.16 S10 Wapasu Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.029	-	-	3.502	0.531	0.801	-	-
2	-	-	-	-	0.020	-	-	4.325	0.564	0.846	-	-
3	-	-	-	-	0.016	-	-	5.238	0.507	0.889	-	-
4	-	-	-	-	0.012	-	-	5.120	0.986	0.898	-	-
5	-	-	-	-	0.012	-	-	4.729	1.345	0.884	-	-
6	-	-	-	-	0.008 P	-	-	4.541	1.456	0.876	-	-
7	-	-	-	-	-	-	-	3.951	1.504	0.882	-	-
8	-	-	-	-	-	-	-	3.418	1.485	0.852	-	-
9	-	-	-	-	-	-	-	2.928	1.400	0.832	-	-
10	-	-	-	-	-	-	-	2.439	1.274	0.788	-	-
11	-	-	-	-	-	-	-	2.053	1.173	0.729	-	-
12	-	-	-	-	-	-	-	1.730	1.034	0.670	-	-
13	-	-	-	-	-	-	-	1.540	0.950	0.672	-	-
14	-	-	-	-	-	-	-	1.509	0.854	0.689	-	-
15	-	-	-	-	-	-	-	1.698	0.787	0.612	-	-
16	-	-	-	-	0.220 P	-	-	1.921	0.718	0.579	-	-
17	-	-	-	-	0.220 P	-	-	1.855	0.665	0.612	-	-
18	-	-	-	-	-	-	-	1.624	0.598	0.581 P	-	-
19	-	-	-	-	0.224 P	-	-	1.526	0.570	-	-	-
20	-	-	-	-	0.223 P	-	-	1.645	0.641	-	-	-
21	-	-	-	-	-	-	-	1.660	0.764	-	-	-
22	-	-	-	-	-	-	-	1.505	0.743	-	-	-
23	-	-	-	0.274 P	-	-	-	1.339	0.752	-	-	-
24	-	-	-	0.220	-	-	-	1.175	0.760	-	-	-
25	-	-	-	0.161	-	-	-	1.010	0.753	-	-	-
26	-	-	-	0.111	-	-	-	1.041	0.744	-	-	-
27	-	-	-	0.094	-	-	-	0.871	0.727	-	-	-
28	-	-	-	0.094	-	-	-	0.759	0.724	-	-	-
29	-	-	-	0.062	-	-	-	0.652	0.825	-	-	-
30	-	-	-	0.042	-	-	-	0.586	0.821	-	-	-
31	-	-	-	-	-	-	3.070 P	0.540	-	-	-	-
min	-	-	-	0.042	0.008	-	3.070	0.540	0.507	0.579	-	-
mean	-	-	-	0.132	0.098	-	3.070	2.207	0.889	0.761	-	-
max	-	-	-	0.274	0.224	-	3.070	5.238	1.504	0.898	-	-

Notes: P - Partial daily average.

Table VII.17 S10 Wapasu Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 320.160 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	319.590	-	-	320.531	319.971	320.064	-	-
2	-	-	-	-	319.567	-	-	320.619	319.984	320.077	-	-
3	-	-	-	-	319.550	-	-	320.707	319.962	320.089	-	-
4	-	-	-	-	319.536	-	-	320.696	320.107	320.092	-	-
5	-	-	-	-	319.537	-	-	320.659	320.201	320.088	-	-
6	-	-	-	-	319.506 P	-	-	320.641	320.224	320.085	-	-
7	-	-	-	-	-	-	-	320.581	320.234	320.087	-	-
8	-	-	-	-	-	-	-	320.521	320.230	320.079	-	-
9	-	-	-	-	-	-	-	320.460	320.212	320.073	-	-
10	-	-	-	-	-	-	-	320.392	320.185	320.060	-	-
11	-	-	-	-	-	-	-	320.333	320.162	320.041	-	-
12	-	-	-	-	-	-	-	320.277	320.128	320.022	-	-
13	-	-	-	-	-	-	-	320.241	320.106	320.022	-	-
14	-	-	-	-	-	-	-	320.235	320.079	320.028	-	-
15	-	-	-	-	-	-	-	320.271	320.059	320.001	-	-
16	-	-	-	-	319.813 P	-	-	320.311	320.038	319.990	-	-
17	-	-	-	-	319.813 P	-	-	320.300	320.020	320.001	-	-
18	-	-	-	-	-	-	-	320.255	319.996	319.989	-	-
19	-	-	-	-	319.816 P	-	-	320.237	319.986	319.982 B	-	-
20	-	-	-	-	319.813 P	-	-	320.261	320.012	320.072 B	-	-
21	-	-	-	-	-	-	-	320.264	320.052	319.962 B	-	-
22	-	-	-	-	-	-	-	320.234	320.046	319.947 B	-	-
23	-	-	-	319.848 P	-	-	-	320.199	320.049	319.930 B	-	-
24	-	-	-	319.812	-	-	-	320.162	320.051	319.908 B	-	-
25	-	-	-	319.767	-	-	-	320.122	320.049	319.909 BP	-	-
26	-	-	-	319.720	-	-	-	320.128	320.046	-	-	-
27	-	-	-	319.700	-	-	-	320.084	320.040	-	-	-
28	-	-	-	319.700	-	-	-	320.050	320.040	-	-	-
29	-	-	-	319.656	-	-	-	320.015	320.071	-	-	-
30	-	-	-	319.622	-	-	-	319.992	320.070	-	-	-
31	-	-	-	-	-	-	320.478 P	319.975	-	-	-	-
min	-	-	-	319.622	319.506	-	320.478	319.975	319.962	319.908	-	-
mean	-	-	-	319.728	319.652	-	320.478	320.315	320.080	320.024	-	-
max	-	-	-	319.848	319.816	-	320.478	320.707	320.234	320.092	-	-

Notes: P - Partial daily average.
B - Ice effects.

Table VII.18 S11 Poplar Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.151	0.193	0.070	0.826	1.807	1.689	-	-
2	-	-	-	-	0.178	0.172	0.128	0.793	1.882	1.637	-	-
3	-	-	-	-	0.132	0.168	0.086	0.776	1.781	1.695	-	-
4	-	-	-	-	0.160	0.145	0.074	0.744	2.074	1.689	-	-
5	-	-	-	-	0.129	0.140	0.091	0.839	2.893	1.673	-	-
6	-	-	-	-	0.118	0.241	0.084	1.213	3.248	1.598	-	-
7	-	-	-	-	0.121	0.449	0.070	1.189	3.382	1.580	-	-
8	-	-	-	-	0.159	0.342	0.051	1.133	3.543	1.514	-	-
9	-	-	-	-	0.114	0.268	0.040	1.070	3.485	1.477	-	-
10	-	-	-	-	0.076	0.195	0.031	0.956	3.367	1.454	-	-
11	-	-	-	-	0.070	0.174	0.026	0.822	3.285	1.350	-	-
12	-	-	-	-	0.076	0.155	0.023	X	3.031	1.293	-	-
13	-	-	-	-	0.067	0.139	0.019	0.889	2.857	1.275	-	-
14	-	-	-	-	0.059	0.108	0.019	X	2.556	-	-	-
15	-	-	-	-	0.063	0.090	0.019	X	2.341	-	-	-
16	-	-	-	-	0.071	0.099	0.016	9.994	2.175	-	-	-
17	-	-	-	-	0.045	0.087	0.013	2.870	2.076	-	-	-
18	-	-	-	-	0.036	0.081	0.013	2.191	1.939	-	-	-
19	-	-	-	-	0.031	0.073	0.015	1.418	1.818	-	-	-
20	-	-	-	-	0.061	0.053	0.058	1.712	1.828	-	-	-
21	-	-	-	-	0.065	0.059	0.216	2.036	1.817	-	-	-
22	-	-	-	-	0.035	0.043	0.142	1.938	1.797	-	-	-
23	-	-	-	0.543 P	0.026	0.035	0.125	1.804	1.738	-	-	-
24	-	-	-	0.405	0.022	0.031	0.111	1.636	1.702	-	-	-
25	-	-	-	0.385	0.026	0.027	0.090	1.509	1.678	-	-	-
26	-	-	-	0.332	0.026	0.020	0.075	1.971	1.620	-	-	-
27	-	-	-	0.298	0.025	0.018	0.065	1.964	1.606	-	-	-
28	-	-	-	0.300	0.040	0.017	0.201	1.848	1.583	-	-	-
29	-	-	-	0.267	0.152	0.019	0.248	1.779	1.711	-	-	-
30	-	-	-	0.208	0.297	0.045	0.310	1.791	1.739	-	-	-
31	-	-	-	-	0.223	-	0.587	1.887	-	-	-	-
min	-	-	-	0.208	0.022	0.017	0.013	0.744	1.583	1.275	-	-
mean	-	-	-	0.342	0.092	0.123	0.100	1.771	2.279	1.533	-	-
max	-	-	-	0.543	0.297	0.449	0.587	9.994	3.543	1.695	-	-

Notes: P - Partial daily average.
X - Water levels exceeded range of stage-discharge rating curve.

Table VII.19 S11 Poplar Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 244.550 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	240.970	240.984	240.927	241.077	241.167	241.157	-	-
2	-	-	-	-	240.979	240.977	240.961	241.074	241.173	241.152	-	-
3	-	-	-	-	240.963	240.976	240.940	241.072	241.165	241.157	-	-
4	-	-	-	-	240.970	240.968	240.932	241.069	241.188	241.157	-	-
5	-	-	-	-	240.961	240.965	240.943	241.077	241.242	241.155	-	-
6	-	-	-	-	240.956	240.995	240.939	241.110	241.262	241.149	-	-
7	-	-	-	-	240.958	241.035	240.929	241.107	241.269	241.147	-	-
8	-	-	-	-	240.968	241.018	240.914	241.101	241.277	241.141	-	-
9	-	-	-	-	240.954	241.003	240.903	241.096	241.274	241.137	-	-
10	-	-	-	241.568 P	240.934	240.984	240.893	241.087	241.268	241.135	-	-
11	-	-	-	241.460	240.929	240.978	240.885	241.076	241.264	241.125	-	-
12	-	-	-	241.272	240.934	240.971	240.879	242.324	241.250	241.119	-	-
13	-	-	-	241.249	240.927	240.965	240.872	241.082	241.240	241.117 P	-	-
14	-	-	-	241.241	240.921	240.952	240.871	242.207	241.221	-	-	-
15	-	-	-	241.239	240.919	240.942	240.872	242.158	241.207	-	-	-
16	-	-	-	241.237	240.929	240.947	240.864	241.459	241.195	-	-	-
17	-	-	-	241.240	240.907	240.941	240.856	241.237	241.188	-	-	-
18	-	-	-	241.239	240.898	240.937	240.858	241.189	241.178	-	-	-
19	-	-	-	241.238	240.893	240.931	240.861	241.132	241.168	-	-	-
20	-	-	-	241.241	240.917	240.916	240.901	241.157	241.169	-	-	-
21	-	-	-	241.244	240.926	240.921	240.990	241.181	241.168	-	-	-
22	-	-	-	241.245	240.896	240.906	240.966	241.177	241.166	-	-	-
23	-	-	-	241.048	240.884	240.898	240.960	241.167	241.161	-	-	-
24	-	-	-	241.028	240.878	240.892	240.953	241.152	241.158	-	-	-
25	-	-	-	241.024	240.883	240.886	240.942	241.141	241.156	-	-	-
26	-	-	-	241.016	240.884	240.874	240.933	241.179	241.151	-	-	-
27	-	-	-	241.009	240.882	240.869	240.926	241.179	241.149	-	-	-
28	-	-	-	241.010	240.901	240.867	240.983	241.170	241.147	-	-	-
29	-	-	-	241.003	240.963	240.871	240.998	241.165	241.159	-	-	-
30	-	-	-	240.988	241.009	240.905	241.012	241.166	241.161	-	-	-
31	-	-	-	-	240.992	-	241.052	241.173	-	-	-	-
min	-	-	-	240.988	240.878	240.867	240.856	241.069	241.147	241.117	-	-
mean	-	-	-	241.183	240.932	240.942	240.926	241.250	241.198	241.142	-	-
max	-	-	-	241.568	241.009	241.035	241.052	242.324	241.277	241.157	-	-

Notes: P - Partial daily average.

Table VII.20 S12 Fort Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	0.052	0.164	0.052	0.031	-	-
2	-	-	-	-	-	-	0.105	0.172	0.056	0.034	-	-
3	-	-	-	-	-	-	0.087	0.151	0.051	0.041	-	-
4	-	-	-	-	-	-	0.071	0.135	0.104	0.042	-	-
5	-	-	-	-	-	-	0.088	0.101	0.122	0.040	-	-
6	-	-	-	-	-	-	0.104	0.158	0.107	0.038	-	-
7	-	-	-	-	-	-	0.052	0.151	0.104	0.040	-	-
8	-	-	-	-	-	-	0.058	0.104	0.094	0.038	-	-
9	-	-	-	-	-	0.116P	0.039	0.087	0.085	0.038	-	-
10	-	-	-	-	-	0.105	0.043	0.071	0.075	0.038	-	-
11	-	-	-	-	-	0.089	0.025	0.067	0.065	0.034	-	-
12	-	-	-	-	-	0.051	0.041	0.052	0.055	0.032	-	-
13	-	-	-	-	-	0.042	0.021	0.053	0.056	0.034	-	-
14	-	-	-	-	-	0.044	0.019	0.056	0.049	0.034	-	-
15	-	-	-	-	-	0.038	0.026	0.073	0.045	0.031	-	-
16	-	-	-	-	-	0.035	0.016	0.156	0.042	0.031	-	-
17	-	-	-	-	-	0.031	0.014	0.120	0.041	0.040	-	-
18	-	-	-	-	-	0.035	0.019	0.122	0.039	0.035	-	-
19	-	-	-	-	-	0.028	0.019	0.132	0.039	0.033	-	-
20	-	-	-	-	-	0.025	0.059	0.130	0.037	0.033	-	-
21	-	-	-	-	-	0.027	0.116	0.107	0.033	0.028	-	-
22	-	-	-	-	-	0.028	0.086	0.105	0.032	0.028	-	-
23	-	-	-	-	-	0.027	0.085	0.095	0.031	0.027P	-	-
24	-	-	-	-	-	0.028	0.077	0.076	0.029	-	-	-
25	-	-	-	-	-	0.651	0.055	0.062	0.028	-	-	-
26	-	-	-	-	-	0.177	0.055	0.063	0.027	-	-	-
27	-	-	-	-	-	0.021	0.164	0.065	0.026	-	-	-
28	-	-	-	-	-	0.015	0.070	0.054	0.028	-	-	-
29	-	-	-	-	-	0.011	0.070	0.050	0.039	-	-	-
30	-	-	-	-	-	0.021	0.127	0.052	0.035	-	-	-
31	-	-	-	-	-	-	0.200	0.050	-	-	-	-
min	-	-	-	-	-	0.011	0.014	0.050	0.026	0.028	-	-
mean	-	-	-	-	-	0.073	0.066	0.098	0.054	0.035	-	-
max	-	-	-	-	-	0.651	0.200	0.172	0.122	0.042	-	-

Notes: Backwater effects from downstream ice begin on 23 October; no subsequent discharges reported.
P - Partial daily average. B - Ice effects.

Table VII.21 S12 Fort Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 253.440 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	251.016	251.086	251.020	250.995	-	-
2	-	-	-	-	-	-	251.058	251.087	251.024	250.999	-	-
3	-	-	-	-	-	-	251.047	251.081	251.018	251.007	-	-
4	-	-	-	-	-	-	251.036	251.073	251.056	251.010	-	-
5	-	-	-	-	-	-	251.045	251.055	251.067	251.007	-	-
6	-	-	-	-	-	-	251.052	251.082	251.059	251.004	-	-
7	-	-	-	-	-	-	251.017	251.079	251.057	251.006	-	-
8	-	-	-	-	-	-	251.025	251.057	251.052	251.005	-	-
9	-	-	-	-	-	251.064 P	251.005	251.047	251.046	251.004	-	-
10	-	-	-	-	-	251.058	251.009	251.036	251.039	251.004	-	-
11	-	-	-	-	-	251.048	250.985	251.032	251.031	251.000	-	-
12	-	-	-	-	-	251.018	251.005	251.020	251.022	250.996	-	-
13	-	-	-	-	-	251.008	250.978	251.020	251.023	250.999	-	-
14	-	-	-	-	-	251.010	250.973	251.024	251.017	250.999	-	-
15	-	-	-	-	-	251.004	250.987	251.035	251.013	250.996	-	-
16	-	-	-	-	-	251.000	250.966	251.083	251.009	250.994	-	-
17	-	-	-	-	-	250.995	250.961	251.066	251.008	251.007	-	-
18	-	-	-	-	-	251.000	250.974	251.067	251.005	251.001	-	-
19	-	-	-	-	-	250.991	250.974	251.072	251.005	250.998	-	-
20	-	-	-	-	-	250.985	251.014	251.071	251.003	251.047	-	-
21	-	-	-	-	-	250.989	251.064	251.059	250.998	250.991	-	-
22	-	-	-	-	-	250.991	251.046	251.058	250.996	251.015	-	-
23	-	-	-	-	-	250.989	251.046	251.052	250.994	250.989 P	-	-
24	-	-	-	-	-	250.991	251.040	251.039	250.992	-	-	-
25	-	-	-	-	-	251.090	251.022	251.029	250.990	-	-	-
26	-	-	-	-	-	251.056	251.021	251.029	250.989	-	-	-
27	-	-	-	-	-	250.978	251.054	251.031	250.987	-	-	-
28	-	-	-	-	-	250.964	251.032	251.021	250.991	-	-	-
29	-	-	-	-	-	250.955	251.035	251.018	251.006	-	-	-
30	-	-	-	-	-	250.976	251.065	251.020	251.000	-	-	-
31	-	-	-	-	-	-	251.098	251.018	-	-	-	-
min	-	-	-	-	-	250.955	250.961	251.018	250.987	250.989	-	-
mean	-	-	-	-	-	251.007	251.021	251.050	251.017	251.003	-	-
max	-	-	-	-	-	251.090	251.098	251.087	251.067	251.047	-	-

Notes: P - Partial daily average.
B - Ice effects.

Table VII.22 S13 Albian Sands Pond #3 Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.006	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.003	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.001	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.024	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.003	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.012	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.007	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.004	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.006	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000
29	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.048	0.000	0.000
30	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.043	0.000	0.000
31	0.000	-	0.000	-	0.000	-	0.050	0.000	-	0.028	-	0.000
min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
mean	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.003	0.003	0.005	0.000	0.000
max	0.000	0.000	0.000	0.000	0.000	0.000	0.050	0.025	0.029	0.048	0.000	0.000

Notes: P - Partial daily average.
Monitoring period 5 May - 7 December; no pond releases outside of this period.

Table VII.23 S13 Albian Sands Pond #3 Mean Daily Water Levels (m) Based on Permanent Benchmark el. 279.590 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	278.151	278.144	278.986	278.368	278.591	278.120	278.134
2	-	-	-	-	-	278.153	278.147	278.930	278.342	278.532	278.127	278.131
3	-	-	-	-	-	278.154	278.152	278.781	278.795	278.478	278.132	278.130
4	-	-	-	-	-	278.157	278.146	278.678	279.014	278.428	278.132	278.138
5	-	-	-	-	278.115	278.155	278.147	278.614	278.976	278.380	278.131	278.137
6	-	-	-	-	278.113	278.149	278.150	278.568	278.914	278.336	278.132	278.136
7	-	-	-	-	278.115	278.153	278.154	278.520	278.772	278.295	278.132	278.131
8	-	-	-	-	278.117	278.157	278.157	278.483	278.677	278.255	278.133	-
9	-	-	-	-	278.120	278.155	278.158	278.677	278.850	278.222	278.134	-
10	-	-	-	-	278.123	278.155	278.160	279.012	278.947	278.189	278.134	-
11	-	-	-	-	278.122	278.155	278.158	278.964	278.927	278.153	278.134	-
12	-	-	-	-	278.126	278.155	278.157	278.944	278.916	278.149	278.130	-
13	-	-	-	-	278.130	278.155	278.156	278.938	278.870	278.140	278.131	-
14	-	-	-	-	278.130	278.152	278.150	278.938	278.735	278.138	278.133	-
15	-	-	-	-	278.130	278.151	278.150	278.944	278.646	278.734	278.136	-
16	-	-	-	-	278.135	278.149	278.151	278.976	278.573	278.945	278.135	-
17	-	-	-	-	278.138	278.149	278.151	278.916	278.515	278.920	278.133	-
18	-	-	-	-	278.141	278.152	278.147	278.780	278.462	278.880	278.132	-
19	-	-	-	-	278.137	278.147	278.484	278.909	278.420	278.737	278.134	-
20	-	-	-	-	278.137	278.151	279.005	278.973	278.379	278.629	278.134	-
21	-	-	-	-	278.141	278.152	278.986	278.955	278.333	278.547	278.134	-
22	-	-	-	-	278.141	278.156	278.943	278.946	278.293	278.484	278.134	-
23	-	-	-	-	278.142	278.158	278.921	278.901	278.729	278.429	278.137	-
24	-	-	-	-	278.146	278.154	278.871	278.772	278.935	278.380	278.137	-
25	-	-	-	-	278.146	278.157	278.720	278.677	278.909	278.330	278.137	-
26	-	-	-	-	278.150	278.160	278.615	278.611	278.921	278.277	278.137	-
27	-	-	-	-	278.151	278.159	278.538	278.556	278.910	278.229	278.137	-
28	-	-	-	-	278.153	278.152	278.497	278.510	278.893	278.653	278.135	-
29	-	-	-	-	278.148	278.152	278.437	278.469	278.780	279.061	278.134	-
30	-	-	-	-	278.148	278.146	278.419	278.430	278.670	279.050	278.134	-
31	-	-	-	-	278.147	-	278.874	278.396	-	278.747	-	-
min	-	-	-	-	278.113	278.146	278.146	278.396	278.293	278.138	278.127	278.130
mean	-	-	-	-	278.135	278.154	278.397	278.759	278.728	278.491	278.134	278.134
max	-	-	-	-	278.153	278.160	279.005	279.012	279.014	279.061	278.137	278.138

Notes: P - Partial daily average.
Monitoring period 5 May - 7 December; no pond releases outside of this period.

Table VII.24 S14 Ells River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	6.469	3.523	3.512	12.397	8.597	5.908	-	-
2	-	-	-	-	5.800	3.501	3.789	14.151	8.319	5.987	-	-
3	-	-	-	-	5.228	3.501	4.016	13.958	8.044	5.916	-	-
4	-	-	-	-	5.202	3.472	5.172	13.003	8.418	5.873	-	-
5	-	-	-	-	5.245	3.481	5.602	12.509	8.309	6.019	-	-
6	-	-	-	-	5.145	3.752	5.444	12.408	8.178	5.979	-	-
7	-	-	-	-	4.619	3.859	5.555	12.661	8.401	6.031	-	-
8	-	-	-	-	4.140	3.909	5.541	12.751	8.210	5.907	-	-
9	-	-	-	-	3.755	4.356	5.228	12.548	7.836	5.895	-	-
10	-	-	-	-	11.917	4.388	5.058	11.935	7.561	5.819	-	-
11	-	-	-	-	9.852	4.220	4.907	11.552	7.315	5.791	-	-
12	-	-	-	-	5.386	3.957	4.788	11.215	7.144	5.750	-	-
13	-	-	-	-	4.956	3.838	4.670	10.938	7.056	5.571	-	-
14	-	-	-	-	5.513	3.654	4.864	10.855	6.840	5.557	-	-
15	-	-	-	-	6.114	3.517	4.844	10.981	6.764	6.034	-	-
16	-	-	-	-	5.961	3.500	4.794	11.489	6.587	5.733	-	-
17	-	-	-	-	5.441	3.292	4.915	11.727	6.559	5.974	-	-
18	-	-	-	-	5.228	3.218	5.551	12.037	6.441	4.937	-	-
19	-	-	-	-	4.880	3.228	5.459	12.023	6.395	5.233	-	-
20	-	-	-	-	4.481	3.156	5.706	11.792	6.300	5.940	-	-
21	-	-	-	-	4.043	3.098	6.796	11.708	6.215	-	-	-
22	-	-	-	-	3.767	3.040	7.317	11.038	6.285	-	-	-
23	-	-	-	-	3.759	2.946	8.045	10.521	6.204	-	-	-
24	-	-	-	-	3.496	2.975	7.847	10.114	6.040	-	-	-
25	-	-	-	-	3.372	2.850	7.975	9.607	5.894	-	-	-
26	-	-	-	-	3.159	2.858	7.868	9.490	5.810	-	-	-
27	-	-	-	-	3.092	2.897	7.847	9.358	5.741	-	-	-
28	-	-	-	8.393 P	3.106	2.959	8.527	9.252	5.671	-	-	-
29	-	-	-	7.233	3.127	2.958	8.032	9.123	5.831	-	-	-
30	-	-	-	6.580	3.258	3.110	9.566	9.035	5.808	-	-	-
31	-	-	-	-	3.210	-	10.494	8.898	-	-	-	-
min	-	-	-	-	3.092	2.850	3.512	8.898	5.671	4.937	-	-
mean	-	-	-	-	4.927	3.434	6.120	11.325	6.959	5.793	-	-
max	-	-	-	-	11.917	4.388	10.494	14.151	8.597	6.034	-	-

Notes: P - Partial daily average.
B - Ice effects.

Table VII.25 S14 Ells River Mean Daily Water Levels (m) Based on Permanent Benchmark el. 236.615 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	233.776	233.620	233.618	233.964	233.856	233.751	-	-
2	-	-	-	-	233.746	233.618	233.638	234.007	233.846	233.755	-	-
3	-	-	-	-	233.718	233.618	233.652	234.003	233.837	233.752	-	-
4	-	-	-	-	233.717	233.616	233.715	233.980	233.850	233.750	-	-
5	-	-	-	-	233.720	233.617	233.737	233.968	233.846	233.756	-	-
6	-	-	-	-	233.715	233.635	233.730	233.966	233.841	233.755	-	-
7	-	-	-	-	233.687	233.642	233.735	233.972	233.849	233.757	-	-
8	-	-	-	-	233.659	233.645	233.734	233.974	233.842	233.751	-	-
9	-	-	-	-	233.634	233.672	233.719	233.969	233.829	233.751	-	-
10	-	-	-	-	233.953	233.674	233.710	233.954	233.819	233.747	-	-
11	-	-	-	-	233.884	233.664	233.703	233.944	233.810	233.746	-	-
12	-	-	-	-	233.726	233.648	233.696	233.935	233.803	233.744	-	-
13	-	-	-	-	233.705	233.641	233.690	233.927	233.800	233.736	-	-
14	-	-	-	-	233.733	233.629	233.700	233.925	233.791	233.734	-	-
15	-	-	-	-	233.760	233.619	233.699	233.928	233.788	233.757	-	-
16	-	-	-	-	233.753	233.618	233.697	233.942	233.781	233.743	-	-
17	-	-	-	-	233.728	233.604	233.703	233.948	233.780	233.754	-	-
18	-	-	-	-	233.718	233.598	233.735	233.956	233.775	233.703	-	-
19	-	-	-	-	233.701	233.599	233.730	233.956	233.773	233.717	-	-
20	-	-	-	-	233.679	233.594	233.742	233.950	233.769	233.763	-	-
21	-	-	-	-	233.653	233.589	233.789	233.948	233.765	234.130	-	-
22	-	-	-	-	233.636	233.585	233.810	233.930	233.768	234.025	-	-
23	-	-	-	-	233.635	233.577	233.837	233.915	233.765	233.891	-	-
24	-	-	-	-	233.618	233.580	233.830	233.903	233.757	234.098	-	-
25	-	-	-	-	233.609	233.570	233.834	233.888	233.751	234.246	-	-
26	-	-	-	-	233.594	233.570	233.830	233.884	233.747	234.208	-	-
27	-	-	-	-	233.589	233.574	233.830	233.880	233.744	234.130 P	-	-
28	-	-	-	233.849 P	233.590	233.578	233.853	233.877	233.740	-	-	-
29	-	-	-	233.806	233.591	233.578	233.836	233.873	233.748	-	-	-
30	-	-	-	233.780	233.601	233.590	233.886	233.870	233.747	-	-	-
31	-	-	-	-	233.598	-	233.914	233.866	-	-	-	-
min	-	-	-	-	233.589	233.570	233.618	233.866	233.740	233.703	-	-
mean	-	-	-	-	233.691	233.612	233.753	233.935	233.794	233.839	-	-
max	-	-	-	-	233.953	233.674	233.914	234.007	233.856	234.246	-	-

Notes: P - Partial daily average.
B - Ice effects.

Table VII.26 S15 Tar River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	2.769	0.461	0.530	2.496	0.525	0.538	-	-
2	-	-	-	-	1.898	0.469	1.307	1.949	0.502	0.532	-	-
3	-	-	-	-	2.589	0.519	1.401	1.559	0.471	0.524	-	-
4	-	-	-	-	2.065	0.511	1.037	1.350	0.549	0.592	-	-
5	-	-	-	-	1.673	0.488	0.908	1.232	0.795	0.663	-	-
6	-	-	-	-	1.433	0.518	0.904	1.241	0.933	0.625	-	-
7	-	-	-	-	1.196	0.630	0.799	1.229	0.929	0.587	-	-
8	-	-	-	-	1.048	0.987	0.698	1.085	0.865	0.568	-	-
9	-	-	-	-	0.836	1.131	0.633	0.947	0.776	0.548	-	-
10	-	-	-	-	0.710	1.066	0.562	0.816	0.703	0.546	-	-
11	-	-	-	-	0.986	0.880	0.495	0.737	0.634	0.525	-	-
12	-	-	-	-	1.089	0.754	0.471	0.677	0.589	0.508	-	-
13	-	-	-	-	1.201	0.665	0.447	0.622	0.551	0.459	-	-
14	-	-	-	-	1.302	0.560	0.444	0.587	0.518	0.501	-	-
15	-	-	-	-	1.106	0.512	0.532	0.621	0.485	0.449	-	-
16	-	-	-	-	0.823	0.511	0.655	0.831	0.463	0.390	-	-
17	-	-	-	-	0.705	0.481	0.701	1.249	0.444	-	-	-
18	-	-	-	-	0.668	0.506	0.844	1.110	0.447	-	-	-
19	-	-	-	-	0.622	0.466	0.734	1.031	0.419	-	-	-
20	-	-	-	-	0.521	0.442	1.005	0.927	0.417	-	-	-
21	-	-	-	-	0.471	0.384	1.896	0.834	0.431	-	-	-
22	-	-	-	-	0.429	0.374	1.913	0.739	0.531	-	-	-
23	-	-	-	-	0.471	0.379	1.427	0.651	0.577	-	-	-
24	-	-	-	-	0.460	0.392	1.302	0.584	0.551	-	-	-
25	-	-	-	-	0.421	0.375	1.252	0.534	0.519	-	-	-
26	-	-	-	-	0.406	0.358	1.094	0.517	0.484	-	-	-
27	-	-	-	-	0.416	0.380	1.004	0.529	0.476	-	-	-
28	-	-	-	-	0.430	0.358	1.143	0.507	0.458	-	-	-
29	-	-	-	-	0.432	0.346	1.463	0.476	0.473	-	-	-
30	-	-	-	-	0.460	0.383	1.325	0.459	0.521	-	-	-
31	-	-	-	-	0.484	-	1.942	0.503	-	-	-	-
min	-	-	-	-	0.406	0.346	0.444	0.459	0.417	0.390	-	-
mean	-	-	-	-	0.972	0.543	0.996	0.924	0.568	0.535	-	-
max	-	-	-	-	2.769	1.131	1.942	2.496	0.933	0.663	-	-

Notes: P - Partial daily average.

Table VII.27 S15 Tar River Mean Daily Water Levels (m) Based on Permanent Benchmark el. 285.908 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	283.133	282.819	282.836	283.117	282.839	282.843	-	-
2	-	-	-	-	283.063	282.822	282.990	283.068	282.832	282.841	-	-
3	-	-	-	-	283.119	282.837	283.006	283.026	282.822	282.839	-	-
4	-	-	-	-	283.075	282.835	282.952	283.000	282.846	282.858	-	-
5	-	-	-	-	283.036	282.828	282.929	282.983	282.906	282.877	-	-
6	-	-	-	-	283.008	282.837	282.929	282.984	282.934	282.867	-	-
7	-	-	-	-	282.974	282.868	282.908	282.983	282.933	282.857	-	-
8	-	-	-	-	282.949	282.943	282.885	282.960	282.921	282.852	-	-
9	-	-	-	-	282.911	282.967	282.869	282.937	282.903	282.846	-	-
10	-	-	-	-	282.887	282.957	282.850	282.911	282.886	282.845	-	-
11	-	-	-	-	282.938	282.923	282.830	282.894	282.869	282.839	-	-
12	-	-	-	-	282.958	282.897	282.822	282.880	282.858	282.834	-	-
13	-	-	-	-	282.977	282.876	282.814	282.866	282.847	282.818	-	-
14	-	-	-	-	282.990	282.849	282.813	282.857	282.837	282.832	-	-
15	-	-	-	-	282.960	282.834	282.840	282.866	282.827	282.814	-	-
16	-	-	-	-	282.904	282.834	282.874	282.912	282.820	282.793	-	-
17	-	-	-	-	282.885	282.825	282.884	282.985	282.813	282.834	-	-
18	-	-	-	-	282.877	282.832	282.913	282.964	282.814	282.820	-	-
19	-	-	-	-	282.866	282.820	282.889	282.951	282.804	282.830	-	-
20	-	-	-	-	282.838	282.811	282.947	282.933	282.803	282.891	-	-
21	-	-	-	-	282.822	282.791	283.054	282.915	282.809	282.849 P	-	-
22	-	-	-	-	282.807	282.787	283.064	282.894	282.841	-	-	-
23	-	-	-	-	282.821	282.789	283.010	282.874	282.854	-	-	-
24	-	-	-	283.214 P	282.818	282.794	282.993	282.856	282.847	-	-	-
25	-	-	-	283.193	282.805	282.787	282.986	282.842	282.837	-	-	-
26	-	-	-	283.205	282.799	282.780	282.962	282.837	282.826	-	-	-
27	-	-	-	283.184	282.802	282.789	282.947	282.841	282.824	-	-	-
28	-	-	-	283.137	282.808	282.780	282.969	282.834	282.818	-	-	-
29	-	-	-	283.115	282.809	282.775	283.014	282.824	282.823	-	-	-
30	-	-	-	283.115	282.818	282.789	282.996	282.818	282.838	-	-	-
31	-	-	-	-	282.826	-	283.063	282.832	-	-	-	-
min	-	-	-	283.115	282.799	282.775	282.813	282.818	282.803	282.793	-	-
mean	-	-	-	283.166	282.912	282.836	282.930	282.918	282.848	282.842	-	-
max	-	-	-	283.214	283.133	282.967	283.064	283.117	282.934	282.891	-	-

Notes: P - Partial daily average.

Table VII.28 S16 Calumet River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	0.024	0.039	0.591	0.098	0.080	-	-
2	-	-	-	-	-	0.025	0.052	0.586	0.105	0.081	-	-
3	-	-	-	-	-	0.029	0.044	0.439	0.099	0.086	-	-
4	-	-	-	-	-	0.028	0.050	0.324	0.171	0.086	-	-
5	-	-	-	-	-	0.028	0.053	0.316	0.179	0.083	-	-
6	-	-	-	-	-	0.035	0.047	0.368	0.180	0.081	-	-
7	-	-	-	-	-	0.053	0.041	0.332	0.172	0.079	-	-
8	-	-	-	-	-	0.086	0.038	0.279	0.160	0.085	-	-
9	-	-	-	-	-	0.073	0.033	0.230	0.142	0.086	-	-
10	-	-	-	-	-	0.056	0.031	0.190	0.127	0.084	-	-
11	-	-	-	-	-	0.045	0.028	0.161	0.119	0.077	-	-
12	-	-	-	-	-	0.040	0.026	0.142	0.108	0.074	-	-
13	-	-	-	-	-	0.037	0.024	0.148	0.110	0.074	-	-
14	-	-	-	-	-	0.035	0.025	0.150	0.101	0.073	-	-
15	-	-	-	-	-	0.033	0.029	0.159	0.094	0.065	-	-
16	-	-	-	-	0.056 P	0.030	0.024	0.316	0.096	0.063	-	-
17	-	-	-	-	0.048	0.028	0.022	0.304	0.085	0.072	-	-
18	-	-	-	-	0.040	0.026	0.026	0.273	0.078	0.074	-	-
19	-	-	-	-	0.060	0.026	0.028	0.263	0.082	0.076	-	-
20	-	-	-	-	0.045	0.024	0.061	0.231	0.084	0.066	-	-
21	-	-	-	-	0.083	0.021	0.196	0.180	0.080	0.059	-	-
22	-	-	-	-	0.045	0.021	0.143	0.162	0.079	0.058	-	-
23	-	-	-	-	0.032	0.020	0.193	0.142	0.077	0.057	-	-
24	-	-	-	-	0.027	0.021	0.139	0.127	0.074	0.058	-	-
25	-	-	-	-	0.023	0.017	0.095	0.106	0.072	0.059	-	-
26	-	-	-	-	0.026	0.015	0.108	0.112	0.071	0.058	-	-
27	-	-	-	-	0.042	0.015	0.115	0.108	0.070	0.056 P	-	-
28	-	-	-	-	0.026	0.015	0.235	0.100	0.073	-	-	-
29	-	-	-	-	0.019	0.017	0.286	0.097	0.086	-	-	-
30	-	-	-	-	0.025	0.022	0.306	0.097	0.082	-	-	-
31	-	-	-	-	0.024	-	0.472	0.087	-	-	-	-
min	-	-	-	-	0.019	0.015	0.022	0.087	0.070	0.056	-	-
mean	-	-	-	-	0.039	0.032	0.097	0.230	0.105	0.072	-	-
max	-	-	-	-	0.083	0.086	0.472	0.591	0.180	0.086	-	-

Notes: P - Partial daily average.

Table VII.29 S16 Calumet River Mean Daily Water Levels (m) Based on Permanent Benchmark el. 266.300 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	263.980	264.009	264.240	264.076	264.060	-	-
2	-	-	-	-	-	263.984	264.030	264.239	264.081	264.062	-	-
3	-	-	-	-	-	263.991	264.019	264.208	264.077	264.066	-	-
4	-	-	-	-	-	263.990	264.026	264.178	264.119	264.066	-	-
5	-	-	-	-	-	263.991	264.031	264.176	264.124	264.063	-	-
6	-	-	-	-	-	264.003	264.022	264.191	264.125	264.061	-	-
7	-	-	-	-	-	264.032	264.015	264.181	264.121	264.059	-	-
8	-	-	-	-	-	264.064	264.009	264.164	264.115	264.065	-	-
9	-	-	-	-	-	264.054	264.000	264.146	264.105	264.066	-	-
10	-	-	-	-	-	264.034	263.996	264.130	264.096	264.064	-	-
11	-	-	-	-	-	264.020	263.990	264.116	264.091	264.057	-	-
12	-	-	-	-	-	264.013	263.985	264.105	264.083	264.055	-	-
13	-	-	-	-	-	264.008	263.981	264.108	264.084	264.055	-	-
14	-	-	-	-	-	264.004	263.984	264.109	264.078	264.053	-	-
15	-	-	-	-	-	264.000	263.993	264.113	264.072	264.045	-	-
16	-	-	-	-	264.035 P	263.994	263.981	264.176	264.074	264.044	-	-
17	-	-	-	-	264.025	263.990	263.976	264.172	264.065	264.052	-	-
18	-	-	-	-	264.012	263.987	263.985	264.162	264.059	264.055	-	-
19	-	-	-	-	264.040	263.986	263.991	264.159	264.062	264.057	-	-
20	-	-	-	-	264.018	263.982	264.030	264.147	264.064	264.047	-	-
21	-	-	-	-	264.063	263.975	264.110	264.125	264.061	264.038	-	-
22	-	-	-	-	264.020	263.973	264.105	264.116	264.059	264.038	-	-
23	-	-	-	-	263.999	263.972	264.130	264.105	264.058	264.036	-	-
24	-	-	-	-	263.988	263.972	264.102	264.095	264.055	264.038	-	-
25	-	-	-	-	263.980	263.962	264.073	264.081	264.053	264.038	-	-
26	-	-	-	-	263.987	263.956	264.082	264.085	264.052	264.037	-	-
27	-	-	-	-	264.011	263.954	264.087	264.083	264.050	264.034 P	-	-
28	-	-	-	-	263.982	263.954	264.147	264.077	264.054	-	-	-
29	-	-	-	-	263.967	263.962	264.166	264.075	264.065	-	-	-
30	-	-	-	-	263.984	263.976	264.170	264.075	264.062	-	-	-
31	-	-	-	-	263.982	-	264.216	264.067	-	-	-	-
min	-	-	-	-	263.967	263.954	263.976	264.067	264.050	264.034	-	-
mean	-	-	-	-	264.006	263.992	264.047	264.136	264.078	264.052	-	-
max	-	-	-	-	264.063	264.064	264.216	264.240	264.125	264.066	-	-

Notes: P - Partial daily average.

Table VII.30 S17 Tar River Upland Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	364.085	363.894	363.980	363.900	363.936	-	-
2	-	-	-	-	-	364.086	363.890	363.894	363.900	363.940	-	-
3	-	-	-	-	-	364.085	363.890	363.898	363.899	363.942	-	-
4	-	-	-	-	-	364.088	363.888	363.897	363.899	363.937	-	-
5	-	-	-	-	-	364.090	363.886	363.897	363.897	363.936	-	-
6	-	-	-	-	-	364.097	363.891	363.898	363.897	363.939	-	-
7	-	-	-	-	-	364.137	363.890	363.899	363.896	363.939	-	-
8	-	-	-	-	-	363.907	363.896	363.899	363.896	363.939	-	-
9	-	-	-	-	-	363.957	364.002	363.900	363.897	363.942	-	-
10	-	-	-	-	-	363.884	363.897	363.899	363.897	363.942	-	-
11	-	-	-	-	-	363.883	363.903	363.899	363.897	363.938	-	-
12	-	-	-	-	-	363.883	363.903	363.900	363.911	363.940	-	-
13	-	-	-	-	-	363.881	363.901	363.901	363.926	363.941	-	-
14	-	-	-	-	-	363.883	363.902	363.900	363.923	363.940	-	-
15	-	-	-	-	-	363.885	363.900	363.899	363.926	363.938 P	-	-
16	-	-	-	-	364.224 P	363.884	363.899	363.896	363.926	-	-	-
17	-	-	-	-	364.166	363.878	363.899	363.895	363.930	-	-	-
18	-	-	-	-	364.113	363.881	363.902	363.896	363.932	-	-	-
19	-	-	-	-	364.107	363.881	363.902	363.897	363.935	-	-	-
20	-	-	-	-	364.097	363.886	363.901	363.896	363.932	-	-	-
21	-	-	-	-	364.108	363.892	363.901	363.898	363.923	-	-	-
22	-	-	-	-	364.115	363.892	363.901	363.900	363.929	-	-	-
23	-	-	-	-	364.101	363.900	363.903	363.900	363.924	-	-	-
24	-	-	-	-	364.090	363.906	363.903	363.901	363.924	-	-	-
25	-	-	-	-	364.089	363.900	363.904	363.899	363.861	-	-	-
26	-	-	-	-	364.094	363.903	363.904	363.901	363.912	-	-	-
27	-	-	-	-	364.094	363.906	363.903	363.901	363.928	-	-	-
28	-	-	-	-	364.091	363.898	363.902	363.902	363.935	-	-	-
29	-	-	-	-	364.091	363.905	363.899	363.902	363.942	-	-	-
30	-	-	-	-	364.092	363.899	363.898	363.902	363.939	-	-	-
31	-	-	-	-	364.090	-	363.896	363.901	-	-	-	-
min	-	-	-	-	364.089	363.878	363.886	363.894	363.861	363.936	-	-
mean	-	-	-	-	364.110	363.941	363.902	363.901	363.914	363.939	-	-
max	-	-	-	-	364.224	364.137	364.002	363.980	363.942	363.942	-	-

Notes: P - Partial daily average.

Table VII.31 S17 Tar River Upland Mean Daily Water Levels (m) Based on Permanent Benchmark el. 366.546 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	364.085	363.894	363.980	363.900	363.936	-	-
2	-	-	-	-	-	364.086	363.890	363.894	363.900	363.940	-	-
3	-	-	-	-	-	364.085	363.890	363.898	363.899	363.942	-	-
4	-	-	-	-	-	364.088	363.888	363.897	363.899	363.937	-	-
5	-	-	-	-	-	364.090	363.886	363.897	363.897	363.936	-	-
6	-	-	-	-	-	364.097	363.891	363.898	363.897	363.939	-	-
7	-	-	-	-	-	364.137	363.890	363.899	363.896	363.939	-	-
8	-	-	-	-	-	363.907	363.896	363.899	363.896	363.939	-	-
9	-	-	-	-	-	363.957	364.002	363.900	363.897	363.942	-	-
10	-	-	-	-	-	363.884	363.897	363.899	363.897	363.942	-	-
11	-	-	-	-	-	363.883	363.903	363.899	363.897	363.938	-	-
12	-	-	-	-	-	363.883	363.903	363.900	363.911	363.940	-	-
13	-	-	-	-	-	363.881	363.901	363.901	363.926	363.941	-	-
14	-	-	-	-	-	363.883	363.902	363.900	363.923	363.940	-	-
15	-	-	-	-	-	363.885	363.900	363.899	363.926	363.938 P	-	-
16	-	-	-	-	364.224 P	363.884	363.899	363.896	363.926	-	-	-
17	-	-	-	-	364.166	363.878	363.899	363.895	363.930	-	-	-
18	-	-	-	-	364.113	363.881	363.902	363.896	363.932	-	-	-
19	-	-	-	-	364.107	363.881	363.902	363.897	363.935	-	-	-
20	-	-	-	-	364.097	363.886	363.901	363.896	363.932	-	-	-
21	-	-	-	-	364.108	363.892	363.901	363.898	363.923	-	-	-
22	-	-	-	-	364.115	363.892	363.901	363.900	363.929	-	-	-
23	-	-	-	-	364.101	363.900	363.903	363.900	363.924	-	-	-
24	-	-	-	-	364.090	363.906	363.903	363.901	363.924	-	-	-
25	-	-	-	-	364.089	363.900	363.904	363.899	363.861	-	-	-
26	-	-	-	-	364.094	363.903	363.904	363.901	363.912	-	-	-
27	-	-	-	-	364.094	363.906	363.903	363.901	363.928	-	-	-
28	-	-	-	-	364.091	363.898	363.902	363.902	363.935	-	-	-
29	-	-	-	-	364.091	363.905	363.899	363.902	363.942	-	-	-
30	-	-	-	-	364.092	363.899	363.898	363.902	363.939	-	-	-
31	-	-	-	-	364.090	-	363.896	363.901	-	-	-	-
min	-	-	-	-	364.089	363.878	363.886	363.894	363.861	363.936	-	-
mean	-	-	-	-	364.110	363.941	363.902	363.901	363.914	363.939	-	-
max	-	-	-	-	364.224	364.137	364.002	363.980	363.942	363.942	-	-

Notes: P - Partial daily average.

Table VII.32 S18A Calumet River Upland Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	-	-	0.026	-	-
2	-	-	-	-	-	-	-	-	-	0.028	-	-
3	-	-	-	-	-	-	-	-	-	0.025	-	-
4	-	-	-	-	-	-	-	-	-	0.026	-	-
5	-	-	-	-	-	-	-	-	-	0.023	-	-
6	-	-	-	-	-	-	-	-	-	0.022	-	-
7	-	-	-	-	-	-	-	-	-	0.022	-	-
8	-	-	-	-	-	-	-	-	-	0.023	-	-
9	-	-	-	-	-	-	-	0.024 A	-	0.024	-	-
10	-	-	-	-	-	0.008 A	0.006 A	-	-	0.022	-	-
11	-	-	-	-	-	-	-	-	-	0.019	-	-
12	-	-	-	-	-	-	-	-	-	0.018	-	-
13	-	-	-	-	-	-	-	-	0.028 P	0.019	-	-
14	-	-	-	-	-	-	-	-	0.027	0.018	-	-
15	-	-	-	-	-	-	-	-	0.026	0.019	-	-
16	-	-	-	-	-	-	-	-	0.027	0.018	-	-
17	-	-	-	-	-	-	-	-	0.032	0.020	-	-
18	-	-	-	-	-	-	-	-	0.038	-	-	-
19	-	-	-	-	-	-	-	-	0.029	-	-	-
20	-	-	-	-	-	-	-	-	0.024	-	-	-
21	-	-	-	-	-	-	-	-	0.023	-	-	-
22	-	-	-	-	-	-	-	-	0.023	-	-	-
23	-	-	-	-	-	-	-	-	0.023	-	-	-
24	-	-	-	-	-	-	-	-	0.023	-	-	-
25	-	-	-	-	-	-	-	-	0.022	-	-	-
26	-	-	-	-	-	-	-	-	0.020	-	-	-
27	-	-	-	-	-	-	-	-	0.022	0.005 AB	-	-
28	-	-	-	-	-	-	-	-	0.026	-	-	-
29	-	-	-	-	-	-	-	-	0.028	-	-	-
30	-	-	-	-	-	-	-	-	0.026	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
min	-	-	-	-	-	-	-	-	0.020	0.005	-	-
mean	-	-	-	-	-	-	-	-	0.026	0.021	-	-
max	-	-	-	-	-	-	-	-	0.038	0.028	-	-

Notes: P - Partial daily average. A - Manual measurement.
B - Ice effects.

Table VII.33 S18A Calumet River Upland Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	-	-	97.508	-	-
2	-	-	-	-	-	-	-	-	-	97.515	-	-
3	-	-	-	-	-	-	-	-	-	97.506	-	-
4	-	-	-	-	-	-	-	-	-	97.507	-	-
5	-	-	-	-	-	-	-	-	-	97.497	-	-
6	-	-	-	-	-	-	-	-	-	97.494	-	-
7	-	-	-	-	-	-	-	-	-	97.491	-	-
8	-	-	-	-	-	-	-	-	-	97.497	-	-
9	-	-	-	-	-	-	-	97.496 A	-	97.499	-	-
10	-	-	-	-	-	97.414 A	97.374 A	-	-	97.492	-	-
11	-	-	-	-	-	-	-	-	-	97.477	-	-
12	-	-	-	-	-	-	-	-	-	97.471	-	-
13	-	-	-	-	-	-	-	-	97.517 P	97.477	-	-
14	-	-	-	-	-	-	-	-	97.511	97.471	-	-
15	-	-	-	-	-	-	-	-	97.508	97.478	-	-
16	-	-	-	-	-	-	-	-	97.511	97.472	-	-
17	-	-	-	-	-	-	-	-	97.527	97.480	-	-
18	-	-	-	-	-	-	-	-	97.545	97.459 B	-	-
19	-	-	-	-	-	-	-	-	97.519	97.451 B	-	-
20	-	-	-	-	-	-	-	-	97.503	97.451 B	-	-
21	-	-	-	-	-	-	-	-	97.496	97.453 B	-	-
22	-	-	-	-	-	-	-	-	97.496	97.456 B	-	-
23	-	-	-	-	-	-	-	-	97.497	97.478 B	-	-
24	-	-	-	-	-	-	-	-	97.495	97.441 B	-	-
25	-	-	-	-	-	-	-	-	97.490	97.419 B	-	-
26	-	-	-	-	-	-	-	-	97.485	97.422 B	-	-
27	-	-	-	-	-	-	-	-	97.493	97.430 BP	-	-
28	-	-	-	-	-	-	-	-	97.508	-	-	-
29	-	-	-	-	-	-	-	-	97.515	-	-	-
30	-	-	-	-	-	-	-	-	97.508	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
min	-	-	-	-	-	-	-	-	97.485	97.419	-	-
mean	-	-	-	-	-	-	-	-	97.507	97.474	-	-
max	-	-	-	-	-	-	-	-	97.545	97.515	-	-

Notes: P - Partial daily average.
A - Manual measurement.
B - Ice effects.

Table VII.34 S19 Tar River Lowland Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.022	0.002	0.018	0.044	0.008	0.007	-	-
2	-	-	-	-	0.022	0.002	0.043	0.040	0.007	0.008	-	-
3	-	-	-	-	0.016	0.002	0.043	0.037	0.006	0.010	-	-
4	-	-	-	-	0.007	0.002	0.039	0.034	0.020	0.011	-	-
5	-	-	-	-	0.006	0.002	0.037	0.035	0.024	0.010	-	-
6	-	-	-	-	0.005	0.003	0.034	0.036	0.022	0.006	-	-
7	-	-	-	-	0.003	0.007	0.029	0.033	0.023	0.006	-	-
8	-	-	-	-	0.003	0.006	0.027	0.030	0.022	0.006	-	-
9	-	-	-	-	0.014 P	0.004	0.022	0.029	0.021	0.006	-	-
10	-	-	-	-	-	0.003	0.018	0.028	0.019	0.006	-	-
11	-	-	-	-	-	0.003	0.012	0.027	0.015	0.006	-	-
12	-	-	-	-	0.003 P	0.002	0.011	0.026	0.011	0.006	-	-
13	-	-	-	-	0.002	0.002	0.007	0.023	0.010	0.006	-	-
14	-	-	-	-	0.003	0.002	0.008	0.022	0.009	0.006	-	-
15	-	-	-	-	0.003	0.002	0.007	0.024	0.008	0.005	-	-
16	-	-	-	-	0.003	0.002	0.004	0.031	0.007	0.006	-	-
17	-	-	-	-	0.000	0.002	0.004	0.028	0.007	0.006	-	-
18	-	-	-	-	0.002	0.002	0.005	0.028	0.006	0.006	-	-
19	-	-	-	-	0.002	0.002	0.005	0.031	0.006	0.006	-	-
20	-	-	-	-	0.002	0.002	0.019	0.030	0.006	0.005	-	-
21	-	-	-	-	0.002	0.002	0.034	0.028	0.005	0.005 P	-	-
22	-	-	-	-	0.002	0.002	0.033	0.026	0.005	-	-	-
23	-	-	-	-	0.002	0.002	0.032	0.024	0.005	-	-	-
24	-	-	-	0.021 P	0.002	0.002	0.031	0.021	0.005	-	-	-
25	-	-	-	0.019	0.002	0.002	0.028	0.019	0.005	-	-	-
26	-	-	-	0.020	0.002	0.002	0.027	0.020	0.005	-	-	-
27	-	-	-	0.021	0.002	0.001	0.027	0.017	0.005	-	-	-
28	-	-	-	0.023	0.002	0.001	0.037	0.013	0.006	-	-	-
29	-	-	-	0.023	0.002	0.002	0.033	0.010	0.009	-	-	-
30	-	-	-	0.022	0.002	0.002	0.038	0.010	0.008	-	-	-
31	-	-	-	-	0.002	-	0.047	0.009	-	-	-	-
min	-	-	-	0.019	0.000	0.001	0.004	0.009	0.005	0.005	-	-
mean	-	-	-	0.021	0.005	0.002	0.025	0.026	0.010	0.007	-	-
max	-	-	-	0.023	0.022	0.007	0.047	0.044	0.024	0.011	-	-

Notes: P - Partial daily average.
A - Manual measurement.

Table VII.35 S19 Tar River Lowland Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	100.729	100.386	100.617	100.888	100.549	100.536	-	-
2	-	-	-	-	100.733	100.384	100.883	100.866	100.530	100.563	-	-
3	-	-	-	-	100.660	100.380	100.883	100.847	100.516	100.590	-	-
4	-	-	-	-	100.542	100.377	100.859	100.827	100.711	100.605	-	-
5	-	-	-	-	100.515	100.376	100.846	100.830	100.747	100.594	-	-
6	-	-	-	-	100.475	100.400	100.824	100.839	100.737	100.511	-	-
7	-	-	-	-	100.431	100.544	100.795	100.819	100.742	100.515	-	-
8	-	-	-	-	100.416	100.516	100.775	100.800	100.738	100.514	-	-
9	-	-	-	-	100.612 P	100.465	100.733	100.791	100.725	100.519	-	-
10	-	-	-	-	-	100.432	100.691	100.783	100.701	100.518	-	-
11	-	-	-	-	-	100.413	100.618	100.772	100.662	100.515	-	-
12	-	-	-	-	100.406 P	100.403	100.597	100.768	100.612	100.506	-	-
13	-	-	-	-	100.403	100.401	100.534	100.735	100.598	100.513	-	-
14	-	-	-	-	100.404	100.395	100.552	100.733	100.569	100.514	-	-
15	-	-	-	-	100.409	100.391	100.534	100.753	100.554	100.500	-	-
16	-	-	-	-	100.404	100.388	100.463	100.805	100.535	100.506	-	-
17	-	-	-	-	0.000	100.386	100.459	100.785	100.537	100.523	-	-
18	-	-	-	-	100.385	100.381	100.475	100.783	100.513	100.517	-	-
19	-	-	-	-	100.381	100.376	100.474	100.805	100.506	100.513	-	-
20	-	-	-	-	100.380	100.372	100.654	100.800	100.513	100.497	-	-
21	-	-	-	-	100.378	100.370	100.830	100.781	100.497	100.482 P	-	-
22	-	-	-	-	100.375	100.366	100.823	100.765	100.492	-	-	-
23	-	-	-	-	100.368	100.361	100.816	100.748	100.491	-	-	-
24	-	-	-	100.722 P	100.366	100.361	100.806	100.728	100.482	-	-	-
25	-	-	-	100.709	100.363	100.357	100.781	100.705	100.479	-	-	-
26	-	-	-	100.718	100.361	100.353	100.776	100.712	100.476	-	-	-
27	-	-	-	100.723	100.358	100.348	100.778	100.680	100.481	-	-	-
28	-	-	-	100.740	100.356	100.348	100.847	100.637	100.501	-	-	-
29	-	-	-	100.742	100.363	100.352	100.823	100.594	100.572	-	-	-
30	-	-	-	100.735	100.375	100.389	100.849	100.586	100.552	-	-	-
31	-	-	-	-	100.378	-	100.907	100.575	-	-	-	-
min	-	-	-	100.709	0.000	100.348	100.459	100.575	100.476	100.482	-	-
mean	-	-	-	100.727	96.977	100.392	100.719	100.759	100.577	100.526	-	-
max	-	-	-	100.742	100.733	100.544	100.907	100.888	100.747	100.605	-	-

Notes: P - Partial daily average.
A - Manual measurement.

Table VII.36 S20 Muskeg River Upland Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.0918	0.144	-	-	-	-	-	-
2	-	-	-	-	0.0811	0.157	-	-	-	-	-	-
3	-	-	-	-	0.1105	0.141	-	-	-	-	-	-
4	-	-	-	-	0.0818	0.132	-	-	-	-	-	-
5	-	-	-	-	0.0710	0.119	-	-	-	-	-	-
6	-	-	-	-	0.0630	0.269	-	-	-	-	-	-
7	-	-	-	-	0.0603	0.537	-	-	-	-	-	-
8	-	-	-	-	0.0594	0.476	-	-	-	-	-	-
9	-	-	-	-	0.0627	0.448 P	-	-	-	-	-	-
10	-	-	-	-	0.0604	-	-	-	-	-	-	-
11	-	-	-	-	0.0671	-	0.581 A	1.723 A	-	-	-	-
12	-	-	-	-	0.1100	-	-	-	-	-	-	-
13	-	-	-	-	0.1257	-	-	-	1.219 P	-	-	-
14	-	-	-	-	0.1267	-	-	-	1.232 P	-	-	-
15	-	-	-	-	0.1321	-	-	-	-	-	-	-
16	-	-	-	-	0.1289	-	-	-	-	-	-	-
17	-	-	-	-	0.1252	-	-	-	-	-	-	-
18	-	-	-	-	0.1183	-	-	-	-	-	-	-
19	-	-	-	-	0.0979	-	-	-	-	-	-	-
20	-	-	-	-	0.0901	-	-	-	-	-	-	-
21	-	-	-	-	0.0895	-	-	-	-	-	-	-
22	-	-	-	-	0.0666	-	-	-	-	-	-	-
23	-	-	-	-	0.0447	-	-	-	-	-	-	-
24	-	-	-	-	0.0705	-	-	-	-	-	-	-
25	-	-	-	0.132 P	0.0564	-	-	-	-	0.526 A	-	-
26	-	-	-	0.0846	0.0419	-	-	-	-	-	-	-
27	-	-	-	0.0769	0.0436	-	-	-	-	-	-	-
28	-	-	-	0.0678	0.0519	-	-	-	-	-	-	-
29	-	-	-	0.0697	0.0742	-	-	-	-	-	-	-
30	-	-	-	0.0972	0.1373	-	-	-	-	-	-	-
31	-	-	-	-	0.1049	-	-	-	-	-	-	-
min	-	-	-	0.068	0.042	0.119	-	-	-	-	-	-
mean	-	-	-	0.088	0.085	0.269	-	-	-	-	-	-
max	-	-	-	0.132	0.137	0.537	-	-	-	-	-	-

Notes: P - Partial daily average. A – Manual Measurement

Table VII.37 S20 Muskeg River Upland Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	98.6209	98.683	-	-	-	99.698 X	-	-
2	-	-	-	-	98.6051	98.696	-	-	-	99.666 X	-	-
3	-	-	-	-	98.6408	98.680	-	-	-	99.658 X	-	-
4	-	-	-	-	98.6058	98.670	-	-	-	99.676 X	-	-
5	-	-	-	-	98.5891	98.656	-	-	-	99.685 X	-	-
6	-	-	-	-	98.5741	98.764	-	-	-	99.693 X	-	-
7	-	-	-	-	98.5701	98.922	-	-	-	99.711 X	-	-
8	-	-	-	-	98.5683	98.896	-	-	-	99.717 X	-	-
9	-	-	-	-	98.5745	98.883 P	-	-	-	99.723 X	-	-
10	-	-	-	-	98.5705	-	-	-	-	99.730 X	-	-
11	-	-	-	-	98.5810	-	-	-	-	99.738 X	-	-
12	-	-	-	-	98.6428	-	-	-	-	99.736 X	-	-
13	-	-	-	-	98.6636	-	-	-	99.126 P	99.742 X	-	-
14	-	-	-	-	98.6650	-	-	-	99.138	99.741 X	-	-
15	-	-	-	-	98.6709	-	-	-	99.162 X	99.749 X	-	-
16	-	-	-	-	98.6675	-	-	-	99.186 X	99.739 X	-	-
17	-	-	-	-	98.6634	-	-	-	99.228 X	99.735 X	-	-
18	-	-	-	-	98.6554	-	-	-	99.278 X	99.734 X	-	-
19	-	-	-	-	98.6299	-	-	-	99.357 X	99.718 X	-	-
20	-	-	-	-	98.6192	-	-	-	99.459 X	99.712 X	-	-
21	-	-	-	-	98.6183	-	-	-	99.524 X	99.698 X	-	-
22	-	-	-	-	98.5817	-	-	-	99.553 X	99.688 X	-	-
23	-	-	-	-	98.5376	-	-	-	99.578 X	99.686 X	-	-
24	-	-	-	-	98.5791	-	-	-	99.595 X	99.689 X	-	-
25	-	-	-	98.668 P	98.5623	-	-	-	99.605 X	99.690 X	-	-
26	-	-	-	98.6105	98.5302	-	-	-	99.618 X	-	-	-
27	-	-	-	98.5990	98.5358	-	-	-	99.623 X	-	-	-
28	-	-	-	98.5842	98.5542	-	-	-	99.633 X	-	-	-
29	-	-	-	98.5874	98.5909	-	-	-	99.662 X	-	-	-
30	-	-	-	98.6278	98.6761	-	-	-	99.684 X	-	-	-
31	-	-	-	-	98.6389	-	-	-	-	-	-	-
min	-	-	-	98.584	98.530	98.656	-	-	99.126	99.658	-	-
mean	-	-	-	98.613	98.606	98.761	-	-	99.445	99.710	-	-
max	-	-	-	98.668	98.676	98.922	-	-	99.684	99.749	-	-

Notes: P - Partial daily average. X – Beaver Dam Effects

Table VII.38 S21 Shelley Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-	0.035 A	-	-	-	-
10	-	-	-	-	-	0.000 A	-	-	-	-	-	-
11	-	-	-	-	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	0.000 A	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	-	-	-	-	-	-	-	-	-
22	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	-	-	-	-	-	-	-	-	-	-	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
min	-	-	-	-	-	-	-	-	-	-	-	-
mean	-	-	-	-	-	-	-	-	-	-	-	-
max	-	-	-	-	-	-	-	-	-	-	-	-

Notes: A - Manual measurement.

Table VII.39 S21 Shelley Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 295.891m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	295.102	295.413	295.598	295.593	295.580	-	-
2	-	-	-	-	-	295.102	295.516	295.602	295.593	295.588	-	-
3	-	-	-	-	-	295.104	295.519	295.605	295.592	295.583	-	-
4	-	-	-	-	-	295.103	295.512	295.614	295.608	295.582	-	-
5	-	-	-	-	-	295.100	295.516	295.627	295.613	295.581	-	-
6	-	-	-	-	-	295.149	295.510	295.634	295.610	295.583	-	-
7	-	-	-	-	-	295.334	295.503	295.633	295.606	295.581	-	-
8	-	-	-	-	-	295.411	295.489	295.628	295.604	295.584	-	-
9	-	-	-	-	-	295.417	295.470	295.620	295.605	295.586	-	-
10	-	-	-	-	-	295.439	295.443	295.614	295.606	295.581	-	-
11	-	-	-	-	-	295.484	295.415	295.610	295.606	295.576	-	-
12	-	-	-	-	-	295.461	295.387	295.608	295.608	295.573	-	-
13	-	-	-	-	-	295.438	295.358	295.610	295.607	295.578	-	-
14	-	-	-	-	-	295.415	295.334	295.613	295.606	295.575	-	-
15	-	-	-	-	-	295.394	295.317	295.614	295.605	295.572	-	-
16	-	-	-	-	295.112 P	295.380	295.299	295.617	295.605	295.572	-	-
17	-	-	-	-	295.117	295.369	295.282	295.614	295.603	295.574	-	-
18	-	-	-	-	295.126	295.358	295.277	295.612	295.601	295.571	-	-
19	-	-	-	-	295.131	295.354	295.272	295.613	295.600	295.570	-	-
20	-	-	-	-	295.135	295.361	295.328	295.614	295.596	295.568	-	-
21	-	-	-	-	295.140	295.357	295.504	295.612	295.591	295.564	-	-
22	-	-	-	-	295.135	295.343	295.516	295.608	295.589	295.562	-	-
23	-	-	-	-	295.129	295.326	295.514	295.605	295.587	295.564 P	-	-
24	-	-	-	-	295.124	295.310	295.517	295.602	295.584	-	-	-
25	-	-	-	-	295.120	295.294	295.515	295.599	295.582	-	-	-
26	-	-	-	-	295.114	295.276	295.519	295.599	295.579	-	-	-
27	-	-	-	-	295.109	295.260	295.531	295.598	295.578	-	-	-
28	-	-	-	-	295.103	295.244	295.561	295.595	295.584	-	-	-
29	-	-	-	-	295.107	295.233	295.569	295.592	295.584	-	-	-
30	-	-	-	-	295.114	295.284	295.580	295.591	295.581	-	-	-
31	-	-	-	-	295.105	-	295.595	295.593	-	-	-	-
min	-	-	-	-	295.103	295.100	295.272	295.591	295.578	295.562	-	-
mean	-	-	-	-	295.120	295.307	295.454	295.610	295.597	295.576	-	-
max	-	-	-	-	295.140	295.484	295.595	295.634	295.613	295.588	-	-

Notes: P - Partial daily average.

Table VII.40 S22 Muskeg Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	0.001	-	6.715	2.403	2.299	-	-
2	-	-	-	-	-	0.000	-	7.610	2.315	2.459	-	-
3	-	-	-	-	-	0.001	-	8.480	2.242	2.680	-	-
4	-	-	-	-	-	0.001	-	8.278	3.224	2.856	-	-
5	-	-	-	-	-	0.001	-	8.439	3.847	2.851	-	-
6	-	-	-	-	-	0.014	-	8.881	4.516	2.851	-	-
7	-	-	-	-	-	0.091	-	8.473	5.547	2.894	-	-
8	-	-	-	-	-	0.164	-	8.029	5.772	2.860	-	-
9	-	-	-	-	-	0.267 P	1.108 P	7.222	5.537	2.814	-	-
10	-	-	-	-	-	-	1.004	6.438	5.158	2.685	-	-
11	-	-	-	-	-	-	0.791	5.721	4.764	2.582	-	-
12	-	-	-	-	-	-	0.567	5.130	4.317	2.364	-	-
13	-	-	-	-	-	-	0.442	4.835	4.003	2.313	-	-
14	-	-	-	-	-	-	0.347	4.913	3.658	2.333	-	-
15	-	-	-	-	-	-	0.276	5.396	3.420	2.099	-	-
16	-	-	-	-	-	-	0.200	6.535	3.132	2.082	-	-
17	-	-	-	-	-	-	0.157	6.824	2.869	2.165 P	-	-
18	-	-	-	-	0.090	-	0.154	6.759	2.555	-	-	-
19	-	-	-	-	0.091	-	0.145	7.066	2.378	-	-	-
20	-	-	-	-	0.016	-	0.352	6.861	2.426	-	-	-
21	-	-	-	-	0.014	-	1.063	6.278	2.331	-	-	-
22	-	-	-	-	0.007	-	1.520	5.719	2.211	-	-	-
23	-	-	-	-	0.004	-	2.127	5.190	2.103	-	-	-
24	-	-	-	-	0.003	-	2.672	4.644	2.006	-	-	-
25	-	-	-	-	0.001	-	2.812	4.115	1.912	-	-	-
26	-	-	-	-	0.000	-	2.752	3.857	1.878	-	-	-
27	-	-	-	-	0.000	-	2.792	3.560	1.855	-	-	-
28	-	-	-	-	0.000	-	3.190	3.297	1.857	-	-	-
29	-	-	-	-	0.001	-	2.962	3.023	2.185	-	-	-
30	-	-	-	-	0.001	-	3.394	2.811	2.268	-	-	-
31	-	-	-	-	0.001	-	5.089	2.549	-	-	-	-
min	-	-	-	-	0.000	0.000	0.145	2.549	1.855	2.082	-	-
mean	-	-	-	-	0.016	0.060	1.561	5.924	3.156	2.540	-	-
max	-	-	-	-	0.091	0.267	5.089	8.881	5.772	2.894	-	-

Notes: P - Partial daily average.

Table VII.41 S22 Muskeg Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 306.476 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	304.413 B	303.254	-	304.270	303.947	303.936	-	-
2	-	-	-	-	304.415 B	303.250	-	304.319	303.937	303.953	-	-
3	-	-	-	-	304.326	303.258	-	304.362	303.929	303.976	-	-
4	-	-	-	-	304.290	303.256	-	304.353	304.025	303.993	-	-
5	-	-	-	-	304.292	303.256	-	304.360	304.081	303.993	-	-
6	-	-	-	-	304.304	303.303	-	304.382	304.131	303.993	-	-
7	-	-	-	-	304.313	303.442	-	304.362	304.201	303.997	-	-
8	-	-	-	304.620 BP	304.322	303.494	-	304.340	304.215	303.994	-	-
9	-	-	-	304.627 B	304.320	303.548 P	303.770 P	304.299	304.201	303.989	-	-
10	-	-	-	304.651 B	304.290	-	303.751	304.255	304.176	303.977	-	-
11	-	-	-	304.636 B	304.299	-	303.706	304.212	304.149	303.966	-	-
12	-	-	-	304.644 B	304.264	-	303.652	304.174	304.117	303.943	-	-
13	-	-	-	304.606 B	304.264	-	303.615	304.154	304.093	303.937	-	-
14	-	-	-	304.579 B	304.264	-	303.582	304.160	304.065	303.939	-	-
15	-	-	-	304.580 B	304.149	-	303.553	304.192	304.045	303.913	-	-
16	-	-	-	304.562 B	303.906	-	303.516	304.261	304.019	303.911	-	-
17	-	-	-	304.543 B	303.738	-	303.491	304.277	303.995	303.920	-	-
18	-	-	-	304.544 B	303.437	-	303.490	304.273	303.963	303.945	-	-
19	-	-	-	304.561 B	303.439	-	303.484	304.290	303.944	303.903	-	-
20	-	-	-	304.610 B	303.333	-	303.566	304.279	303.949	304.063	-	-
21	-	-	-	304.624 B	303.330	-	303.762	304.246	303.939	304.070	-	-
22	-	-	-	304.562 B	303.303	-	303.836	304.212	303.926	303.864	-	-
23	-	-	-	304.489 B	303.291	-	303.915	304.178	303.913	303.850	-	-
24	-	-	-	304.476 B	303.280	-	303.975	304.141	303.901	303.799	-	-
25	-	-	-	304.458 B	303.259	-	303.989	304.102	303.890	303.799 P	-	-
26	-	-	-	304.444 B	303.249	-	303.983	304.081	303.885	-	-	-
27	-	-	-	304.454 B	303.245	-	303.987	304.057	303.882	-	-	-
28	-	-	-	304.481 B	303.236	-	304.025	304.034	303.883	-	-	-
29	-	-	-	304.467 B	303.250	-	304.004	304.009	303.922	-	-	-
30	-	-	-	304.441 B	303.263	-	304.040	303.989	303.932	-	-	-
31	-	-	-	-	303.265	-	304.171	303.962	-	-	-	-
min	-	-	-	304.441	303.236	303.250	303.484	303.962	303.882	303.799	-	-
mean	-	-	-	304.550	303.818	303.340	303.777	304.212	304.009	303.945	-	-
max	-	-	-	304.651	304.415	303.548	304.171	304.382	304.215	304.070	-	-

Notes: P - Partial daily average.

Table VII.42 S23 Aurora Boundary Weir Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	0.035 B	0.011 B	0.008 B	0.005	0.188	0.034	0.040	0.015	0.027	0.023	0.016 B	0.025 B
2	0.016 B	0.011 B	0.007 B	0.003	0.111	0.030	0.043	0.013	0.023	0.025	0.017 B	0.020 B
3	0.017 B	0.010 B	0.007 B	0.011	0.079	0.014	0.038	0.012	0.022	0.025	0.019 B	0.021 B
4	0.015 B	0.009 B	0.008 B	0.006	0.081	0.017	0.039	0.008	0.059	0.024	0.020 B	0.020 B
5	0.013 B	0.009 B	0.008 B	0.007	0.091	0.011	0.039	0.009	0.048	0.024	0.020 B	0.015 B
6	0.015 B	0.009 B	0.006 B	0.005	0.086	0.035	0.037	0.010	0.054	0.024	0.018 B	0.010 B
7	0.012 B	0.011 B	0.005 B	0.005	0.110	0.054	0.033	0.008	0.047	0.023	0.018 B	0.014 B
8	0.014 B	0.015 B	0.004 B	0.005	0.089	0.046	0.027	0.027	0.039	0.022	0.019 B	0.007 B
9	0.010 B	0.010 B	0.004 B	0.006	0.072	0.038	0.061	0.118	0.024	0.026	0.018 B	0.008 B
10	0.010 B	0.010 B	0.006 B	0.009	0.097	0.035	0.186	0.124	0.017	0.024	0.017 B	0.008 B
11	0.009 B	0.010 B	0.005 B	0.026	0.063	0.031	0.138	0.121	0.012	0.023	0.017 B	0.005 B
12	0.010 B	0.009 B	0.003 B	0.016	0.079	0.030	0.151	0.106	0.010	0.022	0.016 B	0.003 B
13	0.009 B	0.012 B	0.004 B	0.018	0.063	0.016	0.200	0.137	0.018	0.024	0.017 B	0.004 B
14	0.012 B	0.011 B	0.004 B	0.015	0.106	0.011	0.167	0.133	0.018	0.023	0.022 B	0.004 B
15	0.009 B	0.007 B	0.005 B	0.011	0.135	0.009	0.212	0.133	0.019	0.022	0.022 B	0.004 B
16	0.008 B	0.008 B	0.007 B	0.009	0.095	0.010	0.218	0.139	0.017	0.023	0.016 B	0.005 B
17	0.009 B	0.027 B	0.007 B	0.012	0.125	0.006	0.199	0.119	0.011	0.024	0.026 B	0.005 B
18	0.014 B	0.035 B	0.006 B	0.014	0.114	0.012	0.187	0.118	0.008	0.022	0.018 B	0.005 B
19	0.010 B	0.052 B	0.006 B	0.012	0.107	0.024	0.178	0.134	0.014	0.021	0.016 B	0.008 B
20	0.008 B	0.087 B	0.004 B	0.028	0.102	0.031	0.041	0.122	0.016	0.019	0.017 B	0.000 B
21	0.010 B	0.075 B	0.003 B	0.050	0.106	0.030	0.025	0.101	0.014	0.019 B	0.025 B	0.000 B
22	0.013 B	0.068 B	0.000 B	0.055	0.091	0.029	0.011	0.087	0.008	0.020 B	0.028 B	0.000 B
23	0.010 B	0.067 B	0.000 B	0.052	0.080	0.025	0.004	0.024	0.006	0.021 B	0.015 B	0.000 B
24	0.008 B	0.054 B	0.000 B	0.051	0.079	0.032	0.003	0.084	0.006	0.023 B	0.025 B	0.000 B
25	0.012 B	0.043 B	0.000 B	0.037	0.076	0.027	0.002	0.093	0.010	0.022 B	0.015 B	0.000 B
26	0.011 B	0.033 B	0.000 B	0.018	0.049	0.022	0.003	0.116	0.018	0.021 B	0.012 B	0.000 B
27	0.010 B	0.021 B	0.006 B	0.039	0.042	0.020	0.005	0.121	0.040	0.020 B	0.022 B	0.000 B
28	0.011 B	0.029 B	0.005 B	0.044	0.042	0.011	0.009	0.118	0.057	0.019 B	0.019 B	0.000 B
29	0.009 B	-	0.000 B	0.043	0.035	0.012	0.003	0.046	0.027	0.016 B	0.018 B	0.000 B
30	0.010 B	-	0.000 B	0.071	0.028	0.025	0.005	0.023	0.024	0.016 B	0.024 B	0.000 B
31	0.011 B	-	0.000 B	-	0.034	-	0.017	0.026	-	0.018 B	-	0.000 B
min	0.008	0.007	0.000	0.003	0.028	0.006	0.002	0.008	0.006	0.016	0.012	0.000
mean	0.012	0.027	0.004	0.023	0.086	0.024	0.075	0.079	0.024	0.022	0.019	0.006
max	0.035	0.087	0.008	0.071	0.188	0.054	0.218	0.139	0.059	0.026	0.028	0.025

Notes: P - Partial daily average.
B - Ice effects.

Table VII.43 S23 Aurora Boundary Weir Mean Daily Water Levels (m) Based on Permanent Benchmark el. 295.280 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	292.438 B	292.457 B	292.356 B	292.342	292.618	292.439	292.452	292.388	292.423	292.413	292.392 B	292.415 B
2	292.395 B	292.440 B	292.391 B	292.322	292.549	292.430	292.457	292.383	292.414	292.418	292.394 B	292.403 B
3	292.462 B	292.369 B	292.353 B	292.363	292.509	292.385	292.447	292.378	292.410	292.419	292.401 B	292.451 B
4	292.389 B	292.368 B	292.411 B	292.342	292.512	292.393	292.450	292.358	292.480	292.416	292.405 B	292.474 B
5	292.381 B	292.363 B	292.449 B	292.351	292.525	292.373	292.450	292.361	292.465	292.416	292.406 B	292.388 B
6	292.390 B	292.365 B	292.409 B	292.343	292.519	292.437	292.445	292.369	292.474	292.415	292.398 B	292.369 B
7	292.376 B	292.490 B	292.383 B	292.342	292.548	292.476	292.437	292.357	292.462	292.414	292.398 B	292.384 B
8	292.384 B	292.482 B	292.371 B	292.343	292.523	292.463	292.424	292.403	292.448	292.412	292.400 B	292.352 B
9	292.370 B	292.369 B	292.404 B	292.346	292.502	292.446	292.455	292.557	292.415	292.419	292.400 B	292.410 B
10	292.368 B	292.371 B	292.379 B	292.361	292.532	292.441	292.612	292.563	292.395	292.417	292.395 B	292.360 B
11	292.366 B	292.371 B	292.352 B	292.408	292.490	292.433	292.572	292.560	292.376	292.412	292.395 B	292.342 B
12	292.368 B	292.362 B	292.347 B	292.384	292.511	292.432	292.587	292.542	292.368	292.411	292.392 B	292.329 B
13	292.366 B	292.374 B	292.330 B	292.389	292.490	292.389	292.627	292.575	292.397	292.416	292.396 B	292.333 B
14	292.376 B	292.371 B	292.345 B	292.384	292.538	292.374	292.597	292.572	292.400	292.414	292.409 B	292.335 B
15	292.366 B	292.356 B	292.359 B	292.370	292.573	292.364	292.636	292.572	292.403	292.409	292.408 B	292.335 B
16	292.362 B	292.372 B	292.402 B	292.364	292.529	292.368	292.640	292.578	292.395	292.414	292.391 B	292.342 B
17	292.461 B	292.457 B	292.471 B	292.375	292.564	292.350	292.627	292.557	292.373	292.415	292.419 B	292.341 B
18	292.441 B	292.443 B	292.416 B	292.384	292.552	292.377	292.612	292.556	292.359	292.411	292.398 B	292.343 B
19	292.367 B	292.469 B	292.401 B	292.377	292.544	292.415	292.603	292.573	292.384	292.408	292.394 B	292.376 B
20	292.360 B	292.522 B	292.349 B	292.414	292.538	292.433	292.454	292.561	292.391	292.403	292.394 B	292.370 B
21	292.369 B	292.507 B	292.327 B	292.469	292.544	292.430	292.419	292.537	292.385	292.402 B	292.411 B	292.620 B
22	292.380 B	292.498 B	292.308 B	292.478	292.527	292.427	292.371	292.520	292.359	292.405 B	292.422 B	292.618 B
23	292.398 B	292.530 B	292.295 B	292.474	292.513	292.418	292.335	292.413	292.345	292.409 B	292.389 B	292.297 B
24	292.388 B	292.546 B	292.330 B	292.472	292.512	292.436	292.323	292.517	292.344	292.412 B	292.412 B	292.295 B
25	292.472 B	292.493 B	292.359 B	292.443	292.507	292.424	292.309	292.528	292.369	292.410 B	292.388 B	292.295 B
26	292.480 B	292.435 B	292.346 B	292.396	292.467	292.411	292.327	292.555	292.397	292.407 B	292.378 B	292.296 B
27	292.513 B	292.442 B	292.367 B	292.443	292.455	292.404	292.345	292.560	292.438	292.405 B	292.406 B	292.297 B
28	292.449 B	292.487 B	292.368 B	292.454	292.453	292.373	292.364	292.557	292.474	292.402 B	292.401 B	292.297 B
29	292.393 B	-	292.343 B	292.453	292.440	292.375	292.318	292.460	292.424	292.391 B	292.399 B	292.298 B
30	292.413 B	-	292.331 B	292.468	292.424	292.415	292.324	292.414	292.415	292.390 B	292.414 B	292.301 B
31	292.418 B	-	292.326 B	-	292.438	-	292.396	292.420	-	292.397 B	-	292.288 B
min	292.360	292.356	292.295	292.322	292.424	292.350	292.309	292.357	292.344	292.390	292.378	292.288
mean	292.402	292.432	292.367	292.395	292.514	292.411	292.465	292.492	292.406	292.410	292.400	292.366
max	292.513	292.546	292.471	292.478	292.618	292.476	292.640	292.578	292.480	292.419	292.422	292.620

Notes: P - Partial daily average.
B - Ice effects.

Table VII.44 S24 Athabasca River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	111 B	103 B	102 B	98.5 B	354 BE	590	936	764	479	374	253 BE	124 B
2	110 B	103 B	101 B	99.0 B	416 BE	550	952	816	494	367	223 BE	123 B
3	110 B	103 B	101 B	99.0 B	477 BE	534	1,013	846	504	371	193 BE	123 B
4	109 B	103 B	101 B	99.2 B	539 BE	558	1,115	818	505	382	164 BE	123 B
5	108 B	103 B	101 B	99.1 B	601 BE	634	1,128	769	518	381	135 BE	123 B
6	108 B	103 B	101 B	99.3 B	619 BE	727	1,058	738	540	382	127 BE	123 B
7	107 B	103 B	100 B	100 B	527	751	956	701	568	378	127 BE	123 B
8	106 B	103 B	100 B	100 B	642	710	827	670	568	376	128 BE	122 B
9	105 B	102 B	100 B	100 B	633	668	718	637	562	388	128 BE	122 B
10	105 B	102 B	99.3 B	100 B	552	644	636	607	558	393	125 B	121 B
11	105 B	102 B	98.8 B	100 B	485	658	583	591	540	387	124 B	121 B
12	105 B	102 B	98.6 B	101 B	436	745	550	568	525	386	125 B	121 B
13	105 B	102 B	98.5 B	101 B	403	784	519	552	504	388	125 B	122 B
14	105 B	102 B	98.7 B	101 B	376	725	491	543	491	400	125 B	121 B
15	105 B	102 B	98.7 B	101 B	358	634	476	528	471	410	125 B	121 B
16	105 B	102 B	98.8 B	102 B	350	566	519	522	456	412	124 B	120 B
17	105 B	102 B	98.5 B	102 B	367	530	615	518	443	411	124 B	120 B
18	105 B	102 B	98.3 B	103 B	406	546	677	523	424	401	124 B	120 B
19	105 B	102 B	97.7 B	103 B	454	620	734	537	409	389	124 B	120 B
20	105 B	102 B	97.1 B	103 B	497	819	770	540	399	375	125 B	120 B
21	106 B	102 B	97.2 B	103 B	564	1,031	794	529	394	354	125 B	119 B
22	106 B	102 B	97.4 B	104 B	604	1,138	833	539	395	343	125 B	118 B
23	106 B	102 B	97.7 B	107 B	610	1,176	873	571	397	342	125 B	118 B
24	105 B	102 B	97.8 B	107 B	618	1,134	875	578	391	327	126 B	118 B
25	105 B	102 B	98.0 B	106 B	624	1,042	862	561	386	336	126 B	119 B
26	104 B	102 B	98.0 B	106 B	624	935	853	539	386	340	125 B	120 B
27	104 B	102 B	98.4 B	115 B	644	841	841	529	382	330	125 B	119 B
28	104 B	101 B	98.8 B	169 B	679	803	814	511	370	321	124 B	120 B
29	104 B	-	98.9 B	230 BE	693	837	772	499	378	328	124 B	120 B
30	103 B	-	99.0 B	292 BE	673	896	736	486	384	312 BE	124 B	119 B
31	103 B	-	98.5 B	-	635	-	738	480	-	283 BE	-	119 B
min	103.011	101.430	97.072	98.508	350.257	530.347	476.247	479.822	369.932	282.655	123.876	117.562
mean	105.821	102.236	99.011	114.955	531.025	760.873	782.700	600.307	460.672	366.720	136.563	120.638
max	111.322	103.140	101.559	292.107	692.614	1175.561	1127.555	845.879	568.404	411.765	252.928	123.815

Notes: P - Partial daily average. E – Estimated.
B - Ice effects.

Table VII.45 S24 Athabasca River Mean Daily Water Levels (m) Based on Permanent Benchmark el. 231.347 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	225.816 B	225.681 B	225.731 B	225.713 B	227.199 B	226.615	227.186	226.924	226.384	226.130	225.946 B	226.090 B
2	225.798 B	225.688 B	225.730 B	225.729 B	227.086 B	226.536	227.210	227.008	226.418	226.110	225.978 B	226.072 B
3	225.783 B	225.684 B	225.723 B	225.728 B	226.943 B	226.501	227.293	227.054	226.439	226.121	225.991 B	226.069 B
4	225.768 B	225.690 B	225.723 B	225.735 B	226.893 B	226.551	227.426	227.011	226.440	226.149	226.005 B	226.065 B
5	225.756 B	225.690 B	225.722 B	225.730 B	227.309 B	226.699	227.442	226.933	226.468	226.147	226.053 B	226.069 B
6	225.743 B	225.687 B	225.720 B	225.736 B	226.763 B	226.863	227.353	226.882	226.514	226.150	226.067 B	226.072 B
7	225.727 B	225.684 B	225.711 B	225.744 B	226.488	226.903	227.213	226.818	226.572	226.139	226.068 B	226.058 B
8	225.706 B	225.690 B	225.714 B	225.753 B	226.712	226.833	227.024	226.763	226.572	226.135	226.101 B	226.036 B
9	225.696 B	225.689 B	225.713 B	225.765 B	226.697	226.761	226.848	226.703	226.560	226.166	226.123 B	226.024 B
10	225.694 B	225.677 B	225.695 B	225.765 B	226.539	226.717	226.703	226.647	226.551	226.180	226.110 B	226.002 B
11	225.699 B	225.674 B	225.681 B	225.765 B	226.398	226.742	226.601	226.617	226.514	226.163	226.092 B	225.995 B
12	225.699 B	225.677 B	225.679 B	225.776 B	226.285	226.892	226.534	226.572	226.484	226.160	226.096 B	226.004 B
13	225.707 B	225.682 B	225.680 B	225.790 B	226.204	226.956	226.470	226.539	226.439	226.165	226.107 B	226.032 B
14	225.711 B	225.688 B	225.690 B	225.797 B	226.134	226.859	226.411	226.521	226.409	226.195	226.102 B	226.016 B
15	225.709 B	225.695 B	225.695 B	225.803 B	226.087	226.698	226.378	226.490	226.366	226.222	226.111 B	226.000 B
16	225.707 B	225.704 B	225.699 B	225.822 B	226.065	226.568	226.469	226.478	226.331	226.226	226.089 B	225.990 B
17	225.710 B	225.712 B	225.695 B	225.833 B	226.110	226.495	226.663	226.469	226.301	226.224	226.079 B	225.979 B
18	225.720 B	225.710 B	225.691 B	225.838 B	226.211	226.526	226.777	226.480	226.256	226.199	226.084 B	225.990 B
19	225.724 B	225.716 B	225.679 B	225.845 B	226.327	226.672	226.875	226.508	226.218	226.168	226.092 B	225.988 B
20	225.730 B	225.722 B	225.662 B	225.849 B	226.424	227.009	226.934	226.515	226.193	226.132	226.112 B	225.973 B
21	225.738 B	225.722 B	225.668 B	225.844 B	226.564	227.316	226.973	226.492	226.181	226.075	226.121 B	225.946 B
22	225.746 B	225.720 B	225.680 B	225.879 B	226.642	227.455	227.033	226.512	226.184	226.044	226.127 B	225.924 B
23	225.745 B	225.720 B	225.690 B	225.959 B	226.653	227.502	227.095	226.577	226.190	226.042	226.133 B	225.904 B
24	225.730 B	225.725 B	225.692 B	225.966 B	226.669	227.450	227.097	226.592	226.173	225.998	226.144 B	225.907 B
25	225.719 B	225.725 B	225.698 B	225.932 B	226.680	227.331	227.079	226.558	226.161	226.023	226.143 B	225.958 B
26	225.713 B	225.727 B	225.696 B	225.932 B	226.680	227.184	227.064	226.513	226.160	226.037	226.140 B	225.982 B
27	225.709 B	225.723 B	225.709 B	226.000 B	226.716	227.046	227.046	226.493	226.150	226.007	226.125 B	225.965 B
28	225.706 B	225.724 B	225.723 B	226.371 B	226.780	226.987	227.003	226.453	226.118	225.980	226.105 B	225.974 B
29	225.700 B	-	225.724 B	226.942 B	226.804	227.040	226.937	226.427	226.139	226.003	226.099 B	225.977 B
30	225.688 B	-	225.726 B	227.530 B	226.770	227.128	226.877	226.399	226.154	225.970 B	226.101 B	225.959 B
31	225.679 B	-	225.712 B	-	226.701	-	226.881	226.386	-	225.897 B	-	225.949 B
min	225.679	225.674	225.662	225.713	226.065	226.495	226.378	226.386	226.118	225.897	225.946	225.904
mean	225.725	225.701	225.702	225.929	226.598	226.895	226.932	226.624	226.335	226.108	226.088	225.999
max	225.816	225.727	225.731	227.530	227.309	227.502	227.442	227.054	226.572	226.226	226.144	226.090

Notes: P - Partial daily average. B - Ice effects.

Table VII.46 S25 Susan Lake Outlet Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	-	0.046	0.047	-	-
2	-	-	-	-	-	-	-	-	0.046	0.048	-	-
3	-	-	-	-	-	-	-	-	0.045	0.053	-	-
4	-	-	-	-	-	-	-	-	0.062	0.050	-	-
5	-	-	-	-	-	-	-	-	0.094	0.048	-	-
6	-	-	-	-	-	-	-	-	0.083	0.049	-	-
7	-	-	-	-	-	-	-	-	0.073	0.050	-	-
8	-	-	-	-	-	-	-	-	0.065	0.052	-	-
9	-	-	-	-	-	-	-	-	0.061	0.051	-	-
10	-	-	-	-	-	-	-	0.073 A	0.055	0.052	-	-
11	-	-	-	-	-	0.057 A	-	-	0.054	0.050	-	-
12	-	-	-	-	-	-	-	-	0.050	0.048	-	-
13	-	-	-	-	-	-	-	-	0.049	0.049	-	-
14	-	-	-	-	-	-	-	-	0.047	0.051	-	-
15	-	-	-	-	-	-	-	-	0.047	0.050	-	-
16	-	-	-	-	-	-	-	-	0.046	0.050	-	-
17	-	-	-	-	-	-	-	-	0.047	0.053	-	-
18	-	-	-	-	-	-	-	-	0.046	0.056 P	-	-
19	-	-	-	-	-	-	-	0.069 P	0.045	-	-	-
20	-	-	-	-	-	-	-	0.064	0.049	-	-	-
21	-	-	-	-	-	-	-	0.058	0.048	-	-	-
22	-	-	-	-	-	-	-	0.053	0.047	-	-	-
23	-	-	-	-	-	-	-	0.049	0.046	-	-	-
24	-	-	-	-	-	-	-	0.047	0.048	-	-	-
25	-	-	-	-	-	-	-	0.044	0.045	-	-	-
26	-	-	-	-	-	-	-	0.045	0.044	-	-	-
27	-	-	-	-	-	-	-	0.043	0.044	-	-	-
28	-	-	-	-	-	-	-	0.041	0.044	-	-	-
29	-	-	-	-	-	-	-	0.040	0.056	-	-	-
30	-	-	-	-	-	-	-	0.045	0.052	-	-	-
31	-	-	-	-	-	-	-	0.046	-	-	-	-
min	-	-	-	-	-	-	-	0.040	0.044	0.047	-	-
mean	-	-	-	-	-	-	-	0.051	0.053	0.050	-	-
max	-	-	-	-	-	-	-	0.073	0.094	0.056	-	-

Notes: P - Partial daily average.
A - Manual reading.

Table VII.47 S25 Susan Lake Outlet Mean Daily Water Levels (m) Based on Permanent Benchmark el. 231.339 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	-	228.253	228.254	-	-
2	-	-	-	-	-	-	-	-	228.252	228.255	-	-
3	-	-	-	-	-	-	-	-	228.251	228.260	-	-
4	-	-	-	-	-	-	-	-	228.268	228.258	-	-
5	-	-	-	-	-	-	-	-	228.293	228.255	-	-
6	-	-	-	-	-	-	-	-	228.286	228.256	-	-
7	-	-	-	-	-	-	-	-	228.278	228.257	-	-
8	-	-	-	-	-	-	-	-	228.271	228.259	-	-
9	-	-	-	-	-	-	-	-	228.268	228.259	-	-
10	-	-	-	-	-	-	-	228.267 A	228.263	228.259	-	-
11	-	-	-	-	-	228.264 A	-	-	228.261	228.257	-	-
12	-	-	-	-	-	-	-	-	228.257	228.255	-	-
13	-	-	-	-	-	-	-	-	228.256	228.255	-	-
14	-	-	-	-	-	-	-	-	228.254	228.258	-	-
15	-	-	-	-	-	-	-	-	228.254	228.257	-	-
16	-	-	-	-	-	-	-	-	228.252	228.257	-	-
17	-	-	-	-	-	-	-	-	228.254	228.260	-	-
18	-	-	-	-	-	-	-	-	228.253	228.264 P	-	-
19	-	-	-	-	-	-	-	228.275 P	228.251	-	-	-
20	-	-	-	-	-	-	-	228.270	228.256	-	-	-
21	-	-	-	-	-	-	-	228.265	228.255	-	-	-
22	-	-	-	-	-	-	-	228.260	228.254	-	-	-
23	-	-	-	-	-	-	-	228.256	228.252	-	-	-
24	-	-	-	-	-	-	-	228.254	228.254	-	-	-
25	-	-	-	-	-	-	-	228.250	228.252	-	-	-
26	-	-	-	-	-	-	-	228.251	228.250	-	-	-
27	-	-	-	-	-	-	-	228.249	228.251	-	-	-
28	-	-	-	-	-	-	-	228.247	228.250	-	-	-
29	-	-	-	-	-	-	-	228.245	228.263	-	-	-
30	-	-	-	-	-	-	-	228.251	228.259	-	-	-
31	-	-	-	-	-	-	-	228.252	-	-	-	-
min	-	-	-	-	-	-	-	228.245	228.250	228.254	-	-
mean	-	-	-	-	-	-	-	228.257	228.259	228.257	-	-
max	-	-	-	-	-	-	-	228.275	228.293	228.264	-	-

Notes: P - Partial daily average.
A - Manual measurement.

Table VII.48 S26 MacKay River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	0.297 B	0.092 B	0.050 B	0.110 B	3.693 B	2.716	1.558	10.363	6.638	6.483	3.431 B	1.082 B
2	0.269 B	0.082 B	0.051 B	0.120 B	3.269 B	2.755	1.957	10.434	6.075	6.862 A	3.623 B	1.140 B
3	0.236 B	0.066 B	0.051 B	0.130 B	2.446 B	2.663	1.852	11.490	5.605	7.183	3.059 B	1.166 B
4	0.250 B	0.059 B	0.052 B	0.140 B	2.906 B	2.557	1.889	12.731	6.089	7.686	2.582 B	1.068 B
5	0.251 B	0.059 B	0.053 B	0.150 B	2.009 B	2.513	1.809	14.118	6.970	7.856	2.069 B	0.980 B
6	0.278 B	0.062 B	0.053 B	0.220 B	2.329 B	2.662	1.918	15.232	8.113	8.053 A	1.652 B	1.024 B
7	0.323 B	0.062 B	0.054 B	0.340 B	2.236 B	3.065	1.952	15.500	10.030	8.291	1.560 B	1.018 B
8	0.358 B	0.059 B	0.054 B	0.460 B	2.043 B	2.989	1.935	15.211	13.117	8.243 A	1.478 B	1.003 B
9	0.391 B	0.057 B	0.055 B	0.580 B	2.211 B	2.855	2.951	14.350	13.929	8.220	1.471 B	1.051 B
10	0.442 B	0.062 B	0.056 B	0.700 B	2.677 B	2.875	3.492	13.286	12.669	8.148	1.492 B	1.096 B
11	0.494 B	0.072 B	0.056 B	3.248 B	2.894 B	2.798	3.538	12.214	12.487	7.964	1.443 B	1.089 B
12	0.542 B	0.076 B	0.057 B	2.423 B	2.867 A	2.750	3.572	10.822	11.179	7.698	1.308 B	1.098 B
13	0.603 B	0.085 B	0.055 B	1.882 B	2.711	2.672	3.315	9.340	10.397	7.576 B	1.243 B	1.086 B
14	0.617 B	0.098 B	0.055 B	1.753 B	2.655	2.661	3.265	8.111	9.624	6.061 B	1.194 B	1.017 B
15	0.325 B	0.111 B	0.060 B	1.800 B	3.180	2.469	2.933	7.432	9.019 A	5.846 B	1.102 B	0.934 B
16	0.362 B	0.124 B	0.060 B	1.780 B	3.237 A	2.393	2.888	7.742	8.322	5.509 B	1.047 B	0.854 B
17	0.456 B	0.141 B	0.060 B	1.780 B	2.693	2.290	2.553	7.883	7.972	5.270 B	1.127 B	0.925 B
18	0.418 B	0.159 B	0.060 B	1.800 B	2.732 A	2.254	2.649	7.407	7.442 A	5.075 B	1.166 B	0.968 B
19	0.356 B	0.192 B	0.065 B	1.850 B	2.895	2.210	2.392	7.342	7.149	4.967 B	1.189 B	0.827 B
20	0.303 B	0.228 B	0.070 B	2.154 B	3.023	2.137	2.612	7.579	7.135	4.560 B	1.240 B	0.776 B
21	0.269 B	0.251 B	0.080 B	2.313 B	2.987	2.026	2.958	7.775	6.789	4.120 B	1.311 B	0.572 B
22	0.229 B	0.263 B	0.090 B	3.865 B	2.819	1.747	3.073	7.611	6.829 A	3.764 B	1.299 B	0.461 B
23	0.195 B	0.286 B	0.100 B	3.958 B	2.712	1.518	2.950	7.288	6.294	4.729 B	1.204 B	0.350 B
24	0.164 B	0.319 B	0.100 B	2.681 B	2.876	1.423	2.982	6.748	6.017	3.673 B	1.161 B	0.291 B
25	0.136 B	0.275 B	0.095 B	2.145 B	2.970	1.346	2.929	6.218	5.983	3.816 B	1.111 B	0.287 B
26	0.113 B	0.090 B	0.092 B	3.292 B	3.233	1.255	3.685	6.072	5.850	3.285 B	0.972 B	0.304 B
27	0.107 B	0.050 B	0.090 B	4.000 B	2.976	1.161	4.804	7.007	5.670	2.810 B	0.928 B	0.354 B
28	0.102 B	0.035 B	0.090 B	4.000 B	2.778	1.113	5.896	6.719	5.477	2.631 B	0.958 B	0.425 B
29	0.096 B	-	0.090 B	4.000 B	2.608	1.091	5.817	6.319	6.027	2.493 B	0.968 B	0.449 B
30	0.088 B	-	0.091 B	3.771 B	2.642	1.216	6.124	6.150	6.324	2.344 B	0.970 B	0.452 B
31	0.087 B	-	0.100 B	-	2.865	-	7.406	6.587 A	-	2.012 B	-	0.471 B
min	0.088	0.035	0.050	0.110	2.009	1.091	1.558	6.072	5.477	2.012	0.928	0.287
mean	0.302	0.126	0.068	1.915	2.777	2.206	3.215	9.454	8.041	5.588	1.512	0.794
max	0.617	0.319	0.100	4.000	3.693	3.065	7.406	15.500	13.929	8.291	3.623	1.166

Notes: Data for period 1 Mar - 31 Oct from Environment Canada Station 07DB001. P - Partial daily average.
B - Ice effects. A - Manual reading.
E - Estimated.

Table VII.49 S26 MacKay River Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	97.273 B	97.276 B	97.215 B	-	-	-	-	-	-	-	97.491 B	97.360 B
2	97.265 B	97.273 B	97.181 B	-	-	-	-	-	-	-	97.500 B	97.369 B
3	97.254 B	97.262 B	97.169 B	-	-	-	-	-	-	-	97.477 B	97.375 B
4	97.261 B	97.260 B	97.168 B	-	-	-	-	-	-	-	97.454 B	97.368 B
5	97.262 B	97.264 B	97.169 B	-	-	-	-	-	-	-	97.425 B	97.361 B
6	97.272 B	97.273 B	97.158 B	-	-	-	-	-	-	-	97.397 B	97.370 B
7	97.287 B	97.278 B	97.161 B	-	-	-	-	-	-	-	97.391 B	97.372 B
8	97.298 B	97.279 B	97.155 B	-	-	-	-	-	-	-	97.384 B	97.374 B
9	97.307 B	97.277 B	97.145 B	-	-	-	-	-	-	-	97.384 B	97.382 B
10	97.320 B	97.283 B	-								97.385 B	97.390 B
11	97.332 B	97.293 B	-	-	-	-	-	-	-	-	97.381 B	97.393 B
12	97.343 B	97.297 B	-	-	-	-	-	-	-	-	97.369 B	97.397 B
13	97.355 B	97.307 B	-	-	-	-	-	-	-	-	97.363 B	97.399 B
14	97.358 B	97.317 B	-	-	-	-	-	-	-	-	97.359 B	97.394 B
15	97.296 B	97.327 B	-	-	-	-	-	-	-	-	97.350 B	97.388 B
16	97.311 B	97.336 B	-	-	-	-	-	-	-	-	97.344 B	97.381 B
17	97.339 B	97.346 B	-	-	-	-	-	-	-	-	97.352 B	97.393 B
18	97.335 B	97.357 B	-	-	-	-	-	-	-	-	97.356 B	97.401 B
19	97.325 B	97.373 B	-	-	-	-	-	-	-	-	97.358 B	97.387 B
20	97.315 B	97.388 B	-	-	-	-	-	-	-	-	97.363 B	97.383 B
21	97.309 B	97.396 B	-	-	-	-	-	-	-	-	97.370 B	97.354 B
22	97.300 B	97.401 B	-	-	-	-	-	-	-	-	97.369 B	97.335 B
23	97.291 B	97.408 B	-	-	-	-	-	-	-	-	97.360 B	97.312 B
24	97.281 B	97.418 B	-	-	-	-	-	-	-	97.614 B	97.355 B	97.298 B
25	97.271 B	97.402 B	-	-	-	-	-	-	-	97.644 B	97.350 B	97.300 B
26	97.261 B	97.309 B	-	-	-	-	-	-	-	97.585 B	97.335 B	97.308 B
27	97.262 B	97.267 B	-	-	-	-	-	-	-	97.480 B	97.330 B	97.326 B
28	97.264 B	97.243 B	-	-	-	-	-	-	-	97.443 B	97.336 B	97.347 B
29	97.264 B	-	-	-	-	-	-	-	-	97.444 B	97.341 B	97.355 B
30	97.263 B	-	-	-	-	-	-	-	-	97.464 B	97.344 B	97.359 B
31	97.267 B	-	-	-	-	-	-	-	-	97.451 B	-	97.367 B
min	97.254	97.243	97.145	-	-	-	-	-	-	97.443	97.330	97.298
mean	97.295	97.318	97.169	-	-	-	-	-	-	97.516	97.379	97.364
max	97.358	97.418	97.215	-	-	-	-	-	-	97.644	97.500	97.401

Notes: All data measured at RAMP station S26.
B - Ice effects.
A - Manual reading.
P - Partial daily average.
E - Estimated.

Table VII.50 S27 Firebag River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	8.460 B	6.726 B	7.000 B	12.000 B	18.000 B	21.189	34.169	107.893	39.421	45.289	23.026 BE	15.122 B
2	8.353 B	6.715 B	7.000 B	11.900 B	17.000 B	21.639	52.347	114.135	38.791	44.924	24.851 BE	14.457 B
3	8.208 B	6.804 B	7.000 B	11.800 B	18.000 B	21.852	69.021	114.220	38.207	44.608	24.306 B	13.852 B
4	8.102 B	6.935 B	7.000 B	11.700 B	22.036 B	21.605	76.201	111.460	40.441	45.764	20.484 B	13.510 B
5	7.983 B	7.092 B	7.000 B	11.800 B	20.917 B	21.354	80.643	107.604	49.858	47.727	19.037 B	13.180 B
6	7.873 B	7.206 B	7.000 B	11.900 B	20.698 B	21.664	80.796	103.859	57.568	47.892	21.988 B	12.858 B
7	7.775 B	7.156 B	7.000 B	12.000 B	20.296 B	22.898	78.971	99.470	60.674	47.562	21.233 B	12.670 B
8	7.732 B	7.173 B	7.000 B	12.100 B	21.081 B	26.092	75.145	93.388	60.605	46.845	25.611 B	12.496 B
9	7.658 B	7.215 B	7.000 B	13.000 B	22.109 B	29.511	70.192	87.166	58.515	46.190	30.166 B	12.587 B
10	7.626 B	7.243 B	7.000 B	13.500 B	23.093	30.565	64.089	80.317	55.418	45.381	28.836 B	12.616 B
11	7.577 B	7.327 B	7.000 B	14.000 B	25.085	29.982	56.567	73.767	52.910	44.247	23.964 B	12.734 B
12	7.525 B	7.258 B	6.960 B	14.500 B	27.323	28.778	50.065	68.006	50.215	43.014	26.515 B	12.560 B
13	7.543 B	7.289 B	7.000 B	13.000 B	28.458	27.245	45.011	62.134	47.531	41.623	28.538 B	12.494 B
14	7.441 B	7.319 B	7.000 B	13.000 B	32.058	25.711	41.142	58.076	45.204	40.929	28.364 B	12.492 B
15	7.441 B	7.362 B	7.000 B	12.500 B	31.286	24.042	38.497	57.294	43.396	38.641 B	30.266 B	12.534 B
16	7.370 B	7.416 B	7.000 B	12.800 B	27.763	22.639	36.692	58.176	41.542	36.449 B	30.367 B	12.631 B
17	7.306 B	7.505 B	7.500 B	14.100 B	26.456	21.631	35.358	60.266	39.952	36.475 B	27.447 B	12.600 B
18	7.405 B	7.650 B	8.000 B	15.400 B	25.683	20.718	34.617	60.481	38.389	34.528 B	26.750 B	12.552 B
19	7.450 B	7.748 B	9.000 B	16.700 B	24.870	20.213	33.975	60.058	37.236	35.015 B	26.666 B	12.448 B
20	7.440 B	7.860 B	10.000 B	18.000 B	24.371	20.022	34.751	59.912	37.874	32.361 B	25.644 B	12.379 B
21	7.453 B	8.049 B	10.100 B	17.700 B	23.621	19.723	49.895	58.097	41.260	31.277 B	26.071 B	12.306 B
22	7.430 B	8.152 B	10.600 B	17.300 B	22.703	19.581	80.667	55.888	46.810	31.095 B	22.993 B	12.350 B
23	7.369 B	8.226 B	11.100 B	17.000 B	21.743	19.076	91.511	53.226	49.927	29.458 B	22.583 B	12.249 B
24	7.281 B	8.287 B	11.600 B	18.000 B	21.055	19.088	98.985	50.399	50.656	28.202 B	21.950 B	12.141 B
25	7.187 B	8.290 B	12.200 B	19.000 B	20.587	18.497	100.749	47.728	49.929	27.139 B	21.549 B	11.846 B
26	7.182 B	8.246 B	12.700 B	20.000 B	19.757	18.231	97.687	44.888	47.988	25.684 B	20.867 B	11.762 B
27	7.176 B	8.198 B	12.600 B	21.000 B	19.518	18.225	92.949	44.010	46.481	24.760 B	19.192 B	11.689 B
28	7.028 B	8.063 B	12.500 B	21.500 B	19.342	18.183	90.979	43.094	44.901	24.237 B	17.792 B	11.637 B
29	6.908 B	-	12.400 B	19.500 B	19.703	18.501	88.178	42.208	44.772	22.343 B	16.518 B	11.549 B
30	6.829 B	-	12.300 B	17.000 B	20.018	24.377	86.313	41.067	45.326	20.636 B	15.804 B	11.452 B
31	6.778 B	-	12.100 B	-	20.551	-	95.955	39.690	-	21.211 B	-	11.343 B
min	6.778	6.715	6.960	11.700	17.000	18.183	33.975	39.690	37.236	20.636	15.804	11.343
mean	7.513	7.518	8.925	15.123	22.748	22.428	66.520	69.612	46.727	36.500	23.979	12.551
max	8.460	8.290	12.700	21.500	32.058	30.565	100.749	114.220	60.674	47.892	30.367	15.122

Notes: Data for period 1 Mar - 31 Oct from Environment Canada Station 07DC001.
B - Ice effects.
A - Manual reading.
P - Partial daily average.
E - Estimated.

Table VII.51 S27 Firebag River Mean Daily Water Levels (m) Based on Permanent Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	97.471 B	97.494 B	97.585 B	97.638 B	97.565 B	-	-	-	-	-	97.645 B	97.658 B
2	97.473 B	97.494 B	97.580 B	97.638 B	97.562 B	-	-	-	-	-	97.725 B	97.645 B
3	97.473 B	97.499 B	97.578 B	97.642 B	97.547 B	-	-	-	-	-	97.714 B	97.633 B
4	97.475 B	97.505 B	97.577 B	97.649 B	97.522 B	-	-	-	-	-	97.627 B	97.626 B
5	97.477 B	97.513 B	97.574 B	97.652 B	97.505 B	-	-	-	-	-	97.596 B	97.619 B
6	97.478 B	97.518 B	97.573 B	97.659 B	97.489 B	-	-	-	-	-	97.678 B	97.612 B
7	97.480 B	97.517 B	97.573 B	97.664 B	97.413 B	-	-	-	-	-	97.665 B	97.610 B
8	97.484 B	97.519 B	97.574 B	97.667 B	97.302 B	-	-	-	-	-	97.777 B	97.608 B
9	97.487 B	97.522 B	97.576 B	97.670 B	97.312 B	-	-	-	-	-	97.886 B	97.614 B
10	97.492 B	97.525 B	97.580 B	97.674 B	97.337	-	-	-	-	-	97.862 B	97.618 B
11	97.496 B	97.530 B	97.583 B	97.675 B	97.351	-	-	-	-	-	97.759 B	97.626 B
12	97.500 B	97.529 B	97.587 B	97.674 B	97.396	-	-	-	-	-	97.825 B	97.623 B
13	97.507 B	97.532 B	97.591 B	97.675 B	97.438	-	-	-	-	-	97.877 B	97.625 B
14	97.508 B	97.535 B	97.596 B	97.677 B	97.465 P	-	-	-	-	-	97.880 B	97.628 B
15	97.509 B	97.538 B	97.599 B	97.677 B	-	-	-	-	-	-	97.928 B	97.633 B
16	97.507 B	97.542 B	97.600 B	97.675 B	-	-	-	-	-	-	97.937 B	97.639 B
17	97.506 B	97.547 B	97.602 B	97.672 B	-	-	-	-	-	-	97.879 B	97.642 B
18	97.510 B	97.555 B	97.605 B	97.659 B	-	-	-	-	-	-	97.870 B	97.644 B
19	97.513 B	97.560 B	97.608 B	97.642 B	-	-	-	-	-	-	97.875 B	97.644 B
20	97.514 B	97.567 B	97.611 B	97.628 B	-	-	-	-	-	-	97.858 B	97.645 B
21	97.515 B	97.576 B	97.614 B	97.622 B	-	-	-	-	-	-	97.875 B	97.646 B
22	97.515 B	97.581 B	97.617 B	97.629 B	-	-	-	-	-	-	97.808 B	97.651 B
23	97.513 B	97.586 B	97.620 B	97.642 B	-	-	-	-	-	97.554 BP	97.805 B	97.651 B
24	97.510 B	97.590 B	97.623 B	97.634 B	-	-	-	-	-	97.565 B	97.796 B	97.651 B
25	97.507 B	97.592 B	97.625 B	97.629 B	-	-	-	-	-	97.576 B	97.793 B	97.645 B
26	97.508 B	97.591 B	97.626 B	97.629 B	-	-	-	-	-	97.539 B	97.782 B	97.645 B
27	97.509 B	97.591 B	97.629 B	97.634 B	-	-	-	-	-	97.491 B	97.745 B	97.646 B
28	97.503 B	97.588 B	97.630 B	97.623 B	-	-	-	-	-	97.475 B	97.714 B	97.648 B
29	97.499 B	-	97.632 B	97.606 B	-	-	-	-	-	97.444 B	97.685 B	97.649 B
30	97.497 B	-	97.632 B	97.589 B	-	-	-	-	-	97.426 B	97.671 B	97.649 B
31	97.495 B	-	97.634 B	-	-	-	-	-	-	97.530 B	-	97.649 B
min	97.471	97.494	97.573	97.589	97.302	-	-	-	-	97.426	97.596	97.608
mean	97.498	97.544	97.601	97.648	97.443	-	-	-	-	97.511	97.785	97.636
max	97.515	97.592	97.634	97.677	97.565	-	-	-	-	97.576	97.937	97.658

Notes: All data measured at RAMP station S27.
B - Ice effects.
A - Manual reading.
P - Partial daily average.
E - Estimated.

Table VII.52 S28 Khahago Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	0.415	0.565	3.266	0.941	0.958	-	-
2	-	-	-	-	-	0.425	0.681	3.522	0.927	1.006	-	-
3	-	-	-	-	-	0.456	0.739	3.439	0.912	1.045	-	-
4	-	-	-	-	-	0.471	0.793	3.236	1.064	1.046	-	-
5	-	-	-	-	-	0.481	0.874	3.057	1.443	1.023	-	-
6	-	-	-	-	-	0.502	0.898	3.140	1.878	1.029	-	-
7	-	-	-	-	-	0.558	0.869	3.010	1.984	1.029	-	-
8	-	-	-	-	-	0.598	0.843	2.647	1.895	1.008	-	-
9	-	-	-	-	-	0.613	0.815	2.312	1.751	0.996	-	-
10	-	-	-	-	-	0.594	0.777	2.001	1.579	0.969	-	-
11	-	-	-	-	-	0.574	0.734	1.775	1.439	0.927	-	-
12	-	-	-	-	-	0.568	0.698	1.580	1.298	0.878	-	-
13	-	-	-	-	-	0.557	0.663	1.466	1.223	0.871	-	-
14	-	-	-	-		0.543	0.640	1.501	1.147	0.873	-	-
15	-	-	-	-	-	0.535	0.622	1.653	1.067	0.816	-	-
16	-	-	-	-	-	0.536	0.604	2.054	0.997	0.791	-	-
17	-	-	-	-	0.198 P	0.532	0.590	2.091	0.941	0.792	-	-
18	-	-	-	-	0.209	0.524	0.597	1.986	0.885	0.788	-	-
19	-	-	-	-	0.221	0.516	0.600	1.971	0.852	0.778	-	-
20	-	-	-	-	0.229	0.510	0.688	1.869	0.844	0.737	-	-
21	-	-	-	-	0.231	0.513	1.037	1.722	0.831	0.694	-	-
22	-	-	-	-	0.266	0.504	1.318	1.577	0.818	0.682	-	-
23	-	-	-	-	0.294	0.504	1.588	1.402	0.821	0.672	-	-
24	-	-	-	-	0.301	0.499	1.603	1.248	0.825	0.671	-	-
25	-	-	-	-	0.307	0.486	1.504	1.131	0.817	0.681	-	-
26	-	-	-	-	0.323	0.480	1.449	1.100	0.811	0.681 P	-	-
27	-	-	-	-	0.342	0.484	1.373	1.083	0.808	-	-	-
28	-	-	-	-	0.345	0.482	1.463	1.056	0.827	-	-	-
29	-	-	-	-	0.354	0.490	1.442	1.015	0.921	-	-	-
30	-	-	-	-	0.365	0.518	1.516	0.965	0.958	-	-	-
31	-	-	-	-	0.390	-	2.417	0.950	-	-	-	-
min	-	-	-	-	0.198	0.415	0.565	0.950	0.808	0.671	-	-
mean	-	-	-	-	0.292	0.516	1.000	1.962	1.117	0.863	-	-
max	-	-	-	-	0.390	0.613	2.417	3.522	1.984	1.046	-	-

Notes: P - Partial daily average.

Table VII.53 S28 Khahago Creek Mean Daily Water Levels (m) Based on Permanent Benchmark el. 325.175 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	323.964	324.036	324.529	324.165	324.170	-	-
2	-	-	-	-	-	323.969	324.082	324.554	324.161	324.183	-	-
3	-	-	-	-	-	323.985	324.103	324.546	324.157	324.193	-	-
4	-	-	-	-	-	323.993	324.121	324.527	324.197	324.193	-	-
5	-	-	-	-	-	323.998	324.146	324.508	324.281	324.187	-	-
6	-	-	-	-	-	324.008	324.153	324.517	324.358	324.189	-	-
7	-	-	-	-	-	324.034	324.144	324.503	324.374	324.189	-	-
8	-	-	-	-	-	324.050	324.137	324.462	324.361	324.183	-	-
9	-	-	-	-	-	324.056	324.128	324.420	324.337	324.180	-	-
10	-	-	-	-	-	324.049	324.115	324.377	324.307	324.173	-	-
11	-	-	-	-	-	324.041	324.101	324.341	324.281	324.161	-	-
12	-	-	-	-	-	324.038	324.088	324.308	324.252	324.147	-	-
13	-	-	-	-	-	324.033	324.076	324.286	324.236	324.145	-	-
14	-	-	-	-		324.027	324.067	324.293	324.218	324.145	-	-
15	-	-	-	-	-	324.024	324.060	324.321	324.198	324.128	-	-
16	-	-	-	-	-	324.024	324.053	324.385	324.180	324.120	-	-
17	-	-	-	-	323.804 P	324.022	324.047	324.390	324.165	324.120	-	-
18	-	-	-	-	323.816	324.018	324.050	324.375	324.149	324.119	-	-
19	-	-	-	-	323.827	324.015	324.051	324.372	324.139	324.116	-	-
20	-	-	-	-	323.834	324.012	324.083	324.357	324.137	324.102	-	-
21	-	-	-	-	323.836	324.013	324.190	324.333	324.133	324.087	-	-
22	-	-	-	-	323.866	324.009	324.256	324.307	324.129	324.083	-	-
23	-	-	-	-	323.887	324.009	324.309	324.274	324.130	324.079	-	-
24	-	-	-	-	323.892	324.007	324.312	324.241	324.131	324.079	-	-
25	-	-	-	-	323.897	324.001	324.294	324.214	324.128	324.082	-	-
26	-	-	-	-	323.907	323.998	324.283	324.207	324.127	324.082 P	-	-
27	-	-	-	-	323.920	324.000	324.268	324.203	324.126	-	-	-
28	-	-	-	-	323.922	323.999	324.286	324.196	324.131	-	-	-
29	-	-	-	-	323.928	324.002	324.282	324.185	324.159	-	-	-
30	-	-	-	-	323.935	324.016	324.295	324.172	324.170	-	-	-
31	-	-	-	-	323.949	-	324.432	324.168	-	-	-	-
min	-	-	-	-	323.804	323.964	324.036	324.168	324.126	324.079	-	-
mean	-	-	-	-	323.881	324.014	324.163	324.351	324.201	324.140	-	-
max	-	-	-	-	323.949	324.056	324.432	324.554	324.374	324.193	-	-

Notes: P - Partial daily average.

Table VII.54 S29 Christina River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	1.523 B	2.164 A	7.018	4.532 A	-	24.208 A	-	-	10.443 B	3.750 B
2	-	-	1.347 B	2.154 A	6.626 A	4.499 A	-	26.010 A	-	-	10.322 B	3.588 B
3	-	-	1.349 B	2.063 A	7.823 A	4.469 A	-	27.305 A	-	-	9.843 B	3.139 B
4	-	2.790 B	1.482 B	2.168 A	7.263 A	4.411 A	-	27.685 A	-	-	8.723 B	3.268 B
5	-	2.845 B	1.745 B	2.115 A	5.538 A	4.598 A	-	27.977	-	-	7.685 B	3.206 B
6	-	2.893 B	1.947 B	2.615	5.778 A	4.844	-	27.985	-	-	7.611 B	3.056 B
7	-	2.945 B	1.883 B	2.952	6.706 A	6.069 A	-	27.614	-	-	6.892 B	3.051 B
8	-	2.981 B	1.733 B	2.984 A	8.088 A	9.838 A	-	26.703	-	-	5.794 B	3.026 B
9	-	2.987 B	1.725 B	3.298 A	7.992 A	13.084 A	-	25.525	-	-	6.244 B	3.062 B
10	-	2.940 B	1.961 B	3.478 A	7.221 A	14.138	-	23.795	-	-	6.279 B	3.076 B
11	-	2.904 B	2.269 B	3.641	7.621 A	14.412	-	22.292 A	-	-	6.359 B	3.104 B
12	-	2.777 B	2.384 B	3.857 A	7.818 A	13.618	-	20.812	-	-	6.180 B	3.037 B
13	2.747 B	2.526 B	2.595 B	3.994 A	7.298	12.925	-	19.488	-	-	6.090 B	2.942 B
14	-	2.711 B	1.673 A	3.908	7.082	12.217	-	18.596	-	-	6.086 B	2.889 B
15	-	2.720 B	2.098	4.043 A	6.612 A	11.777 A	-	19.262 A	-	-	5.951 B	2.866 B
16	-	2.590 B	2.500 A	4.123 A	6.365	11.470	-	22.819 A	-	-	5.905 B	2.867 B
17	-	2.410 B	2.530 A	4.502 A	6.170	10.711 A	-	24.420 A	-	-	5.859 B	2.855 B
18	-	2.527 B	2.146 A	4.632 A	6.105	9.722 A	-	26.101 A	-	-	5.706 B	2.732 B
19	-	2.633 B	2.866 A	4.235 A	6.175 A	-	-	28.474 A	-	-	5.509 B	2.560 B
20	-	2.179 B	3.376 A	4.331	6.132	-	-	29.410	-	-	5.338 B	2.349 B
21	-	2.704 B	2.901	5.103	5.866 A	-	-	29.084 A	-	-	5.172 B	2.317 B
22	2.527 B	2.624 B	2.785	5.956 A	5.455 A	-	-	28.066	-	-	4.983 B	2.137 B
23	2.737 B	2.369 B	2.605 A	5.271 A	5.278 A	-	-	26.840	-	-	4.348 B	2.009 B
24	3.070 B	1.966 B	2.486 A	6.641 A	5.129 A	-	-	25.588	-	-	4.915 B	2.013 B
25	-	1.587 B	2.371 A	6.507	5.044 A	-	21.928 A	24.404 A	-	-	4.785 B	2.119 B
26	-	1.395 B	2.666 A	6.453 A	4.953 A	-	21.344	23.712	-	-	4.421 B	2.128 B
27	-	1.403 B	2.369 A	7.591 A	4.945 A	-	21.305	23.096 A	-	15.203 B	4.340 B	2.210 B
28	-	1.550 B	2.249 A	7.421 A	4.902 A	-	21.173	-	-	10.966 B	4.277 B	2.274 B
29	-	-	2.176 A	7.906 A	4.868	-	20.949	-	-	9.239 B	3.989 B	2.286 B
30	-	-	2.063 A	7.361 A	4.824	-	20.729 A	-	-	9.018 B	3.881 B	2.307 B
31	-	-	2.103 A	-	4.619	-	21.850 A	-	-	10.777 B	-	2.239 B
min	2.527	1.395	1.347	2.063	4.619	4.411	20.729	18.596	-	9.018	3.881	2.009
mean	2.770	2.478	2.191	4.449	6.236	9.296	21.325	25.084	-	11.041	6.131	2.725
max	3.070	2.987	3.376	7.906	8.088	14.412	21.928	29.410	-	15.203	10.443	3.750

Notes: Data for period 14 Mar - 27 Aug from Environment Canada Station 07CE002. P - Partial daily average.
B - Ice effects. E - Estimated.
A - Manual reading.

Table VII.55 S29 Christina River Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	94.996 B	95.164	-	-	-	-	-	-	95.294 B	95.051 B
2	-	-	94.976 B	95.172	-	-	-	-	-	-	95.293 B	95.044 B
3	-	-	94.980 B	95.161	-	-	-	-	-	-	95.276 B	95.012 B
4	-	95.030 B	95.003 B	95.155	-	-	-	-	-	-	95.230 B	95.028 B
5	-	95.037 B	95.040 B	95.151	-	-	-	-	-	-	95.184 B	95.028 B
6	-	95.046 B	95.068 B	95.174	-	-	-	-	-	-	95.185 B	95.020 B
7	-	95.055 B	95.065 B	95.188	-	-	-	-	-	-	95.151 B	95.024 B
8	-	95.062 B	95.051 B	95.193	-	-	-	-	-	-	95.093 B	95.027 B
9	-	95.067 B	95.054 B	95.200	-	-	-	-	-	-	95.123 B	95.035 B
10	-	95.067 B	95.086 B	95.204	-	-	-	-	-	-	95.130 B	95.042 B
11	-	95.068 B	95.123 B	95.199	-	-	-	-	-	-	95.138 B	95.049 B
12	-	95.060 B	95.139 B	95.191	-	-	-	-	-	-	95.132 B	95.048 B
13	94.900 B	95.038 B	95.164 B	95.207	-	-	-	-	-	-	95.131 B	95.045 B
14	-	95.062 B	95.189 A	95.199	-	-	-	-	-	-	95.135 B	95.045 B
15	-	95.067 B	95.214	95.202	-	-	-	-	-	-	95.131 B	95.048 B
16	-	95.059 B	95.233	95.202	-	-	-	-	-	-	95.132 B	95.053 B
17	-	95.046 B	95.229	95.225	-	-	-	-	-	-	95.133 B	95.057 B
18	-	95.061 B	95.203	95.228	-	-	-	-	-	-	95.128 B	95.051 B
19	-	95.076 B	95.239	95.208	-	-	-	-	-	-	95.120 B	95.040 B
20	-	95.033 B	95.265	95.212	-	-	-	-	-	-	95.114 B	95.024 B
21	-	95.091 B	95.239	95.245	-	-	-	-	-	-	95.108 B	95.026 B
22	94.950 B	95.088 B	95.228	95.262	-	-	-	-	-	94.784 B	95.099 B	95.012 B
23	94.974 B	95.067 B	95.217	-	-	-	-	-	-	94.777 B	95.060 B	95.003 B
24	95.008 B	95.028 B	95.204	-	-	-	-	-	-	94.843 B	95.103 B	95.008 B
25	-	94.987 B	95.194	-	-	-	-	-	-	94.901 B	95.098 B	95.025 B
26	-	94.966 B	95.207	-	-	-	-	-	-	94.978 B	95.078 B	95.031 B
27	-	94.971 B	95.187	-	-	-	-	-	-	95.351 B	95.076 B	95.045 B
28	-	94.995 B	95.179	-	-	-	-	-	-	95.296 B	95.076 B	95.056 B
29	-	-	95.171	-	-	-	-	-	-	95.229 B	95.059 B	95.063 B
30	-	-	95.160	-	-	-	-	-	-	95.223 B	95.056 B	95.070 B
31	-	-	95.160	-	-	-	-	-	-	95.304 B	-	95.068 B
min	94.900	94.966	94.976	95.151	-	-	-	-	-	94.777	95.056	95.003
mean	94.958	95.045	95.144	95.197	-	-	-	-	-	95.068	95.136	95.038
max	95.008	95.091	95.265	95.262	-	-	-	-	-	95.351	95.294	95.070

Notes: P - Partial daily average. B - Ice effects.
E - Estimated. A - Manual reading.

Table VII.56 S30 Hangingstone River Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	14.607	0.620	0.374	-	-
2	-	-	-	-	-	-	-	10.638	0.525	0.355	-	-
3	-	-	-	-	-	-	-	7.880	0.549	0.391	-	-
4	-	-	-	-	-	-	-	6.099	0.941	0.446	-	-
5	-	-	-	-	-	-	-	4.902	1.033	0.431	-	-
6	-	-	-	-	-	-	-	4.377	1.101	0.396	-	-
7	-	-	-	-	-	-	-	3.451	1.060	0.406	-	-
8	-	-	-	-	-	1.068 A	-	2.775	0.911	0.435	-	-
9	-	-	-	-	-	-	0.215 P	2.194	0.754	0.413	-	-
10	-	-	-	-	-	-	0.159	1.749	0.619	0.423	-	-
11	-	-	-	-	-	-	0.089	1.394	0.521	0.450	-	-
12	-	-	-	-	-	-	0.045	1.158	0.445	0.414	-	-
13	-	-	-	-	1.073 A	-	0.024	0.992	0.474	0.419	-	-
14	-	-	-	-	-	-	0.017	1.090	0.479	0.367	-	-
15	-	-	-	-	-	-	0.015	3.695	0.402	0.420	-	-
16	-	-	-	-	-	-	0.006	9.384	0.356	0.446	-	-
17	-	-	-	-	-	-	0.001	9.084	0.361	0.413	-	-
18	-	-	-	-	-	-	0.006	7.076	0.283	0.639	-	-
19	-	-	-	-	-	-	0.379	5.663	0.258	0.901	-	-
20	-	-	-	-	-	-	1.509	4.572	0.318	0.876	-	-
21	-	-	-	-	-	-	18.248	3.555	0.412	0.511 P	-	-
22	-	-	-	-	-	-	16.229	2.753	0.429	-	-	-
23	-	-	-	-	-	-	11.119	2.193	0.392	-	-	-
24	-	-	-	-	-	-	8.370	1.764	0.354	-	-	-
25	-	-	-	-	-	-	6.497	1.367	0.312	-	-	-
26	-	-	-	-	-	-	6.223	1.326	0.272	-	-	-
27	-	-	-	-	-	-	7.301	1.179	0.269	-	-	-
28	-	-	-	-	-	-	7.394	0.963	0.290	-	-	-
29	-	-	-	-	-	-	6.581	0.789	0.428	-	-	-
30	-	-	-	-	-	-	5.476	0.675	0.436	-	-	-
31	-	-	-	-	-	-	11.360	0.681	-	-	-	-
min	-	-	-	-	-	-	0.001	0.675	0.258	0.355	-	-
mean	-	-	-	-	-	-	4.664	3.872	0.520	0.473	-	-
max	-	-	-	-	-	-	18.248	14.607	1.101	0.901	-	-

Notes: P - Partial daily average. B - Ice effects.
E - Estimated. A - Manual reading.

Table VII.57 S30 Hangingstone River Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	-	-	99.049	98.195	98.149	-	-
2	-	-	-	-	-	-	-	98.885	98.178	98.145	-	-
3	-	-	-	-	-	-	-	98.755	98.182	98.152	-	-
4	-	-	-	-	-	-	-	98.658	98.243	98.164	-	-
5	-	-	-	-	-	-	-	98.586	98.256	98.161	-	-
6	-	-	-	-	-	-	-	98.552	98.265	98.154	-	-
7	-	-	-	-	-	-	-	98.486	98.259	98.156	-	-
8	-	-	-	-	-	-	-	98.433	98.239	98.161	-	-
9	-	-	-	-	-	-	98.111 P	98.382	98.216	98.157	-	-
10	-	-	-	-	-	-	98.094	98.338	98.195	98.159	-	-
11	-	-	-	-	-	-	98.069	98.300	98.178	98.164	-	-
12	-	-	-	-	-	-	98.048	98.272	98.163	98.157	-	-
13	-	-	-	-	-	-	98.035	98.250	98.169	98.158	-	-
14	-	-	-	-	-	-	98.028	98.262	98.170	98.147	-	-
15	-	-	-	-	-	-	98.027	98.499	98.155	98.155	-	-
16	-	-	-	-	-	-	98.016	98.826	98.145	98.163	-	-
17	-	-	-	-	-	-	98.007	98.814	98.145	98.157	-	-
18	-	-	-	-	-	-	98.013	98.713	98.128	98.193	-	-
19	-	-	-	-	-	-	98.138	98.633	98.122	98.237	-	-
20	-	-	-	-	-	-	98.285	98.565	98.136	98.233	-	-
21	-	-	-	-	-	-	99.169	98.494	98.157	98.254	-	-
22	-	-	-	-	-	-	99.108	98.431	98.160	98.284 BP	-	-
23	-	-	-	-	-	-	98.906	98.382	98.153	-	-	-
24	-	-	-	-	-	-	98.780	98.340	98.145	-	-	-
25	-	-	-	-	-	-	98.681	98.297	98.135	-	-	-
26	-	-	-	-	-	-	98.663	98.292	98.126	-	-	-
27	-	-	-	-	-	-	98.725	98.274	98.124	-	-	-
28	-	-	-	-	-	-	98.730	98.246	98.130	-	-	-
29	-	-	-	-	-	-	98.686	98.222	98.160	-	-	-
30	-	-	-	-	-	-	98.622	98.204	98.162	-	-	-
31	-	-	-	-	-	-	98.906	98.205	-	-	-	-
min	-	-	-	-	-	-	98.007	98.204	98.122	98.145	-	-
mean	-	-	-	-	-	-	98.428	98.472	98.173	98.175	-	-
max	-	-	-	-	-	-	99.169	99.049	98.265	98.284	-	-

Notes: P - Partial daily average. B - Ice effects.
E - Estimated. A - Manual reading.

Table VII.58 S31 Hangingstone Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.177	0.095	0.500	4.265	1.106	1.132	-	-
2	-	-	-	-	0.181	0.086	0.634	4.131	1.096	1.112	-	-
3	-	-	-	-	0.147	0.080	0.651	3.426	1.123	1.152	-	-
4	-	-	-	-	0.173	0.078	0.585	2.725	1.345	1.198	-	-
5	-	-	-	-	0.152	0.075	0.528	2.216	1.689	1.135	-	-
6	-	-	-	-	0.140	0.082	0.447	2.042	1.740	1.121	-	-
7	-	-	-	-	0.142	0.108	0.420	1.860	1.601	1.133	-	-
8	-	-	-	-	0.145	0.143	0.429	1.722	1.548	1.168	-	-
9	-	-	-	-	0.153	0.147	0.446	1.598	1.472	1.167	-	-
10	-	-	-	0.096 P	0.154	0.136	0.494	1.303	1.316	1.188	-	-
11	-	-	-	0.102	0.151	0.130	0.481	1.071	1.153	1.244	-	-
12	-	-	-	0.114	0.176	0.106	0.487	0.975	1.057	1.214	-	-
13	-	-	-	0.133	0.189	0.090	0.484	0.933	1.040	1.227	-	-
14	-	-	-	0.129	0.194	0.083	0.415	0.917	1.040	1.299	-	-
15	-	-	-	0.147	0.168	0.080	0.331	1.438	1.068	1.277	-	-
16	-	-	-	0.134	0.181	0.077	0.210	3.720	0.997	-	-	-
17	-	-	-	0.139	0.162	0.074	0.195	4.938	0.955	-	-	-
18	-	-	-	0.153	0.137	0.083	0.224	4.756	1.018	-	-	-
19	-	-	-	0.217	0.136	0.086	0.406	4.499	0.987	-	-	-
20	-	-	-	0.217	0.148	0.088	0.937	3.990	0.947	-	-	-
21	-	-	-	0.243	0.155	0.083	5.269	2.999	1.081	-	-	-
22	-	-	-	0.260	0.148	0.076	6.509	2.446	1.169	-	-	-
23	-	-	-	0.200	0.145	0.070	5.725	2.340	1.153	-	-	-
24	-	-	-	0.312	0.155	0.069	4.369	2.163	1.149	-	-	-
25	-	-	-	0.354	0.135	0.062	3.440	1.838	1.135	-	-	-
26	-	-	-	0.212	0.151	0.061	3.111	1.734	1.108	-	-	-
27	-	-	-	0.187	0.116	0.059	2.916	1.813	1.053	-	-	-
28	-	-	-	0.174	0.102	0.056	2.454	1.374	1.069	-	-	-
29	-	-	-	0.181	0.104	0.069	2.653	1.304	1.138	-	-	-
30	-	-	-	0.181	0.108	0.302	2.375	1.173	1.152	-	-	-
31	-	-	-	-	0.093	-	3.078	1.188		-	-	-
min	-	-	-	-	0.093	0.056	0.195	0.917	0.947	1.112	-	-
mean	-	-	-	-	0.149	0.094	1.652	2.352	1.184	1.184	-	-
max	-	-	-	-	0.194	0.302	6.509	4.938	1.740	1.299	-	-

Notes: P - Partial daily average.

Table VII.59 S31 Hangingstone Creek Mean Daily Water Levels (m) Based on Temporary Benchmark el. 100.000 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	98.259	98.201	98.404	98.992	98.563	98.569	-	-
2	-	-	-	-	98.263	98.193	98.446	98.978	98.561	98.564	-	-
3	-	-	-	-	98.240	98.187	98.451	98.905	98.567	98.573	-	-
4	-	-	-	-	98.255	98.185	98.431	98.822	98.611	98.582	-	-
5	-	-	-	-	98.245	98.182	98.413	98.754	98.672	98.569	-	-
6	-	-	-	-	98.236	98.189	98.385	98.728	98.680	98.566	-	-
7	-	-	-	-	98.237	98.212	98.375	98.700	98.658	98.569	-	-
8	-	-	-	-	98.240	98.239	98.379	98.678	98.648	98.576	-	-
9	-	-	-	-	98.245	98.241	98.385	98.657	98.635	98.576	-	-
10	-	-	-	98.202 P	98.246	98.234	98.401	98.603	98.606	98.580	-	-
11	-	-	-	98.206	98.244	98.229	98.397	98.554	98.573	98.592	-	-
12	-	-	-	98.217	98.260	98.210	98.399	98.534	98.552	98.585	-	-
13	-	-	-	98.231	98.268	98.197	98.398	98.524	98.549	98.588	-	-
14	-	-	-	98.228	98.271	98.190	98.372	98.520	98.549	98.602	-	-
15	-	-	-	98.241	98.255	98.187	98.337	98.626	98.555	98.598	-	-
16	-	-	-	98.231	98.263	98.184	98.280	98.932	98.539	98.620	-	-
17	-	-	-	98.236	98.251	98.181	98.272	99.055	98.530	98.651	-	-
18	-	-	-	98.245	98.235	98.190	98.288	99.038	98.544	98.662	-	-
19	-	-	-	98.284	98.234	98.193	98.367	99.014	98.536	98.681	-	-
20	-	-	-	98.283	98.242	98.195	98.515	98.963	98.527	98.685 P	-	-
21	-	-	-	98.297	98.247	98.190	99.073	98.855	98.558	-	-	-
22	-	-	-	98.306	98.242	98.183	99.184	98.785	98.576	-	-	-
23	-	-	-	98.272	98.239	98.177	99.122	98.771	98.573	-	-	-
24	-	-	-	98.326	98.246	98.175	99.000	98.746	98.572	-	-	-
25	-	-	-	98.339	98.233	98.168	98.906	98.697	98.569	-	-	-
26	-	-	-	98.281	98.244	98.167	98.869	98.680	98.564	-	-	-
27	-	-	-	98.267	98.218	98.165	98.845	98.693	98.552	-	-	-
28	-	-	-	98.259	98.207	98.160	98.787	98.616	98.555	-	-	-
29	-	-	-	98.263	98.209	98.175	98.813	98.603	98.570	-	-	-
30	-	-	-	98.263	98.212	98.315	98.776	98.577	98.573	-	-	-
31	-	-	-	-	98.200	-	98.862	98.580	-	-	-	-
min	-	-	-	98.202	98.200	98.160	98.272	98.520	98.527	98.564	-	-
mean	-	-	-	98.261	98.242	98.196	98.723	98.748	98.577	98.599	-	-
max	-	-	-	98.339	98.271	98.315	99.184	99.055	98.680	98.685	-	-

Notes: P - Partial daily average.

Table VII.60 S32 Surmont Creek Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	0.155	0.279	-	0.659	0.468	-	-
2	-	-	-	-	-	0.151	0.341	4.278 P	0.617	0.460	-	-
3	-	-	-	-	-	0.142	0.431	3.697	0.604	0.479	-	-
4	-	-	-	-	-	0.137	0.384	2.897	0.678	0.498	-	-
5	-	-	-	-	-	0.142	0.429	2.396	0.676	0.496	-	-
6	-	-	-	-	-	0.162	0.351	2.193	0.677	0.509	-	-
7	-	-	-	-	-	0.240	0.294	1.849	0.666	0.518	-	-
8	-	-	-	-	-	0.250	0.248	1.642	0.631	0.523	-	-
9	-	-	-	-	-	0.189	0.210	1.415	0.588	0.515	-	-
10	-	-	-	-	-	0.166	0.180	1.228	0.550	0.517	-	-
11	-	-	-	-	-	0.152	0.166	1.070	0.517	0.537	-	-
12	-	-	-	-	-	0.141	0.173	0.948	0.487	0.510	-	-
13	-	-	-	-	-	0.130	0.140	0.852	0.482	0.512	-	-
14	-	-	-	-	-	0.128	0.137	0.818	0.472	0.514	-	-
15	-	-	-	-	-	0.124	0.154	1.536	0.451	0.509	-	-
16	-	-	-	-	-	0.120	0.135	3.169	0.438	0.523	-	-
17	-	-	-	-	-	0.118	0.124	3.244	0.416	0.544	-	-
18	-	-	-	-	0.242 P	0.123	0.120	2.632	0.398	-	-	-
19	-	-	-	-	0.219	0.118	0.166	2.240	0.386	-	-	-
20	-	-	-	-	0.199	0.116	0.325	1.977	0.425	-	-	-
21	-	-	-	-	0.191	0.110	2.942 P	1.720	0.502	-	-	-
22	-	-	-	-	0.169	0.107	4.275 P	1.512	0.523	-	-	-
23	-	-	-	-	0.145	0.103	3.706 P	1.334	0.505	-	-	-
24	-	-	-	-	0.136	0.098	2.900	1.193	0.494	-	-	-
25	-	-	-	-	0.134	0.097	2.335	1.072	0.471	-	-	-
26	-	-	-	-	0.143	0.094	2.237	1.026	0.454	-	-	-
27	-	-	-	-	0.144	0.091	2.331	0.947	0.440	-	-	-
28	-	-	-	-	0.149	0.089	2.678	0.864	0.436	-	-	-
29	-	-	-	-	0.151	0.092	2.820	0.786	0.490	-	-	-
30	-	-	-	-	0.176	0.152	2.385	0.735	0.488	-	-	-
31	-	-	-	-	0.163	-	3.008 P	0.708	-	-	-	-
min	-	-	-	-	0.134	0.089	0.120	0.708	0.386	0.460	-	-
mean	-	-	-	-	0.169	0.135	1.733	1.732	0.521	0.508	-	-
max	-	-	-	-	0.242	0.250	4.275	4.278	0.678	0.544	-	-

Notes: P - Partial daily average.
B - Ice effects.

Table VII.61 S32 Surmont Creek Mean Daily Water Levels (m) Based on Temporary Benchmark el. 97.942 m (local), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	-	96.566	96.690	-	96.926	96.824	-	-
2	-	-	-	-	-	96.560	96.734	97.748 P	96.905	96.819	-	-
3	-	-	-	-	-	96.549	96.801	97.662	96.898	96.830	-	-
4	-	-	-	-	-	96.543	96.770	97.530	96.934	96.842	-	-
5	-	-	-	-	-	96.549	96.800	97.435	96.934	96.840	-	-
6	-	-	-	-	-	96.574	96.747	97.392	96.934	96.848	-	-
7	-	-	-	-	-	96.654	96.703	97.314	96.929	96.853	-	-
8	-	-	-	-	-	96.665	96.664	97.262	96.912	96.856	-	-
9	-	-	-	-	-	96.606	96.627	97.200	96.890	96.851	-	-
10	-	-	-	-	-	96.579	96.596	97.143	96.870	96.852	-	-
11	-	-	-	-	-	96.563	96.579	97.091	96.852	96.863	-	-
12	-	-	-	-	-	96.548	96.588	97.047	96.835	96.847	-	-
13	-	-	-	-	-	96.533	96.546	97.010	96.832	96.850	-	-
14	-	-	-	-	-	96.530	96.542	96.996	96.826	96.851	-	-
15	-	-	-	-	-	96.524	96.564	97.228	96.814	96.843	-	-
16	-	-	-	-	-	96.518	96.540	97.569	96.806	96.855	-	-
17	-	-	-	-	-	96.516	96.524	97.590	96.792	96.870	-	-
18	-	-	-	-	96.657 P	96.524	96.518	97.481	96.780	96.968 B	-	-
19	-	-	-	-	96.636	96.516	96.576	97.403	96.771	97.012 B	-	-
20	-	-	-	-	96.616	96.513	96.702	97.344	96.797	97.005 B	-	-
21	-	-	-	-	96.608	96.504	97.525 P	97.282	96.843	96.949 B	-	-
22	-	-	-	-	96.582	96.498	97.747 P	97.227	96.855	97.054 BP	-	-
23	-	-	-	-	96.553	96.492	97.664 P	97.176	96.846	-	-	-
24	-	-	-	-	96.542	96.485	97.531	97.132	96.839	-	-	-
25	-	-	-	-	96.539	96.482	97.422	97.092	96.826	-	-	-
26	-	-	-	-	96.550	96.478	97.402	97.076	96.815	-	-	-
27	-	-	-	-	96.552	96.473	97.422	97.047	96.807	-	-	-
28	-	-	-	-	96.559	96.468	97.488	97.015	96.804	-	-	-
29	-	-	-	-	96.561	96.474	97.517	96.983	96.837	-	-	-
30	-	-	-	-	96.591	96.550	97.433	96.961	96.836	-	-	-
31	-	-	-	-	96.576	-	97.543 P	96.948	-	-	-	-
min	-	-	-	-	96.539	96.468	96.518	96.948	96.771	96.819	-	-
mean	-	-	-	-	96.580	96.534	97.116	97.246	96.851	96.881	-	-
max	-	-	-	-	96.657	96.665	97.747	97.748	96.934	97.054	-	-

Notes: P - Partial daily average.
B - Ice effects.

Table VII.62 L1 McClelland Lake Mean Daily Discharges (m^3/s), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	0.016	0.011	0.006	0.016	0.016	0.014	0.016 B	0.000 B
2	-	-	-	-	0.017	0.012	0.006	0.015	0.016	0.015	0.016 B	0.000 B
3	-	-	-	-	0.017	0.012	0.006	0.015	0.014	0.015	0.016 B	0.000 B
4	-	-	-	-	0.017	0.012	0.006	0.015	0.017	0.014	0.016 B	0.000 B
5	-	-	-	-	0.016	0.012	0.007	0.016	0.020	0.014	0.016 B	0.000 B
6	-	-	-	-	0.016	0.012	0.006	0.017	0.019	0.014	0.016 B	0.000 B
7	-	-	-	-	0.016	0.013	0.006	0.017	0.019	0.014	0.017 B	0.000 B
8	-	-	-	-	0.017	0.013	0.006	0.017	0.019	0.014	0.017 B	0.000 B
9	-	-	-	-	0.016	0.013	0.006	0.017	0.020	0.014	0.017 B	0.000 B
10	-	-	-	-	0.016	0.011	0.006	0.015	0.019	0.014	0.018 B	0.000 B
11	-	-	-	-	0.017	0.010	0.005	0.014	0.020	0.013	0.018 B	0.000 B
12	-	-	-	-	0.016	0.009	0.005	0.014	0.018	0.013	0.018 B	0.000 B
13	-	-	-	-	0.016	0.009	0.004	0.014	0.018	0.013	0.018 B	0.000 B
14	-	-	-	-	0.016	0.008	0.005	0.014	0.017	0.013	0.017 B	0.000 B
15	-	-	-	-	0.016	0.007	0.005	0.015	0.018	0.013	0.018 B	0.000 B
16	-	-	-	-	0.016	0.007	0.004	0.016	0.017	0.013	0.018 B	0.000 B
17	-	-	-	-	0.015	0.006	0.003	0.016	0.017	0.015	0.018 B	0.000 B
18	-	-	-	-	0.015	0.006	0.004	0.016	0.017	0.015	0.018 B	0.000 B
19	-	-	-	-	0.014	0.006	0.004	0.016	0.016	0.015 B	0.018 B	0.000 B
20	-	-	-	-	0.014	0.006	0.005	0.016	0.017	0.015 B	0.018 B	0.000 B
21	-	-	-	-	0.013	0.005	0.006	0.016	0.016	0.015 B	0.018 B	0.000 B
22	-	-	-	-	0.013	0.005	0.006	0.016	0.016	0.015 B	0.018 B	0.000 B
23	-	-	-	-	0.012	0.005	0.007	0.016	0.016	0.015 B	0.018 B	0.000 B
24	-	-	-	-	0.012	0.005	0.009	0.016	0.015	0.016 B	0.018 B	0.000 B
25	-	-	-	-	0.012	0.005	0.010	0.016	0.014	0.016 B	0.018 B	0.000 B
26	-	-	-	-	0.011	0.004	0.010	0.016	0.014	0.016 B	0.018 B	0.000 B
27	-	-	-	-	0.010	0.005	0.011	0.016	0.013	0.016 B	0.018 B	0.000 B
28	-	-	-	0.017 P	0.010	0.004	0.013	0.016	0.013	0.016 B	0.000 B	0.000 B
29	-	-	-	0.017	0.011	0.004	0.012	0.016	0.014	0.015 B	0.000 B	0.000 B
30	-	-	-	0.017	0.011	0.005	0.013	0.016	0.014	0.015 B	0.000 B	0.000 B
31	-	-	-	-	0.011	-	0.016	0.016	-	0.016 B	-	0.000 B
min	-	-	-	0.017	0.010	0.004	0.003	0.014	0.013	0.013	0.000	0.000
mean	-	-	-	0.017	0.014	0.008	0.007	0.016	0.017	0.015	0.016	0.000
max	-	-	-	0.017	0.017	0.013	0.016	0.017	0.020	0.016	0.018	0.000

Notes: P - Partial daily average.
B - Ice effects.

Table VII.63 L1 McClelland Lake Mean Daily Water Levels (m) Based on Permanent Benchmark el. 295.840 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	-	-	-	-	294.423	294.389	294.340	294.418	294.420	294.407	294.418 B	294.473 B
2	-	-	-	-	294.426	294.392	294.345	294.415	294.418	294.412	294.418 B	294.474 B
3	-	-	-	-	294.425	294.395	294.342	294.417	294.412	294.412	294.418 B	294.472 B
4	-	-	-	-	294.424	294.393	294.341	294.416	294.427	294.407	294.419 B	294.475 B
5	-	-	-	-	294.423	294.394	294.349	294.418	294.440	294.407	294.421 B	294.475 B
6	-	-	-	-	294.422	294.397	294.343	294.427	294.440	294.407	294.421 B	294.476 B
7	-	-	-	-	294.423	294.404	294.338	294.427	294.439	294.408	294.426 B	294.475 B
8	-	-	-	-	294.424	294.402	294.337	294.428	294.439	294.408	294.426 B	294.475 B
9	-	-	-	-	294.422	294.399	294.336	294.427	294.442	294.407	294.427 B	294.476 B
10	-	-	-	-	294.423	294.388	294.333	294.412	294.437	294.407	294.430 B	294.477 B
11	-	-	-	-	294.425	294.377	294.324	294.410	294.439	294.402	294.430 B	294.480 B
12	-	-	-	-	294.422	294.374	294.324	294.407	294.430	294.400	294.429 B	294.480 B
13	-	-	-	-	294.423	294.368	294.317	294.407	294.430	294.402	294.430 B	294.480 B
14	-	-	-	-	294.421	294.361	294.319	294.410	294.428	294.401	294.429 B	294.481 B
15	-	-	-	-	294.421	294.356	294.330	294.414	294.429	294.403	294.430 B	294.482 B
16	-	-	-	-	294.419	294.351	294.306	294.421	294.424	294.403	294.431 B	294.487 B
17	-	-	-	-	294.415	294.345	294.300	294.420	294.427	294.416	294.433 B	294.488 B
18	-	-	-	-	294.412	294.343	294.306	294.419	294.423	294.417	294.433 B	294.487 B
19	-	-	-	-	294.407	294.342	294.309	294.421	294.423	294.417 B	294.433 B	294.487 B
20	-	-	-	-	294.408	294.339	294.322	294.420	294.427	294.417 B	294.433 B	294.487 B
21	-	-	-	-	294.402	294.332	294.337	294.420	294.420	294.417 B	294.433 B	294.486 B
22	-	-	-	-	294.399	294.330	294.337	294.422	294.418	294.417 B	294.433 B	294.485 B
23	-	-	-	-	294.396	294.327	294.350	294.421	294.419	294.417 B	294.432 B	294.485 B
24	-	-	-	-	294.396	294.327	294.375	294.421	294.412	294.418 B	294.432 B	294.487 B
25	-	-	-	-	294.396	294.325	294.379	294.418	294.408	294.420 B	294.432 B	294.486 B
26	-	-	-	-	294.390	294.318	294.381	294.420	294.406	294.419 B	294.432 B	294.487 B
27	-	-	-	-	294.382	294.319	294.385	294.421	294.402	294.420 B	294.432 B	294.488 B
28	-	-	-	294.429 P	294.383	294.316	294.399	294.421	294.403	294.419 B	294.441 B	294.488 B
29	-	-	-	294.426	294.388	294.316	294.396	294.420	294.411	294.418 B	294.473 B	294.488 B
30	-	-	-	294.425	294.391	294.331	294.404	294.419	294.409	294.417 B	294.473 B	294.487 B
31	-	-	-	-	294.390	-	294.419	294.419	-	294.418 B	-	294.488 B
min	-	-	-	294.425	294.382	294.316	294.300	294.407	294.402	294.400	294.418	294.472
mean	-	-	-	294.427	294.410	294.358	294.346	294.419	294.423	294.412	294.432	294.482
max	-	-	-	294.429	294.426	294.404	294.419	294.428	294.442	294.420	294.473	294.488

Notes: P - Partial daily average.
B - Ice effects.

Table VII.64 L2 Kearl Lake Mean Daily Water Levels (m) Based on Permanent Benchmark el. 333.063 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	332.151	332.111	332.071	-	331.920	331.838	331.805	332.063	332.246	332.222	332.163	332.093
2	332.150	332.109	332.069	-	331.920	331.837	331.820	332.093	332.245	332.223	332.159	332.092
3	332.150	332.108	332.068	-	331.917	331.837	331.817	332.123	332.241	332.235	332.154	332.090
4	332.150	332.107	332.068	-	331.917	331.835	331.819	332.149	332.256	332.228	332.151	332.088
5	332.149	332.105	332.066	-	331.913	331.831	331.821	332.175	332.262	332.226	332.152	332.085
6	332.148	332.109	332.065	-	331.909	331.839	331.823	332.199	332.262	332.224	332.150	332.084
7	332.147	332.108	332.062	-	331.906	331.851	331.828	332.215	332.263	332.224	332.153	332.081
8	332.146	332.106	332.061	331.992 P	331.904	331.850	331.831	332.226	332.264	332.221	332.150	332.078
9	332.145	332.104	332.059	331.989	331.902	331.848	331.832	332.235	332.263	332.221	332.148	332.077
10	332.143	332.102	332.059	331.985	331.900 P	331.844	331.830	332.240	332.262	332.221	332.147	332.075
11	332.142	332.100	332.057	331.982	-	331.841	331.832	332.244	332.261	332.217	332.144	332.074
12	332.141	332.099	332.056	331.976	-	331.837	331.833	332.246	332.259	332.214	332.141	332.073
13	332.141	332.098	332.056	331.975	-	331.833	331.833	332.251	332.257	332.213	332.138	332.072
14	332.140	332.095	332.055	331.971	-	331.827	331.831	332.261	332.253	332.214	332.135	332.070
15	332.138	332.093	332.053	331.966	331.882 P	331.821	331.826	332.268	332.249	332.210	332.132	332.068
16	332.138	332.091	332.052	331.963	331.878	331.819	331.825	332.280	332.246	332.209	332.129	332.069
17	332.137	332.089	332.051	331.959	331.872	331.813	331.823	332.282	332.242	332.215	332.128	332.068
18	332.137	332.087	332.050	331.954	331.864	331.808	331.827	332.283	332.236	332.211	332.125	332.066
19	332.137	332.086	332.048	331.951	331.856	331.805	331.830	332.292	332.234	332.208	332.123	332.064
20	332.136	332.086	332.046	331.949	331.857	331.802	331.848	332.292	332.246	332.203	332.120	332.062
21	332.135	332.082	332.043	331.948	331.858	331.803	331.869	332.291	332.246	332.198	332.118	332.060
22	332.133	332.080	332.041	331.947	331.849	331.798	331.872	332.290	332.241	332.194	332.116	332.059
23	332.131	332.079	332.038	331.945	331.842	331.794	331.883	332.287	332.223	332.190	332.112	332.057
24	332.130	332.078	332.036	331.942	331.840	331.791	331.901	332.284	332.225	332.188	332.110	332.055
25	332.127	332.076	332.034	331.939	331.841	331.785	331.916	332.279	332.224	332.189	332.107	332.054
26	332.125	332.074	332.031	331.934	331.838	331.783	331.932	332.277	332.223	332.188	332.105	332.052
27	332.124	332.073	332.028 P	331.932	331.839	331.780	331.946	332.273	332.219	332.185	332.103	332.050
28	332.121	332.072	-	331.930	331.831	331.778	331.968	332.266	332.218	332.182	332.101	332.048
29	332.120	-	-	331.928	331.832	331.779	331.977	332.260	332.237	332.178	332.097	332.046
30	332.118	-	-	331.924	331.838	331.789	331.995	332.256	332.237	332.173	332.095	332.045
31	332.115	-	-	-	331.840	-	332.037	332.250	-	332.169	-	332.043
min	332.115	332.072	332.028	331.924	331.831	331.778	331.805	332.063	332.218	332.169	332.095	332.043
mean	332.137	332.093	332.053	331.956	331.873	331.817	331.866	332.240	332.245	332.206	332.130	332.068
max	332.151	332.111	332.071	331.992	331.920	331.851	332.037	332.292	332.264	332.235	332.163	332.093

Notes: P - Partial daily average.
A - Manual reading.

Table VII.65 L3 Isadore's Lake Mean Daily Water Levels (m) Based on Permanent Benchmark el. 235.910 m (geodetic), 2002

Date	January	February	March	April	May	June	July	August	September	October	November	December
1	233.745	233.744	233.804	233.822	233.831	233.702	233.688	233.718	-	-	233.705	233.669
2	233.775	233.773	233.789	233.827	233.856	233.689	233.691	233.709	-	-	233.704	233.670
3	233.764	233.732	233.787	233.834	233.905	233.707	233.671	233.733	-	-	233.701	233.672
4	233.768	233.752	233.793	233.819	233.843	233.707	233.672	233.738	-	-	233.699	233.668
5	233.757	233.773	233.812	233.817	233.846	233.714	233.684	233.729	-	-	233.697	233.667
6	233.772	233.768	233.802	233.828	233.809	233.697	233.673	233.720	-	-	233.697	233.672
7	233.745	233.771	233.796	233.816	233.805	233.699	233.676	233.716	-	-	233.695	233.675
8	233.742	233.776	233.809	233.836	233.830	233.694	233.651	233.725	-	-	233.694	233.677
9	233.751	233.772	233.811	233.844	233.865	233.671	233.657	233.724 P	-	-	233.698	233.677
10	233.738	233.774	233.797	233.838	233.904	233.658	233.655	-	-	-	233.696	233.680
11	233.740	233.773	233.823	233.826	233.928	233.690	233.652	-	-	-	233.695	233.684
12	233.731	233.767	233.808	233.830	233.840	233.705	233.660	-	-	-	233.694	233.687
13	233.751	233.754	233.812	233.834	233.833	233.705	233.663	-	-	-	233.691	233.691
14	233.760	233.769	233.827	233.835	233.854	233.679	233.695	-	-	-	233.686	233.692
15	233.747	233.764	233.820	233.850	233.805	233.686	233.734	-	-	-	233.684	233.695
16	233.735	233.766	233.818	233.841	233.792	233.689	233.716	-	-	-	233.682	233.695
17	233.763	233.769	233.811	233.821	233.780	233.704	233.661	-	-	-	233.682	233.698
18	233.763	233.772	233.800	233.844	233.809	233.711	233.672	-	-	-	233.683	233.706
19	233.760	233.789	233.797	233.840	233.781	233.720	233.698	-	-	-	233.686	233.707
20	233.763	233.761	233.803	233.840	233.779	233.708	233.676	-	-	-	233.683	233.704
21	233.765	233.768	233.812	233.840	233.788	233.689	233.717	-	-	-	233.680	233.701
22	233.775	233.761	233.804	233.850	233.762	233.681	233.687	-	-	-	233.677	233.699
23	233.764	233.799	233.807	233.866	233.748	233.684	233.695	-	-	-	233.676	233.699
24	233.753	233.799	233.805	233.860	233.758	233.695	233.722	-	-	-	233.675	233.699
25	233.777	233.802	233.811	233.887	233.765	233.677	233.713	-	-	-	233.669	233.700
26	233.752	233.788	233.823	233.865	233.760	233.673	233.744	-	-	-	233.670	233.704
27	233.766	233.799	233.805	233.867	233.758	233.642	233.761	-	-	-	233.668	233.706
28	233.764	233.801	233.839	233.863	233.737	233.662	233.765	-	-	-	233.669	233.710
29	233.765	-	233.817	233.856	233.717	233.638	233.724	-	-	233.726 P	233.672	233.709
30	233.777	-	233.822	233.849	233.725	233.669	233.711	-	-	233.724	233.674	233.709
31	233.767	-	233.808	-	233.705	-	233.726	-	-	233.720	-	233.710
min	233.731	233.732	233.787	233.816	233.705	233.638	233.651	233.709	-	233.720	233.668	233.667
mean	233.758	233.773	233.809	233.841	233.804	233.688	233.694	233.723	-	233.723	233.686	233.691
max	233.777	233.802	233.839	233.887	233.928	233.720	233.765	233.738	-	233.726	233.705	233.710

Notes: P - Partial daily average.

APPENDIX VIII

WATER AND SEDIMENT ANALYTICAL METHODS

This appendix contains a summary of the analytical methods used by:

- Enviro-Test Laboratories (Tables VIII.1 and VIII.2);
- HydroQual Laboratories (Tables VIII.3 and VIII.4); and
- AXYS Laboratories (pages VIII-6 and VIII-7).

Table VIII.1 Analytical Methods used by EnviroTest Labs when Analyzing RAMP Water Samples

Parameter	Units	Detection Limits	Analytical Methods[a]
Conventional Parameters			
bicarbonate (HCO3)	mg/L	5	APHA 2320B
calcium	mg/L	0.5	APHA 3120 B
carbonate (CO3)	mg/L	5	APHA 2320 B
chloride	mg/L	1	APHA 4500
colour	T.C.U.	3	APHA 2120B
conductance	µS/cm	0.2	APHA 2510 B
dissolved organic carbon	mg/L	1	APHA 5310 B
hardness	mg/L	1	APHA 2340 B
magnesium	mg/L	0.1	APHA 3120 B
pH		0.1	APHA 4500-H
potassium	mg/L	0.1	APHA 3120 B
sodium	mg/L	1	APHA 3120 B
sulphate	mg/L	0.5	APHA 4110 B
sulphide	µg/L	3	AEP
total alkalinity	mg/L	5	APHA 2320 B
total dissolved solids	mg/L	10	APHA 2540 c
total organic carbon	mg/L	1	APHA 5310 B
total suspended solids	mg/L	3	APHA 2540-D
Nutrients			
nitrate + nitrite	mg/L	0.1	APHA 4500NO3H
nitrogen - ammonia	mg/L	0.05	APHA 4500NH3F
nitrogen - kjeldahl	mg/L	0.2	APHA 4500N-C
phosphorus, total	µg/L	2	APHA 4500-PBE
phosphorus, total dissolved	µg/L	2	APHA 4500-PBE
Biochemical Oxygen Demand			
biochemical oxygen demand	mg/L	2	APHA 5210 B
Organics			
naphthenic acids	mg/L	1	FTIR
total phenolics	µg/L	1	EPA 420.2
total recoverable hydrocarbons	mg/L	0.5	APHA 5520 F
Metals (Total)			
aluminum (Al)	µg/L	20	SW6010
antimony (Sb)	µg/L	0.8	SW 3015
arsenic (As)	µg/L	1	ICP-MS
barium (Ba)	µg/L	0.2	SW6010
beryllium (Be)	µg/L	1	SW6010
boron (B)	µg/L	4	SW6010
cadmium (Cd)	µg/L	0.2	SW6010
calcium (Ca)	µg/L	100	APHA 3120 B
chromium (Cr)	µg/L	0.8	SW6010
cobalt (Co)	µg/L	0.2	SW6010
copper (Cu)	µg/L	1	SW6010
iron (Fe)	µg/L	20	SW6010
lead (Pb)	µg/L	0.1	SW6010
lithium (Li)	µg/L	6	SW3015
magnesium (Mg)	µg/L	20	APHA 3120 B

Table VIII.1 Analytical Methods used by EnviroTest Labs when Analyzing RAMP Water Samples (continued)

Parameter	Units	Detection Limits	Analytical Methods[(a)]
manganese (Mn)	µg/L	0.2	SW6010
mercury (Hg)	µg/L	0.2	APHA 3112 B
molybdenum (Mo)	µg/L	0.1	SW6010
nickel (Ni)	µg/L	0.2	SW6010
potassium (K)	µg/L	20	APHA 3120 B
selenium (Se)	µg/L	0.8	SW 3015
silver (Ag)	µg/L	0.4	SW6010
sodium (Na)	µg/L	200	APHA 3120 B
strontium (Sr)	µg/L	0.2	SW6010
titanium (Ti)	µg/L	0.6	SW 3015
uranium (U)	µg/L	0.1	SW 3015
vanadium (V)	µg/L	0.2	SW6010
zinc (Zn)	µg/L	4	SW6010
Metals (Dissolved)			
aluminum (Al)	µg/L	10	APHA 3120 B
antimony (Sb)	µg/L	0.8	ICP-MS
arsenic (As)	µg/L	0.4	ICP-MS
barium (Ba)	µg/L	0.1	APHA 3120 B
beryllium (Be)	µg/L	0.5	APHA 3120 B
boron (B)	µg/L	2	APHA 3120 B
cadmium (Cd)	µg/L	0.1	APHA 3120 B
chromium (Cr)	µg/L	0.4	APHA 3120 B
cobalt (Co)	µg/L	0.1	APHA 3120 B
copper (Cu)	µg/L	0.6	APHA 3120 B
iron (Fe)	µg/L	10	APHA 3120 B
lead (Pb)	µg/L	0.1	APHA 3120 B
lithium (Li)	µg/L	3	APHA 3120 B
manganese (Mn)	µg/L	0.1	APHA 3120 B
mercury (Hg)	µg/L	0.01 - 0.1	ICP-MS
molybdenum (Mo)	µg/L	0.1	APHA 3120 B
nickel (Ni)	µg/L	0.1	APHA 3120 B
selenium (Se)	µg/L	0.4 - 0.8	ICP-MS
silver (Ag)	µg/L	0.2	APHA 3120 B
strontium (Sr)	µg/L	0.1	APHA 3120 B
titanium (Ti)	µg/L	0.3	APHA 3120 B
uranium (U)	µg/L	0.1	ICP
vanadium (V)	µg/L	0.1	APHA 3120 B
zinc (Zn)	µg/L	2	APHA 3120 B

(a) APHA = Protocols developed by the American Public Health Association.

EPA and SW = Protocols established by the United States Environmental Protection Agency.

AEP = Protocol developed by Alberta Environment Protection.

ICP = Inductively Coupled Plasma.

MS = Mass spectrometry.

FTIR = Fourier Transform Infrared Spectroscopy.

Table VIII.2 Analytical Methods used by EnviroTest Labs when Analyzing RAMP Sediment Samples

Parameter	Units	Detection Limits	Analytical Methods[a]
Conventional Parameters			
particle size - % sand	%	1	gravimetric
particle size - % silt	%	1	gravimetric
particle size - % clay	%	1	gravimetric
total inorganic carbon	% by wt	0.01	combustion/acid reaction
total organic carbon	% by wt	0.01	combustion/acid reaction
total carbon	% by wt	0.01	combustion/acid reaction
General Organics			
total recoverable hydrocarbons	µg/g	100	APHA 5520 C
Metals (Total)			
aluminum (Al)	µg/g	10	SW 3051/6010
antimony (Sb)	µg/g	0.02	APHA 3114 C
arsenic (As)	µg/g	0.05	APHA 3114 C
barium (Ba)	µg/g	0.5	SW 3051/6010
beryllium (Be)	µg/g	1	SW 3051/6010
cadmium (Cd)	µg/g	0.5	SW 3051/6010
calcium (Ca)	µg/g	100	SW 3051/6010
chromium (Cr)	µg/g	0.5	SW 3051/6010
cobalt (Co)	µg/g	1	SW 3051/6010
copper (Cu)	µg/g	1	SW 3051/6010
iron (Fe)	µg/g	1	SW 3051/6010
lead (Pb)	µg/g	5	SW 3051/6010
magnesium (Mg)	µg/g	10	SW 3051/6010
manganese (Mn)	µg/g	0.1	SW 3051/6010
mercury (Hg)	µg/g	0.04	APHA 3114 C
molybdenum (Mo)	µg/g	1	SW 3051/6010
nickel (Ni)	µg/g	2	SW 3051/6010
potassium (K)	µg/g	20	SW 3051/6010
selenium (Se)	µg/g	0.1	APHA 3114 C
silver (Ag)	µg/g	1	SW 3051/6010
sodium (Na)	µg/g	100	SW 3051/6010
strontium (Sr)	µg/g	1	SW 3051/6010
sulphur (S)	µg/g	100	SW 3051/6010
titanium (Ti)	µg/g	5	SW 3051/6010
vanadium (V)	µg/g	1	SW 3051/6010
zinc (Zn)	µg/g	0.5	SW 3051/6010

[a] APHA = Protocols developed by the American Public Health Association.
SW = Protocols established by the United States Environmental Protection Agency.

Table VIII.3 Analytical Methods used by HydroQual Labs when Analyzing RAMP Water and Sediment Samples

Parameter	Analytical Methods
Water	
Microtox®	Toxicity testing using luminescent bacteria (*Vibrio fischeri*). 1992. Environment Canada. EPS 1/RM/24.
chlorophyll *a*	Spectrophotometric determination of chlorophyll. Standard methods for the examination of water and wastewater, 18th ed. 1992. American Public Health Association.
Selenastrum capricornutum	Growth inhibition test using the freshwater alga *Selenastrum capricornutum* . 1992. Environment Canada. EPS 1/RM/25. Amended November 1997.
Ceriodaphnia dubia (growth and survival)	Test of reproduction and survival using the Cladoceran *Ceriodaphnia dubia*. 1992. Environment Canada. EPS 1/RM/21. Amended November 1997.
fathead minnow (growth and survival)	Test of larval growth and survival using fathead minnow. 1992. Environment Canada. EPS 1/RM/22. Amended November 1997.
Sediments	
Chironomus tentans (growth and survival)	Test for survival and growth in sediment using the larvae of freshwater midges (*Chironomus tentans* or *Chironomus riparius*). 1997. Environment Canada. EPS 1/RM/32.
Hyalella azteca (growth and survival)	Test for survival and growth in sediment using the freshwater amphipod *Hyalella azteca*. 1997. Environment Canada. EPS 1/RM/33.
Lumbriculus variegatus (growth and survival)	Standard test methods for measuring the toxicity of sediment-associated contaminant with freshwater invertebrates. 1995. ASTM E 1706-98a.

Table VIII.4 Analytical Methods used by Alberta Research Council when Analyzing RAMP Water and Sediment Samples

Parameter	Units	Detection Limits	Analytical Methods [a]
Trace Metals			
mercury	ng/L	0.6	EPA Method 6020 CLP-M, Version 7.0
silver	ng/L	5	Envirodat Code system (VMV 101979, method code 2858); based on EPA Method 1631

[a] EPA = Protocols established by the United States Environmental Protection Agency.

SUMMARY OF THE ANALYTICAL PROTOCOL USED BY AXYS LABS TO ANALYZE FOR POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) IN RAMP SEDIMENT SAMPLES

Summary

Sediments were analyzed for a suite of polycyclic aromatic hydrocarbons (PAHs), including alkylated PAHs. All samples were spiked with an aliquot of surrogate standard solution containing perdeuterated analogues of acenaphthene, chrysene, naphthalene, 2-methylnaphthalene, perylene, phenanthrene, pyrene, dibenz(a,h)anthracene, benzo(g,h,i)perylene and benzo(a)pyrene prior to analysis. Sediment samples were extracted by elution through a chromatographic column. Each extract was cleaned up on silica gel prior to analysis of PAHs by high resolution gas chromatography with low resolution (quadrupole) mass spectrometric detection (HRGC/MS).

Extraction Methods

A sub-sample of homogenized sediment was dried overnight at 105°C to determine moisture content.

Homogenized sediment sample was dried by grinding with anhydrous sodium sulphate. The mixture was transferred to a glass chromatographic column containing methanol. An aliquot of surrogate standard solution was added and the column was eluted with dichloromethane. The eluate was backwashed by shaking with potassium hydroxide solution followed by solvent extracted distilled water. The extract was dried over anhydrous sodium sulphate and concentrated. Activated copper was added to the extract to remover sulphur. The extract was ready for chromatographic cleanup procedures.

Chromatographic Cleanup Procedures

The extract was loaded onto a silica gel column (5% deactivated) and eluted with pentane (F1, discarded) followed by dichloromethane (F2, retained). The F2 fraction was concentrated and an aliquot of recovery standard, containing perdeuterated analogues of benzo(b)fluoranthene, fluoranthene and acenaphthylene was added. The extract was transferred to an autosampler vial in preparation for GC/MS analysis.

GC/MS Analysis

Analysis of the extract for PAHs was carried out using a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 gas chromatograph with CTC autosampler and a Prolab Envirolink data system for MS control and data acquisition. The mass spectrometer was operated at unit mass resolution, in the EI mode (70 Ev), using Multiple Ion Detection (MID) to enhance sensitivity. At least two characteristic ions for each target analyte and surrogate standard were monitored. A Restek Rtx-5 capillary chromatography column (30 m, 0.25 mm i.d. x 0.25 mm film thickness), used for chromatographic separation, was coupled to the MS source. A splitless/split injection sequence was used.

Quantitation Procedures

Concentrations of PAHs were calculated using the internal standard (isotope dilution) method of quantitation, comparing the area of the quantitation ion to that of the corresponding deuterated standard and correcting for response factors. Response factors were determined daily using authentic PAHs. Quantification was carried out using HP EnviroQuant and Prolab MS Extend software.

Concentrations of analytes were corrected based on the percent recovery of surrogate standards. Concentrations were reported on a dry weight basis.

APPENDIX IX

INDUSTRIAL MONITORING DATA PROVIDED TO RAMP

This appendix contains water quality and toxicity data collected from the Muskeg River by Albian Sands and Syncrude in accordance to their respective *Environmental Protection and Enhancement Act* (EPEA) approvals. The water quality and toxicity data are provided in Table IX.1 and IX.2, respectively.

Table IX.1 Water Quality Samples Collected From the Muskeg River by Industry in 2002

Parameter	Units	Muskeg River											
		Mouth to Jackpine Creek (MUR-2)				Jackpine Creek to Muskeg Creek (MUR-4)				u/s of Muskeg Creek (MUR-5)[(a)]			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Field measured													
pH		7.4	7.7	7.9	7.9	-	-	-	-	7.2	7.5	8.1	7.8
Specific Conductance	µS/cm	-	-	-	-	-	-	-	-	-	-	-	-
Temperature	°C	0.1	0.1	18.1	4.9	-	-	-	1.9	0.1	0.1	17.4	4.3
Dissolved Oxygen	mg/L	1.8	0.7	6.2	10.8	-	-	-	-	0.7	2.7	5.3	10.9
Conventional Parameters													
Colour	T.C.U.	128	125	108	97	-	-	110	91	122	14	90	80
Conductance	µS/cm	576	548	237	214	549	440	269	234	-	-	-	-
Dissolved Organic Carbon	mg/L	17	24	25	24	17	23	23	23	-	-	-	-
Hardness	mg/L	310	270	110	110	300	210	130	110	-	-	-	-
pH		7.4	7.7	7.9	7.9	-	-	-	-	7.2	7.5	8.1	7.8
Total Alkalinity	mg/L	305	295	118	117	302	235	138	123	-	-	-	-
Total Dissolved Solids	mg/L	333	304	123	122	310	237	141	124	331	319	167	143
Total Suspended Solids	mg/L	4	4	3	2	-	-	-	-	6	9	1	3
Major Ions													
Bicarbonate	mg/L	372	360	144	143	368	287	168	151	-	-	-	-
Calcium	mg/L	93	76	29	29	89	59	35	28	-	-	-	-
Carbonate	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	-	-	-
Chloride	mg/L	8	6	2	2	5	3	1	2	2	4	1	1
Magnesium	mg/L	20	20	8	8	20	16	10	9	-	-	-	-
Potassium	mg/L	1	2	< 0.3	1.1	1.3	1.5	1	1	-	-	-	-
Sodium	mg/L	16	18	12	10	13	14	9	8	-	-	-	-
Sulphate	mg/L	10	3	2	2	1	2	2	2	1	1	2	1
Sulphide	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nutrients and Chloropyll *a*													
Nitrate + Nitrite	mg/L	0.02	0.04	0.02	0.01	0.01	0.05	0.02	0.02	< 0.003	0.009	0.063	0.01
Nitrogen - ammonia	mg/L	0.55	0.66	0.02	-	-	-	-	-	0.86	0.96	0.07	0.04
Phosphorus, total	mg/L	0.2	0.2	< 0.1	< 0.1	0.3	0.2	< 0.1	< 0.1	0.1	0.1	1.6	< 0.1
Biological Oxygen Demand													
Biochemical Oxygen Demand	mg/L	2	2	0.4	0.9	-	-	-	-	1.5	4.4	0.9	1.2
General Organics													
Naphthenic acids	mg/L	< 1	< 1	2	< 1	< 1	< 1	2	2	< 1	< 1	3	2
Total Phenolics	mg/L	0.005	0.008	0.01	0.006	0.005	0.008	0.009	0.005	0.006	0.005	0.007	0.006
Total Recoverable Hydrocarbons	mg/L	< 2	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Metals (Total)													

Table IX.1 Water Quality Samples Collected From the Muskeg River by Industry in 2002 (continued)

Parameter	Units	Muskeg River											
		Mouth to Jackpine Creek (MUR-2)				Jackpine Creek to Muskeg Creek (MUR-4)				u/s of Muskeg Creek (MUR-5)[a]			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Aluminum (Al)	mg/L	0.03	0.02	0.05	0.04	0.01	0.04	0.03	0.03	0.01	0.05	0.23	0.03
Antimony (Sb)	mg/L	< 0.0002	< 0.0002	0.0045	0.0002	< 0.0002	< 0.0002	0.0016	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0003
Arsenic (As)	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Barium (Ba)	mg/L	0.078	0.078	0.03	0.021	0.08	0.06	0.039	0.02	-	-	-	-
Beryllium (Be)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0003	< 2E-04
Boron (B)	mg/L	0.05	0.08	0.07	0.04	0.04	0.07	0.07	0.04	-	-	-	-
Cadmium (Cd)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 2E-04
Chromium (Cr)	mg/L	0.001	0.002	0.01	0.002	< 0.001	0.003	0.01	0.002	< 0.001	0.006	0.008	0.002
Cobalt (Co)	mg/L	0.0006	-	0.0003	< 0.0003	-	-	< 0.0003	< 0.0003	-	-	-	-
Copper (Cu)	mg/L	0.0004	0.0012	0.0016	0.0022	0.0004	0.0044	0.0014	0.0022	0.0023	0.001	0.0127	0.0022
Iron (Fe)	mg/L	2.02	1.17	0.8	0.63	2.86	2.07	1.04	0.68	3.58	3.22	1.4	0.92
Lead (Pb)	mg/L	< 0.0003	< 0.0003	0.0005	0.0008	< 0.0003	< 0.0003	0.0005	0.0005	< 0.0003	< 0.0003	0.0155	0.0011
Lithium (Li)	mg/L	0.012	0.013	< 0.004	0.005	0.011	0.01	< 0.004	0.004	-	-	-	-
Manganese (Mn)	mg/L	1.09	0.491	0.032	0.031	0.763	0.289	0.036	0.045	-	-	-	-
Mercury (Hg)	mg/L	< 0.00005	< 0.00005	< 5E-05	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.05
Molybdenum (Mo)	mg/L	< 0.0002	< 0.0002	0.0009	< 0.0002	< 0.0002	< 0.0002	0.0006	< 0.0002	-	-	-	-
Nickel (Ni)	mg/L	0.0022	0.0065	0.0077	0.0011	0.0017	0.0063	0.0061	0.001	0.0039	0.0069	0.0014	0.001
Selenium (Se)	mg/L	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Silver (Ag)	mg/L	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.001	< 1E-04
Strontium (Sr)	mg/L	0.183	0.196	0.077	0.077	0.182	0.166	0.086	0.063	-	-	-	-
Thallium (Tl)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 2E-04
Titanium (Ti)	mg/L	-	0.003	0.002	0.001	-	0.003	0.002	< 0.001	-	-	-	-
Uranium (U)	mg/L	< 0.0004	< 0.0004	0.0018	< 0.0004	< 0.0004	< 0.0004	0.0017	< 0.0004	-	-	-	-
Vanadium (V)	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	-	-	-	-
Zinc (Zn)	mg/L	0.008	0.007	0.012	0.011	0.008	0.01	0.025	0.02	0.008	0.033	0.149	0.014
Metals (Dissolved)													
Iron (Fe)	mg/L	0.12	0.29	0.41	0.38	0.11	0.18	0.54	-	-	-	-	-
Manganese (Mn)	mg/L	1.04	0.491	0.01	0.004	0.54	< 0.004	0.014	-	-	-	-	-
Target PAHs and Alkylated PAHs													
Naphthalene	µg/L	< 0.1	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	< 0.1	< 0.1
Acenaphthene	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Acenaphthylene	µg/L	-	< 0.1	< 0.1	< 0.1	-	-	-	-	-	< 0.1	< 0.1	< 0.1

Table IX.1 Water Quality Samples Collected From the Muskeg River by Industry in 2002 (continued)

Parameter	Units	Muskeg River											
		Mouth to Jackpine Creek (MUR-2)				Jackpine Creek to Muskeg Creek (MUR-4)				u/s of Muskeg Creek (MUR-5)[a]			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Anthracene	µg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
Dibenzo(a,h)anthracene	µg/L	-	< 0.05	< 0.05	< 0.05	-	-	-	-	-	< 0.05	< 0.05	< 0.05
Benzo(a)Anthracene / Chrysene	µg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.02	< 0.05	< 0.05	< 0.05
Benzo(a)pyrene	µg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.03	< 0.01	< 0.01	< 0.01
Benzo(g,h,i)perylene	µg/L	-	< 0.05	< 0.05	< 0.05	-	-	-	-	-	< 0.05	< 0.05	< 0.05
Fluoranthene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Fluorene	µg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Indeno(c,d-123)pyrene	µg/L	-	< 0.1	< 0.1	< 0.1	-	-	-	-	-	< 0.1	< 0.1	< 0.1
Phenanthrene	µg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Pyrene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02
Target PANHs													
quinoline	µg/L	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	-	-	-	-
Acridine	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
Volatile organics													
Benzene	µg/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Ethylbenzene	µg/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Toluene	µg/L	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	0.5	< 0.4	< 0.4	< 0.4
Xylenes	µg/L	< 0.8	< 0.8	< 0.8	0.8	-	-	-	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8

[a] u/s = Upstream.

Table IX.2 Toxicity Data Collected by Industry in Fall, 2002

Parameter	Units	Muskeg River											
		Mouth to Jackpine Creek (MUR-2)				Jackpine Creek to Muskeg Creek (MUR-4)				u/s of Muskeg Creek (MUR-5)[a]			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Toxicity													
Ceriodaphnia 7 d Mortality Test - LC25	%	> 100	> 100	> 100	> 100	-	-	> 100	> 100	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Mortality Test - LC50	%	> 100	> 100	> 100	> 100	-	-	> 100	> 100	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Reproduction Test - IC25	%	> 100	> 100	> 100	> 100	-	-	> 100	> 100	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Reproduction Test - IC50	%	> 100	> 100	> 100	> 100	-	-	> 100	> 100	> 100	> 100	> 100	> 100
Fathead Minnow 7d Growth - IC25	%	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100
Fathead Minnow 7d Growth - IC50	%	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100
Fathead Minnow 7d Mortality Test - LC25	%	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	79.2	46.2	> 100	> 100
Fathead Minnow 7d Mortality Test - LC50	%	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100	> 100

[a] u/s = Upstream.

APPENDIX X

WATER QUALITY DATA COLLECTED BY RAMP IN 2002

This appendix contains a series of tables presenting water quality from locations sampled in the 2002 RAMP survey, including:

- the Athabasca River (Tables X.1 and X.4);
- the Clearwater River (Tables X.2 and X.4);
- the Christina River (Tables X.3 and X.4);
- tributaries located east of the Athabasca River (Table X.5);
- tributaries located west of the Athabasca River (Tables X.6 and X.7);
- the Muskeg River watershed (Tables X.7 and X.8);
- the wetlands (Table X.9); and
- the OPTI Lakes (Table X.10).

Continuous temperature monitoring conducted by RAMP in the Clearwater River, the Muskeg River, McLean and Fort creeks and the Alsands Drain is presented in Figures X.1 to X.5.

Table X.1 Water Quality Samples Collected from the Athabasca River in 2002

Parameter	Units	Upstream of Donald Creek (Fall)			Upstream of the Steepbank River (Fall)		Upstream of the Muskeg River (Fall)		Upstream of Fort Creek (Fall)		Downstream of all Development (x-channel)					Upstream of the Firebag River (east bank)
		X-Channel	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	Winter 1	Winter 2[(a)]	Spring	Summer	Fall	
Field measured																
pH		9	8.8	9.1	8.9	9.1	8.7	9.1	8.8	9	7.4	7.1	8.5	8.9	8.9	8.2
specific conductance	µS/cm	237	155	186	213	267	215	265	250	252	444	259	210	265	181	274
temperature	°C	16	16	16.2	15.3	15.7	15.6	16.4	16.2	16.1	0.1	0.1	14.1	20.7	15.7	15.1
dissolved oxygen	mg/L	12.9	11.2	12.3	12.3	6.2	8.5	7.8	-	-	3.6	8.6	10.1	9.9	8.8	9.6
Conventional Parameters																
colour	T.C.U.	35	30	15	50	20	50	20	50	40	30	50	50	25	50	50
conductance	µS/cm	257	231	270	230	266	243	266	252	260	535	456	235	250	257	248
dissolved organic carbon	mg/L	4	7	4	8	4	9	5	7	6	6	7	12	6	6	8
hardness	mg/L	114	93	121	94	132	96	129	106	113	176	147	98	108	109	104
pH		8.1	8	8.2	8	8.2	8	8.2	8.2	8.2	7.9	7	7.7	7.9	8.2	7.9
total alkalinity	mg/L	98	84	105	83	102	86	101	92	97	157	137	92	90	92	92
total dissolved solids	mg/L	80	90	90	60	100	40	100	140	140	260	320	440	190	130	190
total organic carbon	mg/L	5	8	4	9	4	0	5	8	8	7	8	14	7	8	10
total suspended solids	mg/L	11	10	9	11	14	11	5	17	8	< 3	< 3	157	27	12	14
Major Ions																
bicarbonate	mg/L	120	102	128	101	125	105	124	112	119	192	168	112	110	113	112
calcium	mg/L	31	25	33	25	35	25	35	28	30	48	40	28	30	29	28
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	2	7	2	9	1	10	2	8	7	36	48	4	7	7	8
magnesium	mg/L	9	8	10	8	11	8	10	9	9	13	11	7	8	9	8
potassium	mg/L	1	1	1	1	2	1	1	1	1	2	2	2	1	1	1
sodium	mg/L	9	12	10	14	9	14	10	12	13	41	42	12	11	12	13
sulphate	mg/L	28	19	30	20	35	20	33	24	28	56	42	22	33	26	22
sulphide	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0.007	0.003	< 0.003	0.005
Nutrients and Chloropyll *a*																
nitrate + nitrite	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.2	0.2	< 0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	< 0.05	< 0.05	0.14	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	0.12	< 0.05	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	0.4	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.4	0.7	1.4	< 0.2	0.4
phosphorus, total	mg/L	0.023	0.027	0.031	0.023	0.013	0.027	0.012	0.021	0.024	0.044	0.026	0.119	0.034	0.023	0.026
phosphorus, dissolved	mg/L	0.005	0.01	0.008	0.009	0.002	0.009	0.003	0.005	0.005	0.031	0.017	0.017	0.004	0.004	0.006
chlorophyll *a*	ug/L	2	2	2	2	2	2	4	3	3	2	< 1	3	5	3	5
Biological Oxygen Demand																
biochemical oxygen demand	mg/L	3	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
General Organics																
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5

Table X.1 Water Quality Samples Collected from the Athabasca River in 2002 (continued)

Parameter	Units	Upstream of Donald Creek (Fall)			Upstream of the Steepbank River (Fall)		Upstream of the Muskeg River (Fall)		Upstream of Fort Creek (Fall)		Downstream of all Development (x-channel)					Upstream of the Firebag River (east bank)
		X-Channel	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	Winter 1	Winter 2[(a)]	Spring	Summer	Fall	
Metals (Total)																
aluminum (Al)	mg/L	0.52	0.51	0.48	0.49	0.45	0.48	0.3	0.56	0.43	0.08	0.05	6.56	0.89	0.53	0.28
antimony (Sb)	mg/L	0.00006	0.00004	0.00005	0.00003	0.00006	0.00006	0.00005	0.00005	0.00006	< 0.005	0.00005	< 0.005	0.0006	0.00004	0.00006
arsenic (As)	mg/L	0.0006	0.0006	0.0006	0.0007	0.0005	0.0007	0.0005	0.0007	0.0006	< 0.001	0.0008	0.002	0.0018	0.0006	0.0006
barium (Ba)	mg/L	0.05	0.037	0.049	0.036	0.05	0.039	0.048	0.042	0.045	0.075	0.064	0.116	0.056	0.044	0.042
beryllium (Be)	mg/L	< 0.00004	< 4E-05	< 0.00004	< 0.00004	< 0.00004	< 0.00004	0.00013	< 4E-05	< 4E-05	< 0.001	0.00034	< 0.001	< 0.001	< 0.00004	0.00009
boron (B)	mg/L	0.021	0.022	0.027	0.026	0.02	0.025	0.02	0.024	0.027	0.04	0.042	0.03	0.02	0.025	0.023
cadmium (Cd)	mg/L	0.00003	0.00003	0.00003	0.00003	0.00003	0.00002	0.00002	< 2E-05	0.00003	< 0.0002	0.00005	< 0.0002	< 0.0002	0.00005	< 0.00002
chromium (Cr)	mg/L	0.00074	0.00058	0.00069	0.00059	0.00055	0.00069	0.00048	0.00072	0.00055	0.0022	0.00045	0.0076	0.0039	0.00079	0.00037
cobalt (Co)	mg/L	0.00026	0.00021	0.00027	0.00024	0.00021	0.00023	0.00017	0.00025	0.00021	< 0.0002	0.00014	0.002	0.0005	0.00026	0.00022
copper (Cu)	mg/L	0.0012	0.0009	0.0012	0.0008	0.0011	0.0009	0.0006	0.0012	0.001	0.001	0.0007	0.007	0.002	0.0014	0.0007
iron (Fe)	mg/L	0.47	0.65	0.42	0.62	0.36	0.68	0.28	0.61	0.49	0.32	0.42	5.27	0.84	0.6	0.5
lead (Pb)	mg/L	0.0004	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002	0.0004	0.0003	0.0001	0.0002	0.003	0.0006	0.0005	0.0003
lithium (Li)	mg/L	0.004	0.005	0.005	0.005	0.005	0.006	0.004	0.005	0.006	0.01	0.008	0.01	< 0.006	0.006	0.005
manganese (Mn)	mg/L	0.022	0.035	0.019	0.033	0.023	0.036	0.02	0.031	0.028	0.017	0.026	0.123	0.047	0.034	0.034
mercury (Hg)	mg/L	0.0000036	1.3E-06	< 6E-07	0.000001	< 6E-07	8E-07	2.5E-06	< 6E-07	< 6E-07	< 6E-07	< 6E-07	0.0000013	< 6E-07	< 6E-07	< 0.0000006
molybdenum (Mo)	mg/L	0.0007	0.0005	0.0007	0.0005	0.0007	0.0005	0.0007	0.0006	0.0006	0.0008	0.0009	0.001	0.0011	0.0006	0.0006
nickel (Ni)	mg/L	0.0001	0.0012	0.0001	0.0002	< 0.0001	0.0002	0.0002	0.0003	0.0004	< 0.0002	0.0004	0.0072	0.0083	0.0004	0.0003
selenium (Se)	mg/L	0.0006	0.0007	0.0006	0.0011	0.0008	0.0014	0.001	0.0007	0.001	0.001	0.0008	< 0.0008	0.0009	0.001	< 0.0005
silver (Ag)	mg/L	0.000006	< 5E-06	< 5E-06	< 0.000005	< 0.000005	< 5E-06	0.00002	< 5E-06	1.5E-05	< 5E-06	0.000099	0.000013	0.00014	< 5E-06	0.00001
strontium (Sr)	mg/L	0.260714	0.18742	0.271108	0.182816	0.27866	0.19256	0.266794	0.21018	0.22427	0.319	0.307569	0.185	0.206	0.22219	0.197576
thallium (Tl)	mg/L	0.000043	1.7E-05	0.000004	0.000023	< 0.000003	0.000019	0.000031	0.0001	0.0001	< 0.0001	0.000034	< 0.0001	< 0.0001	0.000056	0.00003
titanium (Ti)	mg/L	0.012	0.01	0.011	0.015	0.008	0.011	0.007	0.013	0.01	0.037	0.003	0.192	0.02	0.011	0.006
uranium (U)	mg/L	0.0004	0.0003	0.0004	0.0002	0.0004	0.0002	0.0004	0.0003	0.0003	0.0005	0.0004	0.0007	0.0006	0.0003	0.0003
vanadium (V)	mg/L	0.0014	0.0013	0.0013	0.0015	0.0012	0.0016	0.0008	0.0017	0.0012	0.0016	0.0005	0.0166	0.0036	0.0016	0.001
zinc (Zn)	mg/L	0.02	0.013	0.007	0.003	0.006	0.008	0.009	0.007	0.005	0.019	0.002	0.13	0.005	0.007	0.013
Metals (Dissolved)																
aluminum (Al)	mg/L	0.011	0.01	0.011	0.009	0.008	0.012	0.008	0.009	0.009	0.03	0.005	0.01	0.14	0.009	0.008
antimony (Sb)	mg/L	0.00004	0.00003	0.00006	0.00002	0.00005	0.00005	0.00004	0.00002	0.00002	< 0.0008	0.00004	< 0.0008	0.0004	0.00005	0.00005
arsenic (As)	mg/L	0.0004	0.0005	0.0003	0.0006	0.0004	0.0005	0.0004	0.0005	0.0005	0.0006	0.0006	< 0.0004	0.0006	0.0004	0.0005
barium (Ba)	mg/L	0.045	0.032	0.044	0.031	0.048	0.032	0.046	0.038	0.038	0.078	0.062	0.052	0.052	0.039	0.038
beryllium (Be)	mg/L	0.00011	< 4E-05	< 0.00004	< 0.00004	< 0.00004	< 0.00004	0.00029	< 4E-05	< 4E-05	< 0.0005	0.0004	< 0.0005	< 0.0005	< 0.00004	0.00029
boron (B)	mg/L	0.019	0.02	0.026	0.023	0.019	0.026	0.02	0.023	0.025	0.054	0.039	0.014	0.061	0.022	0.022
cadmium (Cd)	mg/L	0.00003	0.00002	0.00004	0.00001	0.00004	0.00003	0.00003	0.00001	0.00003	0.0001	0.00005	< 0.0001	< 0.0001	0.00001	< 0.00001
chromium (Cr)	mg/L	0.00012	0.00013	0.00012	0.00011	< 0.00008	0.00011	0.00014	0.00019	0.00021	< 0.0004	0.00092	< 0.0004	0.0034	< 0.00008	0.00013
cobalt (Co)	mg/L	0.00008	0.00006	0.00008	0.00005	0.00004	0.00006	0.00005	0.00006	0.00005	< 0.0001	0.00011	< 0.0001	0.0002	0.00005	0.00004
copper (Cu)	mg/L	0.0009	0.0005	0.0008	0.0005	0.0007	0.0005	0.0004	0.0007	0.0007	0.0008	0.0006	0.002	0.0009	0.0008	0.0005
iron (Fe)	mg/L	0.05	0.16	0.04	0.16	0.03	0.16	0.04	0.1	0.08	0.1	0.21	0.12	0.06	0.07	0.12

Table X.1 Water Quality Samples Collected from the Athabasca River in 2002 (continued)

Parameter	Units	Upstream of Donald Creek (Fall)			Upstream of the Steepbank River (Fall)		Upstream of the Muskeg River (Fall)		Upstream of Fort Creek (Fall)		Downstream of all Development (x-channel)					Upstream of the Firebag River (east bank)
		X-Channel	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	Winter 1	Winter 2[a]	Spring	Summer	Fall	
lead (Pb)	mg/L	0.0001	0.0001	0.0001	0.0001	0.00003	0.0001	0.0001	0.0001	0.0001	< 0.0001	0.0003	0.0001	0.0001	0.0001	0.0001
lithium (Li)	mg/L	0.004	0.004	0.005	0.005	0.004	0.005	0.004	0.005	0.006	0.01	0.008	0.005	0.005	0.005	0.005
manganese (Mn)	mg/L	0.001	0.002	0.001	0.002	0.001	0.002	0.001	0.002	0.002	0.011	0.023	0.003	0.009	0.002	0.002
mercury (Hg)	mg/L	< 0.00004	< 4E-05	< 0.00004	< 0.00004	< 0.00004	< 0.00004	< 0.00004	< 4E-05	< 4E-05	0.0001	< 0.00004	< 0.0001	< 0.0001	< 0.00004	< 0.00004
molybdenum (Mo)	mg/L	0.0007	0.0005	0.0008	0.0005	0.0007	0.0005	0.0007	0.0006	0.0006	0.0008	0.001	0.0007	0.0008	0.0006	0.0005
nickel (Ni)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 1E-04	< 1E-04	0.0003	0.0006	0.0014	0.0007	< 0.0001	< 0.0001
selenium (Se)	mg/L	0.001	< 0.0005	0.0013	0.0012	< 0.0005	0.0009	< 0.0005	0.0007	0.0007	< 0.0004	< 0.0005	< 0.0004	< 0.0004	0.0005	< 0.0005
silver (Ag)	mg/L	0.000006	< 5E-06	< 5E-06	< 0.000005	0.000012	< 5E-06	< 5E-06	9E-06	< 5E-06	< 0.0002	0.000043	< 0.0002	< 0.0002	< 5E-06	0.000015
strontium (Sr)	mg/L	0.261552	0.18824	0.27607	0.186806	0.272979	0.183999	0.262405	0.20819	0.22701	0.333	0.303668	0.164	0.208	0.223906	0.200195
thallium (Tl)	mg/L	0.000032	0.00002	0.000003	0.000021	< 0.000003	0.000007	0.000038	9.9E-05	0.00013	< 0.00005	0.000068	< 0.00005	< 5E-05	0.00006	0.000033
titanium (Ti)	mg/L	0.001	0.0011	0.0006	0.001	< 0.0002	0.0005	< 0.0002	0.0007	0.0009	0.0019	0.0019	0.0031	0.0036	0.0008	0.0013
uranium (U)	mg/L	0.0003	0.0002	0.0004	0.0002	0.0004	0.0002	0.0004	0.0003	0.0003	0.0005	0.0004	0.0004	0.0004	0.0003	0.0003
vanadium (V)	mg/L	0.0003	0.0003	0.0003	0.0004	0.0003	0.0004	0.0003	0.0003	0.0003	0.0005	0.0005	0.0004	0.0017	0.0003	0.0004
zinc (Zn)	mg/L	0.01	0.005	0.004	0.002	0.004	0.006	0.006	0.004	0.003	0.005	0.004	0.068	< 0.002	0.002	0.009

* Winter samples collected in January 2003, rather than early December 2002 due to delays during freeze-up.

Table X.2 Water Quality Samples Collected from the Clearwater River in 2002

Parameter	Units	Upstream of Fort McMurray				Upstream of Christina River			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Field measured									
pH		9.9	8.6	7.6	8.1	9.6	8.3	7.7	7.8
specific conductance	µS/cm	236	264	216	223	199	206	166	170
temperature	°C	0.4	15.9	21.5	14.8	0	15.4	20.9	14.9
dissolved oxygen	mg/L	0.3	9.5	7.2	10.1	1.2	9.1	7.2	10
Conventional Parameters									
colour	T.C.U.	30	40	50	60	40	30	30	50
conductance	µS/cm	404	269	238	177	265	194	186	138
dissolved organic carbon	mg/L	5	6	7	10	4	5	6	8
hardness	mg/L	81	56	59	58	60	45	45	40
pH		7.5	7.6	7.8	7.7	7.4	7.4	7.7	7.6
total alkalinity	mg/L	74	58	59	59	54	43	44	39
total dissolved solids	mg/L	200	150	160	60	140	130	140	40
total organic carbon	mg/L	6	7	9	12	5	6	7	10
total suspended solids	mg/L	< 3	17	10	12	< 3	14	8	7
Major Ions									
bicarbonate	mg/L	91	71	71	72	66	53	53	48
calcium	mg/L	21	15	15	15	15	11	11	10
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	60	39	30	17	38	26	24	16
magnesium	mg/L	7	5	5	5	5	4	4	4
potassium	mg/L	1	2	2	1	1	1	1	1
sodium	mg/L	47	29	25	16	30	20	19	13
sulphate	mg/L	14	10	10	5	10	8	6	4
sulphide	mg/L	0.016	0.006	0.004	0.005	0.029	< 0.003	0.004	0.004
Nutrients and Chloropyll *a*									
nitrate + nitrite	mg/L	0.3	0.1	< 0.1	< 0.1	0.3	0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	0.08	< 0.05	< 0.05	< 0.05	0.08	< 0.05	< 0.05	< 0.05

Table X.2 Water Quality Samples Collected from the Clearwater River in 2002 (continued)

Parameter	Units	Upstream of Fort McMurray				Upstream of Christina River			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
nitrogen - kjeldahl	mg/L	0.4	2	1.8	0.6	0.3	1.9	1.3	1.1
phosphorus, total	mg/L	0.042	0.043	0.042	0.051	0.041	0.045	0.037	0.043
phosphorus, dissolved	mg/L	0.019	0.009	0.018	0.021	0.021	0.011	0.018	0.021
chlorophyll *a*	ug/L	< 1	5	6	2	1	5	5	2
Biological Oxygen Demand									
biochemical oxygen demand	mg/L	< 2	< 2	2	< 2	< 2	2	< 2	< 2
General Organics									
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Metals (Total)									
aluminum (Al)	mg/L	0.09	0.41	0.77	0.54	0.09	0.45	0.19	0.21
antimony (Sb)	mg/L	< 0.005	< 0.005	0.0006	0.00004	< 0.005	< 0.005	0.0005	0.00001
arsenic (As)	mg/L	< 0.001	< 0.001	0.0006	0.0008	< 0.001	< 0.001	0.0004	0.0005
barium (Ba)	mg/L	0.023	0.019	0.019	0.019	0.018	0.016	0.013	0.013
beryllium (Be)	mg/L	< 0.001	< 0.001	< 0.001	0.00022	< 0.001	< 0.001	< 0.001	< 0.00004
boron (B)	mg/L	0.05	0.03	0.03	0.027	0.03	< 0.02	0.02	0.018
cadmium (Cd)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.00002	< 0.0002	< 0.0002	< 0.0002	< 0.00002
chromium (Cr)	mg/L	< 0.0008	< 0.0008	< 0.0008	0.00076	< 0.0008	< 0.0008	< 0.0008	0.00042
cobalt (Co)	mg/L	< 0.0002	< 0.0002	0.0004	0.00022	< 0.0002	< 0.0002	0.0002	0.00011
copper (Cu)	mg/L	0.003	< 0.001	0.001	0.0003	< 0.001	0.001	< 0.001	< 0.0001
iron (Fe)	mg/L	0.7	0.96	0.62	1.02	0.69	0.97	0.47	0.79
lead (Pb)	mg/L	0.0001	0.0002	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001
lithium (Li)	mg/L	0.009	0.007	0.006	0.005	< 0.006	< 0.006	< 0.006	0.004
manganese (Mn)	mg/L	0.025	0.055	0.083	0.051	0.027	0.05	0.055	0.044
mercury (Hg)	mg/L	0.0000016	0.0000042	< 6E-07	< 6E-07	< 6E-07	0.0000032	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.0003	0.0004	0.0003	0.0002	0.0002	0.0002	0.0002	0.0001

Table X.2 Water Quality Samples Collected from the Clearwater River in 2002 (continued)

Parameter	Units	Upstream of Fort McMurray				Upstream of Christina River			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
nickel (Ni)	mg/L	0.0003	0.0016	0.0007	0.0003	< 0.0002	0.0006	0.0004	0.0001
selenium (Se)	mg/L	< 0.0008	0.001	< 0.0004	< 0.0005	< 0.0008	< 0.0008	< 0.0004	< 0.0005
silver (Ag)	mg/L	0.00001	0.000063	0.000014	< 0.000005	< 0.000005	0.000031	0.000006	0.000007
strontium (Sr)	mg/L	0.14	0.115	0.101	0.0791	0.0971	0.0788	0.0776	0.060758
thallium (Tl)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.000037	< 0.0001	< 0.0001	< 0.0001	0.00003
titanium (Ti)	mg/L	< 0.005	0.009	0.006	0.011	< 0.005	0.011	< 0.005	0.006
uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	0.00004
vanadium (V)	mg/L	0.0007	0.0015	0.0014	0.0017	0.0007	0.0014	0.001	0.001
zinc (Zn)	mg/L	0.012	0.098	< 0.004	0.004	0.016	0.102	< 0.004	0.003
Metals (Dissolved)									
aluminum (Al)	mg/L	0.02	0.02	0.04	0.01	0.04	0.03	0.04	0.011
antimony (Sb)	mg/L	< 0.0008	< 0.0008	< 0.0004	0.00002	< 0.0008	< 0.0008	< 0.0004	0.00003
arsenic (As)	mg/L	0.0006	< 0.0004	0.0005	0.0006	0.0004	< 0.0004	0.0004	0.0005
barium (Ba)	mg/L	0.024	0.015	0.014	0.013	0.018	0.012	0.01	0.01
beryllium (Be)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.00004	< 0.0005	< 0.0005	< 0.0005	0.00009
boron (B)	mg/L	0.057	0.039	0.037	0.026	0.029	0.025	0.026	0.016
cadmium (Cd)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00001	0.0002	< 0.0001	< 0.0001	< 0.00001
chromium (Cr)	mg/L	< 0.0004	< 0.0004	< 0.0004	0.00014	0.0006	< 0.0004	< 0.0004	0.0001
cobalt (Co)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00015	< 0.0001	< 0.0001	< 0.0001	0.00005
copper (Cu)	mg/L	0.0012	0.0011	< 0.0006	< 0.0001	0.002	0.0008	< 0.0006	< 0.0001
iron (Fe)	mg/L	0.23	0.38	0.15	0.35	0.25	0.44	0.21	0.33
lead (Pb)	mg/L	0.0002	< 0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	0.0001
lithium (Li)	mg/L	0.01	0.007	0.007	0.005	0.006	0.005	0.005	0.004
manganese (Mn)	mg/L	0.011	0.014	0.028	0.008	0.019	0.014	0.026	0.008
mercury (Hg)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00004	< 0.0001	< 0.0001	< 0.0001	< 0.00004
molybdenum (Mo)	mg/L	0.0003	0.0002	0.0003	0.0002	0.0002	0.0001	0.0002	0.0001
nickel (Ni)	mg/L	0.0004	< 0.0001	0.0004	< 0.0001	0.0006	< 0.0001	0.0003	< 0.0001
selenium (Se)	mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.0005	< 0.0004	< 0.0004	< 0.0004	< 0.0005

Table X.2 Water Quality Samples Collected from the Clearwater River in 2002 (continued)

Parameter	Units	Upstream of Fort McMurray				Upstream of Christina River			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
silver (Ag)	mg/L	< 0.0002	< 0.0002	0.0003	0.000006	< 0.0002	< 0.0002	< 0.0002	< 0.000005
strontium (Sr)	mg/L	0.16	0.102	0.0972	0.077322	0.102	0.0775	0.076	0.060766
thallium (Tl)	mg/L	< 0.00005	< 0.00005	< 0.00005	0.000045	< 0.00005	< 0.00005	< 0.00005	0.000036
titanium (Ti)	mg/L	0.0027	0.0021	0.0024	0.0016	0.0025	0.0023	0.0026	0.0008
uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00004	< 0.0001	< 0.0001	< 0.0001	0.00003
vanadium (V)	mg/L	0.0011	0.0004	0.0004	0.0005	0.0008	0.0004	0.0004	0.0005
zinc (Zn)	mg/L	0.118	< 0.002	< 0.002	0.001	0.037	< 0.002	< 0.002	0.001

Table X.3 Water Quality Samples Collected from the Christina River in 2002

Parameter	Units	Upstream of Fort McMurray				Upstream of Janvier			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Field measured									
pH		8.4	9	8.2	8.4	7.3	7.7	7.9	7.8
specific conductance	µS/cm	1300	770	395	370	518	230	246	223
temperature	^{o}C	0.4	15.8	20.3	14.6	0.6	19.9	21.6	12.8
dissolved oxygen	mg/L	4	9.8	7.6	9.9	1.4	8.3	7.1	9.5
Conventional Parameters									
colour	T.C.U.	50	30	50	60	50	-	50	70
conductance	µS/cm	1390	751	444	295	543	299	274	226
dissolved organic carbon	mg/L	14	12	13	16	13	-	13	15
hardness	mg/L	266	147	116	104	253	136	124	108
pH		7.9	8.2	8.2	8.1	7.6	8	8.1	8.2
total alkalinity	mg/L	259	155	120	110	277	139	132	113
total dissolved solids	mg/L	790	450	300	140	280	180	200	240
total organic carbon	mg/L	16	14	16	18	15	20	15	18
total suspended solids	mg/L	3	3	13	< 3	< 3	16	740	8
Major Ions									
bicarbonate	mg/L	316	189	146	134	338	169	162	138
calcium	mg/L	71	39	30	27	70	37	34	29
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	279	131	56	24	1	< 1	< 1	2
magnesium	mg/L	22	12	10	9	19	11	10	9
potassium	mg/L	3	3	1	1	3	3	1	1
sodium	mg/L	212	100	50	25	22	11	10	8
sulphate	mg/L	48	27	12	7	27	13	9	6
sulphide	mg/L	0.008	< 0.003	0.005	0.005	0.021	0.018	0.004	< 0.003
Nutrients and Chloropyll *a*									
nitrate + nitrite	mg/L	0.7	< 0.1	< 0.1	< 0.1	0.8	< 0.1	< 0.1	< 0.1

Table X.3 Water Quality Samples Collected from the Christina River in 2002 (continued)

Parameter	Units	Upstream of Fort McMurray				Upstream of Janvier			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
nitrogen - ammonia	mg/L	0.17	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	1.4	2	1.7	1.5	5.4	1	0.9	0.7
phosphorus, total	mg/L	0.056	0.031	0.049	0.058	0.039	0.079	0.058	0.048
phosphorus, dissolved	mg/L	0.02	0.01	0.017	0.025	0.011	0.016	0.025	0.033
chlorophyll *a*	ug/L	2	4	-	1	< 1	8	7	2
Biological Oxygen Demand									
biochemical oxygen demand	mg/L	< 2	2	2	< 2	< 2	-	2	< 2
General Organics									
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Metals (Total)									
aluminum (Al)	mg/L	0.13	0.31	0.53	0.73	0.04	0.34	0.15	0.05
antimony (Sb)	mg/L	< 0.005	< 0.005	0.0006	0.00005	< 0.005	< 0.005	0.0007	0.00003
arsenic (As)	mg/L	0.001	0.001	0.001	0.0012	< 0.001	< 0.001	0.0012	0.0009
barium (Ba)	mg/L	0.064	0.036	0.033	0.03	0.089	0.045	0.037	0.033
beryllium (Be)	mg/L	< 0.001	< 0.001	< 0.001	< 0.00004	< 0.001	< 0.001	< 0.001	< 0.00004
boron (B)	mg/L	0.24	0.13	0.08	0.049	0.12	0.06	0.05	0.037
cadmium (Cd)	mg/L	0.0018	< 0.0002	< 0.0002	< 0.00002	< 0.0002	< 0.0002	0.0003	< 0.00002
chromium (Cr)	mg/L	< 0.0008	< 0.0008	< 0.0008	0.00083	0.001	< 0.0008	0.0035	0.00018
cobalt (Co)	mg/L	0.0004	< 0.0002	0.0003	0.00031	< 0.0002	0.0003	0.0006	0.00011
copper (Cu)	mg/L	0.002	0.001	0.001	0.0011	< 0.001	0.001	0.002	0.0001
iron (Fe)	mg/L	0.74	0.36	0.51	1.11	0.6	0.98	0.68	1
lead (Pb)	mg/L	0.0005	0.0003	0.0001	0.0004	< 0.0001	0.0003	0.0005	0.0001
lithium (Li)	mg/L	0.038	0.022	0.012	0.009	0.027	0.012	0.011	0.008
manganese (Mn)	**mg/L**	**0.03**	**0.057**	**0.128**	**0.059**	**0.108**	**0.145**	**0.084**	**0.055**

Table X.3 Water Quality Samples Collected from the Christina River in 2002 (continued)

Parameter	Units	Upstream of Fort McMurray				Upstream of Janvier			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
mercury (Hg)	mg/L	0.000001	0.0000038	< 6E-07	< 6E-07	< 6E-07	0.0000033	< 6E-07	< 0.0000006
molybdenum (Mo)	mg/L	0.001	0.0009	0.0006	0.0004	0.0012	0.001	0.001	0.0004
nickel (Ni)	mg/L	0.0018	0.0008	0.0008	0.0004	0.0077	0.0008	0.0012	< 0.0001
selenium (Se)	mg/L	0.0011	0.0011	< 0.0004	< 0.0005	< 0.0008	< 0.0008	< 0.0004	< 0.0005
silver (Ag)	mg/L	0.00004	0.000022	0.000012	0.000011	0.000012	0.000007	< 0.000005	0.000007
strontium (Sr)	mg/L	0.517	0.301	0.183	0.124407	0.316	0.171	0.142	0.116865
thallium (Tl)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.000069	< 0.0001	< 0.0001	< 0.0001	< 0.000003
titanium (Ti)	mg/L	0.008	0.008	0.007	0.013	< 0.005	0.007	< 0.005	0.002
uranium (U)	mg/L	0.0005	0.0002	0.0001	0.0001	0.0002	0.0002	0.0005	0.0001
vanadium (V)	mg/L	0.0017	0.0014	0.0014	0.0019	< 0.0002	0.001	0.0007	0.0003
zinc (Zn)	mg/L	0.015	0.009	< 0.004	0.009	0.006	0.005	0.005	0.004
Metals (Dissolved)									
aluminum (Al)	mg/L	0.04	0.03	0.04	0.009	0.02	< 0.01	0.03	0.008
antimony (Sb)	mg/L	< 0.0008	< 0.0008	< 0.0004	0.00002	< 0.0008	< 0.0008	< 0.0004	0.00004
arsenic (As)	mg/L	0.0014	0.0004	0.001	0.0009	0.0005	0.0005	0.0009	0.0007
barium (Ba)	mg/L	0.065	0.035	0.028	0.025	0.09	0.035	0.033	0.028
beryllium (Be)	mg/L	< 0.0005	< 0.0005	< 0.0005	0.00022	< 0.0005	< 0.0005	< 0.0005	< 0.00004
boron (B)	mg/L	0.236	0.139	0.086	0.049	0.126	0.056	0.055	0.037
cadmium (Cd)	mg/L	0.0002	< 0.0001	< 0.0001	< 0.00001	< 0.0001	< 0.0001	< 0.0001	0.00001
chromium (Cr)	mg/L	< 0.0004	< 0.0004	< 0.0004	0.00024	0.0006	< 0.0004	< 0.0004	0.00022
cobalt (Co)	mg/L	< 0.0001	0.0001	0.0001	0.00009	< 0.0001	0.0001	0.0002	0.00006
copper (Cu)	mg/L	0.0027	0.0014	0.0008	0.0012	< 0.0006	< 0.0006	< 0.0006	< 0.0001
iron (Fe)	mg/L	0.04	0.12	0.12	0.34	0.68	0.12	0.32	0.64
lead (Pb)	mg/L	0.0001	< 0.0001	0.0001	0.0002	< 0.0001	< 0.0001	< 0.0001	0.00002
lithium (Li)	mg/L	0.037	0.023	0.014	0.008	0.026	0.015	0.012	0.008
manganese (Mn)	mg/L	0.002	0.016	0.055	0.01	0.116	0.035	0.042	0.015
mercury (Hg)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00004	< 0.0001	< 0.0001	< 0.0001	< 0.00004
molybdenum (Mo)	mg/L	0.0007	0.0009	0.0006	0.0004	0.001	0.0009	0.0009	0.0005

Table X.3 Water Quality Samples Collected from the Christina River in 2002 (continued)

Parameter	Units	Upstream of Fort McMurray				Upstream of Janvier			
		Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
nickel (Ni)	mg/L	0.001	0.0003	0.0008	0.0001	< 0.0001	< 0.0001	0.0006	< 0.0001
selenium (Se)	mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.0005	< 0.0004	< 0.0004	< 0.0004	< 0.0005
silver (Ag)	mg/L	< 0.0002	< 0.0002	< 0.0002	0.000005	< 0.0002	< 0.0002	< 0.0002	0.000006
strontium (Sr)	mg/L	0.512	0.298	0.176	0.121994	0.293	0.173	0.143	0.115996
thallium (Tl)	mg/L	0.00017	< 0.00005	< 0.00005	0.000084	< 0.00005	< 0.00005	< 0.00005	< 0.000003
titanium (Ti)	mg/L	0.0041	0.0018	0.0017	0.0018	0.0029	0.0007	0.0016	0.0008
uranium (U)	mg/L	0.0002	0.0002	0.0001	0.0001	0.0002	0.0002	0.0001	0.0001
vanadium (V)	mg/L	0.0023	0.0008	0.0006	0.0005	0.0002	< 0.0001	0.0001	0.0003
zinc (Zn)	mg/L	0.04	< 0.002	< 0.002	0.006	0.005	< 0.002	< 0.002	0.004

Table X.4 PAH Samples Collected by RAMP in Fall, 2002

Parameter	Units	Athabasca River u/s of Donald Creek	Athabasca River d/s of Development	Clearwater River-u/s Fort McMurray	Clearwater River-u/s Christina River	Christina River-u/s Fort McMurray	Christina River-u/s Janvier
Target PAHs and Alkylated PAHs							
Naphthalene	µg/L	< 0.02	0.05	< 0.02	< 0.02	< 0.02	0.04
C1 subst'd naphthalenes	µg/L	< 0.04	< 0.04	< 0.02	< 0.02	< 0.02	0.03
C2 subst'd naphthalenes	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	0.05
C3 subst'd naphthalenes	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C4 subst'd naphthalenes	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Acenaphthene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C1 subst'd acenaphthene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Acenaphthylene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Anthracene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dibenzo(a,h)anthracene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Benzo(a)Anthracene/Chrysene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C1 subst'd benzo(a)anthracene/chrysene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 subst'd benzo(a)anthracene/chrysene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Benzo(a)pyrene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C1 subst'd benzo(b&k) fluoranthen / benzo(a)pyrene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 subst'd benzo(b& k) fluoranthene / benzo(a)pyrene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Benzo(b&k)fluoranthene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Benzo(g,h,i)perylene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Biphenyl	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C1 subst'd biphenyl	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 subst'd biphenyl	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Dibenzothiophene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C1 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04

Table X.4 PAH Samples Collected by RAMP in Fall, 2002 (continued)

Parameter	Units	Athabasca River u/s of Donald Creek	Athabasca River d/s of Development	Clearwater River-u/s Fort McMurray	Clearwater River-u/s Christina River	Christina River-u/s Fort McMurray	Christina River-u/s Janvier
C3 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C4 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Fluoranthene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C1 subst'd fluoranthene / pyrene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Fluorene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
C1 subst'd fluorene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 subst'd fluorene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Indeno(c,d-123)pyrene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Phenanthrene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03
C1 subst'd phenanthrene/anthracene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C2 subst'd phenanthren/anthracene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C3 subst'd phenanthrene/anthracene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
C4 subst'd phenanthrene/anthracene	µg/L	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04	< 0.04
Pyrene	µg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

u/s = Upstream.

d/s = Downstream.

Table X.5 Water Quality Samples Collected from the Tributaries North of Fort McMurray (East of the Athabasca River), 2002

Parameter	Units	McLean Creek (mouth)	Steepbank River				North Steepbank River (mouth)			Fort Creek (mouth)	Firebag River							
			Mouth		u/s Millennium [(a)]						Mouth				u/s of Suncor Firebag[(a)]			
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
Field measured																		
pH		7.7	7.9	8.3	7.5	7.7	8.5	7	6.9	8.5	7.4	8.6	7.5	7.5	7.4	8.3	6.5	6.9
specific conductance	µS/cm	280	730	151	703	132	227	98	102	436	255	228	155	169	235	152	81	107
temperature	^{o}C	12.6	1.1	11.6	0.1	11.3	9.7	14.7	9.7	12.9	0	12.2	17.5	12.1	1.8	9.8	14	10.4
dissolved oxygen	mg/L	10.1	3.3	10.7	1.2	10.7	10.4	5.6	10.3	4.9	3.6	9.2	6.5	9.7	2.9	9.4	6.5	9.1
Conventional Parameters																		
colour	T.C.U.	70	50	120	50	100	60	70	100	50	30	30	80	70	70	60	100	100
conductance	µS/cm	300	743	164	713	142	226	130	110	432	285	226	188	178	251	154	106	113
dissolved organic carbon	mg/L	28	13	26	11	22	13	18	16	13	5	11	16	13	8	9	19	15
hardness	mg/L	148	329	79	292	71	118	66	61	233	144	117	92	97	127	80	58	62
pH		8.1	8.1	7.9	8.1	7.8	7.7	7.5	7.5	8.1	7.8	7.8	7.7	7.9	7.6	7.5	7.2	7.4
total alkalinity	mg/L	144	406	79	375	71	115	62	55	231	141	112	89	87	125	76	51	57
total dissolved solids	mg/L	250	430	180	380	160	140	130	120	260	160	140	170	130	130	80	120	110
total organic carbon	mg/L	30	14	27	12	26	15	20	19	15	6	13	16	16	9	13	21	19
total suspended solids	mg/L	83	< 3	32	< 3	8	< 3	< 3	4	5	3	11	15	12	< 3	5	< 3	6
Major Ions																		
bicarbonate	mg/L	176	495	96	458	86	140	75	67	282	172	137	109	106	153	92	62	69
calcium	mg/L	41	87	21	77	19	32	18	17	69	39	32	24	25	34	21	16	16
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	5	9	1	3	2	< 1	< 1	1	2	3	2	2	2	1	1	< 1	1
magnesium	mg/L	11	27	7	24	6	9	5	5	15	12	9	8	8	10	6	5	5
potassium	mg/L	2	3	1	3	1	3	0.3	1	1	1	2	1	1	1	2	0.1	1
sodium	mg/L	12	58	8	54	6	6	2	2	9	6	5	4	3	3	3	2	2
sulphate	mg/L	9	22	5	17	4	4	3	2	5	10	7	4	3	5	3	2	2
sulphide	mg/L	0.011	< 0.003	0.006	< 0.003	0.007	0.006	0.005	0.004	< 0.003	< 0.003	0.005	0.007	0.005	0.003	0.008	0.003	0.005
Nutrients and Chloropyll *a*																		
nitrate + nitrite	mg/L	< 0.1	0.5	< 0.1	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.33	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	0.9	0.7	0.8	< 0.2	1.4	0.5	1.4	0.6	0.3	0.7	0.4	1.5	1.6	0.7	0.5	1.3	1.1
phosphorus, total	mg/L	0.07	0.039	0.041	0.041	0.035	0.057	0.037	0.027	0.021	0.035	0.051	0.061	0.07	0.089	0.046	0.054	0.047
phosphorus, dissolved	mg/L	0.031	0.011	0.016	0.011	0.022	0.036	0.026	0.016	0.01	0.018	0.015	0.031	0.036	0.05	0.032	0.041	0.035
chlorophyll *a*	ug/L	1	< 1	7	< 1	1	2	< 1	< 1	< 1	< 1	3	16	3	< 1	3	< 1	< 1
Biological Oxygen Demand																		
biochemical oxygen demand	mg/L	< 2	< 2	< 2	< 2	< 2	11	< 2	< 2	2	< 2	3	< 2	< 2	< 2	< 2	< 2	< 2
General Organics																		
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	1	< 1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

Table X.5 Water Quality Samples Collected from the Tributaries North of Fort McMurray (East of the Athabasca River), 2002 (continued)

Parameter	Units	McLean Creek (mouth)	Steepbank River				North Steepbank River (mouth)			Fort Creek (mouth)	Firebag River							
			Mouth		u/s Millennium [(a)]						Mouth				u/s of Suncor Firebag[(a)]			
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
total recoverable hydrocarbons	mg/L	1.9	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Metals (Total)																		
aluminum (Al)	mg/L	2.58	0.07	1.14	0.09	0.24	0.04	0.06	0.13	0.06	0.06	0.41	0.31	0.29	0.18	0.1	0.05	0.08
antimony (Sb)	mg/L	0.00004	< 0.005	0.00002	< 0.005	0.000004	< 0.005	0.0004	0.00001	0.00001	< 0.005	< 0.005	0.0005	0.00001	< 0.005	< 0.005	< 0.0004	0.000004
arsenic (As)	mg/L	0.0014	< 0.001	0.0008	< 0.001	0.0007	0.001	0.0007	0.0005	0.0003	< 0.001	< 0.001	0.0004	0.0005	< 0.001	< 0.001	< 0.0004	0.0003
barium (Ba)	mg/L	0.055	0.108	0.029	0.1	0.022	0.042	0.028	0.022	0.091	0.036	0.03	0.027	0.025	0.03	0.022	0.017	0.014
beryllium (Be)	mg/L	0.00034	< 0.001	0.00014	< 0.001	0.00011	< 0.001	< 0.001	0.00022	< 0.00004	< 0.001	< 0.001	< 0.001	0.00012	< 0.001	< 0.001	< 0.001	0.00042
boron (B)	mg/L	0.042	0.4	0.036	0.33	0.029	0.04	< 0.02	0.011	0.043	0.03	0.02	< 0.02	0.014	< 0.02	< 0.02	< 0.02	0.008
cadmium (Cd)	mg/L	0.00007	< 0.0002	< 2E-05	< 0.0002	< 0.00002	< 0.0002	< 0.0002	0.00002	< 0.00002	< 2E-04	0.0004	< 0.0002	< 2E-05	0.0002	< 0.0002	< 0.0002	< 2E-05
chromium (Cr)	mg/L	0.00324	< 0.0008	0.00123	0.0023	0.00049	< 0.0008	< 0.0008	0.00024	0.00012	< 8E-04	0.0011	< 0.0008	0.00045	0.003	< 0.0008	< 0.0008	0.00017
cobalt (Co)	mg/L	0.00314	< 0.0002	0.00046	< 0.0002	0.00017	< 0.0002	< 0.0002	0.0001	0.00007	< 2E-04	0.0005	0.0002	0.00015	0.0002	< 0.0002	< 0.0002	0.00005
copper (Cu)	mg/L	0.0032	< 0.001	0.0005	0.001	< 0.0001	< 0.001	< 0.001	< 0.0001	0.0002	< 0.001	0.003	< 0.001	< 1E-04	< 0.001	< 0.001	< 0.001	< 0.0001
iron (Fe)	mg/L	3.46	0.61	1.47	0.54	0.84	1.14	0.62	0.51	0.6	0.48	0.74	0.68	1.05	2.39	0.53	0.38	0.39
lead (Pb)	mg/L	0.0035	0.0001	0.0005	< 0.0001	0.0001	0.0001	< 0.0001	0.00003	0.0001	< 1E-04	0.0009	0.0001	0.0001	0.0002	< 0.0001	< 0.0001	0.00002
lithium (Li)	mg/L	0.011	0.035	0.006	0.033	0.005	0.008	< 0.006	0.003	0.012	0.006	< 0.006	< 0.006	0.004	< 0.006	< 0.006	< 0.006	0.002
manganese (Mn)	mg/L	0.277	0.016	0.06	0.024	0.042	0.05	0.049	0.028	0.071	0.043	0.046	0.071	0.059	0.384	0.036	0.023	0.021
mercury (Hg)	mg/L	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.0001	0.0012	0.0002	0.0006	0.0001	0.0009	< 0.0001	0.0002	0.00003	0.0003	0.0006	< 0.0001	0.0001	0.0001	0.0001	< 0.0001	0.00004
nickel (Ni)	mg/L	0.0042	< 0.0002	0.0006	< 0.0002	0.0001	< 0.0002	0.0009	< 0.0001	< 0.0001	< 2E-04	0.0005	0.0006	< 1E-04	< 0.0002	< 0.0002	0.0003	< 0.0001
selenium (Se)	mg/L	< 0.0005	< 0.0008	< 0.0005	< 0.0008	< 0.0005	< 0.0008	< 0.0004	< 0.0005	< 0.0005	< 8E-04	< 8E-04	< 0.0004	< 5E-04	< 0.0008	< 0.0008	< 0.0004	0.0008
silver (Ag)	mg/L	0.000006	< 5E-06	< 5E-06	0.000006	0.000006	0.000011	0.000008	< 5E-06	0.000007	< 5E-06	9E-06	< 5E-06	1.1E-05	< 5E-06	< 5E-06	< 5E-06	< 5E-06
strontium (Sr)	mg/L	0.120627	0.362	0.07538	0.311	0.063534	0.162	0.0652	0.04945	0.164151	0.0888	0.0748	0.0605	0.05264	0.0527	0.0383	0.0288	0.02844
thallium (Tl)	mg/L	0.000061	< 0.0001	< 3E-06	< 0.0001	< 0.000003	< 0.0001	< 0.0001	< 3E-06	< 0.000003	< 1E-04	< 1E-04	< 0.0001	1.1E-05	< 0.0001	< 0.0001	< 0.0001	0.000005
titanium (Ti)	mg/L	0.04	0.005	0.015	0.006	0.004	< 0.005	< 0.005	0.002	0.002	< 0.005	0.009	0.006	0.007	< 0.005	< 0.005	< 0.005	0.001
uranium (U)	mg/L	0.0003	0.0002	0.0001	0.0002	0.0004	< 0.0001	< 0.0001	1.9E-05	0.000029	< 1E-04	0.0005	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	0.000006
vanadium (V)	mg/L	0.0066	0.0005	0.0023	0.0013	0.0007	< 0.0002	< 0.0002	0.0004	0.0003	0.0003	0.0015	0.0009	0.001	0.0013	0.0003	< 0.0002	0.0003
zinc (Zn)	mg/L	0.011	0.016	0.003	0.005	0.002	0.009	0.007	0.001	0.002	0.008	0.02	< 0.004	0.002	0.275	0.007	< 0.004	0.001
Metals (Dissolved)																		
aluminum (Al)	mg/L	0.016	0.04	0.018	0.03	0.018	0.02	0.03	0.015	0.003	< 0.01	0.04	0.02	0.009	< 0.01	0.02	0.02	0.011
antimony (Sb)	mg/L	0.00001	< 0.0008	0.00003	< 0.0008	0.000004	< 0.0008	< 0.0004	0.00001	0.00001	< 8E-04	< 8E-04	< 0.0004	0.00001	< 0.0008	< 0.0008	< 0.0004	0.000004
arsenic (As)	mg/L	0.0007	0.0007	0.0006	< 0.0004	0.0005	0.0004	0.0008	0.0005	0.0002	< 4E-04	< 4E-04	< 0.0004	0.0006	< 0.0004	< 0.0004	< 0.0004	0.0003
barium (Ba)	mg/L	0.026	0.109	0.02	0.115	0.018	0.046	0.028	0.02	0.087	0.037	0.028	0.023	0.021	1.12	0.023	0.015	0.013
beryllium (Be)	mg/L	0.00018	< 0.0005	< 4E-05	< 0.0005	< 0.00004	< 0.0005	< 0.0005	< 4E-05	< 0.00004	< 5E-04	< 5E-04	< 0.0005	0.00011	< 0.0005	< 0.0005	< 0.0005	0.00008
boron (B)	mg/L	0.036	0.351	0.034	0.453	0.029	0.04	0.017	0.011	0.043	0.025	0.017	0.019	0.013	0.273	0.009	0.011	0.008
cadmium (Cd)	mg/L	< 0.00001	< 0.0001	< 1E-05	< 0.0001	< 0.00001	< 0.0001	< 0.0001	< 1E-05	0.00002	< 1E-04	< 1E-04	< 0.0001	< 1E-05	< 0.0001	< 0.0001	< 0.0001	< 1E-05
chromium (Cr)	mg/L	0.00026	< 0.0004	0.00016	< 0.0004	0.00023	< 0.0004	< 0.0004	0.00014	0.00013	0.0005	< 4E-04	< 0.0004	0.00016	0.001	< 0.0004	< 0.0004	< 8E-05
cobalt (Co)	mg/L	0.00023	0.0001	0.0001	< 0.0001	0.00005	0.0001	0.0001	0.00005	0.00004	< 1E-04	< 1E-04	< 0.0001	0.00006	0.0003	< 0.0001	< 0.0001	0.00004
copper (Cu)	mg/L	< 0.0001	< 0.0006	< 0.0001	< 0.0006	< 0.0001	0.0006	< 0.0006	< 0.0001	0.0002	< 6E-04	< 6E-04	< 0.0006	< 1E-04	< 0.0006	< 0.0006	< 0.0006	< 0.0001

Table X.5 Water Quality Samples Collected from the Tributaries North of Fort McMurray (East of the Athabasca River), 2002 (continued)

Parameter	Units	McLean Creek (mouth)	Steepbank River				North Steepbank River (mouth)			Fort Creek (mouth)	Firebag River							
			Mouth		u/s Millennium [a]						Mouth				u/s of Suncor Firebag[a]			
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall
iron (Fe)	mg/L	0.27	0.01	0.37	0.04	0.39	0.96	0.64	0.28	0.23	0.15	0.32	0.21	0.4	0.89	0.41	0.26	0.26
lead (Pb)	mg/L	0.0001	0.0001	0.00004	< 0.0001	0.00002	< 0.0001	< 0.0001	0.00001	0.00003	< 1E-04	< 1E-04	< 0.0001	0.00003	< 0.0001	< 0.0001	< 0.0001	0.00001
lithium (Li)	mg/L	0.008	0.034	0.005	0.034	0.004	0.011	0.003	0.003	0.012	0.006	0.004	0.004	0.003	0.004	0.002	0.002	0.002
manganese (Mn)	mg/L	0.06	0.007	0.011	0.019	0.01	0.014	0.052	0.007	0.024	0.034	0.019	0.009	0.007	0.218	0.007	0.001	0.006
mercury (Hg)	mg/L	< 0.00004	< 0.0001	< 4E-05	< 0.0001	0.00005	< 0.0001	< 0.0001	< 4E-05	< 0.00004	< 1E-04	< 1E-04	< 0.0001	< 4E-05	0.0002	< 0.0001	< 0.0001	< 4E-05
molybdenum (Mo)	mg/L	0.0002	0.001	0.0002	0.0006	0.0002	0.0009	0.0003	0.0001	0.00004	0.0003	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
nickel (Ni)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0013	< 0.0001	< 0.0001	< 1E-04	< 1E-04	0.0007	< 1E-04	< 0.0001	< 0.0001	0.0006	< 0.0001
selenium (Se)	mg/L	0.0007	< 0.0004	< 0.0005	< 0.0004	< 0.0005	< 0.0004	< 0.0004	< 0.0005	0.0006	< 4E-04	< 4E-04	< 0.0004	0.0008	< 0.0004	< 0.0004	< 0.0004	< 0.0005
silver (Ag)	mg/L	0.000018	< 0.0002	0.000012	< 0.0002	< 0.000005	< 0.0002	< 0.0002	< 5E-06	< 0.000005	< 2E-04	< 2E-04	< 0.0002	< 5E-06	< 0.0002	< 0.0002	< 0.0002	< 5E-06
strontium (Sr)	mg/L	0.123086	0.338	0.071355	0.321	0.062673	0.166	0.0669	0.0486	0.160038	0.0885	0.0702	0.0607	0.05326	0.0541	0.0359	0.029	0.028719
thallium (Tl)	mg/L	0.000025	< 5E-05	< 3E-06	< 5E-05	< 0.000003	< 0.00005	< 0.00005	< 3E-06	< 0.000003	< 5E-05	< 5E-05	< 0.00005	0.00002	< 5E-05	< 0.00005	< 5E-05	0.00001
titanium (Ti)	mg/L	0.0026	0.005	0.0012	0.005	0.0009	0.0011	0.0008	0.0002	0.0012	0.002	0.0018	0.0017	0.0011	0.0021	0.0015	0.0009	0.0007
uranium (U)	mg/L	0.0001	0.0003	0.00004	0.0002	0.00003	0.0004	< 0.0001	1.2E-05	0.000023	0.0001	< 1E-04	< 0.0001	2.3E-05	< 0.0001	< 0.0001	< 0.0001	0.000004
vanadium (V)	mg/L	0.0004	0.0003	0.0003	0.0003	0.0003	< 0.0001	< 0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	0.0004	0.0002	0.0001	< 0.0001	0.0002
zinc (Zn)	mg/L	0.001	0.006	0.003	0.004	0.002	0.173	< 0.002	0.001	0.001	0.002	< 0.002	< 0.002	0.001	0.164	< 0.002	< 0.002	0.001

[a] u/s = Upstream.

Table X.6 Water Quality Samples Collected from the Tributaries North of Fort McMurray (West of the Athabasca River), 2002

Parameter	Units	Poplar Creek (mouth)	MacKay River				Ells River (mouth)			Tar River (mouth)			Calumet River (mouth)		
			Mouth		u/s P.C. MacKay [(a)]										
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
Field measured															
pH		7.8	8.2	9.1	7.9	8.2	8.7	8.2	9.3	8.5	8.6	8.7	8.2	8.3	8.7
specific conductance	µS/cm	353	950	255	832	201	242	245	187	311	361	298	455	626	460
temperature	°C	14.4	2	15.9	1.5	12.7	15.8	19.7	15.7	12.3	17.3	13.4	4.9	16	12.9
dissolved oxygen	mg/L	9.5	2.4	8.6	3.2	10.6	9.8	-	8.8	9.5	-	-	10.5	-	-
Conventional Parameters															
colour	T.C.U.	70	70	140	70	140	60	35	50	60	80	50	100	100	120
conductance	µS/cm	374	1150	252	938	202	241	232	186	315	345	302	465	601	463
dissolved organic carbon	mg/L	24	26	22	25	25	11	15	11	13	16	14	25	31	30
hardness	mg/L	117	398	105	360	82	98	100	90	133	154	141	153	216	154
pH		8.2	8.1	8.1	8.1	7.8	7.9	8.3	8.4	7.9	8	8.1	7.9	7.9	8.1
total alkalinity	mg/L	176	474	103	414	85	92	93	78	125	154	139	180	245	216
total dissolved solids	mg/L	270	720	210	660	190	160	200	140	180	270	170	280	440	300
total organic carbon	mg/L	25	26	26	27	30	14	16	13	14	17	17	29	34	35
total suspended solids	mg/L	61	5	< 3	3	10	8	4	5	8	9	15	4	< 3	4
Major Ions															
bicarbonate	mg/L	214	578	126	505	104	113	113	94	152	188	170	220	299	263
calcium	mg/L	28	100	27	93	21	27	27	24	36	42	38	40	56	39
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	7	63	4	11	2	1	1	< 1	2	3	2	18	21	14
magnesium	mg/L	11	36	9	31	7	8	8	7	11	12	11	13	18	13
potassium	mg/L	3	4	2	4	2	2	1	1	2	2	2	3	4	3

Table X.6 Water Quality Samples Collected from the Tributaries North of Fort McMurray (West of the Athabasca River), 2002 (continued)

Parameter	Units	Poplar Creek (mouth)	MacKay River				Ells River (mouth)			Tar River (mouth)			Calumet River (mouth)		
			Mouth		u/s P.C. MacKay [(a)]										
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
sodium	mg/L	44	128	20	94	15	14	11	8	17	18	15	46	59	47
sulphate	mg/L	15	105	21	118	18	29	24	15	38	28	20	35	49	14
sulphide	mg/L	< 0.003	0.032	0.032	0.011	0.021	0.005	0.006	0.006	0	0.008	0.005	0.01	0.013	0.02
Nutrients and Chloropyll *a*															
nitrate + nitrite	mg/L	0.1	0.6	< 0.1	0.9	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.2	< 0.1	< 0.1
nitrogen - ammonia	mg/L	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	1	1.4	0.3	2.7	1.3	0.5	1.5	< 0.2	0.7	2	0.5	1.2	2.1	1.3
phosphorus, total	mg/L	0.06	0.04	0.038	0.07	0.074	0.035	0.012	0.014	0.064	0.055	0.085	0.086	0.075	0.089
phosphorus, dissolved	mg/L	0.009	0.009	0.012	0.024	0.039	0.014	0.007	0.007	0.023	0.027	0.05	0.047	0.039	0.076
chlorophyll *a*	ug/L	5	< 1	3	2	5	4	< 1	< 1	2	< 1	< 1	5	2	< 1
Biological Oxygen Demand															
biochemical oxygen demand	mg/L	2	2	< 2	< 2	< 2	< 2	< 2	< 2	2	< 2	3	3	< 2	2
General Organics															
naphthenic acids	mg/L	< 1	1	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	2	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0	0	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Metals (Total)															
aluminum (Al)	mg/L	1.44	0.12	0.27	0.19	0.47	0.47	0.13	0.16	0.5	0.54	0.92	0.07	0.04	0.05
antimony (Sb)	mg/L	0.00004	< 0.005	0.00003	< 0.005	0.00003	< 0.005	0.0007	8E-05	< 0.01	0.0005	0.00005	< 0.005	0.0005	0.00004
arsenic (As)	mg/L	0.0011	< 0.001	0.0008	< 0.001	0.001	< 0.001	0.0015	0.0009	0	0.0015	0.0016	< 0.001	0.001	0.001
barium (Ba)	mg/L	0.047	0.091	0.025	0.072	0.022	0.043	0.035	0.029	0.044	0.049	0.045	0.049	0.061	0.035
beryllium (Be)	mg/L	< 0.00004	< 0.001	< 4E-05	< 0.001	0.00009	< 0.001	< 0.001	0	0	< 0.001	< 4E-05	< 0.001	< 0.001	< 4E-05
boron (B)	mg/L	0.165	0.36	0.084	0.36	0.058	0.08	0.1	0.041	0.08	0.09	0.057	0.1	0.13	0.083

Table X.6 Water Quality Samples Collected from the Tributaries North of Fort McMurray (West of the Athabasca River), 2002 (continued)

Parameter	Units	Poplar Creek (mouth)	MacKay River				Ells River (mouth)			Tar River (mouth)			Calumet River (mouth)		
			Mouth		u/s P.C. MacKay [(a)]										
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
cadmium (Cd)	mg/L	< 0.00002	< 0.0002	< 2E-05	< 0.0002	< 0.00002	< 0.0002	< 0.0002	0	0	< 0.0002	0.00005	< 0.0002	< 0.0002	< 2E-05
chromium (Cr)	mg/L	0.00192	< 0.0008	0.00055	< 0.0008	0.00073	0.0008	0.0023	0.0002	0	< 0.0008	0.00091	< 0.0008	< 0.0008	0.00021
cobalt (Co)	mg/L	0.00087	< 0.0002	0.0002	< 0.0002	0.00026	0.0003	0.0004	0.0002	0.0003	0.0004	0.00035	0.0004	0.0004	0.00021
copper (Cu)	mg/L	0.0013	0.002	0.0007	0.002	0.0005	0.001	0.001	0.0006	0.005	0.002	0.0015	0.001	< 0.001	0.0004
iron (Fe)	mg/L	2.06	0.81	0.83	1.29	1.28	0.85	0.29	0.51	1.35	1.31	1.69	1.36	1.22	0.6
lead (Pb)	mg/L	0.0009	0.0002	0.0002	0.0002	0.0002	0.0003	0.0002	0.0001	0.0006	0.0004	0.0005	0.0001	< 0.0001	0.0001
lithium (Li)	mg/L	0.02	0.083	0.018	0.069	0.013	0.016	0.016	0.011	0.018	0.02	0.015	0.022	0.03	0.021
manganese (Mn)	mg/L	0.099	0.036	0.071	0.017	0.104	0.045	0.026	0.027	0.03	0.076	0.053	0.185	0.093	0.047
mercury (Hg)	mg/L	0.000004	< 6E-07	< 6E-07	< 6E-07	< 6E-07	3.3E-06	< 6E-07	0	4E-06	< 6E-07	7E-07	0.000003	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.0002	0.0006	0.0004	0.001	0.0004	0.001	0.0013	0.0006	0.0013	0.0016	0.0012	0.0005	0.0004	0.0002
nickel (Ni)	mg/L	0.0013	0.0101	0.0006	0.001	0.0006	0.0017	0.0022	0.0005	0.0033	0.003	0.0016	0.0016	0.002	0.0004
selenium (Se)	mg/L	< 0.0005	< 0.0008	< 0.0005	< 0.0008	0.0005	< 0.0008	0.0005	0	0	0.0004	0.0008	< 0.0008	0.0004	0.0012
silver (Ag)	mg/L	0.000006	0.000007	< 5E-06	< 5E-06	0.000011	0.000006	< 5E-06	0	1E-05	0.000007	< 5E-06	< 5E-06	< 5E-06	< 5E-06
strontium (Sr)	mg/L	0.167728	0.562	0.144749	0.524	0.113587	0.127	0.138	0.095	0.146	0.174	0.14999	0.183	0.278	0.19538
thallium (Tl)	mg/L	0.000034	< 0.0001	< 3E-06	< 0.0001	< 0.000003	< 0.0001	< 0.0001	0	0	< 0.0001	8E-06	< 0.0001	< 0.0001	2.7E-05
titanium (Ti)	mg/L	0.022	< 0.005	0.01	0.008	0.01	0.014	< 0.005	0.003	0.017	0.014	0.023	< 0.005	< 0.005	0.001
uranium (U)	mg/L	0.0002	0.0007	0.0001	0.0009	0.0001	0.0003	0.0002	0.0001	0.0008	0.0007	0.0004	0.0004	0.0003	0.0002
vanadium (V)	mg/L	0.0038	0.001	0.001	0.0008	0.0013	0.0013	0.0014	0.0006	0.0016	0.0021	0.0022	0.0011	0.0005	0.0006
zinc (Zn)	mg/L	0.006	0.017	0.002	0.012	0.002	0.006	0.004	0.001	0.414	0.059	0.006	< 0.004	< 0.004	0.002
Metals (Dissolved)															
aluminum (Al)	mg/L	0.007	< 0.01	0.029	< 0.01	0.025	< 0.01	0.07	0.009	0.01	0.26	0.01	< 0.01	0.01	0.006
antimony (Sb)	mg/L	0.00003	< 0.0008	0.00004	< 0.0008	0.00003	< 0.0008	< 0.0004	5E-05	0	< 0.0004	0.00007	< 0.0008	< 0.0004	0.00005
arsenic (As)	mg/L	0.0008	0.0009	0.0008	0.0006	0.0009	< 0.0004	0.001	0.0008	0	0.0015	0.001	< 0.0004	0.0011	0.0011
barium (Ba)	mg/L	0.03	0.097	0.021	0.07	0.016	0.04	0.035	0.028	0.039	0.048	0.036	0.045	0.063	0.032

Table X.6 Water Quality Samples Collected from the Tributaries North of Fort McMurray (West of the Athabasca River), 2002 (continued)

Parameter	Units	Poplar Creek (mouth)	MacKay River				Ells River (mouth)			Tar River (mouth)			Calumet River (mouth)		
			Mouth		u/s P.C. MacKay [a]										
			Winter	Fall	Winter	Fall	Spring	Summer	Fall	Spring	Summer	Fall	Spring	Summer	Fall
beryllium (Be)	mg/L	0.00022	< 0.0005	0.00009	< 0.0005	< 0.00004	< 0.0005	< 0.0005	0	0	< 0.0005	< 4E-05	< 0.0005	< 0.0005	< 4E-05
boron (B)	mg/L	0.169	0.39	0.084	0.363	0.057	0.066	0.092	0.041	0.064	0.103	0.057	0.082	0.148	0.083
cadmium (Cd)	mg/L	< 0.00001	< 0.0001	< 1E-05	< 0.0001	0.00001	< 0.0001	< 0.0001	0	0	< 0.0001	0.00003	< 0.0001	< 0.0001	0.00001
chromium (Cr)	mg/L	0.00023	< 0.0004	0.00028	0.0005	0.00026	< 0.0004	0.003	0.0002	0	0.0033	0.0001	< 0.0004	0.0028	0.0003
cobalt (Co)	mg/L	0.00014	0.0001	0.00013	0.0001	0.00012	0.0001	0.0002	0.0001	0.0002	0.0003	0.00012	0.0003	0.0003	0.00019
copper (Cu)	mg/L	< 0.0001	0.0038	0.0007	0.0011	0.0003	0.0009	0.0007	0.0005	0.0011	0.0013	0.0012	0.0008	< 0.0006	0.0004
iron (Fe)	mg/L	0.18	0.78	0.42	0.15	0.53	0.63	0.21	0.22	1.08	0.98	0.63	1.12	1.16	0.49
lead (Pb)	mg/L	0.0001	0.0002	0.0001	< 0.0001	0.0001	< 0.0001	< 0.0001	4E-05	0	0.0002	0.0001	< 0.0001	< 0.0001	0.0001
lithium (Li)	mg/L	0.02	0.085	0.018	0.069	0.013	0.015	0.017	0.011	0.018	0.021	0.015	0.022	0.032	0.022
manganese (Mn)	mg/L	0.008	0.035	0.01	0.01	0.019	0.027	0.018	0.007	0.023	0.059	0.007	0.108	0.056	0.027
mercury (Hg)	mg/L	< 0.00004	< 0.0001	< 4E-05	< 0.0001	< 0.00004	< 0.0001	< 0.0001	0	0	< 0.0001	< 4E-05	< 0.0001	< 0.0001	0.00005
molybdenum (Mo)	mg/L	0.0003	0.0006	0.0004	0.001	0.0004	0.001	0.001	0.0007	0.0012	0.0016	0.0011	0.0004	0.0004	0.0002
nickel (Ni)	mg/L	< 0.0001	0.0005	0.0004	0.0005	0.0004	0.0014	0.0015	0.0005	0.0021	0.0025	0.001	0.0013	0.0018	0.0004
selenium (Se)	mg/L	0.0006	< 0.0004	< 0.0005	< 0.0004	< 0.0005	< 0.0004	< 0.0004	0	0	0.0005	0.0007	< 0.0004	0.0005	0.0012
silver (Ag)	mg/L	0.000013	< 0.0002	< 5E-06	< 0.0002	0.000012	< 0.0002	< 0.0002	0	0	< 0.0002	< 5E-06	< 0.0002	< 0.0002	< 5E-06
strontium (Sr)	mg/L	0.169027	0.58	0.145893	0.5	0.109635	0.122	0.14	0.094	0.139	0.178	0.14752	0.176	0.282	0.20304
thallium (Tl)	mg/L	0.000027	< 5E-05	< 3E-06	< 5E-05	< 0.000003	< 5E-05	< 5E-05	0	0	< 0.00005	0.00001	< 0.00005	< 0.00005	6.1E-05
titanium (Ti)	mg/L	0.0006	0.0018	0.0015	0.0018	0.0014	0.0016	0.003	0.0008	0.002	0.0147	0.0015	0.0018	0.0019	0.0007
uranium (U)	mg/L	0.0001	0.0006	0.0001	0.0009	0.0001	0.0003	0.0002	0.0001	0.0007	0.0006	0.0004	0.0004	0.0003	0.0002
vanadium (V)	mg/L	0.0005	0.0009	0.0004	0.0003	0.0004	0.0001	0.0013	0.0003	0.0002	0.0021	0.0004	0.0004	0.0014	0.0005
zinc (Zn)	mg/L	0.002	0.018	0.001	0.003	0.002	0.006	< 0.002	0.002	0.341	< 0.002	0.003	< 0.002	< 0.002	0.001

[a] u/s = Upstream.

Table X.7 Toxicity Data Collected by RAMP in Fall, 2002

Parameter	Units	Ells River (mouth)	Tar River (mouth)	Calumet River (mouth)	Muskeg River u/s of Wapasu Creek[(a)]
Toxicity					
Algal Growth Inhibition Test (72 h) - IC25	%	> 100	> 100	> 100	> 100
Algal Growth Inhibition Test (72 h) - IC50	%	> 100	> 100	> 100	> 100
Algal Growth Inhibition Test (72 h) - LOEC	%	> 100	> 100	> 100	> 100
Algal Growth Inhibition Test (72 h) - NOEC	%	100	100	100	100
Ceriodaphnia 7 d Mortality Test - LC25	%	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Mortality Test - LC50	%	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Mortality Test - LOEC	%	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Mortality Test - NOEC	%	100	100	100	100
Ceriodaphnia 7 d Reproduction Test - IC25	%	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Reproduction Test - IC50	%	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Reproduction Test - LOEC	%	> 100	> 100	> 100	> 100
Ceriodaphnia 7 d Reproduction Test - NOEC	%	100	100	100	100
Fathead Minnow 7d Growth - IC25	%	> 100	> 100	> 100	> 100
Fathead Minnow 7d Growth - IC50	%	> 100	> 100	> 100	> 100
Fathead Minnow 7d Growth - LOEC	%	> 100	> 100	> 100	> 100
Fathead Minnow 7d Growth - NOEC	%	100	100	100	100
Fathead Minnow 7d Mortality Test - LC25	%	86	> 100	> 100	> 100
Fathead Minnow 7d Mortality Test - LC50	%	> 100	> 100	> 100	> 100
Fathead Minnow 7d Mortality Test - LOEC	%	100	> 100	> 100	> 100
Fathead Minnow 7d Mortality Test - NOEC	%	50	100	100	100

(a) u/s = Upstream.

Table X.8 Water Quality Samples Collected from the Muskeg River Watershed by RAMP in 2002

Parameter	Units	Muskeg River		Muskeg River Tributaries					
		Mouth (MUR-1) (Fall)	u/s of Wapasu Creek (MUR-6) (Fall)[(a)]	Jackpine Creek (Fall)	Muskeg Creek (Fall)	Stanley Creek			
						Winter	Spring	Summer	Fall
Field Measured									
pH		8.7	7.2	7.8	8	7	7.9	7.1	6.9
specific conductance	µS/cm	266	238	187	189	515	226	191	281
temperature	°C	14.8	11.6	11.2	13.4	0.5	3.4	10.9	10.1
dissolved oxygen	mg/L	10.2	9	10.1	8.6	1.5	8	4.2	2.4
Conventional Parameters									
colour	T.C.U.	120	100	80	140	150	40	30	40
conductance	µS/cm	263	233	183	188	597	230	269	294
dissolved organic carbon	mg/L	24	19	22	26	17	14	10	8
hardness	mg/L	138	126	85	91	316	126	144	159
pH		8	7.8	7.8	7.5	8	8.1	7.4	7.6
total alkalinity	mg/L	131	121	94	93	319	119	141	157
total dissolved solids	mg/L	240	180	220	200	320	120	200	200
total organic carbon	mg/L	27	23	27	30	19	16	10	9
total suspended solids	mg/L	< 3	4	8	4	7	< 3	< 3	6
Major Ions									
bicarbonate	mg/L	160	147	115	114	389	145	172	192
calcium	mg/L	38	31	23	23	91	36	42	45
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	1	< 1	2	< 1	3	< 1	< 1	1
magnesium	mg/L	10	12	7	8	22	9	10	11
potassium	mg/L	1	1	0.9	1.6	1.6	1.4	0.5	1.1
sodium	mg/L	11	3	11	14	10	2	2	2
sulphate	mg/L	5	5	4	4	9	3	4	2
sulphide	mg/L	0.022	0.006	0.009	0.028	< 0.003	< 0.003	0.005	0.005

Table X.8 Water Quality Samples Collected from the Muskeg River Watershed by RAMP in 2002 (continued)

Parameter	Units	Muskeg River		Muskeg River Tributaries					
		Mouth (MUR-1) (Fall)	u/s of Wapasu Creek (MUR-6) (Fall)[(a)]	Jackpine Creek (Fall)	Muskeg Creek (Fall)	Stanley Creek			
						Winter	Spring	Summer	Fall
Nutrients and Chloropyll *a*									
nitrate + nitrite	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	0.97	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	0.3	0.7	0.9	0.3	1.2	0.4	2.1	2
phosphorus, total	mg/L	0.022	0.02	0.019	0.017	0.078	0.014	0.041	0.08
phosphorus, dissolved	mg/L	0.013	0.014	0.012	0.013	0.003	0.009	0.014	0.032
chlorophyll *a*	ug/L	< 1	1	< 1	< 1	< 1	< 1	3	2
Biological Oxygen Demand									
biochemical oxygen demand	mg/L	< 2	< 2	< 2	< 2	4	< 2	< 2	< 2
General Organics									
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	1.9	< 0.5	< 0.5	< 0.5
Metals (Total)									
aluminum (Al)	mg/L	0.07	0.08	0.1	0.09	< 0.02	0.03	< 0.02	0.01
antimony (Sb)	mg/L	0.00004	0.00002	0.00003	0.00003	< 0.005	< 0.005	0.0005	0.00001
arsenic (As)	mg/L	0.0004	0.0004	0.0005	0.0005	< 0.001	< 0.001	< 0.0004	0.0005
barium (Ba)	mg/L	0.027	0.019	0.017	0.014	0.102	0.037	0.059	0.066
beryllium (Be)	mg/L	0.00007	0.00014	< 0.00004	< 0.00004	< 0.001	< 0.001	< 0.001	0.00008
boron (B)	mg/L	0.042	0.016	0.046	0.047	0.05	< 0.02	0.02	0.023
cadmium (Cd)	mg/L	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.0002	< 0.0002	< 0.0002	< 2E-05
chromium (Cr)	mg/L	0.00021	0.00033	0.00029	0.0003	0.0024	< 0.0008	< 0.0008	< 8E-05
cobalt (Co)	mg/L	0.00014	0.00005	0.00015	0.00015	< 0.0002	< 0.0002	< 0.0002	0.00003
copper (Cu)	mg/L	0.0001	< 0.0001	< 0.0001	0.0001	< 0.001	0.002	< 0.001	< 1E-04

Table X.8 Water Quality Samples Collected from the Muskeg River Watershed by RAMP in 2002 (continued)

Parameter	Units	Muskeg River		Muskeg River Tributaries					
		Mouth (MUR-1) (Fall)	u/s of Wapasu Creek (MUR-6) (Fall)[(a)]	Jackpine Creek (Fall)	Muskeg Creek (Fall)	Stanley Creek			
						Winter	Spring	Summer	Fall
iron (Fe)	mg/L	0.98	0.21	0.45	0.45	4.74	0.12	0.13	1.54
lead (Pb)	mg/L	0.00004	0.00002	0.00006	0.00005	< 0.0001	< 0.0001	< 0.0001	0.00002
lithium (Li)	mg/L	0.008	0.003	0.008	0.007	0.014	< 0.006	0.007	0.006
manganese (Mn)	mg/L	0.042	0.014	0.025	0.022	0.483	0.012	0.019	0.093
mercury (Hg)	mg/L	< 6E-07	< 0.0000006	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.0001	0.0001	0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	0.00004
nickel (Ni)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0002	< 0.0002	< 0.0002	< 1E-04
selenium (Se)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0008	< 0.0008	< 0.0004	< 5E-04
silver (Ag)	mg/L	< 5E-06	0.000019	0.000013	< 0.000005	0.000008	0.000021	< 5E-06	1.1E-05
sodium (Na)	mg/L	9.155	2.493	11.988	11.646	9	2	2	1.361
strontium (Sr)	mg/L	0.092603	0.058321	0.092398	0.06899	0.2	0.0684	0.0846	0.09048
thallium (Tl)	mg/L	< 3E-06	< 0.000003	< 0.000003	< 0.000003	< 0.0001	< 0.0001	< 0.0001	< 3E-06
titanium (Ti)	mg/L	0.001	0.001	0.005	0.001	< 0.005	< 0.005	< 0.005	0.001
uranium (U)	mg/L	0.00004	0.00002	0.00003	0.00002	< 0.0001	< 0.0001	< 0.0001	0.00001
vanadium (V)	mg/L	0.0004	0.0003	0.0005	0.0004	0.0013	< 0.0002	< 0.0002	0.0001
zinc (Zn)	mg/L	0.001	0.001	0.002	0.001	0.008	< 0.004	< 0.004	0.002
Metals (Dissolved)									
aluminum (Al)	mg/L	0.007	0.006	0.009	0.011	< 0.01	< 0.01	< 0.01	0.002
antimony (Sb)	mg/L	0.00004	0.00004	0.00003	0.00001	< 0.0008	< 0.0008	< 0.0004	< 4E-06
arsenic (As)	mg/L	0.0004	0.0003	0.0004	0.0005	< 0.0004	< 0.0004	< 0.0004	0.0003
barium (Ba)	mg/L	0.026	0.019	0.015	0.014	1.21	0.041	0.06	0.061
beryllium (Be)	mg/L	0.00009	0.00016	0.00013	< 0.00004	< 0.0005	< 0.0005	< 0.0005	0.00005
boron (B)	mg/L	0.043	0.012	0.046	0.047	0.402	0.013	0.03	0.021
cadmium (Cd)	mg/L	< 0.00001	< 0.00001	< 0.00001	< 0.00001	0.0002	< 0.0001	< 0.0001	< 1E-05
chromium (Cr)	mg/L	0.00025	0.00024	0.00015	0.00028	0.0012	< 0.0004	< 0.0004	< 8E-05
cobalt (Co)	mg/L	0.00011	0.00005	0.00007	0.00006	0.0002	< 0.0001	< 0.0001	< 2E-05

Table X.8 Water Quality Samples Collected from the Muskeg River Watershed by RAMP in 2002 (continued)

Parameter	Units	Muskeg River		Muskeg River Tributaries					
		Mouth (MUR-1) (Fall)	u/s of Wapasu Creek (MUR-6) (Fall)[a]	Jackpine Creek (Fall)	Muskeg Creek (Fall)	Stanley Creek			
						Winter	Spring	Summer	Fall
copper (Cu)	mg/L	0.0001	< 0.0001	< 0.0001	0.0002	< 0.0006	0.0021	< 0.0006	0.0006
iron (Fe)	mg/L	0.72	0.13	0.24	0.27	0.02	0.1	0.07	0.54
lead (Pb)	mg/L	0.00003	0.00001	0.00001	0.00001	< 0.0001	0.0011	< 0.0001	0.00002
lithium (Li)	mg/L	0.008	0.003	0.008	0.007	0.014	0.006	0.007	0.007
manganese (Mn)	mg/L	0.013	0.006	0.003	0.003	0.158	0.011	0.004	0.068
mercury (Hg)	mg/L	< 0.00004	< 0.00004	< 0.00004	< 0.00004	< 0.0001	< 0.0001	< 0.0001	< 4E-05
molybdenum (Mo)	mg/L	0.0001	0.0001	0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	0.00004
nickel (Ni)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.0005	< 1E-04
selenium (Se)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0004	< 0.0004	< 0.0004	0.0006
silver (Ag)	mg/L	< 5E-06	< 0.000005	0.000006	< 0.000005	< 0.0002	< 0.0002	< 0.0002	1.3E-05
strontium (Sr)	mg/L	0.095549	0.059755	0.091462	0.069001	0.203	0.0635	0.0859	0.08847
thallium (Tl)	mg/L	< 3E-06	< 0.000003	< 0.000003	< 0.000003	< 5E-05	< 5E-05	< 5E-05	< 3E-06
titanium (Ti)	mg/L	0.0006	0.0005	0.0014	0.0005	0.0018	0.0009	0.001	0.0008
uranium (U)	mg/L	0.00003	0.00002	0.00003	0.00001	< 0.0001	< 0.0001	< 0.0001	0.00001
vanadium (V)	mg/L	0.0003	0.0001	0.0002	0.0002	0.0002	< 0.0001	< 0.0001	0.0001
zinc (Zn)	mg/L	0.001	0.001	0.001	0.001	0.572	0.01	< 0.002	0.002

[a] u/s = Upstream.

Table X.9 Water Quality Samples Collected from the Wetlands by RAMP in 2002

Parameter	Units	Kearl Lake (Fall)	McClelland Lake (Fall)	Shipyard Lake	
				Summer	Fall
Field measured					
pH		6.86	7.76	7.64	6.88
specific conductance	µS/cm	170	217	366	363
temperature	°C	16.5	15.1	21	15.6
dissolved oxygen	mg/L	6.4	8.9	7.6	3.6
Conventional Parameters					
colour	T.C.U.	80	15	60	70
conductance	µS/cm	181	230	394	379
dissolved organic carbon	mg/L	21	12	18	20
hardness	mg/L	83	116	142	163
pH		7.7	8.3	8	7.7
total alkalinity	mg/L	88	123	180	171
total dissolved solids	mg/L	180	80	310	220
total organic carbon	mg/L	22	12	20	23
total suspended solids	mg/L	< 3	5	22	4
Major Ions					
bicarbonate	mg/L	107	149	219	209
calcium	mg/L	21	19	49	47
carbonate	mg/L	< 5	< 5	< 5	< 5
chloride	mg/L	< 1	< 1	15	12
magnesium	mg/L	8	17	5	11
potassium	mg/L	1.4	3.2	12.7	1.8
sodium	mg/L	11	5	24	17
sulphate	mg/L	5	1	13	8
sulphide	mg/L	0.01	< 0.003	0.008	0.011
Nutrients and Chloropyll *a*					
nitrate + nitrite	mg/L	< 0.1	< 0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	0.53	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	0.4	0.9	1.7	0.8
phosphorus, total	mg/L	0.009	0.01	0.013	0.021
phosphorus, dissolved	mg/L	0.002	0.002	0.006	0.013
chlorophyll *a*	ug/L	1	1	2	< 1
Biological Oxygen Demand					
biochemical oxygen demand	mg/L	< 2	< 2	< 2	2
General Organics					
naphthenic acids	mg/L	< 1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5

Table X.9 Water Quality Samples Collected from the Wetlands by RAMP in 2002 (continued)

Parameter	Units	Kearl Lake (Fall)	McClelland Lake (Fall)	Shipyard Lake	
				Summer	Fall
Metals (Total)					
aluminum (Al)	mg/L	0.01	0.03	0.05	0.01
antimony (Sb)	mg/L	0.00002	0.00001	0.0009	0.00002
arsenic (As)	mg/L	0.0004	0.0003	0.0008	0.0008
barium (Ba)	mg/L	0.017	0.027	0.039	0.04
beryllium (Be)	mg/L	< 0.00004	0.00011	< 0.001	< 0.00004
boron (B)	mg/L	0.047	0.065	0.05	0.04
cadmium (Cd)	mg/L	< 0.00002	< 0.00002	0.0004	0.00004
chromium (Cr)	mg/L	0.00018	0.00016	0.0009	< 0.00008
cobalt (Co)	mg/L	0.00003	< 0.00002	0.0005	0.00012
copper (Cu)	mg/L	0.0001	< 0.0001	0.001	0.0002
iron (Fe)	mg/L	0.14	0.08	0.62	1.26
lead (Pb)	mg/L	0.00002	0.00002	0.0007	0.00007
lithium (Li)	mg/L	0.006	0.019	0.011	0.011
manganese (Mn)	mg/L	0.02	0.021	0.021	0.097
mercury (Hg)	mg/L	< 0.0000006	< 0.0000006	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.00006	< 0.00002	0.0004	0.00007
nickel (Ni)	mg/L	0.0006	< 0.0001	0.001	< 0.0001
selenium (Se)	mg/L	< 0.0005	< 0.0005	< 0.0004	< 0.0005
silver (Ag)	mg/L	< 0.000005	< 0.000005	< 0.000005	< 0.000005
strontium (Sr)	mg/L	0.059789	0.131779	0.154	0.157288
thallium (Tl)	mg/L	< 0.000003	< 0.000003	< 0.0001	0.00003
titanium (Ti)	mg/L	0.0009	0.0009	< 0.005	0.0007
uranium (U)	mg/L	0.00001	0.0005	0.0005	0.000019
vanadium (V)	mg/L	0.0002	0.0002	0.0008	0.0003
zinc (Zn)	mg/L	0.001	0.001	0.006	0.003
Metals (Dissolved)					
aluminum (Al)	mg/L	0.005	0.002	< 0.01	0.003
antimony (Sb)	mg/L	0.000026	0.000013	0.0005	0.000011
arsenic (As)	mg/L	0.0003	0.0002	0.0005	0.0007
barium (Ba)	mg/L	0.017	0.026	0.036	0.038
beryllium (Be)	mg/L	0.00024	< 0.00004	< 0.0005	< 0.00004
boron (B)	mg/L	0.045	0.064	0.04	0.044
cadmium (Cd)	mg/L	0.00001	< 0.00001	< 0.0001	0.00003
chromium (Cr)	mg/L	0.0002	0.00016	< 0.0004	0.00024
cobalt (Co)	mg/L	0.00004	< 0.00002	< 0.0001	0.00009
copper (Cu)	mg/L	0.0001	< 0.0001	< 0.0006	0.0001
iron (Fe)	mg/L	0.12	0.01	0.36	0.86
lead (Pb)	mg/L	0.00004	0.00002	0.0003	0.00009

Table X.9 Water Quality Samples Collected from the Wetlands by RAMP in 2002 (continued)

Parameter	Units	Kearl Lake (Fall)	McClelland Lake (Fall)	Shipyard Lake	
				Summer	Fall
lithium (Li)	mg/L	0.006	0.019	0.012	0.011
manganese (Mn)	mg/L	0.018	0.001	0.008	0.043
mercury (Hg)	mg/L	< 0.00004	< 0.00004	< 0.0001	< 0.00004
molybdenum (Mo)	mg/L	0.00006	< 0.00002	< 0.0001	0.00005
nickel (Ni)	mg/L	< 0.0001	< 0.0001	0.0015	< 0.0001
selenium (Se)	mg/L	< 0.0005	< 0.0005	< 0.0004	< 0.0005
silver (Ag)	mg/L	< 0.000005	< 0.000005	< 0.0002	0.000008
strontium (Sr)	mg/L	0.059658	0.129042	0.15	0.151249
thallium (Tl)	mg/L	< 0.000003	< 0.000003	< 0.00005	0.000056
titanium (Ti)	mg/L	< 0.0002	0.0006	< 0.0003	0.0006
uranium (U)	mg/L	0.000005	0.000005	< 0.0001	0.000019
vanadium (V)	mg/L	0.0002	0.0002	< 0.0001	0.0003
zinc (Zn)	mg/L	0.003	0.001	< 0.002	0.002

Table X.10 Water Quality Samples Collected from OPTI Lakes in 2002

Parameter	Units	Birch Lake		Canoe Lake		Caribou Lake		Frog Lake		Gregoire Lake		Kiskatinaw Lake		Long Lake		Poison Lake		Pushup Lake		Rat Lake		Sucker Lake		Unnamed Lake I		Unnamed Lake 2		Unnamed Lake 3	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Field measured																													
pH		8.43	6.71	7.96	6.75	8.46	7.9	8.58	7.69	8.2	7.9	8.53	7.64	7.86	7.23	8.92	8.48	8.98	7.34	8.74	7.7	8.64	8.27	6.72	5.99	7.57	6.58	8.37	8.1
specific conductance	µS/cm	96	90	94	90	190	176	202	182	138	144	202	186	62	70	190	199	86	89	229	207	238	223	22	22	34	33	226	198
temperature	°C	16.92	14.72	16.82	14.54	15.82	14.97	18.19	14.98	14.91	14.12	14.83	15.26	18.35	14.04	20.33	15.05	17	14.69	16.38	14.94	16.94	15.56	17.93	13.78	17.87	14.08	18.2	13.66
dissolved oxygen	mg/L	8.39	8.25	10.27	8.37	10.12	9.16	10.27	7.52	4.69	9.47	10.08	7.02	10.28	7.74	11.34	9.7	8.38	6.84	8.68	8.31	11.68	6.68	6.84	8	10.17	7.65	6.77	8.99
Conventional Parameters																													
colour	T.C.U.	100	100	60	50	40	60	100	80	20	10	50	50	70	120	50	25	20	20	40	40	50	30	50	70	140	140	60	50
conductance	µS/cm	94	93	97.8	93.6	191	182	201	181	148	146	201	185	71.1	72.7	195	200	86	89.7	209	206	239	219	29	26.1	42.3	41.5	223	201
dissolved organic carbon	mg/L	23	25	20	21	19	22	32	30	11	11	19	40	17	30	23	34	28	30	18	18	19	20	19	21	24	33	35	34
hardness	mg/L	45	44	41	39	96	85	101	92	71	66	98	85	27	31	89	93	41	40	102	101	104	101	10	11	18	18	103	86
pH		7.5	7.1	7.5	7.2	8	7.2	7.9	7.6	7.8	7.6	7.8	7.7	7.2	7	7.7	7.9	7.5	7.3	7.8	7.7	7.8	7.8	6.2	6	6.8	5.6	7.8	7.8
total alkalinity	mg/L	46	42	41	41	91	74	97	88	66	64	100	92	28	27	95	100	41	41	104	103	115	113	8	8	14	7	112	100
total dissolved solids	mg/L	90	140	110	110	160	180	190	200	80	120	160	160	80	120	150	200	100	140	140	180	180	190	60	90	90	100	190	200
total organic carbon	mg/L	29	31	23	25	22	26	39	36	12	12	21	41	18	34	27	39	31	32	22	20	22	22	23	25	31	34	45	38
total suspended solids	mg/L	8	5	5	< 3	< 3	< 3	5	3	< 3	< 3	< 3	< 3	5	6	15	11	4	3	5	4	5	8	< 3	22	7	< 3	18	7
Major Ions																													
bicarbonate	mg/L	56	51	50	50	111	90	118	108	81	78	122	112	34	33	116	123	50	50	126	125	140	138	9	9	17	9	137	122
calcium	mg/L	12.6	12.1	10.9	10.2	25.2	22	27.3	24.3	20	18.3	26.3	22.7	7.5	8.2	25.4	24.5	11.9	11.7	27.6	26.6	28.1	26.7	2.5	3	4.9	5	29	23.4
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	< 1	< 1	6	< 1	5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	1	2	< 1
magnesium	mg/L	3.3	3.4	3.4	3.2	8.1	7.4	7.9	7.5	5.2	4.9	7.9	6.9	2.1	2.6	6.2	7.8	2.7	2.7	8.1	8.3	8.3	8.3	0.8	0.8	1.5	1.4	7.4	6.7
potassium	mg/L	2.5	2	1.5	1	1.1	0.7	1.7	0.9	1.2	1.1	0.9	0.7	0.9	0.5	1.6	1.4	3	2.8	1.6	1.2	1.8	1.7	2.1	1.2	2.1	1	2.9	2.2
sodium	mg/L	5	4	6	5	6	6	10	9	4	4	7	7	4	4	8	11	2	2	7	8	11	11	< 1	< 1	2	2	12	12
sulphate	mg/L	2.6	2	2.1	2.3	4.3	16.1	4	3.4	8.2	6.7	4.1	3.8	4.5	6.1	2.8	2.8	1.1	1.2	6.1	4.4	5	4	1.5	2	2	6.2	6	5.1
sulphide	mg/L	0.004	0.007	0.004	0.007	0.005	0.005	0.004	0.007	0.003	< 0.003	0.005	0.004	0.009	0.006	0.004	0.008	< 0.003	0.003	0.005	0.005	0.004	0.004	0.009	0.008	0.009	0.006	0.005	0.005
Nutrients and Chloropyll *a*																													
nitrate + nitrite	mg/L	< 0.1	< 0.1	0.2	< 0.1	0.2	< 0.1	0.2	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.2	< 0.1	0.2	< 0.1	0.1	< 0.1	< 0.1	< 0.1	0.2	< 0.1	0.2	< 0.1	0.2	< 0.1	0.1	< 0.1
nitrogen - ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.29	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	1.2	1.1	1.2	1.1	0.8	1.1	1.9	1.2	0.8	0.8	0.9	1	1	1.7	2.4	3.1	1.2	1.3	1.2	1.2	1.2	1.4	0.9	1.2	1.2	1.1	2.9	2.1
phosphorus, total	mg/L	0.048	0.07	0.037	0.035	0.021	0.038	0.076	0.042	0.017	0.025	0.047	0.025	0.049	0.048	0.066	0.045	0.027	0.024	0.035	0.045	0.04	0.084	0.029	0.032	0.047	0.026	0.088	0.063
phosphorus, dissolved	mg/L	0.014	0.02	0.006	0.013	0.013	0.009	0.012	0.015	0.007	0.006	0.018	0.008	0.011	0.02	0.01	0.014	0.009	0.008	0.009	0.009	0.013	0.013	0.019	0.023	0.018	0.014	0.029	0.016
Metals (Total)																													
aluminum (Al)	mg/L	0.06	0.029	0.03	0.014	0.07	0.116	0.13	0.035	0.06	0.021	0.06	0.002	0.06	0.058	0.06	0.031	0.03	0.027	0.05	0.016	0.05	0.01	0.11	0.058	0.16	0.021	0.06	0.018
antimony (Sb)	mg/L	< 0.005	4.4E-05	< 0.005	0.00003	< 0.005	0.00004	< 0.005	0.00004	< 0.005	8.7E-05	< 0.005	< 4E-06	< 0.005	3.3E-05	< 0.005	4.1E-05	< 0.005	4.1E-05	< 0.005	4E-05	< 0.005	2.7E-05	< 0.005	5E-05	< 0.005	6.4E-05	< 0.005	0.000033
arsenic (As)	mg/L	< 0.001	0.00036	< 0.001	0.00023	< 0.001	0.00028	< 0.001	0.00044	< 0.001	0.0011	< 0.001	< 2E-05	< 0.001	0.00037	< 0.001	0.00045	< 0.001	0.00041	< 0.001	0.0004	< 0.001	0.0005	< 0.001	0.0004	< 0.001	0.00054	< 0.001	0.00043
barium (Ba)	mg/L	0.0211	0.0184	0.0152	0.0187	0.0119	0.0093	0.0259	0.0258	0.0285	0.022	0.0136	< 1E-04	0.0087	0.0069	0.0451	0.0497	0.0085	0.0161	0.0178	0.0224	0.0263	0.0232	0.003	0.0094	0.0091	0.0119	0.0268	0.0173
beryllium (Be)	mg/L	< 0.001	< 4E-05	< 0.001	< 4E-05	< 0.001	< 4E-05	< 0.001	< 4E-05	< 0.001	< 4E-05	< 0.001	< 4E-05	< 0.001	< 4E-05	< 0.001	0.00006	< 0.001	< 4E-05	< 0.001	9E-05	< 0.001	< 4E-05	< 0.001	0.0002	< 0.001	< 4E-05	< 0.001	0.00022
boron (B)	mg/L	0.03	0.02195	< 0.02	0.01762	0.03	0.0113	0.06	0.06964	0.02	0.01857	0.05	< 8E-05	0.02	0.01069	0.05	0.08127	< 0.02	0.02655	0.04	0.0341	0.06	0.06852	0.04	0.0249	< 0.02	0.03938	0.05	0.02214
cadmium (Cd)	mg/L	0.0004	0.00003	< 0.0002	0.00004	< 2E-04	0.00008	< 0.0002	0.00002	< 2E-04	0.00025	< 0.0002	< 2E-05	0.0005	0.00002	< 2E-04	0.00003	< 2E-04	0.0001	< 2E-04	2E-05	< 0.0002	< 2E-05	< 0.0002	0.0002	< 0.0002	0.00033	< 0.0002	0.00024

Table X.10 Water Quality Samples Collected from OPTI Lakes in 2002 (continued)

Parameter	Units	Birch Lake		Canoe Lake		Caribou Lake		Frog Lake		Gregoire Lake		Kiskatinaw Lake		Long Lake		Poison Lake		Pushup Lake		Rat Lake		Sucker Lake		Unnamed Lake I		Unnamed Lake 2		Unnamed Lake 3	
		Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
chromium (Cr)	mg/L	< 0.0008	0.00018	0.0053	0.00012	0.0058	0.00021	0.0072	< 8E-05	< 8E-04	0.00009	0.0075	< 8E-05	0.0085	0.00017	0.0061	0.00014	< 8E-04	< 8E-05	< 8E-04	< 8E-05	0.0155	< 8E-05	< 0.0008	0.0002	0.0068	< 8E-05	< 0.0008	0.00008
cobalt (Co)	mg/L	0.0005	0.00011	< 0.0002	0.00004	< 2E-04	0.00007	< 0.0002	0.00007	< 2E-04	0.00008	< 0.0002	< 2E-05	0.0006	0.00004	< 2E-04	0.00004	< 2E-04	0.00004	< 2E-04	4E-05	< 0.0002	0.00003	< 0.0002	7E-05	< 0.0002	0.00011	< 0.0002	0.00003
copper (Cu)	mg/L	0.001	< 8E-05	< 0.001	< 8E-05	< 0.001	0.00016	< 0.001	< 8E-05	0.001	0.00158	< 0.001	< 8E-05	0.001	< 8E-05	< 0.001	0.00029	< 0.001	0.00014	0.001	< 8E-05	< 0.001	< 8E-05	0.001	0.0005	< 0.001	0.00033	< 0.001	0.0002
iron (Fe)	mg/L	0.858	0.504	0.397	0.165	0.13	0.24	0.422	0.268	0.132	0.119	0.13	< 0.003	0.118	0.11	0.068	0.056	0.089	0.371	0.126	0.314	0.46	0.462	0.105	0.162	0.273	0.142	0.115	0.361
lead (Pb)	mg/L	0.0011	0.00027	0.0004	0.00046	0.0002	0.00187	0.0012	0.00023	0.0009	0.00141	0.0004	< 1E-05	0.0013	0.0003	0.0012	0.00094	0.0003	0.00099	0.0008	0.0002	0.0019	0.0003	0.0004	0.0026	0.0152	0.0008	0.0006	0.00099
lithium (Li)	mg/L	< 0.006	0.0047	< 0.006	0.0023	< 0.006	0.0013	0.009	0.0076	< 0.006	0.0059	< 0.006	0.0002	< 0.006	0.0012	0.008	0.0097	< 0.006	0.0039	0.007	0.0067	0.01	0.0092	< 0.006	0.0042	< 0.006	0.0043	0.008	0.0038
manganese (Mn)	mg/L	0.053	0.06928	0.041	0.07322	0.011	0.01252	0.131	0.05466	0.088	0.04984	0.019	0.00004	0.016	0.01597	0.017	0.01843	0.038	0.03342	0.086	0.1506	0.188	0.30125	0.016	0.0159	0.02	0.01577	0.088	0.0328
mercury (Hg)	mg/L	1E-06	< 6E-07	1.5E-06	< 6E-07	6E-07	< 6E-07	7E-07	< 6E-07	2.6E-06	< 6E-07	1.2E-06	< 6E-07	2.4E-06	< 6E-07	1E-06	< 6E-07	< 6E-07	< 6E-07	1.3E-06	< 6E-07	4.3E-06	< 6E-07	2E-06	< 6E-07	1.5E-06	< 6E-07	1.2E-06	< 6E-07
molybdenum (Mo)	mg/L	0.0004	< 2E-05	< 0.0001	< 2E-05	< 1E-04	0.00002	< 0.0001	0.00006	0.0006	0.00074	< 0.0001	< 2E-05	0.0005	0.00002	0.0002	0.00021	< 1E-04	0.00003	0.0001	7E-05	0.0002	0.00006	< 0.0001	0.0001	< 0.0001	0.00009	0.0001	0.00004
nickel (Ni)	mg/L	0.001	0.00016	< 0.0002	< 6E-05	0.0006	0.00032	0.0003	< 6E-05	0.0007	0.0004	0.0004	< 6E-05	0.0007	0.00018	< 2E-04	< 6E-05	< 2E-04	< 6E-05	0.0007	< 6E-05	0.0005	< 6E-05	0.0003	0.0023	0.0004	0.00048	0.0002	< 6E-05
selenium (Se)	mg/L	< 0.0008	< 5E-04	< 0.0008	< 5E-04	< 8E-04	< 0.0005	0.0008	< 5E-04	< 8E-04	< 5E-04	0.001	< 5E-04	0.0012	< 0.0005	0.0009	< 5E-04	< 8E-04	< 5E-04	< 8E-04	< 5E-04	0.002	< 5E-04	< 0.0008	< 5E-04	0.001	< 5E-04	< 0.0008	< 0.0005
silver (Ag)	mg/L	1.2E-05	< 5E-06	< 5E-06	5E-06	< 5E-06	0.00002	0.000006	7E-06	5E-06	< 5E-06	1.2E-05	1.1E-05	1.1E-05	< 5E-06	-5E-06	1.4E-05	< 5E-06	< 5E-06	0.00001	< 5E-06	0.000008	< 5E-06	0.00001	2E-05	< 5E-06	0.00001	8E-06	< 5E-06
strontium (Sr)	mg/L	0.0501	0.04862	0.0354	0.03664	0.0659	0.01697	0.102	0.09931	0.0813	0.07936	0.0709	0.00001	0.0335	0.00977	0.11	0.12602	0.0332	0.03847	0.0917	0.1004	0.106	0.11959	0.0046	0.0421	0.0214	0.06312	0.101	0.03682
thallium (Tl)	mg/L	0.0002	< 3E-06	< 0.0001	< 3E-06	< 1E-04	< 3E-06	< 0.0001	< 3E-06	< 1E-04	2.2E-05	< 0.0001	< 3E-06	< 1E-04	< 3E-06	< 1E-04	< 3E-06	< 1E-04	4E-06	< 1E-04	< 3E-06	< 0.0001	< 3E-06	< 0.0001	< 3E-06	< 0.0001	< 3E-06	< 0.0001	< 3E-06
titanium (Ti)	mg/L	< 0.005	0.0006	< 0.005	0.0007	< 0.005	0.0008	< 0.005	0.0017	< 0.005	0.0012	< 0.005	0.0002	< 0.005	0.0006	< 0.005	0.0011	< 0.005	0.0011	< 0.005	0.0012	< 0.005	0.0013	< 0.005	0.0012	< 0.005	0.0017	< 0.005	0.0008
uranium (U)	mg/L	0.0005	1.8E-05	< 0.0001	1.1E-05	< 1E-04	1.7E-05	< 0.0001	2.5E-05	0.0001	7.8E-05	< 0.0001	8E-06	0.0005	8E-06	< 1E-04	1.3E-05	< 1E-04	1.6E-05	< 1E-04	5E-05	< 0.0001	6.9E-05	< 0.0001	4E-05	< 0.0001	6.6E-05	< 0.0001	0.000019
vanadium (V)	mg/L	0.0004	0.0002	0.0019	0.00017	0.0021	0.00064	0.0025	0.00015	< 2E-04	0.00035	0.0025	4.3E-05	0.0032	0.00033	0.0022	0.00023	< 2E-04	0.00023	< 2E-04	0.0002	0.0051	0.00013	0.0002	0.0004	0.0026	0.00029	< 0.0002	0.000186
zinc (Zn)	mg/L	0.008	0.0143	< 0.004	0.0207	< 0.004	0.0047	0.004	0.0117	0.007	0.0161	0.006	0.0006	0.005	0.0078	0.012	0.0082	0.005	0.0798	0.007	0.0102	0.007	0.0107	0.005	0.0072	0.01	0.1635	0.004	0.06

Figure X.1 Water Temperature in the Clearwater River in 2002

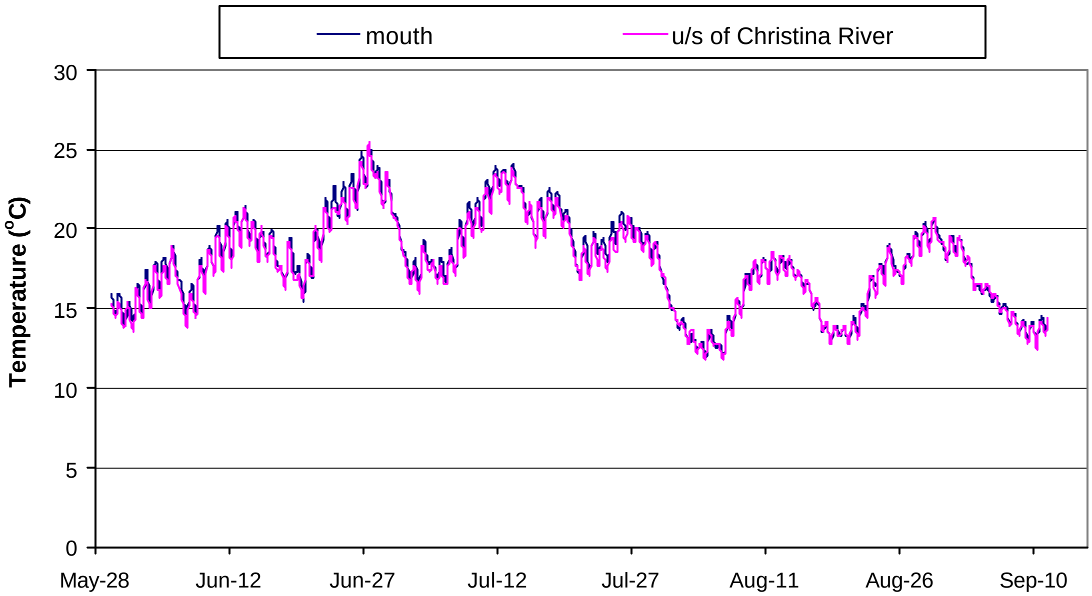


Figure X.2 Water Temperature in the Muskeg River 2002

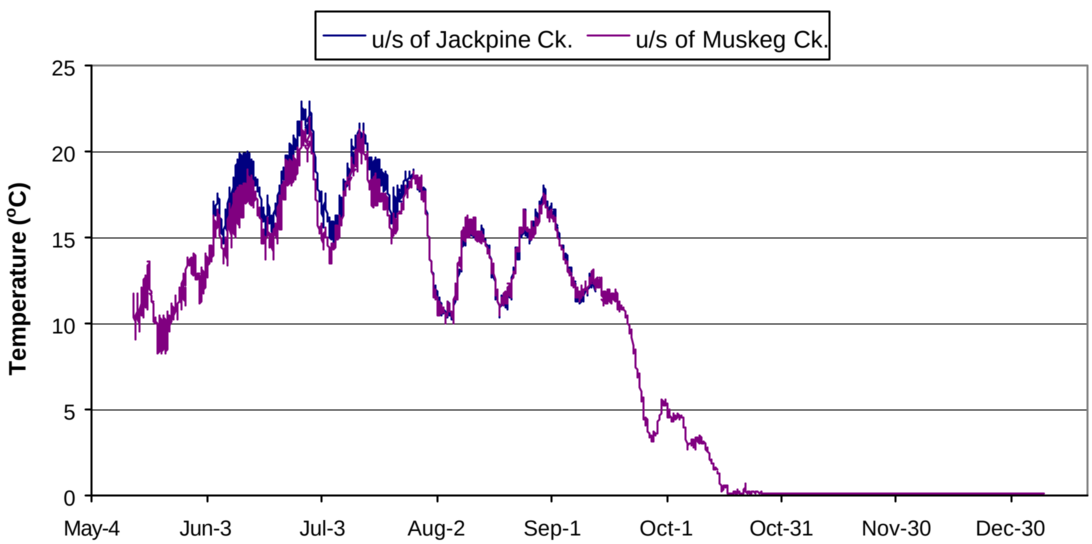


Figure X.3 Water Temperature in McLean Creek in 2002

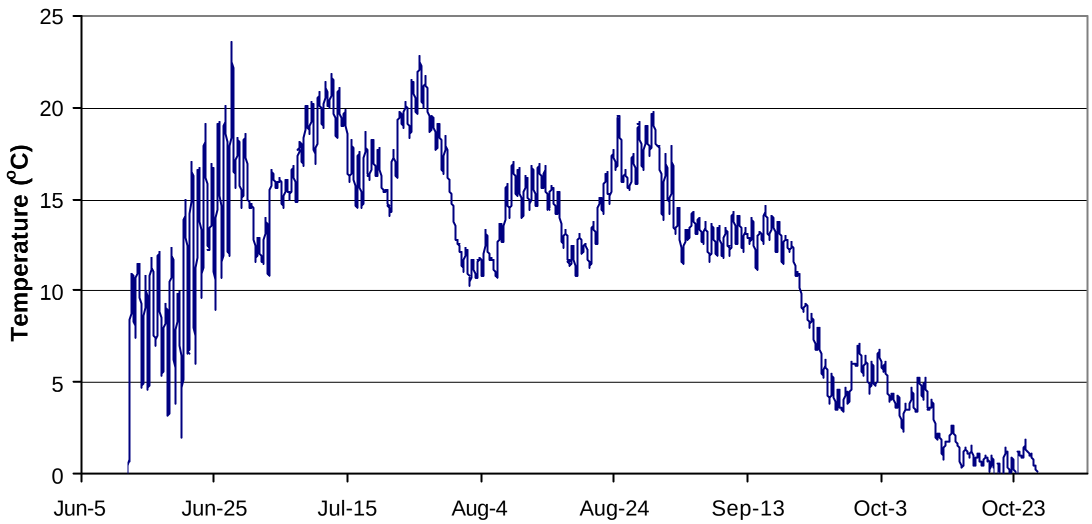


Figure X.4 Water Temperature in Fort Creek in 2002

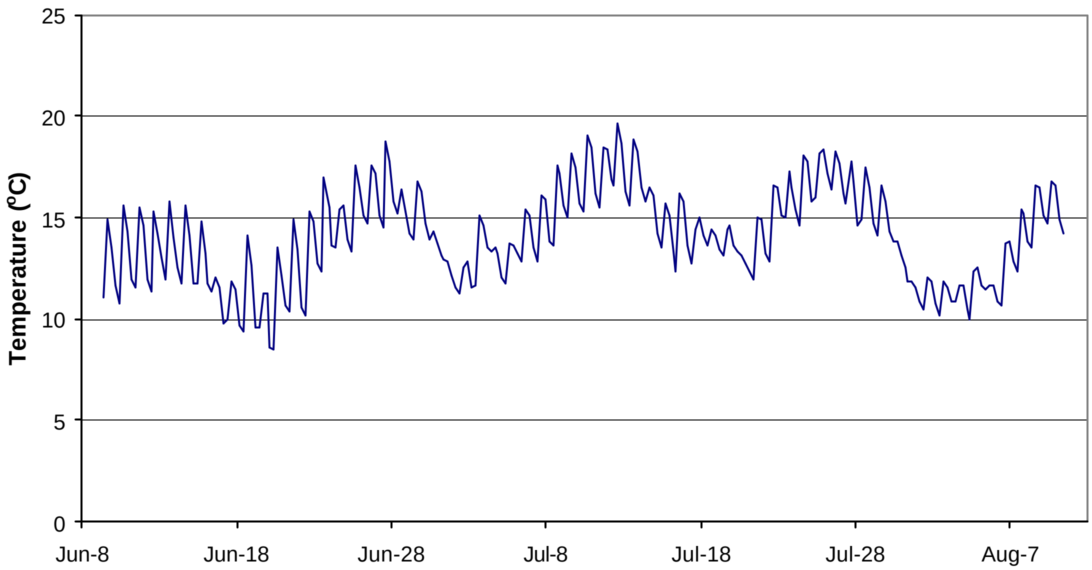


Figure X.5 Water Temperature in the Alsands Drain in 2002

APPENDIX XI

SEDIMENT QUALITY DATA COLLECTED BY RAMP IN 2002

This appendix contains a series of tables presenting sediment quality from locations sampled in the 2002 RAMP survey, including:

- the Athabasca River (Table XI.1);
- tributaries leading to the Athabasca River (Table XI.2); and
- the Muskeg River watershed and wetlands (Table XI.3).

Table XI.1 Sediment Quality Samples Collected from the Athabasca River by RAMP in 2002

Parameter	Units	u/s of Ft. McMurray (x-channel)	u/s of Donald Creek		u/s of Steepbank River		u/s of Muskeg River		u/s of Fort Creek		d/s of all Development		u/s of Firebag River		u/s of Embarras River (x-channel)	Big Point Channel	Fletcher Channel	Goose Island Channel
			East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank				
Particle Size																		
partice size - % sand	%	52	79	97	40	45	35	20	32	44	81	62	63	42	57	23	51	32
partice size - % silt	%	32	14	1	39	37	44	55	44	33	13	15	25	36	30	51	35	46
partice size - % clay	%	16	6	3	21	18	21	25	24	24	6	23	12	22	14	26	14	22
moisture content	%	30	22	23	39	29	38	43	33	35	23	30	28	32	26	33	30	29
Carbon Content																		
total inorganic carbon	% by wt	0.6	0.6	0.7	1.1	1	1.1	1.6	0.9	1.1	0.03	0.57	0.69	0.61	0.66	1.03	0.75	0.87
total organic carbon	% by wt	1.6	2.8	< 0.1	2.1	1.1	1	1.8	1.6	1	4.7	0.9	1	1.4	1.1	< 0.1	1	1.7
total carbon	% by wt	1.6	2.8	< 0.1	2.1	1.1	1	1.8	1.6	1	4.7	0.9	1	1.4	1.1	< 0.1	1	1.7
Toxicity																		
chironomus tentans - 10d survival	% control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	129	86	100
chironomus tentans - 10d growth	% control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	77	100	100
hyalella azteca - 10d survival	% control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	113	113	88
hyalella azteca - 10d growth	% control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	100	100
lumbriculus variegatus - 10d survival	% control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	100	100
lumbriculus variegatus - 10d growth	% control	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93	87	86
Organics																		
total recoverable hydrocarbons	mg/kg	700	22100	< 100	900	400	600	400	1700	800	14900	500	600	600	900	600	600	700
total volatile hydrocarbons (c5-c10)	mg/kg	19	9.4	13	5.1	5.4	11	23	2.5	< 0.5	42	2.2	9.3	11	< 0.5	< 0.5	< 0.5	< 0.5
total extractable hydrocarbons (c11-c30)	mg/kg	310	13000	7	320	200	180	99	820	230	18000	130	140	84	260	54	270	350
Metals (Total)																		
aluminum (Al)	µg/g	6910	2760	1400	9020	7360	9740	17700	10800	19000	4720	6820	2990	5660	5190	7660	5810	6470
arsenic (As)	µg/g	5.7	2.3	2.6	7.5	7	6.6	8.3	5	5.8	2.9	5.1	3.5	6.6	4.3	4.9	4.1	4.5
barium (Ba)	µg/g	198	50	41	200	190	191	262	155	222	55	117	84	150	131	166	150	150
beryllium (Be)	µg/g	0.5	0.2	< 0.2	0.7	0.5	0.6	0.9	0.5	0.7	0.4	0.4	0.3	0.5	0.4	0.6	0.4	0.5
boron (B)	µg/g	5	5	< 2	9	7	13	21	12	16	8	8	3	4	4	5	4	4
cadmium (Cd)	µg/g	0.2	< 0.1	< 0.1	0.3	0.2	0.2	0.3	0.2	0.3	< 0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2
calcium (Ca)	µg/g	25200	6100	3700	29300	27700	22500	50900	26000	54000	2900	16800	11400	18400	15700	24100	18900	20700
chromium (Cr)	µg/g	14.3	7	3.4	35.1	37	28.8	41.9	19.7	28.2	10.4	12.7	6.5	11.4	11.5	16.3	13.3	12.5
cobalt (Co)	µg/g	7.8	3.9	2.4	10.1	9.1	8.8	11.9	7.1	9.6	5	6.8	4.5	9.4	6.7	8.1	6.7	7.6
copper (Cu)	µg/g	13	5	< 2	21	14	16	24	11	18	4	10	7	16	10	14	10	20

Table XI.1 Sediment Quality Samples Collected from the Athabasca River by RAMP in 2002 (continued)

Parameter	Units	u/s of Ft. McMurray (x-channel)	u/s of Donald Creek		u/s of Steepbank River		u/s of Muskeg River		u/s of Fort Creek		d/s of all Development		u/s of Firebag River		u/s of Embarras River (x-channel)	Big Point Channel	Fletcher Channel	Goose Island Channel
			East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank				
iron (Fe)	µg/g	16700	9100	5700	25600	22800	19700	26800	18800	24800	8200	15900	8900	16600	13900	17800	13800	15800
lead (Pb)	µg/g	8.1	3.6	1.8	10.9	9	8.2	12.6	7.6	11.5	4.5	6.3	5.5	9.1	6.2	9	6.9	8.1
magnesium (Mg)	µg/g	8010	2560	1110	7820	7210	8640	14000	8530	12800	1450	5600	3810	6360	5890	8360	6840	7470
manganese (Mn)	µg/g	362	192	107	456	352	424	576	462	759	260	363	209	459	252	445	297	380
mercury (Hg)	µg/g	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
molybdenum (Mo)	µg/g	0.4	0.5	0.1	0.4	0.6	0.4	0.6	0.4	0.6	0.3	0.3	0.3	0.6	0.3	0.3	0.3	0.3
nickel (Ni)	µg/g	19.6	10.2	4.8	27.2	24.6	23.1	32.6	16.9	23.8	10.2	14.4	10.6	20	16.3	21.2	17.2	18.8
potassium (K)	µg/g	1130	580	270	1780	1480	1690	3230	1740	3370	840	1080	1070	870	810	1130	890	950
selenium (Se)	µg/g	0.3	< 0.2	< 0.2	0.5	0.6	0.4	0.4	0.4	0.5	< 0.2	0.3	< 0.2	0.4	0.3	0.4	0.3	0.4
silver (Ag)	µg/g	0.1	< 0.1	< 0.1	0.2	0.1	0.2	0.2	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.1
sodium (Na)	µg/g	90	110	< 20	110	100	130	220	150	250	60	110	360	160	60	100	80	80
strontium (Sr)	µg/g	66	18	14	86	79	68	133	65	116	20	47	31	56	44	65	50	57
thallium (Tl)	µg/g	0.1	< 0.1	< 0.1	0.2	0.2	0.2	0.3	0.2	0.3	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1
titanium (Ti)	µg/g	40.9	49.1	31.3	37.9	36.8	32	40.4	33.9	35.7	53.4	27.1	41.1	43.5	48.6	35.9	49.6	37.2
uranium (U)	µg/g	0.9	0.4	0.2	1.3	1.1	1	1.2	0.9	1.2	0.6	0.8	0.5	0.8	0.7	0.9	0.8	0.8
vanadium (V)	µg/g	18.3	17.3	5.1	29.7	29.2	26.6	42.1	24.9	36.7	16.3	17.8	9.4	16.5	14.4	17.9	15.4	16
zinc (Zn)	µg/g	67	24	12	58	55	55	73	55	70	24	44	67	74	53	68	52	63
Target PAHs and Alkylated PAHs																		
naphthalene	µg/g	0.01	0.079	0.001	0.021	*0.019	0.011	0.022	0.012	0.017	0.016	0.005	0.006	0.008	0.009	0.012	0.007	0.009
C1 subst'd naphthalenes	µg/g	0.026	0.047	0.002	0.062	0.05	0.03	0.069	0.036	0.057	0.025	0.015	0.014	0.02	0.023	0.031	0.019	0.026
C2 subst'd naphthalenes	µg/g	0.04	0.046	0.002	0.089	0.067	0.047	0.092	0.061	0.083	0.184	0.024	0.02	0.029	0.04	0.043	0.03	0.04
C3 subst'd naphthalenes	µg/g	0.04	0.162	0.001	0.082	0.061	0.044	0.067	0.096	0.075	0.794	0.025	0.018	0.028	0.038	0.043	0.025	0.035
C4 subst'd naphthalenes	µg/g	0.057	0.56	0.001	0.068	0.044	0.042	0.034	0.203	0.055	3.54	0.021	0.013	0.02	0.027	0.025	0.017	0.025
Acenaphthene	µg/g	0.0009	0.0195	< 0.0002	0.0016	0.0014	0.0015	0.0013	0.0024	0.0015	0.0113	0.0007	0.0005	0.0007	0.001	0.0009	0.0007	0.0012
C1 subst'd acenaphthene	µg/g	*0.0003	< 0.0048	< 0.0002	< 0.0003	< 0.0002	< 0.0003	< 0.0003	*0.0005	< 0.0003	0.0035	< 0.0002	< 0.0003	< 0.0002	< 0.0003	< 0.0002	< 0.0003	< 0.0004
Acenaphthylene	µg/g	< 0.0002	*0.0173	< 0.0001	< 0.0003	< 0.0002	*0.0006	< 0.0003	*0.0004	*0.0005	*0.0062	< 0.0002	< 0.0003	< 0.0003	< 0.0004	< 0.0003	< 0.0003	< 0.0004
Anthracene	µg/g	< 0.001	< 0.051	< 0.0002	*0.0038	0.0086	*0.0019	*0.0012	< 0.0031	*0.001	< 0.0385	*0.0004	< 0.0004	< 0.0004	< 0.001	< 0.0006	< 0.0007	< 0.0011
Dibenzo(a,h)anthracene	µg/g	< 0.002	< 0.043	< 0.0004	*0.008	0.0162	*0.0039	*0.0019	< 0.004	*0.0021	0.0417	< 0.0014	< 0.0012	< 0.0016	< 0.0045	< 0.002	< 0.0035	< 0.0048
Benzo(a)anthracene	µg/g	0.003	< 0.048	< 0.0002	0.019	0.0448	0.0076	0.0043	0.0076	0.0038	< 0.0406	0.002	*0.0009	0.0011	*0.0024	0.0022	0.0015	0.0029
C1 subst'd benzo(a)anthracene/ chrysene	µg/g	0.306	8.47	0.008	0.618	1.1	0.41	0.228	0.481	0.259	10.2	0.108	0.09	0.11	0.175	0.187	0.122	0.218

Table XI.1 Sediment Quality Samples Collected from the Athabasca River by RAMP in 2002 (continued)

Parameter	Units	u/s of Ft. McMurray (x-channel)	u/s of Donald Creek		u/s of Steepbank River		u/s of Muskeg River		u/s of Fort Creek		d/s of all Development		u/s of Firebag River		u/s of Embarras River (x-channel)	Big Point Channel	Fletcher Channel	Goose Island Channel
			East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank				
C2 subst'd benzo(a)anthracene/ chrysene	µg/g	0.134	3.72	0.003	0.165	0.273	0.114	0.051	0.15	0.077	3.92	0.031	0.028	0.035	0.058	0.057	0.043	0.07
Benzo(a)pyrene	µg/g	0.006	0.077	< 0.001	*0.025	0.052	0.011	*0.006	0.008	0.006	0.095	0.004	< 0.003	< 0.003	< 0.007	0.004	< 0.005	< 0.007
C1 subst'd benzo(b&k) fluoranthene/ benzo(a)pyrene	µg/g	0.066	0.871	0.002	0.129	0.218	0.074	0.046	0.08	0.054	1.35	0.035	0.019	0.032	0.067	0.033	0.02	0.04
C2 subst'd benzo(b& k) fluoranthene/ benzo(a)pyrene	µg/g	0.02	0.26	0.001	0.078	0.101	0.045	0.018	0.041	0.025	0.532	0.011	0.007	0.014	0.016	0.013	0.006	0.015
Benzofluoranthenes	µg/g	0.018	0.248	*0.001	0.03	0.038	0.021	0.015	0.021	0.019	0.296	0.012	0.007	0.009	0.016	0.013	0.014	0.018
Benzo(g,h,i)perylene	µg/g	0.01	0.11	*0.0004	*0.0222	0.0325	0.0134	0.0084	0.0167	0.0106	0.148	0.0072	*0.0048	0.0055	*0.0102	0.0069	*0.0072	*0.0106
Biphenyl	µg/g	0.006	0.027	*0.0003	0.0127	0.0059	0.0071	0.0177	0.0091	0.0155	0.0058	0.0037	0.0034	0.0046	0.0056	0.0072	0.0047	0.0064
C1 subst'd biphenyl	µg/g	< 0.0001	< 0.0049	< 0.0001	< 0.0002	< 0.0003	< 0.0002	< 0.0001	< 0.0004	< 0.0003	0.0049	< 0.0002	< 0.0003	< 0.0002	< 0.0003	< 0.0003	< 0.0003	< 0.0003
C2 subst'd biphenyl	µg/g	0.008	0.0497	0.0003	0.0195	0.0105	0.0099	0.0223	0.0134	0.018	*0.0537	0.0064	0.0054	0.0074	0.0086	0.0111	0.0061	0.0095
Chrysene	µg/g	0.024	0.665	0.001	0.055	0.092	0.032	0.022	0.041	0.025	1.01	0.011	0.008	0.01	0.02	0.016	0.013	0.021
Dibenzothiophene	µg/g	*0.0012	< 0.0312	< 0.0001	*0.0067	0.0168	0.0046	0.0038	*0.0044	*0.0045	*0.048	*0.0014	*0.0013	*0.0014	*0.0024	*0.0021	*0.0023	*0.0024
C1 subst'd dibenzothiophene	µg/g	0.018	0.514	< 0.0003	0.0409	0.0889	0.0303	0.0152	0.0726	0.0233	1.19	0.0094	0.0061	0.0087	0.0183	0.0131	0.011	0.015
C2 subst'd dibenzothiophene	µg/g	0.062	3.34	< 0.0004	0.108	0.179	0.113	0.0298	0.383	0.078	5.4	0.0283	0.0217	0.0274	0.0556	0.0431	0.0317	0.0544
C3 subst'd dibenzothiophene	µg/g	0.094	6.74	< 0.0004	0.113	0.14	0.166	0.0274	0.467	0.0849	12.7	0.0323	0.0271	0.0335	0.068	0.0605	0.0387	0.0548
C4 subst'd dibenzothiophene	µg/g	0.255	9.66	0.004	0.209	0.15	0.256	0.051	0.451	0.138	18.3	0.049	0.051	0.064	0.106	0.102	0.063	0.096
Fluoranthene	µg/g	0.006	0.071	0.0005	0.0092	0.0102	0.0068	0.0062	0.0075	0.0075	0.0655	0.0033	0.0019	0.0026	0.0044	0.0038	0.0034	0.0045
C1 subst'd fluoranthene/pyrene	µg/g	0.057	1.25	0.002	0.081	0.085	0.054	0.034	0.077	0.046	1.76	0.017	0.014	0.018	0.025	0.035	0.021	0.023
C2 subst'd fluoranthene/pyrene	µg/g	0.138	2.65	0.004	0.168	0.152	0.102	0.058	0.182	0.079	2	0.032	0.026	0.034	0.048	0.058	0.032	0.04
C3 subst'd fluoranthene/pyrene	µg/g	0.162	2.37	0.005	0.141	0.106	0.101	0.044	0.159	0.055	3.73	0.028	0.022	0.033	0.054	0.051	0.03	0.039
Fluorene	µg/g	*0.0021	*0.0191	< 0.0001	*0.0043	*0.0025	0.0028	*0.0056	*0.0047	0.0057	0.0115	*0.0012	*0.0013	*0.0015	*0.0034	*0.0024	*0.0029	*0.0032
C1 subst'd fluorene	µg/g	0.0088	< 0.0136	< 0.0002	0.0147	0.0128	0.0075	0.0164	0.0187	0.0138	0.111	0.0043	0.0034	0.0043	0.0052	0.0076	0.0041	0.0069
C2 subst'd fluorene	µg/g	0.0468	*0.247	< 0.0003	0.0608	0.0494	0.0349	0.0438	0.1	0.0438	0.912	0.0172	0.0122	0.0171	0.0197	0.0299	0.0154	0.0253
C3 subst'd fluorene	µg/g	0.0764	0.895	< 0.0005	0.0929	0.0816	0.0551	0.0477	0.166	0.0489	2	0.0255	0.0176	0.0216	0.0252	0.036	0.0177	0.035
Indeno(1,2,3,cd)pyrene	µg/g	0.0058	0.0766	< 0.0003	*0.0108	0.0115	0.0076	*0.0041	*0.0079	0.0059	0.0665	0.0044	*0.0023	0.0038	*0.004	0.0043	*0.0043	*0.006
Phenanthrene	µg/g	0.02	< 0.04	0.001	0.036	0.037	0.022	0.036	0.031	0.035	0.189	0.01	0.009	0.012	0.018	0.016	0.014	0.017
C1 subst'd phenanthrene/ anthracene	µg/g	0.05	0.13	0.002	0.113	0.136	0.063	0.081	0.114	0.087	0.565	0.027	0.022	0.03	0.042	0.042	0.03	0.043
C2 subst'd phenanthren/ anthracene	µg/g	0.09	0.97	0.001	0.134	0.147	0.101	0.082	0.24	0.1	2.54	0.036	0.028	0.037	0.051	0.056	0.034	0.057

Table XI.1 Sediment Quality Samples Collected from the Athabasca River by RAMP in 2002 (continued)

Parameter	Units	u/s of Ft. McMurray (x-channel)	u/s of Donald Creek		u/s of Steepbank River		u/s of Muskeg River		u/s of Fort Creek		d/s of all Development		u/s of Firebag River		u/s of Embarras River (x-channel)	Big Point Channel	Fletcher Channel	Goose Island Channel
			East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank	East Bank	West Bank				
C3 subst'd phenanthrene/ anthracene	µg/g	0.14	2.83	0.002	0.133	0.102	0.108	0.05	0.251	0.074	7.91	0.03	0.026	0.032	0.045	0.059	0.027	0.037
C4 subst'd phenanthrene/ anthracene	µg/g	0.47	10.2	0.01	0.93	0.2	0.29	0.17	0.45	0.22	17.7	0.1	0.09	0.09	0.14	0.18	0.1	0.11
1-Methyl-7-isopropyl-phenanthrene (Retene)	µg/g	0.06	*0.72	0.003	0.402	0.052	0.066	0.081	*0.076	0.076	*1.21	0.029	0.02	0.031	0.059	0.051	0.021	0.027
Pyrene	µg/g	0.013	0.325	*0.001	0.028	0.042	0.016	0.013	0.02	0.015	0.435	0.007	0.005	0.006	0.011	0.011	0.008	0.008

u/s = Upstream, d/s = Downstream.

* PAH concentrations are reported with the limitation that interference from the sample matrix resulted in a GCMS spectrum without clear, easy to identify peaks (i.e., these numbers may contain a larger degree of error than those produced from clearly defined spectra).

Table XI.2 Sediment Quality Samples Collected from the Athabasca River Tributaries by RAMP in 2002

Parameter	Units	Clearwater R. (u/s of Fort McMurray)	Clearwater R. (u/s of Christina R.)	Christina R. (u/s of Fort McMurray)	Christina R. (u/s of Janvier)	McLean Creek	Poplar Creek	Steepbank River	Steepbank R. (u/s of Proj. Millenium)	North Steepbank River	MacKay River	Ells River	Tar River	Calumet River	Fort Creek	Firebag River	Firebag R. (u/s of Suncor Firebag)
Particle Size																	
partice size - % sand	%	38	73	58	69	79	12	74	88	89	52	85	46	52	56	74	77
partice size - % silt	%	29	16	25	22	5	53	15	6	8	27	8	34	30	29	21	10
partice size - % clay	%	33	11	17	8	17	35	11	7	3	21	7	20	18	15	6	13
moisture content	%	31	35	33	53	21	44	26	22	38	44	28	38	29	41	30	28
Carbon Content																	
total inorganic carbon	% by wt	0.1	0.05	0.34	0.12	0.06	1.04	0.16	0.1	0.06	0.65	0.26	0.36	0.65	0.72	0.39	0.09
total organic carbon	% by wt	1	0.5	2	1.1	4.1	2.2	1.9	0.5	1.7	1.9	0.7	1.1	0.6	4.7	2.2	1
total carbon	% by wt	1	0.5	2	1.1	4.1	2.2	1.9	0.5	1.7	1.9	0.7	1.1	0.6	4.7	2.2	1
Toxicity																	
Chironomus tentans - 10d survival	% control	63	100	-	-	0	113	13	100	114	75	63	88	113	113	100	57
Chironomus tentans - 10d growth	% control	79	79	-	-	-	85	20	100	100	129	150	100	90	75	100	105
Hyalella azteca - 10d survival	% control	88	100	-	-	33	100	44	67	100	67	100	100	100	89	100	89
Hyalella azteca - 10d growth	% control	100	100	-	-	200	100	100	100	100	100	100	100	100	100	100	100
Lumbriculus variegatus - 10d survival	% control	100	100	-	-	80	100	90	100	100	100	90	90	100	90	100	100
Lumbriculus variegatus - 10d growth	% control	89	119	-	-	30	81	26	159	159	82	87	91	85	69	157	181
Organics																	
total recoverable hydrocarbons	mg/kg	1100	300	2800	400	11300	2200	15900	< 100	100	3300	3000	800	500	7200	2500	400
total volatile hydrocarbons (C5-C10)	mg/kg	< 0.5	< 0.5	< 0.5	8.2	15	15	6.2	8.3	13	< 0.5	1.4	2.9	1.8	2.4	12	12
total extractable hydrocarbons (C11-C30)	mg/kg	67	91	2300	270	10000	900	9500	31	74	1619	2421	720	500	2300	1100	120
Metals (Total)																	
aluminum (Al)	ug/g	14100	5960	7900	5020	4750	9860	2000	1100	1280	6600	3840	6760	8960	6420	1800	6390
arsenic (As)	ug/g	6.7	3.4	5.6	5.5	2.9	6.5	2.2	1.1	1.5	5.5	3.6	5.2	4.4	2.8	1.1	1.7
barium (Ba)	ug/g	91	47	85	144	44	173	31	15	30	94	65	124	126	122	30	54
beryllium (Be)	ug/g	0.7	0.3	0.4	0.3	0.3	0.6	< 0.2	< 0.2	< 0.2	0.5	0.3	0.5	0.5	0.3	< 0.2	0.4
boron (B)	ug/g	10	8	12	10	14	13	5	4	3	12	7	13	2	12	5	8
cadmium (Cd)	ug/g	< 0.1	< 0.1	0.1	0.1	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.2	0.2	0.1	< 0.1	< 0.1
calcium (Ca)	ug/g	5900	2700	9000	4600	3000	26100	2400	700	1200	10700	4000	4200	22800	22500	3600	1500
chromium (Cr)	ug/g	20.8	9.6	13.7	12.1	10.2	19.5	4.2	1.7	1.9	12.8	7	12.7	14.6	11.4	3.5	11.5
cobalt (Co)	ug/g	9.9	4.4	7.7	5.5	5	8.4	2.7	1	1	5.6	3.7	5.5	6.3	3.9	1.5	4.3
copper (Cu)	ug/g	21	7	12	12	9	25	3	< 2	< 2	10	5	9	12	8	< 2	11
iron (Fe)	ug/g	20400	9700	15900	18600	8000	18900	5700	3000	3700	17300	9400	14700	16500	12000	5300	8300
lead (Pb)	ug/g	9.3	4.6	6.5	5.5	4.9	9.4	2.8	1.2	1.4	6.1	3.9	6.6	6.9	4.6	2	4.8

Table XI.2 Sediment Quality Samples Collected from the Athabasca River Tributaries by RAMP in 2002 (continued)

Parameter	Units	Clearwater R. (u/s of Fort McMurray)	Clearwater R. (u/s of Christina R.)	Christina R. (u/s of Fort McMurray)	Christina R. (u/s of Janvier)	McLean Creek	Poplar Creek	Steepbank River	Steepbank R. (u/s of Proj. Millenium)	North Steepbank River	MacKay River	Ells River	Tar River	Calumet River	Fort Creek	Firebag River	Firebag R. (u/s of Suncor Firebag)
magnesium (Mg)	ug/g	5640	2280	5150	2310	1960	7600	1020	450	470	6500	2690	2590	6830	3680	1940	1760
manganese (Mn)	ug/g	264	166	615	879	194	467	98.6	90	98.2	307	151	292	398	351	142	148
mercury (Hg)	ug/g	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1
molybdenum (Mo)	ug/g	0.2	0.1	0.2	0.2	0.4	0.5	0.2	< 0.1	< 0.1	0.2	0.2	0.3	0.2	0.3	0.2	0.1
nickel (Ni)	ug/g	15.3	1.6	7.3	9	11.2	20.9	6.3	1.6	1.6	12.3	7.6	12.2	15.1	10.7	3.2	9.1
potassium (K)	ug/g	2210	1120	1410	930	1200	1870	420	220	160	1420	830	1250	1290	1050	350	1070
selenium (Se)	ug/g	0.4	< 0.2	0.4	0.3	0.3	0.6	< 0.2	< 0.2	< 0.2	0.4	0.2	0.4	0.4	0.2	0.2	< 0.2
silver (Ag)	ug/g	0.1	< 0.1	< 0.1	0.2	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	0.4
sodium (Na)	ug/g	140	90	140	60	100	250	60	30	20	110	60	100	160	80	30	50
strontium (Sr)	ug/g	37	19	28	29	19	72	12	8	9	42	21	33	56	51	11	25
thallium (Tl)	ug/g	0.1	0.1	0.1	0.1	0.1	0.2	< 0.1	< 0.1	< 0.1	0.1	0.1	0.2	0.1	0.1	< 0.1	0.1
titanium (Ti)	ug/g	11.5	22.5	28.8	25.8	30	24.6	9.2	17.9	14.8	14.4	19.6	9.9	6.5	22.2	46	34.5
uranium (U)	ug/g	0.8	0.4	0.8	0.6	0.6	1.1	0.4	0.1	0.2	0.7	0.5	0.7	0.7	0.5	0.3	0.5
vanadium (V)	ug/g	30.9	16.2	22.3	12.8	18.1	23.9	9.7	3.3	3	16.9	11.2	16.9	17.4	20.4	7.2	13.8
zinc (Zn)	ug/g	71	35	55	37	26	60	15	8	16	46	26	41	49	28	12	23
Target PAHs and Alkylated PAHs																	
naphthalene	ug/g	0.002	0.002	0.008	0.003	0.015	0.016	0.015	0.0009	0.002	0.012	0.005	0.004	0.011	0.008	0.01	0.009
C1 subst'd naphthalenes	ug/g	0.001	0.001	0.005	0.003	0.013	0.058	0.009	0.001	0.003	0.012	0.005	0.004	0.031	0.017	0.006	0.006
C2 subst'd naphthalenes	ug/g	0.003	0.002	0.014	0.008	0.035	0.092	0.031	0.003	0.006	0.042	0.013	0.012	0.047	0.03	0.011	0.009
C3 subst'd naphthalenes	ug/g	0.003	0.002	0.013	0.005	0.312	0.083	0.651	0.001	0.003	0.161	0.056	0.075	0.042	0.038	0.015	0.005
C4 subst'd naphthalenes	ug/g	0.003	0.002	0.181	0.003	1.73	0.063	3.89	< 0.0003	0.0021	0.556	0.125	0.155	0.0328	0.105	0.0161	< 0.001
Acenaphthene	ug/g	< 0.0003	< 0.0004	< 0.0021	0.0003	0.0196	0.0022	0.0441	< 0.0003	< 0.0005	0.0073	0.0018	0.0022	0.001	0.0017	0.0012	0.0019
C1 subst'd acenaphthene	ug/g	< 0.0002	< 0.0002	< 0.0011	< 0.0001	0.0053	*0.0004	*0.0186	< 0.0001	< 0.0002	< 0.0031	*0.0005	*0.0006	< 0.0002	*0.0003	< 0.0007	< 0.0005
Acenaphthylene	ug/g	< 0.0002	< 0.0002	< 0.0021	*0.0002	*0.0039	< 0.0003	< 0.003	< 0.0001	< 0.0002	*0.0026	< 0.0006	*0.0004	*0.0003	*0.0004	*0.001	*0.0016
Anthracene	ug/g	< 0.0002	< 0.0003	*0.0032	*0.0003	< 0.0179	*0.0014	< 0.0305	< 0.0002	< 0.0002	< 0.0067	< 0.0063	< 0.0011	< 0.0008	< 0.0032	< 0.002	< 0.0006
Dibenzo(a,h)anthracene	ug/g	< 0.0013	< 0.0016	< 0.0117	*0.0007	< 0.0291	*0.0046	< 0.0389	< 0.0005	< 0.0005	< 0.011	< 0.0097	< 0.0024	< 0.0017	< 0.0165	< 0.0075	< 0.0029
Benzo(a)anthracene	ug/g	< 0.0003	< 0.0001	*0.0088	0.0007	*0.0406	0.0046	< 0.08	< 0.0002	< 0.0003	< 0.0126	< 0.0109	0.0021	0.0026	< 0.0062	< 0.0055	< 0.0008
C1 subst'd benzo(a)anthracene/ chrysene	ug/g	0.057	0.032	1.49	0.04	4.04	0.263	5.91	0.015	0.044	1.31	0.76	0.227	0.188	0.612	0.47	0.025
C2 subst'd benzo(a)anthracene/ chrysene	ug/g	0.025	0.018	0.593	0.015	1.65	0.082	1.91	0.004	0.003	0.544	0.272	0.075	0.056	0.19	0.22	0.016
Benzo(a)pyrene	ug/g	< 0.002	< 0.002	0.025	0.001	*0.045	0.008	< 0.072	0.001	< 0.001	< 0.029	< 0.013	0.004	0.005	< 0.016	< 0.012	< 0.003
C1 subst'd benzo(b&k) fluoranthene/ benzo(a)pyrene	ug/g	0.022	0.018	0.262	0.013	0.528	0.064	0.444	0.008	0.01	0.314	0.131	0.038	0.04	0.115	0.098	0.005
C2 subst'd benzo(b& k) fluoranthene/ benzo(a)pyrene	ug/g	0.008	0.009	0.07	0.003	0.262	0.028	0.114	0.001	0.003	0.151	0.053	0.01	0.014	0.059	0.045	0.005
Benzofluoranthenes	ug/g	0.005	0.003	*0.061	0.005	0.117	0.024	0.101	0.003	0.001	*0.042	*0.023	0.011	0.013	0.019	*0.015	0.003

Table XI.2 Sediment Quality Samples Collected from the Athabasca River Tributaries by RAMP in 2002 (continued)

Parameter	Units	Clearwater R. (u/s of Fort McMurray)	Clearwater R. (u/s of Christina R.)	Christina R. (u/s of Fort McMurray)	Christina R. (u/s of Janvier)	McLean Creek	Poplar Creek	Steepbank River	Steepbank R. (u/s of Proj. Millenium)	North Steepbank River	MacKay River	Ells River	Tar River	Calumet River	Fort Creek	Firebag River	Firebag R. (u/s of Suncor Firebag)
Benzo(g,h,i)perylene	ug/g	0.006	0.0047	*0.0274	0.003	< 0.0667	0.015	0.0508	0.0017	< 0.0014	0.0282	0.0165	*0.0079	0.0084	0.0307	*0.0207	*0.0033
Biphenyl	ug/g	0.0003	0.0003	*0.0019	0.0014	0.0038	0.0128	0.003	< 0.0002	0.0009	0.0034	0.001	0.0019	0.0078	0.0043	0.0016	0.0032
C1 subst'd biphenyl	ug/g	< 0.0003	< 0.0002	< 0.001	< 0.0002	< 0.0027	< 0.0002	< 0.0015	< 0.0001	< 0.0002	< 0.0015	< 0.0003	< 0.0002	< 0.0004	< 0.0003	< 0.0007	< 0.0006
C2 subst'd biphenyl	ug/g	0.0024	0.0023	*0.0104	*0.0007	0.0192	0.0183	*0.0239	< 0.0002	< 0.0005	*0.0131	*0.004	0.0036	0.012	0.007	0.003	< 0.0008
Chrysene	ug/g	0.003	0.003	0.083	0.004	0.386	0.033	0.518	0.001	0.002	0.105	0.072	0.017	0.019	0.055	0.041	0.003
Dibenzothiophene	ug/g	< 0.0006	< 0.0002	< 0.0057	*0.0004	< 0.0264	*0.0047	< 0.0902	< 0.0002	*0.0003	< 0.0223	< 0.0051	< 0.0025	*0.0027	*0.0031	< 0.0024	*0.0009
C1 subst'd dibenzothiophene	ug/g	0.0007	< 0.0003	0.082	0.0013	0.909	0.025	1.69	< 0.0003	0.0009	0.21	0.0714	0.0638	0.0169	0.0335	0.014	< 0.0007
C2 subst'd dibenzothiophene	ug/g	0.0033	0.0011	0.37	0.0047	3.63	0.0697	9.02	< 0.0003	0.0029	0.946	0.393	0.29	0.0648	0.281	0.0845	< 0.001
C3 subst'd dibenzothiophene	ug/g	0.0061	0.001	0.773	0.0041	5.19	0.0736	11.6	< 0.0004	0.0041	1.05	0.595	0.321	0.0751	0.468	0.182	< 0.001
C4 subst'd dibenzothiophene	ug/g	0.016	0.002	2.09	0.01	6.54	0.134	13.8	0.001	0.013	1.7	0.822	0.267	0.151	0.545	0.418	0.018
Fluoranthene	ug/g	*0.0006	0.0004	0.0139	0.0036	0.064	0.0093	0.0461	0.0004	*0.0007	0.0098	< 0.0064	0.0026	0.0048	< 0.0046	0.0037	0.0011
C1 subst'd fluoranthene/pyrene	ug/g	0.006	0.006	0.227	0.007	1.01	0.052	1.41	0.002	0.011	0.241	0.143	0.037	0.036	0.096	0.071	0.005
C2 subst'd fluoranthene/pyrene	ug/g	0.019	0.022	0.552	0.011	1.59	0.087	2.24	0.005	0.005	0.584	0.33	0.08	0.07	0.267	0.206	0.016
C3 subst'd fluoranthene/pyrene	ug/g	0.024	0.028	0.611	0.008	1.74	0.073	1.89	0.004	0.003	0.641	0.307	0.092	0.069	0.317	0.276	0.02
Fluorene	ug/g	< 0.0002	< 0.0003	*0.0019	0.0009	0.0155	*0.0069	0.0164	< 0.0002	*0.0005	0.0068	*0.0019	0.0024	*0.0033	*0.0024	0.0016	0.0011
C1 subst'd fluorene	ug/g	0.0005	< 0.0003	0.0112	0.0015	0.123	0.0137	0.232	< 0.0003	0.0014	0.0395	0.0108	0.0117	0.0072	0.0077	0.0048	< 0.0012
C2 subst'd fluorene	ug/g	0.0026	*0.0009	0.202	0.0058	1.12	0.0459	0.126	< 0.0003	0.0031	0.345	0.0904	0.0653	0.028	0.0655	0.0345	< 0.001
C3 subst'd fluorene	ug/g	0.0072	*0.0008	0.596	0.0035	2.37	0.0517	3.05	0.0005	0.0046	0.632	0.16	0.107	0.0421	0.129	0.0829	0.0035
Indeno(1,2,3,cd)pyrene	ug/g	0.0048	0.0041	0.0329	*0.0027	< 0.0531	*0.0077	< 0.0313	0.0018	< 0.0013	*0.0157	< 0.0112	*0.0052	*0.0047	< 0.0177	< 0.0137	*0.0024
Phenanthrene	ug/g	0.001	0.001	0.008	0.004	0.059	0.036	0.15	0.001	0.002	0.03	0.015	0.016	0.02	0.019	0.009	0.003
C1 subst'd phenanthrene/ anthracene	ug/g	0.002	0.001	0.054	0.007	0.629	0.082	1.41	0.001	0.005	0.209	0.074	0.082	0.051	0.063	0.031	0.003
C2 subst'd phenanthren/ anthracene	ug/g	0.006	0.003	0.436	0.008	3.13	0.108	5.18	0.001	0.006	0.687	0.224	0.168	0.067	0.142	0.075	0.002
C3 subst'd phenanthrene/ anthracene	ug/g	0.01	0.003	0.938	0.01	5.3	0.084	6.56	0.001	0.003	0.804	0.371	0.156	0.064	0.213	0.128	0.003
C4 subst'd phenanthrene/ anthracene	ug/g	0.04	0.02	1.84	0.11	8.35	0.32	11.5	0.02	0.77	1.75	1.15	0.33	0.22	0.73	0.7	0.01
1-Methyl-7-isopropyl-phenanthrene (Retene)	ug/g	0.01	*0.004	*0.149	0.092	*0.385	0.104	*0.715	0.018	0.749	0.125	*0.067	0.043	0.05	0.055	0.125	0.006
Pyrene	ug/g	0.001	0.001	0.03	0.003	0.249	0.019	0.219	0.001	0.001	0.032	0.024	0.008	0.01	0.019	0.017	0.002

Note: Samples collected from mouth of tributary unless otherwise mentioned.

* PAH concentrations are reported with the limitation that interference from the sample matrix resulted in a GCMS spectrum without clear, easy to identify peaks (i.e., these numbers may contain a larger degree of error than those produced from clearly defined spectra).

Table XI.3 Sediment Quality Samples Collected from Muskeg River and Wetlands in Fall, 2002

Parameter	Units	Muskeg River (mouth)	McClelland Lake	Shipyard Lake
Particle Size				
partice size - % sand	%	58	14	2
partice size - % silt	%	27	37	45
partice size - % clay	%	16	49	53
moisture content	%	46	93	84
Carbon Content				
total inorganic carbon	% by wt	1.57	1.66	0.34
total organic carbon	% by wt	2.5	30	15.5
total carbon	% by wt	2.5	30	15.8
Toxicity				
Chironomus tentans - 10d survival	% control	100	-	88
Chironomus tentans - 10d growth	% control	86	-	75
Hyalella azteca - 10d survival	% control	89	-	67
Hyalella azteca - 10d growth	% control	100	-	100
Lumbriculus variegatus - 10d survival	% control	90	-	100
Lumbriculus variegatus - 10d growth	% control	83	-	63
Organics				
total recoverable hydrocarbons	mg/kg	2100	1200	3400
total volatile hydrocarbons (c5-c10)	mg/kg	< 0.5	9.3	1.7
total extractable hydrocarbons (c11-c30)	mg/kg	395	310	570
Metals (Total)				
aluminum (Al)	µg/g	4590	4430	19900
arsenic (As)	µg/g	2.5	4.2	7.4
barium (Ba)	µg/g	89	179	191
beryllium (Be)	µg/g	0.3	0.3	0.9
boron (B)	µg/g	7	68	21
cadmium (Cd)	µg/g	< 0.1	0.3	0.3
calcium (Ca)	µg/g	40800	65100	19500
chromium (Cr)	µg/g	8.6	16.3	96.7
cobalt (Co)	µg/g	4.2	3.7	10.9
copper (Cu)	µg/g	7	7	22
iron (Fe)	µg/g	16600	13200	27500
lead (Pb)	µg/g	5.2	4	12.4
magnesium (Mg)	µg/g	4580	3960	7280

Table XI.3 Sediment Quality Samples Collected from Muskeg River and Wetlands in Fall, 2002 (continued)

Parameter	Units	Muskeg River (mouth)	McClelland Lake	Shipyard Lake
manganese (Mn)	µg/g	489	368	360
mercury (Hg)	µg/g	< 0.1	0.1	< 0.1
molybdenum (Mo)	µg/g	0.2	0.5	1.6
nickel (Ni)	µg/g	9.2	9.7	69
potassium (K)	µg/g	810	1020	3200
selenium (Se)	µg/g	0.2	1	0.7
silver (Ag)	µg/g	< 0.1	0.1	0.1
sodium (Na)	µg/g	80	150	570
strontium (Sr)	µg/g	73	191	67
thallium (Tl)	µg/g	0.1	0.1	0.3
titanium (Ti)	µg/g	16	68.4	14.7
uranium (U)	µg/g	0.5	0.3	1.3
vanadium (V)	µg/g	12.2	17.2	48.4
zinc (Zn)	µg/g	32	86	75
Target PAHs and Alkylated PAHs				
naphthalene	µg/g	0.011	-[(a)]	-[(a)]
C1 subst'd naphthalenes	µg/g	0.019	0.008	0.061
C2 subst'd naphthalenes	µg/g	0.036	0.037	0.16
C3 subst'd naphthalenes	µg/g	0.042	0.015	0.087
C4 subst'd naphthalenes	µg/g	0.0373	0.0104	0.061
Acenaphthene	µg/g	0.001	< 0.0014	0.0034
C1 subst'd acenaphthene	µg/g	*0.0001	< 0.0004	<0.0017
Acenaphthylene	µg/g	0.0004	< 0.0009	<0.0013
Anthracene	µg/g	*0.0009	0.001	0.004
Dibenzo(a,h)anthracene	µg/g	*0.0032	< 0.002	*0.0067
Benzo(a)anthracene	µg/g	*0.0052	*0.0009	0.0159
C1 subst'd benzo(a)anthracene / chrysene	µg/g	0.295	0.054	0.505
C2 subst'd benzo(a)anthracene / chrysene	µg/g	0.102	0.012	0.14
Benzo(a)pyrene	µg/g	0.008	< 0.003	0.019
C1 subst'd benzo(b&k) fluoranthene / benzo(a)pyrene	µg/g	0.086	< 0.006	0.091
C2 subst'd benzo(b& k) fluoranthene / benzo(a)pyrene	µg/g	0.034	< 0.004	0.037
Benzofluoranthenes	µg/g	0.017	*0.003	0.028
Benzo(g,h,i)perylene	µg/g	*0.021	*0.0025	0.022

Table XI.3 Sediment Quality Samples Collected from Muskeg River and Wetlands in Fall, 2002 (continued)

Parameter	Units	Muskeg River (mouth)	McClelland Lake	Shipyard Lake
Biphenyl	µg/g	0.0046	*0.0045	0.0103
C1 subst'd biphenyl	µg/g	< 0.0001	< 0.0007	<0.00171
C2 subst'd biphenyl	µg/g	0.0049	*0.002	0.0126
Chrysene	µg/g	0.029	0.003	0.045
Dibenzothiophene	µg/g	*0.003	*0.0012	*0.011
C1 subst'd dibenzothiophene	µg/g	0.0205	0.0029	0.0501
C2 subst'd dibenzothiophene	µg/g	0.0725	0.0077	0.112
C3 subst'd dibenzothiophene	µg/g	0.0873	0.0045	0.102
C4 subst'd dibenzothiophene	µg/g	0.11	0.009	0.136
Fluoranthene	µg/g	0.0042	0.0057	0.0061
C1 subst'd fluoranthene / pyrene	µg/g	0.047	0.007	0.042
C2 subst'd fluoranthene / pyrene	µg/g	0.094	0.006	0.059
C3 subst'd fluoranthene / pyrene	µg/g	0.1	0.004	0.046
Fluorene	µg/g	0.002	0.0066	0.0081
C1 subst'd fluorene	µg/g	0.0075	0.0091	0.0277
C2 subst'd fluorene	µg/g	0.0307	0.0183	0.151
C3 subst'd fluorene	µg/g	0.042	0.0121	0.097
Indeno(1,2,3,cd)pyrene	µg/g	*0.0122	*0.003	*0.0097
Phenanthrene	µg/g	0.017	0.011	0.037
C1 subst'd phenanthrene / anthracene	µg/g	0.045	0.014	0.103
C2 subst'd phenanthren / anthracene	µg/g	0.082	0.01	0.085
C3 subst'd phenanthrene / anthracene	µg/g	0.085	0.015	0.057
C4 subst'd phenanthrene / anthracene	µg/g	0.3	0.04	0.17
1-Methyl-7-isopropyl-phenanthrene (Retene)	µg/g	0.063	0.019	0.046
Pyrene	µg/g	0.012	0.004	0.014

(a) Naphthalene could not be quantified.

* PAH concentrations are reported with the limitation that interference from the sample matrix resulted in a GCMS spectrum without clear, easy to identify peaks (i.e., these numbers may contain a larger degree of error than those produced from clearly defined spectra).

APPENDIX XII

BENTHIC INVERTEBRATE SAMPLING LOCATIONS, ABUNDANCE DATA AND SUPPORTING DATA

Table XII.1 Benthic Invertebrate Abundance (numbers/Ekman grab sample) in Samples Collected from the Athabasca River Delta, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	Fletcher Channel					Goose Island Channel				
			A	B	C	D	E	A	B	C	D	E
Nematoda	-	-	5	0	22	32	16	88	32	12	52	16
Oligochaeta	Naididae	-	4	0	0	0	0	0	0	0	0	0
	Tubificidae	-	1	2	3	1	17	0	0	0	1	0
Hydracarina	-	-	0	0	0	0	0	1	0	0	0	0
Cladocera	Macrothricidae	-	0	4	0	0	0	0	0	4	4	4
Ostracoda	-	-	0	0	16	20	0	40	12	0	4	0
Copepoda-Cyclopoida	-	-	0	0	0	0	0	0	4	0	0	0
Pelecypoda	Sphaeridae	(i/d)	0	1	1	8	0	71	23	17	315	127
Gastropoda	Hydrobiididae	*Probithinella?*	0	0	0	8	0	33	13	8	110	57
	Planorbidae	(i/d)	0	0	0	1	0	0	0	0	0	0
Ephemeroptera	Leptohyphidae	*Tricorythodes*	4	0	0	0	0	0	0	0	0	0
Odonata - Anisoptera	Gomphidae	*Gomphus*	0	0	0	0	0	0	0	0	0	1
		Ophiogomphus	0	0	0	0	0	0	0	0	0	1
Trichoptera	Hydropsychidae	*Hydropsyche*	0	0	0	0	0	0	0	0	1	0
	Polycentropodidae	*Neureclipsis*	0	0	0	0	0	0	0	0	5	6
Diptera	Ceratopogonidae	(i/d)	0	13	10	0	4	0	16	0	14	5
	Empididae	*Hemerodromia*	2	2	0	0	0	0	0	0	0	0
	Chironomidae	(i/d)	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	*Procladius*	1	12	2	4	0	51	57	15	10	0
		Thienemannimyia gr.	0	0	0	0	0	0	0	0	5	0
	Chironomini	(i/d)	0	0	0	0	0	0	0	4	0	1
		Chironomus	1	3	2	0	4	0	0	0	4	0
		Cryptochironomus	3	3	1	7	7	0	0	0	2	0
		Demicryptochironomus	0	0	0	0	0	0	0	1	6	1
		Microchironomus	0	9	3	4	0	8	0	0	0	0
		Paracladopelma	9	13	20	12	0	40	20	0	4	0
		Paralauterborniella	16	15	36	32	4	56	37	16	36	24
		Polypedilum	48	197	312	204	188	1025	826	304	340	136
	Tanytarsini	*Cladotanytarsus*	0	0	0	0	0	8	4	4	0	0
		Micropsectra	0	0	1	0	0	0	0	0	0	0
		Stempellina	0	0	8	0	0	0	0	0	0	0
		Tanytarsus	0	0	0	0	0	8	0	0	4	4
	Orthocladiinae	*Euryhapsis*	1	0	0	0	0	0	0	0	0	0
		Parakiefferiella	0	0	0	0	0	8	0	0	0	0
		Psectrocladius	0	0	0	0	0	0	0	0	1	0
	Diamesinae	*Potthastia longimana* gr.	0	1	0	0	0	1	0	0	8	0
Total			95	275	437	333	240	1438	1044	385	926	383

(i/d) = immature or damaged specimen.

Table XII.2 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for McClelland, Kearl and Shipyard Lakes, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	McClelland Lake										Kearl Lake										Shipyard Lake									
			MCL-1	MCL-2	MCL-3	MCL-4	MCL-5	MCL-6	MCL-7	MCL-8	MCL-9	MCL-10	KEL-1	KEL-2	KEL-3	KEL-4	KRL-5	KEL-6	KEL-7	KEL-8	KEL-9	KEL-10	SHL-1	SHL-2	SHL-3	SHL-4	SHL-5	SHL-6	SHL-7	SHL-8	SHL-9	SHL-10
Nematoda	-	-	0	0	0	11	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	49	0	0	1	0	11	0	1	0	0
Oligochaeta	Naididae	-	0	0	0	0	0	0	0	1	6	0	0	10	0	0	0	0	0	0	0	0	0	11	73	0	0	0	0	20	10	75
		Stylaria	0	0	0	0	35	0	1	0	170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Hirudinea	Erpobdellidae	(i/d)	0	0	12	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossiphoniidae	*Glossiphonia complanata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
		Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera	-	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Chydoridae	(i/d)	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Daphnidae	*Daphnia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copepoda - Calanoida		-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copepoda - Cyclopoida		-	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Physidae	*Physa*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
	Planorbidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Armiger crista	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	10	0	0	10	31	20
		Gyraulus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
	Valvatidae	*Valvata sincera*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	31	10	0	0	0	20	0	31
		Valvata tricarinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	20	0	10	0	10	0	10	31
Pelecypoda	Sphaeriidae	(i/d)	0	3	0	14	0	0	0	1	1	0	0	0	12	22	18	0	0	0	0	0	22	0	166	10	51	0	0	10	32	82
Acari - Hydracarina	-	-	0	1	0	0	0	0	0	0	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10
Ostracoda	-	-	2	0	39	12	1	0	31	0	57	3	41	30	0	0	0	0	8	6	5	19	50	332	109	152	39	56	14	13	142	146
Amphipoda	Gammaridae	*Gammarus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Talitridae	*Hyalella azteca*	0	0	9	0	1	2	1	3	44	25	65	93	16	37	231	131	148	30	83	43	0	33	19	6	15	4	1	2	20	2
Ephemeroptera	Caenidae	*Caenis*	0	10	0	11	0	0	1	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	143	0	0	0	0	0	10	0
Odonata - Anisoptera	Corduliidae	*Somatochlora?* [b]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
	Ceoenagrionidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Trichoptera	-	(i/d)	0	0	0	0	0	0	0	0	8	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptoceridae	*Mystacides*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
		Oecetis	0	0	1	0	0	0	0	0	0	2	1	0	0	0	1	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0
	Phryganeidae	*Agrypnia?*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		Phryganea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Polycentropodidae	*Polycentropus*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0	2	2	0
Diptera	Ceratopogonidae	(i/d)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
	Chaoboridae	*Chaoborus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Chironomidae	(i/d)	0	0	0	2	0	0	0	0	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironominae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironomini	*Chironomus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	36	649	52	51	37	38	65	58	140	269
		Cladopelma	1	0	0	0	0	0	0	0	16	0	0	0	0	1	0	0	0	0	0	0	0	4	41	1	0	0	0	0	0	23
		Cryptochironomus	0	1	1	1	10	0	1	0	0	0	6	6	0	0	4	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0
		Dicrotendipes	10	52	20	109	0	0	11	0	10	22	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	3
		Einfeldia	0	0	0	0	0	0	0	0	0	0	3	123	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
		Endochironomus	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	13	29	3	6	11	1	0	0
		Glyptotendipes	0	3	12	20	0	0	20	0	4	55	0	11	0	0	0	0	0	0	0	0	0	4	5	5	10	0	0	3	1	0
		Microtendipes	0	0	0	0	0	0	0	0	0	0	0	49	51	11	58	10	2	0	2	109	0	0	9	0	0	0	0	0	0	0
		Parachironomus	0	12	10	10	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
		Polypedilum	0	10	3	26	0	3	23	1	11	17	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
		Tribelos	0	2	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pseudochironomini	*Psudochironomus*	0	0	0	0	0	0	0	0	0	2	0	20	1	0	0	0	0	4	25	0	0	0	0	0	0	0	0	0	0	0
	Tanytarsini	*Cladotanytarsus*	0	0	0	0	0	0	0	0	0	20	0	3	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		Paratanytarsus	0	11	0	72	0	0	0	1	1	10	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	10
		Tanytarsus	0	1	0	2	0	0	0	0	2	0	0	10	0	1	0	0	13	0	2	0	0	4	58	1	0	11	0	11	15	54
	Orthocladiinae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Corynoneurini	*Corynoneura*	0	0	0	0	0	0	0	0	2	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Orthocladiini	*Parametriocnemus ?* [a]	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	31	0	0	0	0	0	0	0	0	0	0
		Psectrocladius	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tanypodinae	(i/d)	0	0	0	4	0	0	0	0	0	22	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	1	0	0
	Macropelopiini	*Procladius*	2	13	3	12	0	0	0	0	6	34	26	48	49	27	52	23	38	8	18	63	13	90	91	5	1	43	4	9	35	101
		Psectrotanypus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
	Pentaneurini	*Ablabesmyia*	14	3	1	31	0	0	0	0	3	42	0	0	1	0	0	0	2	0	0	3	0	0	49	0	0	10	0	4	0	0
	Tanypodini	*Tanypus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	4	0	0	0
Total			30	125	113	340	47	5	89	7	361	358	154	405	139	101	372	164	214	50	147	274	179	1190	947	284	191	181	110	168	473	869

[a] - McLelland and Kearl lakes.
[b] - Shipyard Lake.
(i/d) = immature or damaged specimen.

Table XII.3 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for Fort Creek, Fall 2002

Major Taxon	Family (Subfamily/Tribe)	Genus/Species	FOC-D-1	FOC-D-2	FOC-D-3	FOC-D-4	FOC-D-5
Nematoda		-	0	12	8	20	11
Hirudinea	Glossiphoniidae	*Helobdella stagnalis*	2	0	0	0	0
	Erpobdellidae	*Erpobdella punctata*	0	0	0	1	0
Oligochaeta	Enchytraeidae	-	0	0	16	0	0
	Naididae	-	0	12	8	10	20
	Tubificidae	-	4	0	0	0	21
Copepoda - Cyclopoida		-	0	0	0	0	10
Copepoda - Harpacticoida		-	0	0	0	20	0
Cladocera	Macrothricidae	-	0	0	0	0	10
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	0	0	0	30	0
Diptera	Tipulidae	*Dicranota*	0	10	0	0	0
		Hexatoma	0	1	0	0	0
	Tabanidae	*Tabanus ?*	0	0	0	1	0
	Ceratopogoninae	(i/d)	0	0	0	0	10
	Chironomidae	(i/d)	0	0	0	0	0
	Tanypodinae	*Procladius*	0	0	1	24	12
		Thienemannimyia complex	0	0	0	12	0
	Chironomini	*Chironomus*	0	0	10	0	0
		Cladopelma	0	0	8	10	0
		Cryptochironomus	0	0	1	11	4
		Cryptotendipes	0	0	8	0	0
		Dicrotendipes	0	0	0	1	0
		Paracladopelma	0	0	0	10	0
		Paratendipes	0	1	248	550	1011
		Phaenopsectra	0	0	0	10	10
		Polypedilum	1	0	16	80	21
		Stictochironomus	0	0	0	0	2
	Tanytarsini	(i/d)	0	0	80	170	30
		Stempellinella	1	0	8	0	0
		Tanytarsus	0	0	448	780	210
	Orthocladiinae	(i/d)	0	0	8	20	10
		Corynoneura	0	0	0	10	0
		Heterotrissocladius	0	0	120	180	111
		Nanocladius	0	0	0	10	0
		Parakiefferiella	0	0	16	260	70
		Thienemanniella	0	0	0	0	10
		Zalutschia	0	0	0	10	0
Terrestrial	-	-	1	10	0	1	0
Total			**9**	**46**	**1004**	**2231**	**1583**

(i/d) = immature or damaged specimen.

Table XII.4 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for the Clearwater River, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	Clearwater River Downstream of Christina River (depositional)															Clearwater River upstream of Christina River (depositional)														
			CLR-D-1	CLR-D-2	CLR-D-3	CLR-D-4	CLR-D-5	CLR-D-6	CLR-D-7	CLR-D-8	CLR-D-9	CLR-D-10	CLR-D-11	CLR-D-12	CLR-D-13	CLR-D-14	CLR-D-15	CLR-D-16	CLR-D-17	CLR-D-18	CLR-D-19	CLR-D-20	CLR-D-21	CLR-D-22	CLR-D-23	CLR-D-24	CLR-D-25	CLR-D-26	CLR-D-27	CLR-D-28	CLR-D-29	CLR-D-30
Nematoda	-	-	0	0	0	0	0	0	0	0	10	0	0	1	0	0	0	0	10	10	1	0	2	20	1	0	0	10	0	10	0	0
Oligochaeta	Enchytraeidae	-	0	0	30	0	0	0	0	20	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lumbriculidae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0
	Naididae	-	0	0	0	0	10	0	0	101	0	0	0	0	0	0	0	41	0	10	20	31	4	330	0	21	124	0	0	0	0	0
	Tubificidae	-	10	0	0	10	95	110	6	104	25	0	0	1	0	0	8	31	57	407	744	243	78	107	30	0	1	135	1	37	10	83
Hydracarina	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda	-	-	0	0	0	0	0	0	0	40	20	16	0	0	0	0	0	220	100	60	0	62	20	116	110	10	32	10	20	10	10	0
Copepoda - Cyclopoida	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera	Chydoridae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	10	0	0	0	0	0	0	0	0	0	0	0	0
	Macrothricidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	190	110	0	30	20	0	130	0	0	30	0	10	0	0
Amphipoda	Talitridae	*Hyalella azteca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Gastropoda	Hydrobiidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	17	0	0	0	0	0	0	0	0
	Lymnaeidae	*Stagnicola (?)*	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	2	4	0	0	0	0	0	3	0	0	0	0	0	0
	Physidae	*Physa*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Planorbidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
	Valvatidae	*Valvata tricarinata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	2	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	0	0	1	0	4	3	0	149	43	0	0	0	0	0	3	49	19	19	130	327	59	40	14	182	33	86	0	1	5	152
Ephemeroptera	Baetidae	*Baetis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Procloeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Heptageniidae	*Heptagenia*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stenonema	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Isonychiidae	*Isonychia campestris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptohyphidae	*Tricorythodes*	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Caenidae	*Caenis*	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	Leptophlebiidae	*Leptophlebia*	1	0	10	0	10	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	1
Plecoptera	Perlodidae	*Isoperla*	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taeniopterygidae	*Taeniopteryx*	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae	*Brachycentrus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	*Cheumatopsyche*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hydropsyche	0	0	15	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptoceridae	*Ceraclea*	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Oecetis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Lepidostomatidae	*Lepidostoma*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Odonata - Anisoptera	Gomphidae	*Gomphus*	2	1	4	1	0	0	0	11	2	0	2	0	0	1	6	0	7	0	2	2	4	1	15	0	1	4	2	2	4	2
		Ophiogomphus	0	0	4	0	0	0	0	6	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata - Zygoptera	Calopterygidae	*Calopteryx aequabilis*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Haliplidae	*Haliplus*	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Hemiptera	Corixidae	*Sigara*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Lepidoptera	-	-	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera - Nematocera	Simuliidae	*Simulium*	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
	Tipulidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Hexatoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Diptera - Brachycera	-	(i/d)	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tabanidae	*Chrysops*	1	0	1	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	3	0
	Empididae	*Hemerodromia*	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	21	10	0	0	0	0	0	0	0	0	0	0	0	0
	Ceratopogonidae	(i/d)	0	0	11	0	0	0	0	10	30	4	0	0	0	1	0	0	41	40	0	10	20	0	0	0	0	0	10	11	0	11
	Chironomidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		(pupa)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	(i/d)	0	0	0	0	0	0	0	13	1	0	0	0	0	0	0	0	71	10	1	0	10	23	0	0	0	0	0	0	0	0
		Ablabesmyia	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	1	0	0	0	0
		Clinotanypus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
		Labrundinia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0
		Procladius	16	0	1	0	40	390	50	164	37	21	82	0	0	1	20	626	21	163	27	59	89	106	44	18	10	51	10	81	178	284
		Thienemannimyia complex	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironomini	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
		Chironomus	33	0	0	0	61	45	139	43	12	54	43	0	0	1	17	62	0	0	0	20	0	0	121	1	0	15	0	43	0	0
		Cryptochironomus	0	0	0	0	0	0	7	0	11	0	0	0	0	0	0	0	60	1	11	0	10	0	0	0	0	0	10	0	10	11
		Demicryptochironomus	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
		Endochironomus	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Harnischia complex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0
		Microtendipes	0	0	0	0	0	0	0	11	20	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
		Paracladopelma	1	8	10	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Paralauterborniella	122	0	80	10	21	10	36	24	113	40	10	0	0	1	4	30	320	130	21	20	140	2	235	20	16	11	20	72	60	50
		Paratendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
		Phaenopsectra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	11	0	0	0	0	0	0	10	0	0	0	0
		Polypedilum	143	0	51	0	20	10	0	30	94	40	1	0	0	0	4	50	80	62	59	106	10	1112	130	0	0	33	50	105	10	1
		Tribelos	1	0	0	0	0	0	0	24	0	0	0	0	0	0	0	0	0	6	25	40	0	32	0	1	0	26	0	1	1	0
	Tanytarsini	*Micropsectra*	0	0	0	0	0	0	0	10	10	0	0	0	0	0	0	0	40	80	1	0	0	0	0	0	0	0	0	0	0	0
		Paratanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0
		Rheotanytarsus	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stempellinella	0	0	0	0	10	0	0	0	31	0	10	0	0	0	0	0	60	0	0	0	0	0	12	0	0	0	0	1	0	0
		Tanytarsus	0	0	10	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	10	1	20	0	0	0	0	0	0	10
	Orthocladiinae	*Brillia*	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	10	0	1	0	0	0	0	0	0	0	0	0	0	0
		Cricotopus/Orthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	0	0	21	0	0	0	0	0	0	0	0	0
		Parametriocnemus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0	0	0	0	0
Total			**333**	**10**	**297**	**21**	**272**	**568**	**238**	**877**	**512**	**179**	**148**	**3**	**2**	**6**	**64**	**1251**	**1251**	**1177**	**1056**	**970**	**501**	**1922**	**862**	**262**	**226**	**424**	**123**	**386**	**291**	**605**

(i/d) = immature or damaged specimen.
Ephemerellidae (i/d) - early instars but probably all *Ephemerella.*

Table XII.5 Benthic Invertebrate Abundance Data (numbers/Neill cylinder sample) for the MacKay River, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the MacKay River (erosional)															Upper Reach of the MacKay River (erosional)														
			MAR-E-1	MAR-E-2	MAR-E-3	MAR-E-4	MAR-E-5	MAR-E-6	MAR-E-7	MAR-E-8	MAR-E-9	MAR-E-10	MAR-E-11	MAR-E-12	MAR-E-13	MAR-E-14	MAR-E-15	MAR-E-16	MAR-E-17	MAR-E-18	MAR-E-19	MAR-E-20	MAR-E-21	MAR-E-22	MAR-E-23	MAR-E-24	MAR-E-25	MAR-E-26	MAR-E-27	MAR-E-28	MAR-E-29	MAR-E-30
Hydrozoa	Hydridae	*Hydra*	5	8	8	0	40	10	0	32	16	0	12	10	48	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
Nematoda	-	-	5	56	201	171	40	73	25	152	192	40	88	47	0	36	20	111	155	93	22	84	297	115	21	31	112	31	31	114	71	64
Oligochaeta	Enchytraeidae	-	0	8	176	420	21	11	10	39	62	73	99	26	25	74	5	4	31	3	0	10	85	1	20	41	22	0	10	10	50	2
	Naididae	-	145	340	572	4	132	122	422	704	761	675	41	676	25	42	84	1704	558	1269	2034	697	1714	694	741	984	642	761	1437	1730	2428	1395
	Tubificidae	-	31	2	24	1	91	0	20	0	16	112	24	10	4	4	1	10	0	3	0	0	1	0	1	2	0	11	0	0	3	1
Hydracarina	-	-	25	24	25	80	10	31	152	16	99	32	22	50	4	3	28	278	120	150	181	131	221	262	103	302	110	80	170	241	20	350
Ostracoda	-	-	0	0	0	0	300	225	128	160	128	72	130	30	48	4	32	130	3	10	0	0	1	0	0	0	0	0	0	0	0	0
Copepoda - Cyclopoida	-	-	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
Cladocera	Chydoridae	(i/d)	0	0	0	0	20	25	0	16	8	8	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Daphnidae	*Daphnia*	0	0	0	0	0	0	0	8	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Macrothricidae	(i/d)	0	0	0	0	50	15	0	32	8	0	0	5	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Ancylidae	*Ferrissia rivularis*	0	3	0	0	0	0	0	0	6	16	0	0	4	0	16	11	0	5	4	22	6	26	4	7	0	0	5	4	15	11
	Lymnaeidae	*Stagnicola (?)*	0	0	0	1	24	0	0	0	0	0	6	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physidae	*Physa*	0	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planorbidae	(i/d)	0	0	0	3	69	1	0	3	14	41	10	22	100	0	0	1	11	3	3	1	8	0	0	0	0	0	6	0	1	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	0	1	2	4	42	0	1	2	85	5	1	0	3	0	1	24	8	25	4	0	28	4	2	3	2	2	3	1	6	8
Ephemeroptera	Ameletidae	*Ameletus subnotatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	0	0	1	1	0	0	0	1	0	0	0	0	0	0
	Baetidae	*Acentrella*	0	0	8	0	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
		Baetis	156	110	132	239	110	54	311	132	132	253	93	32	34	4	85	57	21	62	33	13	42	12	10	50	12	0	31	26	30	72
	Ephemerellidae	(i/d)	0	0	8	0	0	5	8	0	0	0	0	5	0	0	0	20	0	0	0	0	0	1	0	10	1	0	0	0	0	10
		Timpanoga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ephemeridae	*Ephemera*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	7	3	0	0	4	0	0	1	1	0	0	0	4	2
	Heptageniidae	(i/d)	0	24	40	0	0	10	16	0	24	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Heptagenia	2	0	2	21	0	6	1	1	1	16	1	5	0	0	2	13	0	0	3	2	3	2	1	0	1	0	1	10	2	1
		Rhithrogena	11	0	6	0	0	11	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Stenonema	14	11	4	3	0	1	2	3	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptohyphidae	*Tricorythodes*	0	0	8	0	0	0	1	1	1	9	3	9	18	0	0	1	11	1	1	11	6	12	0	8	11	11	4	2	3	3
	Caenidae	*Caenis*	0	0	0	2	4	0	0	0	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptophlebiidae	*Leptophlebia*	21	1	1	10	5	0	0	46	0	1	2	1	8	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
Plecoptera	-	(i/d)	0	0	0	0	0	0	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chloroperlidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	10	1	0	0	12	2	20	1	0	0	2	0	1
	Perlidae	*Acroneuria*	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	1	3	0	0	1	1	0	0	0	1	0	0	1	0	1
		Claassenia sabulosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	1	0	3	2	2	1	1	0	1	0	2	0	1	0
	Perlodidae	*Isogenoides*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	0	1	0	0	0	0	0	1	0	0
		Isoperla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0
	Pteronarcyidae	*Pteronarcys*	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Taeniopterygidae	*Taeniopteryx*	7	5	9	9	2	5	6	17	19	0	1	4	0	0	1	3	6	4	1	2	1	3	6	3	0	1	0	1	0	1
Trichoptera	-	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Brachycentridae	*Brachycentrus*	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	5	6	2	4	13	2	4	1	0	6	7	69	1	0	0
	Glossosomatidae	*Glossosoma*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	0	1	0	0	2	0	0
	Helicopsychidae	*Helicopsyche*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45	6	44	6	11	23	2	8	8	0	2	74	12	2	0
	Hydroptilidae	*Hydroptila*	0	0	0	0	3	0	0	0	0	0	0	2	2	0	0	1	1	23	11	1	4	0	1	0	1	0	1	2	1	4
	Hydropsychidae	(i/d)	0	8	0	0	0	5	0	0	0	0	0	0	0	0	88	10	1	10	0	0	0	0	0	0	0	0	0	0	0	10
		Cheumatopsyche	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	85	3	13	16	7	4	21	5	1	2	0	0	4	1	7
		Hydropsyche	7	22	102	20	1	39	34	24	37	4	2	7	0	3	45	147	45	34	76	13	24	93	21	14	4	1	15	33	2	5
	Leptoceridae	*Ceraclea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	1	0	0	0	0	0
		Mystacides	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Oecetis	1	0	1	3	0	0	1	2	0	0	0	0	0	0	0	0	0	2	2	1	3	0	1	2	0	0	2	4	0	3
	Lepidostomatidae	*Lepidostoma*	0	1	0	2	0	0	0	0	1	0	0	0	0	0	1	0	1	10	1	0	1	0	0	0	0	0	1	0	0	0
	Philopotamidae	*Chimarra*	0	1	10	1	0	0	8	0	0	0	0	0	0	0	0	103	2	11	1	12	3	20	5	0	1	0	1	1	10	1
	Psychomyiidae	*Psychomyia*	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	106	3	174	53	16	59	137	78	181	33	54	41	114	92	30
Odonata - Anisoptera	Gomphidae	*Ophiogomphus*	2	10	17	29	11	0	20	64	16	8	15	22	1	0	4	0	0	2	0	1	0	0	2	3	1	0	3	1	1	11
Diptera - Nematocera	Simuliidae	*Simulium*	0	0	0	0	0	10	1	0	0	11	0	0	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tipulidae	*Hexatoma*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Diptera - Brachycera	Dolichopodidae	*Rhaphium*	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Empididae	*Hemerodromia*	20	59	92	35	5	51	70	80	26	45	8	41	12	5	11	13	3	11	18	4	42	18	28	3	1	32	5	6	22	21
	Ceratopogonidae	(i/d)	1	1	4	30	0	5	10	11	19	0	0	0	4	0	13	10	11	0	1	11	21	1	13	0	0	0	1	1	0	11
		Dasyhelea	0	0	0	0	0	0	0	0	0	0	24	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironomidae	(pupa)	0	0	8	0	0	10	1	0	0	0	4	5	8	2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Tanypodinae	(i/d)	25	8	1	40	10	11	0	20	25	16	12	16	13	4	8	52	45	24	30	0	12	22	0	22	21	10	10	22	11	1
		Ablabesmyia	0	0	0	0	11	5	8	4	0	0	0	5	16	0	0	0	0	10	0	0	12	0	0	0	0	0	0	0	0	1
		Procladius	0	0	0	0	0	0	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thienemannimyia complex	31	54	27	17	59	27	160	107	139	123	30	47	64	7	10	103	89	90	31	2	47	15	7	55	1	10	4	103	36	47
	Chironomini	(i/d)	0	0	8	0	0	0	0	8	64	0	24	10	4	20	4	20	0	0	0	0	0	10	10	0	0	10	0	0	0	0
		Cryptochironomus	0	0	0	0	0	5	16	1	0	16	14	10	0	0	0	1	1	0	0	1	21	10	0	0	0	10	0	1	1	10
		Demicryptochironomus	0	0	9	10	1	10	1	1	8	2	0	1	5	0	0	10	0	0	0	0	0	0	1	0	0	0	0	12	0	10
		Microtendipes	1	0	0	1	0	0	0	0	26	2	7	16	8	0	0	20	15	40	10	1	57	0	0	10	1	14	1	1	20	3
		Paralauterborniella	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Paratendipes	5	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Phaenopsectra	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Polypedilum	0	0	0	21	0	10	16	75	120	41	16	45	4	4	40	20	15	20	0	1	21	21	22	60	11	31	20	20	30	30
		Stictochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
		Saetheria	0	0	0	20	0	10	0	16	8	8	4	0	4	145	4	10	10	0	83	20	343	50	0	30	20	144	0	103	20	30
	Tanytarsini	(i/d)	0	0	0	0	0	10	48	48	32	8	4	25	0	4	16	40	10	0	20	20	50	10	20	20	20	20	0	10	1	0
		Cladotanytarsus	0	0	0	10	0	5	8	0	0	112	16	25	8	0	0	10	12	41	20	10	343	30	50	70	10	427	82	10	0	32
		Micropsectra	5	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Rheotanytarsus	20	24	8	1	30	0	64	16	64	129	28	40	32	0	4	189	211	362	100	41	61	22	22	20	43	10	21	111	172	42
		Stempellina	0	0	0	10	20	0	48	72	32	56	4	15	36	0	12	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
		Stempellinella	5	8	0	0	10	0	32	80	40	32	16	15	24	0	8	60	30	20	10	10	40	0	10	20	0	30	0	0	40	10
		Sublettea	11	24	0	0	10	0	64	8	9	24	0	30	0	0	0	351	307	353	284	81	171	124	72	222	91	30	70	214	270	111
		Tanytarsus	35	72	64	50	70	35	289	322	168	104	56	100	24	0	36	62	86	100	62	40	171	20	30	30	20	30	40	71	40	130
	Orthocladiinae	(i/d)	0	0	8	0	0	20	24	16	8	8	4	5	0	0	0	40	30	40	30	50	0	10	0	20	30	0	302	2	40	20
		Corynoneura	5	0	0	10	0	0	0	8	16	8	16	0	4	0	8	10	10	10	0	0	0	0	0	0	0	0	0	0	10	0

Table XII.5 Benthic Invertebrate Abundance Data (numbers/Neill cylinder sample) for the MacKay River, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the MacKay River (erosional)															Upper Reach of the MacKay River (erosional)														
			MAR-E-1	MAR-E-2	MAR-E-3	MAR-E-4	MAR-E-5	MAR-E-6	MAR-E-7	MAR-E-8	MAR-E-9	MAR-E-10	MAR-E-11	MAR-E-12	MAR-E-13	MAR-E-14	MAR-E-15	MAR-E-16	MAR-E-17	MAR-E-18	MAR-E-19	MAR-E-20	MAR-E-21	MAR-E-22	MAR-E-23	MAR-E-24	MAR-E-25	MAR-E-26	MAR-E-27	MAR-E-28	MAR-E-29	MAR-E-30
		Cricotopus/Orthocladius	0	0	1	0	0	99	0	0	0	1	0	10	0	0	0	0	2	2	12	12	32	1	2	12	0	0	30	0	1	2
		Eukiefferiella	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Lopescladius	0	8	33	30	0	10	8	16	16	0	0	0	0	2	0	60	81	101	10	120	382	261	90	90	20	41	0	150	1	40
		Nanocladius	0	0	0	0	0	0	8	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
		Parakiefferiella	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Parametriocnemus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	10	0
		Synorthocladius	0	0	0	0	0	0	0	0	8	25	24	5	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thienemanniella	0	0	0	0	10	5	0	0	0	0	0	0	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	10	0	0
		Tvetenia	0	24	89	50	0	91	64	0	16	16	4	5	0	2	4	82	33	12	50	63	0	83	62	10	20	0	70	30	0	11
	Diamesinae	*Potthastia* (*longimanus* type)	0	16	0	20	0	0	18	2	23	10	1	1	0	2	0	2	0	5	1	1	9	0	0	11	0	0	0	12	0	1
Terrestrial	-	-	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			598	941	1728	1378	1211	1079	2128	2383	2516	2173	884	1462	640	377	623	4073	2009	3210	3245	1543	4378	2136	1477	2387	1276	1810	2573	3209	3489	2556

(i/d) = immature or damaged specimen.
Ephemerellidae (i/d) - early instars but probably all *Ephemerella.*

Table XII.-6 Benthic Invertebrate Abundance Data (numbers/Neill cylinder sample) for the Steepbank River, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the Steepbank River (erosional)														
			STR-E-1	STR-E-2	STR-E-3	STR-E-4	STR-E-5	STR-E-6	STR-E-7	STR-E-8	STR-E-9	STR-E-10	STR-E-11	STR-E-12	STR-E-13	STR-E-14	STR-E-15
Nematoda	-	-	0	0	0	0	0	4	0	8	3	0	0	8	0	0	16
Oligochaeta	Enchytraeidae	-	4	4	4	0	0	13	15	36	14	2	32	28	6	16	53
	Naididae	-	3	4	0	0	0	4	0	4	2	0	0	20	0	4	16
	Tubificidae	-	33	12	0	75	4	18	0	8	2	1	35	48	3	1	3
Hydracarina	-	-	1	8	28	0	0	0	1	2	2	2	32	5	8	0	0
Ostracoda	-	-	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
Copepoda - Cyclopoida	-	-	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Copepoda - Harpacticoida	-	-	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0
Gastropoda	Ancylidae	*Ferrissia rivularis*	0	2	0	0	1	0	0	0	0	0	0	0	4	0	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Ephemeroptera	Baetidae	*Acentrella*	2	1	1	0	0	6	5	0	1	0	0	1	0	7	0
		Baetis	8	20	26	4	21	54	13	7	10	13	26	30	40	29	8
	Ephemerellidae	(i/d)	0	1	21	0	0	0	0	0	1	2	0	0	0	8	0
		Timpanoga	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Heptageniidae	(i/d)	0	1	1	9	0	0	0	0	0	0	0	0	8	0	0
		Heptagenia	0	1	6	6	0	0	1	0	0	0	1	6	0	1	0
		Stenonema	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptohyphidae	*Tricorythodes*	0	1	28	11	1	0	0	0	0	1	10	1	0	0	0
Plecoptera	Perlodidae	*Isogenoides*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Isoperla	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0
	Pteronarcyidae	*Pteronarcys*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Taeniopterygidae	*Taeniopteryx*	0	0	4	1	4	0	0	0	0	0	0	0	0	1	0
Trichoptera	-	(i/d)	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	*Hydropsyche*	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0
	Lepidostomatidae	*Lepidostoma*	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0
	Psychomyiidae	*Psychomyia*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Odonata - Anisoptera	Gomphidae	*Ophiogomphus*	0	2	8	3	0	0	0	0	0	0	1	1	0	1	0
Hemiptera	Corixidae	*Sigara*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Lepidoptera	-	-	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0
Diptera - Nematocera	Simuliidae	*Simulium*	3	0	0	0	2	4	0	0	0	2	0	1	8	1	0
Diptera - Brachycera	Athericidae	*Atherix*	0	0	0	1	0	0	2	0	0	0	0	1	1	0	0
	Empididae	*Chelifera*	4	0	8	2	0	0	0	0	1	0	11	9	4	0	0
		Hemerodromia	5	4	20	9	4	0	10	9	7	2	16	12	1	0	15
	Ceratopogonidae	(i/d)	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0
	Chironomidae	(i/d)	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
		(pupa)	0	0	0	4	0	0	0	0	1	0	0	1	0	0	4
	Tanypodinae	(i/d)	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
		Ablabesmyia	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Nilotanypus	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thienemannimyia complex	0	0	1	1	1	0	0	0	0	0	25	1	0	0	0
	Chironomini	(i/d)	0	0	4	0	0	0	0	0	0	2	0	0	0	0	0
		Demicryptochironomus	3	0	0	0	0	0	0	0	2	1	0	8	5	0	10
		Polypedilum	19	8	12	0	8	0	0	0	2	0	16	8	9	4	4
		Saetheria	7	0	8	0	0	20	0	14	19	24	0	0	0	0	20
	Tanytarsini	*Rheotanytarsus*	9	32	94	33	12	0	5	0	2	2	123	17	24	0	4
		Tanytarsus	0	0	8	0	0	0	0	0	0	0	8	0	0	4	0
	Orthocladiinae	(i/d)	3	4	4	0	0	0	0	2	1	0	16	0	0	0	1
		Brillia	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Corynoneura	0	0	0	0	0	0	0	0	0	2	0	0	0	0	4
		Cricotopus/Orthocladius	7	25	32	0	28	16	0	10	10	7	49	31	20	26	10
		Eukiefferiella	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
		Pseudosmittia	0	4	0	0	0	0	0	0	0	0	0	0	4	0	0
		Synorthocladius	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
		Thienemanniella	0	0	0	0	0	0	0	0	1	0	0	4	0	0	0
		Tvetenia	2	0	4	0	1	0	0	0	1	0	9	8	4	0	0
	Diamesinae	*Potthastia* (*longimanus* type)	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial	-	-	0	20	2	0	0	1	10	1	1	1	0	7	7	0	0
Total			115	163	357	159	92	144	62	113	89	65	410	258	156	106	168

(i/d) = immature or damaged specimen.
Ephemerellidae (i/d) - early instars but probably all *Ephemerella.*

Table XII.7 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample [depositional] or Neill cylinder sample [erosional]) for the Muskeg River, Fall 2002

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the Muskeg River (erosional)															Lower to Mid-Reach of the Muskeg River (depositional)															Upper Reach of the Muskeg River (depositional)														
			MUR-E-1	MUR-E-2	MUR-E-3	MUR-E-4	MUR-E-5	MUR-E-6	MUR-E-7	MUR-E-8	MUR-E-9	MUR-E-10	MUR-E-11	MUR-E-12	MUR-E-13	MUR-E-14	MUR-E-15	MUR-D-1	MUR-D-2	MUR-D-3	MUR-D-4	MUR-D-5	MUR-D-6	MUR-D-7	MUR-D-8	MUR-D-9	MUR-D-10	MUR-D-11	MUR-D-12	MUR-D-13	MUR-D-14	MUR-D-15	MUR-D-16	MUR-D-17	MUR-D-18	MUR-D-19	MUR-D-20	MUR-D-21	MUR-D-22	MUR-D-23	MUR-D-24	MUR-D-25	MUR-D-26	MUR-D-27	MUR-D-28	MUR-D-29	MUR-D-30
Hydrozoa	Hydridae	*Hydra*	1	12	0	4	4	0	4	0	0	4	8	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tricladida	Planariidae	*Dugesia tigrina*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematoda	-	-	0	20	28	2	1	32	0	84	52	8	4	12	4	12	4	21	30	50	162	40	23	10	11	130	10	0	20	30	40	90	1	1	1	2	0	3	0	0	0	0	0	2	0	11	0
Hirudinea	Glossiphoniidae	(i/d)	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	3	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Helobdella stagnalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	10	2	1	0	2	0	1	4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	11	1
	Erpobdellidae	(i/d)	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Erpobdella punctata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nephelopsis obscura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	1
Oligochaeta	Enchytraeidae	-	0	0	0	0	0	0	5	12	0	1	4	16	4	0	4	0	0	0	10	0	0	31	43	20	40	20	20	20	30	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lumbriculidae	-	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	3	0	0	0	0	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Naididae	-	20	164	639	64	37	81	81	40	12	12	29	96	140	52	81	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	-	0	0	0	60	2	0	1	0	0	0	15	10	0	0	4	0	33	21	8	64	15	26	17	48	47	20	15	20	12	15	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Hydracarina	-	-	50	108	48	76	42	72	48	168	80	60	136	96	168	184	88	0	0	50	0	10	0	20	10	60	0	0	0	10	10	20	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Ostracoda	-	-	23	12	12	6	16	17	28	20	12	12	20	104	20	4	4	0	153	230	55	80	0	30	0	20	10	0	0	0	0	0	0	0	8	14	7	69	0	0	6	30	0	6	13	1	0
Copepoda - Cyclopoida	-	-	9	4	0	8	46	4	16	4	8	4	4	4	8	16	12	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copepoda - Harpacticoida	-	-	0	0	0	0	0	0	8	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladocera	Chydoridae	(i/d)	6	12	4	0	18	12	20	60	4	12	4	8	16	12	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Daphnidae	*Daphnia*	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Macrothricidae	(i/d)	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	21	80	10	30	0	40	0	60	188	10	10	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amphipoda	Gammaridae	*Gammarus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
	Talitridae	*Hyalella azteca*	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	5	1	0	0	1	0	0	0	0	0	3	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Collembola	-	-	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Gastropoda	Ancylidae	*Ferrissia rivularis*	0	3	4	3	1	0	0	2	1	1	4	3	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Physidae	*Physa*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planorbidae	(i/d)	2	0	1	4	4	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	0	0	10	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Valvatidae	*Valvata sincera*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0
		Valvata tricarinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	30	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	29	72	19	62	22	5	2	25	40	45	40	142	26	4	55	134	31	1	44	0	21	91	0	0	31	0	0	10	20	10	108	32	100	95	1	43	43	126	23	112	135	39	4	46	49
Ephemeroptera	Baetidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Acentrella	1	0	0	0	0	2	2	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Baetis	60	63	73	17	18	10	21	25	4	12	43	12	5	1	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ephemerellidae	(i/d)	0	0	8	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Heptageniidae	(i/d)	1	0	0	0	0	0	4	0	0	4	0	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Heptagenia	1	3	4	4	2	1	6	12	4	3	3	1	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stenonema	0	1	2	0	0	0	1	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptohyphidae	*Tricorythodes*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Caenidae	*Caenis*	0	0	1	0	0	0	4	1	0	0	0	0	0	0	0	0	0	40	0	30	10	0	0	50	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptophlebiidae	*Leptophlebia*	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	10	0	1	20	0	0	0	30	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera	-	(i/d)	9	0	4	0	4	0	8	0	8	8	8	8	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chloroperlidae	(i/d)	7	4	4	13	33	39	30	17	20	50	20	54	44	33	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Perlidae	(i/d)	1	4	0	3	2	0	0	0	4	4	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Acroneuria	1	0	0	0	0	0	0	0	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Claassenia sabulosa	0	0	0	0	0	0	2	13	1	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Perlodidae	*Isogenoides*	0	0	0	3	0	1	1	1	0	2	2	3	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Isoperla	3	1	1	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pteronarcyidae	*Pteronarcys*	17	2	0	0	0	2	5	0	0	5	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Taeniopterygidae	*Taeniopteryx*	2	0	3	1	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae	*Brachycentrus*	11	1	1	0	12	3	14	0	8	28	4	9	9	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Glossosomatidae	*Glossosoma*	1	3	5	0	0	1	3	4	5	0	1	0	8	9	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Protoptila	4	8	0	48	14	0	44	52	20	4	8	12	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Helicopsychidae	*Helicopsyche*	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydroptilidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Oxyethira	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	(i/d)	0	0	0	2	0	8	0	0	0	0	0	4	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cheumatopsyche	1	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hydropsyche	0	0	0	0	1	0	1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Leptoceridae	*Ceraclea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lepidostomatidae	*Lepidostoma*	1	4	0	6	6	0	0	4	2	4	17	20	11	5	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Philopotamidae	*Chimarra*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Wormaldia	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Phryganeidae	*Ptilostomis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Polycentropodidae	*Polycentropus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psychomyiidae	*Psychomyia*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Rhyacophilidae	*Rhyacophila*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odonata - Anisoptera	Aeshnidae	*Aeshna*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Corduliidae	*Somatochlora*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gomphidae	*Ophiogomphus*	1	19	7	4	1	4	2	11	4	4	6	2	1	4	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Elmidae	*Dubiraphia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Optioservus	3	3	3	10	1	2	1	13	10	8	23	11	10	4	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Haliplidae	*Haliplus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera - Nematocera	Tipulidae	*Dicranota*	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Hexatoma	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera - Brachycera	Dolichopodidae	*Rhaphium*	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tabanidae	*Chrysops*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	30	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1
	Empididae	*Hemerodromia*	12	36	18	17	11	4	18	7	36	22	5	22	10	12	24	0	0	0	0	0	0	20	0	0	10	0	0	10	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chaoboridae	*Chaoborus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ceratopogonidae	(i/d)	0	0	1	2	2	4	4	10	0	12	0	20	13	10	0	20	10	34	3	0	40	33	0	24	10	0	10	20	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironomidae	(pupa)	2	0	0	0	2	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	(i/d)	0	0	0	8	2	28	0	12	12	4	13	4	4	4	4	10	1	50	46	30	51	104	0	141	36	0	32	21	63	195	3	0	0	0	0	0	1	3	0	0	0	0	0	2	4
		Ablabesmyia	0	12	0	0	0	0	0	0	4	0	0	0	0	0	0	0	20	30	0	61	0	10	13	10	0	0	0	2	12	13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Labrundinia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Larsia	1	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nilotanypus	1	0	0	0	0	0	0	0	0	0	0	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Procladius	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	21	122	353	92	277	92	178	0	423	570	87	62	48	31	22	110	27	216	89	134	48	64	176	126	56	63	103	35	107	32
		Thienemannimyia complex	5	9	14	10	0	0	12	12	12	8	0	5	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chironomini	(i/d)	0	0	0	0	6	0	0	0	0	0	0	0	4	0	0	0	0	10	10	10	0	0	0	10	10	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	1	0	0	0
		Chironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	50	0	0	0	0	0	0	0	0	0	13	1	12	221	1	0	1	1	0	0	38	10	0
		Cladopelma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	10	0	2	0	0	0	0	0	0	0
		Cryptochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	10	0	1	1	2	0	11	0	2	21	10	10	0	0	0	3	1	1	1	6	2	4	2	1	0	0	1	2	1	0
		Demicryptochironomus	0	4	0	0	0	0	0	8	4	0	0	0	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Dicrotendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	237	0	18	0	20	22	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Endochironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
		Harnischia complex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	10	0	0	0
		Microtendipes	0	0	1	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	1	2	0	0	0	0	1	1
		Pagastiella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	121	0	30	0	0	90	90	0	120	102	10	20	30	30	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Parachironomus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
		Paratendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	0	0	10	10	0	0	10	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	10	0	0	0
		Phaenopsectra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
		Polypedilum	1	16	24	16	2	0	32	28	0	8	0	8	16	12	12	21	10	0	4	0	40	71	0	10	104	20	12	8	20	4	0	0	0	0	0	0	0	0	0	10	10	0	0	10	0
		Sergentia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Stictochironomus	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Saetheria	0	0	0	0	2	0	0	0	8	0	0	0	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tribelos	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	1	1	0	1	1	9	1
	Tanytarsini	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	20	0	10	0	10	42	0	10	10	10	0	1	0	1	0	0	1	2	1	4	5	0	1	0	0	0
		Cladotanytarsus	0	0	0	2	2	8	8	8	12	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Micropsectra	43	188	184	42	26	92	92	152	56	60	52	20	52	32	72	0	133	551	170	280	20	50	0	310	266	10	33	80	66	100	39	0	7	4	4	14	7	71	14	0	22	13	0	0	12
		Rheotanytarsus	5	103	180	40	2	0	16	52	8	33	28	8	12	0	56	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stempellina	0	8	4	4	0	0	0	4	13	4	4	0	4	25	44	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stempellinella	0	0	12	24	6	8	4	93	20	20	48	0	12	32	4	0	20	40	20	0	0	1	0	30	330	0	42	12	10	20	0	0	2	1	0	2	1	1	2	0	6	0	0	1	1
		Tanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	130	10	20	10	0	0	30	90	0	0	0	0	0	14	1	0	1	0	1	1	33	6	30	1	0	0	0	5
	Orthocladiinae	(i/d)	0	0	4	2	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	1	0	0	0	2	2	1	1	0	0	0	0	0	6
		Brillia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		Corynoneura	9	4	4	2	0	4	0	0	0	4	4	8	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Cricotopus/Orthocladius	2	8	2	0	0	22	8	4	0	0	0	0	8	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Eukiefferiella	0	0	0	2	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Euryhapsis	0	0	0	0	0	2	8	1	34	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Heterotrissocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	10	10	0	0	0	32	10	10	12	0	0	6	0	2	2	0	5	13	5	1	0	13	0	0	4	16
		Krenosmittia	0	0	0	0	0	0	0	0	0	0	0	0	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Lopescladius	4	20	20	9	32	56	45	77	68	368	12	144	44	80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Nanocladius	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Parakiefferiella	0	0	0	0	2	0	0	0	8	4	0	0	0	0	0	0	0	0	70	10	10	0	30	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Parametriocnemus	0	0	0	0	0	0	4	0	0	0	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Synorthocladius	0	4	8	0	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thienemanniella	0	0	0	2	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tvetenia	0	12	20	4	0	8	0	8	4	4	4	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Diamesinae	*Potthastia* (*longimanus* type)	4	0	2	0	0	0	0	0	1	0	4	4	0	0	0	0	0	0	10	0	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial	-	-	0	8	0	0	0	0	4	0	0	0	0	0	0	0	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			354	960	1395	591	390	534	626	1100	613	870	596	882	710	597	615	391	624	2000	792	1074	453	874	241	1594	2034	218	306	363	354	753	298	63	355	228	166	426	152	433	192	250	253	187	95	218	132

(i/d) = immature or damaged specimen.
Ephemerellidae (i/d) - early instars but probably all *Ephemerella.*

TableXII.8 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for Jackpine Creek, Fall 2002.

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of Jackpine Creek (depositional)														
			JAC-D-1	JAC-D-2	JAC-D-3	JAC-D-4	JAC-D-5	JAC-D-6	JAC-D-7	JAC-D-8	JAC-D-9	JAC-D-10	JAC-D-11	JAC-D-12	JAC-D-13	JAC-D-14	JAC-D-15
Nematoda	-	-	1	0	8	40	65	24	40	41	53	16	80	10	0	1	64
Oligochaeta	Enchytraeidae	-	0	0	8	0	0	0	0	0	0	16	1	0	0	0	0
	Naididae	-	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	-	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0
Hydracarina	-	-	14	24	32	0	40	0	0	0	10	8	0	0	0	0	8
Ostracoda	-	-	0	0	8	0	0	0	0	0	0	0	10	0	0	0	0
Copepoda - Cyclopoida	-	-	0	0	8	0	0	0	0	0	0	0	0	20	0	0	0
Cladocera	Macrothricidae	(i/d)	0	0	8	0	0	0	0	0	0	0	10	0	0	0	0
Collembola	-	-	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
Gastropoda	Planorbidae	(i/d)	0	0	0	0	0	0	0	0	0	8	0	0	1	0	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	0	0	2	3	21	0	2	0	6	48	27	20	0	15	1
Ephemeroptera	Baetidae	*Baetis*	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
	Leptophlebiidae	*Leptophlebia*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Lepidostomatidae	*Lepidostoma*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Limnephilidae	(i/d)	0	0	0	0	0	16	0	0	0	0	0	0	1	0	0
Odonata - Anisoptera	Aeshnidae	*Aeshna*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Hemiptera	Corixidae	*Hesperocorixa*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Diptera - Nematocera	Simuliidae	*Simulium*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	Tipulidae	*Hexatoma*	0	0	3	0	9	12	0	1	0	0	0	0	0	0	0
Diptera - Brachycera	Tabanidae	*Chrysops*	0	2	3	1	1	0	0	2	7	0	1	6	0	2	0
	Empididae	*Chelifera*	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0
		Hemerodromia	0	0	0	0	0	0	0	0	10	0	10	0	10	0	0
	Ceratopogonidae	(i/d)	15	0	0	20	38	0	33	26	10	8	52	2	0	8	8
	Chironomidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	(i/d)	1	0	16	30	8	8	0	16	10	17	0	0	0	8	0
		Ablabesmyia	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
		Labrundinia	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
		Procladius	1	0	9	94	1	0	0	1	10	1	21	10	10	8	0
	Chironomini	(i/d)	32	8	8	0	0	8	0	0	0	40	80	20	20	8	8
		Chironomus	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0
		Cryptochironomus	14	0	0	20	1	0	0	0	0	0	20	0	0	0	8
		Paracladopelma	24	16	0	20	48	0	40	1	40	16	70	0	0	0	1
		Paralauterborniella	111	88	120	490	96	0	56	40	60	0	160	110	30	56	8
		Paratendipes	4	0	0	1	0	8	8	0	50	0	30	0	0	0	8
		Phaenopsectra	0	0	0	0	0	0	0	0	0	0	11	0	1	0	0
		Polypedilum	68	128	101	95	47	92	16	214	377	133	399	219	292	96	126
		Stictochironomus	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0
	Tanytarsini	(i/d)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
		Micropsectra / Tanytarsus	80	64	105	481	8	120	32	0	70	32	140	50	20	64	80
	Orthocladiinae	(i/d)	4	40	0	0	1	0	0	16	20	32	10	20	0	16	24
		Heterotrissocladius	64	32	56	80	24	48	16	24	30	64	20	10	10	64	32
		Nanocladius	0	0	0	0	0	0	0	0	0	10	30	0	0	0	0
		Parakiefferiella	68	72	577	250	80	72	16	32	210	24	130	10	0	24	64
		Synorthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
		Thienemanniella	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0
Terrestrial	-	-	0	0	1	0	1	8	0	0	0	0	0	0	0	0	0
Total			505	474	1082	1646	497	418	260	414	995	477	1312	508	408	378	440

(i/d) = immature or damaged specimen.
Ephemerellidae (i/d) - early instars but probably all *Ephemerella.*

Table XII.9 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for the Calumet River, Fall 2002.

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the Calumet River														
			CAL-D-1	CAL-D-2	CAL-D-3	CAL-D-4	CAL-D-5	CAL-D-6	CAL-D-7	CAL-D-8	CAL-D-9	CAL-D-10	CAL-D-11	CAL-D-12	CAL-D-13	CAL-D-14	CAL-D-15
Nematoda	-	-	1	33	10	0	0	10	0	10	10	1	10	10	101	0	12
Hirudinea	Glossiphoniidae	*Glossiphonia complanata*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Erpobdellidae	*Erpobdella punctata*	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0
Oligochaeta	Enchytraeidae	-	0	0	10	0	0	0	1	0	0	0	10	0	10	0	0
	Naididae	-	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	-	1	0	0	0	3	137	1	11	9	12	27	34	16	23	38
Hydracarina	-	-	0	0	0	0	10	0	1	0	0	0	0	0	10	0	0
Ostracoda	-	-	0	84	23	2	20	30	10	20	10	40	61	30	260	108	42
Copepoda - Cyclopoida	-	-	0	0	0	1	0	0	0	0	0	0	30	0	0	20	10
Copepoda - Harpacticoida	-	-	0	0	0	0	20	0	10	0	0	0	10	10	20	0	0
Cladocera	Chydoridae	-	0	0	0	0	0	0	0	0	0	10	20	0	10	0	0
	Daphnidae	*Daphnia*	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
	Macrothricidae	-	0	0	0	0	0	0	0	0	0	0	20	10	20	10	10
Amphipoda	Gammaridae	*Gammarus lacustris*	0	0	0	0	0	0	0	0	1	9	5	4	2	0	1
	Talitridae	*Hyalella azteca*	0	0	1	0	0	0	0	0	1	13	9	1	0	0	0
Gastropoda	Lymnaeidae	*Stagnicola (?)*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	Planorbidae	(i/d)	0	0	6	27	0	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	0	0	19	28	62	10	33	22	16	5	0	46	23	12	0
Ephemeroptera	Ameletidae	*Ameletus subnotatus*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Caenidae	*Caenis*	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0
	Leptophlebiidae	*Leptophlebia*	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
Plecoptera	Nemouridae	(i/d)	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Trichoptera	Hydroptilidae	(pupa)	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		Oxyethira	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	Limnephilidae (Limnephilini)	(i/d)	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
	Phryganeidae	*Ptilostomis*	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
Odonata - Anisoptera	Corduliidae	*Epitheca*	0	1	7	0	1	0	0	0	0	0	2	0	1	0	0
Coleoptera	Dytiscidae	*Agabus*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Haliplidae	*Haliplus*	0	0	0	3	0	0	0	0	0	2	0	0	2	0	0
Hemiptera	Corixidae	*Sigara*	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Diptera	Tabanidae	*Chrysops*	1	7	0	0	3	3	0	2	3	1	1	1	2	0	0
	Ceratopogonidae	(i/d)	0	10	0	0	13	11	0	22	18	106	11	53	30	24	20
	Chironomidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	(i/d)	0	0	3	61	13	0	11	42	66	121	553	52	111	44	91
		Procladius	0	199	135	35	10	0	0	22	35	93	8	10	117	111	67
	Chironomini	(i/d)	0	0	58	10	60	10	10	20	30	40	60	20	10	33	31
		Chironomus	0	4	9	4	0	0	0	0	0	1	0	0	0	0	0
		Cryptochironomus	0	0	0	0	0	1	0	0	0	2	0	0	1	1	27
		Cryptotendipes / Cladopelma	0	224	246	0	0	0	0	20	10	350	20	30	11	60	80
		Demicryptochironomus	0	0	0	0	1	0	5	0	0	0	0	1	0	12	0
		Dicrotendipes	0	86	1	0	0	0	0	1	2	6	1	1	4	2	0
		Microtendipes	0	0	0	0	0	0	0	0	0	1	0	0	23	1	10
		Parachironomus	0	0	0	0	0	0	0	0	0	0	0	0	1	0	10
		Paracladopelma	0	0	0	0	0	10	11	10	10	1	0	0	0	0	0
		Paratendipes	0	98	68	24	124	150	27	61	88	70	20	30	40	10	22
		Polypedilum	0	24	13	0	121	161	166	86	60	20	10	60	20	10	0
		Stictochironomus	0	0	161	47	44	6	58	12	16	2	0	0	0	0	0
		Saetheria	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
	Tanytarsini	(i/d)	0	0	0	0	10	30	0	10	10	10	60	20	70	50	60
		Cladotanytarsus	0	241	32	0	0	0	0	0	0	10	0	0	0	0	0
		Stempellina	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
		Stempellinella	0	123	66	2	81	0	11	44	89	200	170	90	180	40	50
		Micropsectra / Tanytarsus	0	0	355	632	65	120	90	100	220	180	983	1,105	370	2,717	2,224
	Orthocladiinae	(i/d)	0	0	22	64	32	210	260	180	166	100	20	60	190	169	67
		Corynoneura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31
		Cricotopus / Orthocladius	0	0	0	0	0	0	0	0	0	30	0	10	70	73	10
		Heterotrissocladius	0	5	96	13	50	530	13	420	350	284	177	360	460	177	179
		Metriocnemus	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Parakiefferiella	0	16	39	0	20	111	146	267	232	442	120	90	311	91	20
		Psectrocladius	0	0	2	0	1	0	0	1	1	21	1	0	11	3	3
		Pseudosmittia	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Rheocricotopus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Thienemanniella	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Diamesinae	*Potthastia (longimanus type)*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Terrestrial	-	-	1	1	0	0	0	0	0	0	0	0	0	0	30	0	0
Total			**14**	**1,157**	**1,385**	**954**	**766**	**1,542**	**875**	**1,383**	**1,453**	**2,196**	**2,432**	**2,144**	**2,560**	**3,802**	**3,115**

(i/d) = immature or damaged specimen.

Table XII.10 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for the Christina River, Fall 2002.

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the Christina River															Upper Reach of the Christina River														
			CHR-D-1	CHR-D-2	CHR-D-3	CHR-D-4	CHR-D-5	CHR-D-6	CHR-D-7	CHR-D-8	CHR-D-9	CHR-D-10	CHR-D-11	CHR-D-12	CHR-D-13	CHR-D-14	CHR-D-15	CHR-D-16	CHR-D-17	CHR-D-18	CHR-D-19	CHR-D-20	CHR-D-21	CHR-D-22	CHR-D-23	CHR-D-24	CHR-D-25	CHR-D-26	CHR-D-27	CHR-D-28	CHR-D-29	CHR-D-30
Nematoda	-	-	1	0	0	0	10	0	0	20	10	10	0	1	0	0	4	10	1	32	10	10	20	0	20	10	0	0	30	29	10	0
Hirudinea	Glossiphoniidae	(i/d)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Glossiphonia complanata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0
Oligochaeta	Naididae	-	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tubificidae	-	166	47	992	219	35	81	539	471	211	91	45	302	64	71	143	463	739	16	49	342	23	17	143	459	99	3	2,151	158	33	491
Ostracoda	-	-	0	4	10	0	10	0	10	50	40	30	10	0	5	4	4	303	334	160	70	134	328	4	50	80	334	1	330	36	150	3,045
Copepoda - Cyclopoida	-	-	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	12	0	0
Cladocera	Chydoridae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0
	Macrothricidae	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	20	0	0	0
Gastropoda	Ancylidae	*Ferrissia rivularis*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lymnaeidae	*Stagnicola (?)*	0	0	0	0	0	0	63	41	52	0	9	0	3	2	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0
	Physidae	*Physa*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Unionidae	*Lampsilis radiata*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sphaeriidae	*Pisidium / Sphaerium*	28	1	1	20	52	48	463	35	66	0	55	0	18	36	51	96	142	8	20	160	0	0	12	8	10	1	21	17	55	92
Ephemeroptera	Ametropodidae	*Ametropus neavei*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Baetidae	*Baetis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	2	0	0
	Baetiscidae	*Baetisca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0
	Ephemeridae	*Hexagenia limbata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	41	27	30	46	5	0	13	18	30	0	30	4	7	25
	Heptageniidae	*Stenonema*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Leptohyphidae	*Tricorythodes*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0
	Caenidae	*Brachycercus prudens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
	Leptophlebiidae	*Leptophlebia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	10	0	1	0	0	1	0	0	0	0	0
Plecoptera	Taeniopterygidae	*Taeniopteryx*	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae	*Brachycentrus*	0	0	0	1	5	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hydroptilidae	(pupa)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Hydropsychidae	*Hydropsyche*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Leptoceridae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0
	Limnephilidae (Limnephilini)	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Odonata - Anisoptera	Gomphidae	*Gomphus*	1	1	0	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Ophiogomphus	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	2	0	10	1	0	0	10	5	0	0
Hemiptera	Corixidae	*Sigara*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	9	0	0	0	1	0	0	0	0	1
Diptera	Tipulidae	*Hexatoma*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	1	2	0	0	0	0	0	11	1	0	0
	Tabanidae	*Chrysops*	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0	4	2	1	1	0	1	0	0	2	2	0	0	1	0	10
	Empididae	*Hemerodromia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	10	0	12	0
	Ceratopogonidae	(i/d)	0	0	0	10	0	8	0	2	1	10	0	0	0	0	0	41	34	19	41	41	101	0	40	81	44	0	32	1	11	41
	Chironomidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	(i/d)	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3	19	1	0	0	3	0	10	0	0	1	10	8	50	0
		Ablabesmyia	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	2	7	10	0	0	0	3	0	1	0	20	0
		Procladius	4	0	0	2	3	78	37	260	41	0	38	0	0	1	1	41	100	3	53	109	26	5	0	5	13	0	13	0	1	60
	Chironomini	(i/d)	0	0	10	1	0	0	0	0	0	0	0	0	0	0	0	0	10	8	0	0	0	0	0	0	0	1	10	8	20	0
		Chironomus	4	0	0	0	41	21	29	0	11	21	268	0	0	0	0	0	0	3	0	0	29	0	0	0	2	0	11	0	1	0
		Cryptochironomus	0	0	15	22	10	40	50	31	29	31	0	2	12	8	4	21	20	174	2	0	21	0	120	0	0	0	112	30	21	11
		Demicryptochironomus	0	5	16	3	1	0	0	0	0	0	0	1	0	0	0	1	0	10	0	0	0	0	22	0	0	0	13	0	0	0
		Harnischia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
		Microtendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0
		Paracladopelma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	24	0	0	10	0	30	0	0	1	30	48	70	0
		Paralauterborniella	4	0	0	40	20	136	30	30	21	60	28	0	0	0	0	52	33	88	41	0	65	1	70	20	20	0	40	12	20	30
		Paratendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Polypedilum	20	4	99	214	101	283	78	21	38	60	62	0	148	161	234	150	36	1,868	123	4	119	1	480	42	57	5	1,723	432	163	104
		Robackia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71	0	0	0	0
		Tribelos	0	0	0	0	3	7	4	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanytarsini	*Cladotanytarsus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	8	10	0	1	0	0	0	0	0	90	61	60	0
		Paratanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	10	0
		Rheotanytarsus	0	0	0	0	10	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Stempellinella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	8	0	0	0	0	0	0	0	0	30	8	0	0
		Tanytarsus	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Micropsectra / Tanytarsus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	33	80	30	14	158	0	40	0	2	2	290	104	922	0
	Orthocladiinae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
		Brillia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
		Cricotopus / Orthocladius	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	10	0	0	0
		Epoicocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	1	21	10	0	21	5	2	0	11	0	0	0
		Heterotrissocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	8	0	0	0	0	10	0	0	0	40	12	50	0
		Parakiefferiella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	10	0	30	24	110	0
		Parametriocnemus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
		Thienemanniella	4	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Tvetenia	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Diamesinae	*Potthastia (longimanus type)*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	11	1	2	0	0	1	0	0
Terrestrial	-	-	1	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total invertebrates			**235**	**74**	**1,148**	**534**	**313**	**712**	**1,305**	**1,027**	**522**	**313**	**518**	**308**	**250**	**284**	**442**	**1,231**	**1,566**	**2,592**	**502**	**903**	**1,000**	**31**	**1,122**	**733**	**636**	**86**	**5,109**	**1,017**	**1,822**	**3,911**

(i/d) = immature or damaged specimen.

Table XII.11 Benthic Invertebrate Abundance Data (numbers/Ekman grab sample) for the Tar River, Fall 2002.

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the Tar River														
			TAR-D-1	TAR-D-2	TAR-D-3	TAR-D-4	TAR-D-5	TAR-D-6	TAR-D-7	TAR-D-8	TAR-D-9	TAR-D-10	TAR-D-11	TAR-D-12	TAR-D-13	TAR-D-14	TAR-D-15
Nematoda	-	-	1	8	14	18	11	70	21	106	10	10	32	68	10	8	9
	Erpobdellidae	*Erpobdella punctata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Nephelopsis obscura	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Oligochaeta	Naididae	-	0	0	0	0	0	10	0	0	0	0	0	1	0	0	16
	Tubificidae	-	30	63	798	58	51	142	32	52	21	2	278	85	1	9	119
Hydracarina	-	-	11	1	0	0	0	0	0	10	0	0	20	0	0	0	0
Ostracoda	-	-	22	44	105	8	10	2	0	40	0	0	0	0	8	1	152
Copepoda - Cyclopoida	-	-	0	0	20	16	0	0	0	0	0	1	10	0	0	0	8
Cladocera	Chydoridae	-	0	0	1	0	0	0	0	0	0	0	0	0	0	0	8
Amphipoda	Talitridae	*Hyalella azteca*	0	1	2	0	0	0	0	0	0	0	18	0	0	0	1
Gastropoda	Physidae	*Physa*	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
Pelecypoda	Sphaeriidae	*Pisidium / Sphaerium*	0	6	30	11	10	10	0	10	4	0	33	26	0	0	35
Ephemeroptera	Baetidae	*Procloeon*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		(i/d)	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0
	Leptohyphidae	*Tricorythodes*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Leptophlebiidae	*Leptophlebia*	10	6	9	0	10	0	0	0	0	0	0	0	0	0	17
Plecoptera	Perlodidae	*Diura*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Trichoptera	Brachycentridae	*Brachycentrus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
	Hydroptilidae	(pupa)	0	0	9	0	0	1	0	0	0	0	0	0	0	0	0
	Phryganeidae	*Ptilostomis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Odonata - Anisoptera	Aeshnidae	*Aeshna*	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Corduliidae	*Epitheca*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coleoptera	Dytiscidae	*Agabus*	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0
	Haliplidae	*Haliplus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Tipulidae	(i/d)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Dicranota	0	0	0	0	10	1	5	1	0	0	0	0	9	0	0
		Hexatoma	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
	Tabanidae	*Chrysops*	0	1	2	7	14	21	1	0	0	0	9	21	0	1	0
	Empididae	*Hemerodromia*	162	32	10	16	0	0	0	0	0	0	1	0	0	0	0
	Ceratopogonidae	(i/d)	40	10	2	0	0	0	1	11	10	11	40	24	0	8	10
	Chironomidae	(i/d)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae	(i/d)	90	68	75	8	0	11	0	0	1	2	63	4	0	0	72
		Ablabesmyia	408	221	301	48	20	104	0	0	10	10	194	49	0	0	188
		Procladius	186	120	52	44	23	20	0	0	21	27	42	39	0	0	74
	Chironomini	(i/d)	8	22	50	152	30	120	8	0	4	0	310	81	0	32	25
		Cryptochironomus	0	0	0	16	10	22	0	0	8	10	41	8	0	0	9
		Demicryptochironomus	0	0	0	0	1	2	0	1	0	0	0	0	0	0	0
		Microtendipes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
		Paracladopelma	0	0	0	8	0	0	7	0	8	10	60	0	12	10	8
		Paralauterborniella	18	8	10	32	0	0	24	10	10	40	121	24	0	0	0
		Paratendipes	0	1	11	8	0	0	20	10	0	0	60	0	0	16	0
		Polypedilum	84	46	22	184	120	200	565	346	220	180	930	160	16	80	64
		Stictochironomus	10	2	0	0	0	38	15	0	0	0	0	0	18	185	8
	Tanytarsini	*Cladotanytarsus*	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0
		Paratanytarsus	120	131	173	8	30	122	0	10	8	0	131	24	0	0	17
		Stempellina	20	0	0	0	0	0	0	0	0	0	80	0	0	0	0
		Stempellinella	54	41	33	8	20	20	0	0	0	0	40	16	0	0	0
		Micropsectra / Tanytarsus	786	410	270	168	180	917	4	44	66	70	1,723	304	209	152	257

Major Taxon	Family (subfamily/tribe)	Genus/Species	Lower Reach of the Tar River														
			TAR-D-1	TAR-D-2	TAR-D-3	TAR-D-4	TAR-D-5	TAR-D-6	TAR-D-7	TAR-D-8	TAR-D-9	TAR-D-10	TAR-D-11	TAR-D-12	TAR-D-13	TAR-D-14	TAR-D-15
	Orthocladiinae	(i/d)	24	26	43	8	20	222	8	26	20	20	212	104	0	24	9
		Brillia	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Corynoneura	10	0	0	0	0	1	0	0	0	0	0	0	0	0	0
		Cricotopus / Orthocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
		Doncricotopus	1	11	15	16	0	48	0	0	0	0	0	0	0	8	0
		Heterotrissocladius	388	281	203	304	200	858	12	56	88	150	197	97	184	312	699
		Nanocladius	32	1	2	8	0	5	0	0	0	0	0	0	0	0	1
		Paracladius	0	0	0	0	0	0	0	0	0	0	62	3	40	0	0
		Parakiefferiella	72	51	37	265	231	191	20	66	81	121	6	40	33	144	72
		Psectrocladius	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		Rheocricotopus	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
		Thienemanniella	0	0	0	0	0	20	0	0	0	0	0	0	8	0	0
	Diamesinae	*Potthastia (longimanus type)*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Total invertebrates			**2,590**	**1,614**	**2,304**	**1,420**	**1,001**	**3,192**	**743**	**808**	**590**	**667**	**4,717**	**1,178**	**548**	**1,006**	**1,898**

(i/d) = immature or damaged specimen.

Table XII-12 Supporting Data Collected During the Fall 2002 Benthic Surveys in Rivers and Streams

River/Stream	Site	General Habitat Type	Sample Date	Sample Time	Location: UTM E (NAD 83)	Location: UTM N (NAD 83)	Field Water Quality: Dissolved Oxygen (mg/L)	Conduc-tivity (µS/cm)	pH	Water Temp. (°C)	Water Depth (m)	Current Velocity (m/s)	Bankfull Channel Width (m)	Wetted Channel Width (m)	Habitat Type	Amount of Benthic Algae (visual est.)	Benthic Algal Chlorophyll a (mg/m^2)	Macro-phyte cover (%)	Macrophyte Species	Bottom Sediments (lab analysis): Sand (%)	Silt (%)	Clay (%)	Total Organic Carbon (%)	Substratum as Areal Cover (visual estimates): Sand/ Silt/ Clay (%)	Small Gravel (%)	Large Gravel (%)	Small Cobble (%)	Large Cobble (%)	Boulder (%)	Bedrock (%)
Calumet	CAL-D-1	depositional	2-Oct-02	14:15	460840	6363208	12.5	295	7.6	5.2	0.41	0.02	11	9	Backwater	-	-	0	-	36	40	24	1.9	-	-	-	-	-	-	-
Calumet	CAL-D-2	depositional	2-Oct-02	15:29	460774	6363197	12.9	292	7.6	4.9	0.49	0.01	19	12	Backwater	-	-	0	-	68	22	11	2.4	-	-	-	-	-	-	-
Calumet	CAL-D-3	depositional	2-Oct-02	15:57	460703	6363169	12.3	290	7.6	4.6	0.66	0.00	26	9	Run	-	-	0	-	54	40	6	3.5	-	-	-	-	-	-	-
Calumet	CAL-D-4	depositional	2-Oct-02	16:30	460618	6363144	12.1	288	7.6	4.5	0.18	0.01	13	9	Backwater	-	-	0	-	78	16	6	3.0	-	-	-	-	-	-	-
Calumet	CAL-D-5	depositional	2-Oct-02	14:59	459123	6362480	12.1	277	7.4	4.1	0.32	0.06	8	6	Run	-	-	0	-	73	16	11	3.6	-	-	-	-	-	-	-
Calumet	CAL-D-6	depositional	2-Oct-02	15:28	458940	6362494	12.1	277	7.4	4.2	0.08	0.01	7	5	Backwater	-	-	30	macrophytic algae	68	20	12	4.1	-	-	-	-	-	-	-
Calumet	CAL-D-7	depositional	2-Oct-02	16:26	458730	6362627	10.3	275	7.3	4.0	0.20	0.01	8	5	Backwater	-	-	0	-	75	14	11	5.5	-	-	-	-	-	-	-
Calumet	CAL-D-8	depositional	2-Oct-02	17:01	458694	6362701	11.9	277	7.2	4.2	0.82	0.02	12	9	Run	-	-	10	ALGR	71	21	8	4.5	-	-	-	-	-	-	-
Calumet	CAL-D-9	depositional	2-Oct-02	13:42	458082	6362106	11.5	281	7.4	4.9	0.80	0.02	17	13	Backwater	-	-	10	sedge spp.	78	11	11	2.1	-	-	-	-	-	-	-
Calumet	CAL-D-10	depositional	2-Oct-02	14:07	458130	6362066	11.5	280	7.3	4.9	0.21	0.03	22	15	Backwater	-	-	5	sedge spp.	79	13	8	3.3	-	-	-	-	-	-	-
Calumet	CAL-D-11	depositional	2-Oct-02	12:53	458109	6362014	10.6	276	7.3	4.4	0.48	0.00	14	7	R3 Run	-	-	95	60% sedges, 35% filam algae	31	36	33	3.7	-	-	-	-	-	-	-
Calumet	CAL-D-12	depositional	2-Oct-02	12:31	458106	6361935	10.5	274	7.2	4.2	0.39	0.01	17	3	Backwater	-	-	10	sedge sp.	47	25	28	3.8	-	-	-	-	-	-	-
Calumet	CAL-D-13	depositional	2-Oct-02	11:29	457683	6361650	8.9	264	6.9	3.3	0.70	0.01	15	9	Backwater	-	-	15	unknown sp.	41	30	28	13.3	-	-	-	-	-	-	-
Calumet	CAL-D-14	depositional	2-Oct-02	11:05	457670	6361591	9.0	264	7.0	3.3	1.05	0.00	12	9	P2-Pool	-	-	15	POVA & 2 unknown spp.	40	34	26	4.4	-	-	-	-	-	-	-
Calumet	CAL-D-15	depositional	2-Oct-02	10:27	457680	6361527	8.9	268	6.7	3.1	0.66	0.00	13	10	P2-Pool	-	-	30	POVA	63	15	23	1.0	-	-	-	-	-	-	-
Mackay	MAR-E-1	erosional	13-Sep-02	17:54	460789	6336600	10.4	179	7.5	14.2	0.48	0.74	57	53	RF	Low	43	1	POZO	-	-	-	-	30	25	40	5	0	0	0
Mackay	MAR-E-2	erosional	13-Sep-02	17:34	460753	6336665	10.7	179	7.4	14.2	0.41	0.71	66	54	R2 Run	Low	48	0	-	-	-	-	-	25	30	25	15	5	0	0
Mackay	MAR-E-3	erosional	13-Sep-02	16:18	460334	6336915	10.7	178	7.7	14.4	0.32	0.72	59	53	R2 Run	Low	43	0	-	-	-	-	-	30	20	35	0	15	0	0
Mackay	MAR-E-4	erosional	13-Sep-02	17:00	460331	6336981	10.5	179	7.6	14.3	0.40	0.55	61	57	R2 Run	Low	11	0	-	-	-	-	-	25	20	30	20	5	0	0
Mackay	MAR-E-5	erosional	13-Sep-02	14:34	460333	6337159	10.7	178	7.5	14.4	0.40	0.30	67	27	RF	Low	21	0	-	-	-	-	-	25	15	20	25	15	0	0
Mackay	MAR-E-6	erosional	13-Sep-02	14:58	460337	6337182	10.7	178	7.6	14.5	0.30	0.75	63	40	RF	Low	28	0	-	-	-	-	-	20	20	30	25	5	0	0
Mackay	MAR-E-7	erosional	13-Sep-02	15:20	460367	6337213	10.8	179	7.2	14.5	0.36	0.69	71	49	RF	Low	100	0	-	-	-	-	-	20	25	40	15	0	0	0
Mackay	MAR-E-8	erosional	13-Sep-02	15:41	460377	6337249	10.7	178	7.6	14.4	0.41	0.48	54	49	RF	Low	83	0	-	-	-	-	-	25	20	40	15	0	0	0
Mackay	MAR-E-9	erosional	13-Sep-02	13:35	460306	6337720	10.6	177	7.5	14.1	0.46	0.70	60	50	R2 Run	Low	21	0	-	-	-	-	-	15	25	40	20	0	0	0
Mackay	MAR-E-10	erosional	13-Sep-02	13:04	460375	6337998	10.3	176	7.4	13.9	0.38	0.63	58	42	R2	Low	25	0	-	-	-	-	-	20	20	40	20	0	0	0
Mackay	MAR-E-11	erosional	13-Sep-02	9:55	459473	6338835	9.6	172	7.4	12.8	0.35	0.41	35	20	R2 Run	Low	9	0	-	-	-	-	-	25	15	35	20	5	0	0
Mackay	MAR-E-12	erosional	13-Sep-02	10:38	459474	6338975	9.9	173	7.2	12.9	0.48	0.55	40	30	R2 Run	Low	33	0	-	-	-	-	-	25	20	40	15	0	0	0
Mackay	MAR-E-13	erosional	13-Sep-02	11:01	459528	6338977	10.0	173	7.3	13.0	0.48	0.49	40	30	R2 Run	Low	6	0	-	-	-	-	-	20	20	30	20	10	0	0
Mackay	MAR-E-14	erosional	13-Sep-02	11:24	459548	6339009	10.1	169	7.4	13.2	0.36	0.73	43	35	RF	Low	4	0	-	-	-	-	-	30	20	25	0	25	0	0
Mackay	MAR-E-15	erosional	13-Sep-02	11:55	459587	6339013	10.2	174	7.3	13.4	0.40	0.63	45	40	RF	Low	71	0	-	-	-	-	-	20	20	20	10	30	0	0
MacKay	MAR-E-16	erosional	17-Sep-02	16:47	449663	6319967	11.3	151	8.1	14.1	0.38	0.50	56	44	RF/BG	Low	100	0	-	-	-	-	-	20	5	15	30	25	5	0
MacKay	MAR-E-17	erosional	17-Sep-02	16:22	449576	6319922	11.3	150	8.2	14.1	0.30	0.53	62	52	RF/BG	Low	125	0	-	-	-	-	-	20	10	15	30	25	0	0
MacKay	MAR-E-18	erosional	17-Sep-02	15:52	449308	6319917	11.7	151	8.2	14.1	0.52	0.58	58	42	RF/BG	Low	150	0	-	-	-	-	-	20	5	10	35	25	5	0
MacKay	MAR-E-19	erosional	17-Sep-02	14:49	448946	6319655	11.6	149	8.1	13.8	0.38	0.72	53	38	RF/BG	Low	108	0	-	-	-	-	-	20	15	20	20	15	10	0
MacKay	MAR-E-20	erosional	17-Sep-02	15:12	448987	6319603	11.5	150	8.1	13.1	0.38	0.67	63	49	RF/BG	Low	61	0	-	-	-	-	-	20	5	10	40	20	5	0
MacKay	MAR-E-21	erosional	17-Sep-02	13:54	449283	6319362	11.9	149	8.0	13.7	0.40	0.53	56	40	RF	Low	100	0	-	-	-	-	-	20	5	15	20	35	5	0
MacKay	MAR-E-22	erosional	17-Sep-02	14:17	449274	6319298	11.8	149	8.0	13.7	0.44	0.67	55	40	RF/BG	Low	117	0	-	-	-	-	-	20	5	15	25	30	5	0
MacKay	MAR-E-23	erosional	17-Sep-02	12:55	449160	6319198	11.5	147	7.8	13.1	0.41	0.76	57	41	RF/BG	Low	83	0	-	-	-	-	-	20	10	25	30	10	5	0
MacKay	MAR-E-24	erosional	17-Sep-02	13:25	449099	6319197	11.4	147	7.7	13.2	0.30	0.32	64	49	RF/BG	Low	100	0	-	-	-	-	-	20	10	15	25	20	10	0
MacKay	MAR-E-25	erosional	17-Sep-02	11:46	448894	6319304	11.3	145	7.4	12.2	0.32	0.63	46	38	RF/BG	Low	92	0	-	-	-	-	-	20	10	20	30	15	5	0
MacKay	MAR-E-26	erosional	17-Sep-02	12:08	448852	6319321	11.3	145	7.5	12.4	0.38	0.64	48	39	RF/BG	Low/Mod	72	0	-	-	-	-	-	25	10	20	25	15	5	0
MacKay	MAR-E-27	erosional	17-Sep-02	10:53	448754	6319321	11.1	142	7.3	11.8	0.35	0.70	48	40	RF/BG	Moderate	63	0	-	-	-	-	-	15	10	15	20	35	5	0
MacKay	MAR-E-28	erosional	17-Sep-02	11:15	448715	6319301	11.3	143	7.4	12.0	0.35	0.57	50	41	RF/BG	Moderate	73	0	-	-	-	-	-	20	10	10	35	20	5	0
MacKay	MAR-E-29	erosional	17-Sep-02	10:23	448666	6319235	10.7	143	7.3	11.8	0.38	0.46	68	42	RF/BG	Mod/high	73	50	ALGR	-	-	-	-	15	10	15	20	25	15	0
MacKay	MAR-E-30	erosional	17-Sep-02	9:52	448660	6319148	10.5	142	7.2	11.5	0.32	0.68	64	44	RF/BG	Mod/high	100	0	-	-	-	-	-	15	10	25	25	20	5	0
Steepbank	STR-E-1	erosional	16-Sep-02	9:34	471010	6319828	11.4	109	7.3	10.2	0.30	0.61	43	22	RF	Low	<1	0	-	-	-	-	-	15	15	25	45	0	0	0
Steepbank	STR-E-2	erosional	16-Sep-02	11:42	471888	6320099	10.8	110	7.4	10.4	0.42	0.81	39	24	RF	Low	22	0	-	-	-	-	-	15	15	25	25	15	5	0
Steepbank	STR-E-3	erosional	16-Sep-02	12:18	471962	6320029	11.0	109	7.3	10.4	0.31	0.65	37	33	RF	Low	50	0	-	-	-	-	-	20	20	15	30	10	5	0
Steepbank	STR-E-4	erosional	16-Sep-02	10:50	471752	6320367	10.8	109	7.3	10.4	0.44	0.77	23	20	RF	Low	9	0	-	-	-	-	-	15	15	20	15	25	10	0
Steepbank	STR-E-5	erosional	16-Sep-02	10:04	471389	6320185	11.1	109	7.2	10.3	0.38	0.80	47	22	RF	Low	<1	0	-	-	-	-	-	15	15	25	30	15	0	0
Steepbank	STR-E-6	erosional	16-Sep-02	13:06	472982	6319898	11.0	104	7.3	10.3	0.22	0.75	42	24	RF	Low	3	0	-	-	-	-	-	15	10	5	25	35	10	0
Steepbank	STR-E-7	erosional	16-Sep-02	13:29	472995	6319896	11.0	108	7.3	10.4	0.31	0.75	55	22	RF	Low	<1	0	-	-	-	-	-	20	25	15	25	10	5	0
Steepbank	STR-E-8	erosional	16-Sep-02	13:49	473032	6319879	11.1	109	7.4	10.5	0.40	0.70	50	21	RF	Low	2	0	-	-	-	-	-	15	10	20	30	25	0	0
Steepbank	STR-E-9	erosional	16-Sep-02	14:28	473086	6319923	11.3	108	7.4	10.7	0.42	0.67	59	43	RF	Low	5	0	-	-	-	-	-	20	10	25	40	5	0	0
Steepbank	STR-E-10	erosional	16-Sep-02	14:49	473138	6319946	11.2	108	7.4	10.8	0.38	0.76	41	26	R2 Run	Low	5	0	-	-	-	-	-	15	15	25	35	5	5	0
Steepbank	STR-E-11	erosional	16-Sep-02	15:35	473240	6319391	10.9	104	7.5	10.9	0.46	0.69	53	40	RF/BG	Moderate	58	30	macropyhtic algae	-	-	-	-	20	10	15	20	30	5	0
Steepbank	STR-E-12	erosional	16-Sep-02	16:21	473208	6319385	10.9	108	7.5	11.0	0.27	0.71	55	44	RF/BG	Moderate	22	35	macro & filamentous algae	-	-	-	-	10	15	10	25	35	5	0
Steepbank	STR-E-13	erosional	16-Sep-02	16:46	473359	6319376	10.9	104	7.4	11.0	0.40	0.68	42	28	RF	Low	27	0	-	-	-	-	-	30	5	5	20	35	5	0
Steepbank	STR-E-14	erosional	16-Sep-02	17:09	473387	6319363	10.6	105	7.4	11.1	0.46	0.77	44	21	R2 Run	Low	33	0	-	-	-	-	-	25	5	15	20	35	0	0
Steepbank	STR-E-15	erosional	16-Sep-02	17:50	473408	6319362	10.6	109	7.5	11.3	0.52	0.81	55	30	R2 Run	Low	<1	0	-	-	-	-	-	30	5	10	15	35	5	0
Muskeg	MUR-E-1	erosional	19-Sep-02	18:30	463484	6332421	10.3	172	7.4	12.0	0.29	0.62	36	16	RF	Low	24	0	-	-	-	-	-	15	20	40	25	0	0	0
Muskeg	MUR-E-2	erosional	19-Sep-02	16:40	463603	6332477	10.6	172	7.5	12.1	0.32	0.65	40	17	R3 Run	Low	35	0	-	-	-	-	-	15	20	35	30	0	0	0
Muskeg	MUR-E-3	erosional	19-Sep-02	16:23	463652	6332492	10.4	171	7.5	12.0	0.28	0.56	44	42	R3 Run	Low	38	0	-	-	-	-	-	15	25	35	25	0	0	0
Muskeg	MUR-E-4	erosional	19-Sep-02	18:04	464070	6332068	10.3	172	7.5	12.0	0.32	0.51	34	22	RF	Low	22	0	-	-	-	-	-	15	25	25	35	0	0	0
Muskeg	MUR-E-5	erosional	19-Sep-02	17:40	464135	6332059	10.3	171	7.3	12.0	0.28	0.56	32	28	R3 Run	Low	16	0	-	-	-	-	-	20	20	25	35	0	0	0
Muskeg	MUR-E-6	erosional	19-Sep-02	17:18	464180	6332040	10.8	171	7.3	12.0	0.28	0.82	32	28	R3 Run	Low	28	0	-	-	-	-	-	15	20	20	35	10	0	0
Muskeg	MUR-E-7	erosional	19-Sep-02	15:18	465222	6332522	10.6	170	7.6	12.0	0.30	0.80	32	26	RF	Low	8	0	-	-	-	-	-	15	25	35	25	0	0	0
Muskeg	MUR-E-8	erosional	19-Sep-02	14:48	465266	6332590	10.6	170	7.3	11.8	0.29	0.71	51	13	RF	Low	13	0	-	-	-	-	-	15	20	25	35	5	0	0
Muskeg	MUR-E-9	erosional	19-Sep-02	14:22	465256	6332659	10.5	169	7.5	11.8	0.28	0.79	43	41	R3 Run	Low	39	0	-	-	-	-	-	15	20	25	35	5	0	0
Muskeg	MUR-E-10	erosional	19-Sep-02	13:43	465815	6333147	10.3	170	7.4	11.7	0.38	0.68	28	20	RF	Low	17	0	-	-	-	-	-	20	15	25	30	5	5	0
Muskeg	MUR-E-11	erosional	19-Sep-02	13:15	465842	6333255	10.3	169	7.4	11.6	0.32	0.53	65	13	RF	Low	12	0	-	-	-	-	-	15	20	25	35	5	0	0
Muskeg	MUR-E-12	erosional	19-Sep-02	12:53	465758	6333291	10.4	169	7.3	11.6	0.30	0.67	43	30	R3 Run	Low	32	0	-	-	-	-	-	25	10	20	40	5	0	0
Muskeg	MUR-E-13	erosional	19-Sep-02	11:51	465332	6334255	10.4	168	7.1	11.4	0.30	0.73	33	20	Run	Low	18	0	-	-	-	-	-	25	15	30	25	5	0	0
Muskeg	MUR-E-14	erosional	19-Sep-02	11:25	465274	6334368	10.2	169	7.3	11.3	0.32	0.54	31	20	Run adjacent to	Low	16	0	-	-	-	-	-	10	15	25	30	15	5	0
Muskeg	MUR-E-15	erosional	19-Sep-02	10:59	465217	6334400	10.3	169	7.2	11.3	0.32	0.68	24	22	RF	Very low	25	0	-	-	-	-	-	10	25	20	40	5	0	0
Muskeg	MUR-D-1	depositional	23-Sep-02	17:16	465379	6338955	10.5	164	7.0	8.1	0.56	0.04	n/s	n/s	Backwater	-	-	15	CEDU, SACU	71	18	11	4.9	-	-	-	-	-	-	-
Muskeg	MUR-D-2	depositional	23-Sep-02	16:43	465919	6339453	10.2	163	7.2	8.1	0.50	0.06	21	20	Run	-	-	5	PORI	70	20	9	2.6	-	-	-	-	-	-	-
Muskeg	MUR-D-3	depositional	23-Sep-02	16:10	466335	6339841	10.3	164	7.1	8.8	0.82	0.04	20	19	Backwater	-	-	20	ALGR, PORI	54	34	13	6.1	-	-	-	-	-	-	-
Muskeg	MUR-D-4	depositional	23-Sep-02	15:44	466524	6339800	10.3	164	7.0	8.2	0.60	0.01	19	18	Backwater	-	-	0	-	73	18	10	3.2	-	-	-	-	-	-	-
Muskeg	MUR-D-5	depositional	23-Sep-02	15:22	466541	6339856	10.4	164	7.1	8.2	0.67	0.02	17	15	Backwater	-	-	0	-	59	27	13	6.3	-	-	-	-	-	-	-
Muskeg	MUR-D-6	depositional	23-Sep-02	14:43	466542	6339992	10.3	163	7.2	7.9	0.85	0.02	21	20	Backwater	-	-	0	-	80	10	9	1.7	-	-	-	-	-	-	-
Muskeg	MUR-D-7	depositional	23-Sep-02	14:15	466409	6340006	10.3	163	7.1	8.0	0.58	0.06	17	16	Backawater	-	-	30	ALGR	72	17	11	3.5	-	-	-	-	-	-	-
Muskeg	MUR-D-8	depositional	23-Sep-02	13:46	466501	6340113	9.7	167	6.8	8.1	0.60	0.00	34	33	Backwater	-	-	N/S	scouring rush	29	47	24	10.3	-	-	-	-	-	-	-
Muskeg	MUR-D-9	depositional	23-Sep-02	13:20	466626	6340131	10.2	163	7.2	7.9	0.48	0.01	18	16	Run	-	-	20	ALGR	52	33	16	7.2	-	-	-	-	-	-	-
Muskeg	MUR-D-10	depositional	23-Sep-02	12:58	466612	6340254	9.5	162	7.1	7.9	0.85	0.05	18	16	R2 Run	-	-	20	PORI	59	30	12	4.4	-	-	-	-	-	-	-
Muskeg	MUR-D-11	depositional	23-Sep-02	12:36	466564	6340446	10.1	162	6.9	7.8	0.65	0.02	19	17	Run	-	-	10	PORI	68	23	9	4.4	-	-	-	-	-	-	-
Muskeg	MUR-D-12	depositional	23-Sep-02	11:52	466624	6340513	10.0	162	6.9	7.8	0.84	0.05	19	17	Backwater	-	-	15	ALGR	81	14	5	1.6	-	-	-	-	-	-	-
Muskeg	MUR-D-13	depositional	23-Sep-02	11:28	466716	6340707	10.0	161	7.0	7.7	0.71	0.03	19	17	Backwater	-	-	0	-	68	22	11	4.4	-	-	-	-	-	-	-
Muskeg	MUR-D-14	depositional	23-Sep-02	10:52	466888	6340868	10.1	161	7.0	7.7	0.64	0.06	19	17	Backwater	-	-	35	ALGR,POVA, PORI	45	40	15	5.8	-	-	-	-	-	-	-

Table XII-12 Supporting Data Collected During the Fall 2002 Benthic Surveys in Rivers and Streams

River/Stream	Site	General Habitat Type	Sample Date	Sample Time	Location: UTM E (NAD 83)	Location: UTM N (NAD 83)	Field Water Quality: Dissolved Oxygen (mg/L)	Field Water Quality: Conductivity (µS/cm)	Field Water Quality: pH	Field Water Quality: Water Temp. (°C)	Water Depth (m)	Current Velocity (m/s)	Bankfull Channel Width (m)	Wetted Channel Width (m)	Habitat Type	Amount of Benthic Algae (visual est.)	Benthic Algal Chlorophyll a (mg/m²)	Macrophyte cover (%)	Macrophyte Species	Bottom Sediments (lab analysis): Sand (%)	Silt (%)	Clay (%)	Total Organic Carbon (%)	Substratum as Areal Cover (visual estimates): Sand/Silt/Clay (%)	Small Gravel (%)	Large Gravel (%)	Small Cobble (%)	Large Cobble (%)	Boulder (%)	Bedrock (%)
Muskeg	MUR-D-15	depositional	23-Sep-02	10:29	466744	6340919	10.1	162	6.9	7.7	0.50	0.03	18	16	Backwater	-	-	0	-	82	11	7	1.5	-	-	-	-	-	-	-
Muskeg	MUR-D-16	depositional	20-Sep-02	13:35	478854	6355720	7.0	196	6.7	10.4	0.55	0.04	18	17	Backwater	-	-	0	-	31	28	41	33.3	-	-	-	-	-	-	-
Muskeg	MUR-D-17	depositional	20-Sep-02	12:51	479000	6355839	6.7	196	6.7	10.4	0.84	0.05	20	19	R2 Run	-	-	20	ALGR	84	4	12	14.8	-	-	-	-	-	-	-
Muskeg	MUR-D-18	depositional	20-Sep-02	12:05	478969	6356057	6.8	194	6.8	10.4	0.70	0.02	19	18	Backwater	-	-	5	ALGR	62	16	21	26.7	-	-	-	-	-	-	-
Muskeg	MUR-D-19	depositional	20-Sep-02	11:26	479046	6356202	6.8	194	6.7	10.4	0.80	0.04	18	17	Run	-	-	0	-	15	39	46	35.9	-	-	-	-	-	-	-
Muskeg	MUR-D-20	depositional	20-Sep-02	10:53	479178	6356224	6.8	195	6.7	10.4	0.78	0.03	14	13	Backwater	-	-	10	ALGR	24	33	43	32.4	-	-	-	-	-	-	-
Muskeg	MUR-D-21	depositional	20-Sep-02	10:21	479253	6356234	6.8	194	6.7	10.4	0.75	0.12	15	14	R2 Run	-	-	0	-	74	11	15	19.1	-	-	-	-	-	-	-
Muskeg	MUR-D-22	depositional	18-Sep-02	14:30	480053	6357902	6.7	195	6.9	10.9	0.74	0.00	18	17	Run	-	-	0	-	39	22	39	28.1	-	-	-	-	-	-	-
Muskeg	MUR-D-23	depositional	18-Sep-02	13:45	480370	6358396	6.5	194	6.8	10.7	0.84	0.02	18	17	Backwater	-	-	20	CEDE	42	29	29	24.2	-	-	-	-	-	-	-
Muskeg	MUR-D-24	depositional	18-Sep-02	13:15	480542	6358560	6.4	194	6.9	10.7	0.60	0.01	21	20	Backwater	-	-	15	PORI	56	20	24	29.6	-	-	-	-	-	-	-
Muskeg	MUR-D-25	depositional	18-Sep-02	12:41	481134	6359053	6.2	193	6.8	10.6	0.68	0.01	18	17	Backwater	-	-	10	CEDE	34	22	44	31.0	-	-	-	-	-	-	-
Muskeg	MUR-D-26	depositional	18-Sep-02	11:49	481451	6359188	6.4	192	6.8	10.3	0.66	0.01	15	14	Run	-	-	0	-	46	21	33	30.3	-	-	-	-	-	-	-
Muskeg	MUR-D-27	depositional	18-Sep-02	11:12	481816	6359421	6.4	191	6.8	10.4	0.88	0.01	19	17	Backwater	-	-	0	-	51	15	34	38.4	-	-	-	-	-	-	-
Muskeg	MUR-D-28	depositional	18-Sep-02	10:40	482027	6359633	6.5	200	6.8	10.6	0.80	0.01	20	18	Backwater	-	-	15	CEDE	33	24	43	29.3	-	-	-	-	-	-	-
Muskeg	MUR-D-29	depositional	18-Sep-02	10:05	482102	6359692	6.5	201	6.8	10.5	0.65	0.02	18	16	Backwater	-	-	20	ALGR	19	33	48	31.3	-	-	-	-	-	-	-
Muskeg	MUR-D-30	depositional	18-Sep-02	9:31	482135	6359805	7.0	200	6.8	10.6	0.76	0.09	11	11	R2 Run	-	-	30	ALGR, CEDE, PORI	43	29	28	39.0	-	-	-	-	-	-	-
Clearwater d/s[b]	CLR-D-1	depositional	11-Sep-02	17:52	481109	6282983	9.2	131	7.1	15.0	0.50	0.04	n/a	n/a	Backwater	-	-	15	POZO	53	32	15	1.1	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-2	depositional	11-Sep-02	18:18	480829	6282723	9.6	131	7.1	15.0	0.26	0.02	n/a	n/a	Run	-	-	0	-	50	37	13	1.0	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-3	depositional	7-Sep-02	18:18	480657	6282790	9.9	138	7.4	15.0	0.75	0.04	n/a	n/a	Run	-	-	50	TYLA, ALGR	94	3	4	<0.1	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-4	depositional	7-Sep-02	17:47	480726	6282739	9.9	138	7.3	15.0	0.66	0.07	n/a	n/a	Run	-	-	30	TYLA, SC spp.	48	36	16	1.2	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-5	depositional	7-Sep-02	17:13	480218	6283146	9.4	154	7.4	14.8	0.66	0.10	n/a	n/a	Run	-	-	0	-	22	52	27	2.6	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-6	depositional	12-Sep-02	17:41	480205	6283328	10.1	145	7.1	14.0	0.40	0.04	35	30	Backwater	-	-	10	TYLA	25	51	25	2.8	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-7	depositional	7-Sep-02	16:35	480711	6283998	9.2	142	7.3	15.3	0.64	0.04	n/a	n/a	Backwater	-	-	30	TYLA, SC ssp.	81	11	7	0.1	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-8	depositional	7-Sep-02	16:05	480832	6284200	8.9	140	7.4	15.1	0.75	0.03	n/a	n/a	Backwater	-	-	30	SC spp., ALGR	50	33	17	2.5	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-9	depositional	7-Sep-02	15:36	480719	6284382	9.8	141	9.7	14.9	0.72	0.15	n/a	n/a	Backwater	-	-	30	ALGR	69	23	8	0.4	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-10	depositional	7-Sep-02	15:03	480132	6284367	9.1	153	7.5	14.8	0.62	0.01	n/a	n/a	Backwater	-	-	0	-	71	21	7	0.3	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-11	depositional	7-Sep-02	14:27	479991	6284227	9.7	155	7.5	15.0	0.75	0.02	n/a	n/a	Backwater	-	-	30	TYLA, POZO	55	30	15	1.4	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-12	depositional	7-Sep-02	13:57	479640	6284236	7.4	143	7.5	14.9	0.50	0.06	n/a	n/a	Run	-	-	0	-	62	26	12	0.7	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-13	depositional	7-Sep-02	13:06	479533	6284256	9.3	143	7.5	14.9	0.38	0.28	n/a	n/a	Run	-	-	0	-	78	15	6	0.4	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-14	depositional	7-Sep-02	12:27	479441	6284392	9.2	143	7.2	14.7	0.72	0.18	n/a	n/a	Run	-	-	30	SACU, PHCO, TYLA	72	19	9	0.7	-	-	-	-	-	-	-
Clearwater d/s	CLR-D-15	depositional	7-Sep-02	11:50	479900	6284300	9.4	142	7.1	14.5	0.58	0.05	n/a	n/a	Run	-	-	N/S	ALGR	50	35	15	1.5	-	-	-	-	-	-	-
Clearwater u/s[b]	CLR-D-16	depositional	10-Sep-02	18:04	496165	6280460	10.1	100	6.6	14.3	0.40	0.05	n/a	n/a	Run	-	-	65	PORI, TYLA, Carex sp.	74	18	8	0.9	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-17	depositional	10-Sep-02	17:35	496478	6280527	10.7	101	6.9	14.5	0.36	0.03	n/a	n/a	Backwater	-	-	20	ALGR	48	36	16	1.3	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-18	depositional	10-Sep-02	17:05	496926	6280539	10.9	100	7.0	14.6	0.51	0.06	n/a	n/a	Run	-	-	40	PORI	54	34	12	3.3	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-19	depositional	10-Sep-02	16:40	498361	6279899	10.7	99	6.8	14.2	0.42	0.04	n/a	n/a	Run	-	-	10	PORI	47	38	15	3.4	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-20	depositional	10-Sep-02	16:11	498548	6279864	10.6	99	6.7	14.1	0.38	0.12	n/a	n/a	Run	-	-	30	PORI	56	30	14	1.1	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-21	depositional	10-Sep-02	15:28	498885	6279864	10.6	99	6.9	14.1	0.32	0.11	n/a	n/a	Run	-	-	30	ALGR	59	30	11	1.2	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-22	depositional	10-Sep-02	14:59	499157	6279849	10.9	100	7.1	14.5	0.72	0.02	n/a	n/a	Run	-	-	70	ALGR, PORI, scouring rush	59	27	14	1.5	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-23	depositional	10-Sep-02	14:28	499491	6279967	10.9	99	7.0	14.0	0.51	0.05	n/a	n/a	Backwater	-	-	30	PORI	64	23	13	1.1	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-24	depositional	10-Sep-02	14:03	499548	6279574	10.6	99	7.0	13.9	0.48	0.03	n/a	n/a	Backwater	-	-	30	PORI, ALGR, carex sp.	70	20	10	0.6	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-25	depositional	10-Sep-02	13:37	499387	6279169	10.7	97	7.0	13.5	0.42	0.16	n/a	n/a	Run	-	-	0	-	45	27	29	2.5	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-26	depositional	10-Sep-02	13:15	499569	6279116	10.4	98	7.2	13.7	0.58	0.07	n/a	n/a	Run	-	-	40	PORI	38	43	19	3.4	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-27	depositional	10-Sep-02	12:49	499818	6279069	10.9	97	7.0	13.4	0.33	0.05	n/a	n/a	Backwater	-	-	5	ALGR	72	1	27	0.7	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-28	depositional	10-Sep-02	12:01	499906	6279375	9.3	97	6.9	13.0	0.40	0.02	n/a	n/a	Backwater	-	-	5	ALGR	73	18	9	1.6	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-29	depositional	10-Sep-02	11:25	499769	6279773	9.6	97	6.9	13.1	0.75	0.01	n/a	n/a	Backwater	-	-	10	Gramminoid sp. in water	41	34	24	2.5	-	-	-	-	-	-	-
Clearwater u/s	CLR-D-30	depositional	10-Sep-02	10:52	499819	6279839	10.7	97	6.9	12.9	0.60	0.00	n/a	n/a	Run	-	-	50	ALGR, PORI	31	42	26	3.3	-	-	-	-	-	-	-
Christina	CHR-D-1	depositional	11-Sep-02	8:54	495834	6280550	8.7	213	7.4	13.6	0.26	0.09	n/a	n/a	Run	-	-	40	TYLA, PORI, scouring rush	80	12	8	0.5	-	-	-	-	-	-	-
Christina	CHR-D-2	depositional	11-Sep-02	9:24	495765	6280486	9.2	214	7.6	13.7	0.54	0.08	n/a	n/a	Backwater	-	-	0	-	63	24	13	0.9	-	-	-	-	-	-	-
Christina	CHR-D-3	depositional	11-Sep-02	9:53	495783	6280359	9.0	214	7.6	13.8	0.30	0.14	n/a	n/a	Backwater	-	-	25	POZO, ALGR	62	25	13	0.9	-	-	-	-	-	-	-
Christina	CHR-D-4	depositional	11-Sep-02	10:21	495887	6280250	9.1	215	7.5	13.9	0.78	0.10	n/a	n/a	Backwater	-	-	30	ALGR	45	36	19	1.2	-	-	-	-	-	-	-
Christina	CHR-D-5	depositional	11-Sep-02	10:56	496410	6280255	9.4	217	7.6	14.2	0.64	0.07	n/a	n/a	Run	-	-	60	ALGR, TYLA, scirpus sp.	67	18	14	1.2	-	-	-	-	-	-	-
Christina	CHR-D-6	depositional	11-Sep-02	11:29	496749	6279918	9.5	216	7.6	14.3	0.75	0.04	n/a	n/a	Run	-	-	N/S	ALGR, POZO	49	32	20	1.5	-	-	-	-	-	-	-
Christina	CHR-D-7	depositional	11-Sep-02	12:30	497634	6278829	9.7	217	7.6	14.4	0.50	0.04	n/a	n/a	Run	-	-	90	ALGR, PORI, TYLA, scouring ru	29	43	27	2.1	-	-	-	-	-	-	-
Christina	CHR-D-8	depositional	11-Sep-02	13:26	496755	6280039	10.1	220	7.7	15.2	0.49	0.19	n/a	n/a	Run	-	-	85	ALGR, PORI	34	43	23	1.8	-	-	-	-	-	-	-
Christina	CHR-D-9	depositional	11-Sep-02	13:54	496653	6280101	9.9	221	7.7	15.3	0.28	0.06	n/a	n/a	Run	-	-	30	ALGR, TYLA, scirpus sp.	38	39	22	1.8	-	-	-	-	-	-	-
Christina	CHR-D-10	depositional	11-Sep-02	14:32	497003	6279736	10.0	222	7.7	15.3	0.43	0.08	n/a	n/a	Backwater	-	-	30	ALGR, POZO, TYLA	36	44	20	1.7	-	-	-	-	-	-	-
Christina	CHR-D-11	depositional	11-Sep-02	15:00	496992	6279698	9.7	220	7.7	15.0	0.40	0.05	n/a	n/a	Run	-	-	20	ALGR, CALCAN, Scouring rush	24	50	26	2.3	-	-	-	-	-	-	-
Christina	CHR-D-12	depositional	11-Sep-02	15:33	496410	6280298	9.2	223	7.7	15.6	0.63	0.01	n/a	n/a	Backwater	-	-	10	POZO	65	23	12	0.9	-	-	-	-	-	-	-
Christina	CHR-D-13	depositional	11-Sep-02	16:03	496309	6280224	9.7	221	7.6	15.1	0.47	0.04	n/a	n/a	Backwater	-	-	0	-	71	15	14	0.8	-	-	-	-	-	-	-
Christina	CHR-D-14	depositional	11-Sep-02	16:28	496133	6280289	9.7	224	7.8	15.7	0.41	0.01	n/a	n/a	Run	-	-	40	ALGR	44	36	20	1.4	-	-	-	-	-	-	-
Christina	CHR-D-15	depositional	11-Sep-02	16:52	495984	6280320	10.0	223	7.7	15.5	0.40	0.06	n/a	n/a	Backwater	-	-	20	ALGR, TYLA	86	6	8	0.4	-	-	-	-	-	-	-
Christina	CHR-D-16	depositional	26-Sep-02	17:11	510963	6191979	12.0	143	7.5	4.7	0.30	0.02	59	55	Run	-	-	0	-	72	18	10	0.6	-	-	-	-	-	-	-
Christina	CHR-D-17	depositional	26-Sep-02	16:34	510284	6192180	12.1	143	7.5	4.7	0.38	0.00	57	44	Run-no flow	-	-	0	-	46	39	15	2.0	-	-	-	-	-	-	-
Christina	CHR-D-18	depositional	26-Sep-02	16:07	510469	6191859	12.4	143	7.5	4.7	0.45	0.16	59	39	Run	-	-	0	-	76	16	8	0.5	-	-	-	-	-	-	-
Christina	CHR-D-19	depositional	26-Sep-02	15:40	510281	6191769	12.3	143	7.6	4.7	0.24	0.02	58	50	Run	-	-	0	-	48	41	11	1.2	-	-	-	-	-	-	-
Christina	CHR-D-20	depositional	26-Sep-02	15:13	510087	6191847	11.4	143	7.6	4.7	0.58	0.02	50	40	Backwater	-	-	0	-	37	49	14	1.8	-	-	-	-	-	-	-
Christina	CHR-D-21	depositional	26-Sep-02	14:42	509831	6191738	12.4	143	7.5	4.9	0.13	0.02	52	38	Run	-	-	5	EQU spp.	78	16	6	0.7	-	-	-	-	-	-	-
Christina	CHR-D-22	depositional	26-Sep-02	14:16	509802	6191609	12.2	142	7.7	4.5	0.75	0.02	57	42	Run	-	-	0	-	81	12	8	0.3	-	-	-	-	-	-	-
Christina	CHR-D-23	depositional	26-Sep-02	13:42	510168	6191672	12.3	141	7.6	4.2	0.42	0.21	61	43	Run	-	-	0	-	65	27	8	0.9	-	-	-	-	-	-	-
Christina	CHR-D-24	depositional	26-Sep-02	13:15	510329	6191573	11.9	140	7.6	4.1	0.61	0.04	53	42	Backwater	-	-	0	-	60	27	12	1.1	-	-	-	-	-	-	-
Christina	CHR-D-25	depositional	26-Sep-02	12:32	510054	6191307	12.2	139	7.3	4.0	0.19	0.02	52	41	Run	-	-	50	EQU spp.	52	31	16	3.6	-	-	-	-	-	-	-
Christina	CHR-D-26	depositional	26-Sep-02	11:52	509917	6191101	12.2	137	7.6	3.6	0.31	0.31	56	44	Run	-	-	0	-	96	2	2	0.1	-	-	-	-	-	-	-
Christina	CHR-D-27	depositional	26-Sep-02	11:20	510098	6191098	12.2	136	7.4	3.3	0.80	0.13	56	41	Run	-	-	0	-	72	20	8	0.8	-	-	-	-	-	-	-
Christina	CHR-D-28	depositional	26-Sep-02	10:47	510003	6190961	12.5	136	7.4	3.3	0.42	0.07	55	42	Backwater	-	-	0	-	86	10	4	0.2	-	-	-	-	-	-	-
Christina	CHR-D-29	depositional	26-Sep-02	10:10	509728	6190458	12.6	135	7.4	3.1	0.88	0.07	56	42	Backwater	-	-	0	-	70	20	10	0.8	-	-	-	-	-	-	-
Christina	CHR-D-30	depositional	26-Sep-02	9:48	509437	6190475	12.6	135	7.6	3.1	0.46	0.02	60	50	Backwater	-	-	0	-	56	31	14	1.5	-	-	-	-	-	-	-
Tar	TAR-D-1	depositional	24-Sep-02	13:48	458899	6353466	12.7	184	7.4	5.4	0.34	0.06	10	6	Run	-	-	5	macrophytic algae	53	27	20	1.7	-	-	-	-	-	-	-
Tar	TAR-D-2	depositional	24-Sep-02	14:25	458850	6353498	12.8	185	7.5	5.6	0.33	0.27	16	10	Run	-	-	0	-	48	25	27	13.4	-	-	-	-	-	-	-
Tar	TAR-D-3	depositional	30-Sep-02	8:43	458749	6353771	12.9	182	7.2	4.0	0.24	0.02	16	9	Backwater	-	-	80	filamentous algae	51	29	20	2.1	-	-	-	-	-	-	-
Tar	TAR-D-4	depositional	30-Sep-02	9:20	458692	6353753	13.2	174	7.0	3.9	0.22	0.03	23	12	Backwater	-	-	70	filamentous algae	71	17	11	0.7	-	-	-	-	-	-	-
Tar	TAR-D-5	depositional	30-Sep-02	9:57	458612	6353578	11.9	172	7.2	3.8	0.30	0.04	37	17	Backwater	-	-	0	-	73	13	13	1.3	-	-	-	-	-	-	-
Tar	TAR-D-6	depositional	30-Sep-02	10:40	458439	6353419	12.7	170	7.2	3.9	0.23	0.15	17	10	Run	-	-	40	filamentous algae	67	20	13	1.3	-	-	-	-	-	-	-
Tar	TAR-D-7	depositional	30-Sep-02	11:08	458338	6353410	13.1	173	7.1	3.9	0.30	0.11	20	15	Run	-	-	0	-	83	10	7	0.7	-	-	-	-	-	-	-
Tar	TAR-D-8	depositional	30-Sep-02	12:07	457414	6354099	12.8	179	7.4	4.4	0.17	0.09	20	14	Run	-	-	15	macrophytic algae	71	16	13	1.1	-	-	-	-	-	-	-
Tar	TAR-D-9	depositional	30-Sep-02	12:36	457452	6354152	12.7	170	7.4	4.6	0.25	0.01	20	16	Run	-	-	30	10% macroph, 20% filament	78	12	11	1.3	-	-	-	-	-	-	-
Tar	TAR-D-10	depositional	30-Sep-02	13:04	457467	6354228	11.4	177	7.4	4.8	0.25	0.01	25	11	Backwater	-	-	40	10% macroph, 30% filament	67	21	12	1.3	-	-	-	-	-	-	-
Tar	TAR-D-11	depositional	30-Sep-02	14:07	457113	6354494	11.6	177	7.6	5.0	0.33	0.08	30	11	Run	-	-	80	filamentous algae	71	17	12	1.2	-	-	-	-	-	-	-
Tar	TAR-D-12	depositional	30-Sep-02	14:31	457125	6354438	12.3	178	7.5	5.0	0.38	0.05	28	11	Backwater	-	-	60	filamentous algae	73	14	13	1.4	-	-	-	-	-	-	-

Table XII-12 Supporting Data Collected During the Fall 2002 Benthic Surveys in Rivers and Streams

					Location	Field Water Quality														Bottom Sediments (lab analysis)				Substratum as Areal Cover (visual estimates)						
River/Stream	Site	General Habitat Type	Sample Date	Sample Time	UTM E (NAD 83)	UTM N (NAD 83)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH	Water Temp. (°C)	Water Depth (m)	Current Velocity (m/s)	Bankfull Channel Width (m)	Wetted Channel Width (m)	Habitat Type	Amount of Benthic Algae (visual est.)	Benthic Algal Chlorophyll *a* (mg/m^2)	Macrophyte cover (%)	Macrophyte Species	Sand (%)	Silt (%)	Clay (%)	Total Organic Carbon (%)	Sand/ Silt/ Clay (%)	Small Gravel (%)	Large Gravel (%)	Small Cobble (%)	Large Cobble (%)	Boulder (%)	Bedrock (%)
Tar	TAR-D-13	depositional	2-Oct-02	8:53	456400	6355802	13.2	167	7.2	3.4	0.20	0.03	15	11	Run	-	-	0	-	81	9	10	0.4	-	-	-	-	-	-	-
Tar	TAR-D-14	depositional	2-Oct-02	9:17	456396	6355900	12.8	167	7.1	3.4	0.22	0.04	24	17	Backwater	-	-	0	-	92	4	4	0.2	-	-	-	-	-	-	-
Tar	TAR-D-15	depositional	2-Oct-02	9:45	456413	6355942	10.6	167	7.1	3.4	0.22	0.01	23	17	Backwater	-	-	10	POVA	62	24	14	1.4	-	-	-	-	-	-	-
Ells	ELR-D-1	depositional	25-Sep-02	9:56	459252	6351492	13.1	98	7.1	3.0	0.68	0.01	30	22	Backwater	-	-	0	-	55	30	15	1.4	-	-	-	-	-	-	-
Ells	ELR-D-2	depositional	25-Sep-02	17:39	459005	6352025	13.7	103	7.6	5.1	0.80	0.04	30	23	Backwater	-	-	40	POVA	42	38	20	2.7	-	-	-	-	-	-	-
Ells	ELR-D-3	depositional	25-Sep-02	17:10	458891	6351658	13.9	104	7.5	5.1	0.56	0.01	32	24	Backwater	-	-	40	POVA	62	26	12	1.5	-	-	-	-	-	-	-
Ells	ELR-D-4	depositional	25-Sep-02	16:32	458392	6351290	13.2	111	7.1	4.9	0.44	0.02	30	22	Backwater	-	-	40	POVA	49	33	18	2.7	-	-	-	-	-	-	-
Ells	ELR-D-5	depositional	25-Sep-02	16:08	458536	6351240	14.5	103	7.9	4.8	0.66	0.00	54	38	Backwater	-	-	65	POVA	53	27	20	2.3	-	-	-	-	-	-	-
Ells	ELR-D-6	depositional	25-Sep-02	15:38	458675	6351115	14.6	102	7.8	4.7	0.58	0.02	29	26	Backwater	-	-	50	POVA	89	7	4	0.9	-	-	-	-	-	-	-
Ells	ELR-D-7	depositional	25-Sep-02	15:02	458525	6350914	14.8	102	7.6	4.5	0.40	0.07	45	23	Backwater	-	-	5	POVA	50	34	16	2.0	-	-	-	-	-	-	-
Ells	ELR-D-8	depositional	25-Sep-02	14:32	458677	6350910	14.0	106	7.3	4.4	0.55	0.01	34	20	Backwater	-	-	50	PORI, POVA	68	21	10	2.3	-	-	-	-	-	-	-
Ells	ELR-D-9	depositional	25-Sep-02	14:07	458863	6350839	14.0	101	7.5	4.2	0.75	0.02	33	24	Backwater	-	-	50	PORI, POVA	40	37	22	3.1	-	-	-	-	-	-	-
Ells	ELR-D-10	depositional	25-Sep-02	13:38	458852	6350745	13.8	100	7.2	3.9	0.42	0.03	32	22	Backwater	-	-	20	POVA	56	28	17	2.3	-	-	-	-	-	-	-
Ells	ELR-D-11	depositional	25-Sep-02	13:08	458702	6350560	13.6	100	7.7	3.7	0.54	0.01	31	23	Backwater	-	-	20	POVA	76	16	8	1.1	-	-	-	-	-	-	-
Ells	ELR-D-12	depositional	25-Sep-02	12:19	458556	6350604	13.4	99	7.3	3.4	0.55	0.09	32	20	Run	-	-	10	POVA	64	21	15	1.5	-	-	-	-	-	-	-
Ells	ELR-D-13	depositional	25-Sep-02	11:50	458401	6350598	13.3	98	7.3	3.3	0.25	0.02	32	22	Run	-	-	30	POVA	70	21	10	1.3	-	-	-	-	-	-	-
Ells	ELR-D-14	depositional	25-Sep-02	11:07	458474	6350270	13.3	98	7.2	3.1	0.44	0.02	34	19	Run	-	-	0	-	52	32	16	2.3	-	-	-	-	-	-	-
Ells	ELR-D-15	depositional	25-Sep-02	10:44	458335	6350226	13.5	98	7.1	3.1	0.60	0.07	36	28	Backwater	-	-	0	-	44	36	20	2.4	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-1	depositional	27-Sep-02	17:19	471808	6346388	12.5	106	7.1	3.4	0.30	0.05	19	14	Backwater	-	-	0	-	89	9	2	0.5	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-2	depositional	27-Sep-02	16:56	471843	6346386	12.5	105	7.1	3.4	0.37	0.01	24	20	Backwater	-	-	0	-	78	17	5	1.5	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-3	depositional	27-Sep-02	16:29	472035	6346302	12.9	105	7.2	3.3	0.17	0.09	22	15	Run	-	-	0	-	83	14	3	0.9	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-4	depositional	27-Sep-02	16:04	472119	6346386	12.4	105	7.3	3.3	0.30	0.02	19	14	Backwater	-	-	0	-	68	24	8	2.4	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-5	depositional	27-Sep-02	15:27	472353	6346502	12.4	105	7.2	3.3	0.39	0.02	18	15	Backwater	-	-	30	PORI	84	11	5	0.8	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-6	depositional	27-Sep-02	14:50	472564	6346421	12.7	104	7.1	3.2	0.24	0.03	21	18	Backwater	-	-	0	-	85	11	4	1.1	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-7	depositional	27-Sep-02	14:14	472602	6346370	12.6	104	7.1	3.1	0.50	0.02	17	14	Backwater	-	-	0	-	80	16	4	0.8	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-8	depositional	27-Sep-02	13:49	472617	6346434	12.7	104	7.1	3.0	0.42	0.00	13	11	Run	-	-	0	-	86	11	3	1.0	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-9	depositional	27-Sep-02	13:24	472736	6346488	12.6	103	7.1	2.9	0.34	0.01	20	17	Backwater	-	-	0	-	83	13	4	1.3	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-10	depositional	27-Sep-02	13:02	472683	6346366	12.9	103	7.0	2.9	0.23	0.02	16	14	Backwater	-	-	0	-	88	9	3	1.2	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-11	depositional	27-Sep-02	11:57	472826	6346556	12.8	102	7.0	2.7	0.56	0.02	17	15	Backwater	-	-	0	-	77	16	7	1.9	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-12	depositional	27-Sep-02	11:20	472956	6346491	12.9	102	7.0	2.6	0.34	0.02	11	10	Backwater	-	-	0	-	87	10	3	0.9	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-13	depositional	27-Sep-02	10:57	473009	6346333	12.9	102	7.1	2.6	0.39	0.01	14	12	Backwater	-	-	0	-	93	4	4	1.0	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-14	depositional	27-Sep-02	10:25	473060	6346309	13.2	102	7.0	2.6	0.39	0.02	15	13	Backwater	-	-	20	PORI	93	5	2	0.2	-	-	-	-	-	-	-
Jackpine Creek	JAC-D-15	depositional	27-Sep-02	10:01	473024	6346245	13.2	102	7.0	2.6	0.61	0.00	18	14	Backwater	-	-	0	-	91	6	3	1.1	-	-	-	-	-	-	-
Fort Creek	FOC-D-1	depositional	24-Sep-02	9:57	461532	6363114	12.1	256	7.3	4.7	0.19	0.27	10	1	Run	-	-	0	-	84	10	5	1.3	-	-	-	-	-	-	-
Fort Creek	FOC-D-2	depositional	24-Sep-02	10:26	461554	6363109	11.9	257	7.0	4.8	0.23	0.08	9	2	Run	-	-	0	-	89	7	4	0.9	-	-	-	-	-	-	-
Fort Creek	FOC-D-3	depositional	24-Sep-02	11:01	461596	6363110	11.8	258	7.2	4.8	0.15	0.02	10	3	Backwater	-	-	0	-	79	13	8	1.6	-	-	-	-	-	-	-
Fort Creek	FOC-D-4	depositional	24-Sep-02	11:26	461613	6363110	11.7	258	7.3	4.9	0.18	0.13	20	4	Run	-	-	0	-	71	17	12	4.5	-	-	-	-	-	-	-
Fort Creek	FOC-D-5	depositional	24-Sep-02	11:51	461633	6363110	12.0	257	7.3	4.9	0.07	0.01	12	3	Run	-	-	0	-	74	16	10	3.9	-	-	-	-	-	-	-

[a] - = no data.

[b] Clearwater d/s = Clearwater River downstream of Christina River; Clearwater u/s = Clearwater River upstream of Christina River.

Table XII-13 Supporting Data Collected During the Fall 2002 Benthic Surveys in Lakes

Lake	Site	Sample Date	Sample Time	Location		Water Depth (m)	Field Water Quality				Bottom Sediments (lab analysis)				Macro-phyte cover (%)	Macrophyte Species
				UTM E (NAD 83)	UTM N (NAD 83)		Dissolved Oxygen (mg/L)	Conduc-tivity (µS/cm)	pH	Water. Temp (°C)	Sand (%)	Silt (%)	Clay (%)	Total Organic Carbon (%)		
Kearl	KEL-1	4-Sep-02	13:52	484875	6350294	2.0	6.4	147	6.9	16.7	15	48	37	39.9	5	NUVA
Kearl	KEL-2	4-Sep-02		485000	6349556	2.9	-	-	-	-	14	46	39	38.0	0	-
Kearl	KEL-3	4-Sep-02		486004	6349279	2.1	-	-	-	-	6	39	55	37.6	1	NUVA
Kearl	KEL-4	4-Sep-02		486043	6349557	2.2	-	-	-	-	24	33	43	30.5	0	-
Kearl	KEL-5	4-Sep-02		485790	6349787	2.1	6.8	143	6.9	16.7	7	35	58	32.1	0	-
Kearl	KEL-6	4-Sep-02		485757	6350222	2.2	-	-	-	-	11	51	38	35.6	0	-
Kearl	KEL-7	4-Sep-02		486111	6350548	2.2	-	-	-	-	22	35	43	38.0	0	-
Kearl	KEL-8	4-Sep-02		486518	6350983	2.2	-	-	-	-	8	37	54	39.6	0	-
Kearl	KEL-9	4-Sep-02		486204	6351415	2.0	-	-	-	-	19	32	48	41.7	1	NUVA
Kearl	KEL-10	4-Sep-02	18:22	485488	6351174	2.2	6.9	149	7.0	17.0	22	39	40	41.4	0	-
McClelland	MCL-1	6-Sep-02	12:05	479214	6372959	2.0	9.1	173	8.1	15.1	2	51	47	20.7	90	POVA, CEDE
McClelland	MCL-2	6-Sep-02		478928	6372132	2.1	-	-	-	-	8	51	42	31.6	0	-
McClelland	MCL-3	6-Sep-02		478612	6371482	2.2	-	-	-	-	6	50	43	31.0	0	-
McClelland	MCL-4	6-Sep-02		477417	6370085	2.0	-	-	-	-	7	43	50	40.1	0	-
McClelland	MCL-5	6-Sep-02		480905	6373597	2.2	8.9	186	7.9	16.5	5	54	41	32.8	0	-
McClelland	MCL-6	6-Sep-02		480772	6374478	2.2	-	-	-	-	9	40	50	33.1	10	POVA
McClelland	MCL-7	6-Sep-02		480632	6374700	1.8	-	-	-	-	11	49	40	31.0	10	CEDE
McClelland	MCL-8	6-Sep-02		481398	6374262	2.0	-	-	-	-	23	35	42	31.4	0	-
McClelland	MCL-9	6-Sep-02		481705	6374010	2.2	-	-	-	-	11	53	36	31.3	10	CEDE, ALGR
McClelland	MCL-10	6-Sep-02	18:07	480427	6374526	1.6	10.1	180	6.5	16.1	10	48	43	28.9	20	CEDE
Shipyard	SHL-1	12-Sep-02	10:02	473311	6313564	2.0	3.6	286	6.6	14.5	1	37	62	6.0	0	-
Shipyard	SHL-2	12-Sep-02		473387	6313433	1.8	-	-	-	-	-	-	-	16.0	0	ALGR
Shipyard	SHL-3	12-Sep-02		473320	6313273	1.7	-	-	-	-	-	-	-	23.7	5	CEDE
Shipyard	SHL-4	12-Sep-02		473192	6313087	2.0	-	-	-	-	3	50	47	8.3	0	CEDE,POZO
Shipyard	SHL-5	12-Sep-02		473314	6313022	1.6	3.6	302	6.6	15.0	-	-	-	23.3	30	CEDE
Shipyard	SHL-6	12-Sep-02		473467	6313046	2.0	-	-	-	-	1	50	49	6.2	0	CEDE
Shipyard	SHL-7	12-Sep-02		473546	6312970	2.2	-	-	-	-	1	42	57	9.0	30	CEDE
Shipyard	SHL-8	12-Sep-02		473595	6313127	1.8	-	-	-	-	-	-	-	24.5	0	POZO
Shipyard	SHL-9	12-Sep-02		473581	6313221	1.6	-	-	-	-	-	-	-	22.3	30	CEDE, POZO
Shipyard	SHL-10	12-Sep-02	15:22	473548	6313348	1.8	4.3	295	6.7	15.8	-	-	-	15.2	10	POZO

[(a)] - = no data.

APPENDIX XIII

COMMON AND SCIENTIFIC NAMES OF FISH SPECIES

Table XIII.1 Fish Species Common Names, Scientific Names and Abbreviations

Common Name	Scientific Name	Abbreviation[a]
arctic grayling	*Thymallus arcticus*	ARGR
atlantic salmon	*Salmo salar*	n/a
brassy minnow	*Hybognathus hankinsoni*	BRMN
brook stickleback	*Culaea inconstans*	BRST
brook trout	*Salvelinus fontinalis*	BKTR
bull trout	*Salvelinus confluentus*	BLTR
burbot	*Lota lota*	BURB
carp	*Cyprinus carpio*	n/a
chinook salmon	*Oncorhynchus tshawytscha*	n/a
dogfish	*Scyliorhinus canicula*	n/a
emerald shiner	*Notropis atherinoides*	EMSH
fathead minnow	*Pimephales promelas*	FTMN
finescale dace	*Phoxinus neogaeus*	FNDC
flathead chub	*Platygobio gracilis*	FLCH
goldeye	*Hiodon alosoides*	GOLD
Iowa darter	*Etheostoma exile*	IWDR
lake chub	*Couesius plumbeus*	LKCH
lake cisco	*Coregonus artedii*	CISC
lake whitefish	*Coregonus clupeaformis*	LKWH
longnose dace	*Rhinichthys cataractae*	LNDC
longnose sucker	*Catostomus catostomus*	LNSC
mountain whitefish	*Prosopium williamsoni*	MNWH
ninespine stickleback	*Pungitius pungitius*	NNST
northern pike	*Esox lucius*	NRPK
northern redbelly dace	*Phoxinus eos*	NRDC
pearl dace	*Semotilus margarita*	PRDC
rainbow trout	*Oncorhynchus mykiss*	RNTR
river shiner	*Notropis blennius*	RVSH
slimy sculpin	*Cottus cognatus*	SLSC
spoonhead sculpin	*Cottus ricei*	SPSC
spottail shiner	*Notropis hudsonius*	SPSH
trout-perch	*Percopsis omiscomaycus*	TRPR
walleye	*Stizostedion vitreum*	WALL
white sucker	*Catostomus commersoni*	WHSC
yellow perch	*Perca flavescens*	YLPR

[a] According to Mackay et al. (1990).

APPENDIX XIV

EXTERNAL AND INTERNAL PATHOLOGY CODES, DEFINITIONS AND INDEX VALUES

Variable	Variable Condition	Code	Pathology Index Value
eyes	no aberrations; good "clear" eye	N	0
	blind; an opaque eye (one or both)	B	30
	swollen, protruding eye (one or both)	E	30
	hemorrhaging or bleeding in the eye (one or both)	H	30
	missing one or both eyes	M	30
	other; any condition not covered above	OT	30
gills	normal; no apparent aberrations	N	0
	frayed; erosion of tips of gill lamellae resulting in "ragged" gills	F	30
	clubbed; swelling of the tips of the gill lamellae	C	30
	marginate; gills with light, discoloured margin along tips of the lamellae	M	30
	pale; very light in colour	P	30
	other; any condition not covered above	OT	30
pseudobranchs	normal; flat, containing no aberrations	N	0
	swollen; convex in aspect	S	30
	lithic; mineral deposits, white, somewhat amorphous spots	L	30
	inflamed; redness, hemorrhage, or other	I	30
	other; any condition not covered above	OT	30
thymus	no hemorrhage	0	0
	mild hemorrhage	1	10
	moderate hemorrhage	2	20
	Severe hemorrhage	3	30
skin	normal; no aberrations	0	0
	mild skin aberrations	1	10
	moderate skin aberrations	2	20
	severe skin aberrations	3	30
fins	no active erosion	0	0
	light active erosion	1	10
	moderate active erosion with some hemorrhaging	2	20
	severe active erosion with hemorrhaging	3	30
opercle	no shortening	0	0
	mild shortening	1	30
	Severe shortening	2	30
hindgut	normal; no inflammation or reddening	0	0
	slight inflammation or reddening	1	10
	moderate inflammation or reddening	2	20
	severe inflammation or reddening	3	30
body deformities	none	none	0
	any deformity (provide details)	n/a	30

Variable	Variable Condition	Code	Pathology Index Value
mesenteric fat	none	0	n/a
	< 50 % coverage of mesentery	1	n/a
	50 % coverage of mesentery	2	n/a
	> 50 % coverage of mesentery	3	n/a
	100 % coverage of mesentery	4	n/a
liver	normal; solid red or light red colour	A	0
	"fatty" liver; "coffee with cream" colour	C	30
	nodules in the liver; cysts or nodules	D	30
	focal discoloration; distinct localized colour changes	E	30
	general discoloration; colour change in whole liver	F	30
	other; any condition not covered above	OT	30
spleen	normal; black, very dark red, or red	B	0
	granular; rough appearance of spleen	G	30
	nodular; containing fistulas or nodules of varying sizes	D	30
	enlarged; noticeable enlarged	E	30
	other; any condition not covered above	OT	30
gall bladder	normal	0	0
	enlarged	1	30
	parasites	2	n/a
kidney	normal; firm dark red colour, lying relatively flat along vertebral column	N	0
	swollen; enlarged or swollen wholly or in part	S	30
	mottled; gray discoloration	M	30
	granular; granular appearance and texture	G	30
	urolithiasis/nephrocalcinosis; white/cream mineral material in tubules	U	30
	other; any condition not covered above	OT	30
parasites	no observed parasites	0	0
	few observed parasites	1	10
	moderate parasite infestation	2	20
	numerous parasites	3	30

APPENDIX XV

FISH TISSUE COLLECTION DATA, FALL 2002

Table XV.1 Fish Data, Athabasca River Tissue Study, Fall 2002

Species	Fish ID Number	Capture Site (a)	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
lake whitefish	001*	MA	F	PR	486	1,625	1.42	1,056	13	134.00	12.69	21.00	1.99	100	brown yellow	0	empty
	002*	MA	F	PR	422	1,080	1.44	772	8	103.00	13.34	n/a	n/a	50	brown	0	empty
	003*	SA	F	PR	430	1,410	1.77	1,191	7	138.00	11.59	18.00	1.51	1/4	yellow	0	empty
	004*	MA	M	PR	450	1,280	1.40	1,177	13	17.00	1.44	11.00	0.93	25	yellow	0	empty
	005*	SA	F	PR	425	1,224	1.59	1,035	6	115.00	11.11	17.00	1.64	50	green	60	snails
	006	SA	M	PR	362	615	1.30	584	5	15.00	2.57	3.00	0.51	50	yellow	50	unidentifiable
	007	SA	M	PR	379	870	1.60	805	6	18.00	2.24	8.00	0.99	1/8	yellow	20	unidentifiable
	008	SA	M	PR	484	1,607	1.42	1,497	14	27.00	1.80	15.00	1.00	100	dark green	0	empty
	009*	MA	F	PR	422	1,300	1.73	1,035	8	133.00	12.85	25.00	2.42	50	yellow	0	empty
	010	MA	M	PR	462	1,625	1.65	1,428	12	35.00	2.45	0.00	0.00	70	yellow	10	unidentifiable
	011	MA	M	PR	396	1,100	1.77	943	7	23.00	2.44	7.00	0.74	100	yellow	0	empty
	012*	MA	M	PR	400	1,120	1.75	900	6	22.00	2.44	9.00	1.00	75	yellow	0	empty
	013	MA	F	PR	393	980	1.61	803	7	104.00	12.95	15.00	1.87	75	yellow	0	empty
	014*	MA	M	PR	457	1,520	1.59	1,402	16	15.00	1.07	14.00	1.00	75	yellow	0	empty
	015	MA	M	PR	368	750	1.50	694	6	13.00	1.87	6.00	0.86	75	yellow	10	unidentifiable
	016	MA	F	PR	460	1,770	1.82	1,391	11	210.00	15.10	35.00	2.52	75	yellow	10	unidentifiable
	017	MA	F	PR	439	1,530	1.81	1,225	8	208.00	16.98	24.55	2.00	75	yellow	0	empty
	018*	MA	M	PR	475	1,220	1.14	1,106	9	25.10	2.27	8.55	0.77	75	yellow	0	empty
	019	SA	F	PR	424	1,100	1.44	840	7	133.60	15.91	21.90	2.61	100	yellow	0	empty
	020	SA	M	PR	425	1,150	1.50	999	7	23.00	2.30	9.30	0.93	100	yellow	0	empty
	021*	SA	M	PR	438	1,200	1.43	751	12	26.00	3.46	9.70	1.29	50	yellow	0	empty
	022	SA	M	PR	455	1,350	1.43	1,242	16	13.00	1.05	10.90	0.88	70	yellow	0	empty
	023	SA	M	PR	460	1,370	1.41	1,271	12	16.90	1.33	13.40	1.05	70	yellow	0	empty
	024	SA	M	PR	405	1,300	1.96	1,150	8	23.20	2.02	11.10	0.97	0	n/a	0	empty
	025	SA	M	PR	411	940	1.35	901	6	205.00	22.76	7.40	0.82	40	yellow	0	empty
walleye	001*	MA	F	SD	577	2,050	1.07	1,390	8	47.00	3.38	24.00	1.73	0	n/a	0	empty
	002*	SA	F	SD	538	1,596	1.02	1,173	11	43.00	3.67	21.00	1.79	0	n/a	0	empty
	003*	SA	F	SD	603	2,402	1.10	1,876	13	37.00	1.97	20.00	1.07	0	n/a	10	unidentifiable
	004*	SA	F	SD	508	1,411	1.08	1,051	5	11.00	1.05	14.00	1.33	25	yellow	0	empty
	005	SA	M	IM	235	139	1.07	110	2	n/a	n/a	0.75	0.68	25	yellow	0	empty

Table XV.1 Fish Data, Athabasca River Tissue Study, Fall 2002 (continued)

Species	Fish ID Number	Capture Site [a]	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
walleye (con't)	006	SA	U	IM	229	190	1.58	116	1	n/a	n/a	0.92	0.79	0	n/a	100	unidentifiable
	007	SA	U	IM	227	130	1.11	105	2	n/a	n/a	0.94	0.89	50	yellow	0	empty
	008	MA	F	IM	360	460	0.99	402	4	n/a	n/a	3.43	0.85	75	n/a	10	unidentifiable
	009	MA	M	SD	401	770	1.19	607	9	19.02	3.13	16.55	2.73	75	yellow	100	unidentifiable
	010	MA	U	IM	230	120	0.99	86	1	n/a	n/a	0.83	0.97	75	yellow	0	empty
	011	MA	M	SD	431	790	0.99	665	7	15.60	2.35	6.04	0.91	0	n/a	100	unidentifiable
	012	MA	F	IM	450	920	1.01	709	12	n/a	n/a	6.99	0.99	75	yellow	0	empty
	013	MA	U	IM	372	500	0.97	442	5	n/a	n/a	3.24	0.73	0	n/a	10	unidentifiable
	014	MA	M	SD	397	660	1.05	556	8	14.92	2.68	5.96	1.07	100	yellow	0	empty
	015*	MA	F	SD	452	1,010	1.09	757	8	22.56	2.98	11.89	1.57	50	yellow	40	unidentifiable
	016	MA	M	SD	509	1,450	1.10	1,212	12	40.80	3.37	12.50	1.03	50	yellow	0	empty
	017	MA	U	IM	242	230	1.62	103	1	n/a	n/a	1.05	1.02	0	n/a	0	empty
	018*	MA	M	IM	415	710	0.99	441	5	n/a	n/a	3.63	0.82	75	yellow	0	empty
	019	MA	U	IM	295	320	1.25	141	2	n/a	n/a	1.49	1.05	0	n/a	0	empty
	020*	MA	M	SD	505	1,260	0.98	970	10	24.60	2.54	13.95	1.44	50	yellow	0	empty
	021*	SA	M	SD	395	725	1.18	567	5	14.10	2.49	13.00	2.29	25	clear	0	empty
	022	SA	F	MA	465	1,000	0.99	938	9	6.20	0.66	8.20	0.87	80	yellow	0	empty
	023	SA	M	SD	362	510	1.08	396	4	8.30	2.10	6.60	1.67	50	yellow	10	unidentifiable
	024*	SA	M	SD	431	875	1.09	689	12	16.20	2.35	6.60	0.96	50	yellow	0	empty
	025*	SA	M	SD	370	525	1.04	462	4	10.20	2.21	3.80	0.82	0	n/a	0	empty

[a] SA = Steepbank Area, MA = Muskeg Area (See Figure 3.9).

Note: LSI = (liver weight / carcass weight) x 100.
GSI = (gonad weight / carcass weight) x 100.
M = Male; F = Female; U = Unknown; Juvenile: IM = Immature.
Maturity codes; Adult: M = Maturing; PR = Pre-spawning; SD = Seasonal Development.
* = Fish included in composite sample.
n/a = Not applicable.

TableXV.2 Fish Pathology Results for Lake Whitefish and Walleye, Athabasca River Tissue Study, Fall 2002

Species	Fish ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fin	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Conditon															
lake whitefish	001*	N	N	N	0	0	none	0	0	0	1	E	B	0	N	2	50
	002*	N	N	N	0	0	none	1	0	0	1	E	B	0	N	2	60
	003*	N	N	N	0	2	none	0	0	0	0	A	B	0	N	0	20
	004*	N	N	N	0	0	none	2	0	0	1	E	B	0	N	3	80
	005*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	006	N	N	N	0	1	none	0	0	0	0	A	B	0	N	0	10
	007	N	N	N	0	1	none	0	0	0	0	A	B	0	N	1	20
	008	N	N	N	0	2	none	0	0	0	1	A	B	0	N	1	30
	009*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	2	20
	010	N	N	N	0	1	none	1	0	0	1	E	E	0	N	1	90
	011	N	N	N	0	1	none	0	0	0	1	A	B	0	N	1	20
	012*	N	N	N	0	1	none	0	0	0	3	C	B	0	N	1	50
	013	N	N	N	0	1	none	0	0	0	1	A	B	0	N	1	20
	014*	N	N	N	0	0	spinal deformity	0	0	0	2	C	B	0	N	3	90
	015	N	N	N	0	0	none	0	0	0	1	C	B	0	N	3	60
	016	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10
	017	N	N	N	0	1	none	0	0	0	2	OT(enlarged)	B	0	N	0	40
	018*	N	N	N	0	0	none	0	0	0	3	A	E	0	N	1	40
	019	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	020	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	021*	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10
	022	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
	023	N	N	N	0	1	none	1	0	1	0	A	B	0	N	2	50
	024	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10
	025	N	N	N	0	0	none	0	0	2	0	A	B	0	N	0	20

Table XV.2 Fish Pathology Results for Lake Whitefish and Walleye, Athabasca River Tissue Study, Fall 2002 (continued)

Species	Fish ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fin	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Conditon															
walleye	001*	N	N	N	0	0	none	0	0	0	3	E	B	0	N	0	30
	002*	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10
	003*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	004*	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
	005	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	006	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	007	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	008	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
	009	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
	010	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
	011	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
	012	N	N	N	0	0	none	0	0	0	2	C	B	0	N	0	30
	013	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	014	N	N	N	0	0	none	0	0	0	3	C	B	0	N	0	30
	015*	N	N	N	0	0	none	1	0	0	3	A	B	0	N	0	10
	016	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
	017	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	018*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	019	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
	020*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	021*	N	N	N	0	0	none	0	0	0	3	C	B	0	N	0	30
	022	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	023	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
	024*	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
	025*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0

Note: See Appendix XIV for pathology codes.
* = Fish used in composite sample.

Table XV.3 Fish Measurement Data, Muskeg River Tissue Study, Fall 2002

Species	Fish ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
northern pike	001*	M	SD	465	775.0	0.77	620.9	3	13.50	2.17	6.50	1.05	0	n/a	100	1 juv. sucker; 1 rodent
	002*	M	SD	540	1050.0	0.67	968.4	2	29.60	3.06	10.20	n/a	20	green	0	empty
	003	U	IM	165	30.0	0.67	26.1	0	n/a	n/a	0.30	1.15	0	n/a	0	empty
	004*	M	SD	530	1150.0	0.77	969.3	5	23.30	2.40	11.10	1.15	100	yellow	0	empty
	005	U	IM	179	38.3	0.67	32.6	0	n/a	n/a	0.43	1.32	0	n/a	100	unidentifiable
	006	M	IM	186	47.1	0.73	43.2	0	n/a	n/a	0.63	1.46	80	yellow	0	empty

Note: LSI = (liver weight/carcass weight) x 100.

GSI = (gonad weight (g)/carcass weight (g)) x 100.

M = Male; U = Unknown.

Maturity codes: Adult: SD = Seasonal Development; IM = Immature

* = Fish included in composite sample.

n/a = Not applicable

Table XV.4 Fish Pathology Results, Muskeg River Tissue Study, Fall 2002

Species	Fish ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fin	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Condition															
northern pike	001*	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	002*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	003	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	004*	N	N	N	0	1	none	0	0	0	2	A	B	0	N	0	10
	005	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	006	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0

Note: See Appendix XIV for pathology codes.
* = Fish used in composite sample.

Table XV.5 Fish Measurement Data, Gregoire Lake Tissue Study, Fall 2002

Species	Fish ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
lake whitefish	029*	M	PR	502.0	2190.0	1.73	1993.4	12	49.8	2.50	19.6	0.98	80	dark green	70	unidentifiable
	044*	M	PR	472.0	1880.0	1.79	1762.0	9	22.9	1.30	16.7	0.95	30	dark green	0	empty
	045*	F	PR	515.0	2520.0	1.84	1987.7	15	366.3	18.43	36.7	1.85	50	dark green	100	unidentifiable
	046*	M	PR	500.0	2050.0	1.64	1867.9	9	58.2	3.12	19.1	1.02	80	dark green	0	unidentifiable
	047*	F	PR	474.0	2110.0	1.98	1627.4	7	359.2	22.07	38.9	2.39	10	dark green	0	empty
	048*	F	PR	540.0	2780.0	1.77	2137.1	16	470.7	22.03	53.2	2.49	50	green	0	empty
	050*	F	PR	484.0	2260.0	1.99	3738.9	13	410.4	10.98	47.8	1.28	100	dark green	0	empty
	057*	M	SD	511.0	2150.0	1.61	1851.6	9	62.5	3.38	19.1	1.03	50	yellow	100	snail
	058*	M	SD	435.0	1450.0	1.76	1299.3	4	39.3	3.02	12.1	0.93	10	green	50	chironomids, (bivalves) clams
	059*	M	SD	508.0	2200.0	1.68	1874.9	23	108.7	5.80	24.0	1.28	30	green	0	empty
	060*	F	SD	448.0	2390.0	2.66	1822.6	7	392.4	21.53	4.7	0.26	5	green	15	unidentifiable
	061	M	SD	506.0	2270.0	1.75	2034.2	11	51.7	2.54	25.6	1.26	100	dark green	80	detritus
northern pike	018*	F	SD	565.0	1470.0	0.82	1253.5	7	46.0	3.67	35.7	2.85	0	n/a	25	cyprinid
	019	F	SD	723.0	2590.0	0.69	2369.7	10	32.9	1.39	32.2	1.36	80	green	0	empty
	020*	F	SD	557.0	1070.0	0.62	963.4	7	21.3	2.21	15.9	1.65	0	n/a	0	empty
	021*	F	SD	502.0	960.0	0.76	849.6	5	27.5	3.24	20.1	2.37	20	yellow	45	cyprinid
	022*	M	SD	542.0	1170.0	0.73	1063.7	5	25.8	2.43	13.2	1.24	60	green	15	cyprinid
	023*	F	SD	572.0	1120.0	0.60	1014.1	6	26.5	2.61	19.0	1.87	80	green	0	empty
	024*	F	SD	506.0	800.0	0.62	724.2	9	12.7	1.75	10.7	1.48	60	yellow	0	empty
	025	F	SD	1190.0	6700.0	0.40	5868.1	13	172.5	2.94	99.8	1.70	10	dark green	0	empty
	026	M	SD	463.0	700.0	0.71	624.2	6	7.7	1.23	8.5	1.36	50	green	20	unidentifiable
	027	F	MA	487.0	760.0	0.66	694.6	4	7.1	1.02	6.7	0.96	50	dark green	10	unidentifiable
	028	M	SD	490.0	690.0	0.59	634.2	5	16.8	2.65	4.0	0.63	0	n/a	0	empty
	031	M	SD	386.0	420.0	0.73	376.6	3	5.4	1.43	3.8	1.01	0	n/a	50	cyprinid
	037*	M	IM	470.0	670.0	0.65	625.4	5	9.2	1.47	6.1	0.98	100	green	0	empty
	038*	M	MA	472.0	640.0	0.61	534.3	6	9.3	1.74	6.7	1.25	0	n/a	0	empty

Table XV.5 Fish Measurement Data, Gregoire Lake Tissue Study, Fall 2002 (continued)

Species	Fish ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
	039*	M	SD	510.0	890.0	0.67	823.1	7	19.2	2.33	10.2	1.24	5	green	30	yellow perch
	040*	M	SD	511.0	890.0	0.67	821.3	5	16.8	2.05	8.6	1.05	100	dark green	0	empty
	042	F	SD	613.0	1440.0	0.63	1313.8	8	20.6	1.57	21.5	1.64	0	n/a	0	empty
	043	F	SD	643.0	2070.0	0.78	1855.5	7	65.1	3.51	31.7	1.71	100	dark green	0	empty
	049	M	IM	281.0	150.0	0.68	294.9	1	0.5	n/a	1.7	0.58	20	yellow	0	empty
	051	M	SD	393.0	430.0	0.71	402.3	2	6.3	n/a	6.8	1.69	0	n/a	50	cyprinids
	052	F	IM	368.0	350.0	0.70	300.7	1	0.7	0.23	4.3	1.43	20	dark green	40	cyprinids
	053	M	SD	392.0	480.0	0.80	407.5	6	18.5	4.54	7.0	1.72	0	n/a	40	cyprinids
	062	F	SD	395.0	430.0	0.70	391.7	2	3.1	n/a	4.4	1.12	100	dark green	50	cyprinids
	063	M	IM	315.0	220.0	0.70	199.6	1	0.7	0.35	2.5	1.25	0	n/a	0	empty
	064	F	IM	315.0	190.0	0.61	176.5	1	0.5	0.28	2.1	1.19	25	yellow	100	yellow perch
walleye	001*	F	SD	545.0	1780.0	1.10	1600.3	11	51.2	n/a	21.4	1.34	0	n/a	25	unidentifiable
	002*	F	SD	522.0	1670.0	1.17	1487.3	8	53.5	3.60	22.4	1.51	25	green	0	empty
	003	F	SD	479.0	1260.0	1.15	1121.3	7	33.2	2.96	18.7	1.67	0	n/a	1	shrimp
	004	U	IM	201.0	90.0	1.11	82.2	1	n/a	n/a	1.0	1.22	0	n/a	100	cyprinids
	005	U	IM	203.0	80.0	0.96	70.4	1	n/a	n/a	0.8	1.14	50	green	0	empty
	006	F	SD	496.0	1370.0	1.12	1223.5	8	57.4	4.69	25.0	2.04	10	yellow	25	unidentifiable
	007*	F	SD	528.0	1700.0	1.15	1518.2	9	74.7	n/a	24.0	1.58	40	yellow	10	unidentifi able
	008	F	SD	482.0	1210.0	1.08	1090.3	8	43.9	4.03	18.4	1.69	0	n/a	0	empty
	009*	F	SD	541.0	1790.0	1.13	1622.7	13	67.1	4.14	27.8	1.71	0	n/a	25	cyprinids
	010	F	SD	498.0	1420.0	1.15	1210.0	8	49.7	4.11	25.6	2.12	10	yellow	0	empty
	011*	M	SD	441.0	980.0	1.14	891.4	8	29.2	3.28	10.7	1.20	0	n/a	25	unidentifiable
	012	M	SD	364.0	540.0	1.12	491.2	4	16.8	3.42	8.2	1.67	30	yellow	0	empty
	013	M	SD	364.0	550.0	1.14	495.3	5	14.9	3.01	7.6	1.53	40	yellow	50	cyprinid
	014*	F	SD	598.0	2920.0	1.37	2336.9	13	112.7	4.82	63.6	2.72	20	yellow	95	unidentifiable
	015	M	IM	381.0	630.0	1.14	578.7	4	2.3	0.40	8.4	1.45	50	yellow	0	empty
	016	F	IM	391.0	690.0	1.15	635.5	5	1.9	0.30	7.5	1.18	85	yellow	0	empty
	017	M	SD	352.0	500.0	1.15	446.6	4	13.5	3.02	5.6	1.25	25	yellow	0	empty

Table XV.5 Fish Measurement Data, Gregoire Lake Tissue Study, Fall 2002 (continued)

Species	Fish ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
	030	U	IM	205.0	80.0	0.93	81.4	1	n/a	n/a	0.9	1.11	0	n/a	0	empty
	032*	M	MA	429.0	870.0	1.10	776.9	5	3.8	0.49	11.2	1.44	0	n/a	50	spoonhead sculpin
	033*	M	IM	427.0	790.0	1.01	748.1	5	3.1	0.41	5.7	0.76	0	n/a	0	empty
	034*	M	IM	438.0	88.0	0.10	796.9	5	2.9	0.36	6.7	0.84	0	n/a	100	cyprinids
	035*	M	SD	446.0	890.0	1.00	807.1	8	30.1	3.73	6.7	0.83	5	yellow	0	empty
	036	F	SD	601.0	2330.0	1.07	2058.7	14	81.9	3.98	49.1	2.39	100	yellow	0	empty
	041	U	IM	208.0	90.0	1.00	82.3	1	n/a	n/a	1.0	1.22	0	n/a	100	cyprinids
	054	U	IM	212.0	100.0	1.05	90.2	1	n/a	n/a	1.0	1.11	0	n/a	10	unidentifiable
	055	F	IM	200.0	80.0	1.00	70.6	1	0.1	0.14	0.8	1.13	0	n/a	5	cyprinid
	056	M	IM	227.0	120.0	1.03	106.9	1	0.2	0.19	1.0	0.94	0	n/a	0	empty

Note: LSI = (liver weight/carcass weight) x 100.

GSI = (gonad weight/carcass weight) x 100.

M = Male; F = Female; U = Unknown; Juvenile; IM = Immature.

Maturity codes: Adult: Ma = Maturing; PR = Pre-spawning; SD = Seasonal Development.

* = Fish included in composite sample.

n/a = Not applicable.

Table XV.6 Fish Pathology Results Gregoire Lake Tissue Study, Fall 2002

Species	Fish ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fin	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Condition															
lake whitefish	029*	N	N	N	0	3	none	0	0	1	3	F	B	0	N	1	80
	044*	N	N	N	1	1	none	0	0	0	0	A	B	0	N	1	30
	045*	N	N	N	1	1	none	0	0	0	1	A	B	0	N	0	20
	046*	N	N	N	1	1	none	1	1	0	1	A	B	0	N	0	60
	047*	N	N	N	0	2	none	0	0	0	1	A	B	0	N	1	30
	048*	N	M	N	1	2	none	0	0	1	1	A	B	0	N	0	70
	050*	N	N	N	0	1	none	0	0	1	1	A	B	0	N	1	30
	057*	N	N	N	0	0	none	0	0	2	1	A	E	1	N	2	100
	058*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	059*	N	N	N	0	0	none	1	0	0	1	A	OT	0	N	0	40
	060*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	40
	061	N	N	N	0	0	none	1	0	0	1	A	B	0	N	0	40
northern pike	018*	N	F	N	0	0	none	0	0	0	1	A	B	0	N	1	40
	019	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	020*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	021*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	022*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	023*	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
	024*	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	025	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	026	N	N	N	0	0	none	0	1	0	0	A	B	0	N	0	60
	027	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	028	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	031	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	037*	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10

Table XV.6 Fish Pathology Results Gregoire Lake Tissue Study, Fall 2002 (continued)

Species	Fish ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fin	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Condition															
northern pike (cont)	038*	N	N	N	0	0	none	0	1	0	0	A	B	0	N	0	30
	039*	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10
	040*	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	042	B1	N	N	0	0	none	0	0	0	0	A	B	0	N	0	60
	043	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	049	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
	051	N	N	N	0	0	none	0	0	0	0	A	B	0	N	1	10
	052	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	053	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	062	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	40
	063	N	N	N	0	1	none	0	0	0	0	F	B	0	N	1	80
	064	N	N	N	0	0	none	0	0	0	0	F	B	0	N	0	60
walleye	001*	N	N	N	1	0	none	1	0	0	3	A	B	0	N	1	30
	002*	N	N	N	0	0	none	0	0	0	3	A	B	0	N	2	20
	003	N	N	N	1	0	none	0	0	0	3	A	B	0	N	1	20
	004	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	005	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	006	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
	007*	N	N	N	0	0	none	0	0	0	3	A	B	0	N	2	20
	008	N	N	N	0	0	none	1	0	0	2	A	B	0	N	1	20
	009*	B1	N	N	0	0	badly deformed right pectoral fin	0	0	0	2	A	B	0	U	2	110
	010	N	N	N	0	0	none	1	0	0	4	A	B	0	N	1	20
	011*	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
	012	N	N	N	0	0	deformed right pectoral fin	0	0	0	2	A	B	0	N	1	40
	013	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0

Table XV.6 Fish Pathology Results Gregoire Lake Tissue Study, Fall 2002 (continued)

Species	Fish ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fin	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Condition															
walleye (cont)	014*	N	N	N	0	0	none	0	0	0	2	A	B	0	N	1	10
	015	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
	016	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
	017	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
	030	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	032*	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
	033*	N	N	N	0	0	none	1	1	0	3	A	B	0	N	1	50
	034*	N	N	N	0	0	none	0	0	0	4	A	B	0	N	1	10
	035*	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	40
	036	N	N	N	0	1	none	0	0	0	2	A	B	0	N	2	30
	041	B1	N	N	0	0	none	0	0	0	1	A	B	0	N	1	40
	054	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
	055	B1	N	N	0	0	none	0	0	0	1	C	B	0	N	0	90
	056	N	N	N	0	0	none	1	0	0	1	A	B	0	N	2	60

Note: See Appendix XIV for pathology codes.
* = Fish included in composite sample.

Table XV.7 Lake Whitefish Composite Tissue Analysis Results, Athabasca River, Fall 2002

Parameter	Detection Limit (mg/kg)	Results (mg/kg)	
		Female	Male
aluminum	4	<4	<4
antimony	0.04	<0.04	<0.04
arsenic	0.2	<0.2	<0.2
barium	0.08	0.10	0.10
beryllium	0.2	<0.2	<0.2
boron	2	<2	<2
cadmium	0.08	<0.08	<0.08
calcium	10	120	90
chromium	0.2	<0.2	<0.2
cobalt	0.08	<0.08	<0.08
copper	0.08	0.20	0.21
iron	2	3	4
lead	0.04	<0.04	<0.04
lithium	0.5	<0.5	<0.5
magnesium	2	299	301
manganese	0.04	0.16	0.17
molybdenum	0.04	<0.04	<0.04
nickel	0.08	<0.08	<0.08
phosphorus	2	2390	2540
potassium	2	3920	4230
selenium	0.2	0.4	0.4
silver	0.08	<0.08	<0.08
sodium	2	296	308
strontium	0.04	0.13	0.12
thallium	0.04	<0.04	<0.04
tin	0.08	<0.08	<0.08
titanium	0.05	0.67	<0.05
uranium	0.04	<0.04	<0.04
vanadium	0.08	<0.08	<0.08
zinc	0.2	9.6	4.6
thiophene	3	<1	3.00
toluene	130	270.00	130.00
m+p-xylenes	5	<1	5.00
naphthalene	<1	<1	<1

Table XV.8 Walleye Composite Tissue Analysis Results, Athabasca River, Fall 2002

Parameter	Detection Limit (mg/kg)	Results (mg/kg)	
		Female	Male
aluminum	4	<4	<4
antimony	0.04	<0.04	<0.04
arsenic	0.2	<0.2	<0.2
barium	0.08	0.11	0.11
beryllium	0.2	<0.2	<0.2
boron	2	<2	<2
cadmium	0.08	<0.08	<0.08
calcium	10	80	100
chromium	0.2	<0.2	<0.2
cobalt	0.08	<0.08	<0.08
copper	0.08	0.16	0.20
iron	2	3	3
lead	0.04	<0.04	<0.04
lithium	0.5	<0.5	<0.5
magnesium	2	298	291
manganese	0.04	0.11	0.14
molybdenum	0.04	<0.04	<0.04
nickel	0.08	<0.08	<0.08
phosphorus	2	2490	2450
potassium	2	4380	4180
selenium	0.2	0.3	0.3
silver	0.08	<0.08	<0.08
sodium	2	260	237
strontium	0.04	0.06	0.05
thallium	0.04	<0.04	<0.04
tin	0.08	<0.08	<0.08
titanium	0.05	<0.05	<0.05
uranium	0.04	<0.04	<0.04
vanadium	0.08	<0.08	<0.08
zinc	0.2	5.2	6.7
thiophene	3	<1	<1
toluene	130	73	36
m+p-xylenes	5	<1	<1
naphthalene	<1	<1	<1

Table XV.9 Northern Pike Composite Tissue Analysis Results, Muskeg River, Fall 2002

Parameter	Detection Limit (mg/kg)	Results (mg/kg)
aluminum	4	<4
antimony	0.04	<0.04
arsenic	0.2	<0.2
barium	0.08	0.10
beryllium	0.2	<0.2
boron	2	<2
cadmium	0.08	<0.08
calcium	10	120
chromium	0.2	<0.2
cobalt	0.08	<0.08
copper	0.08	0.24
iron	2	4
lead	0.04	<0.04
lithium	0.5	<0.5
magnesium	2	334
manganese	0.04	0.17
molybdenum	0.04	<0.04
nickel	0.08	<0.08
phosphorus	2	2680
potassium	2	4370
selenium	0.2	<0.2
silver	0.08	<0.08
sodium	2	314
strontium	0.04	0.06
thallium	0.04	<0.04
tin	0.08	<0.08
titanium	0.05	<0.05
uranium	0.04	<0.04
vanadium	0.08	<0.08
zinc	0.2	5.6
thiophene	0.01	<0.01
toluene	0.01	65.00
m+p-xylenes	0.01	<0.01
naphthalene	0.01	<0.01

Table XV.10 Lake Whitefish Composite Tissue Analysis Results, Gregoire Lake, Fall 2002

Parameter	Detection Limit (mg/kg)	Results (mg/kg)	
		Female	Male
aluminum	4	<4	<4
antimony	0.04	<0.04	<0.04
arsenic	0.2	<0.2	<0.2
barium	0.08	0.09	0.10
beryllium	0.2	<0.2	<0.2
boron	2	<2	<2
cadmium	0.08	<0.08	<0.08
calcium	10	60	50
chromium	0.2	<0.2	<0.2
cobalt	0.08	<0.08	<0.08
copper	0.08	0.77	1.01
iron	2	15	14
lead	0.04	<0.04	<0.04
lithium	0.5	<0.5	<0.5
magnesium	2	261	250
manganese	0.04	0.17	0.21
molybdenum	0.04	<0.04	<0.04
nickel	0.08	<0.08	<0.08
phosphorus	2	2600	2490
potassium	2	3520	3200
selenium	0.2	0.3	0.3
silver	0.08	<0.08	<0.08
sodium	2	273	252
strontium	0.04	0.09	0.08
thallium	0.04	<0.04	<0.04
tin	0.08	<0.08	<0.08
titanium	0.05	<0.05	0.67
uranium	0.04	<0.04	<0.04
vanadium	0.08	<0.08	<0.08
zinc	0.2	5.9	8.4

Table XV.11 Northern Pike Composite Tissue Analysis Results, Gregoire Lake, Fall 2002

Parameter	Detection Limit (mg/kg)	Results (mg/kg)	
		Female	Male
aluminum	4	<0.04	<0.04
antimony	0.04	<0.04	<0.04
arsenic	0.2	<0.04	<0.04
barium	0.08	<0.04	<0.04
beryllium	0.2	<0.04	<0.04
boron	2	<0.08	<0.08
cadmium	0.08	<0.08	<0.08
calcium	10	<0.08	<0.08
chromium	0.2	<0.08	<0.08
cobalt	0.08	<0.08	<0.08
copper	0.08	<0.08	<0.08
iron	2	<0.2	<0.2
lead	0.04	<0.2	<0.2
lithium	0.5	<0.2	<0.2
magnesium	2	<0.5	<0.5
manganese	0.04	<2	<2
molybdenum	0.04	0.11	<4
nickel	0.08	0.18	0.04
phosphorus	2	0.18	0.09
potassium	2	0.2	0.12
selenium	0.2	0.20	0.15
silver	0.08	0.40	0.17
sodium	2	140	0.3
strontium	0.04	2410	2
thallium	0.04	3	225
tin	0.08	327	2430
titanium	0.05	381	280
uranium	0.04	3900	3990
vanadium	0.08	5	5.7
zinc	0.2	8.9	80

Table XV.12 Walleye Composite Tissue Analysis Results, Gregoire Lake, Fall 2002

Parameter	Detection Limit (mg/kg)	Results (mg/kg)	
		Female	Male
aluminum	4	5	<4
antimony	0.04	<0.04	<0.04
arsenic	0.2	<0.2	<0.2
barium	0.08	0.11	0.11
beryllium	0.2	<0.2	<0.2
boron	2	<2	<2
cadmium	0.08	<0.08	<0.08
calcium	10	110	110
chromium	0.2	<0.2	<0.2
cobalt	0.08	<0.08	<0.08
copper	0.08	0.16	0.16
iron	2	4	<2
lead	0.04	<0.04	<0.04
lithium	0.5	<0.5	<0.5
magnesium	2	318	347
manganese	0.04	0.15	0.16
molybdenum	0.04	<0.04	<0.04
nickel	0.08	<0.08	0.12
phosphorus	2	2660	2650
potassium	2	4850	4680
selenium	0.2	0.3	0.3
silver	0.08	<0.08	<0.08
sodium	2	235	227
strontium	0.04	0.05	<0.04
thallium	0.04	<0.04	<0.04
tin	0.08	<0.08	<0.08
titanium	0.05	1.38	0.25
uranium	0.04	<0.04	<0.04
vanadium	0.08	<0.08	<0.08
zinc	0.2	6.5	5.3

APPENDIX XVI

ATHABASCA RIVER INVENTORY STATISTICAL ANALYSIS RESULTS AND MUSKEG RIVER INVENTORY DATA, SPRING AND SUMMER 2002

Table XVI.1 Multiple Comparisons for Non-Parametric Repeated-Measures Analysis of Variance for Length Frequency Distributions, Athabasca River Spring Inventories, 1995 to 2002

Species	Year	Critical Value [(a)]	Test Statistic[(a)]					
			1995	1996	1997	1998	1999	2002
walleye	1995	3.86	0					
	1996		0.25	0				
	1997		0.06	0.31	0			
	1998		0.25	0.00	0.31	0		
	1999		0.63	0.38	0.69	0.38	0	
	2002		0.06	0.19	0.13	0.19	0.57	0
goldeye	1995	4.03	0					
	1996		0.21	0				
	1997		0.21	0.00	0			
	1998		0.79	1.00	1.00	0		
	1999		1.64	1.86	1.86	0.86	0	
	2002		0.57	0.79	0.79	0.21	1.07	0
longnose sucker	1995	4.03	0					
	1996		1.36	0				
	1997		0.93	0.43	0			
	1998		0.36	1.00	0.57	0		
	1999		0.43	0.93	0.50	0.07	0	
	2002		0.36	1.00	0.57	0.00	0.07	0
white sucker	1995	3.86	0					
	1996							
	1997		0.76		0.00			
	1998		1.01		0.25	0		
	1999		0.00		0.76	1.01	0	
	2002		1.18		0.42	0.17	1.18	0

[(a)] Test statistic indicates significant difference if it is greater than the critical value.

Table XVI.2 Critical Values and F-Values for One-Way ANOVA Analysis of Condition Factors, Athabasca River Spring Inventories, 1995 to 2002

Species	Critical Value	F-Value
goldeye [(a)]	2.24	**8.49**
longnose sucker[(a)]	2.25	**2.66**
walleye [(a)]	2.23	**13.27**
white sucker[(b)]	2.40	**3.96**

[(a)] Comparison of condition factor data from 1995, 1996, 1997, 1998, 1999 and 2002.

[(b)] Comparison of condition factor data from 1995, 1997, 1998, 1999 and 2002.

Note: bold values indicate a significant difference (F-value>critical value) in condition factor among years (a = 0.05).

Table XVI.3 Codes for Muskeg River and Jackpine Creek Fish Measurement Data

Capture Method Codes

EF	boat electrofishing
BP	backpack electrofishing
GN	gill netting
MB	minnow trapping (baited)

Fish Species Codes

BKST	brook stickleback
GOLD	goldeye
LKCH	lake chub
LNDC	longnose dace
LNSC	longnose sucker
MNWH	mountain whitefish
NRPK	northern pike
PRDC	pearl dace
SLSC	slimy sculpin
SPSC	spoonhead sculpin
TRPR	trout-perch
WALL	walleye
WHSC	white sucker

Sex Codes

F	female
M	male
U	unknown

Life Stage Codes

F	fry (young-of-the-year)
J	juvenile
A	adult
U	unknown

State of Maturity Codes

Codes for Immature Fish:	IM	immature
Codes for Mature Fish:	MA	maturing
	SD	seasonal development
	PR	pre-spawning
	RP	ripe
	SP	spent
	RS	resting
	RB	reabsorbing
	UN	unknown

Pathology Codes and Index Values

See Appendix XIV

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Jackpine Creek	July 22	EF	LKCH	72	5	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LKCH	69	5	1.5	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LKCH	85	9	1.5	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LKCH	60	3	1.4	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	109	17	1.3	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	147	44	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	132	32	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	93	11	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	108	15	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	64	3	1.1	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	LNSC	95	8	0.9	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	MMWH	159	63	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	PRDC	90	8	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	EF	SPSC	75	6	1.4	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	BRST	22	1	9.4	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	BRST	30	1	3.7	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 21	BP	BRST	35	--	--	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 21	BP	BRST	34	--	--	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	68	4	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	58	2	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	80	5	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	72	3	0.8	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	71	4	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	66	3	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	75	5	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	65	3	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	72	4	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	64	2	0.8	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	LKCH	64	3	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	26	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	75	4	0.9	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	80	6	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	81	6	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	85	8	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	68	5	1.6	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	72	3	0.8	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	68	5	1.6	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	72	5	1.3	U	A	UN		0	0	0	0	0	0	0	0	0

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002 (continued)

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Jackpine Creek	July 19	BP	PRDC	64	3	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	101	11	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	71	3	0.8	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	75	5	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	80	6	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	80	6	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	75	4	0.9	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	80	6	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	71	3	0.8	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	62	3	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	28	1	4.6	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	38	3	5.5	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	PRDC	25	4	25.6	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 21	BP	PRDC	47	--	--	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 21	BP	PRDC	32	--	--	U	U	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	21	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	22	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	74	5	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	68	4	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	75	6	1.4	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	70	4	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	SPSC	51	2	1.5	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 19	BP	UN	15	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	62	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	89	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	78	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	80	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	64	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	94	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	74	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	79	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	86	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	81	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	66	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	79	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	74	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	63	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	85	--	--	U	A	UN		0	0	0	0	0	0	0	0	0

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002 (continued)

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Jackpine Creek	July 22	MN	LKCH	54	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	66	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	60	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	70	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	72	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	66	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	81	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	60	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	61	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	75	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	63	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	64	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	58	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LKCH	59	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	130	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	112	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	132	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	119	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	30	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	70	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	LNSC	80	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	86	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	76	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	60	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	74	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	68	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	61	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	62	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	66	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	68	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	82	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	71	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	58	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	82	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	61	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	66	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	62	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	51	--	--	U	A	UN		0	0	0	0	0	0	0	0	0

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002 (continued)

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Jackpine Creek	July 22	MN	PRDC	83	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	58	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	87	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	63	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	61	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	60	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	62	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	71	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	72	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	50	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	66	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	61	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	51	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	PRDC	59	--	--	U	A	UN		0	0	0	0	0	0	0	0	0
Jackpine Creek	July 22	MN	WHSC	78	--	--	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	GOLD	361	560	1.2	M	A	UN	3,007	0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LKCH	78	5	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LKCH	73	5	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LKCH	60	3	1.4	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	65	3	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	80	5	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	85	4	0.7	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	88	4	0.6	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	65	3	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	85	6	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	90	5	0.7	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	72	3	0.8	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	85	6	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LKCH	70	4	1.2	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNDC	94	4	0.5	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	225	160	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	179	95	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	312	400	1.3	U	J	IM	3,009	0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	255	220	1.3	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	128	35	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	130	35	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	190	85	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	180	95	1.6	U	J	IM		0	0	0	0	0	0	0	0	0

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002 (continued)

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg River	July 23	EF	LNSC	120	25	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	115	25	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	160	65	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	115	25	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	209	135	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	118	25	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	95	15	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	171	80	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	LNSC	95	11	1.3	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	LNSC	179	95	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	LNSC	202	135	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	LNSC	170	95	1.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	LNSC	145	40	1.3	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	LNSC	313	470	1.5	U	U	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	205	120	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	142	50	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	249	245	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	218	150	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	252	250	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	140	50	1.8	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	137	45	1.8	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	255	250	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	166	70	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	145	55	1.8	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	230	190	1.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	120	50	2.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	125	45	2.3	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	120	50	2.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	158	80	2.0	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	195	75	1.0	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	104	40	3.6	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	105	40	3.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	230	155	1.3	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	180	60	1.0	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	166	45	1.0	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	170	60	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	172	55	1.1	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	160	45	1.1	U	J	IM		0	0	0	0	0	0	0	0	0

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002 (continued)

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg River	July 26	EF	LNSC	170	45	0.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	190	70	1.0	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	250	190	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	195	85	1.1	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	157	65	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	175	60	1.1	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	157	35	0.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	120	20	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	134	25	1.0	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	109	15	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	375	670	1.3	M	A	UN	3,049	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	354	600	1.4	F	A	UN	3,048	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	LNSC	430	945	1.2	F	A	UN	3,045	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	MNWH	185	105	1.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	MNWH	180	90	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	MNWH	145	20	0.7	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	MNWH	135	30	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	NRPK	398	485	0.8	U	J	IM	3,012	0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	NRPK	415	495	0.7	U	U	UN	3,010	0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	NRPK	470	660	0.6	U	J	UN	3,011	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	SPSC	84	3	0.5	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	TRPR	59	2	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	TRPR	58	2	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	TRPR	62	3	1.3	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	TRPR	68	5	1.6	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	TRPR	69	5	1.5	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	TRPR	57	2	1.1	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	TRPR	66	3	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WALL	415	605	0.8	U	U	UN	3,020	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WALL	422	720	1.0	U	A	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WALL	400	700	1.1	U	U	UN	3,047	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WALL	372	555	1.1	U	U	UN	3,046	0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	WHSC	112	25	1.8	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 23	EF	WHSC	392	740	1.2	M	A	UN	3,006	0	0	0	0	20	0	0	0	20
Muskeg River	July 23	EF	WHSC	409	945	1.4	U	A	UN	3,008	0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	285	340	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	76	5	1.1	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	155	60	1.6	U	J	IM		0	0	0	0	0	0	0	0	0

Table XVI.4 Fish Measurement Data, Muskeg River and Jackpine Creek Inventories, Summer 2002 (continued)

Watercourse	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	Floy Tag No.	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg River	July 25	EF	WHSC	239	180	1.3	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	405	940	1.4	F	A	UN	3,015	0	0	0	0	10	0	0	0	10
Muskeg River	July 25	EF	WHSC	393	850	1.4	F	A	UN	3,016	0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	394	970	1.6	F	A	UN	3,017	0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	416	935	1.3	F	A	UN	3,018	0	0	0	0	0	0	0	0	0
Muskeg River	July 25	EF	WHSC	320	520	1.6	U	U	UN		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	256	240	1.4	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	155	70	1.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	230	180	1.5	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	190	65	0.9	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	201	95	1.2	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	255	175	1.1	U	J	IM		0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	335	545	1.4	U	A	UN	3,044	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	420	1035	1.4	F	A	UN	3,021	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	404	870	1.3	F	A	UN	3,022	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	370	745	1.5	F	A	UN	3,023	0	0	0	0	10	0	0	0	10
Muskeg River	July 26	EF	WHSC	376	770	1.4	F	A	UN	3,024	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	400	925	1.4	F	A	UN	3,025	0	0	0	0	0	0	0	0	0
Muskeg River	July 26	EF	WHSC	351	560	1.3	F	A	UN	3,050	0	0	0	0	0	0	0	0	0
Muskeg River	July 24	GN	WHSC	347	590	1.4	U	A	UN	3,014	0	0	0	0	10	0	0	0	10
Muskeg River	July 24	GN	WHSC	314	495	1.6	U	A	UN	3,013	0	0	0	0	10	0	0	0	10

APPENDIX XVII

ATHABASCA RIVER SENTINEL SPECIES DATA, FALL 2002

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 1	001	F	SD	65	3.477	1.27	2.946	3	0.162	5.50	0.062	2.10	50	green	100	unidentifiable
ATR 1	002	M	SD	68	3.543	1.13	3.160	3	0.031	0.98	0.043	1.36	100	green	0	empty
ATR 1	003	M	SD	67	3.463	1.15	3.174	3	0.043	1.35	0.041	1.29	100	green	0	empty
ATR 1	004	M	SD	64	2.982	1.14	2.678	3	0.033	1.23	0.041	1.53	0	n/a	0	empty
ATR 1	005	M	SD	66	4.300	1.50	3.723	3	0.044	1.18	0.052	1.40	100	green	0	empty
ATR 1	006	M	SD	68	3.747	1.19	3.354	3	0.043	1.28	0.038	1.13	0	n/a	0	empty
ATR 1	007	F	SD	70	3.948	1.15	3.307	2	0.167	5.05	0.046	1.39	100	green	100	unidentifiable
ATR 1	008	M	SD	72	4.602	1.23	3.909	3	0.049	1.25	0.058	1.48	0	n/a	0	empty
ATR 1	009	M	SD	72	5.005	1.34	4.114	3	0.058	1.41	0.062	1.51	100	green	0	empty
ATR 1	010	F	SD	85	7.010	1.14	6.073	3	0.317	5.22	0.110	1.81	100	green	0	empty
ATR 1	011	F	SD	60	2.472	1.14	2.178	2	0.099	4.55	0.028	1.29	100	green	0	empty
ATR 1	012	M	SD	78	5.624	1.19	5.016	3	0.053	1.06	0.060	1.20	50	green	0	empty
ATR 1	013	F	SD	66	3.751	1.30	3.282	3	0.161	4.91	0.048	1.46	50	green	25	unidentifiable
ATR 1	014	M	SD	65	3.326	1.21	2.897	2	0.039	1.35	0.042	1.45	0	n/a	0	empty
ATR 1	015	M	SD	69	3.988	1.21	3.559	2	0.041	1.15	0.042	1.18	25	green	0	empty
ATR 1	016	M	SD	78	5.342	1.13	4.884	3	0.071	1.45	0.055	1.13	0	n/a	25	unidentifiable
ATR 1	017	F	SD	70	4.017	1.17	3.535	2	0.192	5.43	0.050	1.41	100	green	0	empty
ATR 1	018	F	SD	73	4.381	1.13	3.846	2	0.189	4.91	0.043	1.12	100	green	0	empty
ATR 1	019	M	SD	70	4.213	1.23	3.648	3	0.043	1.18	0.060	1.64	100	green	0	empty
ATR 1	020	M	SD	79	5.486	1.11	4.989	4	0.042	0.84	0.054	1.08	100	green	0	empty
ATR 1	021	F	SD	78	5.846	1.23	5.007	2	0.253	5.05	0.080	1.60	100	green	0	empty
ATR 1	022	F	SD	80	5.876	1.15	5.219	3	0.226	4.33	0.070	1.34	100	green	0	empty
ATR 1	023	F	SD	73	4.441	1.14	3.727	2	0.163	4.37	0.058	1.56	100	green	0	empty
ATR 1	024	M	SD	73	4.357	1.12	3.868	3	0.050	1.29	0.052	1.34	0	n/a	0	empty
ATR 1	025	F	SD	70	4.501	1.31	3.942	3	0.161	4.08	0.053	1.34	100	green	0	empty
ATR 1	026	F	SD	75	4.873	1.16	4.277	3	0.191	4.47	0.064	1.50	100	green	0	empty
ATR 1	027	M	SD	69	3.593	1.09	3.346	4	0.034	1.02	0.029	0.87	100	green	0	empty
ATR 1	028	M	SD	72	3.486	0.93	3.190	3	0.040	1.25	0.034	1.07	100	green	0	empty
ATR 1	029	M	SD	66	3.166	1.10	2.854	2	0.039	1.37	0.035	1.23	50	green	0	empty

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 1	030	F	SD	71	4.244	1.19	3.660	2	0.173	4.73	0.062	1.69	100	green	50	unidentifiable
ATR 1	031	M	SD	57	1.823	0.98	1.480	1	0.013	0.88	0.021	1.42	100	green	0	empty
ATR 1	032	M	SD	75	5.031	1.19	4.277	3	0.061	1.43	0.056	1.31	100	green	0	empty
ATR 1	033	F	SD	55	1.971	1.18	1.725	1	0.042	2.43	0.021	1.22	100	green	0	empty
ATR 1	034	F	SD	67	3.669	1.22	3.133	3	0.189	6.03	0.056	1.79	100	green	0	empty
ATR 1	035	F	SD	75	4.757	1.13	4.112	4	0.247	6.01	0.066	1.61	100	green	0	empty
ATR 1	036	F	SD	70	4.615	1.35	3.874	3	0.165	4.26	0.065	1.68	100	green	0	empty
ATR 1	037	M	SD	70	4.406	1.28	3.776	3	0.038	1.01	0.051	1.35	100	green	0	empty
ATR 1	038	M	SD	57	2.368	1.28	2.062	1	0.012	0.58	0.025	1.21	100	green	0	empty
ATR 1	039	F	SD	73	4.825	1.24	4.251	3	0.236	5.55	0.067	1.58	0	n/a	0	empty
ATR 1	040	M	SD	69	4.226	1.29	3.692	3	0.044	1.19	0.061	1.65	50	green	0	empty
ATR 1	041	M	SD	69	3.676	1.12	3.316	5	0.044	1.33	0.036	1.09	100	green	0	empty
ATR 1	042	F	SD	65	3.801	1.38	3.315	4	0.219	6.61	0.050	1.51	100	green	0	empty
ATR 1	043	F	SD	71	5.061	1.41	4.474	3	0.214	4.78	0.057	1.27	100	green	0	empty
ATR 1	044	M	SD	60	2.355	1.09	2.132	2	0.018	0.84	0.046	2.16	100	green	0	empty
ATR 1	045	M	SD	53	1.825	1.23	1.660	0	0.011	0.66	0.025	1.51	0	n/a	20	unidentifiable
ATR 1	046	M	SD	56	2.149	1.22	1.910	2	0.022	1.15	0.022	1.15	100	green	0	empty
ATR 1	047	F	SD	68	3.984	1.27	3.396	2	0.198	5.83	0.057	1.68	0	n/a	0	empty
ATR 1	048	M	SD	65	3.378	1.23	3.005	2	0.029	0.97	0.032	1.06	100	green	0	empty
ATR 1	049	M	SD	66	2.889	1.00	2.646	2	0.031	1.17	0.033	1.25	100	green	0	empty
ATR 1	050	M	SD	67	3.530	1.17	3.292	3	0.042	1.28	0.050	1.52	100	green	0	empty
ATR 1	051	F	SD	62	2.911	1.22	2.512	2	0.141	5.61	0.047	1.87	100	green	0	empty
ATR 1	052	M	SD	65	3.329	1.21	2.969	2	0.038	1.28	0.044	1.48	75	green	0	empty
ATR 1	053	M	SD	66	3.125	1.09	2.763	2	0.033	1.19	0.033	1.19	100	green	0	empty
ATR 1	054	M	SD	63	2.606	1.04	2.384	2	0.018	0.76	0.033	1.38	50	green	0	empty
ATR 1	055	F	SD	72	4.011	1.07	3.419	2	0.152	4.45	0.055	1.61	100	green	0	empty
ATR 1	056	M	SD	66	3.368	1.17	2.999	3	0.028	0.93	0.036	1.20	100	green	0	empty
ATR 1	057	M	SD	61	2.757	1.21	2.470	2	0.027	1.09	0.031	1.26	100	green	0	empty
ATR 1	058	F	SD	74	4.338	1.07	3.776	3	0.167	4.42	0.048	1.27	100	green	0	empty

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 1	059	F	SD	68	3.964	1.26	3.440	2	0.159	4.62	0.061	1.77	100	green	0	empty
ATR 1	060	M	SD	64	2.956	1.13	2.509	4	0.018	0.72	0.030	1.20	0	n/a	0	empty
ATR 1	061	M	SD	71	4.463	1.25	4.036	3	0.047	1.16	0.046	1.14	0	n/a	0	empty
ATR 1	062	M	SD	69	4.323	1.32	3.880	3	0.029	0.75	0.057	1.47	100	green	0	empty
ATR 1	063	M	SD	73	4.341	1.12	3.848	4	0.044	1.14	0.053	1.38	100	green	0	empty
ATR 1	064	F	SD	54	2.080	1.32	1.764	0	0.030	1.70	0.025	1.42	0	green	0	empty
ATR 1	065	M	SD	64	3.266	1.25	2.903	2	0.028	0.96	0.030	1.03	100	green	0	empty
ATR 1	066	F	SD	66	3.563	1.24	3.102	2	0.102	3.29	0.048	1.55	100	green	50	unidentifiable
ATR 1	067	M	SD	72	4.467	1.20	4.002	3	0.052	1.30	0.042	1.05	100	green	0	empty
ATR 1	068	M	SD	66	3.522	1.23	3.178	2	0.032	1.01	0.043	1.35	100	green	0	empty
ATR 1	069	M	SD	63	2.777	1.11	2.469	2	0.028	1.13	0.039	1.58	100	green	0	empty
ATR 1	070	M	SD	52	1.911	1.36	1.766	3	0.010	0.57	0.022	1.25	50	green	0	empty
ATR 1	071	F	SD	67	3.345	1.11	2.913	4	0.126	4.33	0.036	1.24	100	green	0	empty
ATR 1	072	F	SD	77	6.673	1.46	5.759	6	0.363	6.30	0.102	1.77	0	n/a	100	unidentifiable
ATR 1	073	F	SD	92	8.561	1.10	7.211	4	0.411	5.70	0.140	1.94	0	n/a	100	unidentifiable
ATR 1	074	F	SD	76	5.030	1.15	4.163	6	0.286	6.87	0.091	2.19	0	n/a	10	unidentifiable
ATR 1	075	F	SD	73	4.790	1.23	4.113	5	0.270	6.56	0.111	2.70	25	green	0	empty
ATR 1	076	F	SD	73	6.256	1.61	5.535	4	0.319	5.76	0.086	1.55	0	n/a	75	unidentifiable
ATR 1	077	F	SD	73	4.973	1.28	4.254	4	0.279	6.56	0.077	1.81	0	n/a	0	empty
ATR 1	078	F	SD	74	5.225	1.29	4.347	3	0.309	7.11	0.089	2.05	0	n/a	75	unidentifiable
ATR 1	079	F	SD	78	6.113	1.29	5.116	3	0.271	5.30	0.102	1.99	100	green	0	empty
ATR 1	080	F	SD	74	4.778	1.18	4.051	4	0.259	6.39	0.082	2.02	0	n/a	75	unidentifiable
ATR 1	081	F	SD	71	4.053	1.13	3.656	2	0.222	6.07	0.082	2.24	20	yellow	80	unidentifiable
ATR 1	082	F	SD	73	4.442	1.14	3.778	2	0.213	5.64	0.075	1.99	75	green	100	chironomids
ATR 1	083	F	SD	72	4.345	1.16	4.014	3	0.273	6.80	0.087	2.17	0	n/a	40	unidentifiable
ATR 1	084	F	SD	73	4.646	1.19	4.018	n/s	0.264	6.57	0.093	2.31	80	green	0	empty
ATR 1	085	F	SD	68	3.442	1.09	3.060	5	0.175	5.72	0.074	2.42	0	n/a	25	unidentifiable
ATR 2	001	M	SD	74	5.082	1.25	4.564	4	0.065	1.42	0.063	1.38	75	green	0	empty
ATR 2	002	M	SD	61	3.115	1.37	2.729	3	0.013	0.48	0.045	1.65	0	n/a	100	unidentifiable

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 2	003	F	SD	77	5.549	1.22	4.610	4	0.336	7.29	0.096	2.08	100	green	75	unidentifiable
ATR 2	004	M	SD	68	3.903	1.24	3.395	3	0.035	1.03	0.047	1.38	100	green	100	unidentifiable
ATR 2	005	F	SD	68	4.310	1.37	3.730	2	0.136	3.65	0.052	1.39	50	green	0	empty
ATR 2	006	F	SD	75	5.709	1.35	4.713	3	0.268	5.69	0.074	1.57	50	green	0	empty
ATR 2	007	M	SD	59	3.209	1.56	2.831	2	0.027	0.95	0.054	1.91	0	n/a	0	empty
ATR 2	008	M	SD	65	3.310	1.21	3.074	5	0.031	1.01	0.053	1.72	75	green	0	empty
ATR 2	009	F	SD	76	5.458	1.24	4.573	3	0.247	5.40	0.079	1.73	75	green	0	empty
ATR 2	010	M	SD	75	4.755	1.13	4.177	4	0.062	1.48	0.077	1.84	25	green	0	empty
ATR 2	011	F	SD	78	6.136	1.29	5.094	3	0.235	4.61	0.086	1.69	50	yellow	0	empty
ATR 2	012	M	SD	69	3.940	1.20	3.358	3	0.017	0.51	0.037	1.10	0	n/a	0	empty
ATR 2	013	M	SD	66	4.146	1.44	3.588	2	0.042	1.17	0.053	1.48	0	n/a	20	unidentifiable
ATR 2	014	F	SD	91	7.995	1.06	6.674	6	0.352	5.27	0.108	1.62	100	green	0	empty
ATR 2	015	M	SD	72	4.303	1.15	3.651	5	0.042	1.15	0.047	1.29	100	green	0	empty
ATR 2	016	M	SD	71	4.450	1.24	3.909	3	0.039	1.00	0.042	1.07	100	green	50	unidentifiable
ATR 2	017	F	SD	70	3.933	1.15	3.322	2	0.181	5.45	0.049	1.48	100	green	0	empty
ATR 2	018	M	SD	74	4.554	1.12	3.958	4	0.047	1.19	0.058	1.47	0	n/a	0	empty
ATR 2	019	F	SD	80	6.637	1.30	5.420	4	0.319	5.89	0.120	2.21	100	green	100	unidentifiable
ATR 2	020	M	SD	68	3.701	1.18	3.091	4	0.034	1.10	0.053	1.71	0	n/a	0	empty
ATR 2	021	M	SD	73	4.564	1.17	3.890	2	0.046	1.18	0.052	1.34	80	green	0	empty
ATR 2	022	M	SD	60	2.947	1.36	2.456	2	0.025	1.02	0.038	1.55	100	green	0	empty
ATR 2	023	M	SD	68	3.853	1.23	3.375	3	0.039	1.16	0.041	1.21	50	green	0	empty
ATR 2	024	M	SD	66	3.870	1.35	3.347	3	0.043	1.28	0.048	1.43	50	green	0	empty
ATR 2	025	M	SD	61	2.396	1.06	2.151	3	0.017	0.79	0.037	1.72	100	green	0	empty
ATR 2	026	F	SD	69	4.317	1.31	3.706	6	0.219	5.91	0.091	2.46	100	green	0	empty
ATR 2	027	M	SD	65	3.084	1.12	2.780	2	0.034	1.22	0.039	1.40	0	n/a	25	unidentifiable
ATR 2	028	F	SD	63	3.197	1.28	2.712	2	0.152	5.60	0.046	1.70	100	green	25	unidentifiable
ATR 2	029	F	SD	73	4.336	1.11	3.662	3	0.187	5.11	0.077	2.10	100	green	0	empty
ATR 2	030	F	SD	82	6.400	1.16	5.476	5	0.329	6.01	0.092	1.68	100	green	0	empty
ATR 2	031	M	SD	65	3.824	1.39	3.426	3	0.032	0.93	0.047	1.37	75	green	0	empty

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 2	032	M	SD	65	4.006	1.46	3.539	2	0.031	0.88	0.054	1.53	50	green	75	unidentifiable
ATR 2	033	M	SD	54	2.268	1.44	2.010	2	0.008	0.40	0.030	1.49	25	green	75	unidentifiable
ATR 2	034	F	SD	65	3.356	1.22	2.958	2	0.145	4.90	0.067	2.27	25	green	0	empty
ATR 2	035	F	SD	67	3.674	1.22	3.248	3	0.157	4.83	0.047	1.45	75	green	0	empty
ATR 2	036	F	SD	68	4.515	1.44	3.886	2	0.210	5.40	0.067	1.72	75	green	0	empty
ATR 2	037	F	SD	83	7.120	1.25	6.112	3	0.308	5.04	0.094	1.54	100	green	0	empty
ATR 2	038	M	SD	68	3.618	1.15	3.176	3	0.038	1.20	0.038	1.20	25	green	0	empty
ATR 2	039	M	SD	68	4.192	1.33	3.766	3	0.055	1.46	0.049	1.30	50	green	0	empty
ATR 2	040	F	SD	66	3.570	1.24	3.074	3	0.164	5.34	0.052	1.69	50	green	0	empty
ATR 2	041	F	SD	78	6.154	1.30	4.993	4	0.286	5.73	0.099	1.98	0	n/a	0	empty
ATR 2	042	F	SD	72	4.418	1.18	3.644	5	0.219	6.01	0.072	1.98	0	n/a	100	unidentifiable
ATR 2	043	M	SD	68	4.087	1.30	3.610	3	0.032	0.87	0.070	1.94	100	green	0	empty
ATR 2	044	F	SD	67	3.873	1.29	3.136	2	0.142	4.53	0.059	1.88	100	green	50	unidentifiable
ATR 2	045	M	SD	65	3.690	1.34	3.247	4	0.029	0.89	0.051	1.57	100	green	0	empty
ATR 2	046	M	SD	72	4.466	1.20	3.923	5	0.044	1.12	0.043	1.10	100	green	0	empty
ATR 2	047	M	SD	66	3.537	1.23	3.100	4	0.035	1.13	0.051	1.65	100	green	0	empty
ATR 2	048	M	SD	67	3.789	1.26	3.239	5	0.041	1.27	0.045	1.39	100	green	0	empty
ATR 2	049	F	SD	72	4.726	1.27	4.108	4	0.238	5.79	0.076	1.85	100	green	0	empty
ATR 2	050	F	SD	68	4.437	1.41	3.676	4	0.211	5.74	0.053	1.44	100	green	0	empty
ATR 2	051	M	SD	70	4.098	1.19	3.826	3	0.043	1.12	0.054	1.41	100	green	0	empty
ATR 2	052	F	SD	77	5.412	1.19	4.726	3	0.211	4.46	0.085	1.80	100	green	0	empty
ATR 2	053	F	SD	68	4.021	1.28	3.464	5	0.152	4.39	0.050	1.44	50	green	0	empty
ATR 2	054	F	SD	70	4.240	1.24	3.639	3	0.155	4.26	0.073	2.01	100	green	0	empty
ATR 2	055	M	SD	62	2.952	1.24	2.674	3	0.030	1.12	0.036	1.35	50	green	0	empty
ATR 2	056	M	SD	71	4.123	1.15	3.444	3	0.039	1.13	0.057	1.66	0	n/a	50	unidentifiable
ATR 2	057	F	SD	68	4.151	1.32	3.549	2	0.187	5.27	0.063	1.78	50	green	0	empty
ATR 2	058	F	SD	75	5.675	1.35	4.888	3	0.258	5.28	0.080	1.64	50	green	50	unidentifiable
ATR 2	059	M	SD	67	3.539	1.18	3.067	3	0.044	1.43	0.040	1.30	50	green	0	empty
ATR 2	060	F	SD	67	3.961	1.32	3.413	3	0.173	5.07	0.054	1.58	50	green	0	empty

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 2	061	M	SD	72	4.485	1.20	4.049	3	0.045	1.11	0.069	1.70	100	green	0	empty
ATR 2	062	F	SD	64	3.631	1.39	3.169	2	0.142	4.48	0.056	1.77	50	green	0	empty
ATR 2	063	M	SD	61	3.335	1.47	3.005	1	0.030	1.00	0.040	1.33	0	n/a	50	unidentifiable
ATR 2	064	M	SD	68	3.857	1.23	3.299	4	0.035	1.06	0.062	1.88	100	green	0	empty
ATR 2	065	M	SD	66	3.029	1.05	2.712	5	0.025	0.92	0.036	1.33	0	n/a	0	empty
ATR 2	066	M	SD	68	4.001	1.27	3.595	2	0.041	1.14	0.050	1.39	100	green	100	unidentifiable
ATR 2	067	M	SD	74	4.664	1.15	4.292	3	0.038	0.89	0.057	1.33	100	green	0	empty
ATR 2	068	M	SD	72	3.952	1.06	3.588	2	0.039	1.09	0.059	1.64	0	n/a	0	empty
ATR 2	069	F	SD	81	6.118	1.15	5.345	4	0.322	6.02	0.082	1.53	100	green	0	empty
ATR 2	070	M	SD	65	3.876	1.41	3.495	3	0.026	0.74	0.048	1.37	50	green	0	empty
ATR 2	071	M	SD	62	3.224	1.35	2.965	2	0.013	0.44	0.027	0.89	100	green	50	unidentifiable
ATR 2	072	F	SD	73	4.984	1.28	4.313	2	0.245	5.68	0.075	1.74	100	green	100	unidentifiable
ATR 2	073	F	SD	66	3.341	1.16	3.149	3	0.154	4.89	0.038	1.21	100	green	0	empty
ATR 2	074	M	SD	62	3.140	1.32	2.814	4	0.025	0.89	0.041	1.46	100	green	0	empty
ATR 2	075	M	SD	65	3.401	1.24	3.050	3	0.046	1.51	0.048	1.57	100	green	0	empty
ATR 2	076	M	SD	62	2.717	1.14	2.355	4	0.028	1.19	0.048	2.04	100	green	0	empty
ATR 2	077	M	SD	66	4.001	1.39	3.630	3	0.027	0.74	0.064	1.76	0	n/a	0	empty
ATR 2	078	M	SD	61	3.290	1.45	2.960	2	0.023	0.78	0.043	1.45	100	green	0	empty
ATR 2	079	M	SD	62	3.554	1.49	2.962	3	0.027	0.91	0.034	1.15	0	n/a	0	empty
ATR 2	080	F	SD	67	3.625	1.21	2.311	3	0.184	7.96	0.066	2.86	0	n/a	50	unidentifiable
ATR 2	081	F	SD	62	2.987	1.25	2.421	2	0.131	5.41	0.067	2.77	0	n/a	100	chironomids
ATR 2	082	F	SD	62	2.956	1.24	2.451	2	0.124	5.06	0.071	2.90	0	n/a	100	chironomids
ATR 2	083	F	SD	72	4.479	1.20	3.752	2	0.297	7.92	0.125	3.33	0	n/a	n/a	chironomids
ATR 2	084	F	SD	79	6.097	1.24	5.087	2	0.412	8.10	0.121	2.38	0	n/a	100	chironomids
ATR 2	085	F	SD	66	3.346	1.16	2.720	2	0.174	6.40	0.064	2.35	0	n/a	100	chironomids
ATR 2	086	F	SD	76	5.324	1.21	4.333	3	0.335	7.73	0.149	3.44	0	n/a	100	chironomids
ATR 2	087	F	SD	51	1.384	1.04	1.278		0.153	11.97	0.025	1.96	0	n/a	100	chironomids
ATR 3	001	F	SD	65	3.556	1.29	2.941	2	0.178	6.05	0.050	1.70	100	green	25	unidentifiable
ATR 3	002	M	SD	61	2.777	1.22	2.343	3	0.027	1.15	0.034	1.45	0	n/a	50	chironomids

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 3	003	F	SD	73	5.410	1.39	4.454	4	0.296	6.65	0.098	2.20	100	green	100	chironomids
ATR 3	004	M	SD	66	3.591	1.25	3.192	3	0.045	1.41	0.050	1.57	100	green	80	chironomids
ATR 3	005	M	SD	74	4.736	1.17	3.930	4	0.066	1.68	0.056	1.42	100	green	80	chironomids
ATR 3	006	M	SD	67	3.914	1.30	3.326	3	0.064	1.92	0.055	1.65	100	green	80	unidentifiable
ATR 3	007	F	SD	66	3.913	1.36	3.270	2	0.216	6.61	0.061	1.87	100	green	0	empty
ATR 3	008	F	SD	77	5.347	1.17	4.408	3	0.265	6.01	0.077	1.75	100	green	30	chironomids
ATR 3	009	F	SD	65	3.751	1.37	3.062	2	0.160	5.23	0.063	2.06	100	green	50	unidentifiable
ATR 3	010	M	SD	66	3.474	1.21	3.021	3	0.022	0.73	0.042	1.39	100	green	40	unidentifiable
ATR 3	011	M	SD	64	3.480	1.33	2.884	2	0.038	1.32	0.047	1.63	0	n/a	0	empty
ATR 3	012	M	SD	63	3.032	1.21	2.107	3	0.030	1.42	0.041	1.95	50	green	100	chironomids
ATR 3	013	F	SD	75	5.516	1.31	4.675	4	0.318	6.80	0.088	1.88	100	green	100	unidentifiable
ATR 3	014	M	SD	65	3.473	1.26	3.088	2	0.058	1.88	0.054	1.75	100	green	100	chironomids
ATR 3	015	F	SD	70	3.852	1.12	3.330	2	0.194	5.83	0.055	1.65	50	green	100	chironomids
ATR 3	016	M	SD	68	3.641	1.16	3.294	3	0.040	1.21	0.052	1.58	0	n/a	100	chironomids
ATR 3	017	F	SD	70	4.380	1.28	3.734	3	0.215	5.76	0.065	1.74	0	n/a	100	chironomids
ATR 3	018	M	SD	73	4.846	1.25	4.245	4	0.057	1.34	0.050	1.18	10	green	100	chironomids
ATR 3	019	M	SD	65	3.200	1.17	2.839	3	0.058	2.04	0.035	1.23	10	green	50	chironomids
ATR 3	020	F	SD	69	4.191	1.28	3.480	2	0.153	4.40	0.070	2.01	10	green	100	chironomids
ATR 3	021	F	SD	79	5.972	1.21	4.972	3	0.318	6.40	0.089	1.79	0	n/a	100	unidentifiable
ATR 3	022	F	SD	75	4.919	1.17	4.059	2	0.192	4.73	0.066	1.63	0	n/a	100	chironomids
ATR 3	023	F	SD	69	4.206	1.28	3.562	5	0.190	5.33	0.067	1.88	0	n/a	100	chironomids
ATR 3	024	F	SD	64	3.340	1.27	2.809	3	0.158	5.62	0.049	1.74	0	n/a	100	chironomids
ATR 3	025	M	SD	70	4.223	1.23	3.696	4	0.051	1.38	0.048	1.30	0	n/a	100	chironomids
ATR 3	026	M	SD	66	3.693	1.28	3.293	2	0.044	1.34	0.036	1.09	0	n/a	25	mayfly
ATR 3	027	M	SD	65	3.686	1.34	3.191	3	0.041	1.28	0.033	1.03	0	n/a	100	chironomids
ATR 3	028	M	SD	66	3.635	1.26	3.171	3	0.053	1.67	0.062	1.96	10	green	50	chironomids
ATR 3	029	F	SD	76	4.938	1.12	4.107	3	0.197	4.80	0.065	1.58	100	green	40	unidentifiable
ATR 3	030	F	SD	89	7.792	1.11	6.680	4	0.399	5.97	0.098	1.47	0	n/a	100	chironomids
ATR 3	031	F	SD	76	4.685	1.07	4.084	2	0.202	4.95	0.095	2.33	100	green	20	unidentifiable

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 3	032	F	SD	81	6.029	1.13	5.173	4	0.251	4.85	0.096	1.86	100	green	30	unidentifiable
ATR 3	033	F	SD	68	3.704	1.18	3.183	2	0.169	5.31	0.047	1.48	50	green	20	unidentifiable
ATR 3	034	M	SD	62	3.061	1.28	2.748	1	0.026	0.95	0.041	1.49	100	green	MT	empty
ATR 3	035	F	SD	74	4.589	1.13	3.973	3	0.172	4.33	0.072	1.81	100	green	0	empty
ATR 3	036	M	SD	58	3.008	1.54	2.688	2	0.025	0.93	0.050	1.86	0	n/a	0	empty
ATR 3	037	F	SD	63	3.145	1.26	2.766	1	0.150	5.42	0.042	1.52	0	n/a	0	empty
ATR 3	038	F	SD	68	3.793	1.21	3.449	3	0.179	5.19	0.052	1.51	100	green	0	empty
ATR 3	039	F	SD	65	3.215	1.17	2.678	2	0.154	5.75	0.035	1.31	100	green	0	empty
ATR 3	040	M	SD	68	3.752	1.19	3.307	3	0.041	1.24	0.052	1.57	0	n/a	0	empty
ATR 3	041	F	SD	64	3.299	1.26	2.916	4	0.126	4.32	0.046	1.58	0	n/a	0	empty
ATR 3	042	F	SD	78	5.819	1.23	5.142	4	0.240	4.67	0.092	1.79	0	n/a	0	empty
ATR 3	043	M	SD	69	4.206	1.28	3.634	3	0.047	1.29	0.062	1.71	100	green	0	empty
ATR 3	044	F	SD	82	6.872	1.25	5.931	5	0.355	5.99	0.113	1.91	100	green	0	empty
ATR 3	045	M	SD	49	1.617	1.37	1.385	1	0.012	0.87	0.023	1.66	0	n/a	0	empty
ATR 3	046	M	SD	61	2.786	1.23	2.524	2	0.037	1.47	0.039	1.55	100	green	0	empty
ATR 3	047	M	SD	70	4.082	1.19	3.644	2	0.046	1.26	0.047	1.29	100	green	0	empty
ATR 3	048	M	SD	56	2.958	1.68	2.625	2	0.027	1.03	0.030	1.14	0	n/a	0	empty
ATR 3	049	M	SD	64	3.329	1.27	2.819	4	0.045	1.60	0.036	1.28	0	n/a	0	empty
ATR 3	050	M	SD	68	3.505	1.11	3.046	2	0.037	1.21	0.050	1.64	50	green	50	chironomids
ATR 3	051	M	SD	68	3.891	1.24	3.520	3	0.055	1.56	0.042	1.19	100	green	0	empty
ATR 3	052	F	SD	70	4.346	1.27	3.009	3	0.206	6.85	0.076	2.53	75	green	10	unidentifiable
ATR 3	053	F	SD	70	4.102	1.20	3.396	4	0.207	6.10	0.054	1.59	0	n/a	25	unidentifiable
ATR 3	054	M	SD	68	3.350	1.07	3.025	3	0.049	1.62	0.037	1.22	80	green	0	empty
ATR 3	055	F	SD	76	5.732	1.31	5.024	2	0.242	4.82	0.080	1.59	50	green	50	chironomids
ATR 3	056	M	SD	63	2.914	1.17	2.562	2	0.037	1.44	0.048	1.87	75	green	0	empty
ATR 3	057	M	SD	65	3.411	1.24	2.980	2	0.043	1.44	0.047	1.58	80	green	25	unidentifiable
ATR 3	058	M	SD	67	3.409	1.13	3.019	2	0.027	0.89	0.047	1.56	100	green	0	empty
ATR 3	059	M	SD	66	3.292	1.15	2.949	2	0.043	1.46	0.034	1.15	50	green	50	chironomids
ATR 3	060	M	SD	56	2.368	1.35	2.075	1	0.025	1.20	0.030	1.45	100	green	20	unidentifiable

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 3	061	F	SD	68	3.906	1.24	3.469	2	0.181	5.22	0.062	1.79	100	green	0	empty
ATR 3	062	M	SD	75	4.563	1.08	4.041	4	0.061	1.51	0.050	1.24	100	green	0	empty
ATR 3	063	F	SD	67	3.957	1.32	3.337	2	0.150	4.50	0.056	1.68	75	green	20	unidentifiable
ATR 3	064	F	SD	68	4.575	1.46	3.890	2	0.177	4.55	0.053	1.36	80	green	0	empty
ATR 3	065	F	SD	68	4.376	1.39	3.725	2	0.230	6.17	0.063	1.69	0		0	empty
ATR 3	066	M	SD	59	2.735	1.33	2.398	2	0.028	1.17	0.039	1.63	40	green	0	empty
ATR 3	067	M	SD	60	3.339	1.55	2.865	2	0.037	1.29	0.041	1.43	0	n/a	0	empty
ATR 3	068	M	SD	66	3.517	1.22	3.089	3	0.038	1.23	0.048	1.55	50	green	0	empty
ATR 3	069	M	SD	65	3.830	1.39	3.498	2	0.039	1.11	0.042	1.20	0	n/a	0	empty
ATR 3	070	F	SD	68	4.464	1.42	3.725	2	0.204	5.48	0.061	1.64	100	green	0	empty
ATR 3	071	F	SD	68	4.518	1.44	3.860	3	0.223	5.78	0.064	1.66	75	green	20	unidentifiable
ATR 3	072	F	SD	73	5.431	1.40	4.333	2	0.234	5.40	0.072	1.66	100	green	0	empty
ATR 3	073	M	SD	65	3.846	1.40	3.354	3	0.024	0.72	0.045	1.34	75	green	10	unidentifiable
ATR 3	074	F	SD	82	6.328	1.15	5.388	2	0.303	5.62	0.071	1.32	100	green	0	empty
ATR 3	075	M	SD	67	4.537	1.51	3.896	4	0.035	0.90	0.059	1.51	80	green	0	empty
ATR 3	076	F	SD	63	3.841	1.54	3.238	3	0.164	5.06	0.066	2.04	20	green	0	empty
ATR 3	077	F	SD	72	5.069	1.36	4.112	4	0.259	6.30	0.083	2.02	20	green	0	empty
ATR 3	078	F	SD	68	4.157	1.32	3.649	3	0.194	5.32	0.064	1.75	50	green	0	empty
ATR 3	079	F	SD	62	2.976	1.25	2.647	2	0.110	4.16	0.049	1.85	0	n/a	0	empty
ATR 3	080	M	SD	61	3.037	1.34	2.656	3	0.022	0.83	0.037	1.39	100	green	0	empty
ATR 4	001	F	SD	59	2.234	1.09	1.949	2	0.096	4.93	0.040	2.05	50	green	30	unidentifiable
ATR 4	002	M	SD	67	3.545	1.18	3.213	3	0.043	1.34	0.036	1.12	70	green	0	empty
ATR 4	003	M	SD	67	3.316	1.10	2.806	3	0.033	1.18	0.044	1.57	0	n/a	0	empty
ATR 4	004	F	SD	84	6.515	1.10	5.180	3	0.311	6.00	0.091	1.76	75	green	0	empty
ATR 4	005	F	SD	68	3.573	1.14	3.171	2	0.174	5.49	0.052	1.64	100	green	25	unidentifiable
ATR 4	006	F	SD	69	4.467	1.36	3.844	3	0.225	5.85	0.056	1.46	0	n/a	100	unidentifiable
ATR 4	007	M	SD	75	4.761	1.13	4.408	4	0.070	1.59	0.060	1.36	50	green	20	unidentifiable
ATR 4	008	F	SD	71	4.002	1.12	3.550	2	0.180	5.07	0.046	1.30	20	green	0	empty
ATR 4	009	F	SD	67	3.639	1.21	3.166	2	0.210	6.63	0.051	1.61	50	green	0	empty

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 4	010	F	SD	81	5.922	1.11	5.300	4	0.224	4.23	0.073	1.38	0	n/a	50	empty
ATR 4	011	F	SD	71	4.848	1.35	4.157	3	0.282	6.78	0.059	1.42	50	green	0	empty
ATR 4	012	M	SD	58	2.619	1.34	2.400	2	0.031	1.29	0.030	1.25	0	n/a	25	unidentifiable
ATR 4	013	F	SD	65	3.185	1.16	2.805	3	0.145	5.17	0.040	1.43	50	green	30	unidentifiable
ATR 4	014	M	SD	62	2.850	1.20	2.546	3	0.036	1.41	0.032	1.26	80	green	75	unidentifiable
ATR 4	015	M	SD	54	2.955	1.88	2.694	2	0.030	1.11	0.021	0.78	0	n/a	0	empty
ATR 4	016	M	SD	59	2.697	1.31	2.385	4	0.034	1.43	0.030	1.26	0	n/a	75	unidentifiable
ATR 4	017	M	SD	60	2.536	1.17	2.347	3	0.024	1.02	0.028	1.19	0	n/a	50	unidentifiable
ATR 4	018	M	SD	62	2.764	1.16	2.374	2	0.028	1.18	0.038	1.60	75	green	10	unidentifiable
ATR 4	019	M	SD	63	2.883	1.15	2.645	5	0.030	1.13	0.027	1.02	25	green	0	empty
ATR 4	020	M	SD	63	2.739	1.10	2.515	3	0.260	10.34	0.380	15.11	75	green	0	empty
ATR 4	021	F	SD	63	3.171	1.27	2.731	2	0.148	5.42	0.044	1.61	80	green	0	empty
ATR 4	022	M	SD	74	4.571	1.13	4.067	2	0.042	1.03	0.048	1.18	50	green	90	unidentifiable
ATR 4	023	F	SD	79	5.584	1.13	4.907	4	0.317	6.46	0.067	1.37	0	n/a	0	empty
ATR 4	024	M	SD	66	3.615	1.26	3.178	3	0.039	1.23	0.045	1.42	0	n/a	75	unidentifiable
ATR 4	025	F	SD	62	2.912	1.22	2.572	2	0.136	5.29	0.031	1.21	50	green	0	empty
ATR 4	026	M	SD	73	3.831	0.98	3.596	3	0.037	1.03	0.039	1.08	50	green	0	empty
ATR 4	027	M	SD	68	3.681	1.17	3.422	4	0.040	1.17	0.037	1.08	0	n/a	0	empty
ATR 4	028	M	SD	64	3.259	1.24	2.966	3	0.040	1.35	0.037	1.25	50	green	50	unidentifiable
ATR 4	029	M	SD	64	2.715	1.04	2.485	5	0.032	1.29	0.031	1.25	0	n/a	0	empty
ATR 4	030	F	SD	72	3.967	1.06	3.441	3	0.206	5.99	0.052	1.51	25	green	0	unidentifiable
ATR 4	031	M	SD	63	2.571	1.03	2.377	3	0.027	1.14	0.032	1.35	0	n/a	0	unidentifiable
ATR 4	032	M	SD	61	2.809	1.24	2.548	2	0.031	1.22	0.033	1.30	50	green	0	unidentifiable
ATR 4	033	M	SD	59	2.570	1.25	2.374	3	0.030	1.26	0.018	0.76	0	n/a	0	unidentifiable
ATR 4	034	F	SD	60	2.842	1.32	2.467	2	0.162	6.57	0.022	0.89	25	green	0	unidentifiable
ATR 4	035	F	SD	72	4.019	1.08	3.542	2	0.154	4.35	0.044	1.24	50	green	0	empty
ATR 4	036	M	SD	75	4.190	0.99	3.808	4	0.025	0.66	0.053	1.39	75	green	25	unidentifiable
ATR 4	037	F	SD	80	0.256	0.05	4.478	2	0.252	5.63	0.074	1.65	100	green	20	unidentifiable
ATR 4	038	M	SD	63	2.837	1.13	2.616	4	0.020	0.76	0.030	1.15	50	green	0	empty

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 4	039	F	SD	85	6.843	1.11	5.981	2	0.293	4.90	0.084	1.40	0	n/a	25	unidentifiable
ATR 4	040	M	SD	62	2.732	1.15	2.377	2	0.023	0.97	0.021	0.88	50	green	50	unidentifiable
ATR 4	041	M	SD	72	3.896	1.04	3.595	4	0.055	1.53	0.043	1.20	100	green	0	empty
ATR 4	042	M	SD	66	3.344	1.16	3.066	4	0.032	1.04	0.038	1.24	0	n/a	0	empty
ATR 4	043	M	SD	70	4.075	1.19	3.769	2	0.067	1.78	0.049	1.30	50	green	0	empty
ATR 4	044	F	SD	56	2.171	1.24	1.198	2	0.076	6.34	0.027	2.25	25	green	0	empty
ATR 4	045	M	SD	65	2.834	1.03	2.586	2	0.036	1.39	0.031	1.20	0	n/a	100	unidentifiable
ATR 4	046	F	SD	64	3.183	1.21	2.774	2	0.174	6.27	0.045	1.62	25	green	25	unidentifiable
ATR 4	047	M	SD	73	4.509	1.16	4.321	4	0.063	1.46	0.058	1.34	0	n/a	25	unidentifiable
ATR 4	048	M	SD	63	2.769	1.11	2.529	2	0.020	0.79	0.026	1.03	25	green	0	empty
ATR 4	049	M	SD	65	2.793	1.02	2.558	3	0.026	1.02	0.030	1.17	50	green	0	empty
ATR 4	050	F	SD	65	3.553	1.29	3.153	4	0.173	5.49	0.047	1.49	25	green	0	empty
ATR 4	051	F	SD	73	4.491	1.15	3.813	3	0.239	6.27	0.060	1.57	100	green	100	unidentifiable
ATR 4	052	M	SD	62	3.029	1.27	2.468	3	0.017	0.69	0.033	1.34	0	n/a	50	unidentifiable
ATR 4	053	M	SD	62	2.819	1.18	2.550	2	0.035	1.37	0.033	1.29	25	green	100	unidentifiable
ATR 4	054	F	SD	66	3.184	1.11	2.660	3	0.156	5.86	0.048	1.80	10	green	100	gamarus & unidentifiable
ATR 4	055	F	SD	76	5.128	1.17	4.449	3	0.236	5.30	0.075	1.69	10	green	100	unidentifiable
ATR 4	056	F	SD	64	3.272	1.25	2.812	2	0.150	5.33	0.048	1.71	100	green	20	unidentifiable
ATR 4	057	F	SD	66	3.441	1.20	3.028	3	0.161	5.32	0.050	1.65	0		0	empty
ATR 4	058	F	SD	58	3.550	1.82	3.123	2	0.116	3.71	0.047	1.50	100	green	20	unidentifiable
ATR 4	059	F	SD	61	2.682	1.18	2.306	3	0.125	5.42	0.039	1.69	100	green	0	empty
ATR 4	060	F	SD	64	3.075	1.17	2.699	2	0.105	3.89	0.039	1.44	0	n/a	10	unidentifiable
ATR 4	061	F	SD	79	5.860	1.19	4.907	4	0.305	6.22	0.073	1.49	0	n/a	50	chironomid & unidentifiable
ATR 4	062	F	SD	66	3.911	1.36	3.204	2	0.187	5.84	0.055	1.72	0	n/a	50	unidentifiable
ATR 4	063	F	SD	69	3.914	1.19	3.384	2	0.167	4.93	0.047	1.39	0	n/a	50	chironomid larva
ATR 4	064	F	SD	75	5.374	1.27	4.472	3	0.190	4.25	0.070	1.57	0	green	50	chironomid & unidentifiable

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 4	065	F	SD	85	7.241	1.18	6.154	4	0.374	6.08	0.109	1.77	0	n/a	70	unidentifiable
ATR 4	066	M	SD	65	3.420	1.25	2.974	2	0.046	1.55	0.032	1.08	0	n/a	25	unidentifiable
ATR 4	067	F	SD	80	5.860	1.14	4.898	4	0.263	5.37	0.092	1.88	100	green	50	unidentifiable
ATR 4	068	F	SD	72	4.469	1.20	3.790	3	0.216	5.70	0.079	2.08	100	green	0	empty
ATR 4	069	M	SD	72	4.018	1.08	3.410	2	0.051	1.50	0.047	1.38	0	n/a	100	unidentifiable
ATR 4	070	F	SD	76	5.226	1.19	4.938	4	0.209	4.23	0.064	1.30	100	green	80	chironomids
ATR 4	071	F	SD	69	3.833	1.17	3.353	3	0.154	4.59	0.051	1.52	100	green	20	unidentifiable
ATR 4	072	M	SD	65	3.388	1.23	3.113	4	0.048	1.54	0.038	1.22	100	green	0	empty
ATR 4	073	F	SD	66	3.293	1.15	2.749	3	0.181	6.58	0.046	1.67	100	green	0	empty
ATR 4	074	M	SD	64	3.150	1.20		3	0.020		0.032		0	n/a	0	empty
ATR 4	075	F	SD	68	4.025	1.28	3.268	2	0.195	5.97	0.063	1.93	100	green	0	empty
ATR 4	076	F	SD	69	3.598	1.10	3.142	3	0.208	6.62	0.049	1.56	0	n/a	0	empty
ATR 4	077	M	SD	60	2.420	1.12	2.195	2	0.028	1.28	0.026	1.18	100	green	0	empty
ATR 4	078	M	SD	59	2.441	1.19	2.299	3	0.026	1.13	0.024	1.04	100	green	0	empty
ATR 4	079	M	SD	61	2.794	1.23	2.503	3	0.021	0.84	0.035	1.40	100	green	0	empty
ATR 4	080	M	SD	67	3.753	1.25	3.227	2	0.063	1.95	0.040	1.24	100	green	0	empty
ATR 5	001	F	SD	64	3.253	1.24	2.772	2	0.150	5.41	0.056	2.02	0	n/a	20%	unidentifiable
ATR 5	002	F	SD	64	3.078	1.17	2.652	2	0.146	5.51	0.052	1.96	0	n/a	40	unidentifiable
ATR 5	003	F	SD	74	5.291	1.31	4.663	4	0.218	4.68	0.066	1.42	50	green	50	unidentifiable
ATR 5	004	M	SD	67	3.909	1.30	3.529	4	0.087	2.47	0.053	1.50	0	n/a	0	empty
ATR 5	005	F	SD	81	6.555	1.23	5.680	4	0.406	7.15	0.101	1.78	0	n/a	0	empty
ATR 5	006	M	SD	72	4.141	1.11	3.793	3	0.055	1.45	0.048	1.27	0	n/a	50	unidentifiable
ATR 5	007	M	SD	59	2.645	1.29	2.330	2	0.048	2.06	0.031	1.33	100	green	10	unidentifiable
ATR 5	008	M	SD	59	2.665	1.30	2.417	3	0.030	1.24	0.044	1.82	0	n/a	100	unidentifiable
ATR 5	009	F	SD	62	3.069	1.29	2.682	2	0.134	5.00	0.049	1.83	25	green	100	unidentifiable
ATR 5	010	F	SD	63	3.118	1.25	2.616	2	0.145	5.54	0.056	2.14	75	green	0	empty
ATR 5	011	M	SD	60	3.073	1.42	2.817	1	0.043	1.53	0.043	1.53	0	n/a	100	unidentifiable
ATR 5	012	M	SD	68	2.576	0.82	2.301	3	0.032	1.39	0.031	1.35	100	green	0	empty
ATR 5	013	M	SD	54	2.440	1.55	2.134	3	0.040	1.87	0.044	2.06	75	green	10	unidentifiable

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 5	014	M	SD	65	3.252	1.18	2.990	2	0.030	1.00	0.038	1.27	0	n/a	0	empty
ATR 5	015	M	SD	54	2.144	1.36	1.847	1	0.022	1.19	0.034	1.84	0	n/a	30	unidentifiable
ATR 5	016	F	SD	76	5.062	1.15	4.278	3	0.213	4.98	0.074	1.73	0	n/a	0	empty
ATR 5	017	F	SD	76	5.122	1.17	4.406	4	0.321	7.29	0.071	1.61	50	green	0	empty
ATR 5	018	F	SD	70	4.445	1.30	3.708	2	0.241	6.50	0.061	1.65	80	green	10	unidentifiable
ATR 5	019	M	SD	61	2.962	1.30	2.618	1	0.025	0.95	0.053	2.02	0	empty	0	empty
ATR 5	020	F	SD	82	6.663	1.21	5.954	2	0.327	5.49	0.117	1.97	100	green	0	empty
ATR 5	021	M	SD	66	3.813	1.33	3.280	3	0.037	1.13	0.051	1.55	20	green	0	empty
ATR 5	022	M	SD	66	3.353	1.17	2.788	2	0.048	1.72	0.046	1.65	100	green	0	empty
ATR 5	023	F	SD	81	6.926	1.30	5.847	3	0.361	6.17	0.116	1.98	40	green	30	unidentifiable
ATR 5	024	F	SD	66	3.845	1.34	3.314	1	0.233	7.03	0.069	2.08	0	n/a	0	empty
ATR 5	025	F	SD	62	3.966	1.66	3.657	3	0.210	5.74	0.085	2.32	0	n/a	30	unidentifiable
ATR 5	026	M	SD	64	3.308	1.26	2.882	1	0.030	1.04	0.048	1.67	50	green	0	empty
ATR 5	027	M	SD	76	5.188	1.18	4.264	2	0.045	1.06	0.097	2.27	100	green	0	empty
ATR 5	028	F	SD	59	2.905	1.41	2.590	2	0.163	6.29	0.061	2.36	50	green	0	empty
ATR 5	029	F	SD	78	6.327	1.33	5.403	3	0.302	5.59	0.166	3.07	100	green	0	empty
ATR 5	030	M	SD	61	2.779	1.22	2.364	2	0.035	1.48	0.051	2.16	80	green	0	empty
ATR 5	031	M	SD	68	4.634	1.47	3.767	4	0.062	1.65	0.077	2.04	30	green	0	empty
ATR 5	032	M	SD	62	3.297	1.38	2.908	3	0.046	1.58	0.066	2.27	0	n/a	0	empty
ATR 5	033	F	SD	78	6.209	1.31	5.302	4	0.318	6.00	0.127	2.40	75	green	0	empty
ATR 5	034	M	SD	68	3.612	1.15	3.230	2	0.059	1.83	0.052	1.61	50	green	0	empty
ATR 5	035	M	SD	77	5.484	1.20	4.898	3	0.081	1.65	0.091	1.86	40	green	10	unidentifiable
ATR 5	036	F	SD	78	5.450	1.15	5.051	2	0.302	5.98	0.107	2.12	0	light green	30	unidentifiable
ATR 5	037	F	SD	68	3.655	1.16	3.324	3	0.220	6.62	0.060	1.81	0	n/a	100	unidentifiable
ATR 5	038	F	SD	70	4.616	1.35	4.032	2	0.230	5.70	0.700	17.36	0	light yellow	100	unidentifiable
ATR 5	039	F	SD	56	2.106	1.20	1.961	1	0.100	5.10	0.030	1.53	0	n/a	100	unidentifiable
ATR 5	040	M	SD	71	4.636	1.30	4.180	3	0.093	2.22	0.085	2.03	0	n/a	90	unidentifiable
ATR 5	041	M	SD	60	2.564	1.19	2.723	2	0.048	1.76	0.035	1.29	25	green	30	chironomids
ATR 5	042	M	SD	58	2.283	1.17	1.917	2	0.045	2.35	0.028	1.46	0	n/a	80	chironomids

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 5	043	F	SD	66	3.573	1.24	3.022	2	0.233	7.71	0.060	1.99	0	n/a	75	mayfly
ATR 5	044	F	SD	68	4.083	1.30	3.463	2	0.214	6.18	0.077	2.22	70	green	0	empty
ATR 5	045	F	SD	65	3.405	1.24	2.861	1	0.121	4.23	0.071	2.48	10	green	20	unidentifiable
ATR 5	046	F	SD	62	3.242	1.36	2.715	1	0.170	6.26	0.046	1.69	0	n/a	100	chironomids
ATR 5	047	M	SD	64	3.141	1.20	2.746	5	0.070	2.55	0.042	1.53	0	n/a	100	chironomids
ATR 5	048	F	SD	67	3.311	1.10	2.892	2	0.143	4.94	0.059	2.04	0	n/a	0	empty
ATR 5	049	M	SD	62	2.809	1.18	2.429	1	0.042	1.73	0.032	1.32	10	green	100	chironomids
ATR 5	050	M	SD	65	2.639	0.96	2.458	1	0.060	2.44	0.052	2.12	0	n/a	0	empty
ATR 5	051	M	SD	62	2.992	1.26	2.947	2	0.077	2.61	0.041	1.39	0	n/a	50	chrionomids
ATR 5	052	F	SD	68	3.662	1.16	3.105	3	0.160	5.15	0.055	1.77	0	n/a	40	unidentifiable
ATR 5	053	F	SD	81	6.298	1.19	5.462	2	0.354	6.48	0.093	1.70	20	green	40	unidentifiable
ATR 5	054	M	SD	72	4.599	1.23	4.036	2	0.068	1.68	0.069	1.71	0	n/a	75	unidentifiable
ATR 5	055	M	SD	52	2.210	1.57	1.886	1	0.010	0.53	0.042	2.23	20	green	0	empty
ATR 5	056	F	SD	69	3.416	1.04	2.900	2	0.166	5.72	0.050	1.72	20	green	0	empty
ATR 5	057	M	SD	66	3.297	1.15	2.971	3	0.048	1.62	0.031	1.04	30	yellow	10	unidentifiable
ATR 5	058	F	SD	61	2.886	1.27	2.451	2	0.150	6.12	0.059	2.41	50	yellow	0	empty
ATR 5	059	F	SD	76	5.617	1.28	4.771	2	0.257	5.39	0.077	1.61	40	yellow	0	empty
ATR 5	060	M	SD	61	2.939	1.29	2.605	2	0.034	1.31	0.026	1.00	20	yellow	20	unidentifiable
ATR 5	061	M	SD	64	2.885	1.10	2.774	1	0.101	3.64	0.010	0.36	50	yellow	50	invertebrates
ATR 5	062	M	SD	57	2.416	1.30	2.023	3	0.031	1.53	0.046	2.27	0	n/a	100	unidentifiable
ATR 5	063	M	SD	73	3.852	0.99	3.244	3	0.055	1.70	0.047	1.45	0	n/a	100	unidentifiable
ATR 5	064	F	SD	71	4.285	1.20	3.484	2	0.213	6.11	0.600	17.22	0	n/a	100	chironomids
ATR 5	065	F	SD	83	5.687	0.99	4.668	4	0.234	5.01	0.080	1.71	0	n/a	100	chironomids
ATR 5	066	M	SD	68	3.352	1.07	2.942	3	0.057	1.94	0.044	1.50	0	n/a	100	chironomids
ATR 5	067	F	SD	77	4.973	1.09	4.049	4	0.286	7.06	0.126	3.11	0	n/a	50	chironomids
ATR 5	068	M	SD	75	4.485	1.06	3.824	2	0.048	1.26	0.067	1.75	0	n/a	100	chironomids
ATR 5	069	M	SD	60	2.654	1.23	2.270	3	0.041	1.81	0.042	1.85	10	yellow	0	empty
ATR 5	070	F	SD	77	4.465	0.98	3.753	3	0.244	6.50	0.062	1.65	80	green	0	empty
ATR 5	071	F	SD	69	4.351	1.32	3.868	2	0.269	6.95	0.118	3.05	0	n/a	100	unidentifiable

Table XVII.1 Trout-perch Measurement Data, Athabasca River Sentinel Species Study, Fall 2002 (continued)

Site	ID Number	Sex	Maturity Code	Fork Length (mm)	Total Weight (g)	Condition Factor	Carcass Weight (g)	Age	Gonad Weight (g)	GSI	Liver Weight (g)	LSI	Gall Bladder Fullness (%)	Bile Color	Stomach Fullness (%)	Stomach Contents
ATR 5	072	M	SD	63	2.960	1.18	2.730	2	0.038	1.39	0.030	1.10	0	n/a	60	unidentifiable
ATR 5	073	F	SD	82	3.368	0.61	5.674	3	0.321	5.66	0.086	1.52	0	n/a	70	unidentifiable
ATR 5	074	F	SD	74	4.798	1.18	3.811	2	0.206	5.41	0.084	2.20	0	n/a	90	unidentifiable
ATR 5	075	F	SD	76	4.272	0.97	3.649	3	0.253	6.93	0.078	2.14	20	green	40	chironomids
ATR 5	076	M	SD	63	3.215	1.29	2.852	1	0.037	1.30	0.034	1.19	0	n/a	50	chironomids
ATR 5	077	F	SD	83	5.529	0.97	4.655	3	0.291	6.25	0.092	1.98	100	green	0	empty
ATR 5	078	F	SD	64	3.061	1.17	2.550	1	0.160	6.27	0.054	2.12	50	green	20	unidentifiable
ATR 5	079	M	SD	61	2.817	1.24	2.615	2	0.044	1.68	0.031	1.19	0	n/a	95	unidentifiable
ATR 5	080	M	SD	69	2.400	0.73	2.182	1	0.024	1.10	0.028	1.28	10	green	75	chironomids

Note: M = Male; F = Female.
Maturity codes: SD = Adults, Seasonal Development
n/a = Not applicable.
n/s = No sample.

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 1	001	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	002	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	003	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	004	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	005	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	006	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	007	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 1	008	N	N	N	0	0	none	0	1	0	2	D	B	0	N	0	60
ATR 1	009	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 1	010	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 1	011	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 1	012	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	013	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	014	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 1	015	N	N	N	0	0	none	0	1	0	4	A	B	0	N	0	30
ATR 1	016	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	017	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	018	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	019	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 1	020	N	N	N	0	0	none	0	0	0	3	A	E	0	N	0	30
ATR 1	021	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	022	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	023	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	024	N	N	N	0	0	none	0	0	0	3	A	E	0	N	2	50
ATR 1	025	N	N	N	0	0	none	0	1	0	4	A	B	0	N	0	30
ATR 1	026	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	027	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	028	N	N	N	0	0	none	0	0	0	2	A	E	0	N	0	30
ATR 1	029	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 1	030	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 1	031	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	032	N	N	N	N	0	none	0	1	0	2	A	B	0	N	0	30
ATR 1	033	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	034	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	035	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	036	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	037	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	038	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	039	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 1	040	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	041	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	042	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	043	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	044	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	045	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	046	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	047	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	048	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	049	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 1	050	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	051	N	N	N	0	0	none	1	0	0	1	A	B	0	N	0	10
ATR 1	052	N	N	N	0	0	none	0	0	0	1	A	E	0	N	0	30
ATR 1	053	N	N	N	0	0	none	0	1	0	0	A	E	0	N	0	60
ATR 1	054	N	N	N	0	0	none	0	0	0	1	F	B	0	N	0	30
ATR 1	055	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	056	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	057	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 1	058	N	N	S	0	0	none	0	0	0	1	A	B	0	N	0	30
ATR 1	059	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	060	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	061	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	062	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	063	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	064	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	065	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 1	066	N	N	N	0	0	none	0	1	0	0	A	B	0	N	0	120
ATR 1	067	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	068	N	N	N	0	0	none	0	0	0	1	A	E	0	N	0	60
ATR 1	069	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	070	N	N	N	0	0	none	0	0	0	4	A	B	0	N	1	10
ATR 1	071	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	072	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	073	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	074	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	075	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	076	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 1	077	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	078	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 1	079	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 1	080	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	081	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	082	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 1	083	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 1	084	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 1	085	N	N	N	0	0	none	0	1	0	0	A	B	0	N	0	30
ATR 2	001	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	002	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
ATR 2	003	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	004	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	005	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	006	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 2	007	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	008	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	009	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	010	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	011	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	012	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	013	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	014	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	015	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	016	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	017	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	018	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	019	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	020	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	021	N	N	N	0	0	none	0	1	0	3	A	B	0	N	0	30
ATR 2	022	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	023	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	024	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	025	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	026	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	027	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	028	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	029	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	030	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	031	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	032	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 2	033	N	N	N	0	1	none	0	0	0	0	A	B	0	N	0	10
ATR 2	034	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 2	035	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	036	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	037	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 2	038	N	N	N	0	0	none	0	1	0	2	D	B	0	N	0	60
ATR 2	039	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	040	N	N	N	0	1	none	0	0	0	0	A	B	0	N	0	10
ATR 2	041	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	042	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	043	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	044	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	045	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	046	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	047	N	N	N	0	0	none	0	1	0	2	A	B	0	N	0	30
ATR 2	048	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	049	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	050	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	051	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	052	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	053	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	054	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	055	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	056	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
ATR 2	057	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	058	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	059	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	060	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 2	061	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	062	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
ATR 2	063	N	N	N	0	0	none	1	0	0	1	D	B	0	N	0	40
ATR 2	064	N	N	N	0	1	none	0	0	0	3	A	B	0	N	0	10
ATR 2	065	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 2	066	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	067	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	068	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 2	069	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 2	070	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	071	N	N	N	0	0	none	2	0	0	1	A	B	0	N	0	20

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 2	072	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	073	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	074	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	075	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	076	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	077	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 2	078	N	N	N	0	0	none	0	0	1	1	A	B	0	N	0	10
ATR 2	079	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 2	080	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	081	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 2	082	N	N	N	0	0	none	0	0	0	0	F	B	0	N	0	30
ATR 2	083	E1	N	N	0	0	none	0	0	0	1	A	E	0	N	0	60
ATR 2	084	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	085	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	086	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 2	087	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 3	001	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	002	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	003	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	004	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 3	005	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	006	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	007	N	N	N	0	0	none	0	0	0	0	A	B	0	N	3	30
ATR 3	008	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	009	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	010	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	011	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	012	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	013	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	014	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 3	015	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	016	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	017	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	018	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	019	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	020	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	021	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	022	N	N	N	0	0	none	0	1	0	3	A	B	0	N	0	30
ATR 3	023	N	N	N	0	0	none	0	1	0	1	D	B	0	N	0	60

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 3	024	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	025	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	026	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	027	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
ATR 3	028	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	029	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	030	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 3	031	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	032	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	033	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	034	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	035	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	036	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 3	037	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	038	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	039	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	040	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	041	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	042	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	043	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	044	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	045	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	046	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	047	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	048	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 3	049	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	050	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
ATR 3	051	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 3	052	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	053	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	054	N	N	N	0	0	none	1	0	0	1	A	B	0	N	0	10
ATR 3	055	N	N	N	0	0	none	0	1	0	3	A	B	0	N	0	30
ATR 3	056	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	057	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	058	N	N	N	0	0	none	1	0	0	3	A	B	0	N	0	10
ATR 3	059	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
ATR 3	060	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	061	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	062	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 3	063	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	064	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 3	065	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	066	N	P	N	0	0	none	0	0	0	1	A	B	0	N	0	30
ATR 3	067	N	N	N	0	1	none	1	0	0	0	A	B	0	N	0	20
ATR 3	068	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	069	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
ATR 3	070	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	071	N	N	N	0	1	none	0	0	0	3	A	B	0	N	0	10
ATR 3	072	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	073	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 3	074	N	N	S	0	1	none	1	0	0	1	A	B	0	N	0	50
ATR 3	075	N	P	N	0	2	none	1	0	0	1	A	B	0	N	0	60
ATR 3	076	N	P	N	0	0	none	0	1	0	1	A	B	0	N	0	60
ATR 3	077	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	078	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
ATR 3	079	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 3	080	N	N	N	0	0	none	0	1	0	3	A	B	0	N	0	30
ATR 4	001	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	002	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 4	003	N	N	N	0	0	none	0	0	0	3	A	OT	0	N	0	30
ATR 4	004	N	N	N	0	0	none	0	0	0	2	D	B	0	N	0	30
ATR 4	005	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	006	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
ATR 4	007	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	008	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	009	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	010	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 4	011	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	012	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	013	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	014	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	015	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	016	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	017	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	018	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	019	N	N	N	0	3	none	0	0	0	3	A	B	0	N	0	30
ATR 4	020	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	021	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
		Condition															
ATR 4	022	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 4	023	N	N	N	0	0	none	0	1	0	2	A	B	0	N	0	30
ATR 4	024	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	025	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 4	026	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	027	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	028	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	029	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 4	030	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	031	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 4	032	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	033	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	034	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	035	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	036	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	037	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	038	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	039	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 4	040	N	N	N	0	0	none	0	1	0	0	A	B	0	N	0	30
ATR 4	041	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	042	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	043	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	044	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	045	N	N	N	0	0	none	0	1	0	1	A	B	0	N	0	30
ATR 4	046	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	047	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	048	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 4	049	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	050	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	051	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 4	052	N	N	N	0	0	none	0	0	0	3	A	B	0	N	1	10
ATR 4	053	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 4	054	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 4	055	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 4	056	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	057	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	058	N	C	N	0	0	none	0	0	0	1	A	B	0	N	0	30
ATR 4	059	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	060	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 4	061	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10
ATR 4	062	N	N	N	0	0	none	0	0	0	1	E	B	0	N	0	30
ATR 4	063	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	064	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 4	065	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	066	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	067	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	068	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	069	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
ATR 4	070	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
ATR 4	071	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	072	N	N	N	0	0	none	0	0	0	3	A	B	0	N	0	0
ATR 4	073	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	074	N	N	N	0	0	none	0	0	0	4	A	B	0	N	0	0
ATR 4	075	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	076	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 4	077	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 4	079	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 4	080	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	001	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	002	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	003	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	004	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	005	N	N	N	0	0	none	0	0	0	1	D	B	0	N	0	30
ATR 5	006	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	007	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	008	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	009	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	010	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	011	N	N	N	0	0	none	0	0	0	2	A	B	0	N	0	0
ATR 5	012	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	013	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	014	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	015	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	016	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	017	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	018	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10
ATR 5	019	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	020	N	N	N	0	0	none	0	0	0	1	A	B	0	N	1	10

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 5	021	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	022	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	023	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	024	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	025	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	026	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	027	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	028	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	029	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	030	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	031	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	032	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	033	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	034	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	035	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	036	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	037	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	038	N	N	N	0	0	none	2	0	0	0	A	B	0	N	0	20
ATR 5	039	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	040	N	N	N	0	0	none	1	0	0	0	A	B	0	N	0	10
ATR 5	041	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	042	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	043	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	044	N	N	N	0	0	none	2	0	0	0	A	B	0	N	0	20
ATR 5	045	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	046	N	N	S	0	0	none	0	0	0	1	F	B	0	N	0	60
ATR 5	047	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	048	N	N	N	0	0	none	0	0	0	0	D	E	0	N	0	60
ATR 5	049	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	050	N	N	N	0	0	none	0	0	0	0	A	E	0	N	0	30
ATR 5	051	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	052	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	053	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	054	N	N	N	0	0	none	0	0	0	0	A	E	0	N	0	30
ATR 5	055	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	056	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	057	N	N	N	0	0	none	0	0	0	0	A	E	0	N	0	30
ATR 5	058	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	059	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0

Table XVII.2 Trout-Perch Pathology Data, Athabasca River Sentinal Species Study, Fall 2002 (continued)

Site	ID Number	Eyes	Gills	Pseudobranchs	Thymus	Skin	Body Deformities	Fins	Opercles	Hindgut	Mesenteric Fat	Liver	Spleen	Gall Bladder	Kidney	Parasites	Pathology Index (PI)
	Condition																
ATR 5	060	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	061	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	062	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	063	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	064	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	065	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	066	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	067	N	N	N	0	0	none	0	0	1	1	A	B	0	N	0	10
ATR 5	068	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	069	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	070	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	071	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	072	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	073	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	074	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	075	N	N	N	0	0	none	0	0	0	1	A	B	0	N	0	0
ATR 5	076	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	077	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	078	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	079	N	N	N	0	0	none	0	0	0	0	A	B	0	N	0	0
ATR 5	080	N	N	N	0	1	none	0	0	0	1	A	B	0	N	0	10

Note: See Appendix XIV for pathology codes.
none = Not applicable.

APPENDIX XVIII

MUSKEG CREEK AND WAP ASU CREEK FYKE NET AND INVENTORY DATA, SPRING AND FALL 2002

Table XVIII.1 Codes for Muskeg and Wapasu Creek Fish Measurement Data (Table XVIII.2)

<u>Capture Method Codes</u>

BP	backpack electrofishing
HN	fyke netting
MB	minnow trapping (baited)

<u>Fish Species Codes</u>

BKST	brook stickleback
LKCH	lake chub
LNSC	longnose sucker
NRPK	northern pike
PRDC	pearl dace
SPSC	spoonhead sculpin
WHSC	white sucker

<u>Sex Codes</u>

F	female
M	male
U	unknown

<u>Life Stage Codes</u>

F	fry (young-of-the-year)
J	juvenile
A	adult
U	unknown

<u>State of Maturity Codes</u>

Codes for Immature Fish:	IM	immature
Codes for Mature Fish:	MA	maturing
	SD	seasonal development
	PR	pre-spawning
	RP	ripe
	SP	spent
	RS	resting
	RB	reabsorbing
	UN	unknown

<u>Pathology Codes and Index Values</u>

See Appendix XIV

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	spring	June 15	BP	LKCH	51	2	1.5	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	LKCH	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	LKCH	52	2	1.4	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	LKCH	42	1	1.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	LKCH	65	3	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	LKCH	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	40	1	1.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	66	3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	76	5	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	38	--	--	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	61	3	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	51	1	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	46	1	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	52	1	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	--	--	--	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	40	1	1.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	42	1	1.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	56	1	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	62	2	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	62	2	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	43	1	1.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	38	1	1.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	70	3	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	42	1	1.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	55	1	0.6	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	spring	June 15	BP	PRDC	58	2	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	42	1	1.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	43	1	1.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	51	2	1.5	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	59	2	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	40	1	1.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	76	3	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	95	7	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	21	1	8.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	72	4	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	51	1	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	68	3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	36	1	2.1	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	51	2	1.5	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	32	1	3.1	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	61	3	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	53	2	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	PRDC	41	1	1.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 15	BP	WHSC	80	6	1.2	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	LKCH	90	8.5	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	LKCH	75	6.2	1.5	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	PRDC	75	7.0	1.7	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	PRDC	76	6.1	1.4	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	PRDC	40	0.4	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	PRDC	25	0.1	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	WHSC	155	38.1	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	BP	WHSC	145	40.1	1.3	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	BRST	55	2	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 26	Fyke	BRST	60	2	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 26	Fyke	BRST	68	3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	spring	May 27	Fyke	BRST	70	3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	BRST	59	2	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	BRST	67	2	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	BRST	70	3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	BRST	52	1	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 28	Fyke	BRST	68	3	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 30	Fyke	BRST	48	1	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 1	Fyke	BRST	50	1	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	June 1	Fyke	BRST	51	1	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	LKCH	92	9	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	LKCH	71	3	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 29	Fyke	LKCH	66	3	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 29	Fyke	LKCH	54	2	1.1	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	LNSC	115	14	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	LNSC	123	17	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 28	Fyke	LNSC	124	18	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	NRPK	500	810	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	10	9	826.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	85	7	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	97	7	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	85	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	114	15	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	80	6	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	92	8	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	90	7	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	62	3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	100	7	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	79	4	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	79	4	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	68	3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	84	5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	spring	May 25	Fyke	PRDC	84	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	87	7	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	100	10	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	94	8	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	87	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	82	5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	95	8	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	82	5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	88	6	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	76	4	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	84	8	1.4	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	80	5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	92	7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 25	Fyke	PRDC	78	5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 26	Fyke	PRDC	115	17	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	115	17	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	90	6	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	95	7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	124	17	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	92	7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	83	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	95	9	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	75	4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	87	6	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	82	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	57	2	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	85	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	93	8	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	85	7	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	90	9	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	94	7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	spring	May 27	Fyke	PRDC	76	5	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 27	Fyke	PRDC	70	5	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 28	Fyke	PRDC	83	7	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 29	Fyke	PRDC	96	9	1.0	M	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 29	Fyke	PRDC	97	9	1.0	F	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 29	Fyke	PRDC	90	8	1.1	F	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 4	Fyke	BRST	38	0.5	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 6	Fyke	BRST	40	0.4	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 6	Fyke	BRST	42	0.6	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 7	Fyke	BRST	44	0.3	0.4	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 7	Fyke	BRST	42	0.4	0.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 8	Fyke	BRST	46	1.1	1.1	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 8	Fyke	BRST	44	0.8	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	BRST	58	1.1	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	BRST	35	0.6	1.4	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	BRST	40	0.5	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	BRST	35	0.4	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	BRST	35	0.3	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	BRST	36	0.4	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	BRST	35	0.4	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	BRST	41	0.4	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	BRST	33	0.3	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	BRST	34	0.3	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	BRST	33	0.4	1.1	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	BRST	32	0.2	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	BRST	35	0.3	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 7	Fyke	LKCH	64	2.5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 7	Fyke	LKCH	67	2.7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 7	Fyke	LKCH	32	0.2	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	LKCH	32	0.1	0.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	LKCH	55	1.9	1.1	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	fall	October 4	Fyke	PRDC	41	0.6	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 4	Fyke	PRDC	40	0.6	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 6	Fyke	PRDC	39	0.4	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 7	Fyke	PRDC	68	2.8	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	PRDC	75	6.0	1.4	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	PRDC	64	2.4	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	PRDC	48	1.6	1.4	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	PRDC	33	1.5	4.2	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	PRDC	33	1.2	3.3	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	PRDC	35	0.4	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	PRDC	61	2.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	PRDC	30	0.2	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	PRDC	30	0.2	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	PRDC	54	1.3	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	PRDC	37	0.4	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	PRDC	62	3.0	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	PRDC	59	1.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	PRDC	70	4.2	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	PRDC	51	1.4	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	PRDC	51	1.2	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 11	Fyke	PRDC	34	0.4	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	PRDC	35	0.2	0.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	PRDC	35	0.2	0.5	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	PRDC	62	2.4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	PRDC	32	0.2	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	PRDC	36	0.5	1.1	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 12	Fyke	PRDC	35	0.4	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	SPSC	93	11.3	1.4	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 6	Fyke	WHSC	129	20.9	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 8	Fyke	WHSC	70	3.3	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 8	Fyke	WHSC	70	3.3	1.0	U	U	IM	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Muskeg Creek	fall	October 8	Fyke	WHSC	62	2.6	1.1	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	WHSC	145	30.3	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Fyke	WHSC	58	2.3	1.2	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 10	Fyke	WHSC	127	23.2	1.1	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	89	7	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	72	4	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	50	1	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	86	5	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	80	5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	78	6	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	76	4	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	88	7	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Muskeg Creek	spring	May 20	Minnow	PRDC	44	1	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Muskeg Creek	fall	October 9	Minnow	BRST	67	2.3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 18	BP	BRST	45		0.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	60	1.7	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	45	0.7	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	54	1.1	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	42	0.6	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	49	0.9	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	41	0.6	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	BRST	48	0.8	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	40	0.5	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	51	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	38	0.5	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	37	0.5	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	50	1.4	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	45	0.5	0.5	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	28	0.1	0.5	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	32	0.3	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	BP	BRST	31	0.3	1.0	U	U	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	fall	October 10	BP	BRST	50	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	53	0.9	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	45	0.9	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	37	0.4	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	61	2.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	52	1.2	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	50	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	61	1.8	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	41	0.5	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	57	1.6	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	BRST	49	0.8	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	PRDC	82	5.4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	PRDC	68	2.8	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	PRDC	85	5.5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	PRDC	77	5.3	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	PRDC	60	1.9	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	PRDC	57	1.7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	PRDC	40	0.5	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	BP	WHSC	135	31.3	1.3	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	WHSC	150	36.5	1.1	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	WHSC	88	7.6	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	BP	WHSC	85	6.5	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	LKCH	85	6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	84	5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	83	6	1.1	M	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	68	2	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	70	3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	63	2	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	95	9	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	83	6	1.0	F	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	90	7	0.9	M	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	spring	May 28	Fyke	PRDC	85	7	1.1	F	0	RP	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	77	4	1.0	M	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	83	6	1.0	M	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	80	5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	83	5	0.9	M	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 28	Fyke	PRDC	58	2	0.8	M	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	BRST	63	2.5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Fyke	BRST	29	0.2	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	BRST	48	1.1	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	BRST	37	0.5	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	BRST	35	0.3	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	BRST	57	1.4	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	BRST	50	0.7	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	BRST	49	0.7	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	BRST	29	0.2	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Fyke	BRST	46	0.6	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	BRST	45	0.7	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	BRST	32	0.4	1.2	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 11	Fyke	BRST	26	0.1	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	70	3.4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	75	4.2	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	55	1.5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	28	0.2	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	30	0.2	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	55	1.6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	BRST	46	0.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	LNSC	90	6.2	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	LNSC	96	9.6	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	LNSC	107	11.5	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	80	4.5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	64	2.4	0.9	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	fall	October 4	Fyke	PRDC	79	4.8	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	61	2.1	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	69	2.3	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	82	5.2	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	70	3.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	64	3.4	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	65	3.3	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	72	3.6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	49	0.9	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	61	2.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	70	3.1	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	89	6.5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	82	5.7	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	79	5.8	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	77	4.9	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	74	5.3	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	79	5.4	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	PRDC	69	3.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Fyke	PRDC	101	7.3	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	PRDC	77	4.4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	PRDC	79	5.5	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	PRDC	72	4.4	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Fyke	PRDC	37	0.5	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	69	3.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	70	3.7	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	69	3.4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	67	3.2	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	54	1.3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	73	2.9	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	69	3.5	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	70	3.7	1.1	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	fall	October 7	Fyke	PRDC	75	4.6	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	64	4.1	1.6	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	82	6.6	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	83	6.4	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	67	3.1	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	60	2.5	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	68	3.5	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	78	5.2	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	72	4.3	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	78	5.2	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	72	3.9	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	70	3.5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Fyke	PRDC	67	3.0	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	PRDC	74	4.1	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	PRDC	67	3.3	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	PRDC	76	4.5	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	PRDC	62	2.7	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	PRDC	75	4.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	PRDC	67	3.4	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Fyke	PRDC	67	3.2	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Fyke	PRDC	72	3.2	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Fyke	PRDC	72	3.5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	PRDC	72	4.0	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 12	Fyke	PRDC	71	4.1	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	110	13.4	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	145	30.8	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	93	8.4	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	111	13.0	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	113	14.5	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	150	38.5	1.1	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 4	Fyke	WHSC	135	36.4	1.5	U	U	IM	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	fall	October 4	Fyke	WHSC	102	10.4	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Fyke	WHSC	108	12.1	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Fyke	WHSC	112	15.1	1.1	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Fyke	WHSC	98	9.4	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	131	24.5	1.1	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	112	13.1	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	104	11.1	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	122	15.8	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	102	10.7	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	103	11.4	1.0	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	95	7.9	0.9	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 9	Fyke	WHSC	116	12.1	0.8	U	U	IM	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 23	Minnow	BRST	56	1	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 23	Minnow	BRST	49	1	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 24	Minnow	BRST	55	2	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	BRST	58	2	1.1	F	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	BRST	50	2	1.3	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	PRDC	76	4	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	PRDC	53	2	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	PRDC	62	3	1.1	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	PRDC	63	2	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	PRDC	69	3	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	spring	May 21	Minnow	PRDC	65	2	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	55	1.6	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	50	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	50	0.8	0.6	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	48	0.9	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	49	0.9	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	60	1.8	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	47	0.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	51	1.2	0.9	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	fall	October 5	Minnow	BRST	51	1.1	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	57	1.5	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	44	0.7	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	46	0.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	47	0.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	42	0.6	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	45	0.8	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	50	1.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	52	1.0	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	45	0.7	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	48	0.8	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	62	1.6	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	47	1.0	1.0	U	A	SP	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 5	Minnow	BRST	51	1.1	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Minnow	BRST	57	1.7	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Minnow	BRST	47	1.0	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 6	Minnow	BRST	45	0.6	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	52	1.2	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	55	1.4	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	47	0.7	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	55	1.1	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	51	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	56	1.2	0.7	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	56	1.5	0.9	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	45	0.6	0.7	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	48	0.9	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	57	0.8	0.4	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 7	Minnow	BRST	51	1.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Minnow	BRST	42	0.6	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Minnow	BRST	42	0.6	0.8	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 8	Minnow	BRST	50	1.1	0.9	U	A	UN	0	0	0	0	0	0	0	0	0

Table XVIII.2 Fish Measurement Data, Muskeg Creek and Wapasu Creek Fyke Net Monitoring and Inventory Sampling, Spring and Fall 2002 (continued)

Watercourse	Season	Date	Capture Method	Species	Fork Length (mm)	Weight (g)	Condition Factor	Sex	Life Stage	State of Maturity	External Pathology Examination								Pathology Index
											Eyes	Gills	Pseudobr.	Thymus	Skin	Fins	Opercles	Body Form	
Wapasu Creek	fall	October 8	Minnow	BRST	46	0.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	PRDC	80	5.1	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	PRDC	94	9.7	1.2	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	57	1.5	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	48	1.2	1.1	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	48	1.1	1.0	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	PRDC	70	3.3	1.0	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	46	0.9	0.9	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	48	0.7	0.6	U	U	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	50	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	51	1.0	0.8	U	A	UN	0	0	0	0	0	0	0	0	0
Wapasu Creek	fall	October 10	Minnow	BRST	46	0.7	0.7	U	U	UN	0	0	0	0	0	0	0	0	0

APPENDIX XIX

WATER CHEMISTRY DATA FOR ACID SENSITIVE LAKES SAMPLED IN 2002

Table XIX.1 Water Chemistry Data for Acid Sensitive Lakes Sampled in 2002

Lake	pH (lab)	Conduc - tivity (µS/cm)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Total Suspended Solids (mg/L)	Colour (TCU)	Dissolved Inorganic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Total Nitrogen (mg/L)	Total Dissolved Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrite + Nitrate (mg/L)	Ammonium (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Chlorophyll a (µg/L)	Total Alkalinity (mg/L as CaCO3)	Gran Alkalinity (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Bicarbonate (mg/L)	Gran Bicarbonate (mg/L)	Chloride (mg/L)	Sulphate (mg/L)	Iron (mg/L)
OIL SANDS SUB-REGIONS																											
North East of Ft. McMurray																											
L4	5.69	22.3	50.5	0.56	2.7	245	0.24	26.25	0.627	0.577	0.621	0.00519	0.012	0.015	0.007	4.18	4.81	4.23	3.47	0.07	1.00	0.46	5.86	5.15	0.10	0.61	0.24
L7	6.08	26.0	84.5	0.57	2.9	300	0.52	31.37	0.620	0.576	0.619	0.00094	0.011	0.023	0.006	2.54	7.07	6.49	4.31	0.10	1.31	0.68	8.62	7.92	0.10	0.75	0.37
L8	6.98	45.8	52.0	1.40	3.3	148	3.45	21.60	0.974	0.765	0.896	0.07797	0.008	0.027	0.011	10.29	18.78	18.32	5.61	0.12	2.14	2.09	22.90	22.33	0.12	0.70	0.06
L39	6.85	26.5	31.5	4.90	17.5	114	2.32	16.02	1.015	0.486	1.014	0.00095	0.008	0.036	0.004	28.50	9.93	8.48	2.84	0.46	1.23	1.90	12.10	10.34	0.34	0.95	0.05
E15 (268)	7.14	68.1	90.5	1.80	1.4	129	5.16	43.30	2.773	2.689	2.765	0.00842	1.509	0.028	0.018	3.61	27.91	28.23	8.01	0.51	1.77	3.42	34.03	34.42	0.29	0.39	0.14
182	6.87	31.4	34.5	1.30	2.7	179	2.04	18.46	0.483	0.401	0.481	0.00211	0.028	0.023	0.008	8.25	11.90	11.00	4.76	0.11	1.30	0.85	14.51	13.41	0.18	1.20	0.22
185	5.20	24.0	64.0	0.52	0.3	257	0.27	31.47	0.687	0.699	0.614	0.07242	0.013	0.012	0.007	1.80	3.43	3.17	3.78	0.06	0.99	0.46	4.19	3.87	0.10	0.76	0.30
209	6.35	22.2	35.0	1.40	4.3	236	0.82	25.72	0.610	0.535	0.609	0.00076	0.010	0.021	0.008	3.94	7.15	6.89	3.97	0.10	1.11	0.72	8.72	8.40	0.11	0.38	0.42
270	8.03	163.9	132.0	2.40	5.5	34	17.79	28.41	1.998	1.695	1.987	0.01128	0.123	0.039	0.012	11.45	81.00	81.17	24.10	0.32	8.09	2.00	98.76	98.97	0.35	0.38	<DL
271	7.87	172.3	101.5	3.10	7.3	31	18.69	23.97	2.390	2.177	2.298	0.09186	0.441	0.052	0.016	3.74	84.53	84.36	21.50	1.60	6.65	6.28	103.07	102.85	0.48	0.48	<DL
Stony Mountains																											
A21	5.00	16.4	45.0	2.70	4.0	272	0.38	21.76	0.642	0.586	0.640	0.00129	0.018	0.058	0.025	8.33	1.75	0.12	1.52	0.31	0.45	0.51	2.13	0.15	0.15	1.61	0.81
A24	4.74	14.8	58.5	5.00	15.3	297	0.29	26.06	0.950	0.722	0.948	0.00116	0.010	0.076	0.029	1.44	1.03	0.00	0.89	0.47	0.36	0.91	1.25	0.00	0.21	0.63	0.71
A26	5.45	15.6	33.0	1.40	1.9	124	0.36	16.70	0.940	0.789	0.876	0.06369	0.076	0.040	0.022	9.23	2.48	0.57	1.39	0.52	0.50	0.45	3.02	0.70	0.18	1.40	0.31
A29	5.67	13.5	39.5	1.30	4.0	74	0.45	16.54	0.758	0.587	0.758	0.00064	0.007	0.026	0.006	3.75	3.02	1.22	1.25	0.35	0.54	0.77	3.68	1.49	0.20	0.87	0.08
A86	6.69	25.8	47.0	1.40	2.1	30	1.36	14.69	0.997	0.903	0.958	0.03920	0.055	0.032	0.010	13.34	7.62	6.10	2.33	1.67	0.93	0.67	9.29	7.44	0.38	2.26	<DL
287	5.18	14.1	33.0	2.70	8.4	146	0.32	15.56	0.840	0.748	0.840	0.00058	0.009	0.053	0.020	9.64	1.86	0.00	1.17	0.40	0.35	0.48	2.26	0.00	0.20	1.91	0.34
289	6.47	15.0	28.0	1.60	5.3	43	1.01	12.17	0.565	0.459	0.564	0.00048	0.011	0.028	0.006	9.07	5.16	3.90	1.74	0.37	0.50	0.62	6.29	4.75	0.21	0.38	0.03
290	5.89	18.2	48.5	0.91	2.6	126	0.38	20.06	0.970	0.668	0.948	0.02135	0.031	0.021	0.009	3.40	3.93	2.66	1.81	0.41	0.88	0.53	4.79	3.24	0.21	0.88	0.11
342	6.84	34.1	122.5	1.00	4.4	52	1.90	26.09	1.281	1.282	1.280	0.00099	0.006	0.023	0.010	5.82	11.39	10.94	3.30	1.33	1.58	1.36	13.88	13.34	0.39	0.52	0.02
354	7.24	62.7	88.5	1.20	2.7	25	5.20	25.44	1.511	1.378	1.505	0.00644	0.150	0.019	0.005	2.74	26.56	26.49	7.57	1.00	2.66	1.44	32.38	32.30	0.44	0.25	<DL
West of Fort McMurray																											
A42	7.01	49.1	139.0	18.00	122.5	60	2.98	55.52	5.664	2.608	5.663	0.00108	0.080	0.210	0.018	144.03	18.57	19.43	7.87	0.79	1.70	2.04	22.64	23.68	0.53	0.61	0.06
A47	6.69	38.2	30.0	2.70	4.0	107	1.48	20.79	1.929	1.924	1.196	0.73239	0.046	0.098	0.070	5.46	9.85	8.79	5.13	0.91	1.14	0.70	12.01	10.71	0.47	2.02	0.19
A59	5.36	25.0	69.5	3.40	15.0	232	0.34	30.01	1.386	0.774	1.385	0.00096	0.013	0.074	0.014	4.38	3.48	2.59	2.81	0.53	0.83	1.47	4.24	3.16	0.29	2.55	0.28
223	7.40	120.2	151.5	2.30	6.8	154	6.83	49.46	2.786	2.195	2.769	0.01618	0.056	0.077	0.024	22.12	40.12	41.67	12.80	1.60	5.95	7.10	48.92	50.80	0.61	13.74	<DL
225	7.41	85.2	81.5	1.80	5.4	57	7.09	31.95	1.693	1.576	1.692	0.00044	0.009	0.034	0.013	10.42	37.53	37.97	11.90	0.93	4.21	1.07	45.76	46.30	0.54	0.90	<DL
226	6.83	42.0	60.5	1.30	4.0	95	2.56	27.60	1.165	1.045	1.164	0.00075	0.011	0.030	0.009	11.64	15.31	15.21	5.63	0.66	1.95	1.29	18.67	18.55	0.14	0.56	0.03
227	7.32	83.6	105.5	1.40	4.9	118	6.38	33.57	1.812	1.624	1.768	0.04369	0.219	0.032	0.015	9.69	35.29	35.66	11.70	0.65	4.09	1.38	43.03	43.48	0.34	2.14	0.03
267	7.64	97.2	60.5	2.00	5.8	19	10.01	22.43	1.471	1.108	1.470	0.00120	0.006	0.032	0.006	7.70	46.31	45.66	13.20	0.92	4.05	1.44	56.46	55.67	0.34	0.72	0.02
Birch Moutains																											
L18	7.12	63.7	23.0	0.87	5.6	12	4.67	8.35	0.349	0.324	0.336	0.01323	0.016	0.030	0.012	14.47	21.28	19.19	6.52	1.06	2.08	2.45	25.95	23.40	0.18	7.62	<DL
L23	6.82	26.2	29.5	1.50	3.1	37	1.77	13.30	0.384	0.342	0.384	0.00044	0.003	0.015	0.005	11.88	9.54	7.96	3.05	0.40	1.07	0.88	11.63	9.71	0.15	1.13	<DL
L25	6.63	28.1	33.0	1.30	5.9	29	1.71	8.61	0.432	0.398	0.396	0.03552	0.033	0.035	0.015	3.20	8.55	6.44	3.04	0.60	0.86	0.84	10.42	7.85	0.22	3.41	0.03
L28	5.19	20.3	65.5	2.10	5.7	422	0.33	27.98	0.665	0.690	0.650	0.01455	0.018	0.084	0.058	3.43	2.62	1.13	2.15	0.26	0.66	1.32	3.20	1.37	0.26	1.41	1.38
L29	4.17	22.1	27.5	3.90	10.5	238	0.33	20.34	0.553	0.498	0.552	0.00109	0.015	0.028	0.006	20.89	0.00	0.00	0.50	0.08	0.16	0.34	0.00	0.00	0.10	0.34	0.41
L46	6.81	54.6	83.0	20.00	7.6	249	2.05	23.25	1.393	0.940	1.221	0.17222	0.016	0.190	0.097	7.37	12.07	11.17	5.58	0.51	1.96	3.26	14.72	13.61	0.19	10.55	2.20
L47	6.78	56.4	72.5	5.30	3.4	153	2.15	20.29	1.265	1.242	0.987	0.27737	0.067	0.086	0.052	1.34	12.25	11.08	6.05	0.66	1.83	2.95	14.93	13.51	0.18	10.60	0.76
L49	6.60	62.7	59.5	6.10	4.1	177	1.35	20.72	1.126	0.966	0.926	0.20017	0.048	0.080	0.051	8.11	8.38	7.34	5.72	0.70	1.85	3.77	10.22	8.95	0.18	16.71	1.17
L60	6.87	60.4	61.5	3.60	7.0	164	2.85	19.71	0.874	0.808	0.813	0.06132	0.055	0.090	0.059	2.58	15.24	14.11	6.51	0.56	2.12	2.80	18.58	17.20	0.19	9.64	0.86
175	7.53	117.2	117.0	7.50	25.5	150	9.56	44.79	3.480	2.385	3.471	0.00977	0.024	0.175	0.035	51.43	49.30	50.48	13.40	0.69	5.05	8.75	60.11	61.55	0.32	9.18	0.10
199	6.76	25.4	14.0	1.80	4.0	57	1.86	14.74	0.910	0.673	0.909	0.00096	0.016	0.042	0.011	14.81	9.17	7.70	2.65	0.43	1.35	0.92	11.18	9.38	0.17	1.32	0.04

Table XIX.1 Water Chemistry Data for Acid Sensitive Lakes Sampled in 2002 (continued)

Lake	pH (lab)	Conduc-tivity (µS/cm)	Total Dissolved Solids (mg/L)	Turbidity (NTU)	Total Suspended Solids (mg/L)	Colour (TCU)	Dissolved Inorganic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Total Nitrogen (mg/L)	Total Dissolved Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrite + Nitrate (mg/L)	Ammonium (mg/L)	Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Chlorophyll a (µg/L)	Total Alkalinity (mg/L as CaCO3)	Gran Alkalinity (mg/L)	Calcium (mg/L)	Potassium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Bicarbonate (mg/L)	Gran Bicarbonate (mg/L)	Chloride (mg/L)	Sulphate (mg/L)	Iron (mg/L)
COMPARISON REGIONS																											
Caribou Mountains																											
E52	7.11	53.2	35.0	1.50	0.6	241	3.61	22.88	0.559	0.633	0.514	0.04514	0.015	0.046	0.039	2.14	20.03	19.41	8.26	0.70	1.88	1.05	24.43	23.66	0.34	3.51	0.83
E59	6.80	29.8	19.0	1.20	1.3	73	1.95	12.51	0.464	0.439	0.409	0.05556	0.018	0.029	0.014	2.31	9.91	8.48	3.97	0.42	1.06	0.50	12.09	10.34	0.15	2.54	0.24
E68	6.80	41.7	50.0	2.70	5.2	217	2.10	20.15	0.724	0.588	0.723	0.00103	0.015	0.060	0.028	14.20	11.74	10.81	5.23	0.26	1.59	1.04	14.31	13.17	0.31	5.02	0.79
O-1	6.15	19.8	20.5	1.60	3.3	239	0.54	19.59	0.736	0.566	0.731	0.00523	0.014	0.046	0.018	11.66	4.82	3.30	3.02	0.18	0.69	0.43	5.88	4.02	0.14	1.30	0.32
O-2	6.88	31.0	43.5	1.10	0.7	280	1.49	22.56	0.593	0.753	0.568	0.02467	0.023	0.036	0.026	2.00	11.47	10.61	5.23	0.16	1.33	0.46	13.98	12.94	0.22	1.05	0.95
Canadian Shield																											
A301	7.21	55.1	27.0	1.90	2.5	29	4.82	13.32	0.568	0.470	0.567	0.00069	0.004	0.018	0.004	3.94	22.51	21.05	6.11	0.61	2.38	1.70	27.45	25.66	1.08	1.18	<DL
L107	7.16	60.3	25.5	0.48	0.3	11	5.04	9.84	0.341	0.388	0.336	0.00526	0.001	0.007	0.003	2.88	23.34	21.33	7.48	1.20	1.57	1.91	28.46	26.01	2.36	0.96	0.04
L109	7.00	51.3	41.0	1.40	2.0	119	3.88	19.09	0.568	0.610	0.545	0.02316	0.014	0.014	0.007	2.17	19.19	18.21	5.98	0.58	2.12	1.96	23.39	22.20	1.78	0.49	0.62
O-10	6.85	32.9	37.5	4.90	18.0	79	2.17	24.83	1.535	0.953	1.534	0.00054	0.007	0.047	0.005	30.83	10.99	10.13	3.33	0.60	1.49	2.62	13.40	12.35	0.89	0.45	<DL
R1	7.03	49.8	32.0	1.70	1.4	55	3.01	15.26	0.468	0.546	0.463	0.00474	0.003	0.010	0.003	3.08	15.23	13.94	4.60	0.50	1.63	1.64	18.56	16.99	1.26	0.50	0.06

Note: DL = detection limit.

APPENDIX XX

QUALITY CONTROL DATACOLLECTED BY RAMP IN 2002

This appendix contains a series of tables presenting QA/AC data from the 2002 RAMP survey, including:

- water quality field blanks (Table XX.1);
- water quality trip blanks (Table XX.2 and XX.3);
- additional water quality field blanks (Table XX.4);
- intra-laboratory split water samples (Table XX.5 and XX.6);
- inter-laboratory split water samples (Table XX.7); and
- duplicate and split sediment samples (Table XX.8).

Table XX.1 Water Quality Field Blanks Collected During the RAMP 2002 Sampling Program

Parameter	Units	Ells River		Clearwater River (Summer)	Steepbank River	Kiskatinaw Lake
		Winter	Spring		Fall	
Conventional Parameters						
Colour	T.C.U.	< 3	10	< 3	< 3	< 3
Conductance	uS/cm	5	2	2	3	2
Dissolved Organic Carbon	mg/L	< 1	< 1	< 1	< 1	< 1
Hardness	mg/L	< 1	< 1	< 1	< 1	< 1
pH		6.1	5.4	5.9	5.6	5.6
Total Alkalinity	mg/L	7	< 5	6	6	6
Total Dissolved Solids	mg/L	< 10	< 10	20	20	20
Total Organic Carbon	mg/L	< 1	< 1	< 1	< 1	1
Total Suspended Solids	mg/L	< 3	< 3	< 3	< 3	< 3
Major Ions						
Bicarbonate	mg/L	8	6	8	7	7
Calcium	mg/L	< 1	< 1	< 1	< 1	< 1
Carbonate	mg/L	< 5	< 5	< 5	< 5	< 5
Chloride	mg/L	< 1	< 1	< 1	< 1	< 1
Magnesium	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Potassium	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/L	< 1	< 1	< 1	< 1	< 1
Sulphate	mg/L	< 1	< 1	< 1	< 1	< 1
Sulphide	mg/L	< 0.003	< 0.003	0.003	< 0.003	< 0.003
Nutrients and Chloropyll *a*		-	-	-	-	-
Nitrate + Nitrite	mg/L	< 0.1	0.1	< 0.1	< 0.1	< 0.1
Nitrogen - ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrogen - Kjeldahl	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Phosphorus, total	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Phosphorus, dissolved	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Chlorophyll *a*	ug/L	< 1	< 1	< 1	< 1	< 1
Biological Oxygen Demand						
Biochemical Oxygen Demand	mg/L	< 2	< 2	< 2	< 2	< 2
General Organics						
Naphthenic acids	mg/L	< 1	< 1	< 1	< 1	< 1
Total Phenolics	mg/L	< 0.001	< 0.001	-	< 0.001	< 0.001
Total Recoverable Hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Metals (Total)						
Aluminum (Al)	mg/L	< 0.02	< 0.02	< 0.02	0.054	0.014
Antimony (Sb)	mg/L	< 0.005	< 0.005	0.0005	< 0.000004	0.000067
Arsenic (As)	mg/L	< 0.001	< 0.001	< 0.0004	< 0.00002	0.00043

Table XX.1 Water Quality Field Blanks Collected During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Ells River		Clearwater River (Summer)	Steepbank River	Kiskatinaw Lake
		Winter	Spring		Fall	
Barium (Ba)	mg/L	0.0003	0.0003	0.0003	0.0004	0.0147
Beryllium (Be)	mg/L	< 0.001	< 0.001	< 0.001	0.00021	0.00011
Boron (B)	mg/L	< 0.02	< 0.02	< 0.02	0.0012	0.0529
Cadmium (Cd)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.00002	0.00021
Chromium (Cr)	mg/L	0.0022	< 0.0008	< 0.0008	0.00008	0.0001
Cobalt (Co)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.00002	0.00006
Copper (Cu)	mg/L	0.001	< 0.001	< 0.001	< 0.0001	0.0003
Iron (Fe)	mg/L	< 0.005	< 0.005	< 0.005	0.006	0.129
Lead (Pb)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00002	0.00092
Lithium (Li)	mg/L	< 0.006	< 0.006	< 0.006	< 0.0001	0.0049
Manganese (Mn)	mg/L	< 0.001	< 0.001	< 0.001	0.00006	0.02679
Mercury (Hg)	mg/L	< 0.0000006	0.0000024	< 0.0000006	< 0.0000006	< 0.0000006
Molybdenum (Mo)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00002	0.00008
Nickel (Ni)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0001	< 0.0001
Selenium (Se)	mg/L	< 0.0008	< 0.0008	< 0.0004	< 0.0005	< 0.0005
Silver (Ag)	mg/L	< 0.000005	0.000012	< 0.000005	0.000006	0.000007
Strontium (Sr)	mg/L	0.0013	0.0003	0.0009	0.000666	0.068163
Thallium (Tl)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.000003	< 0.000003
Titanium (Ti)	mg/L	< 0.005	< 0.005	< 0.005	0.0005	0.0011
Uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.000005	0.000062
Vanadium (V)	mg/L	0.0009	< 0.0002	< 0.0002	0.00012	0.00026
Zinc (Zn)	mg/L	0.005	< 0.004	0.023	0.0011	0.0053
Metals (Dissolved)						
Aluminum (Al)	mg/L	< 0.01	< 0.01	< 0.01	0.0016	-
Antimony (Sb)	mg/L	< 0.0008	< 0.0008	0.0005	< 0.000004	-
Arsenic (As)	mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.00002	-
Barium (Ba)	mg/L	< 0.0001	< 0.0001	0.0004	0.00005	-
Beryllium (Be)	mg/L	< 0.0005	< 0.0005	< 0.0005	0.0001	-
Boron (B)	mg/L	0.004	< 0.002	< 0.002	0.0004	-
Cadmium (Cd)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00002	-
Chromium (Cr)	mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.00008	-
Cobalt (Co)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00002	-
Copper (Cu)	mg/L	0.0011	< 0.0006	< 0.0006	< 0.0001	-
Iron (Fe)	mg/L	< 0.005	< 0.005	< 0.005	< 0.003	-
Lead (Pb)	mg/L	< 0.0001	< 0.0001	0.0004	< 0.00001	-
Lithium (Li)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	-
Manganese (Mn)	mg/L	< 0.001	< 0.001	< 0.001	0.00003	-
Mercury (Hg)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00004	-
Molybdenum (Mo)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00002	-

Table XX.1 Water Quality Field Blanks Collected During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Ells River		Clearwater River (Summer)	Steepbank River	Kiskatinaw Lake
		Winter	Spring		Fall	
Nickel (Ni)	mg/L	< 0.0001	< 0.0001	0.0002	< 0.0001	-
Selenium (Se)	mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.0005	-
Silver (Ag)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.000005	-
Strontium (Sr)	mg/L	< 0.0001	0.0001	0.0002	0.000104	-
Thallium (Tl)	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.000003	-
Titanium (Ti)	mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0002	-
Uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.000003	-
Vanadium (V)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.00008	-
Zinc (Zn)	mg/L	< 0.002	< 0.002	0.006	0.0014	-

Table XX.2 Water Quality Trip Blanks Collected During the RAMP 2002 Sampling Program

Parameter	Units	Winter	Spring	Summer	Fall	
Conventional Parameters						
colour	T.C.U.	< 3	5	< 3	< 3	< 3
conductance	uS/cm	3	2	1	2	2
dissolved organic carbon	mg/L	< 1	1	< 1	< 1	< 1
hardness	mg/L	< 1	< 1	< 1	< 1	< 1
pH		5.2	5.3	5.5	5.7	5.6
total alkalinity	mg/L	< 5	< 5	5	6	6
total dissolved solids	mg/L	< 10	< 10	30	10	30
total organic carbon	mg/L	1	1	< 1	< 1	< 1
total suspended solids	mg/L	< 3	< 3	479	4	< 3
Major Ions						
bicarbonate	mg/L	6	6	6	7	7
calcium	mg/L	< 1	< 1	< 1	< 1	< 1
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	1	< 1	< 1	< 1	< 1
magnesium	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
potassium	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
sodium	mg/L	< 1	< 1	< 1	< 1	< 1
sulphate	mg/L	< 1	< 1	< 1	< 1	< 1
sulphide	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Nutrients and Chloropyll *a*						
nitrate + nitrite	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
nitrogen - kjeldahl	mg/L	< 0.2	< 0.2	0.3	< 0.2	< 0.2
phosphorus, total	mg/L	0.002	< 0.001	< 0.001	< 0.001	0.003
phosphorus, dissolved	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	0.003
chlorophyll *a*	ug/L	< 1	-	< 1	1	< 1
Biological Oxygen Demand						
biochemical oxygen demand	mg/L	< 2	< 2	< 2	< 2	< 2
General Organics						
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	< 1
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Metals (Total)						
aluminum (Al)	mg/L	0.02	< 0.02	< 0.02	0.002	0.002
antimony (Sb)	mg/L	< 0.005	< 0.005	0.0006	< 0.000004	0.000011
arsenic (As)	mg/L	< 0.001	< 0.001	< 0.0004	0.0001	0.00004
barium (Ba)	mg/L	0.0002	0.0003	0.0003	0.0002	< 0.0001
beryllium (Be)	mg/L	< 0.001	< 0.001	< 0.001	< 0.00004	< 0.00004
boron (B)	mg/L	< 0.02	< 0.02	< 0.02	< 0.0001	< 0.0001
cadmium (Cd)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.00002	< 0.00002
chromium (Cr)	mg/L	0.0023	< 0.0008	< 0.0008	< 0.00008	< 0.00008
cobalt (Co)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.00002	< 0.00002

Table XX.2 Water Quality Trip Blanks Collected During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Winter	Spring	Summer	Fall	
copper (Cu)	mg/L	< 0.001	< 0.001	< 0.001	< 0.0001	< 0.0001
iron (Fe)	mg/L	0.01	< 0.01	0.01	0.004	< 0.003
lead (Pb)	mg/L	0.0002	< 0.0001	< 0.0001	< 0.00001	0.00001
lithium (Li)	mg/L	< 0.006	< 0.006	< 0.006	< 0.0001	< 0.0001
manganese (Mn)	mg/L	< 0.001	< 0.001	< 0.001	0.00003	0.00004
mercury (Hg)	mg/L	< 0.0000006	0.0000018	< 0.0000006	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00002	< 0.00002
nickel (Ni)	mg/L	< 0.0002	< 0.0002	0.0003	< 0.0001	< 0.0001
selenium (Se)	mg/L	< 0.0008	< 0.0008	< 0.0004	< 0.0005	< 0.0005
silver (Ag)	mg/L	< 0.000005	0.000007	< 0.000005	< 0.000005	< 0.000005
strontium (Sr)	mg/L	< 0.0002	0.0004	0.001	0.000047	< 0.000004
thallium (Tl)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.000003	< 0.000003
titanium (Ti)	mg/L	< 0.005	< 0.005	< 0.005	< 0.0002	< 0.0002
uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.000003	< 0.000003
vanadium (V)	mg/L	0.0008	< 0.0002	< 0.0002	0.0002	0.00004
zinc (Zn)	mg/L	0.005	< 0.004	0.012	0.0004	0.0006
Metals (Dissolved)						
aluminum (Al)	mg/L	< 0.01	< 0.01	< 0.01	0.0004	0.0001
antimony (Sb)	mg/L	< 0.0008	< 0.0008	0.0006	0.00001	< 0.000004
arsenic (As)	mg/L	< 0.0004	< 0.0004	< 0.0004	0.0001	0.0001
barium (Ba)	mg/L	< 0.0001	< 0.0001	0.0001	< 0.00002	< 0.00002
beryllium (Be)	mg/L	< 0.0005	< 0.0005	< 0.0005	< 0.00004	< 0.00004
boron (B)	mg/L	< 0.002	< 0.002	< 0.002	< 0.0001	< 0.0001
cadmium (Cd)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00001	< 0.00001
chromium (Cr)	mg/L	< 0.0004	< 0.0004	< 0.0004	< 0.00008	< 0.00008
cobalt (Co)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00002	< 0.00002
copper (Cu)	mg/L	< 0.0006	< 0.0006	< 0.0006	< 0.0001	< 0.0001
iron (Fe)	mg/L	< 0.01	< 0.01	< 0.01	< 0.003	< 0.003
lead (Pb)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00001	< 0.00001
lithium (Li)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
manganese (Mn)	mg/L	< 0.001	< 0.001	< 0.001	0.00003	< 0.00001
mercury (Hg)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00004	< 0.00004
molybdenum (Mo)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.00002	< 0.00002
nickel (Ni)	mg/L	< 0.0001	< 0.0001	0.0002	< 0.0001	< 0.0001
selenium (Se)	mg/L	< 0.0004	< 0.0004	< 0.0004	0.0007	< 0.0005
silver (Ag)	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.000005	< 0.000005
strontium (Sr)	mg/L	< 0.0001	< 0.0001	0.0005	< 0.000004	0.000006
thallium (Tl)	mg/L	< 0.00005	< 0.00005	< 0.00005	< 0.000003	< 0.000003
titanium (Ti)	mg/L	< 0.0003	< 0.0003	< 0.0003	< 0.0002	< 0.0002
uranium (U)	mg/L	< 0.0001	< 0.0001	< 0.0001	< 0.000003	< 0.000003
vanadium (V)	mg/L	< 0.0001	< 0.0001	< 0.0001	0.0001	0.00005
zinc (Zn)	mg/L	< 0.002	< 0.002	0.003	0.0003	0.0005

Table XX.3 PAH Concentrations in Water Quality Trip Blanks Collected During the RAMP 2002 Sampling Program

Parameter	Units	Fall	
Anthracene	µg/L	< 0.02	< 0.02
Dibenzo(a,h)anthracene	µg/L	< 0.02	< 0.02
Benzo(a)Anthracene/Chrysene	µg/L	< 0.02	< 0.02
C1 subst'd benzo(a)anthracene/chrysene	µg/L	< 0.04	< 0.04
C2 subst'd benzo(a)anthracene/chrysene	µg/L	< 0.04	< 0.04
Benzo(a)pyrene	µg/L	< 0.02	< 0.02
C1 subst'd benzo(b&k) fluoranthene/benzo(a)pyrene	µg/L	< 0.04	< 0.04
C2 subst'd benzo(b& k) fluoranthene/benzo(a)pyrene	µg/L	< 0.04	< 0.04
Benzo(b&k)fluoranthene	µg/L	< 0.02	< 0.02
Benzo(g,h,i)perylene	µg/L	< 0.02	< 0.02
Biphenyl	µg/L	< 0.04	< 0.04
C1 subst'd biphenyl	µg/L	< 0.04	< 0.04
C2 subst'd biphenyl	µg/L	< 0.04	< 0.04
Dibenzothiophene	µg/L	< 0.02	< 0.02
C1 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
C2 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
C3 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
C4 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
Fluoranthene	µg/L	< 0.02	0.07
C1 subst'd fluoranthene/pyrene	µg/L	< 0.04	< 0.04
Fluorene	µg/L	< 0.02	< 0.02
C1 subst'd fluorene	µg/L	< 0.04	< 0.04
C2 subst'd fluorene	µg/L	< 0.04	< 0.04
Indeno(c,d-123)pyrene	µg/L	< 0.02	< 0.02
Phenanthrene	µg/L	< 0.02	0.03
C1 subst'd phenanthrene/anthracene	µg/L	< 0.04	< 0.04
C2 subst'd phenanthren/anthracene	µg/L	< 0.04	< 0.04
C3 subst'd phenanthrene/anthracene	µg/L	< 0.04	< 0.04
C4 subst'd phenanthrene/anthracene	µg/L	< 0.04	< 0.04
Pyrene	µg/L	< 0.02	0.34

Table XX.4 Additional Water Quality Field Blanks Collected in Spring During the RAMP 2002 Sampling Program

Parameter	Units	Additional Field Blanks	
		Stanley Creek	Christina River (u/s Janvier)
Metals (Dissolved)			
aluminum (Al)	mg/L	< 0.01	< 0.01
antimony (Sb)	mg/L	< 0.0008	< 0.0008
arsenic (As)	mg/L	< 0.0004	< 0.0004
barium (Ba)	mg/L	0.041	< 0.0001
beryllium (Be)	mg/L	< 0.0005	< 0.0005
boron (B)	mg/L	0.013	< 0.002
cadmium (Cd)	mg/L	< 0.0001	< 0.0001
chromium (Cr)	mg/L	< 0.0004	< 0.0004
cobalt (Co)	mg/L	< 0.0001	< 0.0001
copper (Cu)	mg/L	< 0.0006	< 0.0006
iron (Fe)	mg/L	0.099	< 0.005
lead (Pb)	mg/L	< 0.0001	< 0.0001
lithium (Li)	mg/L	0.0059	0.0003
manganese (Mn)	mg/L	0.011	< 0.001
mercury (Hg)	mg/L	< 0.0001	< 0.0001
molybdenum (Mo)	mg/L	< 0.0001	< 0.0001
nickel (Ni)	mg/L	< 0.0001	< 0.0001
selenium (Se)	mg/L	< 0.0004	< 0.0004
silver (Ag)	mg/L	< 0.0002	< 0.0002
strontium (Sr)	mg/L	0.0634	0.0001
thallium (Tl)	mg/L	< 0.00005	< 0.00005
titanium (Ti)	mg/L	0.0009	< 0.0003
uranium (U)	mg/L	< 0.0001	< 0.0001
vanadium (V)	mg/L	< 0.0001	< 0.0001
zinc (Zn)	mg/L	0.002	< 0.002

Table XX.5 Split Water Samples Collected for Intra-laboratory Comparison During the RAMP 2002 Sampling Program

Parameter	Units	Split Samples											
		Atha. River d/s of Development				Tar River		Atha. River d/s of development[(a)]		Atha. River u/s of Donald Creek		Canoe Lake	
		Winter (2002)		Winter (2003)		Spring		Summer		Fall		Fall	
Conventional Parameters													
colour	T.C.U.	30	30	50	50	60	70	25	20	35	15	50	70
conductance	uS/cm	535	539	456	469	315	313	250	254	257	256	94	94
dissolved organic carbon	mg/L	6	6	7	8	13	11	6	6	4	4	21	22
hardness	mg/L	176	179	147	146	133	133	108	108	114	120	39	38
pH		7.9	8	7	7.6	7.9	7.9	7.9	8	8.1	8.1	7.2	7.2
total alkalinity	mg/L	157	162	137	138	125	122	90	91	98	98	41	42
total dissolved solids	mg/L	260	270	320	340	180	180	190	180	80	110	110	110
total organic carbon	mg/L	7	7	8	8	14	14	7	7	5	5	25	26
total suspended solids	mg/L	< 3	< 3	< 3	3	8	9	27	20	11	12	< 3	< 3
Major Ions													
bicarbonate	mg/L	192	198	168	169	152	148	110	111	120	119	50	51
calcium	mg/L	48	49	40	40	36	36	30	30	31	32	10	10
carbonate	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
chloride	mg/L	36	35	48	48	2	2	7	7	2	2	< 1	< 1
magnesium	mg/L	13.4	13.7	11.3	11.3	10.6	10.7	8.1	8.1	9	9.6	3.2	3.2
potassium	mg/L	2.1	2.2	1.9	1.9	2.4	2.3	0.9	0.9	1.2	1.3	1	0.9
sodium	mg/L	41	42	42	43	17	17	11	10	9	10	5	5
sulphate	mg/L	56	56	42	41	38	39	33	27	28	30	2	3
sulphide	mg/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	0	-	-	< 0.003	< 0.003	0.007	0.005
Nutrients and Chloropyll *a*													
nitrate + nitrite	mg/L	0.3	0.2	0.2	0.2	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
nitrogen - ammonia	mg/L	0.06	0.06	0.12	0.12	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table XX.5 Split Water Samples Collected for Intra-laboratory Comparison During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Split Samples											
		Atha. River d/s of Development				Tar River		Atha. River d/s of development[(a)]		Atha. River u/s of Donald Creek		Canoe Lake	
		Winter (2002)		Winter (2003)		Spring		Summer		Fall		Fall	
nitrogen - kjeldahl	mg/L	< 0.2	< 0.2	0.4	0.7	0.7	0.9	1.4	1.3	0.4	< 0.2	1.1	1.2
phosphorus, total	mg/L	0.044	0.044	0.026	0.025	0.064	0.055	0.034	0.056	0.023	0.024	0.035	0.037
phosphorus, dissolved	mg/L	0.031	0.031	0.017	0.016	0.023	0.023	0.004	0.006	0.005	0.005	0.013	0.013
chlorophyll *a*	ug/L	2	5	< 1	< 1	2	2	5	5	2	2	-	-
Biological Oxygen Demand													
biochemical oxygen demand	mg/L	< 2	< 2	< 2	< 2	2	2	< 2	< 2	3	< 2	-	-
General Organics													
naphthenic acids	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	-
total phenolics	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0	< 0.001	< 0.001	< 0.001	< 0.001	-	-
total recoverable hydrocarbons	mg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	-	-
Metals (Total)													
aluminum (Al)	mg/L	0.08	0.08	0.045	0.092	0.5	0.47	-	-	0.522	0.416	0.014	0.017
antimony (Sb)	mg/L	< 0.005	< 0.005	5.2E-05	4.8E-05	< 0.005	< 0.01	-	-	0.00006	0.00005	0.00003	0.00003
arsenic (As)	mg/L	< 0.001	< 0.001	0.00082	0.00086	< 0.001	0	-	-	0.00064	0.00052	0.00023	0.00051
barium (Ba)	mg/L	0.0747	0.0747	0.0641	0.064	0.0443	0.0447	-	-	0.0495	0.0471	0.0187	0.0207
beryllium (Be)	mg/L	< 0.001	< 0.001	0.00034	0.0004	< 0.001	0	-	-	< 0.00004	< 4E-05	< 4E-05	0.00012
boron (B)	mg/L	0.04	0.04	0.0416	0.0419	0.08	0.08	-	-	0.0211	0.0211	0.0176	0.0404
cadmium (Cd)	mg/L	< 0.0002	< 0.0002	0.00005	0.00007	< 0.0002	0	-	-	0.00003	0.00003	0.00004	0.00005
chromium (Cr)	mg/L	0.0022	0.0021	0.00045	0.00042	< 0.0008	0	-	-	0.00074	0.00064	0.00012	0.00015
cobalt (Co)	mg/L	< 0.0002	< 0.0002	0.00014	0.00011	0.0003	0.0002	-	-	0.00026	0.00022	0.00004	0.00005
copper (Cu)	mg/L	0.001	0.001	0.0007	0.0007	0.005	0.002	-	-	0.0012	0.0011	< 0.0001	0.0003
iron (Fe)	mg/L	0.323	0.325	0.42	0.435	1.35	1.3	-	-	0.466	0.444	0.165	0.063
lead (Pb)	mg/L	0.0001	0.0001	0.00017	0.00013	0.0006	0.0005	-	-	0.00043	0.0003	0.00046	0.0007

Table XX.5 Split Water Samples Collected for Intra-laboratory Comparison During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Split Samples									
		Atha. River d/s of Development				Tar River		Atha. River d/s of development[(a)]		Atha. River u/s of Donald Creek		Canoe Lake	
		Winter (2002)		Winter (2003)		Spring		Summer		Fall		Fall	
lithium (Li)	mg/L	0.01	0.01	0.0084	0.0088	0.018	0.018	-	-	0.0043	0.0048	0.0023	0.0076
manganese (Mn)	mg/L	0.017	0.017	0.02641	0.02735	0.03	0.029	-	-	0.02167	0.02277	0.07322	0.03649
mercury (Hg)	mg/L	< 6E-07	8E-07	< 6E-07	< 6E-07	3.6E-06	4E-06	-	-	3.6E-06	< 6E-07	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.0008	0.0007	0.00091	0.00091	0.0013	0.0013	-	-	0.00069	0.00067	< 2E-05	0.00004
nickel (Ni)	mg/L	< 0.0002	0.0012	0.0004	0.0003	0.0033	0.0025	-	-	0.0001	0.0003	< 0.0001	< 1E-04
selenium (Se)	mg/L	0.001	< 0.0008	0.0008	0.0007	< 0.0008	0	-	-	0.0006	< 0.0005	< 0.0005	< 5E-04
silver (Ag)	mg/L	< 5E-06	< 5E-06	9.9E-05	0.00005	0.000014	1E-05	-	-	0.000006	0.000018	0.000005	6E-06
strontium (Sr)	mg/L	0.319	0.324	0.30757	0.31264	0.146	0.15	-	-	0.260714	0.252897	0.03664	0.09324
thallium (Tl)	mg/L	< 0.0001	< 0.0001	3.4E-05	9E-06	< 0.0001	0	-	-	0.000043	0.000025	< 3E-06	< 3E-06
titanium (Ti)	mg/L	0.037	< 0.005	0.0032	0.0037	0.017	0.012	-	-	0.0117	0.0093	0.0007	0.0006
uranium (U)	mg/L	0.0005	0.0005	0.0004	0.00043	0.0008	0.0008	-	-	0.000366	0.000349	0.000011	3.4E-05
vanadium (V)	mg/L	0.0016	0.0015	0.00052	0.00061	0.0016	0.0016	-	-	0.0014	0.00139	0.00017	0.00027
zinc (Zn)	mg/L	0.019	0.024	0.0016	0.0015	0.414	0.026	-	-	0.02	0.0143	0.0207	0.0072
Metals (Dissolved)													
aluminum (Al)	mg/L	0.03	0.03	0.005	0.0051	0.01	0.01	-	-	0.0114	0.0103	-	-
antimony (Sb)	mg/L	< 0.0008	< 0.0008	4.1E-05	0.00004	< 0.0008	0	-	-	0.000044	0.000068	-	-
arsenic (As)	mg/L	0.0006	0.0006	0.0006	0.0007	< 0.0004	0	-	-	0.0004	0.0003	-	-
barium (Ba)	mg/L	0.0775	0.0748	0.06204	0.06159	0.0391	0.0389	-	-	0.0448	0.04315	-	-
beryllium (Be)	mg/L	< 0.0005	< 0.0005	0.0004	0.00046	< 0.0005	0	-	-	0.00011	< 4E-05	-	-
boron (B)	mg/L	0.054	0.054	0.0391	0.0431	0.064	0.062	-	-	0.0193	0.0201	-	-
cadmium (Cd)	mg/L	0.0001	0.0001	0.00005	0.00004	< 0.0001	0	-	-	0.00003	0.00004	-	-
chromium (Cr)	mg/L	< 0.0004	< 0.0004	0.00092	0.00088	< 0.0004	0	-	-	0.0001	0.0001	-	-
cobalt (Co)	mg/L	< 0.0001	< 0.0001	0.00011	0.00009	0.0002	0.0001	-	-	0.00008	0.00007	-	-
copper (Cu)	mg/L	0.0008	0.0007	0.0006	0.0006	0.0011	0.0009	-	-	0.0009	0.0008	-	-

Table XX.5 Split Water Samples Collected for Intra-laboratory Comparison During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Split Samples											
		Atha. River d/s of Development				Tar River		Atha. River d/s of development[a]		Atha. River u/s of Donald Creek		Canoe Lake	
		Winter (2002)		Winter (2003)		Spring		Summer		Fall		Fall	
iron (Fe)	mg/L	0.101	0.096	0.211	0.203	1.08	1.06	-	-	0.052	0.048	-	-
lead (Pb)	mg/L	< 0.0001	< 0.0001	0.00026	0.00016	< 0.0001	0	-	-	0.00009	0.00007	-	-
lithium (Li)	mg/L	0.0103	0.0105	0.0078	0.0082	0.018	0.018	-	-	0.0042	0.0039	-	-
manganese (Mn)	mg/L	0.011	0.011	0.02327	0.02302	0.023	0.016	-	-	0.00124	0.00111	-	-
mercury (Hg)	mg/L	0.0001	0.0001	< 4E-05	< 4E-05	< 0.0001	0	-	-	< 0.00004	0.00005	-	-
molybdenum (Mo)	mg/L	0.0008	0.0008	0.00097	0.00091	0.0012	0.0012	-	-	0.00068	0.00067	-	-
nickel (Ni)	mg/L	0.0003	0.0003	0.0006	0.0003	0.0021	0.0019	-	-	< 0.0001	< 0.0001	-	-
selenium (Se)	mg/L	< 0.0004	< 0.0004	< 5E-04	< 5E-04	< 0.0004	0	-	-	0.001	0.0005	-	-
silver (Ag)	mg/L	< 0.0002	< 0.0002	4.3E-05	4.4E-05	< 0.0002	0	-	-	0.00001	< 1E-05	-	-
strontium (Sr)	mg/L	0.333	0.34	0.30367	0.30246	0.139	0.14	-	-	0.261552	0.258434	-	-
thallium (Tl)	mg/L	< 0.00005	< 5E-05	6.8E-05	0.00003	< 5E-05	0	-	-	0.000032	0.00001	-	-
titanium (Ti)	mg/L	0.0019	0.002	0.0019	0.0014	0.002	0.0016	-	-	0.001	0.0006	-	-
uranium (U)	mg/L	0.0005	0.0005	0.00042	0.00042	0.0007	0.0007	-	-	0.000314	0.000337	-	-
vanadium (V)	mg/L	0.0005	0.0006	0.00049	0.00047	0.0002	0.0002	-	-	0.00032	0.00031	-	-
zinc (Zn)	mg/L	0.005	0.004	0.0035	0.0018	0.341	0.006	-	-	0.01	0.0068	-	-

(a) Sulphide and total and dissolved metals were analyzed by different labs, therefore are presented in the inter-laboratory comparison (Table XX.7).

Table XX.6 PAHs in the Split Water Samples Collected During the RAMP 2002 Fall Sampling Program

Parameter	Units	Atha. River u/s of Donald Creek	
Target PAHs and Alkylated PAHs			
Naphthalene	µg/L	< 0.02	< 0.02
C1 subst'd naphthalenes	µg/L	< 0.04	< 0.04
C2 subst'd naphthalenes	µg/L	< 0.04	< 0.04
C3 subst'd naphthalenes	µg/L	< 0.04	< 0.04
C4 subst'd naphthalenes	µg/L	< 0.04	< 0.04
Acenaphthene	µg/L	< 0.02	< 0.02
C1 subst'd acenaphthene	µg/L	< 0.04	< 0.04
Acenaphthylene	µg/L	< 0.02	< 0.02
Anthracene	µg/L	< 0.02	< 0.02
Dibenzo(a,h)anthracene	µg/L	< 0.02	< 0.02
Benzo(a)Anthracene/ Chrysene	µg/L	< 0.02	< 0.02
C1 subst'd benzo(a)anthracene/ chrysene	µg/L	< 0.04	< 0.04
C2 subst'd benzo(a)anthracene/ chrysene	µg/L	< 0.04	< 0.04
Benzo(a)pyrene	µg/L	< 0.02	< 0.02
C1 subst'd benzo(b&k) fluoranthene/ benzo(a)pyrene	µg/L	< 0.04	< 0.04
C2 subst'd benzo(b& k) fluoranthene/ benzo(a)pyrene	µg/L	< 0.04	< 0.04
Benzo(b&k)fluoranthene	µg/L	< 0.02	< 0.02
Benzo(g,h,i)perylene	µg/L	< 0.02	< 0.02
Biphenyl	µg/L	< 0.04	< 0.04
C1 subst'd biphenyl	µg/L	< 0.04	< 0.04
C2 subst'd biphenyl	µg/L	< 0.04	< 0.04
Dibenzothiophene	µg/L	< 0.02	< 0.02
C1 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
C2 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
C3 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
C4 subst'd dibenzothiophene	µg/L	< 0.04	< 0.04
Fluoranthene	µg/L	< 0.02	< 0.02
C1 subst'd fluoranthene/pyrene	µg/L	< 0.04	< 0.04
Fluorene	µg/L	< 0.02	< 0.02
C1 subst'd fluorene	µg/L	< 0.04	< 0.04
C2 subst'd fluorene	µg/L	< 0.04	< 0.04
Indeno(c,d-123)pyrene	µg/L	< 0.02	< 0.02

Table XX.7 Split Water Samples Collected for Inter-laboratory Comparison During the RAMP 2002 Sampling Program

Parameter	Units	Split Samples					
		North Steepbank River (Spring)		Atha. River d/s of Development			
				Spring		Summer	
		ETL	ARC	ETL	ARC	ETL	ARC
Major Ions							
sulphide	mg/L	0.006	0.005	0.007	0.005	0.003	0.003
Metals (Total)							
aluminum (Al)	mg/L	0.04	0.012	6.56	3.744	0.89	1.663
antimony (Sb)	mg/L	< 0.005	0.000607	< 0.005	0.00039	0.0006	0.00049
arsenic (As)	mg/L	0.001	0.001	0.002	0.0016	0.0018	0.001
barium (Ba)	mg/L	0.0418	0.0409	0.116	0.0915	0.056	0.067
beryllium (Be)	mg/L	< 0.001	< 0.00004	< 0.001	< 4E-05	< 0.001	< 0.00004
boron (B)	mg/L	0.04	0.0413	0.03	0.0199	0.02	0.0229
cadmium (Cd)	mg/L	< 0.0002	< 0.00002	< 0.0002	0.00009	< 0.0002	0.00005
chromium (Cr)	mg/L	< 0.0008	0.00022	0.0076	0.00354	0.0039	0.00214
cobalt (Co)	mg/L	< 0.0002	0.00008	0.002	0.00169	0.0005	0.00066
copper (Cu)	mg/L	< 0.001	0.0006	0.007	0.0055	0.002	0.0018
iron (Fe)	mg/L	1.14	1.098	5.27	4.303	0.841	1.385
lead (Pb)	mg/L	0.0001	0.00011	0.003	0.00253	0.0006	0.00082
lithium (Li)	mg/L	0.008	0.008	0.01	0.0074	< 0.006	0.0058
manganese (Mn)	mg/L	0.05	0.05101	0.123	0.11435	0.047	0.0692
mercury (Hg)	mg/L	< 0.0000006	< 0.00004	1.3E-06	< 4E-05	< 6E-07	< 6E-07
molybdenum (Mo)	mg/L	0.0009	0.00093	0.001	0.00047	0.0011	0.00056
nickel (Ni)	mg/L	< 0.0002	0.0001	0.0072	0.0058	0.0083	0.0019
selenium (Se)	mg/L	< 0.0008	< 0.0005	< 0.0008	< 0.0005	0.0009	0.0013
silver (Ag)	mg/L	0.000011	0.000005	0.000013	3.6E-05	0.00014	0.000093
strontium (Sr)	mg/L	0.162	0.157179	0.185	0.1751	0.206	0.207
thallium (Tl)	mg/L	< 0.0001	< 0.000003	< 0.0001	0.00008	< 0.0001	0.000023
titanium (Ti)	mg/L	< 0.005	0.0007	0.192	0.0494	0.02	0.033
uranium (U)	mg/L	< 0.0001	0.000048	0.0007	0.00054	0.0006	0.00041
vanadium (V)	mg/L	< 0.0002	0.0002	0.0166	0.00671	0.0036	0.00376
zinc (Zn)	mg/L	0.009	0.003	0.13	0.1348	0.005	0.0064
Metals (Dissolved)							
aluminum (Al)	mg/L	0.02	0.004	0.01	0.008	0.14	0.0106
antimony (Sb)	mg/L	< 0.0008	0.000149	< 0.0008	0.00024	0.0004	0.00041
arsenic (As)	mg/L	0.0004	0.0008	< 0.0004	0.0005	0.0006	0.0002
barium (Ba)	mg/L	0.0455	0.038	0.0524	0.0478	0.052	0.047
beryllium (Be)	mg/L	< 0.0005	< 0.00004	< 0.0005	< 4E-05	< 0.0005	0.0002
boron (B)	mg/L	0.04	0.0417	0.014	0.0182	0.061	0.022
cadmium (Cd)	mg/L	< 0.0001	< 0.00002	< 0.0001	< 2E-05	< 0.0001	0.00004
chromium (Cr)	mg/L	< 0.0004	0.00019	< 0.0004	0.0002	0.0034	0.00035

Table XX.7 Split Water Samples Collected for Inter-laboratory Comparison During the RAMP 2002 Sampling Program (continued)

Parameter	Units	Split Samples					
		North Steepbank River (Spring)		Atha. River d/s of Development			
				Spring		Summer	
		ETL	ARC	ETL	ARC	ETL	ARC
cobalt (Co)	mg/L	0.0001	0.00005	< 0.0001	0.00005	0.0002	0.00003
copper (Cu)	mg/L	0.0006	0.0003	0.002	0.0023	0.0009	0.0008
iron (Fe)	mg/L	0.962	0.734	0.12	0.076	0.056	0.02
lead (Pb)	mg/L	< 0.0001	0.00007	0.0001	0.00019	0.0001	0.00003
lithium (Li)	mg/L	0.011	0.008	0.0045	0.005	0.0051	0.004
manganese (Mn)	mg/L	0.014	0.00146	0.003	0.00209	0.009	0.0007
mercury (Hg)	mg/L	< 0.0001	< 0.00004	< 0.0001	< 4E-05	< 0.0001	< 0.00004
molybdenum (Mo)	mg/L	0.0009	0.0009	0.0007	0.00068	0.0008	0.00068
nickel (Ni)	mg/L	< 0.0001	0.0002	0.0014	0.0015	0.0007	0.0005
selenium (Se)	mg/L	< 0.0004	< 0.0005	< 0.0004	< 0.0005	< 0.0004	< 0.0004
silver (Ag)	mg/L	< 0.0002	0.000008	< 0.0002	< 5E-06	< 0.0002	< 0.00005
strontium (Sr)	mg/L	0.166	0.149624	0.164	0.16977	0.208	0.196
thallium (Tl)	mg/L	< 0.00005	0.000005	< 5E-05	1.9E-05	< 5E-05	0.000022
titanium (Ti)	mg/L	0.0011	0.0006	0.0031	0.0016	0.0036	0.0011
uranium (U)	mg/L	0.0004	0.00004	0.0004	0.00039	0.0004	0.00036
vanadium (V)	mg/L	< 0.0001	0.00011	0.0004	0.00042	0.0017	0.00043
zinc (Zn)	mg/L	0.173	0.0018	0.068	0.0564	< 0.002	0.001

Table XX.8 Sediment Quality QAQC Information Collected During the RAMP 2002 Fall Sampling Program

Parameter	Units	Duplicate Samples				Split Sample			
		Atha. River d/s of Development (east bank)		Atha. River near Embarras (x-channel)		Atha. River u/s of Steepbank (east bank)		McClelland Lake	
Particle Size									
partice size - % sand	%	81	77	57	62	40	33	14	13
partice size - % silt	%	13	18	30	26	39	45	37	40
partice size - % clay	%	6	4	14	12	21	22	49	47
moisture content	%	23	25	26	32	39	38	93	92
Carbon Content									
total inorganic carbon	% by wt	0.03	0.12	0.66	0.68	1.08	1.24	1.66	2.22
total organic carbon	% by wt	4.7	2.7	1.1	0.9	2.1	2.1	30	26.4
total carbon	% by wt	4.7	2.7	1.1	0.9	2.1	2.1	30	26.4
Organics									
total recoverable hydrocarbons	mg/kg	14900	14000	900	600	900	800	1200	1600
total volatile hydrocarbons (C5-C10)	mg/kg	42	8.8	< 0.5	< 0.5	5.1	11	9.3	12
total extractable hydrocarbons (C11-C30)	mg/kg	18000	28000	260	220	320	330	310	200
Metals (Total)									
aluminum (Al)	µg/g	4720	4420	5190	4740	9020	8690	4430	4540
arsenic (As)	µg/g	2.9	3.6	4.3	3.8	7.5	6.9	4.2	3.8
barium (Ba)	µg/g	55	57	131	119	200	159	179	162
beryllium (Be)	µg/g	0.4	0.4	0.4	0.4	0.7	0.6	0.3	0.2
boron (B)	µg/g	8	9	4	4	9	12	68	64
cadmium (Cd)	µg/g	< 0.1	0.1	0.2	0.2	0.3	0.2	0.3	0.3
calcium (Ca)	µg/g	2900	3300	15700	14100	29300	23000	65100	56400
chromium (Cr)	µg/g	10.4	11.7	11.5	11.3	35.1	29.1	16.3	16
cobalt (Co)	µg/g	5	6.9	6.7	6.2	10.1	8.5	3.7	3.3
copper (Cu)	µg/g	4	6	10	8	21	16	7	6
iron (Fe)	µg/g	8200	10600	13900	12600	25600	18200	13200	11500
lead (Pb)	µg/g	4.5	5.9	6.2	5.3	10.9	8	4	3.7

Table XX.8 Sediment Quality QAQC Information Collected During the RAMP 2002 Fall Sampling Program (continued)

Parameter	Units	Duplicate Samples				Split Sample			
		Atha. River d/s of Development (east bank)		Atha. River near Embarras (x-channel)		Atha. River u/s of Steepbank (east bank)		McClelland Lake	
magnesium (Mg)	µg/g	1450	1540	5890	5280	7820	7670	3960	3640
manganese (Mn)	µg/g	260	343	252	222	456	374	368	315
mercury (Hg)	µg/g	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	< 0.1
molybdenum (Mo)	µg/g	0.3	0.4	0.3	0.3	0.4	0.4	0.5	0.5
nickel (Ni)	µg/g	10.2	12.3	16.3	14.7	27.2	21.9	9.7	8.9
potassium (K)	µg/g	840	860	810	770	1780	1580	1020	1060
selenium (Se)	µg/g	< 0.2	0.2	0.3	0.4	0.5	0.5	1	0.7
silver (Ag)	µg/g	< 0.1	0.1	< 0.1	< 0.1	0.2	0.2	0.1	< 0.1
sodium (Na)	µg/g	60	60	60	60	110	120	150	120
strontium (Sr)	µg/g	20	23	44	40	86	69	191	167
thallium (Tl)	µg/g	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1
titanium (Ti)	µg/g	53.4	37.3	48.6	47.3	37.9	31.4	68.4	79.8
uranium (U)	µg/g	0.6	0.7	0.7	0.6	1.3	0.9	0.3	0.3
vanadium (V)	µg/g	16.3	19.1	14.4	13.7	29.7	25.7	17.2	17
zinc (Zn)	µg/g	24	28	53	47	58	48	86	59
Target PAHs and Alkylated PAHs									
naphthalene	µg/g	0.016	0.022	0.009	0.008	0.021	0.021	-[a]	0.024
C1 subst'd naphthalenes	µg/g	0.025	0.014	0.023	0.018	0.062	0.061	0.008	0.019
C2 subst'd naphthalenes	µg/g	0.184	0.047	0.04	0.028	0.089	0.087	0.037	0.047
C3 subst'd naphthalenes	µg/g	0.794	0.293	0.038	0.028	0.082	0.084	0.015	0.032
C4 subst'd naphthalenes	µg/g	3.54	1.6	0.0267	0.0205	0.068	0.0651	0.0104	0.0193
acenaphthene	µg/g	0.0113	0.004	0.001	0.0006	0.0016	0.0017	< 0.0014	< 0.0019
C1 subst'd acenaphthene	µg/g	0.0035	< 0.0026	< 0.0003	< 0.0001	< 0.0003	< 0.0003	< 0.0004	< 0.0004
Acenaphthylene	µg/g	*0.0062	*0.0092	< 0.0004	< 0.0003	< 0.0003	< 0.0003	< 0.0009	< 0.0016
Anthracene	µg/g	< 0.0385	*0.0163	< 0.001	< 0.0006	*0.0038	0.0047	0.001	0.0022

Table XX.8 Sediment Quality QAQC Information Collected During the RAMP 2002 Fall Sampling Program (continued)

Parameter	Units	Duplicate Samples				Split Sample			
		Atha. River d/s of Development (east bank)		Atha. River near Embarras (x-channel)		Atha. River u/s of Steepbank (east bank)		McClelland Lake	
Dibenzo(a,h)anthracene	µg/g	0.0417	0.033	< 0.0045	< 0.0013	*0.008	*0.0089	< 0.002	*0.003
Benzo(a)anthracene	µg/g	< 0.0406	*0.0218	*0.0024	0.0018	0.019	0.0221	*0.0009	*0.0019
C1 subst'd benzo(a)anthracene/chrysene	µg/g	10.2	7.33	0.175	0.131	0.618	0.681	0.054	0.087
C2 subst'd benzo(a)anthracene/chrysene	µg/g	3.92	3.44	0.058	0.042	0.165	0.183	0.012	0.021
Benzo(a)pyrene	µg/g	0.095	0.057	< 0.007	< 0.004	*0.025	0.026	< 0.003	0.003
C1 subst'd benzo(b&k) fluoranthene/ benzo(a)pyrene	µg/g	1.35	1.02	0.067	0.022	0.129	0.13	< 0.006	< 0.003
C2 subst'd benzo(b& k) fluoranthene/ benzo(a)pyrene	µg/g	0.532	0.358	0.016	0.007	0.078	0.068	< 0.004	< 0.003
Benzofluoranthenes	µg/g	0.296	0.229	0.016	0.011	0.03	0.031	*0.003	0.003
Benzo(g,h,i)perylene	µg/g	0.148	0.117	*0.0102	0.0064	*0.0222	0.0228	*0.0025	*0.0055
Biphenyl	µg/g	0.0058	*0.0058	0.0056	0.0039	0.0127	0.0117	*0.0045	0.008
C1 subst'd biphenyl	µg/g	0.0049	*0.0021	< 0.0003	< 0.0003	< 0.0002	< 0.0001	< 0.0007	< 0.0007
C2 subst'd biphenyl	µg/g	*0.0537	*0.0205	0.0086	0.0053	0.0195	0.0193	*0.002	*0.0049
Chrysene	µg/g	1.01	0.701	0.02	0.012	0.055	0.06	0.003	0.005
Dibenzothiophene	µg/g	*0.048	< 0.0156	*0.0024	*0.0015	*0.0067	*0.0075	*0.0012	*0.0024
C1 subst'd dibenzothiophene	µg/g	1.19	0.494	0.0183	0.0111	0.0409	0.0466	0.0029	0.0055
C2 subst'd dibenzothiophene	µg/g	5.4	2.49	0.0556	0.0476	0.108	0.0969	0.0077	0.0142
C3 subst'd dibenzothiophene	µg/g	12.7	6.72	0.068	0.0653	0.113	0.104	0.0045	0.0077
C4 subst'd dibenzothiophene	µg/g	18.3	9.97	0.106	0.096	0.209	0.185	0.009	0.016
Fluoranthene	µg/g	0.0655	0.0547	0.0044	0.0033	0.0092	0.01	0.0057	0.0101
C1 subst'd fluoranthene/pyrene	µg/g	1.76	1.16	0.025	0.031	0.081	0.082	0.007	0.011
C2 subst'd fluoranthene/pyrene	µg/g	2	1.52	0.048	0.053	0.168	0.157	0.006	0.01
C3 subst'd fluoranthene/pyrene	µg/g	3.73	2.93	0.054	0.05	0.141	0.158	0.004	0.006
Fluorene	µg/g	0.0115	0.0057	*0.0034	*0.0015	*0.0043	*0.0041	0.0066	0.01
C1 subst'd fluorene	µg/g	0.111	0.0516	0.0052	0.005	0.0147	0.0146	0.0091	0.0171

Table XX.8 Sediment Quality QAQC Information Collected During the RAMP 2002 Fall Sampling Program (continued)

Parameter	Units	Duplicate Samples				Split Sample			
		Atha. River d/s of Development (east bank)		Atha. River near Embarras (x-channel)		Atha. River u/s of Steepbank (east bank)		McClelland Lake	
C2 subst'd fluorene	µg/g	0.912	0.479	0.0197	0.0171	0.0608	0.0621	0.0183	0.0529
C3 subst'd fluorene	µg/g	2	0.949	0.0252	0.0337	0.0929	0.0887	0.0121	0.0318
Indeno(1,2,3,cd)pyrene	µg/g	0.0665	0.0481	*0.004	0.0044	*0.0108	*0.0103	*0.003	*0.0057
Phenanthrene	µg/g	0.189	0.122	0.018	0.011	0.036	0.037	0.011	0.021
C1 subst'd phenanthrene/anthracene	µg/g	0.565	0.205	0.042	0.033	0.113	0.114	0.014	0.025
C2 subst'd phenanthren/anthracene	µg/g	2.54	0.997	0.051	0.064	0.134	0.139	0.01	0.014
C3 subst'd phenanthrene/anthracene	µg/g	7.91	4.01	0.045	0.075	0.133	0.124	0.015	0.027
C4 subst'd phenanthrene/anthracene	µg/g	17.7	12.2	0.14	0.19	0.93	0.47	0.04	0.08
1-Methyl-7-isopropyl-phenanthrene (Retene)	µg/g	*1.21	*0.664	0.059	0.038	0.402	0.267	0.019	0.047
Pyrene	µg/g	0.435	0.338	0.011	0.011	0.028	0.031	0.004	0.006

[a] Naphthalene could not be quantified.

* PAH concentrations are reported with the limitation that interference from the sample matrix resulted in a GCMS spectrum w ithout clear, easy to identify peaks (i.e., these numbers may contain a larger degree of error than those produced from clearly defined spectra).