OVERVIEW OF WATER QUALITY IN THE MUSKEG RIVER BASIN JULY 1972 TO MARCH 2001

Alberta Environment

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SUMMARY

The Muskeg River and its tributaries have been sampled by Alberta Environment (AENV) between 1972 and 2001. During the periods from 1972-1975 and 1989 – 1997 sampling was limited to sites near the Muskeg River mouth. Enhanced monitoring at several sites occurred during 1976-1981, under the Alberta Oil Sands Environmental Research Program (AOSERP), and during 1997-2001 as part of recent work. The latter work has involved regular grab sampling of several sites, two synoptic surveys, and continuous recording meters installed at a range of sites. The purpose of this report is to summarize this data, interpret water quality conditions and controlling factors, check for any trends in water quality over the long term, and assess whether any effects of oil sands development are apparent. The intent is to make a scientific contribution to the knowledge and understanding of the Muskeg River system, and of potential oil sands development effects, in view of the level of development proposed for this basin.

The Muskeg River is a brown-water stream, typical of many in the boreal forest. Calcium and bicarbonate are the major ions, the water is somewhat alkaline and well-buffered, suspended solids and turbidity are low, dissolved organic carbon (DOC) and colour are high, and dissolved oxygen (DO) is low during winter ice cover. The extensive peatlands in the basin are the main source of DOC and are significant to the overall water quality of the Muskeg River.

It appears that a majority of the streamflow comes from shallow groundwater sources. Much of this seems to be routed through organic soils, perhaps at the peat/mineral interface, which may account for the water being rich in minerals as well as DOC. Channel characteristics play an important role in modifying water quality. Phosphorus, DOC and suspended sediment concentrations decline in the low gradient reach of the Muskeg River due to biotic assimilation and sedimentation. Beaver ponds may be important in reducing nutrient concentrations, for example, total phosphorus.

Dissolved oxygen (DO) is low in winter and below Alberta Surface Water Quality Guidelines (ASWQG):

- Low DO occurs because reduced velocities and ice cover inhibit reaeration.
- These conditions seem to be natural in the Muskeg River, however, adequate winter data are lacking prior to 1997.
- The DO concentration is related to discharge, such that maintaining a mean spring discharge of 7.2 m^3/s and a mean summer discharge of 2.6 m^3/s would limit the occurrence of concentrations below ASWQG.
- Generally, biological oxygen demand (BOD) is low ($<2\ mg \bullet L^{-1}$), however, more data are required to determine why occasional pulses in BOD occur.

Currently, the Muskeg River is not at risk of acidification. However, pH levels seem to be declining during recent years, for reasons that are not clear:

- A decline in mean pH from 7.8 in 1997 to 7.3 in 2001 has occurred.

- pH seems to be largely determined by biotic processes in the stream channel. Declining pH could indicate increased prevalence of reducing conditions, which in turn could be related to reduced stream flow in recent years.

Both total phosphorus and total nitrogen concentrations were moderately high with maximum values typically 0.05 and 1.3 mg•L^{-1}, respectively but have not changed appreciably since 1976. Occasional peaks in ammonia concentration (> 0.2 mg•L^{-1}) occurred but fell within the ASWQG for the prevailing temperature and pH. High ammonia concentrations coincided in time with low oxygen conditions which may reflect reduction (denitrification) of nitrate entering in groundwater or from decomposing organic matter.

Total suspended solids concentrations were generally below 20 mg•L^{-1} and do not appear to be impacted in the Muskeg River. However, suspended sediment concentrations were elevated during winter months which may be a natural occurrence related to beaver activity and ice dynamics. The oxidation of suspended solids during winter may contribute to low dissolved oxygen concentrations under ice.

In all cases except iron, metal concentrations were within the ASWQG. Iron has a large natural background source and can be expected to exceed ASWQG.. Based on studies of peatland systems in other regions, mercury is a concern because peatland drainage has the potential of causing mercury leaching to surface waters. AENV data from the Muskeg River do not indicate a problem with aqueous mercury, however, the dataset is small. The Alsands ditch contained elevated concentrations of the metals, barium, copper, iron, strontium, uranium and zinc compared to the Muskeg River.

'Trace organic' pollutants were rarely detected. When detected, polycyclic aromatic hydrocarbon (PAH) concentrations were below the ASWQG. Some PAH compounds were exported from the Alsands ditch, resulting in their detection at downstream sites. Some petroleum-like odour has been noted in the Alsands Ditch but associated chemical analyses have not detected any compounds that could be responsible.

Water quality and other data are also being collected on the Muskeg River system by the Regional Aquatic Monitoring Program (RAMP) and operating oil sands companies (Syncrude Aurora and Albian Muskeg River Mine). As well, water quality modeling of the system is being funded by proponents of additional oil sands developments. A full integration of data from all parties, as well as enhanced monitoring and investigations on the river system, would advance the understanding of its water quality and aid the protection and reclamation of the basin as development progresses.

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ACKNOWLEDGEMENTS

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ABBREVIATIONS

AENV	Alberta Environment
ANC	acid neutralizing capacity
AOSERP	Alberta Oil Sands Environmental Research Program
ASWQG	Alberta Surface Water Quality Guideline
ca.	circa = around or approximately
CCME	Canadian Council of Ministers of Environment
CWQG	Canadian Water Quality Guideline
d/s	downstream
[DO]	dissolved oxygen
EUB	Energy and Utilities Board
m	metres
meq/L	millequivalents per litre
$mg \bullet L^{-1}$	milligrams per litre
mm	millimetres
m^3/s	cubic metres per second
ng/L	nanograms per litre
Q	flow
u/s	upstream
µg/L	micrograms per litre
VMV	Valid Method Variable
WSC	Water Survey of Canada

1.0 INTRODUCTION

Alberta Environment's (AENV) monitoring of the Muskeg River and its tributaries began in 1976 when its basin became the focus of oil sands development. The Muskeg River basin represents peatland-dominated ecosystems that are widespread in northern Alberta but about which scientific understanding is limited. These peatland systems are important to our biological resources, water supply, and ability to offset carbon dioxide emissions through carbon sequestering. Data from the Muskeg River system are important for the management and protection of Alberta's peatland systems as oil sands, forestry, oil and gas, and other development increases. In the Muskeg River basin in particular, a good understanding of its water quality will be important in the protection and reclamation of the catchment. In this report we review historic data from the Muskeg River and its tributaries, summarize previously unreported AENV data since 1998, assess potential effects of oil sands developments on water quality in the Muskeg River basin, and discuss management implications of results from water quality monitoring. In the discussion we highlight knowledge gaps and identify future monitoring to support the management of the Muskeg River basin.

When monitoring of the Muskeg River began in 1976 under the Alberta Oil Sands Environmental Research Program (AOSERP), AENV objectives were: to determine relationships between the landscape, stream flow, and water quality in peatland dominated systems; to estimate variation in water quality parameters spatially and temporally; and to gain an understanding of hydrology in the Muskeg River basin. These goals were accomplished with varying degrees of success and results were published in a number of reports (Appendix 1). Monitoring of water quality resumed in 1996 following oil sands expansion proposals by a number of proponents. The objective was to augment the information base and identify any changes in water quality as oil sands development occurred. In addition to these data, monitoring of the Muskeg River at its mouth began in 1972 and continued after AOSERP through much of the 1990s.

The expanded monitoring initiated by AENV in 1998 involved regular sampling of key sites on the Muskeg River system, synoptic surveys of a broader range of sites during fall and winter, and deployment of recording meters at selected sites and seasons. This was maintained through 1999, then scaled back to focus on one main site, during 2000-01. At the same time, the Regional Aquatic Monitoring Program (RAMP) was increasing the level of monitoring of the Muskeg River system, as were the individual oil sands companies operating in the basin. RAMP provided one of the recording meters deployed by AENV in the basin, as part of overall co-ordination between AENV and RAMP.

2.0 METHODS

2.1 Field Sampling

Grab samples were collected from the main flow at the sites, by filling cleaned, rinsed, composite buckets or polyethylene and glass bottles underneath the water surface with the bottle facing upstream. When ice conditions occurred, the samples were taken from open water leads or below the ice surface using a weighted down-hole bottle holder, after clearing of the sampling hole. Care was taken to avoid contaminating samples from any disturbance of the stream bottom. Sample bottles were triple-rinsed with sample water at each site, except for trace organic and bacteria bottles. The composite bucket was used for split sampling and was acid-washed prior to each sampling trip. A displacement-type APHA sampler was used to collect water for replicated Winkler oxygen analysis (APHA 1992). At each sampling site, temperature, pH, conductance, and oxygen were measured with meters calibrated within the previous 24 hours and recalibrated for oxygen saturation on site (Hydrolab Corp., models H20 and mini sonde 4A). Discharge was measured at selected sites with calibrated velocity meters.

Samples were preserved or kept dark and cool until analyzed. Samples for Winkler oxygen analysis were fixed on site. Samples for chlorophyll *a* and dissolved constituents were filtered within 24 hours. Samples normally reached the lab the morning after collection.

Split and field blank samples were collected periodically for quality assurance and were submitted blind to the laboratories. The blank samples contained distilled water from the analytical lab: the water was taken into the field and used to fill sample bottles, via any appropriate collecting vessel, under normal sampling conditions and procedures.

2.2 Continuous Recording 'Data Sondes'

Temperature, dissolved oxygen, pH and conductivity were measured at selected sites with recording, submersible polarographic meters (Hydrolab Corp., Data Sonde 4, Table 2.1). The meters, protected by metal or PVC cages, were deployed just above the streambed, near the thalweg for periods up to one month.

2.3 Chemical Analytical Methods

Appendix 2 summarizes laboratory methods employed for the examination of water collected in the Muskeg basin after 1996. Analyses for dissolved oxygen, biochemical oxygen demand (BOD) and bacteria occurred within 24 hours of sampling. Samples for BOD analysis were not seeded and supplemental nutrients were not added.

Oxygen, chlorophyll *a*, and phosphorus were analyzed at the AENV McIntyre facility in Edmonton. Most other variables were analyzed at the Alberta Research Council lab in Vegreville. Bacterial analysis was conducted at Provincial Laboratory of Public Health. Split samples were sent to the EnviroTest Laboratory in Edmonton. These laboratories employ standard operating procedures which include operator training, analysis of blanks and standards, instrument calibration, and control charts, among others.

Table 2.1 Inventory of continuous recording "Data Sonde" deployments in the Muskeg River Basin

Stn code		1998												1999											
(AB07_)	Sites	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
DA0595	Muskeg R. u/s Jackpine Ck.												x	x	x	x									x
DA0600	Jackpine Ck. Nr. Mouth												x	x	x										
DA0610	Muskeg R. at gauge			x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x
DA0620	Muskeg R. nr. Mouth												x	x											x
Stn code		**2000**												**2001**											
(AB07_)	**Sites**	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
DA0595	Muskeg R. u/s Jackpine Ck.	x	x	x																					
DA0600	Jackpine Ck. Nr. Mouth	x	x																						
DA0610	Muskeg R. at gauge	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
DA0620	Muskeg R. nr. Mouth	x	x	x																					

X indicates data available for month shown
Icing problems at gauge site prevented recordings Feb.-Apr. 2000

2.4 Data Treatment

For the purposes of this report, parameters with the same name but different Valid Method Variable (VMV) codes were combined into a single column. An example was dissolved arsenic, which was analyzed by VMV 33101, 33104, 101777, and 102021. Samples with concentrations below limits of detection were assigned a value of half the detection limit. For the parameters discussed in this report, few had more than 10% of samples below detection limits. The metals arsenic, chromium, lead, selenium and mercury were exceptions; they each contained more than 10% of data below detection limits of the analytical methods. Mean values for these metals are discussed in the context of both including and excluding data adjusted to half the detection limit.

2.5 Quality Control / Quality Assurance (QA/QC)

Continuous data for dissolved oxygen, pH and conductivity were checked against laboratory or field values determined from samples collected at data sonde installation and retrieval. If the paired values disagreed by a constant number but the intervening time series followed a consistent pattern, the continuous data sonde values were corrected so that initiation and retrieval values matched laboratory values. If a consistent pattern was not apparent, the data sonde values were discarded. Winkler determinations of dissolved oxygen concentration were often lower than those determined from a calibrated membrane electrode. Negative bias in Winkler determined dissolved oxygen concentrations are known to occur in waters with high organic content due to the oxidization of organic matter in the water sample when acidified (APHA 1992). For this reason we calibrated data sondes with laboratory calibrated membrane electrode determinations.

Split samples were sent to EnviroTest to determine comparability of AENV and RAMP data. Split samples were analyzed for a limited set of parameters summarized in Appendix 2. Seventeen blind field blanks were submitted to the analyzing labs from seven dates between 1998 and 2001. Contamination above method detection limits and in some cases above reported values in the Muskeg River occurred for aluminum, antimony, chromium, lead and zinc. Lead in particular had detectable concentrations in 4 of 6 blanks that were 4 to 10 times higher than reported values in the Muskeg River. Detectable concentrations of other metals were found in the field blanks but were generally 10% or less of reported values in the Muskeg River.

2.6 Statistical Methods

Statistical treatments were performed in Systat 10 (SPSS Inc. 2000). Assumptions for normal distribution of data were tested with Kolmogorov-Smirnov procedures. Non-normal data were transformed by logarithm or natural logarithm. Other data reducing functions were employed such as Principle Component Analysis (PCA) to determine driving variables in dissolved oxygen concentration and LOWESS smoothing for interpreting trends in time series data. Probability values and correlation coefficients are reported in the text: the former are reported as $<< 0.01$ when the P value was less than 0.001.

3.0 BASIN CHARACTERISTICS

3.1 Muskeg River and Tributaries

The Muskeg River drains a 1520 km^2 area typical of peatland-dominated systems in the Central Mixedwood ecoregion. Six major tributaries have been monitored by AENV at one to several sites each. The monitored tributaries were, DA0606 (Unnamed), Jackpine (Hartley), Shelly, Muskeg, and Wapasu creeks, which drain from the southeast and Stanley Creek that drains from the northwest. The sampling periods for the Muskeg River and its tributaries are summarized in Table 3.1 and locations are shown on Figure 3.1. All surface water sampling sites including those monitored during AOSERP and previously reported on by Akena (1979) and others (e.g., Schwartz and Milne-Home 1982a) are presented in Tables 3.1 and Figure 3.1.

3.2 Landcover and Physical Habitat

Large tracts of poorly drained peatlands sit above and below relatively well-drained slopes in the Muskeg Basin. Well-drained sites are mixedwood forests dominated by spruce, aspen and poplar. Poorly drained sites are forested bogs typically of black spruce or open peatlands comprised of continental bogs and fens. Continental bogs are situated above groundwater influence while fens receive some groundwater influence and can discharge minerotrophic waters (Vitt et al. 1994). Riparian vegetation is predominately deciduous with willow, alder and aspen interspersed with herbaceous foliage and grasses in wetland areas (Walder et al. 1980). Gradient along the Muskeg River is generally low (0.3 m/km) over 60% of its length with increased gradient at the headwaters (4.2 m/km) and mouth (3.5 m/km) areas.

The Muskeg River channel meanders over most of its lower 80 km, but is relatively wide (10 to 24 m). Stream channel cover by riparian vegetation varies from relatively open in the lower 10 km to moderate and finally almost complete coverage by km 80 (Walder et al 1980). Beaver dams are numerous in the upper 80 km of the Muskeg River. Gravel (2-64 mm diameter) dominate the lower 20 km; fine deposits (<2 mm) comprise ≥ 80% of channel substrate from approximately km 20 to the headwaters. Large fen and bog complexes drain directly to the Muskeg River above km 20. Patterned fens become a large component of the river valley upstream of km 60 and the channel virtually disappears into a fen complex above km 100. Stream banks are typically 0.5 to 1 m high and are considered stable organic matter over silt except in lower reaches where bedrock outcrops are interspersed with layers of silt and sand (Walder et al. 1980).

3.3 Potential Oil Sands Development

Proposed oil sands development will result in the removal of forest cover, organic soils, overburden, and the re-arrangement of local drainage systems. In the case of peatlands, removal first involves drainage and may subsequently result in significant leaching of elements and organic material associated with peat decomposition. Examples are the leaching of sulfates and other acidic ions (Gorham 1991) and leaching of phosphorus from disturbed peat (Bayley et al. 1992). Peat decomposition may also increase methanogenesis and enhance methyl mercury

Table 3.1 Sampling stations in the Muskeg Basin along with period of record

Station Name & Map ID		Station ID (AB07__)	Latitude	Longitude	Basin Area	Period of record
Muskeg River Mouth	(M1)	DA0620	57°08’05”	111 °36’08”	1520	72-78 89-00
WSC Gauge	(M2)	DA0610 S7 (RAMP) AOSERP 1	57 °11’30”	111 °34’05”	1458	75-81 98-01
Muskeg u/s Jackpine	(M3)	DA0595	57 °15’50”	111 °28’21”		98-00
Muskeg d/s Stanley	(M4)	DA2750 S5A (RAMP)	57 °15’52”	111 °22’26”	552	96-00
Muskeg u/s Wapasu	(M5)	DA1125	57 °23’03”	111 °17’45”		98-99
Upper Muskeg River	(M6)	DA0440 AOSERP 4			275	76-81
Upper Muskeg River	(M7)	DA0420 AOSERP 12			159	76-77
Unnamed tributary	(T1)	DA0606	57 °13’03”	111 °31’42”		98-99
Alsands Ditch Alsands Drain	(T2)	DA0605 DA1150 AOSERP A	57 °15’11	111 °29’54”	15.8	98-00 80-81
Jackpine Creek (Hartley Creek)	(T3.1)	DA0600 AOSERP 2	57 °15’34”	111 °27’53”	358 373	98-00 76-81
Jackpine at Moraine	(T3.2)	DA1090 AOSERP 2A			344	76-77
East Jackpine Creek	(T3.3)	DA1150 AOSERP 7			209	76-77
West Jackpine Creek	(T3.3b)	DA1140 AOSERP 6			168	76-77
Upper East Jack	(T3.4)	DA1230 AOSERP 14			40	76-77
Upper West Jack	(T3.4b)	DA1220 AOSERP 13				76-77
Shelley Creek	(T4)	DA2756 DA1160	57 °17’06”	111 °24’45”		98-99 76-77
Muskeg Creek	(T5)	DA2755 DA0530 AOSERP 3	57 °18’27”	111 °23’21”	290	98-99 76-78
Kearl Lake Outflow	(T5.1)	DA1190 AOSERP 10	57 °15’57”	111 °15’57”	73.6 67	98-99 76-78
Iynimin Creek	(T5.2)	DA1200 AOSERP 11	57 °15’00”	111 °10’27”	24.5 57	76-77
Khahago Creek	(T5.3)	DA1180 AOSERP 9			162	76-77
Stanley Creek	(T6)	DA0490 AOSERP3A	57 °21’08”	111 °22’44”	68	98 76-77
Wapasu Creek	(T7)	DA1126 AOSERP 5	57 °19’52”	111 °22’26”	242	98-99

AOSERP sites are from Akena 1979.
RAMP sites are included for comparison. AENV does not archive RAMP site data.

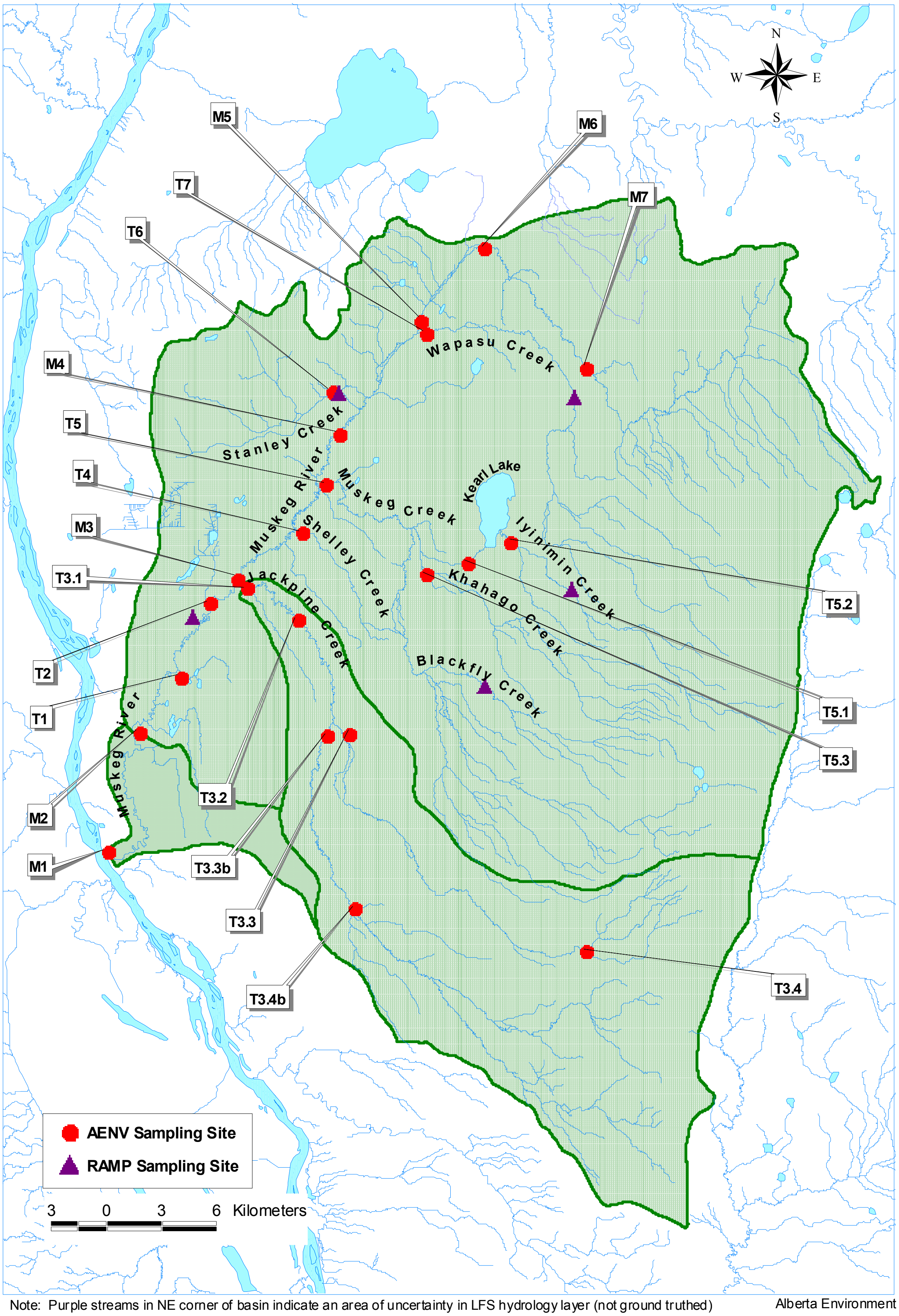


Figure 3.1 Water Quality sampling sites in the Muskeg River drainage basin

accumulation in aquatic biota (Garcia and Carignan 2000) as well as contribute greenhouse gasses to the atmosphere (Gorham 1991). Removal of overburden may similarly result in runoff of drainage waters high in mineral content. Approximately 40% of the Muskeg River basin has a total volume to bitumen in place ratio less than 12 (EUB 2000) and therefore is potentially mineable.

3.4 Climate

The Muskeg River basin receives 460 mm of precipitation annually (Environment Canada, 2000). Approximately 90 mm of water precipitates as snow, the remainder as rain dispersed unevenly through summer months. Most precipitation falls between July and mid-September in four to six wet periods (> 30 mm). A 40 year record of annual precipitation is presented in Figure 3.2. The decade ending in the 1997 hydrologic year was relatively consistent with annual precipitation within 60 mm of the long-term mean. The two years from 1997 through 1999 were exceptionally dry receiving 61 and 76% of the long-term mean precipitation, respectively. The mean annual temperature calculated at Ft McMurray between 1944 and 1997 was 0.1ºC with July as the warmest month (mean 16.5ºC) and January the coldest month (mean -20ºC). Potential and areal evapotranspiration for Ft. McMurray were estimated at 795 and 288 mm, respectively (Alberta Environment data 1972-93). Actual evapotranspiration lies between potential and areal estimates. If the difference between precipitation and water yield is assumed to represent evapotranspiration losses, actual evapotranspiration was likely closer to 370 mm.

3.5 Geology

The geologic setting of the Muskeg River basin determines the chemistry and movement of water flowing through ground pathways. Geology of the Muskeg River basin is typical for northern Alberta with the exception of the bitumen - containing McMurray formation. Glacial and post-glacial deposits of till, silt and sand vary in thickness from 100 m in the upper reaches to < 1 m thick at the mouth of the river. These recent deposits overlay Cretaceous shale, sandstone, siltstone and quartz sands in the Grand Rapids and Clearwater formations (Schwartz and Milne-Home 1982a). These formations and their water bearing capacity can be seen along the lower Muskeg River where the river has cut through laminated beds that seep groundwater from the bank. The Grand Rapids and Clearwater formations, as well as recent deposits, are the primary sources for groundwater to the Muskeg River. In addition to these layers, the Basal Aquifer is an important water bearing formation composed of coarse sand 0 to 40 m thick which overlays upper Devonian sediments. The importance of the Basal Aquifer is in its high salinity (>3500 $mg \bullet L^{-1}$ of total dissolved solids) comprised primarily of sodium and chloride. The Basal Aquifer coincides with and lies beneath the bitumen - containing McMurray formation. The Basal Aquifer is confined by Devonian limestone known as the Woodbend and Beaverhill Lake Group sediments. Hydraulic conductivities average 5×10^{-5} m/s in the Basal Aquifer and approach zero in the bitumen of the McMurray formation (Komex 1997). The low hydraulic conductivity of the McMurray formation restricts movement of groundwater from the Basal Aquifer to the Muskeg River (Schwartz and Milne-Home 1982).

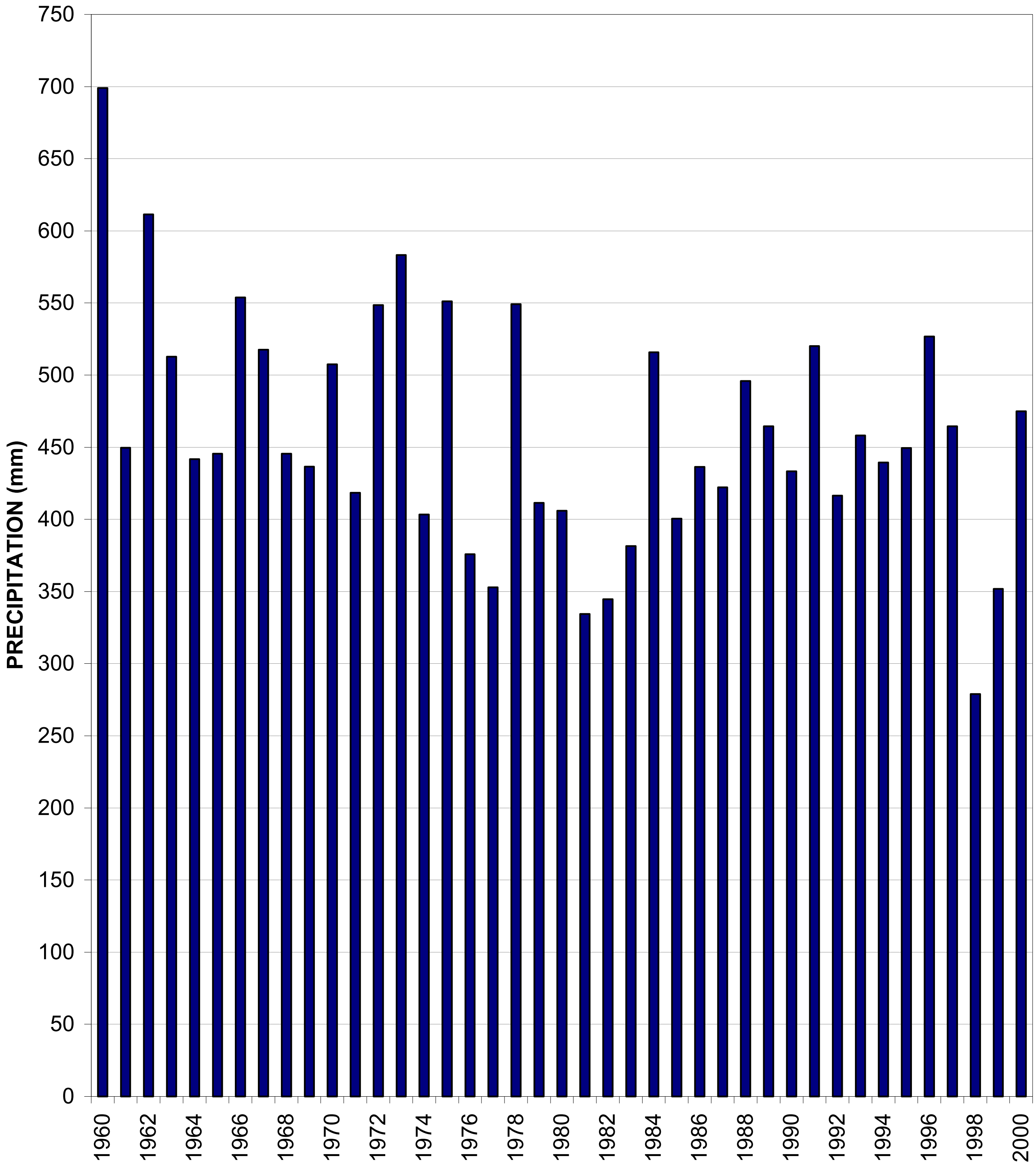


Figure 3.2 Annual total precipitation in the Muskeg River basin averaged from Bitumont, Muskeg and Mildred Lake fire towers and the Ft. McMurray Airport (Environment Canada, 2000)
Recent data from the Aurora climate station were included (Golder 2001).

3.6 Hydrology

3.6.1 Groundwater

Watertables in the Muskeg Basin are typically within 3 m of the ground surface but can change considerably from near-surface following snowmelt to relatively deep (~6 m) during extended dry periods (Schwartz and Milne-Home 1982). Water in the near surface till contains a moderate concentration of ions (Table 3.2) while deeper groundwater such as the Basal Aquifer is more saline (TDS usually above 3000 ranging up to 7400 $mg \bullet L^{-1}$; Golder 2001). A majority of mineral groundwater discharge comes from the glacial and alluvial sand and gravel comprising the overburden instead of deeper groundwater (Schwartz and Milne-Home 1982).

Table 3.2 Groundwater chemistry in the Muskeg River basin

Parameter	Peatwater		Till Groundwater	
	Mean	S.D.	Mean	S.D.
Ca^{2+}	17	8.3	82.9	33.2
Mg^{2+}	4.9	2.6	22.1	8.0
Na^{+}	4.1	6.8	13.3	13.1
K^{+}	0.6	0.5	3.0	2.6
SO_4^{2-}	5.9*	1.5	11.0*	15.3
Cl^{-}	2.4	1.2	7.8	14.8
HCO_3^{-}	80.7	47.0	392	125
Fe	0.2	0.2	1.1	1.6
Conductivity	137	71.6	392	125

Sources: Schwartz and Milne-Home (1982)
* Source cited potential analytical problems with this data

Overland flow is believed to be a minor contributor to runoff in the Muskeg basin. This belief is predicated on results from hydrologic investigations in the Muskeg basin (Neill and Evans 1979; Schwartz and Milne-Home 1982b). Lack of overland flow is further supported by the infiltration characteristics of peat soils which have saturated hydraulic conductivities of 0.1 cm/s at the surface (Ingram 1983) and infiltration studies on bare mineral soils that suggest saturated overland flow is rare in Alberta (Harms and Chanasyk 1998). An exception may occur during snowmelt when frost lenses in upper soils restrict infiltration (Metcalf and Buttle 2001). During snowmelt water may move as overland flow or more likely through shallow soils, however, the important result is that little chemical transformation of melt waters takes place and runoff contains chemical characteristics similar to the snowpack (Metcalf and Buttle 2001).

Mineral soil groundwater contributes the majority of water to river discharge from November through March (Schwartz and Milne-Home 1982). In Jackpine Creek groundwater contributions during this period were estimated at 100%. In the Muskeg River groundwater contributions over winter months ranged from 70 to 80%. The remaining 10 to 30% of winter runoff came from groundwater in peat soils. During snowmelt, as much as 50% of runoff comes from water with low ion concentrations similar to the snowpack. Once snowmelt ends, groundwater from peat soils contribute the majority (~70%) to runoff while the contribution of mineral groundwater increases from 15% to 30% of total discharge through the summer (Schwartz and Milne-Home 1982).

3.6.2 Water Yield

Water yield from the Muskeg basin is variable among its sub-basins. At the Water Survey of Canada (WSC) site, mean annual water yield (1974-2000) was approximately 89 mm. Winter discharges following 1986 were not available. Mean water yield was determined from measured mean annual water yield (78.4 mm) between 1974-1986 and a value determined from measured summer discharge and predicted winter discharge for 1987-2000. Winter discharge was predicted based on a relationship presented below under the flow characteristics section. Water yields and other hydrologic data for the WSC site are summarized in Table 3.3. The highest water yield occurred in 1997 (173 mm) and the lowest in 1999 (17 mm). Water yield from Jackpine Creek averaged 98 mm (1975-93) but averaged only 49 mm from the Unnamed tributary (Site T1, Figure 3.1). Low topographic relief and increased peatlands or wetlands reduces water yield from northern Boreal basins (Prepas et al. 2001). Both Jackpine and Unnamed Creek catchments are dominated by peatlands with 80 and > 90% of surface cover, respectively (Schwartz and Milne-Home 1982, Akena 1979). Jackpine, however, has a steeper total gradient than the Muskeg River accounting for its slightly higher water yield. These factors will require consideration when calibrating hydrologic models for future impact assessment work. Sufficient data to validate most distributed hydrologic models are currently unavailable for peatland systems (Pietroniro et al. 1996).

3.6.3 Flow Patterns

Muskeg River discharge patterns are highly variable among years. Peak discharges occur either during snowmelt (1974, 79, 85, 89, 90) or towards September (1975, 78, 80, 95-97). In two years, peak discharge was delayed until June (1991, 2000). Peak discharges have surpassed 65 m^3/s in heavy snow years and 45 m^3/s in heavy rainfall years. Other years have shown a more even distribution of discharge or have been arid with peak discharges below 20 m^3/s. During 1995-97, the mid - August through October periods were relatively wet (> 100 mm precipitation) and high flows were maintained through October at the WSC site. However, 1998 and 1999 were arid years; and fall discharge averaged 0.7 and 0.4 m^3/s in these years, respectively. The 7-day low flow with a 10 year return period (7Q10) was 0.07 m^3/s for winter months (Golder 1997) and 0.116 m^3/s for the total record (Alberta Environment, Hydrology Branch 2001).

Table 3.3 Hydrologic data for the Muskeg River at the WSC site, 1973-2000

	Mean Summer Mean Daily Q (m^3/s)	Mean Winter Mean Daily Q (m^3/s)	Predicted Mean Winter Mean Daily Q (m^3/s)	Summer Runoff Coeffi cient (%)	Annual Runoff Coeffi cient (%)	Summer Water Yield (mm)	Annual Water Yield (mm)	Total Precip 11/1-10/31	Summer Precip 3/15-10/31	Snowfall up to 3/15	Snow Water at 3/15	Min 7-d Mean Q (m^3/s)	Max 7-d Mean Q (m^3/s)
1973-74	9.03		1.79	32	36	131	144	403	305	98.3		0.21	40.49
1975	8.52	0.69	1.69	22	23	123	128	550	484	66.25		0.34	25.17
1976	2.74	1.23	0.55	11	13	40	48	375	311	64.15		0.14	13.01
1977	3.12	0.63	0.62	13	14	45	50	353	322	31.35		0.16	10.08
1978	7.90	0.68	1.57	21	22	115	119	548	460	88.7		0.23	30.41
1979	6.02	2.00	1.20	21	25	87	101	411	322	89.9		0.45	24.53
1980	4.33	0.86	0.86	15	17	63	69	406	358	47.7		0.20	18.33
1981	1.77	1.19	0.36	8	10	26	34	334	253	81.4		0.11	7.01
1982	2.90	0.23	0.58	12	13	42	44	345	258	86.5		0.13	13.91
1983	1.31	0.34	0.27	5	6	19	21	381	311	70.1		0.06	5.28
1984	5.14	0.20	1.02	14	15	74	76	515	447	68.6		0.04	20.06
1985	5.78	1.35	1.15	21	23	84	93	400	339	61.1		0.21	56.70
1986	6.41	0.59	1.27	21	22	93	97	436	356	80.5		0.26	17.60
1987	5.79	0.59	1.15	20	22	84	92	422	327	94.6		0.34	24.49
1988	7.78		1.54	23	25	113	124	495	417	78.6		**0.31**	**19.27**
1989	9.47		1.88	30	32	137	151	464	394	69.9		**0.38**	**43.27**
1990	7.27		1.44	24	27	105	116	433	338	95.4		**0.19**	**51.74**
1991	5.57		1.11	15	16	77	84	520	430	90.1		**0.26**	**40.89**
1992	5.76		1.14	19	21	79	87	416	332	84.1		**0.40**	**24.77**
1993	5.26		1.05	17	18	76	84	458	407	51.3		**0.23**	**19.50**
1994	4.01		0.80	14	16	58	66	438	360	78.6	est 50	**0.34**	**18.74**
1995	6.63		1.32	22	23	96	102	449	411	38.5	est 30	**0.23**	**35.60**
1996	9.87		1.96	29	30	143	152	526	422	104.519	est 80	**0.54**	**20.96**
1997	10.64		2.11	33	36	159	173	465	392	72.8	88.5	**0.46**	**40.54**
1998	2.85		0.57	15	21	41	57	279	221	58.15	52	**0.36**	**8.92**
1999	0.90		0.19	4	5	13	17	352	286	65.5	52.5	**0.21**	**3.05**
2000	6.87		1.36	21	21	100	101					**0.27**	**33.56**

- Data are summarized from Environment Canada water level monitoring (Hydat) and precipitation data from Alberta Environmental Service. Snow water is from Golder (2000). Estimates of snow water were from AES precipitation data. Summer is 245 days from March 1 to Oct. 31. Winter is the proceeding year Nov. 1 to current year March 1. Annual values are from Nov. 1 of proceeding year to Nov. 1 of current year
- Dotted outline indicates min and max 7-day mean Q were calculated on summer discharge only

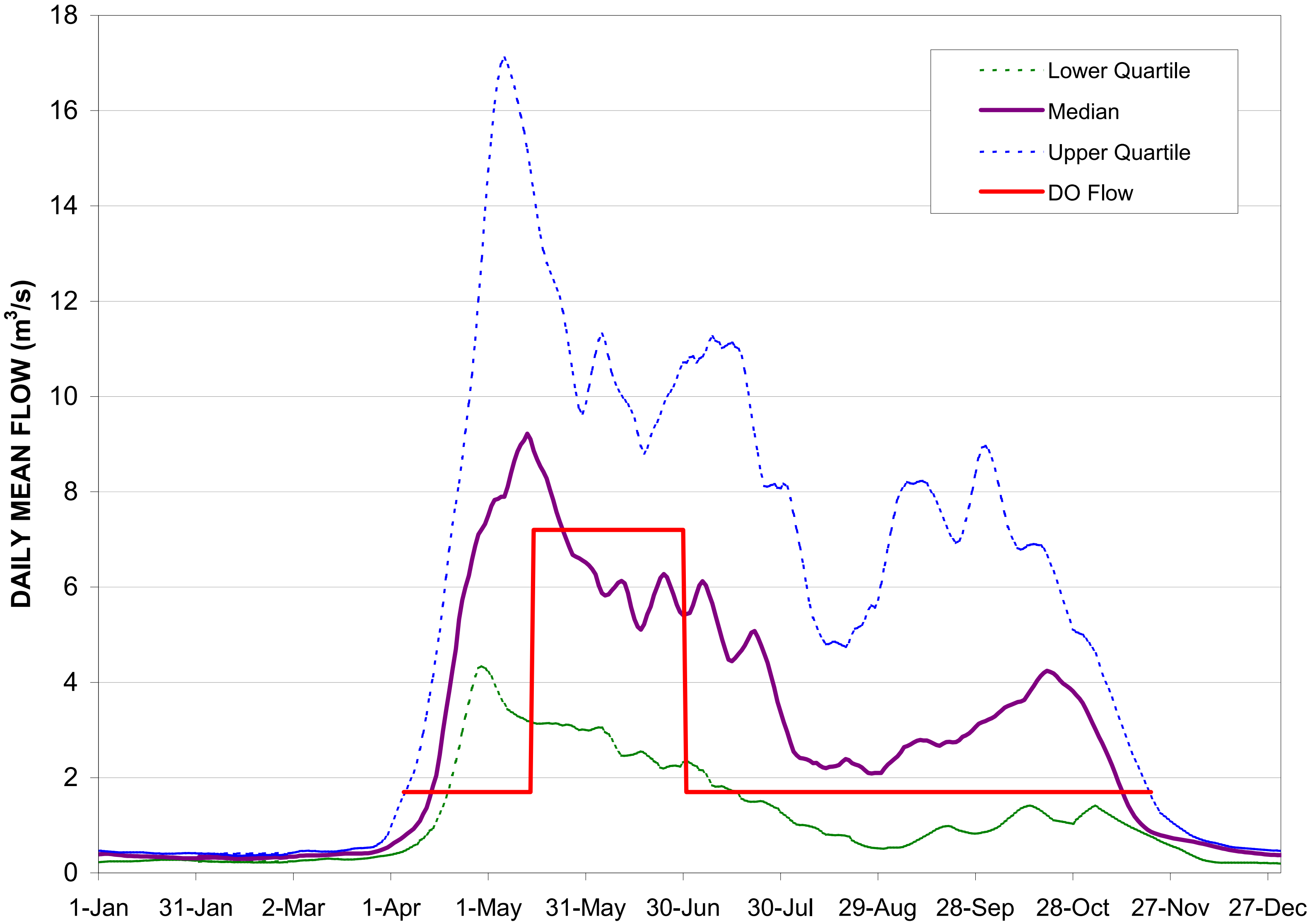


Figure 3.3 **Daily mean flow at the WSC site (1974-2000). Median, upper and lower quartiles are shown along with suggested flows (DO Flow) that would maintain dissolved oxygen concentrations above ASWQG**

Winter flows (November-February) averaged 0.82 m^3/s (1974-87). After 1987 hydrometric recording was reduced to eight months (March-October). Mean winter discharges from 1974-87 were closely correlated with mean monthly discharges averaged over the previous eight months:

$$\text{Mean winter Q} = 0.1974(\text{Mean previous 8 month Q}) + 0.0071 \qquad r^2 = 0.73$$

The formula was derived from linear regression and was used to calculate mean winter discharge and water yield for the years 1988-2000. Results from the equation above were validated with a similar averaging method currently supported by the Hydrology Branch (AENV). In the averaging method, annual water yield was inferred from the ratio between summer and annual water yield (1974-1987). Water yield results from both methods agreed to within 2 mm. The strong relationship between winter discharge and discharge in the preceeding eight months suggested baseflow was determined by near surface groundwater with a short residence time. Indeed, mean winter discharge was strongly correlated with total annual precipitation from the preceeding 12 months ($r^2 = 0.72$) but the correlation declined as additional annual data were included ($r^2 \leq 0.32$).

4.0 TEMPERATURE AND OXYGEN CHARACTERISTICS

4.1 Temperature

Water temperature in the Muskeg River is determined by air temperature. Figure 4.1 shows the close correspondence between air temperature (Environment Canada 2000) and water temperature at the WSC gauge site for 2000. Complete hourly temperature data for the sites monitored during the open-water season are appended (Appendix 5).

4.2 Oxygen

Dissolved oxygen (DO) has been monitored with recording meters and other gear at the WSC site throughout the 1998-2001 period. DO has also been monitored at other sites in the Muskeg catchment, including winter monitoring with recording meters (Table 2.1) Complete hourly records from the recording meters are included in Appendix 6.

From 1998 through November 2000, dissolved oxygen concentrations at the Muskeg River WSC site ranged from 3.6 to 13.1 mg•L^{-1} (Figure 4.2). Median and mean dissolved oxygen concentrations were 7.7 and 7.6 mg•L^{-1} respectively for the April 1998 to 2001 period. A precipitous decline in dissolved oxygen concentration occurred after November 2000 until December. Particularly low dissolved oxygen concentrations (<1.0 mg•L^{-1}) were recorded over an eight day period starting on December 24, 2000. A similar decline was observed in December 2001 (AENV preliminary data, Appendix 6), in contrast to 1998 and 1999.

Dissolved oxygen concentrations at the WSC site were at or above the ASWQG except during June and the winter months (Figure 4.2). Rapid oxygen depletion occurred during winter 2001 with [DO] falling below ASWQG a month earlier than in previous winters and to a minimum (< 1 mg•L^{-1}) less than observed in previous years. Dissolved oxygen concentrations were not correlated with biological oxygen demand (BOD); however, BOD typically was at its lowest in the fall and highest through the winter. BOD will be discussed further in the next subsection.

The Muskeg site upstream of Jackpine Creek contained the lowest recorded winter dissolved oxygen concentrations for the period in which data were available at all sites. However, routine measurements suggested dissolved oxygen concentrations were similar to the WSC site during open water. Dissolved oxygen concentrations in the Muskeg River above Jackpine Creek were often below Alberta surface water quality guidelines (ASWQG), particularly during May through June, periodically during summer months, and through winter months. Only snowmelt and fall periods contained dissolved oxygen concentrations above the ASWQG. Jackpine Creek behaved in a similar fashion (Figure 4.2). Dissolved oxygen concentrations at the mouth of the Muskeg River were elevated compared to other sites and remained above ASWQG most of the year. The only exceptions were in June when the ASWQG was elevated for Mayflies, and in February when [DO] was at its lowest concentration. Higher [DO] near the mouth may result from turbulence and reaeration due to a steeper gradient between the WSC gauge and mouth sites.

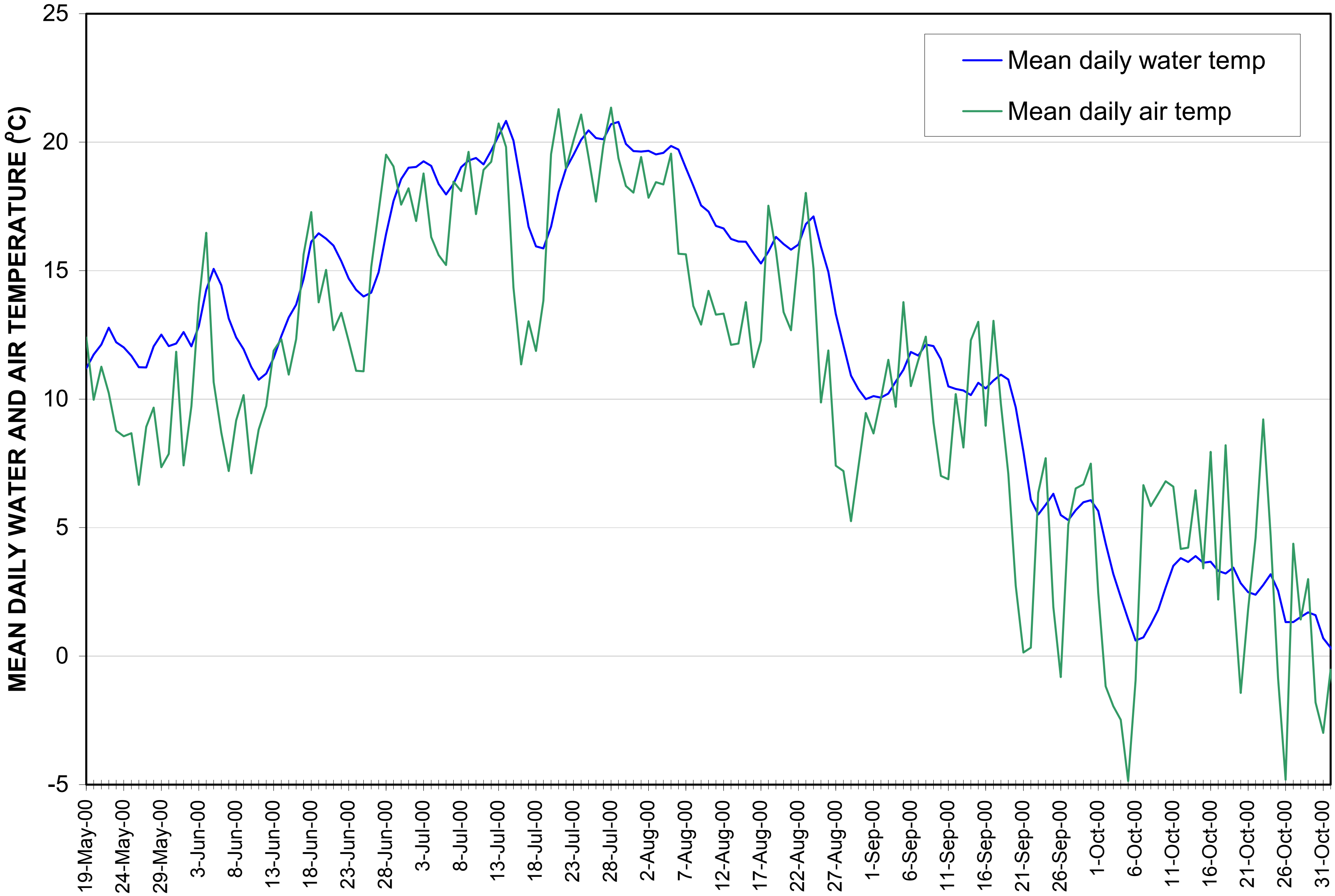


Figure 4.1 Average daily water temperature and air temperature for the Muskeg River, 2000

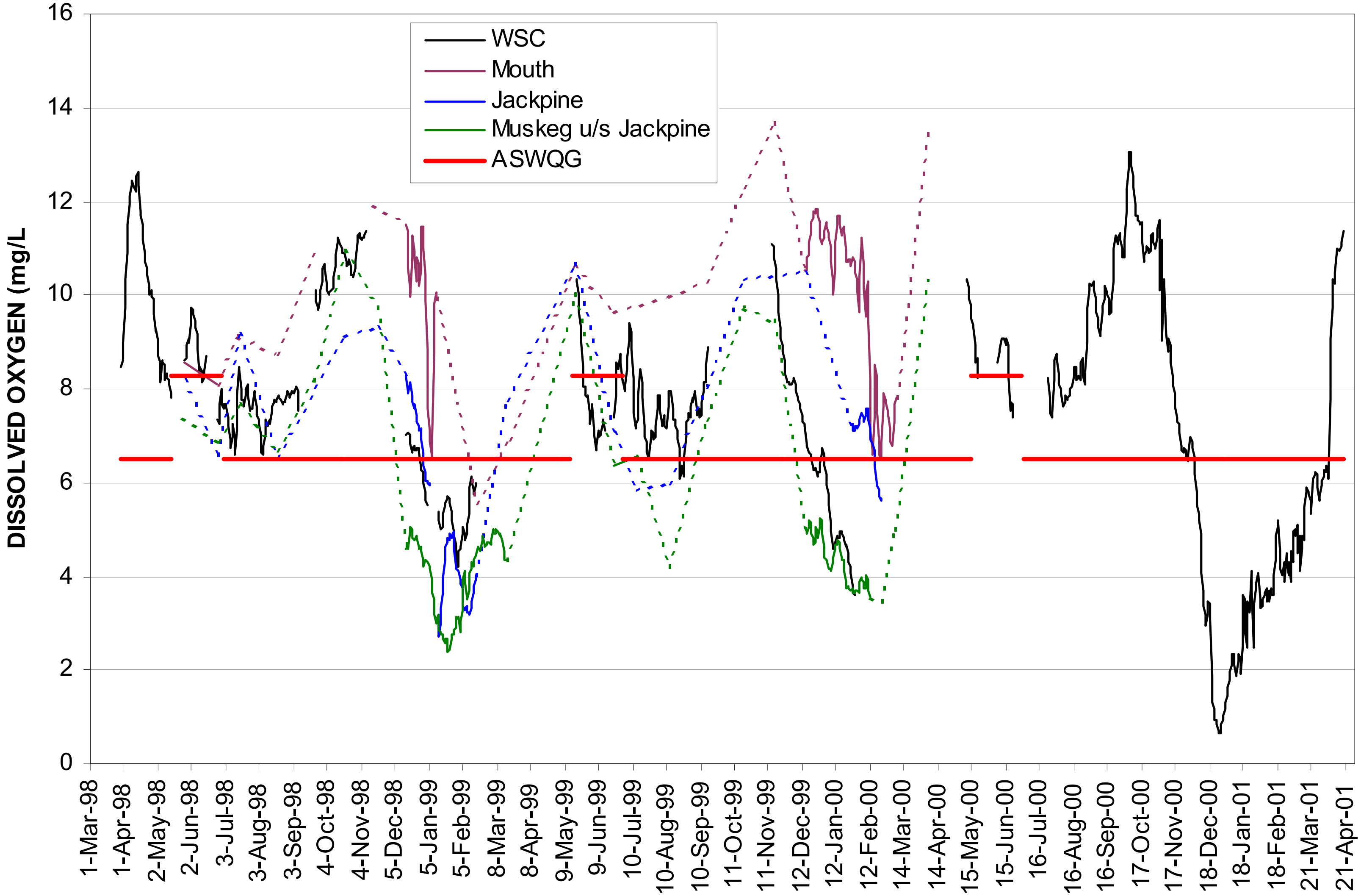


Figure 4.2 Average daily dissolved oxygen concentrations at the Muskeg River WSC site and tributaries, 1998 to 2001
Dashed lines connect DO concentrations determined during monthly site visits.

Dissolved oxygen concentrations in Muskeg streams were strongly related to flow. Dissolved oxygen concentrations at the WSC site were correlated reasonably well with discharge (Q, m^3/s), temperature (T, ºC) and pH:

$$[DO] = 0.39Q - 0.191T + 5.208pH - 31.236 \qquad r^2 = 0.75$$

Predicted and observed dissolved oxygen concentrations at the WSC site are presented in Figure 4.3. The variables were selected in a principle components analysis that suggested 82% of variance in the correlation of the four variables could be explained by two factors; one determined largely by flow and the other determined by temperature and pH. Low [DO] consistently occurred at pH below 7.3, perhaps reflecting periods when CO_2 production (respiration) increased relative to oxygen entrainment. Periods of higher pH and DO may reflect higher in-stream photosynthesis, which would produce oxygen and elevate pH. During midsummer, pH demonstrated daily fluctuations, peaking mid-day often 0.2 units above morning values (Appendix 7) suggesting photosynthesis was influencing proton activity and contributing oxygen to the water.

The importance of this relationship is that declines in flow could impair summer [DO] concentrations. Flow may affect [DO] through turbulence and reaeration, and through 'flushing' of otherwise stagnant conditions in beaver ponds. The relationship indicates at least 7.2 m^3/s is required during spring temperature and pH conditions (15ºC and 7.6, respectively) to maintain 8.3 $mg{\bullet}L^{-1}$ [DO]. At least 2.6 m^3/s of flow would be required during summer months to maintain 6.5 $mg{\bullet}L^{-1}$ [DO] under similar conditions. However, summer discharge could be as low as 1.7 m^3/s assuming pH in the 8.0 range indicates autochthonous photosynthesis is adding DO. The latter number should be viewed with caution because pH likely represent excess photosynthetic activity compared to respiration and is likely dependant on a number of variables influenced by physical conditions in the stream. Photosynthesis causing pH increases to 8 and above is not guaranteed under all summer flow, chemistry and climatic conditions.

The model suggests that low [DO] occurring in recent years was due to flow conditions and enhanced respiration relative to oxygen income. The model was unable to account for declines in [DO] below 5 $mg{\bullet}L^{-1}$ because it did not contain a factor for lost surface entrainment following ice cover. Inclusion of Streeter-Phelps formulae would be required before the above model was useful for prediction in a management context. Low flow and water yield similar to 1999 also occurred in 1983, however, no data are available between 1982 and 1998 for comparison. In 2000, water yield and flow increased to values consistent with the long-term-mean without a similar return in winter [DO] to previous winter values of 4 $mg{\bullet}L^{-1}$. Instead [DO] and pH declined to historic lows in December 2000 suggesting enhanced oxygen consumption and carbon dioxide production relative to oxygen income despite normal water flow. BOD values were unavailable after 1999. In previous years, BOD was usually low at the WSC site during December and January. A simple explanation for low DO in 2000 is not apparent, but may relate to respiration in sediments not assessed in BOD measurements. The organic carbon content of sediments increased from 3 to 14 % wt. moving upstream from the WSC site without a similar pattern in water BOD concentration (RAMP 2000 data). Sediment and biomass accumulation in upper reaches may be enhanced during years of low flow and may be important in causing winter

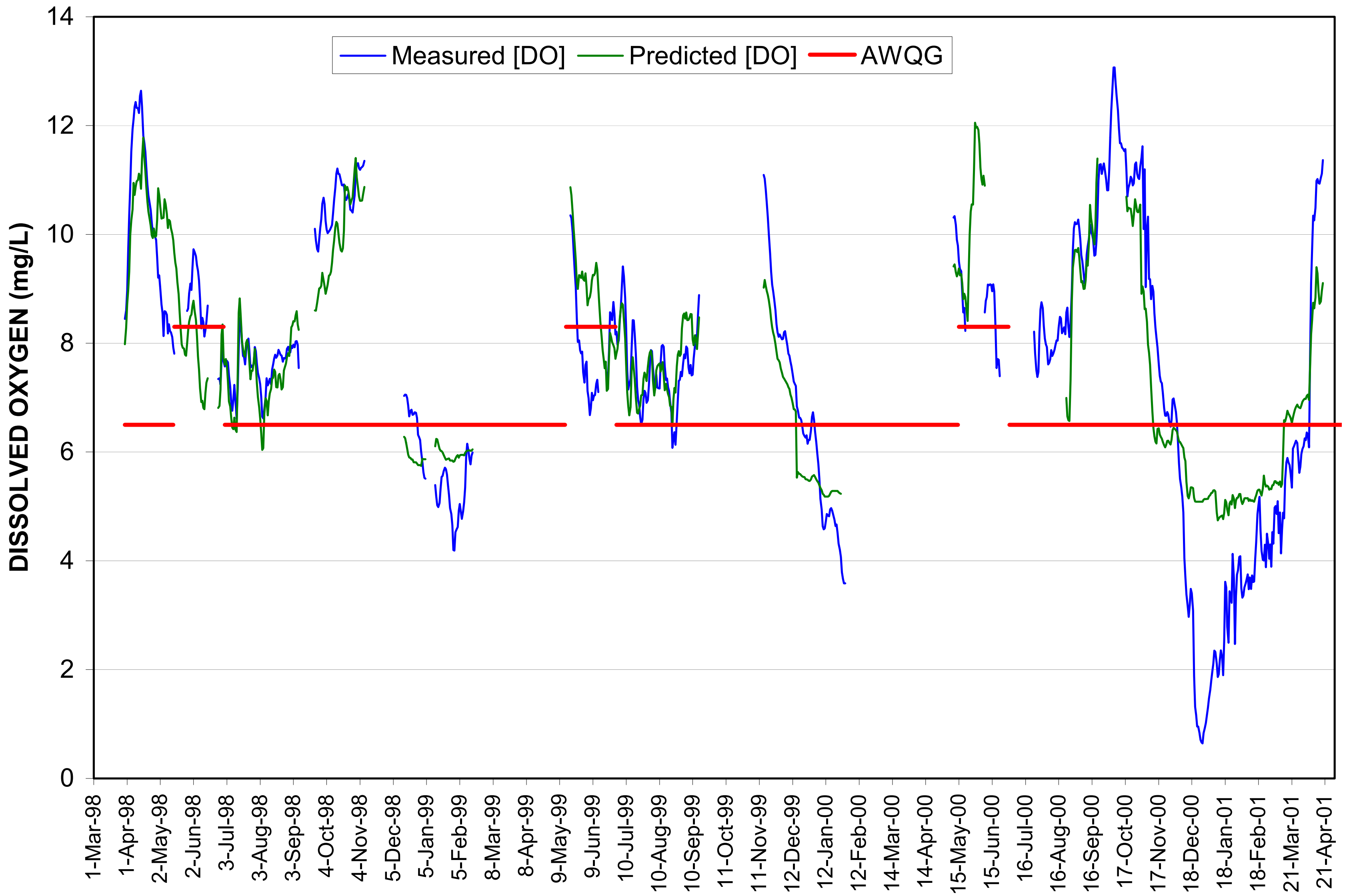


Figure 4.3 Predicted and observed dissolved oxygen concentrations at the Muskeg River WSC site, 1998-2001

oxygen depletion in subsequent years. Continued monitoring of total organic carbon contents of Muskeg River sediments may help decipher the oxygen depletion problem.

Dissolved oxygen concentrations decline in the low gradient reach of the Muskeg River between the Stanley Creek and WSC site confluence. For example, DO recorded at the site located above the Jackpine confluence were consistently lower than those recorded at the WSC site, particularly during winter months (Figure 4.2). This may have been due to anoxic water draining from peatlands, oxygen depletion in beaver ponds, or greater contact of the water with oxygen-demanding sediment in upstream areas. At sites in the upper reaches, above Stanley Creek, summer DO was even lower than in downstream sites with values typically recorded in the 2 to 4 mg•L^{-1} range. Low DO in the headwater sites may have been due to anoxic water draining from peatlands. At these same sites, winter DO was often higher (> 6 mg•L^{-1}) than recorded in downstream sites likely because runoff was not routed through peatland soils once the soils were frozen.

Winter DO was not routinely recorded prior to 1998, however, DO concentrations below 2 mg•L^{-1} were recorded in March 1981 and 1995 at the WSC and Mouth sites, respectively. The only mid-winter value for historic DO was 5.4 mg•L^{-1} in January 1981. Oil sands developments do not seem to be related to recent declines in winter DO, however, any activity that reduces flow in the Muskeg River will result in enhanced winter oxygen depletion. Caution should be exercised because, presently, we do not have enough data to accurately determine the causes of oxygen depletion during winter.

4.3 Biological and Chemical Oxygen Demand (BOD and COD)

Chemical oxygen demand (COD) was analyzed from samples previous to 1982. This variable has been analyzed more frequently in the past, in connection with potential concerns about wastewaters. COD concentrations ranged from 17 to 437 mg•L^{-1} with high values recorded in Jackpine (437 mg•L^{-1}) and Stanley Creek (400 mg•L^{-1}) during April 1977. At the WSC site, COD ranged from 25 to 115 mg•L^{-1} and averaged 56 mg•L^{-1}. COD was not related to nutrient or organic carbon concentrations in stream waters.

Biological oxygen demand was measured from 1998 to present. Excluding Shelley Creek, BOD ranged from 0.3 to 3.4 mg•L^{-1} (Figure 4.4), and 90% of all values were between 0.5 and 2 mg•L^{-1}. In Shelley Creek a BOD of 10.4 mg•L^{-1} was recorded in October 1999. Inorganic nitrogen, ions and colour were elevated 20 to 50% in this sample over values from a sample taken the previous year. Chloride was four-fold and sulfide 10-fold higher in concentration than in the previous year. Suspended solids were five-fold higher than in the previous year. Dissolved oxygen concentrations were correspondingly low (1 mg•L^{-1}). Discharge data were not available and the source of the high BOD could not be inferred. However, Shelley Creek is a relatively minor tributary that drains peatland, and had low flow on the occasions sampled (<0.01 m/s).

As mentioned when discussing dissolved oxygen, BOD appeared to follow a seasonal trend. Unfortunately, the trend cannot be tested with the 1.5 years of data available for most sites. High BOD concentrations occurred between January and August (1.0 to 2.0 mg•L^{-1}) and declined in

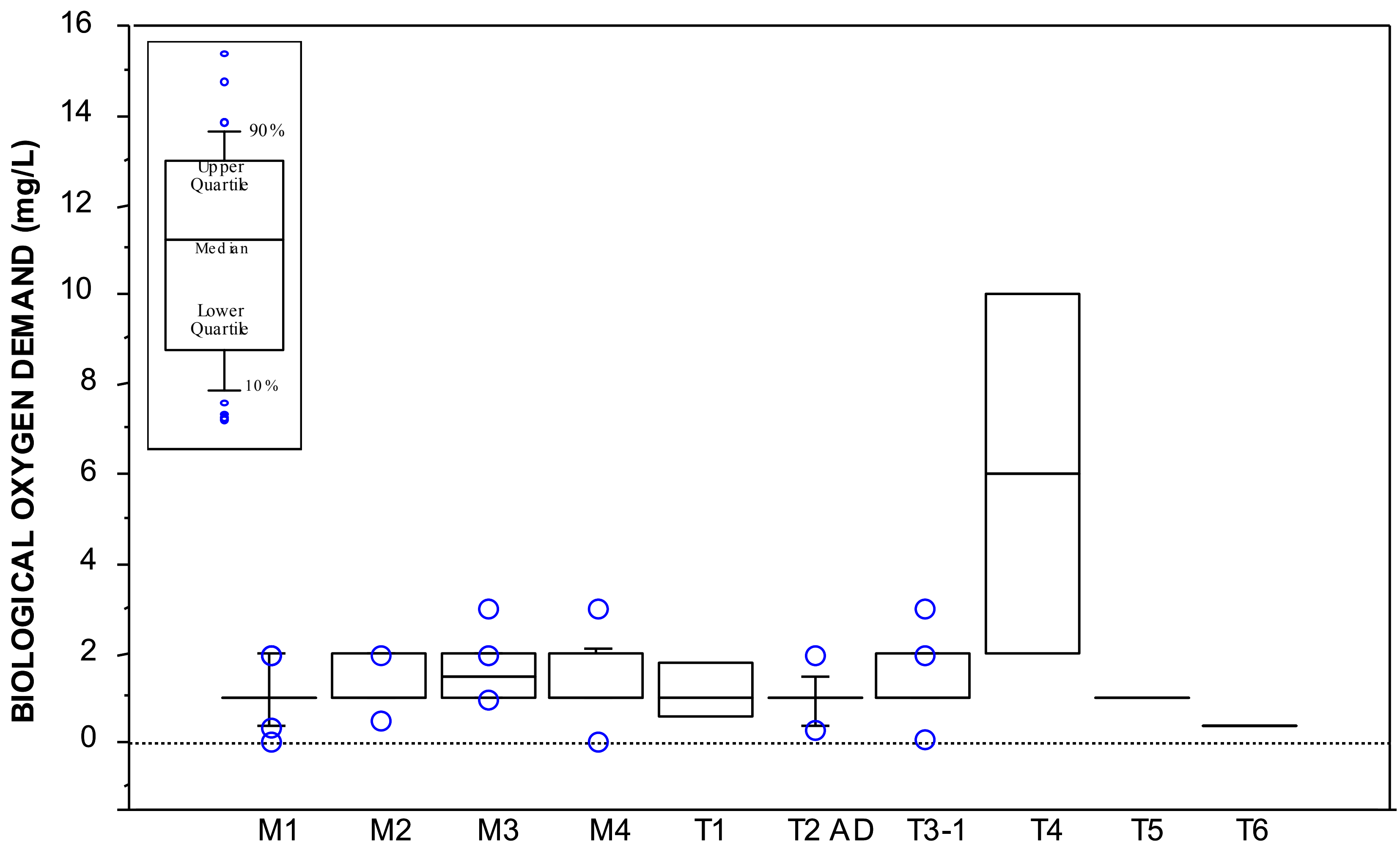


Figure 4.4 Biological oxygen demand (BOD) concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1).

September to reach minimum values between October and December (0.3 to 1.0 mg•L^{-1}). A similar pattern was noted for BOD measurements from RAMP sites (Golder 2001) with January high values in 2000 and 2001 punctuated by two low points in late June and late October. Intermediate summer values were variable (Golder 2001). Continued monitoring will be needed to ascertain if this seasonal pattern is consistent among years and to determine what allochthonous and autochthonous sources determine BOD in the Muskeg River.

5.0 CHEMICAL CONSTITUENTS

5.1 Ions and pH

Major ion concentrations in the Muskeg River and its tributaries were consistent with northern boreal streams receiving mixtures of water from peatlands and shallow mineral soils (Prepas et al. 2001). Ion concentrations are summarized in two groups in Table 5.1; sites sampled prior to 1998 and sites sampled from 1998 to 2000. Seasonally, total cation concentrations at the WSC site peaked at 6 meq•L^{-1} (January through March) declined through April to mean minimum concentrations (2.5 meq•L^{-1}), then rose though June and July to stabilize between 4 and 5 meq/L (Figure 5.1). The Muskeg River is a calcium bicarbonate system. Total cations (meq•L^{-1}) at baseflow (Q < 2.5 m^3•s^{-1}) were comprised of 64% Ca^{2+} and total anions were 92% bicarbonate at the WSC site. Upstream from the WSC site, the relative proportions of bicarbonate varied little through the years. At both the WSC and mouth sites, elevated SO_4^{2-} concentrations during fall 1998 and 1999 resulted in a lowering of bicarbonate to 74% of total anions. Among the anions, SO_4^{2-} and Cl^- were not related to discharge ($r^2 < 0.2$, n = 92). Elevated sulfate concentrations in the WSC and mouth sites were related to discharge of sulfate from the Alsands Ditch site.

Sulfate can be significant because of its potential association with an acid generating oxidation process. Sulfate concentrations measured in the Alsands ditch ranged from 60 to 574 mg•L^{-1} and averaged 230 mg•L^{-1} between May 1998 and October 1999. Sulfate concentrations at the WSC site were typically below 20 mg•L^{-1} and averaged 5 mg•L^{-1} at the WSC site until July 1998. By September of 1998, SO_4^{2-} concentrations at the WSC site rose to 86 mg•L^{-1} and remained elevated through the winter. Though they declined the following summer, SO_4^{2-} concentrations at the WSC site rose again to 82 mg•L^{-1} in the fall of 1999 reflecting inputs from the Alsands Ditch upstream. The oxidation of sulfides is a logical source for the observed sulfate concentrations, but other potential sources do exist such as contact of water with gypsum. In addition to the 8 fold mean increase in sulfate concentration, calcium concentrations approximately doubled in the Alsands ditch. Prior to 1997, Calcium concentrations in the Ditch were similar to till groundwater (Table 3.2). On an equivalent basis the calcium increase represents 60% of the sulfate increase. Oxidation provides an opportunity for the precipitation of iron and release of SO_4^{2-} and potentially acidifying protons. It is important to note that water from the Alsands ditch was not acidic and that in 2000, concentrations of SO_4^{2-} at the WSC site seem to have reverted to pre-1998 levels (Appendix 3). The concern is that the buffering capacity of the Muskeg River may be exceeded by the production of protons as sulfides are oxidized in an expanded development scenario.

Another potential source for sulfate loading is oxidation of sulfides stored in peat which can result in large SO_4^{2-} loading in drainage waters (Gorham et al. 1984). Natural fluctuations of watertables in peatlands are another potential source for SO_4^{2-}. Without watertable data the potential for natural SO_4^{2-} release cannot be determined, however, SO_4^{2-} concentrations in the 10 to 15 mg•L^{-1} range were recorded in streams not receiving overburden drainage waters which were presumably the result of loading from muskeg (e.g., Jackpine Creek May 1999). While not extraordinary for the region, these concentrations occurred during snowmelt when waters were dilute and were 2 to 3-fold higher than mean concentrations in the Muskeg River. Atmospheric deposition may be a source for snowmelt increases in SO_4^{2-}. Atmospheric deposition is a

Table 5.1 Major ion concentrations for the Muskeg River and tributary sites, averaged for years 1976-1997 (1997) and 1998-2000 (2000)

Site	Station	Year	Ca	Mg	Na	K	ALK	Cl	SO4
M1	620	1997	58.91	14.06	14.78	1.24	216.48	5.67	5.7*
M1	620	2000	90.55	16.59	13.48	1.53	253.55	4.73	55.82
M2	610	1997	48.33	12.04	12.74	0.93	183.38	4.67	5.20
M2	610	2000	65.78	12.90	10.62	1.32	206.17	3.91	27.35*
M3	470	1997	51.14	12.75	12.42	1.13	195.83	4.04	4.11
M3	595	2000	60.52	13.51	11.28	1.10	219.75	4.34	3.83*
M4	2750	1997	48.33	12.57	5.63	0.75	170.25	1.50	1.14
M4	2750	2000	63.52	14.68	6.42	1.03	238.80	2.54	4.55*
M5	1125	2000	80.27	20.37	6.73	1.40	296.33	1.77	1.5**
M6	440	1997	55.05	17.06	6.93	1.15	212.12	2.15	3.94
M7	420	1997	55.00	22.47	3.83	1.15	238.33	0.95	4.55
T1	606	2000	75.37	12.83	7.43	1.27	250.33	4.70	1.5**
T2	1050	1997	87.77	14.97	6.09	1.35	274.21	1.42	28.46
T2	605	2000	169.34	22.34	7.85	2.04	286.50	1.90	229.80
T3.1	600	1997	40.33	11.09	16.19	0.88	165.33	5.50	5.07
T3.1	600	2000	51.99	13.17	15.30	1.29	207.00	6.67	2.78*
T3.2	1090	1997	31.95	8.95	12.79	0.79	134.44	2.74	3.94
T3.3	1150	1997	27.39	7.98	11.78	0.58	113.86	1.31	4.41
T3.3b	1140	1997	23.17	6.93	11.82	0.69	103.46	1.84	4.02*
T3.4	1230	1997	29.64	7.80	6.89	0.57	107.18	0.99	4.64
T3.4b	1220	1997	36.55	10.71	17.91	0.88	148.73	2.42	5.32
T4	1160	1997	37.50	11.91	19.33	1.25	169.57	2.17	7.53
T4	2756	2000	76.80	12.85	71.05	1.90	324.50	48.40	5.75*
T5	530	1997	31.06	10.39	17.39	1.56	143.43	2.14	6.34
T5	2755	2000	57.10	15.77	34.67	1.87	258.67	15.10	5.83*
T5.1	1190	1997	21.50	8.05	12.93	1.82	104.78	1.40	5.19
T5.2	1200	1997	22.50	8.91	13.61	0.96	107.51	2.10	7.45
T5.3	1180	1997	26.00	9.14	18.20	0.75	127.10	1.73	5.14
T6	490	1997	42.50	10.41	2.05	0.83	152.13	0.46	2.65
T6	490	2000	40.90	9.72	2.40	0.80	145.00	0.70	1.5**
T7	480	1997	41.00	10.61	8.84	1.21	153.97	1.59	5.27
T7	1126	2000	64.17	12.46	8.13	1.27	227.33	2.00	3.17*

All station numbers refer to labels on Figure 3.1 (map)
Units are mg/L (alkalinity is mg/L as CaCO3)
* mean influenced by values < detection, ** mean determined entirely from half the detection limit

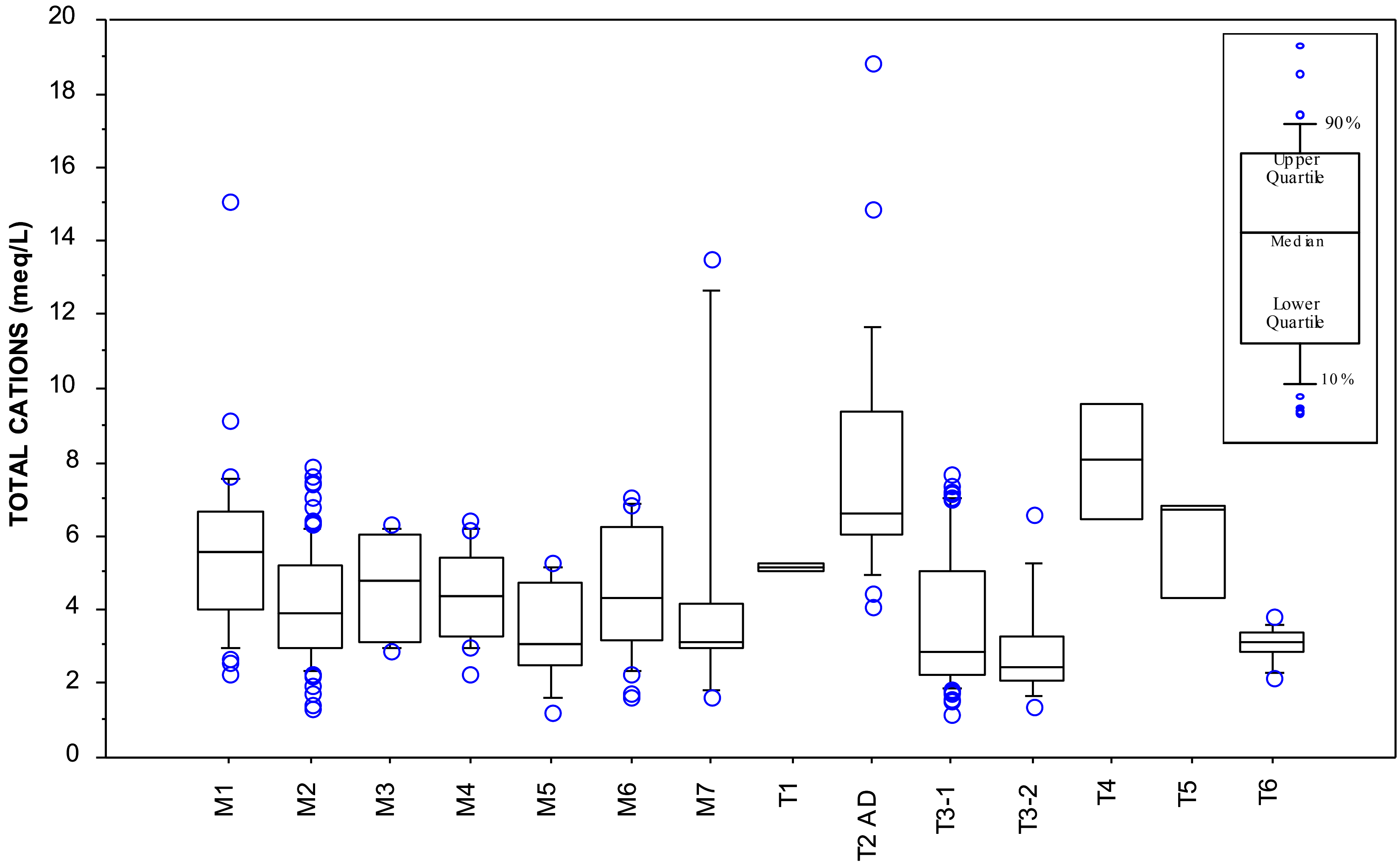


Figure 5.1 **Total cation concentrations (meq/L) at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)**
Sites labels follow map (Figure 3.1).

concern because some of the surrounding lakes are highly sensitive to acid deposition (Saffran and Trew 1996).

Further discussion of ion proportions is warranted because of the applicability for determining source waters. Calcium concentrations declined markedly with increased discharge ($r^2 = 0.62$, n = 92), whereas Na^+ concentration did not ($r^2 = 0.1$, n = 92). However, the proportion of total cations comprised of Ca^{2+} (%Ca) was negatively correlated with %Na ($r^2 = 0.87$, n = 92). The implication was that Na^+ concentrations were not vastly different among baseflow and stormflow source waters but Ca^{2+} concentrations and the ratio of Na^+ to Ca^{2+} did differ. The relatively low and invariant Na^+ concentration supports the hypothesis that baseflow source waters were shallow, however, Na^+ concentrations were expected to decline during high flow conditions because peatwater (surface) contained one-third the Na^+ concentration of groundwater (Schwartz and Milne-Home 1982). In contrast, sodium concentrations of soil water within the anaerobic peat profile were similar to that in mineral groundwater (Schwartz and Milne-Home 1982). The Na^+ signature suggests that storm runoff was routed through minerotrophic peat soil waters, either from fens or at the peat / mineral interface in bogs, instead of lateral flow within shallow organic layers.

The acid neutralizing capacity (ANC) for the Muskeg River at the WSC and mouth sites was calculated from total cations (TC) and other ions ($meq{\bullet}L^{-1}$) as (Reuss et al. 1986):

$$[ANC] = [TC] + [NH_4^+] - [SO_4^{2-}] – [Cl^-] – [NO_3^-]$$

The alternate method based on alkalinity (e.g., Andrews 2000) was not used because it requires an approximation of organic acid ($RO^- + H^+$) and aluminum concentrations. An accurate approximation of organic acids is needed because they can contribute considerably to the anionic charge and acidity of waters in northern Alberta (McEachern et al. 2000). Presumably, organic anions with functional groups that have lost protons can also contribute to the buffering capacity of surface waters. Despite the elevated SO_4^{2-} concentrations during fall and spring, ANC at the WSC and mouth sites remained above 1.2 meq/L. The suggested guideline for ANC in Alberta lakes is 0.1 meq/L (Andrews 2000) to maintain a pH greater than 6. However, the ANC guideline was determined from alkalinity alone, not from the method where non-marine base cations and sulfate are included. ANC guidelines require further development in Alberta lakes and streams that account for organic acids and sulfate deposition rates. We were unable to derive an ANC limit in the Muskeg River because pH occurred within a narrow range. At the present time the Muskeg River is not sensitive to acidification.

Jackpine (Hartley) Creek has the lowest acid neutralizing capacity of the sampled Muskeg tributaries. The sensitivity of Jackpine Creek is partly due to the high proportion of peatlands (ca. 80%) in its basin. Total alkalinity has reached a low of 46 $mg{\bullet}L^{-1}$ ($CaCO_3$) and is typically about 80 $mg{\bullet}L^{-1}$ ($CaCO_3$) during snowmelt and the months of September and October. The pH has remained above seven for samples dating back to 1976 and ANC has remained above 1.0 $meq{\bullet}L^{-1}$. A slight downward trend in Jackpine ANC was apparent between 1976 and 1982, however, ANC in 1998 remained similar to values recorded in 1982.

The hydrogen ion activity $[H^+]$ as determined by pH spanned two orders of magnitude (6.5 to 8.65) for all sites combined. At the WSC site, pH ranged from 6.9 to 8.2 with annual means ranging from 7.6 to 8.1 units. Seasonal and daily fluctuations in pH were apparent (Appendix 7). Minimum monthly pH occurred in the winter, typically between December and January reflecting possible CO_2 (and its solution products carbonic acid and carbonate) accumulation under ice from respiration. Low pH could also occur during snowmelt in March due to acid deposition and runoff pathways limited to organic soils. Between 1976 and 1981, no pH values were recorded below 7.2 at the WSC site. Over two years from 1999 to 2001, seven pH values below 7.2 were recorded and gave the appearance of a recent declining trend in pH. The post 1998 downward trend in pH was significant at the WSC site for grab samples (Figure 5.2a, $r^2 = 0.60$, $P \ll 0.01$) and from the data sonde record (Figure 5.2b, $P \ll 0.01$). Although the decline appears coincident with recent dry conditions and perhaps low flow, flow has returned to longterm mean conditions while pH has continued to decline. More data are required to determine the cause of the declining pH, and whether it is occurring at other locations in the river system.

5.2 Nutrients

5.2.1 Phosphorus

Total phosphorus concentrations ranged from below limits of detection (5 µg/L) to 600 $\mu g \bullet L^{-1}$, with both highs and lows occurring at the mouth site. Mean, minimum and maximum phosphorus concentrations are summarized in Table 5.2 for each site. At Muskeg River downstream sites such as mouth, WSC, and above Jackpine and in the lower tributaries, TP concentrations were usually below ASWQG of 50 $\mu g \bullet L^{-1}$ (Figure 5.3). Most incidents when TP exceeded the ASWQG occurred between December and April, however, concentrations were elevated in July on two occasions (1981, 2000). Elevated mean TP (55 $\mu g \bullet L^{-1}$) occurred at the WSC site in 1979 due to a February sample with 190 $\mu g \bullet L^{-1}$ [TP]. At headwater sites, above Wapasu Creek, TP concentrations were often above ASWQG (Figure 5.3). Total phosphorus concentration at the WSC site were correlated with TSS concentrations ($r^2 = 0.25$, $P < 0.01$, n = 79). Biological uptake and slow flow, allowing sedimentation in beaver ponds, likely reduced TP concentration at downstream sites.

A distinct seasonal trend in TP was apparent with concentrations peaking in March or April, declining to a minimum in August and increasing through fall and winter (Figure 5.4). Total phosphorus concentrations were not related to discharge at the WSC site ($r^2 < 0.01$, n = 83). However, elevated concentrations during spring were likely due to snowmelt runoff, summer lows a result of uptake during the growing season, and winter increases due to nutrient release from reduced sediments along with contributions from groundwater as baseflow was approached. Akena (1979) described similar TP conditions for the Muskeg River.

There is no indication that TP concentrations have increased at the WSC site since 1976 (Figure 5.5). Concentrations of TP observed at the mouth site between 1972 –1975 (200 to 600 µg/L) may be erroneous. These values predate AENV monitoring of the Muskeg River and were 10-fold higher than values reported after 1975.

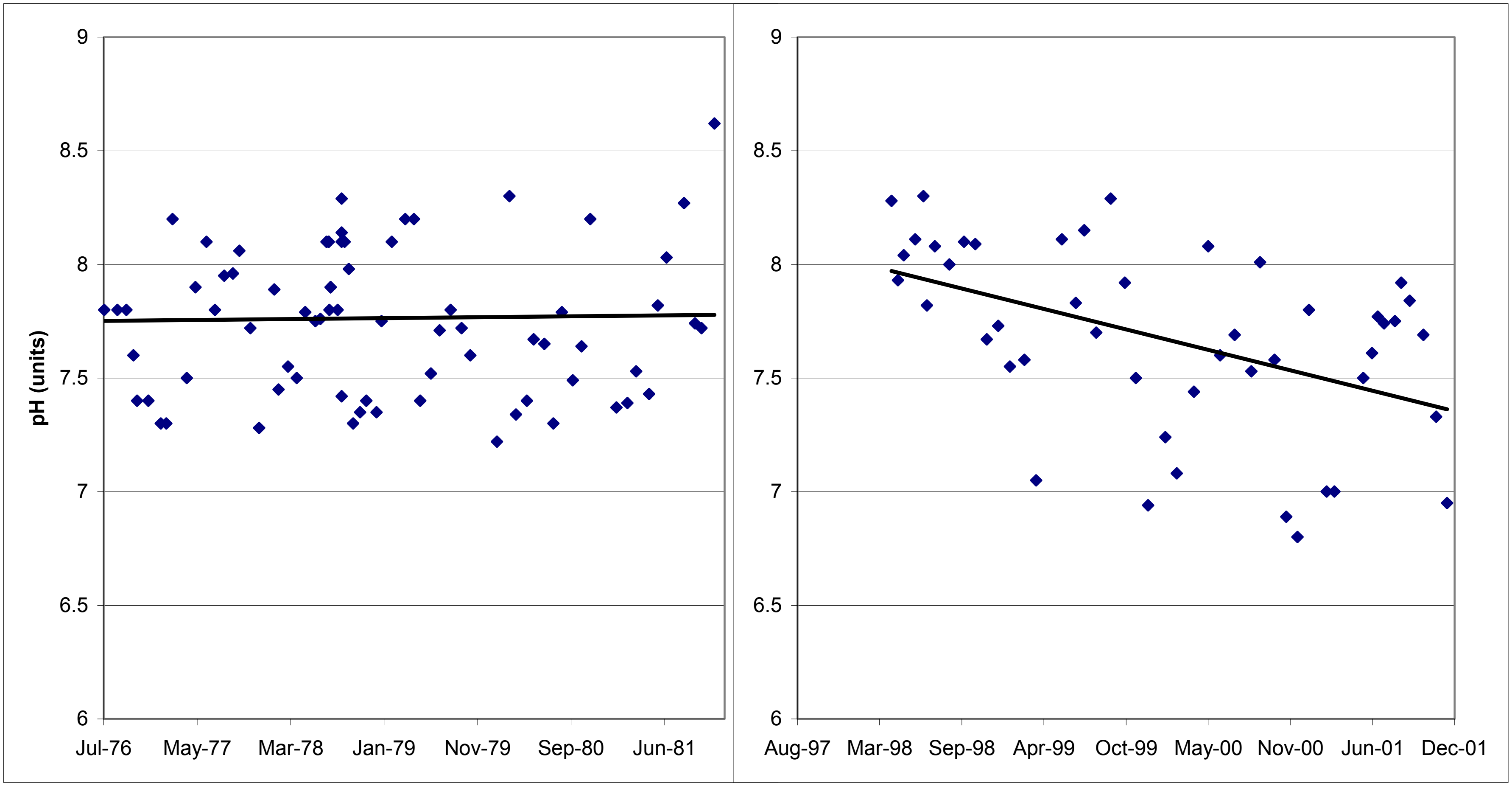


Figure 5.2a pH of surface water (grab) samples at the Muskeg River WSC site, July 1976 to October 1981 and March 1998 to December 2001.

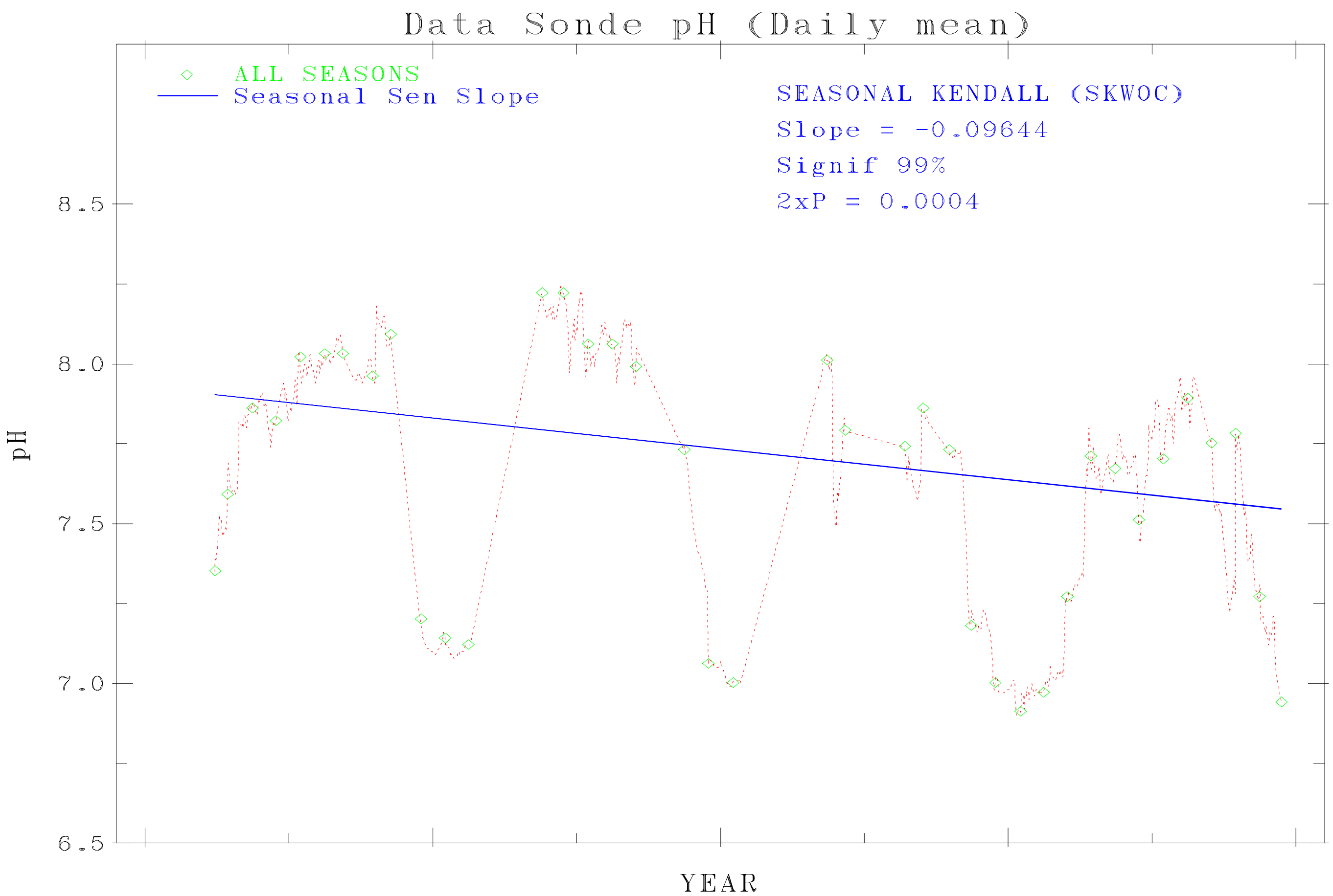


Figure 5.2b Daily mean pH at the Muskeg River WSC site recorded by continuous Data Sondes, March 1998 to December 2001

Green points are interpolated monthly mid-point values used in the seasonal Kendall analysis.

Table 5.2 Yearly average, maximum, minimum and count of nutrient concentrations for the Muskeg River and tributaries

Site	Year	TKN				TP				NO2+NO3				NH4				DOC			
		Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count
M1	1972	1.13	1.13	1.13	1	0.400	0.600	0.200	2	0.057	0.100	0.020	3	0.800	0.900	0.700	2	nd	nd	nd	nd
	1973	nd	nd	nd	nd	0.325	0.600	0.050	2	0.050	0.050	0.050	2	1.250	2.400	0.100	2	nd	nd	nd	nd
	1974	nd	nd	nd	nd	0.050	0.050	0.050	1	0.050	0.050	0.050	1	1.600	1.600	1.600	1	nd	nd	nd	nd
	1975	nd	nd	nd	nd	0.500	0.500	0.500	1	0.050	0.050	0.050	1	0.100	0.100	0.100	1	nd	nd	nd	nd
	1976	1.26	2.89	0.55	5	0.028	0.050	0.002	8	0.102	0.600	0.005	8	0.192	0.640	0.060	5	22.3	27.0	18.0	6
	1977	3.94	3.94	3.94	1	0.070	0.070	0.070	1	0.025	0.025	0.025	1	1.310	1.310	1.310	1	61.0	61.0	61.0	1
	1978	2.03	2.03	2.03	1	0.027	0.027	0.027	1	0.211	0.211	0.211	1	0.380	0.380	0.380	1	9.0	9.0	9.0	1
	1989	1.08	1.28	0.88	2	0.037	0.041	0.033	2	0.195	0.220	0.169	2	0.220	0.290	0.150	2	22.4	23.0	21.7	2
	1990	0.92	0.92	0.92	1	0.032	0.032	0.032	1	0.210	0.210	0.210	1	0.340	0.340	0.340	1	19.3	19.3	19.3	1
	1991	1.05	1.05	1.05	1	0.022	0.022	0.022	1	0.289	0.289	0.289	1	0.230	0.230	0.230	1	24.0	24.0	24.0	1
	1992	0.84	0.84	0.84	1	0.029	0.029	0.029	1	0.320	0.320	0.320	1	0.160	0.160	0.160	1	20.5	20.5	20.5	1
	1993	1.32	1.32	1.32	1	0.027	0.027	0.027	1	0.024	0.024	0.024	1	0.540	0.540	0.540	1	26.8	26.8	26.8	1
	1994	1.04	1.04	1.04	1	0.021	0.021	0.021	1	0.110	0.110	0.110	1	0.320	0.320	0.320	1	21.0	21.0	21.0	1
	1995	1.30	1.30	1.30	1	0.021	0.021	0.021	1	0.043	0.043	0.043	1	0.470	0.470	0.470	1	22.9	22.9	22.9	1
	1996	0.77	0.94	0.63	4	0.027	0.031	0.023	4	0.073	0.282	0.002	4	0.090	0.220	0.020	4	23.2	26.7	20.6	4
	1997	0.89	0.89	0.89	1	0.017	0.017	0.017	1	0.174	0.174	0.174	1	0.280	0.280	0.280	1	16.9	16.9	16.9	1
	1998	0.59	0.85	0.40	4	0.020	0.035	0.007	4	0.008	0.022	0.002	4	0.064	0.210	0.007	6	16.3	22.8	12.6	8
	1999	0.75	0.85	0.65	3	0.022	0.029	0.015	3	0.030	0.147	0.002	6	0.085	0.320	0.005	12	16.4	20.4	14.0	12
	2000	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.235	0.250	0.220	2	15.1	15.6	14.5	2
M2	1976	0.90	1.66	0.35	6	0.032	0.070	0.002	6	0.012	0.030	0.005	6	0.127	0.410	0.020	6	20.5	29.0	7.0	4
	1977	1.21	1.60	0.68	12	0.042	0.090	0.017	12	0.045	0.310	0.003	12	0.190	0.570	0.005	12	22.6	34.0	8.0	12
	1978	1.24	1.95	0.66	23	0.026	0.054	0.009	22	0.023	0.147	0.002	20	0.129	0.580	0.001	21	26.8	53.0	6.0	20
	1979	1.30	3.00	0.28	10	0.055	0.190	0.023	10	0.062	0.200	0.002	10	0.188	0.540	0.018	10	20.3	25.5	15.5	10
	1980	1.01	1.80	0.62	11	0.033	0.083	0.015	11	0.007	0.019	0.002	11	0.143	0.600	0.010	11	19.1	27.0	9.5	11
	1981	1.04	1.28	0.80	7	0.035	0.053	0.020	10	0.019	0.057	0.002	10	0.183	0.490	0.023	10	20.6	24.0	17.0	7
	1998	0.63	0.88	0.42	4	0.022	0.035	0.011	4	0.010	0.048	0.002	8	0.067	0.290	0.004	10	16.4	23.5	12.8	10
	1999	0.74	0.95	0.58	4	0.022	0.035	0.009	4	0.017	0.074	0.002	5	0.123	0.380	0.007	11	17.0	21.5	14.2	11
	2000	0.89	1.21	0.61	3	0.042	0.065	0.028	3	0.003	0.006	0.002	3	0.129	0.460	0.010	9	23.8	34.6	15.2	10
	2001	1.16	1.16	1.16	1	0.045	0.045	0.045	1	0.015	0.015	0.015	1	0.515	0.520	0.510	2	18.0	19.2	16.8	2
M3	1976	0.59	0.88	0.30	2	0.045	0.050	0.040	2	0.008	0.010	0.005	2	0.080	0.130	0.030	2	12.0	12.0	12.0	1
	1980	0.94	1.15	0.80	6	0.040	0.065	0.025	6	0.020	0.083	0.002	6	0.047	0.087	0.017	6	20.3	25.0	14.0	6
	1981	1.10	1.50	0.52	7	0.076	0.138	0.033	9	0.018	0.043	0.002	9	0.266	0.800	0.017	9	22.9	31.3	16.5	7
	1998	0.75	0.90	0.58	6	0.032	0.039	0.020	6	0.017	0.051	0.002	6	0.117	0.510	0.008	8	18.8	25.4	14.3	10
	1999	0.93	1.36	0.68	4	0.039	0.049	0.035	4	0.007	0.016	0.002	5	0.219	0.680	0.008	11	19.0	24.0	16.0	11
	2000	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.615	0.670	0.560	2	16.7	17.5	15.9	2

Table 5.2 Yearly average, maximum, minimum and count of nutrient concentrations for the Muskeg River and tributaries

Site	Year	TKN				TP				NO2+NO3				NH4				DOC			
		Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count
M4	1996	0.69	0.85	0.54	3	0.029	0.036	0.017	3	0.014	0.022	0.003	3	0.032	0.060	0.005	3	22.6	24.7	19.8	3
	1997	1.47	1.47	1.47	1	0.065	0.065	0.065	1	0.012	0.012	0.012	1	0.750	0.750	0.750	1	15.1	15.1	15.1	1
	1998	0.82	0.93	0.64	4	0.041	0.051	0.032	4	0.038	0.083	0.017	4	0.288	0.670	0.039	6	18.1	21.1	14.3	8
	1999	0.95	1.46	0.62	4	0.038	0.045	0.033	4	0.028	0.099	0.002	5	0.387	1.000	0.014	11	17.5	22.4	14.3	11
	2000	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.860	0.900	0.820	2	15.7	15.7	15.6	2
M5	1998	1.08	1.08	1.08	1	0.055	0.055	0.055	1	0.011	0.011	0.011	1	0.470	0.470	0.470	1	17.7	17.7	17.7	1
	1999	nd	nd	nd	nd	nd	nd	nd	nd	0.002	0.002	0.002	1	0.695	1.060	0.330	2	17.4	19.5	15.3	2
M6	1976	1.90	5.50	0.50	4	0.063	0.080	0.040	4	0.013	0.020	0.005	4	0.148	0.260	0.050	4	25.0	27.0	23.0	2
	1977	1.32	2.40	0.83	11	0.083	0.250	0.020	11	0.031	0.140	0.005	11	0.264	1.060	0.020	11	21.8	28.0	9.5	11
	1978	1.31	1.57	0.95	3	0.073	0.096	0.030	3	0.018	0.023	0.015	3	0.265	0.750	0.005	3	29.3	44.0	16.0	3
	1980	1.26	1.26	1.26	1	0.025	0.025	0.025	1	0.002	0.002	0.002	1	3.900	3.900	3.900	1	24.5	24.5	24.5	1
	1981	1.09	1.31	0.81	7	0.073	0.120	0.024	7	0.027	0.055	0.002	7	0.304	0.810	0.020	7	20.6	26.0	15.5	7
M7	1976	1.42	2.45	0.39	2	0.180	0.320	0.040	2	0.005	0.005	0.005	2	0.180	0.290	0.070	2	17.0	17.0	17.0	1
	1977	2.37	4.90	0.84	4	0.098	0.160	0.031	4	0.006	0.010	0.002	4	0.450	1.690	0.010	4	21.6	28.5	12.0	4
T1	1998	0.43	0.43	0.43	1	0.015	0.015	0.015	1	0.008	0.008	0.008	1	0.020	0.020	0.020	1	12.3	12.3	12.3	1
	1999	nd	nd	nd	nd	nd	nd	nd	nd	0.002	0.002	0.002	1	0.081	0.139	0.022	2	12.7	13.4	11.9	2
T2	1980	1.77	2.20	1.08	7	0.041	0.080	0.023	7	0.038	0.098	0.003	7	0.570	1.000	0.048	7	19.9	22.0	17.0	7
	1981	1.75	3.80	0.92	4	0.023	0.044	0.009	6	0.039	0.110	0.010	6	0.431	1.700	0.065	6	19.9	21.0	17.9	4
	1998	0.38	0.53	0.29	4	0.011	0.021	0.006	4	0.005	0.010	0.002	4	0.080	0.280	0.004	6	10.0	11.5	8.8	8
	1999	0.56	0.75	0.44	4	0.010	0.015	0.006	4	0.015	0.052	0.002	5	0.115	0.430	0.008	11	10.9	16.0	7.4	11
	2000	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.135	0.156	0.114	2	8.2	9.0	7.4	2
T3.1	1976	0.96	1.59	0.35	5	0.050	0.110	0.002	5	0.016	0.050	0.005	5	0.122	0.290	0.030	5	28.0	34.0	23.0	3
	1977	1.08	2.25	0.60	12	0.059	0.330	0.006	12	0.018	0.070	0.003	12	0.078	0.250	0.010	12	22.2	29.0	8.0	12
	1978	1.47	4.05	0.60	14	0.037	0.170	0.010	14	0.036	0.200	0.002	14	0.102	0.270	0.020	12	31.6	89.0	11.5	14
	1979	1.20	2.16	0.50	4	0.052	0.087	0.035	4	0.240	0.406	0.044	4	0.074	0.120	0.020	4	18.9	23.5	13.5	4
	1980	0.98	2.42	0.54	8	0.035	0.073	0.020	8	0.007	0.022	0.002	8	0.024	0.050	0.011	8	21.0	27.5	13.0	8
	1981	0.91	1.26	0.66	7	0.048	0.088	0.022	10	0.032	0.146	0.002	10	0.086	0.220	0.020	10	20.5	26.9	16.5	7
	1998	0.74	0.88	0.61	3	0.034	0.037	0.027	3	0.009	0.023	0.002	3	0.014	0.019	0.009	5	22.0	28.3	16.7	7
	1999	0.82	0.91	0.73	4	0.039	0.052	0.029	4	0.006	0.020	0.002	5	0.060	0.210	0.008	12	18.7	26.4	13.9	12
	2000	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.097	0.135	0.058	2	19.0	19.1	18.9	2
T3.2	1976	0.80	1.50	0.30	6	0.044	0.080	0.002	6	0.018	0.060	0.005	6	0.138	0.420	0.050	6	21.6	34.0	12.5	4
	1977	0.93	1.02	0.84	4	0.035	0.060	0.023	4	0.113	0.240	0.005	4	0.036	0.090	0.005	4	19.6	28.0	11.5	4
T3.3	1976	0.81	1.29	0.45	4	0.019	0.050	0.002	4	0.009	0.020	0.005	4	0.115	0.170	0.050	4	22.0	22.0	22.0	2
	1977	1.98	3.74	0.83	5	0.049	0.150	0.010	5	0.009	0.024	0.002	5	0.162	0.340	0.030	5	21.3	28.0	10.0	5
T3.3b	1976	0.64	1.29	0.30	4	0.047	0.140	0.010	4	0.011	0.020	0.005	4	0.063	0.090	0.040	4	18.0	31.0	5.0	2
	1977	1.43	2.28	0.81	5	0.029	0.060	0.014	5	0.004	0.006	0.002	5	0.044	0.080	0.010	5	22.6	30.0	8.0	5

Table 5.2 Yearly average, maximum, minimum and count of nutrient concentrations for the Muskeg River and tributaries

Site	Year	TKN				TP				NO2+NO3				NH4				DOC			
		Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count	Avg	Max	Min	Count
T3.4	1976	0.88	1.40	0.05	3	0.043	0.050	0.040	3	0.010	0.020	0.005	3	0.077	0.120	0.050	3	16.0	16.0	16.0	1
	1977	1.42	3.01	0.76	5	0.113	0.290	0.014	5	0.033	0.120	0.003	5	0.374	1.270	0.040	5	19.9	30.0	9.0	5
T3.4b	1976	0.92	2.10	0.10	5	0.050	0.080	0.030	5	0.006	0.010	0.005	5	0.138	0.450	0.030	5	19.0	24.0	14.0	2
	1977	1.93	4.17	0.93	5	0.172	0.500	0.014	5	0.007	0.010	0.005	5	0.532	1.240	0.050	5	23.3	36.5	7.0	5
T4	1976	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	1977	1.77	2.84	0.92	7	0.152	0.560	0.020	7	0.008	0.020	0.002	7	0.324	0.890	0.010	7	29.2	40.0	10.0	7
	1998	1.26	1.26	1.26	1	0.048	0.048	0.048	1	0.002	0.002	0.002	1	0.390	0.390	0.390	1	27.7	27.7	27.7	1
	1999	nd	nd	nd	nd	nd	nd	nd	nd	0.008	0.008	0.008	1	0.630	0.630	0.630	1	28.6	28.6	28.6	1
T5	1976	1.04	1.71	0.50	4	0.075	0.200	0.010	4	0.025	0.070	0.005	4	0.103	0.260	0.030	4	35.0	41.0	28.0	3
	1977	1.74	2.57	1.13	9	0.057	0.100	0.030	9	0.050	0.150	0.005	9	0.218	0.500	0.030	9	29.6	39.0	12.0	9
	1978	1.93	2.43	1.60	3	0.047	0.052	0.039	3	0.193	0.270	0.120	3	0.125	0.210	0.005	3	36.5	40.0	32.0	3
	1998	1.01	1.01	1.01	1	0.060	0.060	0.060	1	0.008	0.008	0.008	1	0.160	0.160	0.160	1	22.7	22.7	22.7	1
	1999	nd	nd	nd	nd	nd	nd	nd	nd	0.002	0.002	0.002	1	0.094	0.102	0.085	2	25.7	30.8	20.6	2
T5.1	1976	1.54	3.50	0.42	4	0.090	0.190	0.040	4	0.014	0.030	0.005	4	0.143	0.250	0.050	4	28.3	36.0	23.0	3
	1977	1.77	2.41	1.44	5	0.076	0.130	0.038	5	0.008	0.020	0.002	5	0.252	0.590	0.060	5	24.0	35.0	13.0	5
	1978	2.22	2.22	2.22	1	0.016	0.016	0.016	1	0.036	0.036	0.036	1	0.300	0.300	0.300	1	34.0	34.0	34.0	1
T5.2	1976	0.34	0.35	0.32	2	0.057	0.090	0.030	3	0.005	0.005	0.005	2	0.107	0.150	0.060	3	18.3	28.0	8.5	2
	1977	2.55	3.94	1.12	4	0.117	0.310	0.033	4	0.007	0.020	0.002	4	0.430	1.280	0.040	4	23.1	31.0	13.0	4
T5.3	1976	1.27	3.20	0.45	6	0.198	0.470	0.020	6	0.007	0.010	0.005	6	0.080	0.140	0.050	6	25.3	32.0	6.0	4
	1977	1.48	2.40	1.12	4	0.129	0.400	0.026	4	0.007	0.020	0.002	4	0.185	0.560	0.020	4	24.8	32.5	13.0	4
T6	1976	0.84	2.45	0.05	4	0.175	0.320	0.050	4	0.011	0.030	0.005	4	0.130	0.290	0.010	4	5.0	8.0	2.0	2
	1977	0.85	1.20	0.42	7	0.110	0.240	0.023	7	0.020	0.100	0.003	7	0.080	0.190	0.020	7	7.6	16.0	1.0	7
	1998	0.96	0.96	0.96	1	0.079	0.079	0.079	1	0.014	0.014	0.014	1	0.016	0.016	0.016	1	13.9	13.9	13.9	1
T7	1976	0.90	1.85	0.35	3	0.123	0.180	0.030	3	0.027	0.040	0.010	3	0.173	0.270	0.120	3	24.3	36.0	12.5	2
	1977	1.79	2.62	0.92	7	0.159	0.340	0.020	7	0.015	0.048	0.004	7	0.581	1.580	0.020	7	26.2	37.0	9.0	7
	1998	1.84	1.84	1.84	1	0.116	0.116	0.116	1	0.006	0.006	0.006	1	0.910	0.910	0.910	1	26.6	26.6	26.6	1
	1999	nd	nd	nd	nd	nd	nd	nd	nd	0.043	0.043	0.043	1	0.966	1.830	0.101	2	25.8	32.5	19.1	2

All station numbers refer to map reference (Figure 3.1) and are ordered from mouth to headwaters.
All data were averaged within years, irrespective of date. nd = no data
Units are mg/L

Nitrogen concentrations are reported as mg•L^{-1} [N]

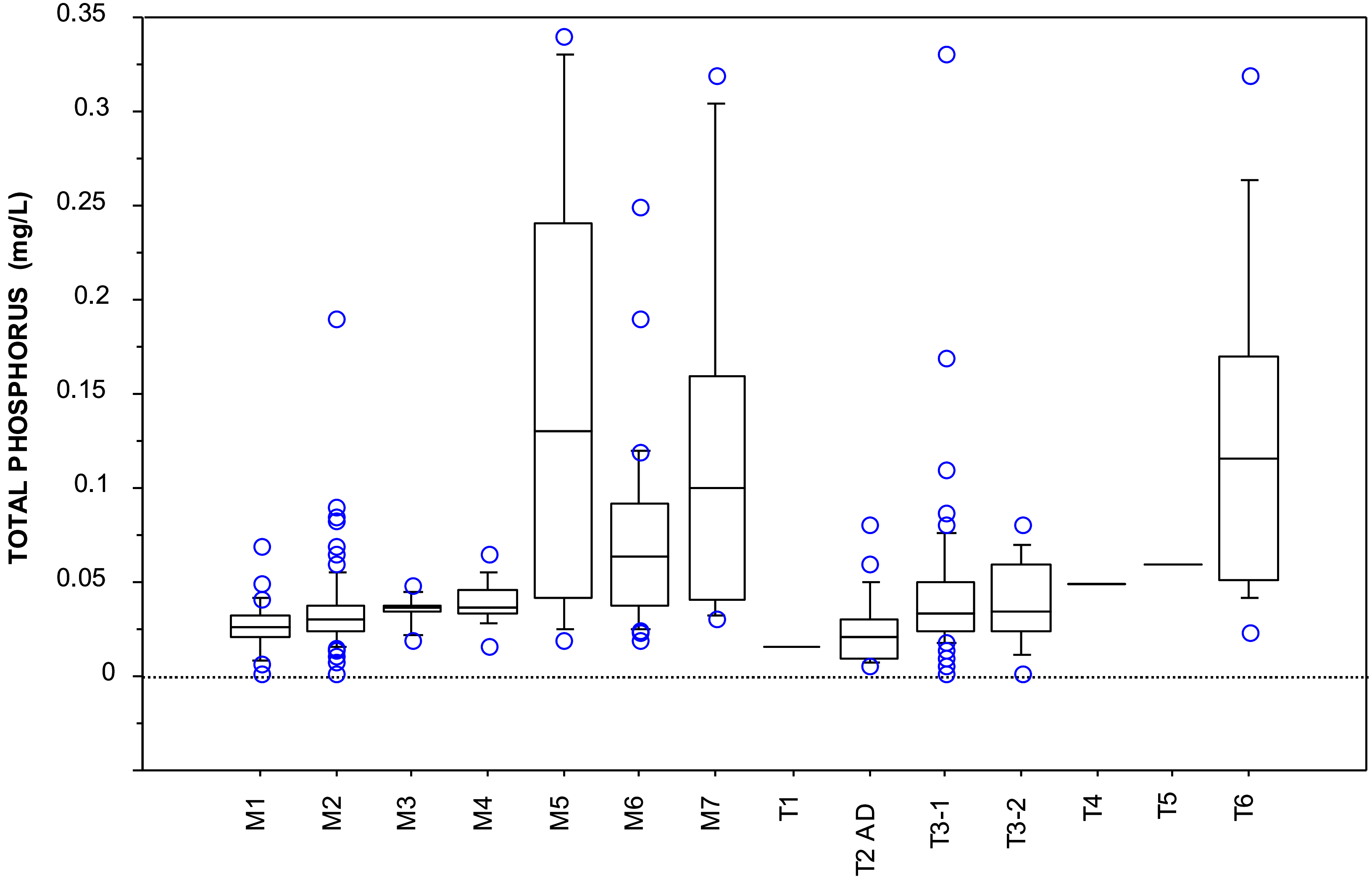


Figure 5.3 Total phosphorus (TP) concentrations at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

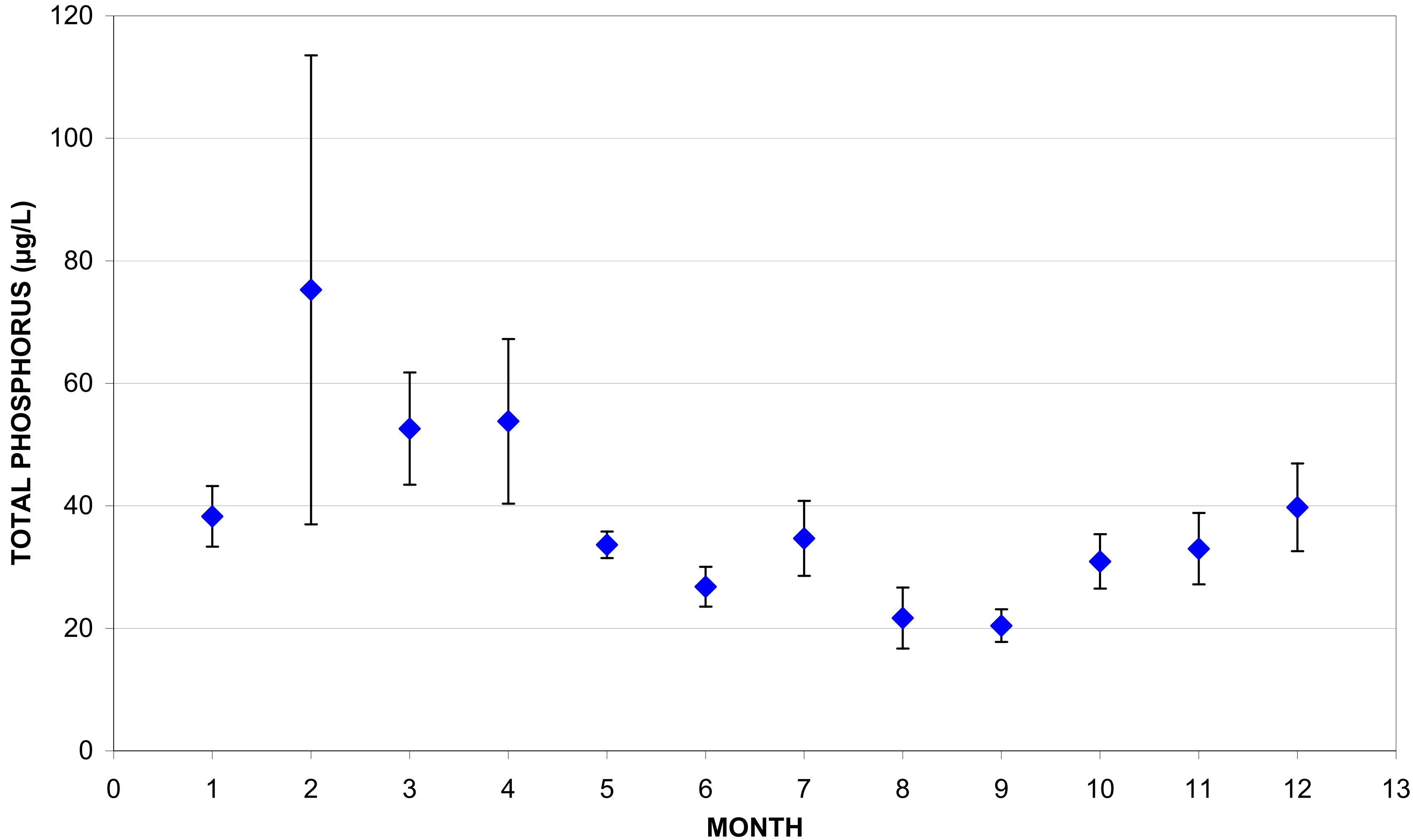


Figure 5.4 Monthly mean and standard error of total phosphorus concentrations at the Muskeg River WSC site, 1976 to 2001

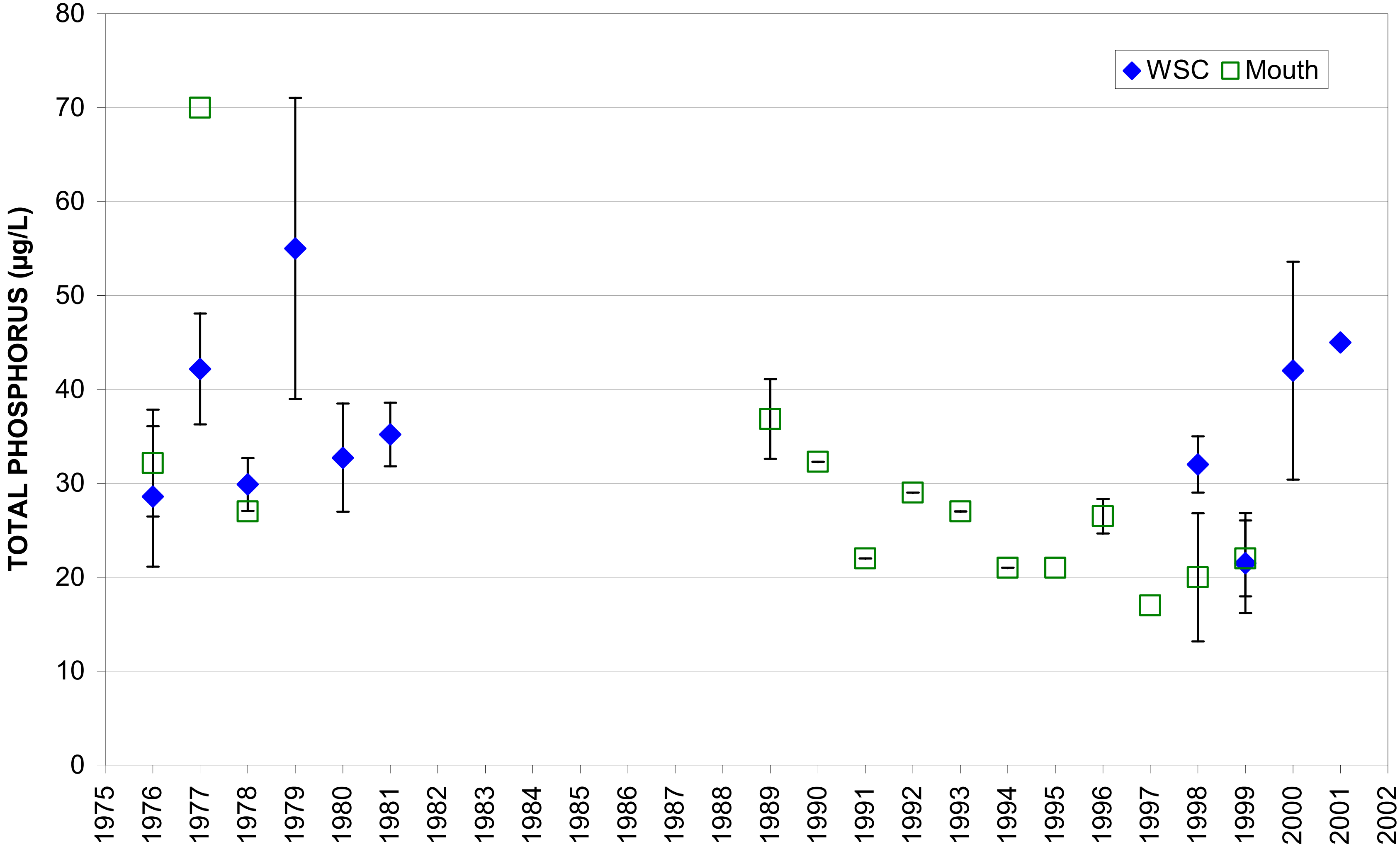


Figure 5.5 Annual mean and standard error of total phosphorus concentrations at the Muskeg River WSC and mouth sites, 1976 to 2001

Total dissolved phosphorus (TDP) was not routinely analyzed. Concentrations ranged from 1 to 47 $\mu g \bullet L^{-1}$ with the high observed at the WSC site. At all sites, annual mean TDP was a consistent proportion of the sites mean total phosphorus pool, averaging 40% of TP, except in Jackpine Creek where it averaged 30% (Appendix 3). Seasonal fluctuations in the proportion of TDP ranged over 2-fold with TDP comprising more of the TP pool during summer. Contrary to the pattern in TP, concentrations of TDP peaked between May and July (11 to 21 $\mu g \bullet L^{-1}$) and remained low (< 10 $\mu g \bullet L^{-1}$) throughout fall and winter months. Total dissolved phosphorus concentration was related to discharge at the WSC site. The nature of the relationship cannot be specified as both linear and exponential relationships fit the limited data ($r^2 = 0.86$ and 0.82, respectively, $n = 11$). In most upland dominated systems, TP is more closely related to discharge than is TDP, however, this was not the case in the Muskeg basin because peatlands likely control the export of phosphorus in particulate and dissolved forms. Wetlands, including peatlands, typically retain particulate material and export dissolved nutrients under elevated flow conditions. Soil water in bogs often contain 10 to 100-fold higher concentrations of TDP than streams in northern Alberta (McEachern unpubl data.). The pattern in TDP can be explained if peatlands contribute water high in TDP during summer months and contribute very little water once frozen.

5.2.2 Nitrogen

Total nitrogen concentrations were assessed as Kjeldahl (organic plus ammonia) nitrogen (TKN) and total nitrogen (TN). Most samples were analyzed as TKN, which requires the addition of nitrate and nitrite concentrations to get a rough equivalent of TN. Concentrations of TKN ranged from 50 $\mu g \bullet L^{-1}$ to 4.0 $mg \bullet L^{-1}$ at the WSC and mouth sites (Figure 5.6). Like TP, concentrations of TKN were elevated in headwaters (Figure 5.6). Unlike TP, concentrations of TKN were also elevated in tributaries where cation data suggested elevated groundwater sources (e.g., Alsands Ditch, Shelley Creek). Despite sources for TKN that differed from TP, reduced TKN concentration in water below Wapasu Creek were likely due to beaver ponds where denitrification could occur. Sporadic values > 2.5 $mg \bullet L^{-1}$ reported between 1976-1980 seem inconsistent with other TKN data collected during the same period and maximum values after 1980. Experience at AENV indicates that TKN is subject to periodic high values, probably resulting from the occurrence of organic debris in the water sample. At the WSC site there was only one occurrence where TKN was > 2.5 $mg \bullet L^{-1}$ (Feb. 1979). At that site, mean annual TKN concentrations were at or above the ASWQG of 1 $mg \bullet L^{-1}$ between 1976-1981. For the period 1998-2000, mean annual TKN was less than 900 $\mu g \bullet L^{-1}$. Data from 2001 contained only winter values and though above 1 $mg \bullet L^{-1}$, the annual mean may decline once summer values are available. Like TP, concentrations of TKN peaked in February and March. Unlike TP, TKN seemed to be at a minimum during spring and increased slightly during the summer (Figure 5.7). TKN was not related to stream discharge ($r^2 = 0.1$, n = 81). TKN was not correlated with TSS at the WSC site ($r^2 = 0.03$, P = 0.3, n = 75). There is no indication that TKN has increased at the WSC or mouth sites since 1976 (Figure 5.8).

5.2.3 Total Ammonia

Unionized ammonia (NH_3) exists in equilibrium with ionized ammonium (NH_4^+), and although this complex is often simply referred to as ammonia, the ammonium ion usually predominates in

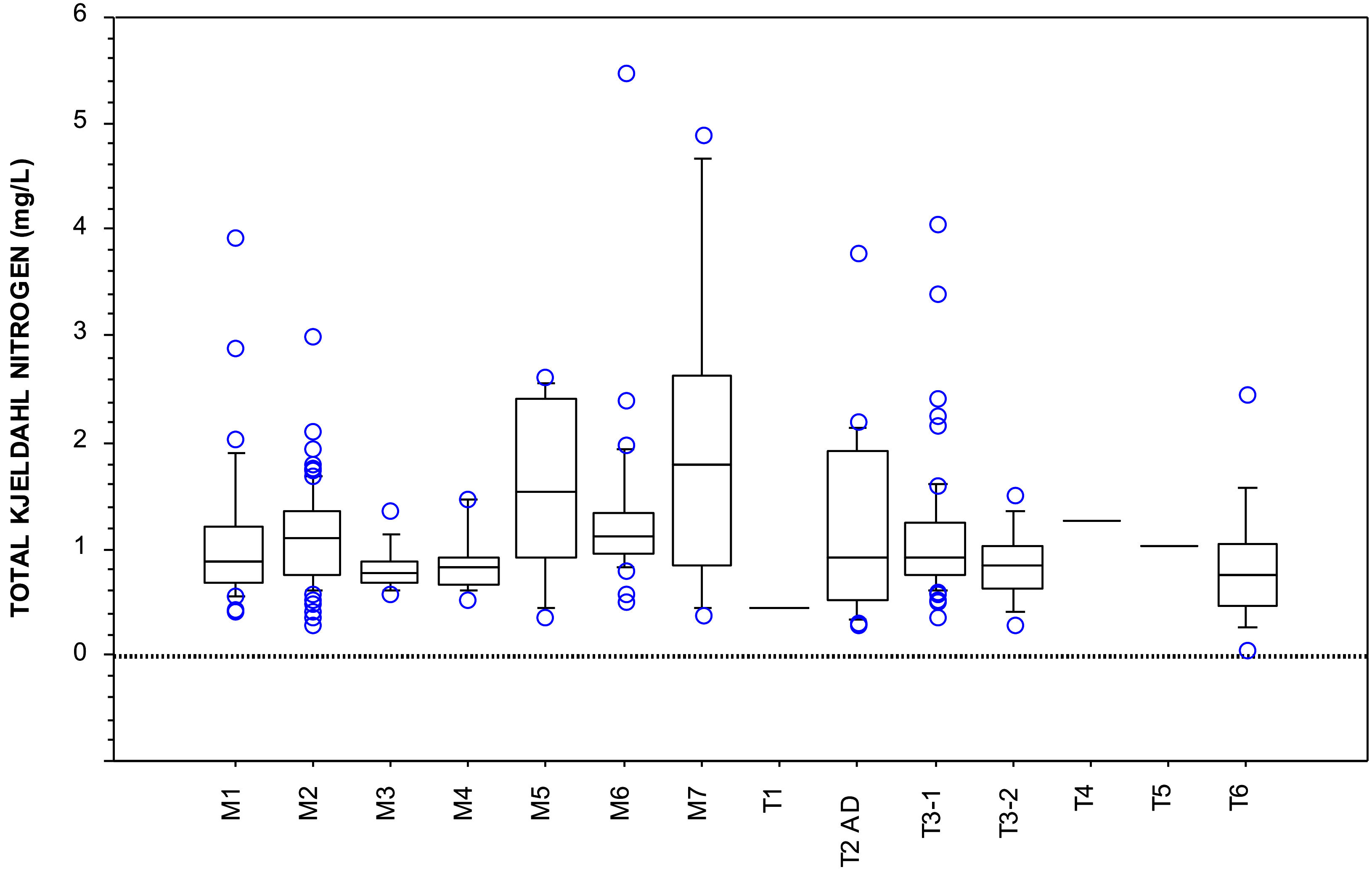


Figure 5.6 Total Kjeldahl nitrogen (TKN) concentrations at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots..

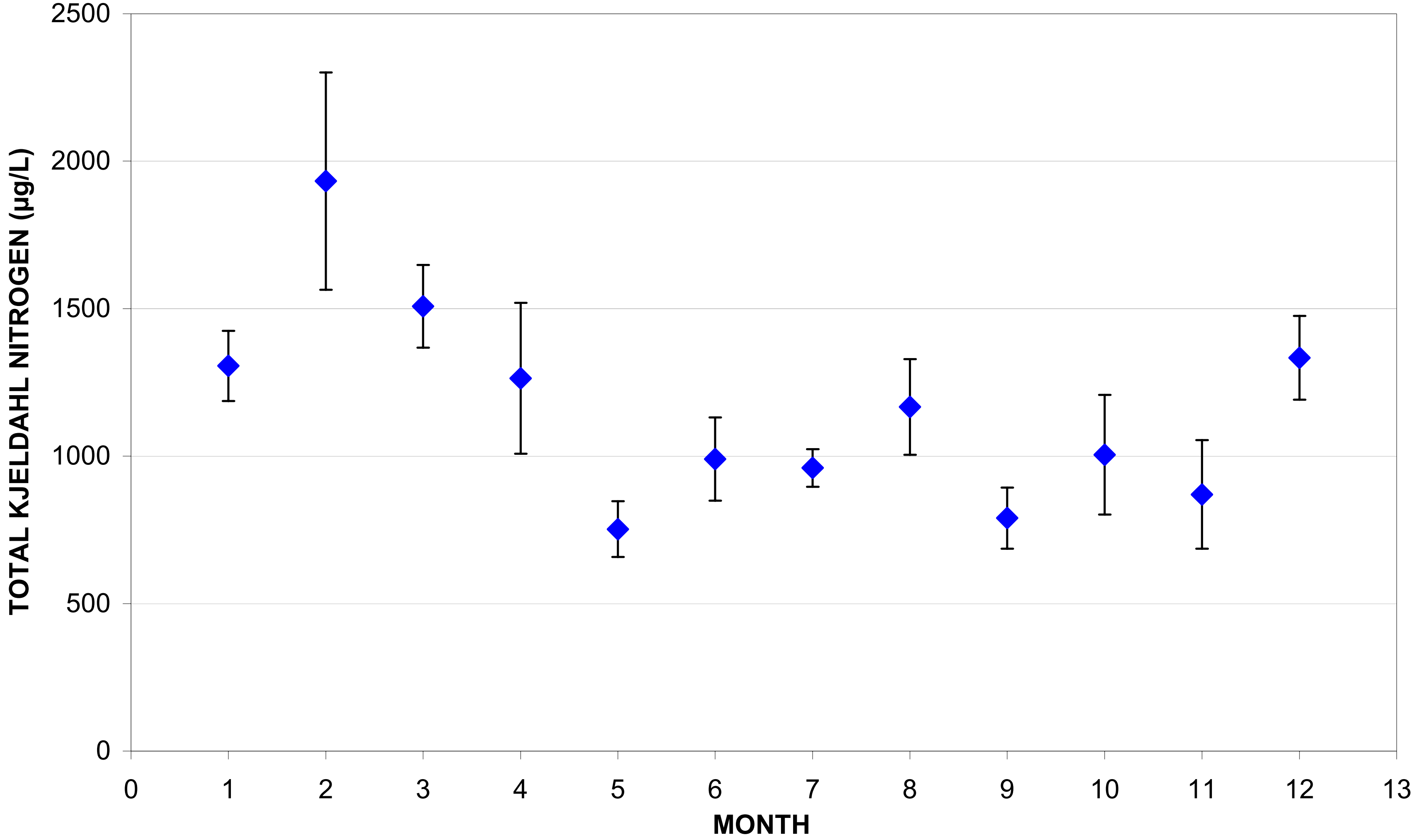


Figure 5.7 Monthly mean and standard error of total Kjeldahl nitrogen concentrations at the Muskeg River WSC site, 1976 to 2001

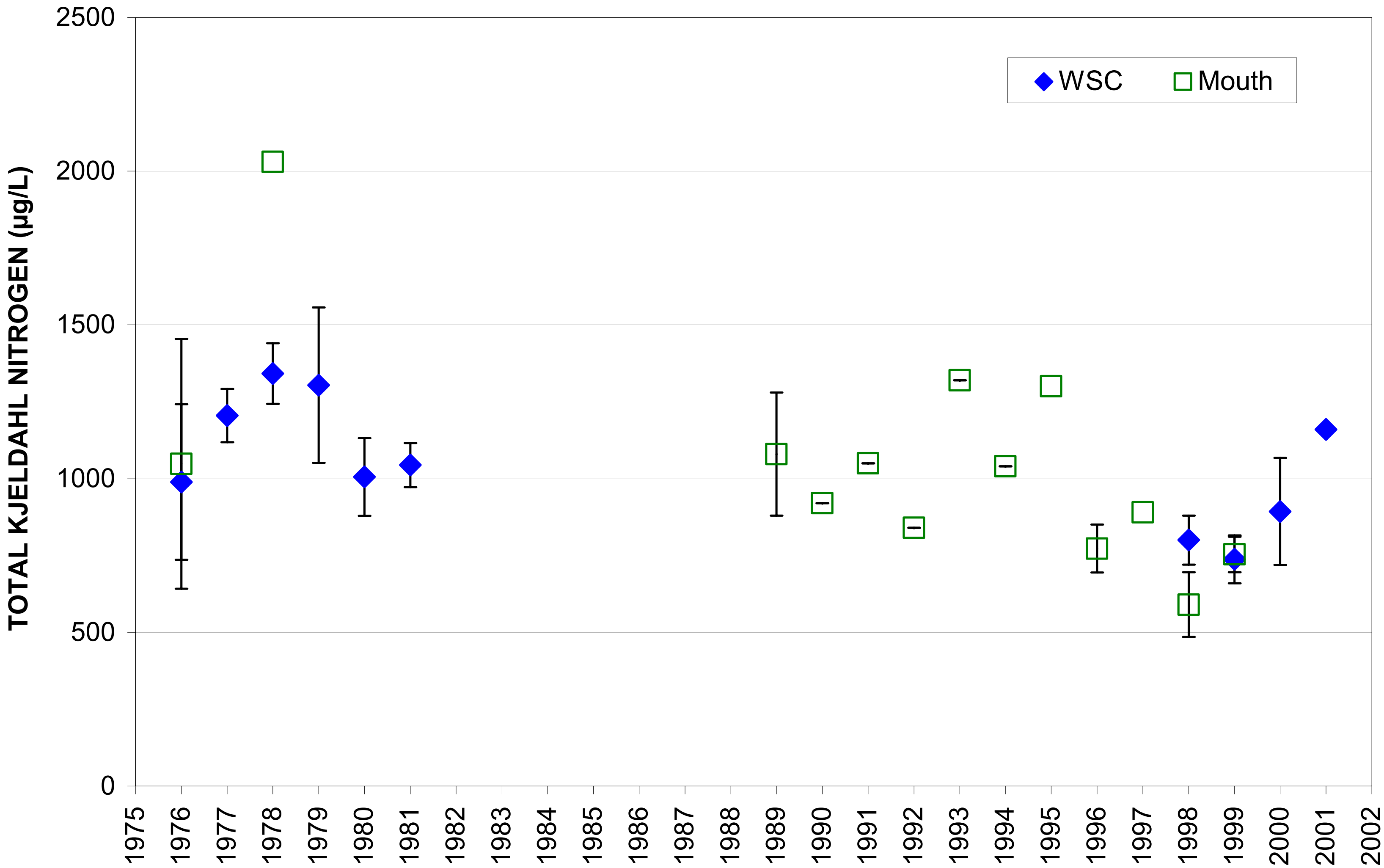


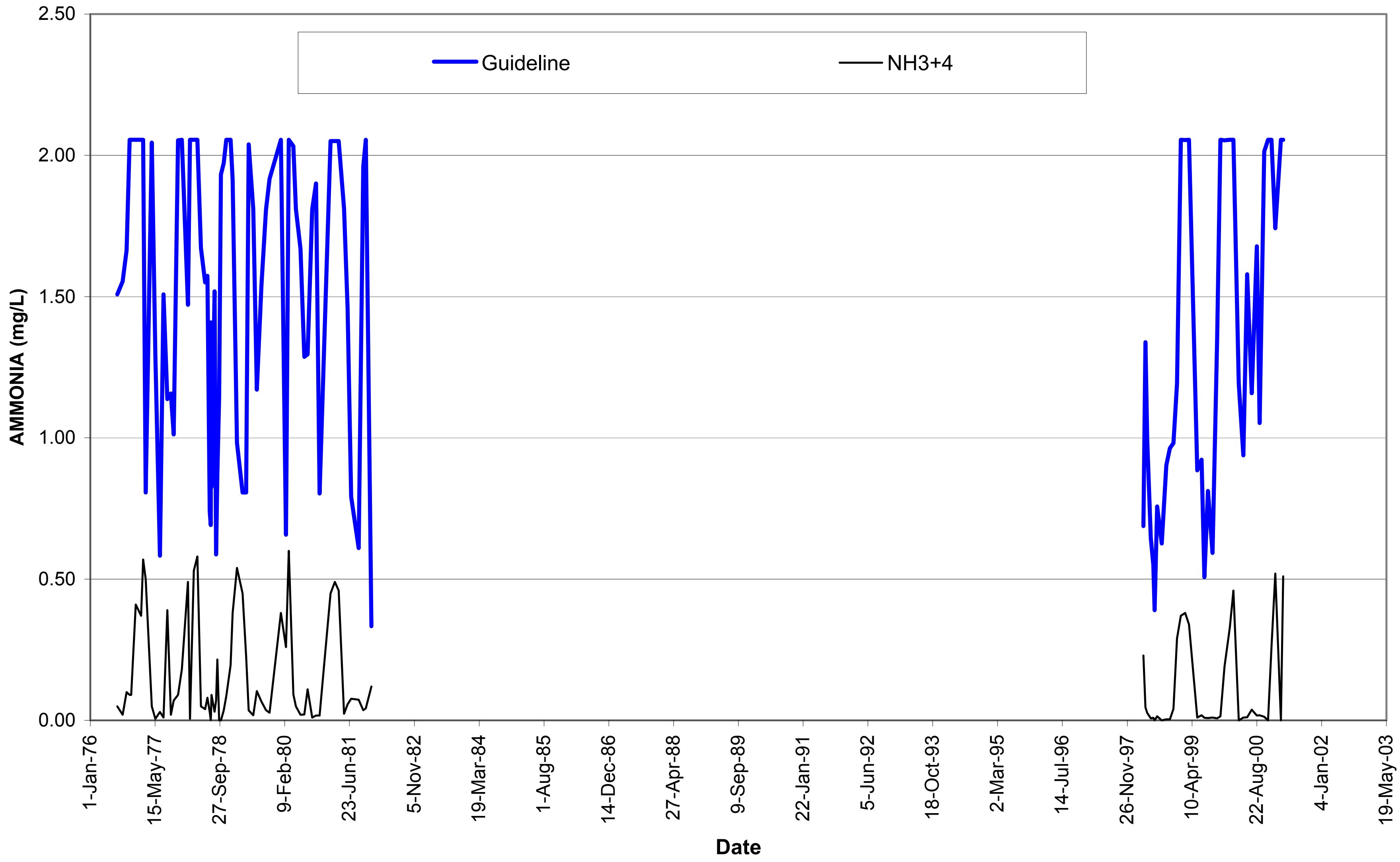
Figure 5.8 **Annual mean and standard error of total Kjeldahl nitrogen concentrations at the Muskeg River WSC and mouth sites, 1976 to 2001**

surface waters. Total ammonia (NH_{3+4}) concentrations (as N) ranged from 1 to 2400 $\mu g \bullet L^{-1}$ with one outlier of 3900 $\mu g \bullet L^{-1}$ recorded in the Muskeg River (1980). Annual mean concentrations of total ammonia at the WSC site ranged from 11 to 198 $\mu g \bullet L^{-1}$ (Table 5.2). Total ammonia concentrations were above 200 $\mu g \bullet L^{-1}$ during the low oxygen conditions from December to April, and were generally below 100 $\mu g \bullet L^{-1}$ through summer months at the WSC site. The higher concentrations in winter may reflect the dominance of decomposition and respiration, versus photosynthesis, during that season. Two summer spikes in ammonia concentration (200 and 400 $\mu g \bullet L^{-1}$) occurred in 1977 and 1978 over the entire period of record. Patterns were similar at the mouth site. Ammonia concentrations have not increased at either the WSC or mouth sites since 1976 (Figure 5.9). However, NH_{3+4}^{+} concentrations increase from the WSC site to headwater sites particularly in the M4 reach from the Muskeg Creek to Wapasu Creek confluences (Figure 5.10). Nitrogen exported from peatlands above the Wapasu confluence was likely converted to ammonia through denitrification in the slow moving waters and beaver ponds of reach M4. Beaver ponds have been shown to be regions of denitrification along streams resulting in significant conversion of influent nitrate to ammonia (Margolis et al. 2001).

The ASWQG for ammonia declines as pH and temperature increase. The maximum pH recorded was during winter (February, Jackpine Creek, 8.65), for which ammonia concentrations should not exceed 400 $\mu g \bullet L^{-1}$ for a water temperature ≤ 5º C. During summer when pH and temperature peak (ca. 8.5, 25ºC), ammonium should not exceed 125 $\mu g \bullet L^{-1}$. Including the two summer spikes, ammonia concentrations at the WSC site were below the ASWQG because of low pH and/or temperature (Figure 5.9). Other sites where high ammonia concentrations were found similarly had low pH or temperature and did not exceed ASWQG. An evaluation of muskeg drainage water data being collected by industry in the area, would help to determine if peat drainage will result in elevated ammonium release, what factors control its concentration, and the potential for elevated concentration under low flow or enhanced microbial activity following peat drainage.

5.2.4 Nitrate

Nitrite and nitrate nitrogen are analyzed and reported together, although the nitrate form (NO_3^-) usually dominates in surface waters. The term nitrate is used in the text here to mean NO_2+NO_3-N. Nitrate concentrations ranged from below detection (~ 1 µg/L) to 310 $\mu g \bullet L^{-1}$ at the WSC site but more commonly were below 150 $\mu g \bullet L^{-1}$ (Table 5.2). The highest nitrate concentration was recorded at the mouth site (600 $\mu g \bullet L^{-1}$ in 1976). Concentrations were slightly higher at the mouth site overall (Figure 5.11). High concentrations at the mouth site may result from a majority of its samples having been collected in mid-March when groundwater contributions would provide elevated nitrate. On a seasonal basis, nitrate concentrations were typically below 50 $\mu g \bullet L^{-1}$ at the WSC site for most of the year. Median nitrate concentrations were elevated in November through December and March through April. The seasonal pattern seems repeated at the mouth site and likely other sites in the Muskeg basin likely reflecting the dominance of groundwater during winter months. Relatively low median nitrate concentrations in January and February likely resulted from reduction in the low oxygen concentrations that were recorded during these months. Twenty-nine of 32 samples below the limit of detection were from summer months, perhaps reflecting uptake by plants during the growing season.



Guideline
NH3+4
AMMONIA (mg/L)
2.50
2.00
1.50
1.00
0.50
0.00
1-Jan-76
15-May-77
27-Sep-78
9-Feb-80
23-Jun-81
5-Nov-82
19-Mar-84
1-Aug-85
14-Dec-86
27-Apr-88
9-Sep-89
22-Jan-91
5-Jun-92
18-Oct-93
2-Mar-95
14-Jul-96
26-Nov-97
10-Apr-99
22-Aug-00
4-Jan-02
19-May-03
Date

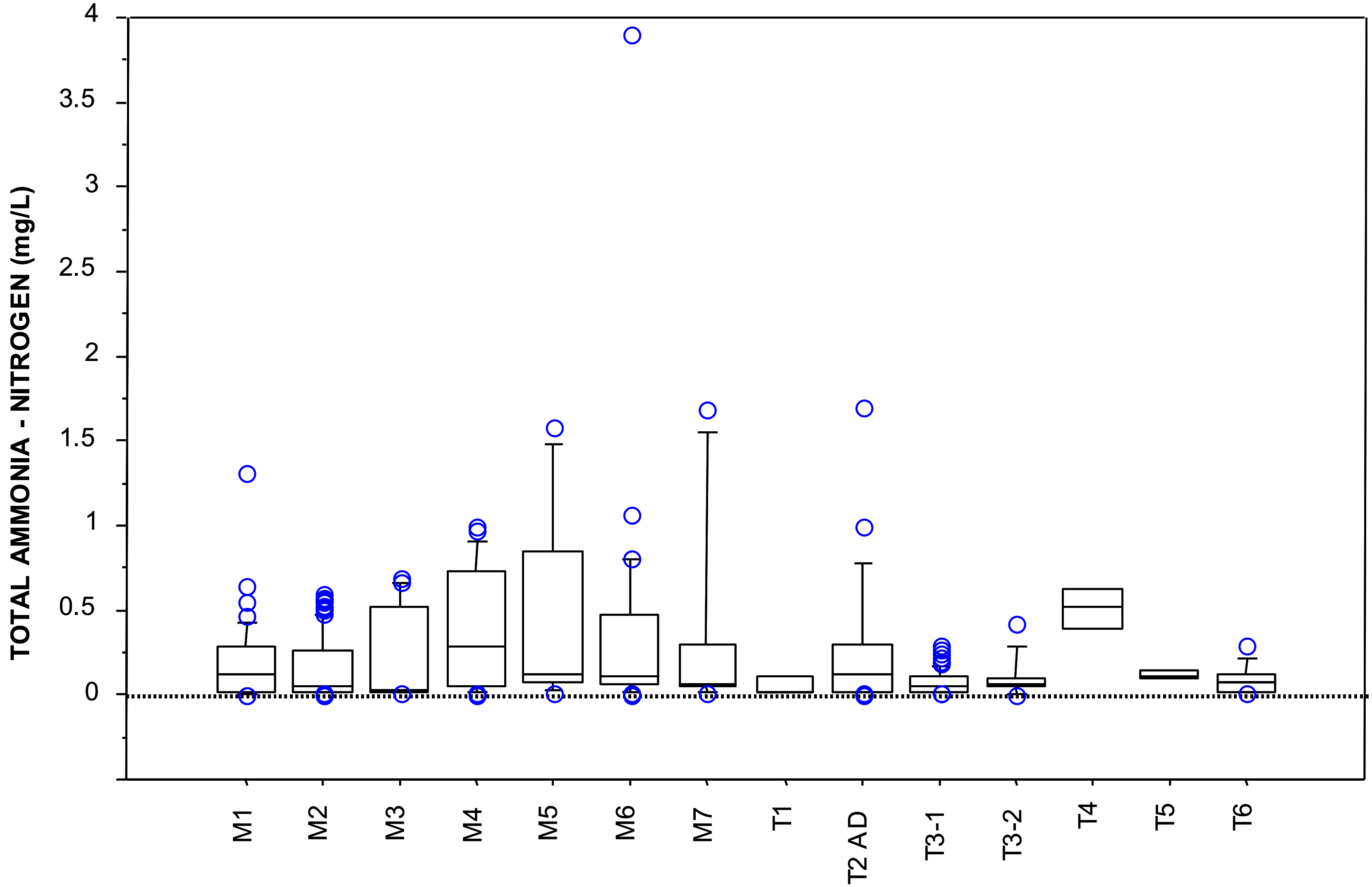


Figure 5.10 Ammonium ($NH4^+$) concentrations at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

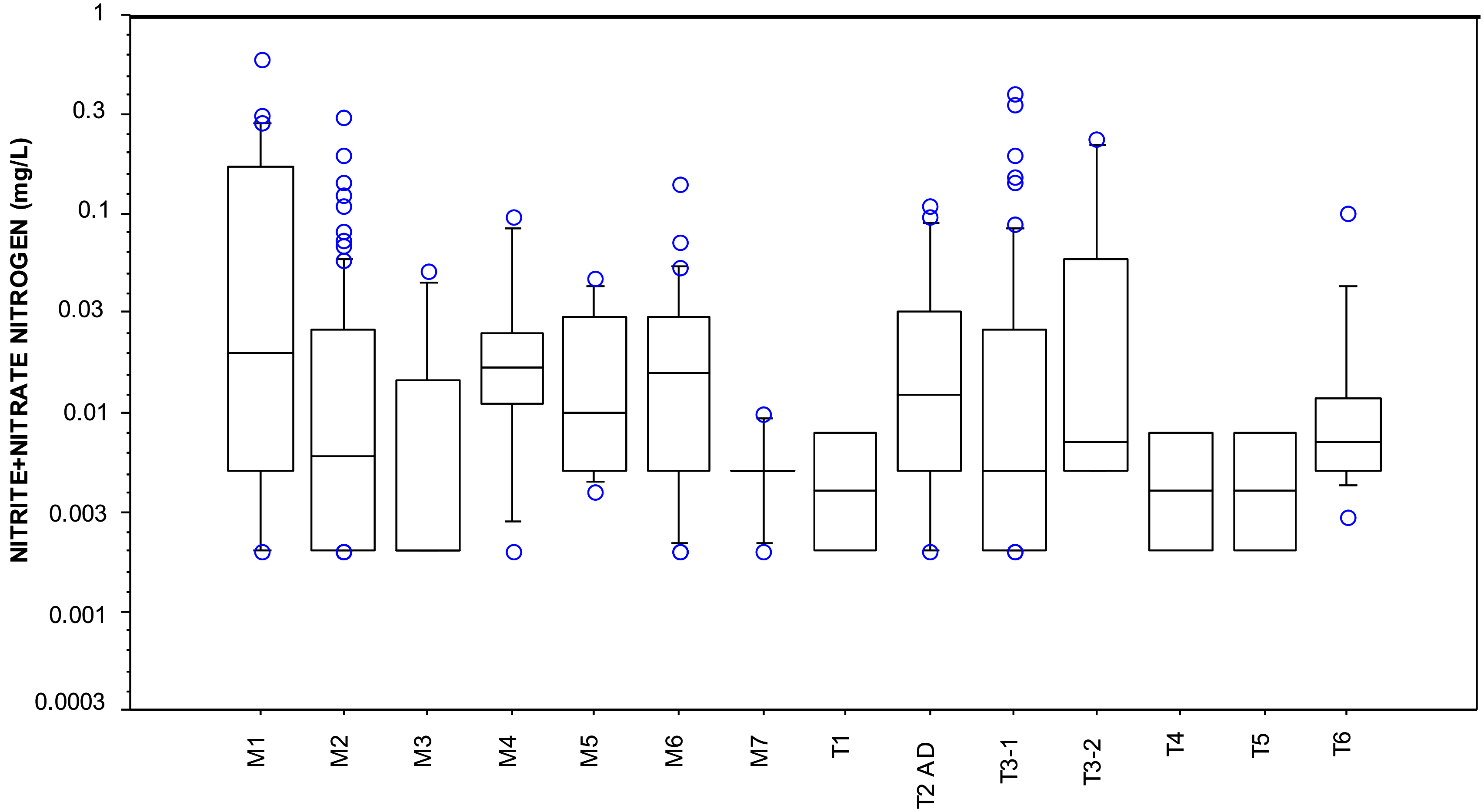


Figure 5.11 Nitrate-nitrite (NO2+3-) concentrations (Log10 scale) at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

Nitrite concentrations are typically low in surface waters because chemical equilibrium favors nitrate under oxidizing conditions and ammonia under reducing conditions. Thus the contrasting seasonal patterns in ammonium and nitrate where the former was highest under winter ice during periods of low DO and the latter highest during periods when both loading from groundwater and instream DO were relatively high, were consistent with their equilibrium characteristics.

Nitrite concentrations may have been an important component of the combined nitrate + nitrite measurement in late December through February months. Nitrite can accumulate because the bacteria that mediate nitrification of ammonia to nitrite (*Nitrosomonas*) are more tolerant of low temperature and pH than are the bacteria (*Nitrobacter*) responsible for the subsequent step of oxidizing nitrite to nitrate. Despite the requirement for oxygen, the nitrification of NH_4^+ to nitrite proceeds under dissolved oxygen concentrations as low as 0.3 mg•L^{-1} (Wetzel 1983). However, nitrification is likely inhibited by high concentrations of dissolved organic compounds such as tannins (Wetzel 1983) and may be another mechanism under which ammonium can predominate over nitrate in brown water systems.

5.3 Carbon

Dissolved organic carbon (DOC) is often high in boreal waters, reflecting the input of organic material from peatlands and coniferous forest soils. Organic carbon is present in water as dissolved molecules, as colloidal suspensions and as particulate matter – both living and dead. The dissolved fraction, or DOC, has the greatest impact on the chemical properties of water and is of greatest interest. DOC contains humic substances, hydrophilic low molecular weight acids, carbohydrates, fatty acids and hydrocarbons. The structure of DOC compounds can be simple or exceedingly complex, containing one to many functional groups capable of covalent, hydrogen and ionic bonding. Thus DOC can reduce the availability of nutrients and contaminants in stream water by binding with other compounds and ions including nutrients and metals. However, DOC can also increase the exposure of biota to elements such as mercury that are largely insoluble except when bound to a DOC molecule (Schnoor 1996). The more labile forms of DOC are metabolized by bacteria in surface waters, sediments and in the guts of aquatic organisms. Respiration using DOC as a carbon source can cause increased oxygen demand and result in exposure of organisms to contaminants bound to DOC (Kukkonen 1999). Water colour is associated with DOC derived from watershed sources, such as organic soils, whereas DOC generated within aquatic systems such as from lake sediments may be less coloured. Colour can negatively influence the light regime and hence primary production in surface waters and can impact feeding efficiencies for visual predators.

In the Muskeg River system, DOC ranged from 1 mg•L^{-1} in Stanley Creek to 89 mg•L^{-1} in Jackpine Creek, but most data have been in the 15 –30 mg/L range (Table 5.2). At the WSC and mouth sites, DOC was consistent among years with annual means ranging from 15 to 27 mg•L^{-1} (Figure 5.12). Through most of the year, DOC concentrations did not show a seasonal pattern and varied over a wide range of almost 50 mg•L^{-1}. However, DOC concentrations consistently declined during snowmelt. DOC was not related to stream discharge at the WSC site (r^2 = 0.02, n = 98). This was because snowmelt discharge contained lower concentrations of DOC (< 18 mg•L^{-1}) than summer storms of similar flow rates (>20 mg•L^{-1}). As a result, DOC flux during winter was three-fold lower (3.3 kg/d) when compared to flux rates during summer and

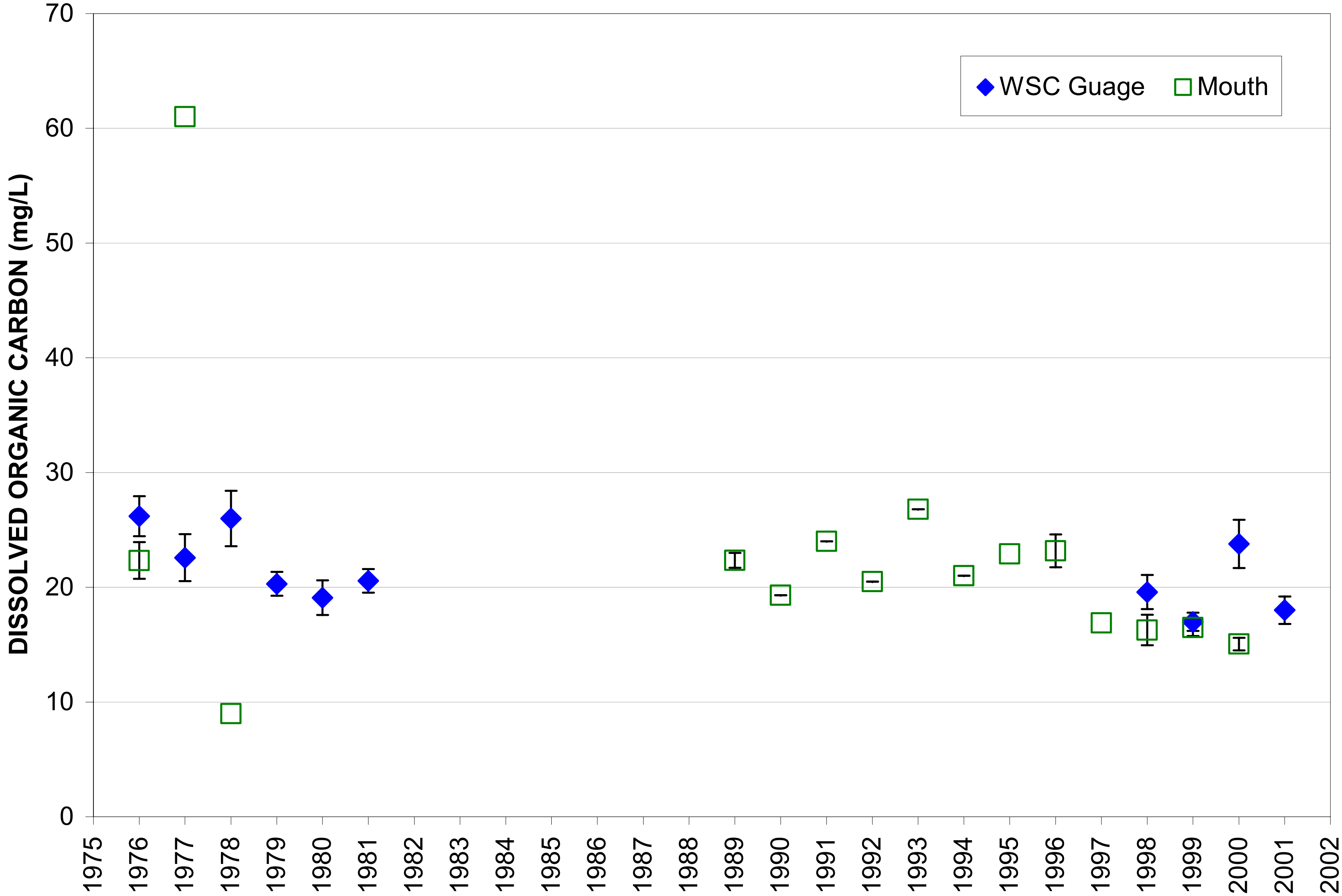


Figure 5.12 Annual mean and standard error of dissolved organic carbon concentrations at the Muskeg River WSC and mouth sites, 1976 to 2001

fall months. Summer and fall DOC concentrations were marginally related to discharge ($r^2 = 0.33$, n = 98).

The DOC flux rate from the Muskeg basin was calculated for the WSC site at 29 kg/ha/yr for the 2000 hydrologic year (Nov-Oct). However, as DOC concentration was related to discharge, so to was DOC flux which was as low as 3 kg/ha/yr during the low flow year of 1999. The 2000 hydrologic year was close to the long-term annual average for water yield and may therefore approximate annual mean DOC flux rates. A DOC flux rate of 29 kg/ha/yr is within a range reported for other Canadian Boreal forest basins (6 to 483 kg/ha/yr; Hudon et al. 1996, Hope et al. 1994). The reported mean DOC flux rate for 55 rivers draining the Precambrian Shield was 34 kg/ha/yr with substantially less DOC derived from tundra systems compared to forested basins (Hudon et al. 1996). Annual DOC flux from the Muskeg River basin likely varies over a wide range depending on climate and river discharge.

The poor relationship between summer DOC and discharge was initially surprising considering the two should be linked if source areas for summer spates were from muskeg (Schwartz and Milne-Home 1982b; Koertelainen 1999). However, several processes can occur that add variation to DOC – discharge relationships in peatland and other regions (Hope *et al.* 1994). Drainage from minerotrophic versus ombotrophic peatlands, variation in peat thickness, soil iron and aluminum concentrations, and climate differences among years all add to variation in DOC – discharge relationships. DOC concentrations were elevated upstream of the Wapasu Creek confluence (M5) and in the tributaries Jackpine, Shelley and Muskeg Creeks (Sites T3, T4, T5: Figure 5.13) compared to downstream sites in the Muskeg River. All of these sites drain extensive peatlands. However, DOC concentrations declined in the slow flowing reach below Wapasu Creek (M4) possibly due to flocculation, sedimentation and microbial respiration in beaver ponds.

Concentrations of DOC and total organic carbon (TOC) were strongly correlated and one could be predicted from the other by the following formula:

$$[TOC] = 0.997 * [DOC] + 0.917 \ (mg \bullet L^{-1}) \quad r^2 = 0.97$$

Most organic carbon in the Muskeg River was in the dissolved fraction.

Water colour in true colour units (TCU) was also related to DOC:

$$[Colour] = 5.67 * [DOC] - 44.87 \qquad r^2 = 0.61$$

The relationship was calculated with all sites included (1998 to 2001). Colour from 1976 to 1982 was determined on unfiltered water and reported in apparent units. Apparent colour was not related to DOC, suspended solids, turbidity, or the combined terms.

5.4 Solids and Turbidity

Total suspended solids (TSS) are also termed non-filterable residue (NFR), and 1998-2000 data for TSS are compiled in Appendix 3. Concentrations were relatively low in the Muskeg River

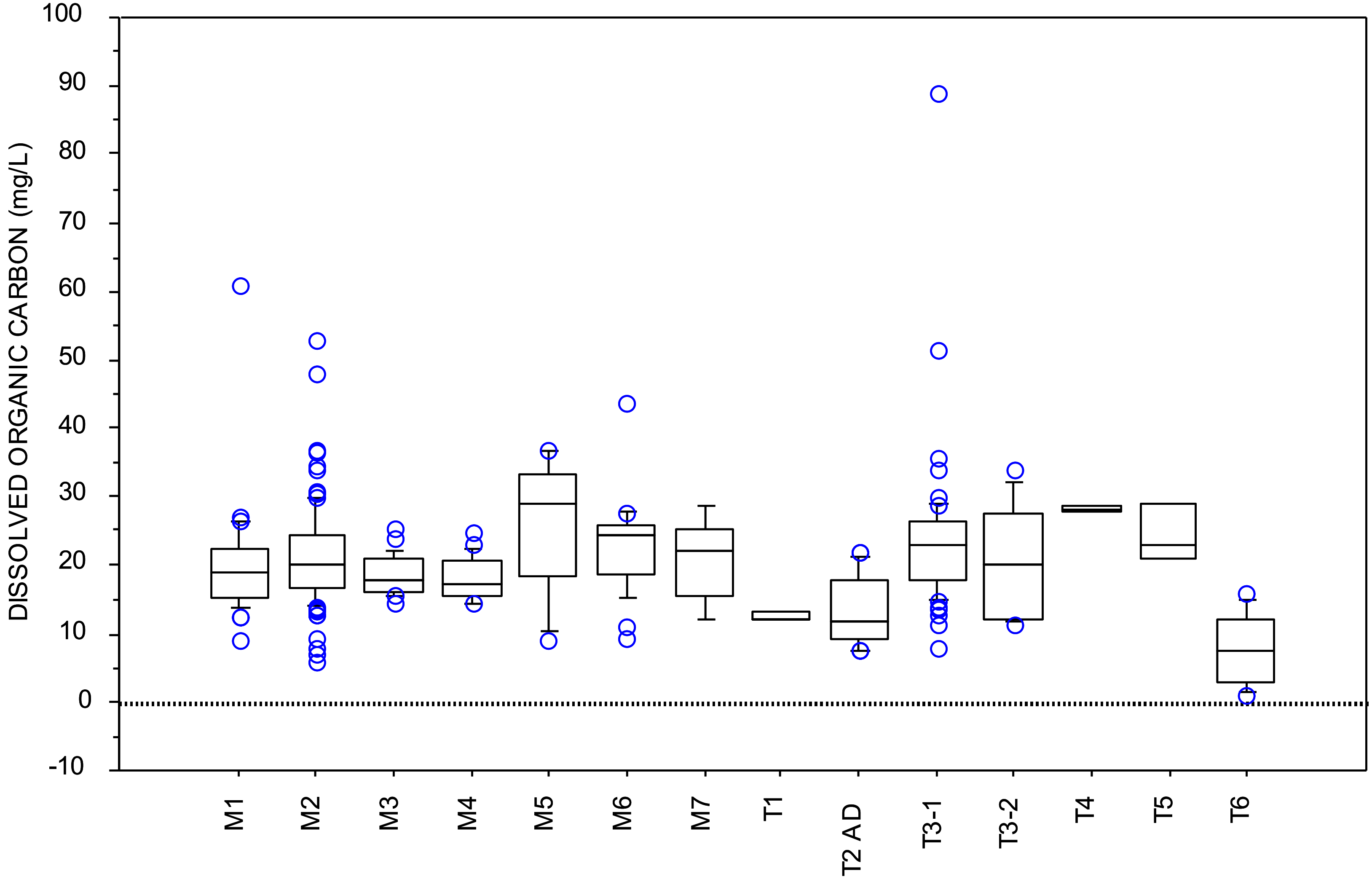


Figure 5.13 Dissolved organic carbon (DOC) concentrations at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

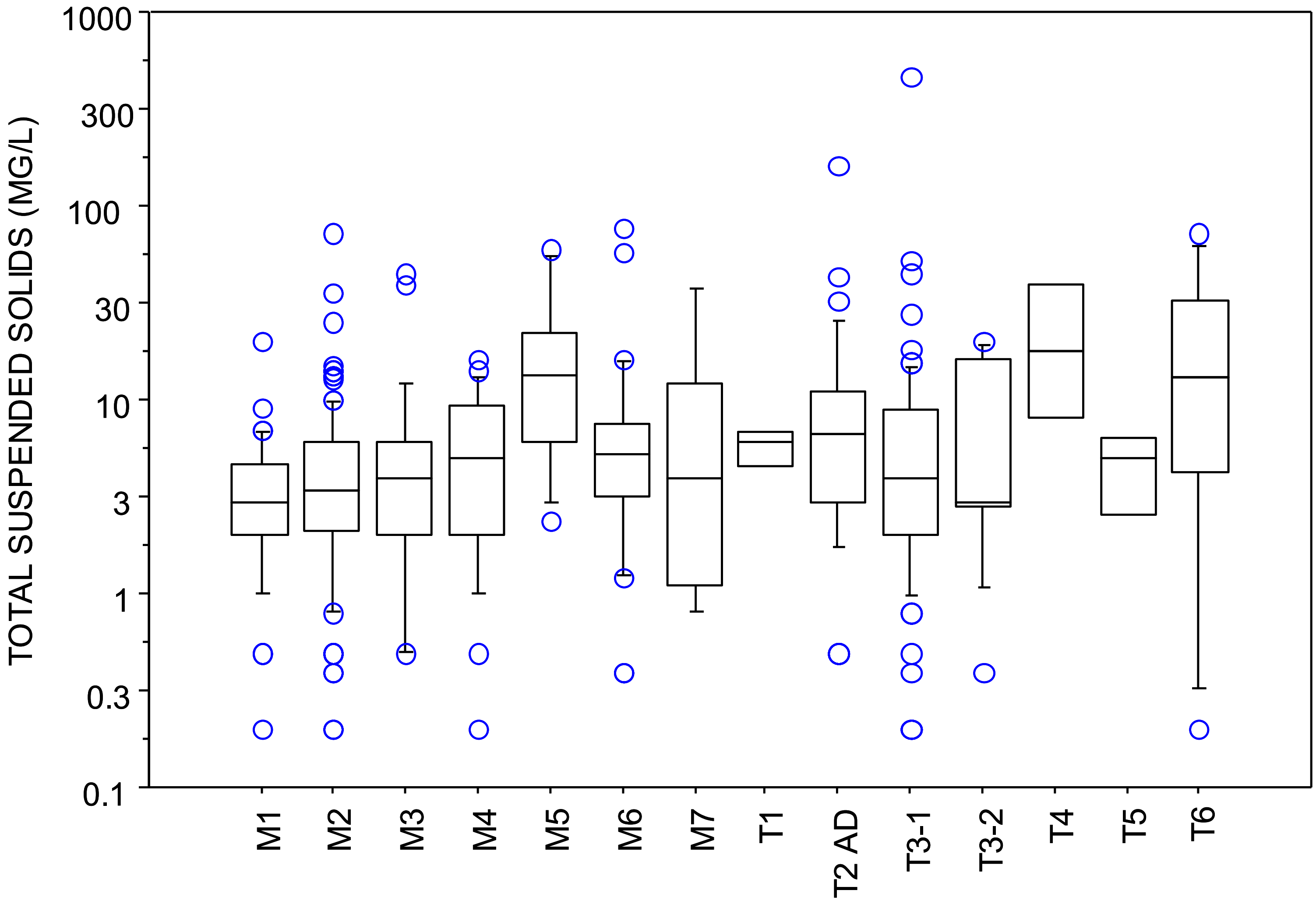


Figure 5.14 Total suspended solids (TSS) concentrations at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

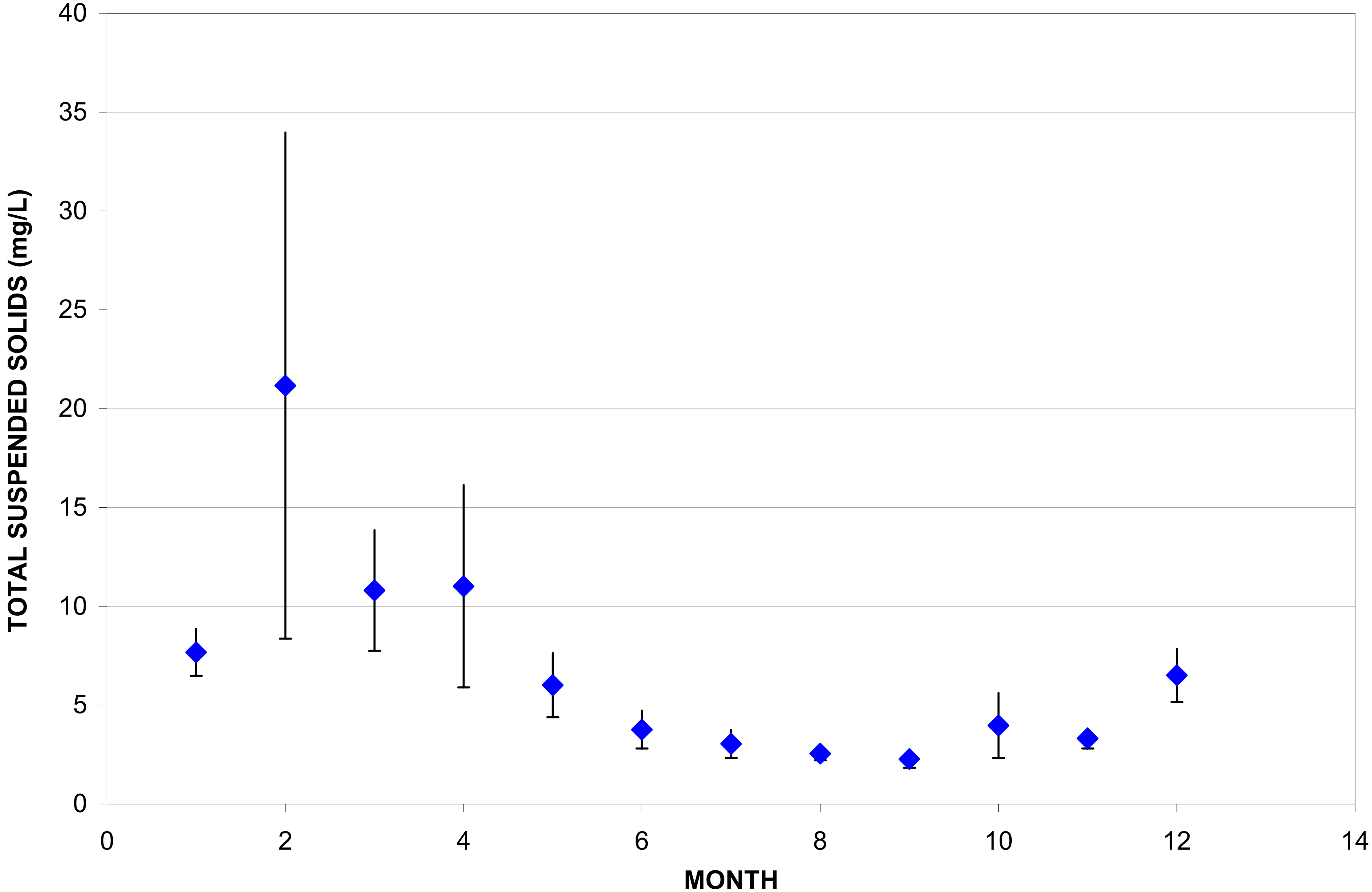


Figure 5.15 Monthly mean and standard errors for total suspended solids concentrations at the Muskeg River WSC site, 1976 to 2001

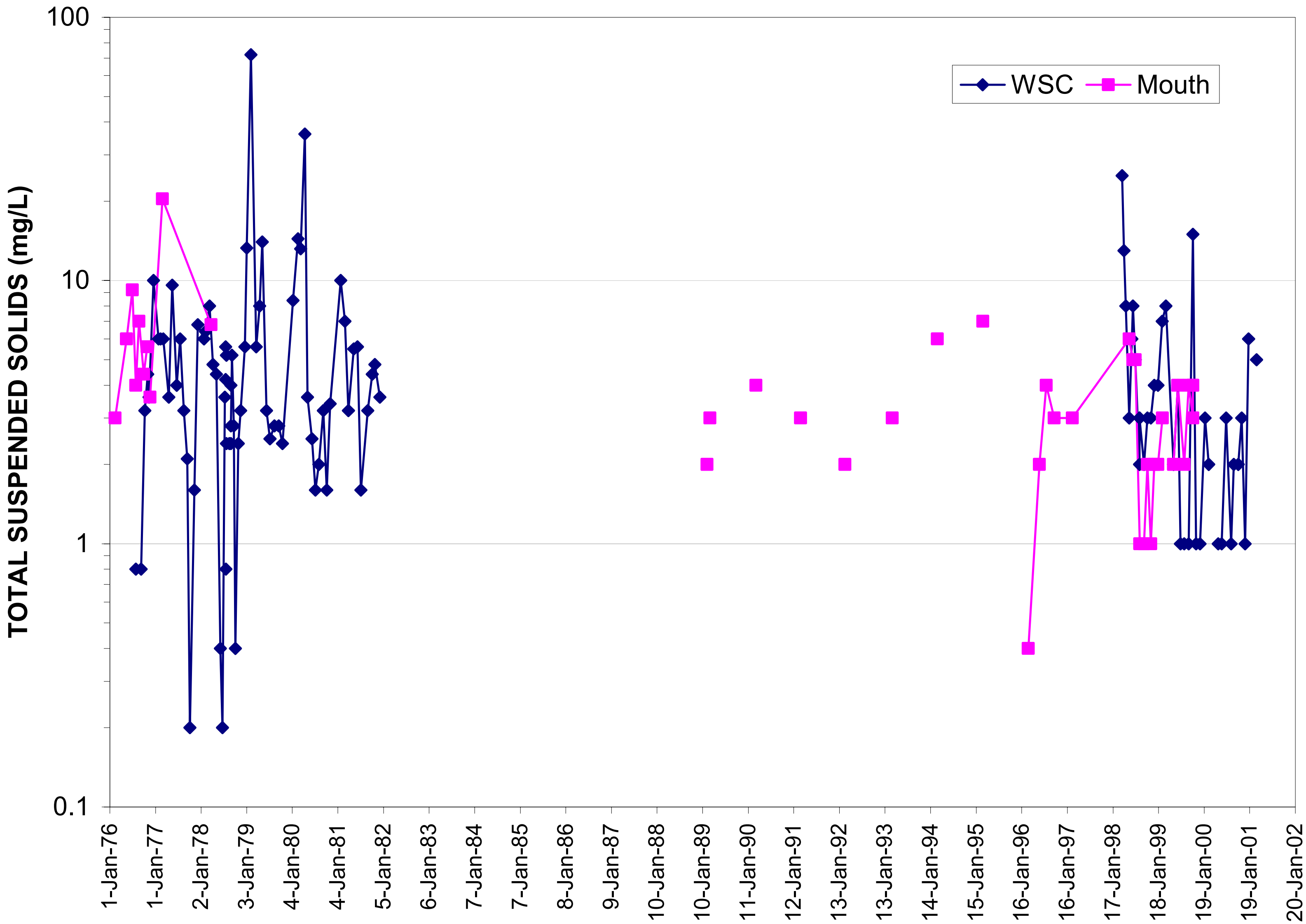


Figure 5.16 Total suspended solids concentrations at the Muskeg River WSC and mouth sites, 1976 to 2001

system, remaining below 10 mg•L^{-1} at the WSC site for 100 of 109 samples collected since 1976. The mean TSS concentration at the WSC site over this period was 5.4 mg•L^{-1} (Figure 5.14). Of the nine TSS concentrations recorded above 10 mg•L^{-1}, most occurred during late winter or during snowmelt (Figure 5.15). The low concentrations of TSS in the Muskeg River system contrast with those of the Athabasca River and some other tributaries of the Athabasca in the area, such as the Ells River. These rivers can be very turbid during high flows, as a result of erodible material in their bed and banks, steeper gradients in some areas (i.e., the upper Ells in the Birch Mountains – Corkum 1985) and probably less dampening of flows by peatlands.

There was no evidence of increasing TSS concentration over time (Figure 5.16) nor was there a relationship with discharge at the WSC site ($r^2 < 0.1$). When samples were limited to baseflow (<2.5 m^3/s) mean TSS was 6.6 mg•L^{-1}. Akena (1979) similarly found high turbidity and suspended solids concentrations at low flow, particularly during winter. He attributed these results as possibly due to sediment disturbance during sample collection, however, great care was exercised in recent sampling to avoid sediment disturbance, with samples often collected from open-water leads. Higher TSS in winter seems to be natural for the Muskeg River. Winter beaver activity, particularly the digging of food reserves and the maintenance of ice-free runs may contribute to the winter sediment load. The buckling and heaving of channel ice may also partly explain increased suspended sediment under winter ice. Both total suspended and non volatile suspended solids were unrelated to discharge at the WSC site indicating erosion during high flow was not an important source for suspended material including mineral soil particles.

Both total dissolved solids (TDS) and non volatile dissolved solids were negatively correlated with discharge at the WSC site (r^2 = 0.59 and 0.66, respectively). The relationships are likely due to dilution of dissolved constituents (e.g., cations and anions) that occurred under increasing flow. Dilution under increased discharge was in keeping with the hypothesis that a majority of storm water was generated from peatlands. The lack of increased suspended solids with discharge further suggests that most event runoff was routed through shallow ground pathways rather than as overland flow.

Turbidity was analyzed between 1976 and 1981 and averaged 7.7 NTU at the WSC site (Figure 5.17). Guidelines do exist for turbidity and are based on increases above background levels. Increases of up to 8 NTU (events) above background is considered acceptable for river systems with turbidity similar to the Muskeg River (Alberta Environment 1999). However, six values (10% of total) from the WSC site exceeded the mean by 9 to 59 NTU suggesting high turbidity may be relatively common. These “events” did not occur during high discharge periods, instead they tended to occur during low flow periods under ice.

5.5 Metals and Elements

Metals are a concern in water because they can accumulate to toxic levels in sediment and biota, and may be toxic in the water phase if at high enough concentrations. Specific to metals is that, while speciation may change, they cannot be mineralized to harmless products through time. Natural remediation is nonexistent except through dilution and immobilization in deep sediments. Bioaccumulation of metals in fish can pose a significant risk for human exposure. Most metals and elements discussed here occur naturally in water as a result of geologic

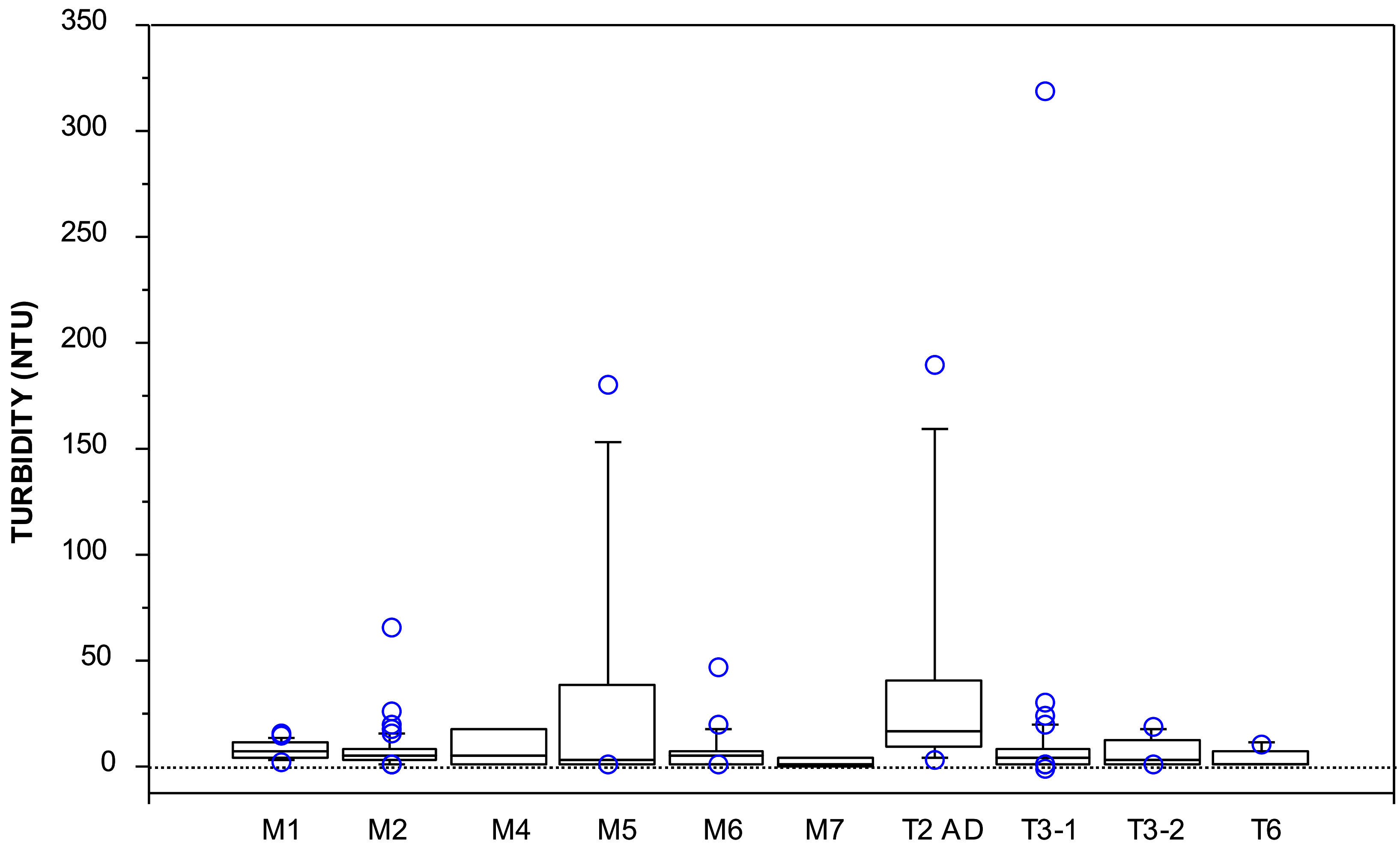


Figure 5.17 Turbidity concentrations at Muskeg River sites from mouth (M1) to headwaters (M7) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

weathering. Other metals such as mercury are deposited from distant industrial sources as a result of long-range atmospheric transport. The aquatic chemistry of metals is complex. Free ions hydrated by water molecules are the most bioavailable and potentially toxic form. Suspended solids, DOC and pH of surface water all influence the speciation of metals, affecting their bioavailability and toxicity. Suspended solids adsorb metal ions, often causing them to precipitate and thus reducing bioavailability and potential toxicity. DOC adsorbs and enhances the transport of metal ions and thus the potential exposure for aquatic biota. However, because the metal ions are associated with DOC, cellular uptake can be reduced. Thus DOC can increase or decrease the net impact on biota depending on the metal and its toxicity. When the hydrogen ion activity is high and pH is low, metals are stripped from base functional groups and enter solution, thus becoming more toxic. This is one of the main reasons for concern about acidification.

In our discussion of metals we focus on three sites, the WSC site (M2), the Alsands ditch (T2-AD) which enters the Muskeg River above the WSC site, and the Muskeg River site above Jackpine Creek (M3) which is above the Alsands ditch. We evaluated data where metals were below the limit of detection, and note that detection limits have changed substantially over the period of record for the Muskeg River. For this reason we focused on data collected since 1998, but utilize older data where possible. Table 5.3 summarizes mean metal concentration at sites in the Muskeg River system, with notations for parameters that include significant deviations due to samples near or below limits of detection.

5.5.1 Aluminum

Aluminum is a naturally occurring metal that is a common component of clay minerals. Its dissociation from soils is pH dependant and its toxicity is markedly increased at pH below 6.5. The ASWQG for aluminum at pH above 6.5 is 100 μg/L. For all samples over the period of record (1976-2000), extractable aluminum concentrations often exceeded the ASWQG while total recoverable aluminum (1998-2000) did so on only limited occasions (9 of 76 samples, Figure 5.18). Extractable aluminum has not been analyzed in recent years, but should be roughly equivalent to total recoverable concentrations. Extractable (1976 through 1979) and total recoverable aluminum (1998 through 2000) both averaged 50 $\mu g \bullet L^{-1}$. High concentrations of extractable aluminum (> 200 $\mu g \bullet L^{-1}$) occurred in 1980. Although extractable aluminum concentrations were elevated in the Alsands ditch, the 1980 data may represent laboratory contamination as concentrations reported from Jackpine Creek were similarly elevated that year. Total recoverable aluminum concentrations at the Alsands ditch were below ASWQG in 1998-2000 except one sample with 580 $\mu g \bullet L^{-1}$. Dissolved aluminum remained below 10 $\mu g \bullet L^{-1}$ at all sites during the same period even when total recoverable aluminum exceeded 500 $\mu g \bullet L^{-1}$. Extractable and total recoverable aluminum were not well correlated with total suspended solids (r^2 <0.05, n = 65, n = 13, respectively). Given the low concentration of dissolved aluminum at all sites, aluminum does not appear to be a concern at this time. However, continued monitoring of drainage water is necessary to determine the probability of loading events like the 580 $\mu g \bullet L^{-1}$ sample.

Table 5.3 Average metals concentration (μg/L) for all sites in the Muskeg River basin, 1976-2000

Station:	M1	M2	M3	M4	M5	M6	M7	T1	T2	T3.1	T3.2
Aluminum, T.	45.01	50.85	56.94	31.86	8.93	nd	nd	55.90	97.28	77.29	nd
Aluminum, D.	3.18	3.19	3.65	3.25	nd	nd	nd	nd	2.92	3.77	nd
Arsenic, T.*	0.29	0.32	0.28	0.23	0.16	nd	nd	0.13	0.31	0.47	nd
Arsenic, D.*	0.30	0.97	0.29	0.90	nd	nd	nd	nd	0.48	0.49	4.09
Barium, T.	79.80	69.81	66.58	72.67	90.10	nd	nd	60.93	173.22	56.53	nd
Barium, D.	71.50	62.65	53.93	63.62	nd	nd	nd	nd	146.00	45.53	nd
Boron, T.	48.18	47.69	44.06	39.77	36.83	nd	nd	34.97	44.60	67.74	nd
Boron, D.	46.46	45.83	40.13	34.68	nd	nd	nd	nd	50.85	66.95	nd
Cadmium, T.	0.8438	nd	nd	0.1	nd	nd	nd	nd	nd	nd	nd
Cadmium, D.	0.0072	0.0098	0.0072	0.0438	nd	nd	nd	nd	0.009	0.0065	nd
Chromium, T.*	0.49	0.57	0.62	1.60	1.24	nd	nd	0.71	0.93	0.58	nd
Chromium, D.	0.04	0.12	0.11	0.17	nd	nd	nd	nd	2.91	0.19	nd
Copper, T.	0.64	0.45	0.35	0.27	1.16	nd	nd	0.29	1.14	0.40	nd
Copper D.	0.53	0.44	0.29	0.20	nd	nd	nd	nd	1.24	0.29	nd
Iron, T.	1035.0	nd	nd	1742.9	nd	nd	nd	nd	nd	nd	nd
Iron, D.*	190.9	211.5	369.6	539.7	135.3	nd	nd	180.7	68.3	281.20	nd
Lead, T.	0.004	nd	nd	0.001	nd	nd	nd	nd	nd	nd	nd
Lead, D.*	0.636	0.044	0.052	0.076	nd	nd	nd	nd	0.144	0.053	nd
Lithium, T.	10.86	9.92	10.36	9.50	12.07	nd	nd	6.53	10.41	14.26	nd
Lithium, D.	10.60	9.93	9.28	8.14	nd	nd	nd	nd	11.30	12.55	nd
Manganese, T.	112.12	196.56	206.72	201.01	361.00	nd	nd	163.00	376.39	132.00	nd
Manganese, D.	58.27	184.67	286.96	241.57	337.00	nd	nd	122.67	411.85	103.64	nd
Mercury, T.*	0.27	0.08	0.21	0.03	nd	0.23	0.73	nd	0.10	0.09	0.55
Molybdenum, T.	0.14	0.13	0.07	0.06	0.05	nd	nd	0.03	0.29	0.13	nd
Molybdenum, D.	0.10	0.10	0.07	0.05	nd	nd	nd	nd	0.22	0.13	nd
Nickel, T.*	3.98	0.24	0.12	6.82	4.55	nd	nd	0.06	1.77	0.37	nd
Nickel, D.*	0.37	0.20	0.15	0.47	nd	nd	nd	nd	5.50	0.36	nd
Selenium, T.*	0.20	0.23	0.20	0.20	0.20	nd	nd	0.20	0.20	0.20	nd
Selenium, D.*	0.19	0.17	0.25	1.44	nd	0.20	0.18	nd	0.15	0.16	0.24
Strontium, T.	220.33	186.40	170.50	175.67	205.00	nd	nd	124.00	308.43	233.00	nd
Strontium, D.	nd	nd	nd	nd	nd	nd	nd	nd	285.00	nd	nd
Uranium, T.	0.24	0.16	0.07	0.03	0.03	nd	nd	0.07	0.69	0.09	nd
Uranium, D.	0.19	0.14	0.07	0.03	nd	nd	nd	nd	0.52	0.06	nd
Vanadium, T.	0.31	0.36	0.35	0.31	0.26			0.70	0.42	0.45	
Vanadium, D.	0.29	0.24	0.20	0.21					0.26	0.23	
Zinc, T.	3.34	3.05	1.49	1.83	6.05	nd	nd	1.44	5.58	2.11	nd
Zinc, D.	0.74	1.11	0.58	1.90	nd	nd	nd	nd	8.16	0.68	nd

All station numbers refer to map reference (Figure 3.1) and are ordered from mouth to headwaters. nd = no data T = total, D = dissolved

*Mean calculation significantly impacted by values below detection limits

Table 5.3 Average metals concentration (μg/L) for all sites in the Muskeg River basin, 1976-2000

Station:	T3.3	T3.3b	T3.4	T3.4b	T4	T5	T5.1	T5.2	T5.3	T6	T7
Aluminum, T.	nd	nd	nd	nd	49.25	56.67	nd	nd	nd	36.90	13.50
Aluminum, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic, T.	nd	nd	nd	nd	0.58	0.39	nd	nd	nd	0.11	0.38
Arsenic, D.	0.63	3.24	0.73	2.31	0.63	0.30	1.73	0.34	0.39	nd	nd
Barium, T.	nd	nd	nd	nd	132.00	44.93	nd	nd	nd	41.00	65.17
Barium, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Boron, T.	nd	nd	nd	nd	218.00	110.67	nd	nd	nd	15.00	34.37
Boron, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cadmium, T.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cadmium, D.	0.5	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd
Chromium, T.	nd	nd	nd	nd	nd	0.46	nd	nd	nd	0.22	2.52
Chromium, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Copper, T.	nd	nd	nd	nd	0.37	0.36	nd	nd	nd	0.20	0.20
Copper D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Iron, T.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Iron, D.	nd	nd	nd	nd	539.0	420.7	nd	nd	nd	194.0	672.0
Lead, T.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Lead, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Lithium, T.	nd	nd	nd	nd	39.30	18.90	nd	nd	nd	6.60	8.10
Lithium, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Manganese, T.	nd	nd	nd	nd	1403.00	221.97	nd	nd	nd	83.30	437.33
Manganese, D.	nd	nd	nd	nd	314.02	187.00	nd	nd	nd	23.40	388.00
Mercury, T.	0.07	0.06	0.06	0.07	0.05	0.08	0.22	0.06	0.24	0.42	0.08
Molybdenum, T.	nd	nd	nd	nd	0.08	0.09	nd	nd	nd	0.04	0.06
Molybdenum, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Nickel, T.	nd	nd	nd	nd	0.40	1.00	nd	nd	nd	0.03	0.10
Nickel, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Selenium, T.	nd	nd	nd	nd	0.20	0.20	nd	nd	nd	0.20	0.20
Selenium, D.	0.36	0.18	0.17	0.24	0.19	0.19	0.16	0.60	0.33	0.34	0.21
Strontium, T.	nd	nd	nd	nd	378.00	249.50	nd	nd	nd	nd	209.00
Strontium, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Uranium, T.	nd	nd	nd	nd	0.03	0.16	nd	nd	nd	0.01	0.01
Uranium, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium, T.					1.20	0.54				0.21	0.94
Vanadium, D.											
Zinc, T.	nd	nd	nd	nd	4.77	2.95	nd	nd	nd	1.10	1.66
Zinc, D.	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

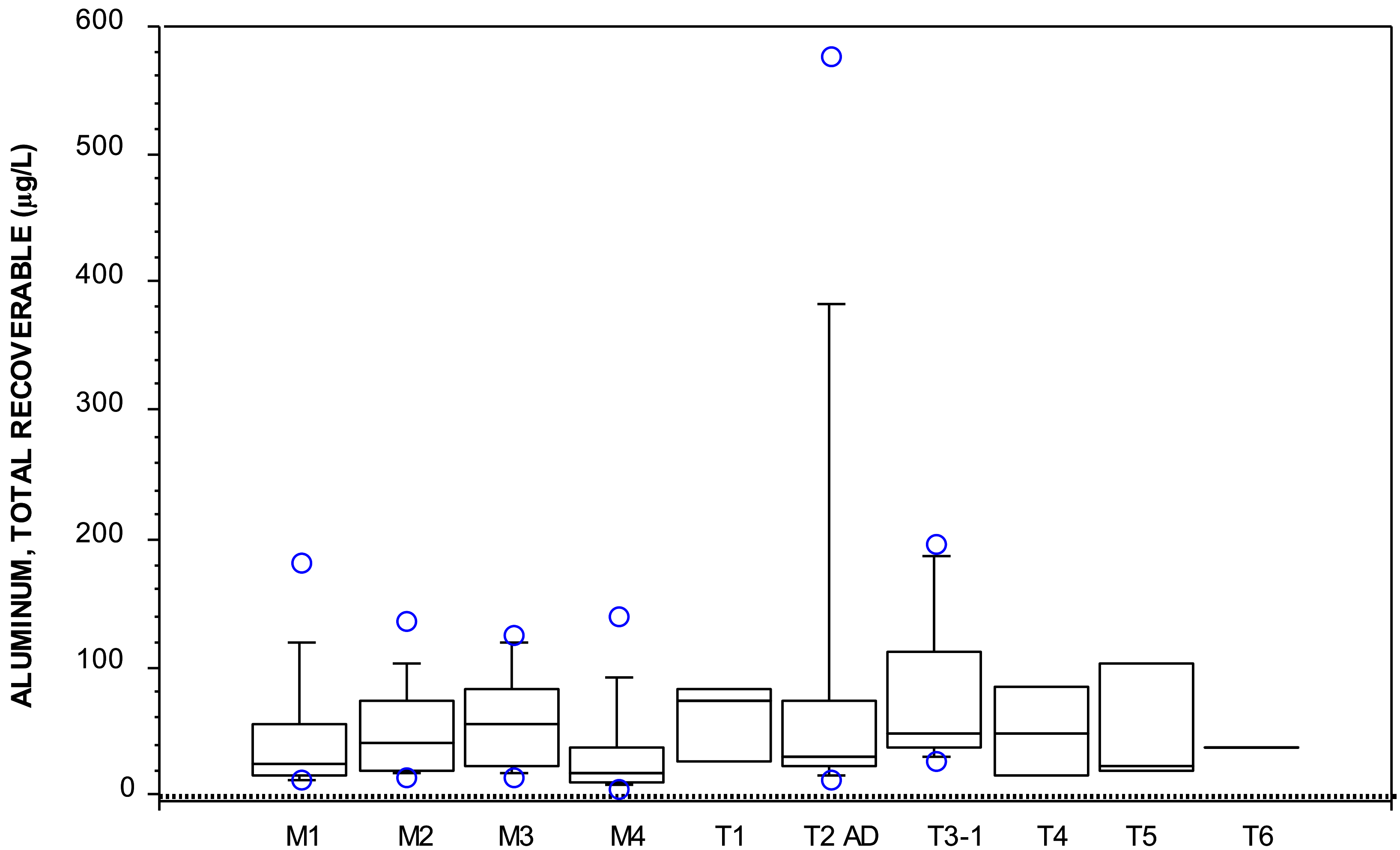


Figure 5.18 Total recoverable aluminum concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

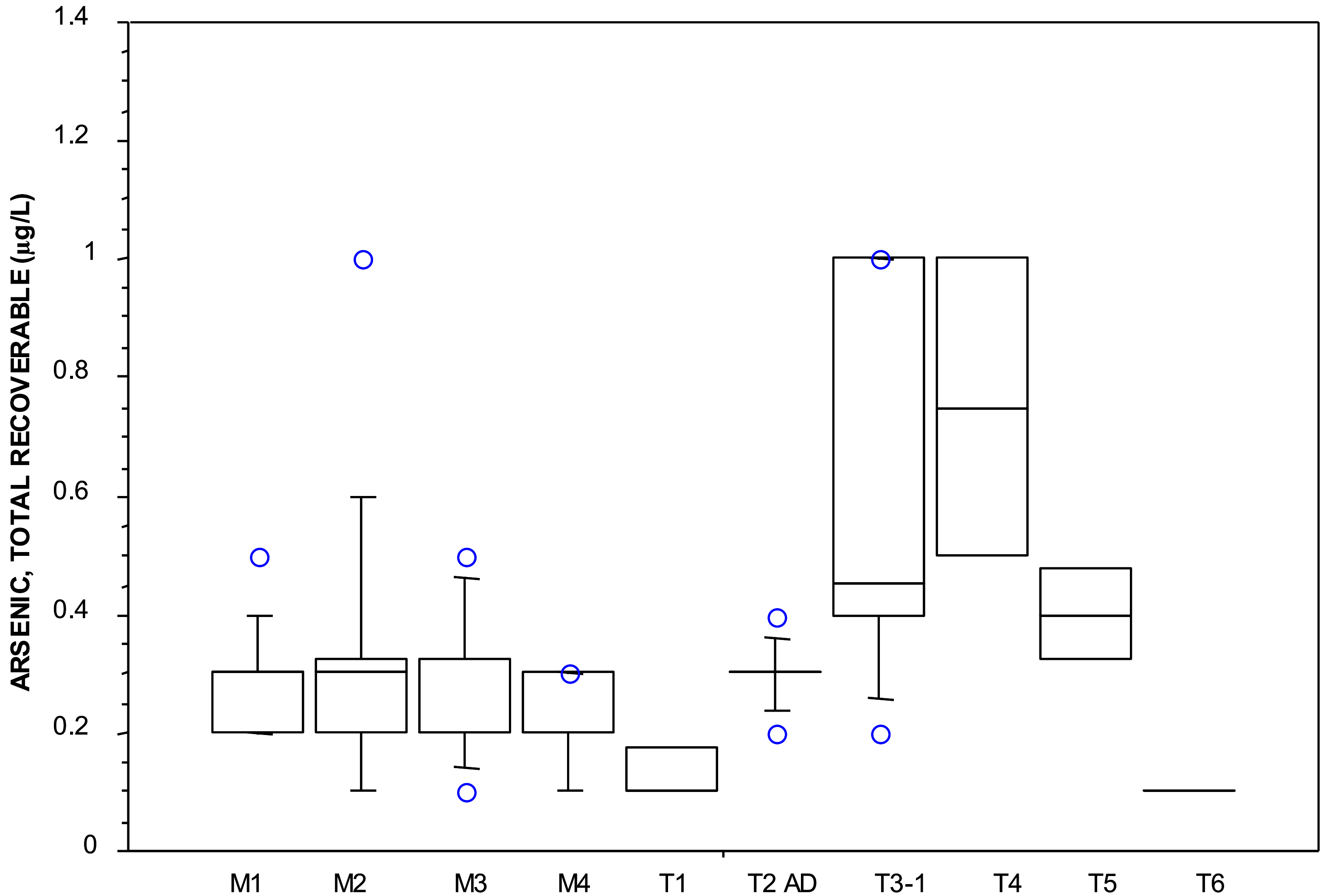


Figure 5.19 Total recoverable arsenic concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

5.5.2 Arsenic

Arsenic exists naturally but can also be deposited from industrial emissions, particularly from fossil fuel combustion (CCREM 1987). The ASWQG is 5 $\mu g \bullet L^{-1}$, which was not exceeded in recent monitoring. Between 1976 and 1977 dissolved arsenic exceeded 5 $\mu g \bullet L^{-1}$ on seven occasions. There were no relationships between arsenic concentration and suspended solids. Both dissolved and total arsenic were measured in 1999; dissolved arsenic comprised 90% of the total arsenic pool. Arsenic concentrations in the Muskeg River do not appear to be increasing at this time. At the WSC site the 1998-2000 mean total arsenic concentration was 0.37 $\mu g \bullet L^{-1}$ and the long term dissolved arsenic concentration (1977-2000) was 0.72 $\mu g \bullet L^{-1}$. Mean arsenic concentrations were similar at the Alsands ditch and M3 sites (0.31 and 0.30 $\mu g \bullet L^{-1}$, respectively). Arsenic concentrations were higher in Muskeg River tributaries, particularly Jackpine and Shelley Creek (Figure 5.19). Arsenic from these sites may be due to leaching from their extensive peatlands. Groundwater sources are less likely because concentrations were positively correlated with flow and were higher during months when groundwater was likely less significant in generating runoff than water from peatlands.

5.5.3 Barium

Barium occurs naturally and at concentrations in water higher than many of the other metals or elements. Drilling wastewater is one potential anthropogenic source of barium to surface waters. Only recent data (1998-2000) exist for barium in the Muskeg River system. Mean barium concentrations at the WSC and mouth sites (70 and 80 $\mu g \bullet L^{-1}$, respectively) were more than 10-fold below the drinking water guideline (1 $mg \bullet L^{-1}$). There is no surface water quality guideline for barium. The Alsands ditch contained higher barium concentrations (0.173 $mg \bullet L^{-1}$, $P << 0.01$, df = 20) than the upstream and WSC sites (Figure 5.20, 5.21). This may reflect overburden drainage water since Ba is often higher in groundwaters than surface waters. Mean barium concentrations at the upstream and the WSC site were not different from each other indicating the barium loading from the Alsands ditch was diluted. Deeper groundwater appears to be the primary source for barium in the Muskeg River.

5.5.4 Boron

Mean boron concentrations for the WSC, ditch and upstream sites were 48, 45 and 44 $\mu g \bullet L^{-1}$, respectively. The only current guideline for boron is 500 $\mu g \bullet L^{-1}$ (Canadian Water Quality Guideline) for irrigation water. Total recoverable boron concentrations did not exceed 220 $\mu g \bullet L^{-1}$ (Shelley Creek 1998 & 99) at any site (Table 5.3). Boron concentrations at the WSC site remained relatively stable seasonally so its source is difficult to determine.

5.5.5 Cadmium

Cadmium is released from mining activities, the burning of fossil fuels and other industrial activities. The ASWQG for cadmium is dependant on water hardness (similar to alkalinity) and ranges from about 0.03 to 0.09 $\mu g \bullet L^{-1}$ for hardness values typical in the Muskeg River and its tributaries (100 to 325 $mg \bullet L^{-1}$ $CaCO_3$ hardness). Dissolved cadmium concentrations at the WSC, ditch and upstream sites were 0.007, 0.009 and 0.010 $\mu g \bullet L^{-1}$, respectively (Figure 5.22).

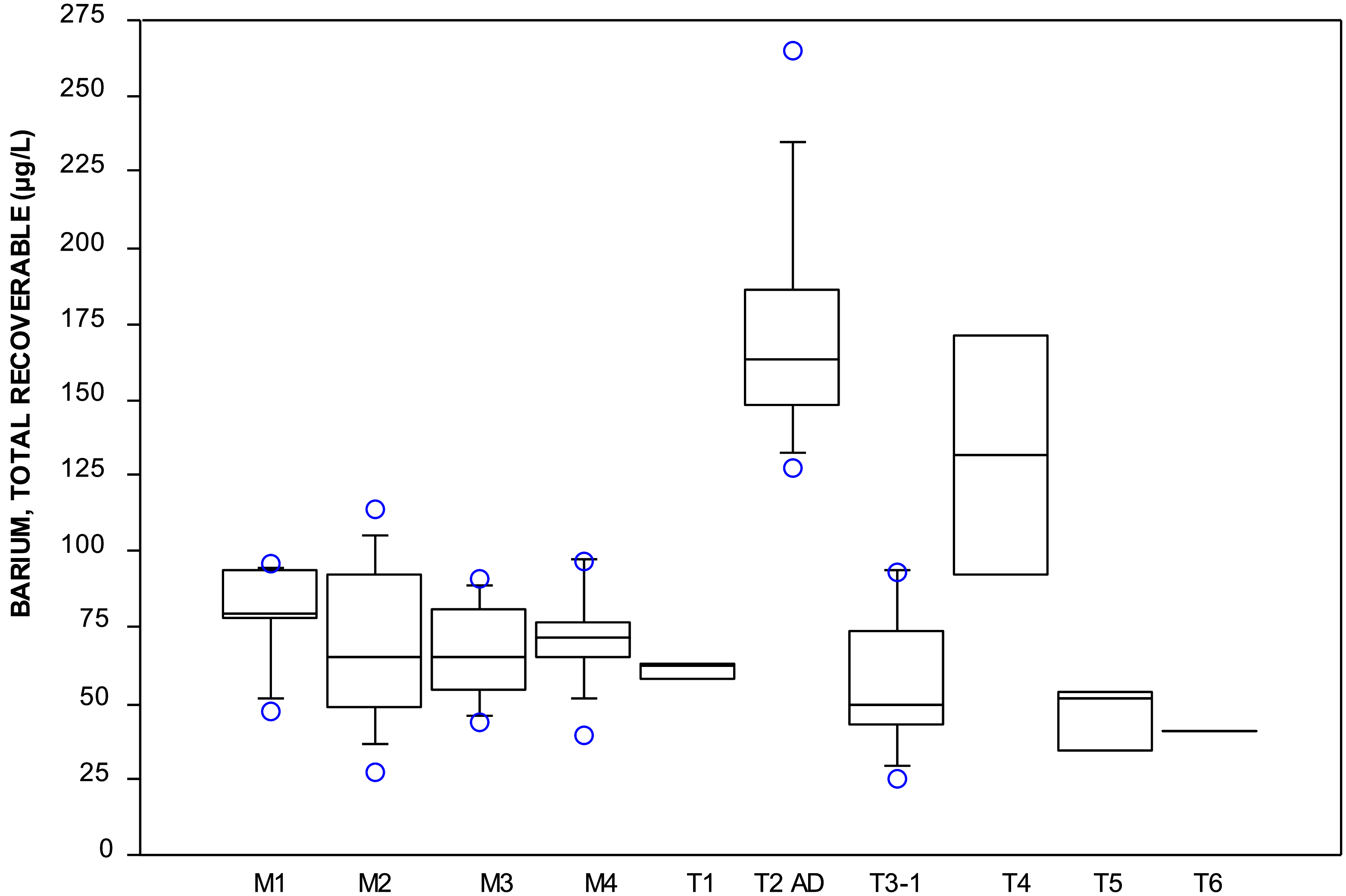


Figure 5.20 Total recoverable barium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

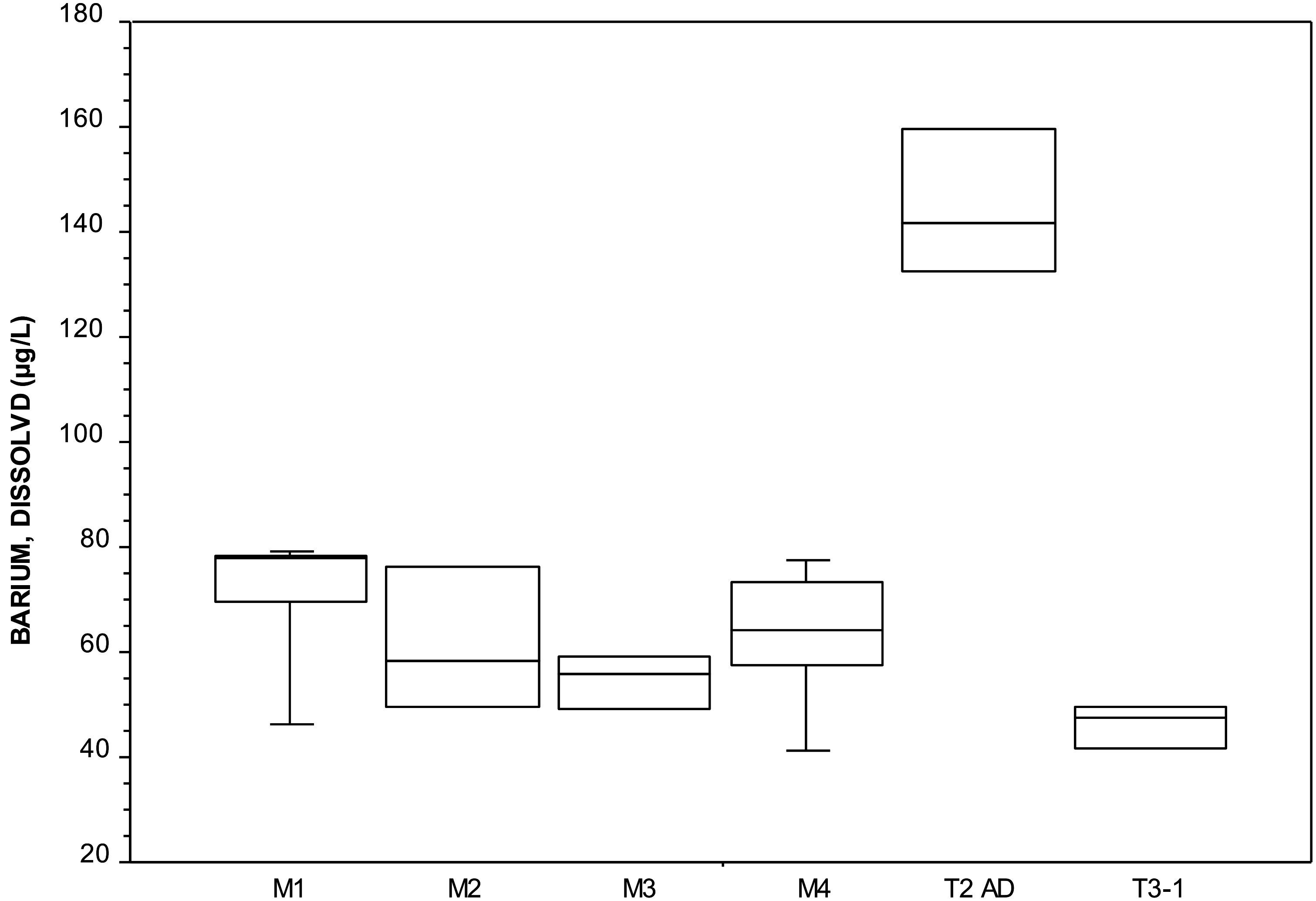


Figure 5.21 Dissolved barium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

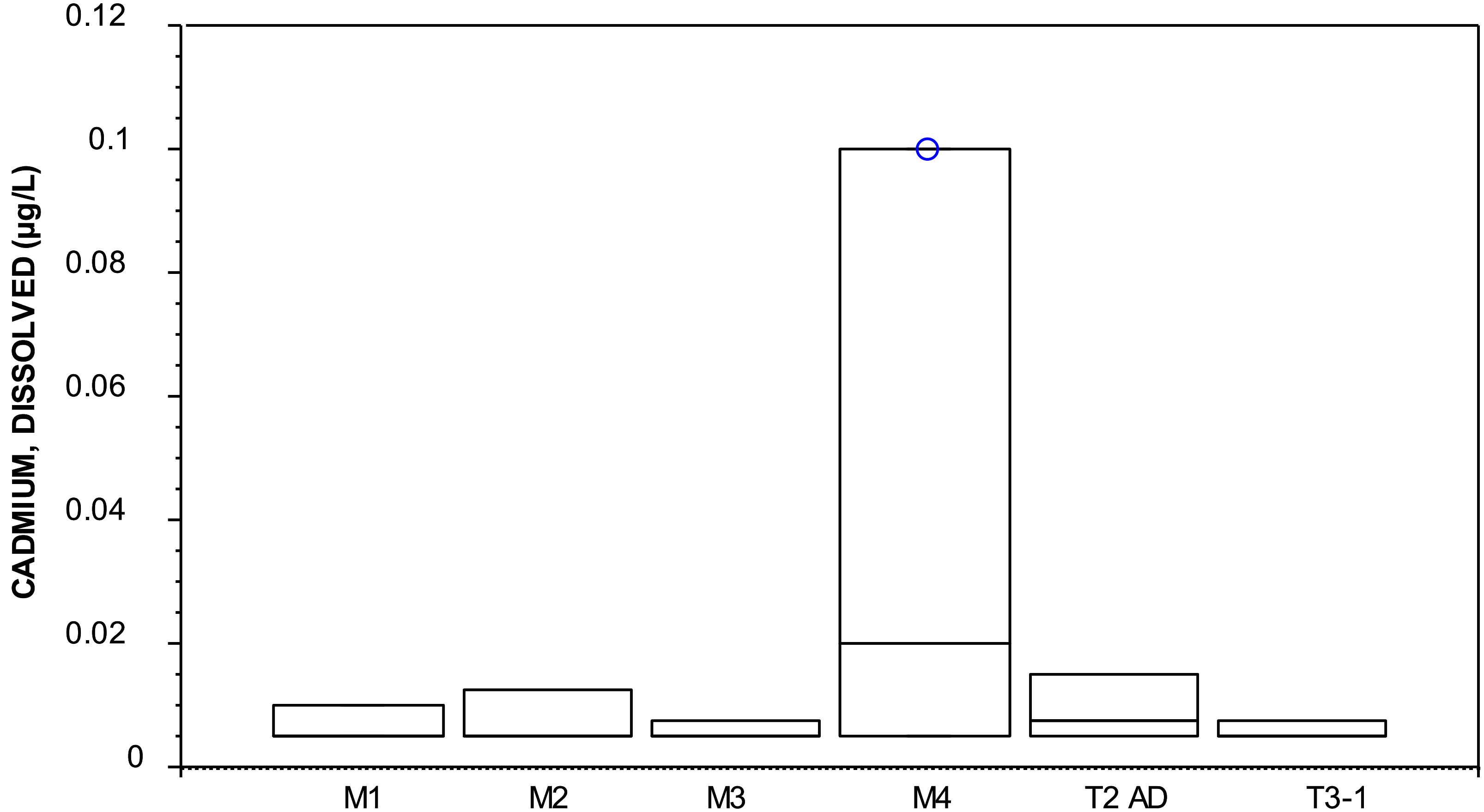


Figure 5.22 Dissolved cadmium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

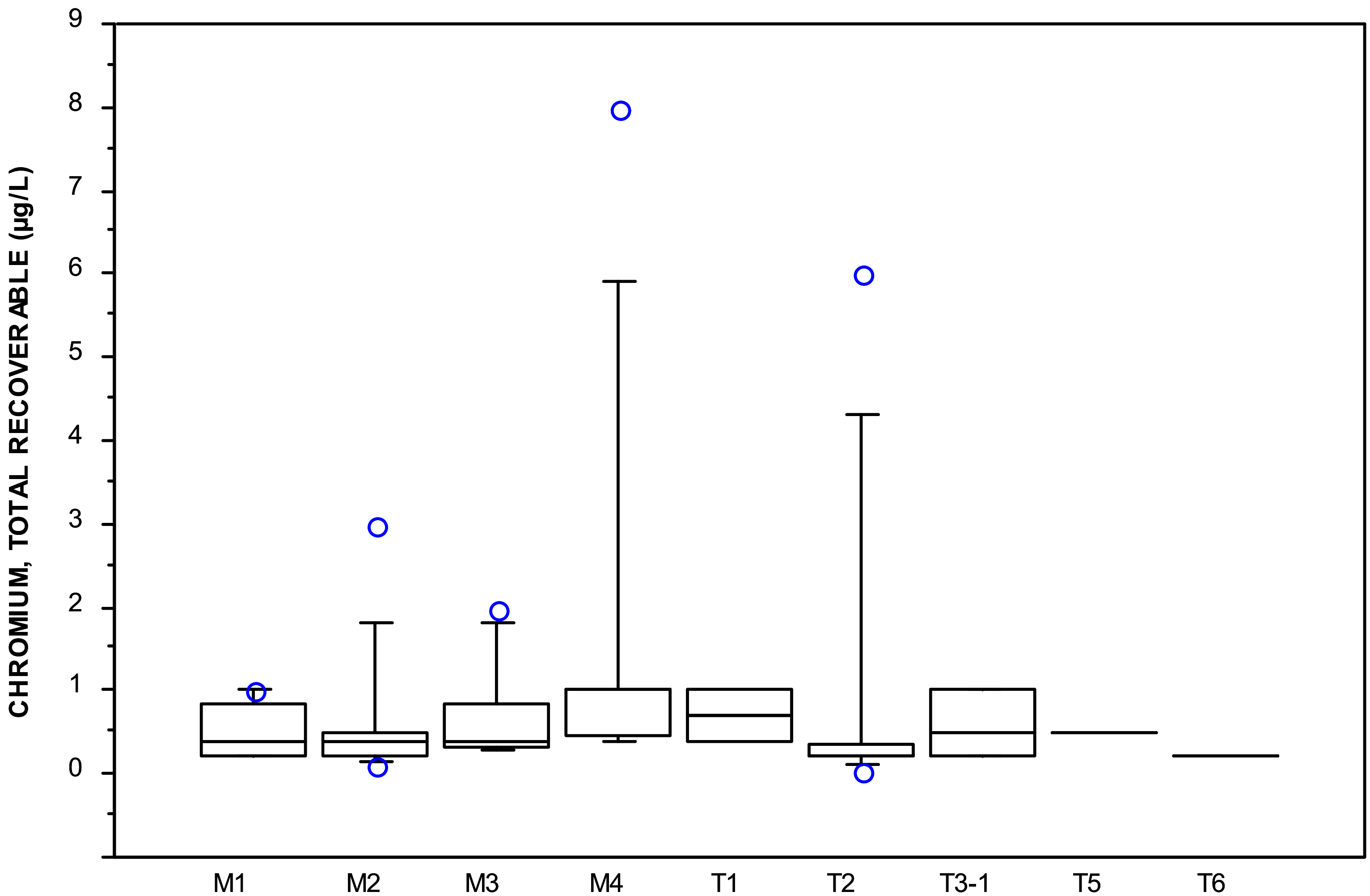


Figure 5.23 Total recoverable chromium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

These mean values were based on four total samples from each site where only one, two and one sample were above detection limits, respectively. The remaining eight samples where included at half the detection limit (Table 5.3). The relatively high total cadmium concentration reported for site M1 in Table 5.3 was due to elevated concentrations in data from 1972 to 1993.

5.5.6 Chromium

Chromium occurs in the aquatic environment due to natural weathering processes. Chromium pollution is predominately associated with metal plating industries. The ASWQG for hexavalent chromium (Cr VI) is 1 $\mu g \bullet L^{-1}$ and is substantially higher for trivalent Cr (Cr III) at 8.9 $\mu g \bullet L^{-1}$. Mean total recoverable chromium concentrations at the WSC, ditch and upstream sites were 0.6, 1.0 and 0.6 $\mu g \bullet L^{-1}$, respectively (Figure 5.23). Chromium (VI) was not analyzed after 1981; concentrations prior to 1981 were above the ASWQG and also above total recoverable chromium measured after 1981. The reported concentrations of chromium (VI) may reflect the limited accuracy of analytical methods prior to 1981. The highest measured total recoverable chromium concentration after 1981 was 8.1 $\mu g \bullet L^{-1}$ (downstream of Stanley Creek). The highest mean concentration was in Wapasu Creek (2.5 µg/L - Table 5.3). Chromium concentrations at the ditch site were not different from the upstream or WSC sites ($P > 0.6$, df = 7). The Muskeg River may have high background chromium concentrations which should be monitored.

5.5.7 Copper

The ASWQG for copper is 7 $\mu g \bullet L^{-1}$ (chronic), applicable to waters with hardness > 50 mg/L. The CWQG ranges from 2 to 4 $\mu g \bullet L^{-1}$ depending on water hardness (CCME 1999). Water hardness conditions in the Muskeg River span the entire guideline range. Mean total recoverable copper concentrations at the WSC, ditch and upstream sites were 0.45, 1.14 and 0.35 µg/L, respectively. Concentrations at the ditch site were significantly higher than at the upstream and WSC sites ($P << 0.01$, df = 8.8), and may reflect contributions from overburden drainage. The highest concentration recorded at the ditch site was 2.2 $\mu g \bullet L^{-1}$ (Figure 5.24), however, hardness was over 300 $mg \bullet L^{-1}$ $CaCO_3$ and the corresponding CWQG for copper would be 4.0 µg/L.

5.5.8 Iron

Iron is one of the most abundant elements on earth and enters surface waters from groundwater outflows, and the weathering of rocks and sandstone. Anthropogenic sources include leaching from mine drainage, coke and coal combustion, mineral processing, and effluent discharges. Natural loading may be enhanced by the presence of peatlands as there is a strong association between DOC and iron concentrations in surface waters draining peatland environments. In the Muskeg River, the relationship between DOC and dissolved iron was strong ($r^2 = 0.77$, n = 11). Drainage from minerotrophic peatlands and the organic-mineral soil interface was likely a significant natural source for iron. Drainage of overburden and muskeg when preparing mine sites may increase iron concentrations in receiving surface waters. Dissolved iron concentration was also negatively correlated with conductivity ($r^2 = 0.76$) consistent with peatlands operating as an iron source. Dissolved iron concentrations at the WSC, ditch and upstream sites were 0.21, 0.10 and 0.37 $mg \bullet L^{-1}$, respectively. Mean iron concentration at the ditch was lower than at the upstream site ($P < 0.01$, df = 15.3), which may reflect lower relative contributions from muskeg

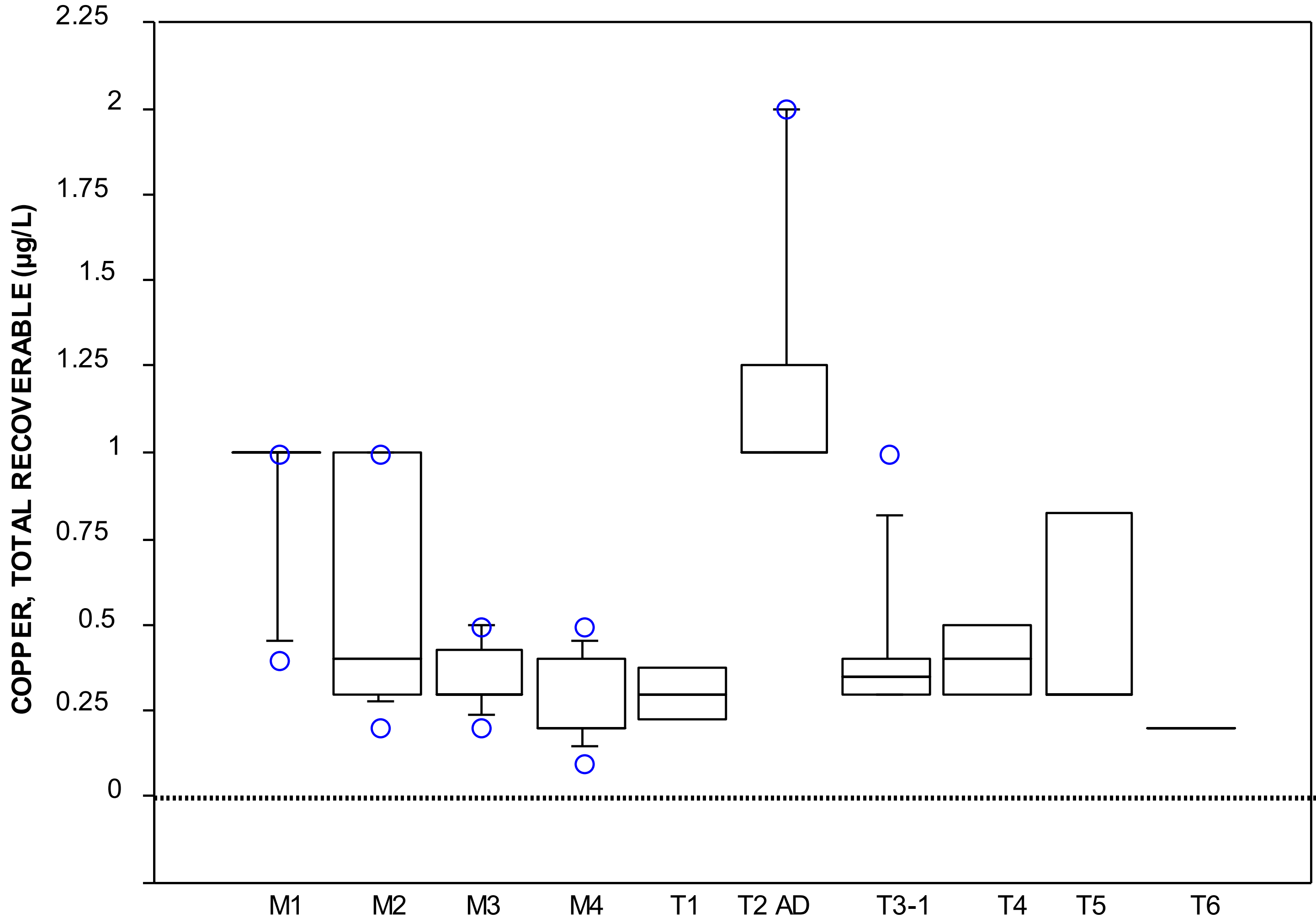


Figure 5.24 Total recoverable copper concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

relative to mineral drainage or a lower capacity to transport dissolved iron due to lower DOC concentrations.

The ASWQG for iron is 0.3 mg•L^{-1}. In the Muskeg basin, water pooled on muskeg contained an average 0.2 mg•L^{-1} dissolved iron, shallow (<10 m) groundwater contained 1.1 mg•L^{-1} dissolved iron, and water in peat soils was a mixture averaging 0.5 mg•L^{-1} dissolved iron (Schwartz and Milne-Home 1982). The Muskeg River is expected to exceed ASWQG for iron naturally, as soil source waters contain higher dissolved concentrations than guideline values for total iron. Water quality guidelines for brown rivers in northern Alberta may have to account for the elevated iron concentrations often associated with high DOC concentrations, keeping in mind that complexes with DOC likely reduce dissolved iron availability.

Total iron concentrations fluctuated seasonally with elevated values from December through March. Low dissolved oxygen concentrations and relatively high TSS concentrations during these months likely account for the seasonal fluctuation in total iron.

5.5.9 Lead

Weathering of sulfide ores is the predominant natural source for lead. However, atmospheric loading from industrial sources and combustion of fossil fuels are often much higher than natural sources. The ASWQG for lead ranges from 1 to 7 µg•L^{-1} depending on water hardness. Mean dissolved lead concentrations at the WSC, ditch and upstream sites were 0.06, 0.19 and 0.1 µg•L^{-1}, respectively. The highest dissolved lead concentration at the drain site was 0.5 µg•L^{-1}, which skewed the limited concentration data (Figure 5.25). Mean concentrations were not different among the three sites. Lead does not appear to be a problem in the Muskeg River at this time.

5.5.10 Lithium

Natural sources for lithium do exist and are often associated with sodium minerals. Significant loading can occur from coal combustion. There are no ASWQG or CCME guidelines for lithium concentrations in the aquatic environment. Total recoverable lithium concentrations at the WSC, ditch and upstream sites were 9.9, 10.4 and 10.4 µg/L, respectively. Mean concentrations were not different among sites. High concentrations of lithium relative to other sites were measured in Shelley Creek (Figure 5.26).

5.5.11 Manganese

Significant sources of manganese to aquatic systems are the weathering of metamorphic and sedimentary rock. Industrial sources in the Muskeg River basin are likely limited to potential loading from site drainages. Surface water quality guidelines for manganese have not been proposed by the CCME or the ASWQG. Total recoverable manganese at the WSC, ditch and upstream sites were 196, 376 and 207 µg•L^{-1}, respectively. The mean concentration of total recoverable and dissolved manganese in water from the ditch site was not different from the WSC and M3 sites ($P > 0.16$), however, occasionally high concentrations were released from the ditch (Figure 5.27a, 5.27b). Manganese concentrations in the ditch were particularly high during

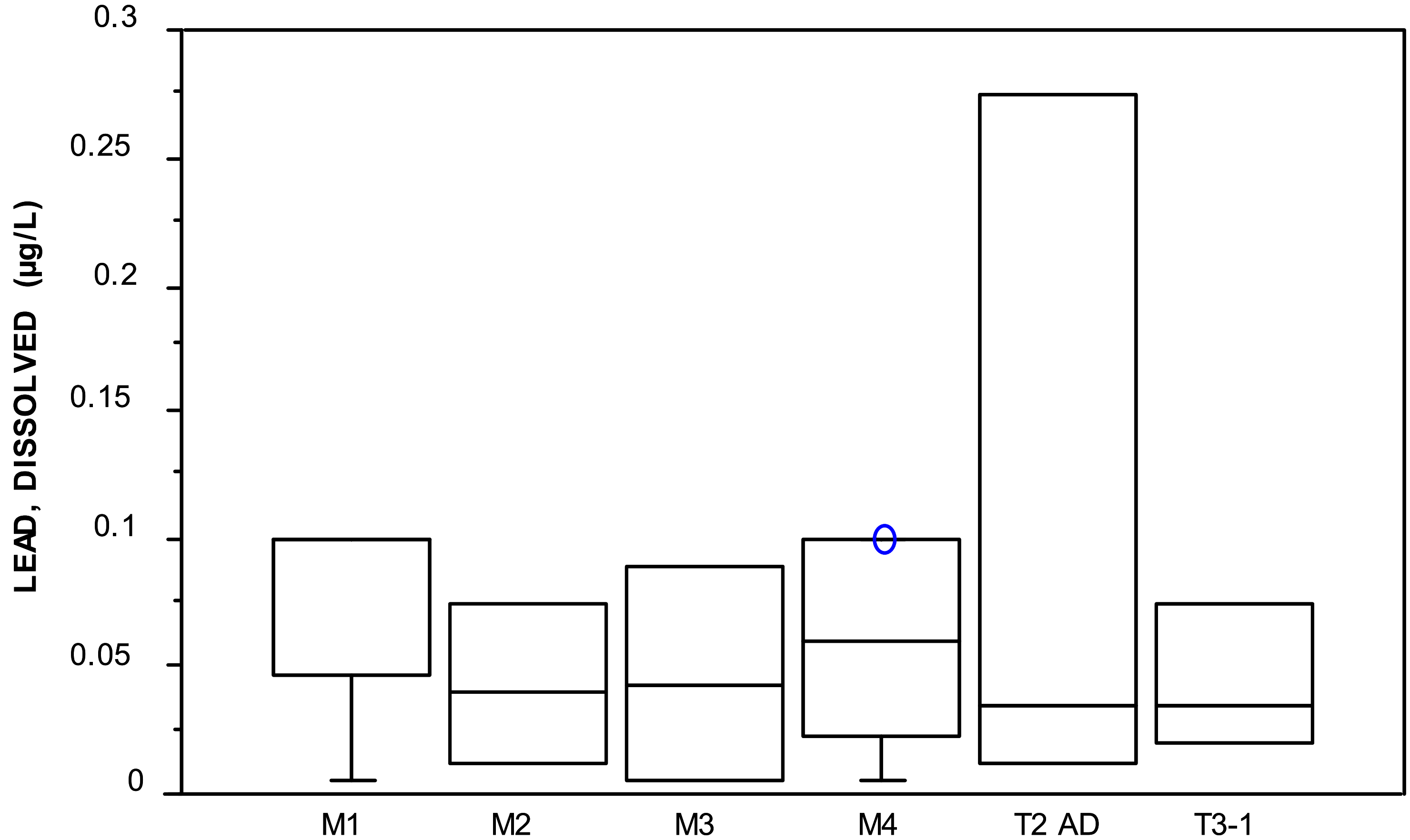


Figure 5.25 Dissolved lead concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

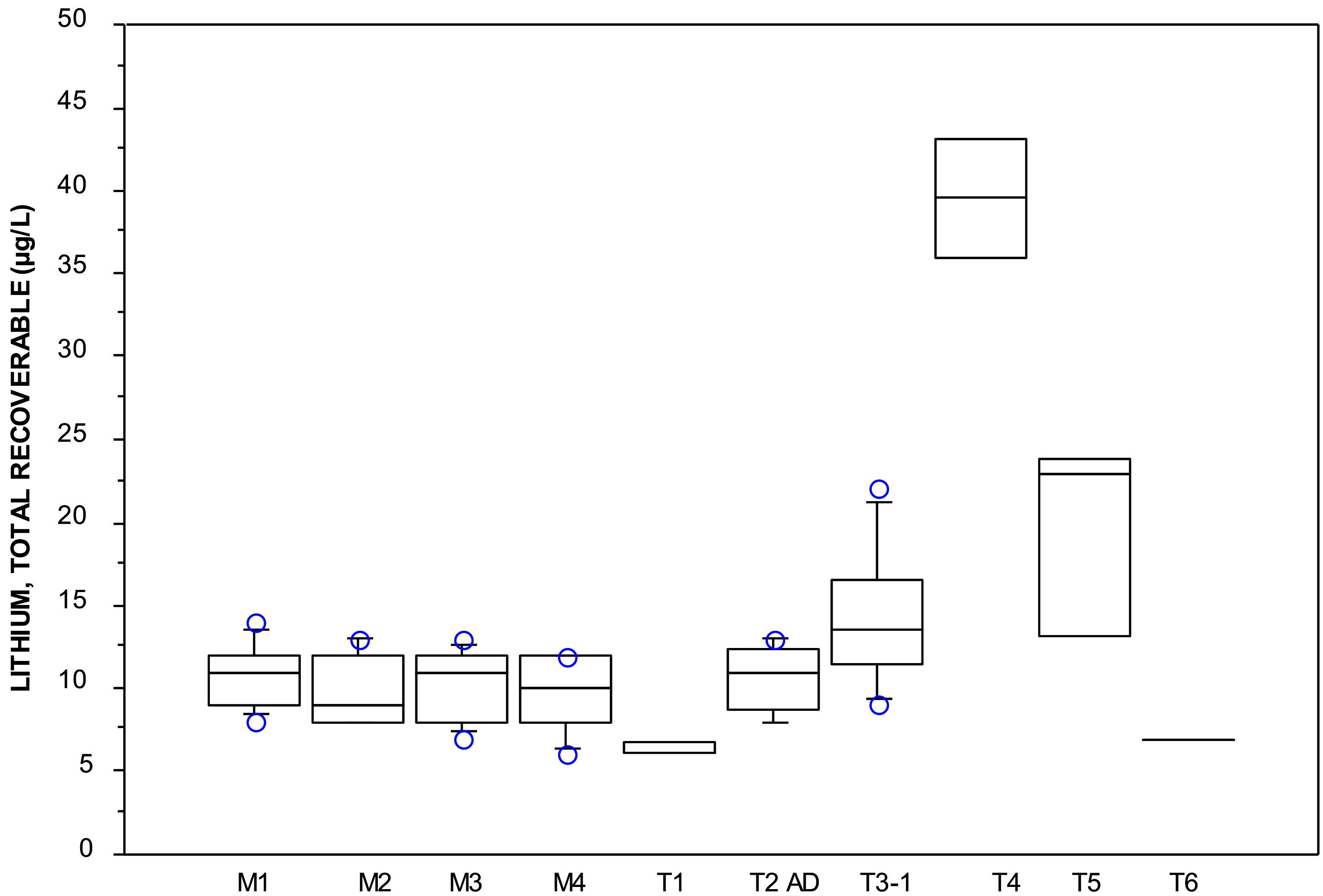


Figure 5.26 Total recoverable lithium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

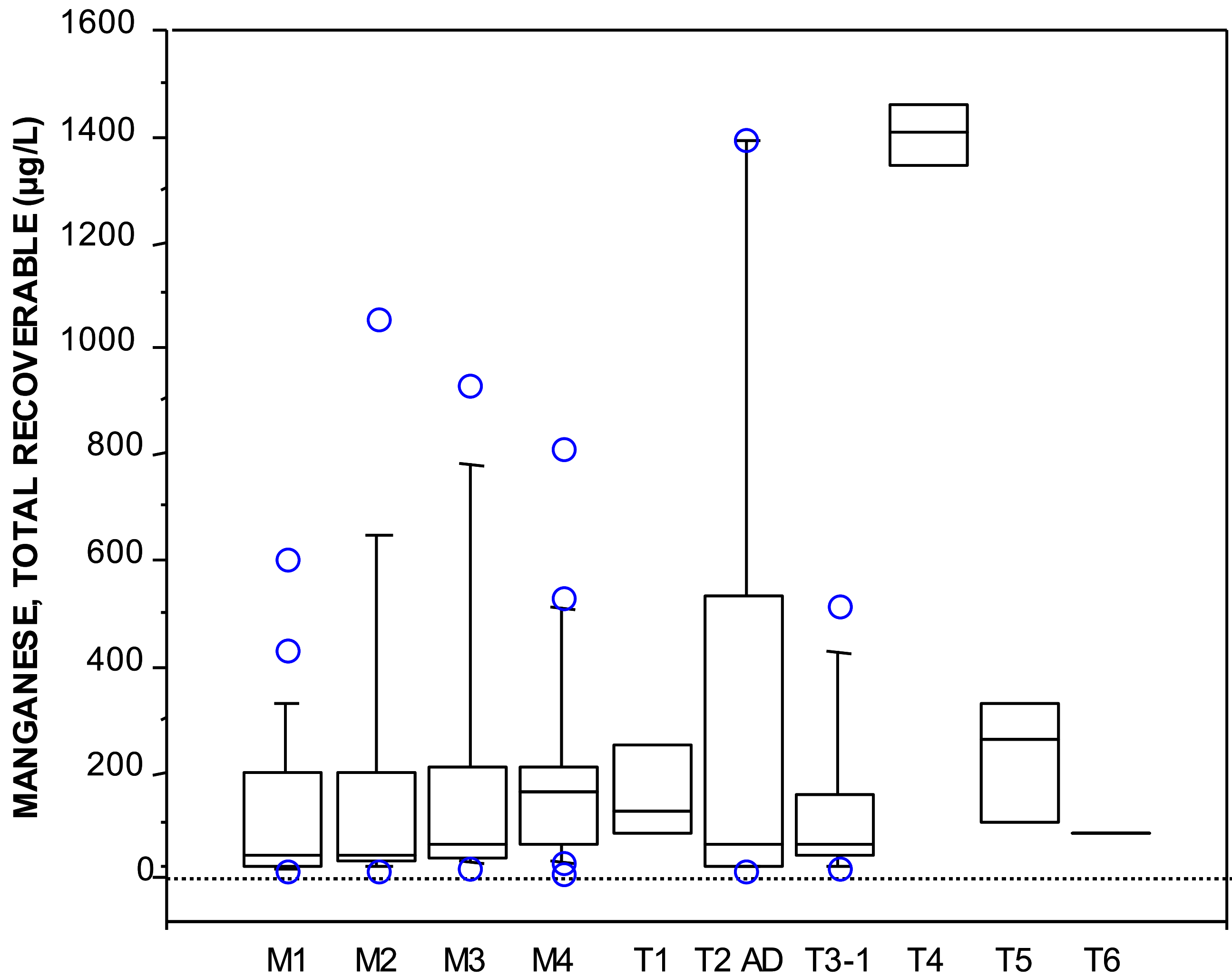


Figure 5.27a Total recoverable manganese concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

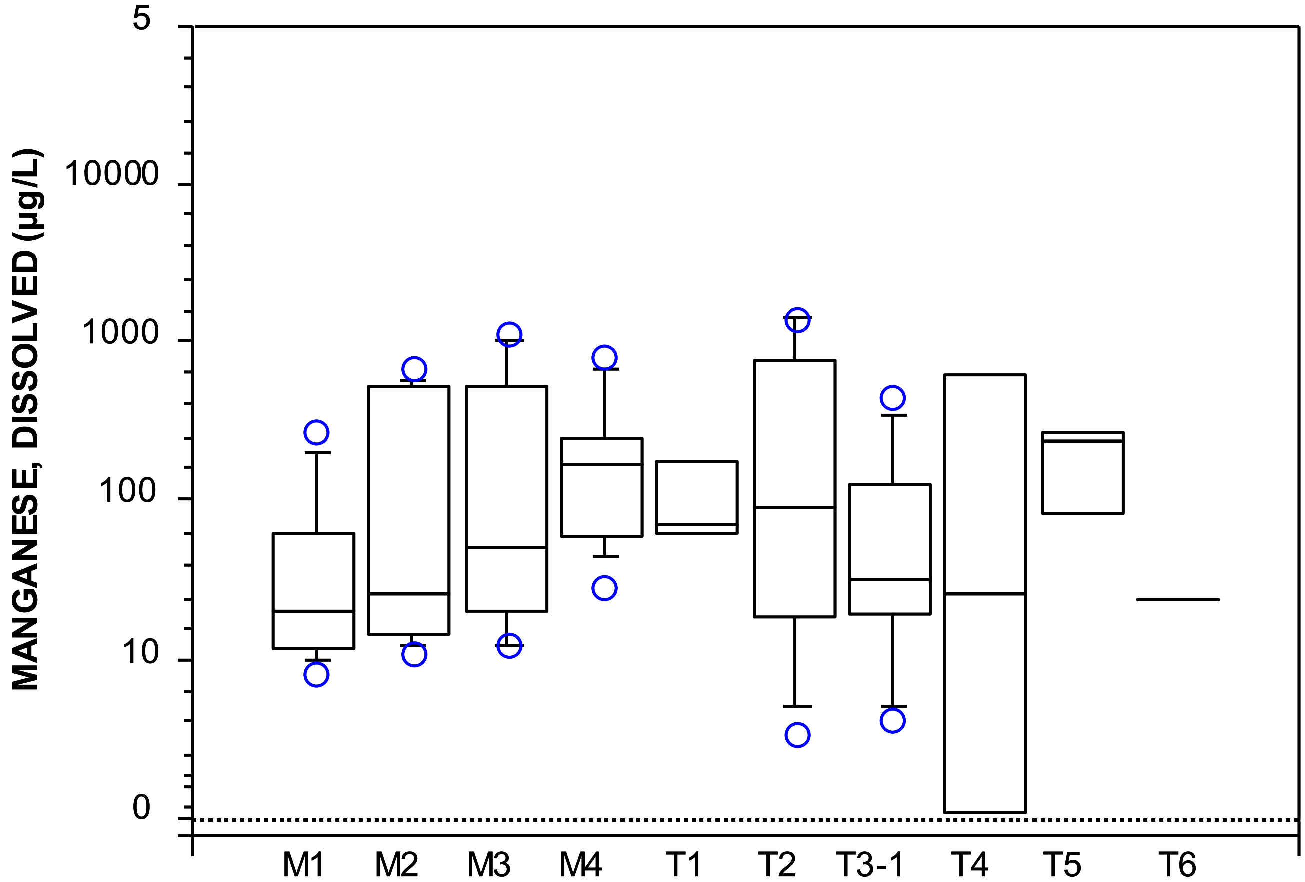


Figure 5.27b Dissolved manganese concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

the winter of 1999 (1400 µg•L^{-1}), almost 2 to 3-fold higher when compared to upstream and WSC concentrations. At all three sites, winter concentrations were often 10 to 20-fold higher than concentrations in open water season samples. Shelley Creek contained high concentrations of total recoverable manganese (> 1300 µg•L^{-1}) but concentrations of dissolved manganese (<1 to 627 µg•L^{-1}) were consistent with other sites. Groundwater is likely the major source for manganese in the Muskeg basin.

Despite the seasonal pattern, manganese was not correlated with TSS concentration at the WSC site. However, mean dissolved manganese concentrations reported in Table 5.3 were slightly higher than total recoverable concentrations for the upstream (M3) and ditch sites because of additional analyses during periods of high concentration which corresponded to periods of high turbidity at those particular sites. Dissolved manganese analyses often returned slightly higher concentrations than total recoverable analyses during periods of high concentration possibly because of sample dilution effects or interference in turbid whole water samples.

5.5.12 Mercury

Mercury was not sampled in 1998-99 but was in 2000 and 2001. Mercury is of particular concern in brown water systems because it readily complexes with DOC, increasing potential exposure of biota. Without DOC mercury tends to bind to soil sulfur groups making it relatively unavailable for biological uptake (Schnoor 1996). Unlike other metals, mercury toxicity may be enhanced by the presence of DOC because microbial reduction of DOC causes the methylation of mercury to the toxic form CH_3Hg^+. Several studies have noted that mercury concentration in lake fish increases with lake DOC concentration (Verta 1990; Rask and Metsala 1991).

Mercury concentrations were below the limit of detection (5 07 ng•L^{-1}) in all four 2000 – 01 samples collected at the WSC site (Figure 5.28). Samples collected at the mouth site between 1995 and 1997 were also below the limit of detection (5 ng•L^{-1}). Most samples collected prior to 1982 were at or below the limit of detection which was substantially higher at that time (100 ng•L^{-1}). Most of the pre-1982 values especially the 4000 ng•L^{-1} concentrations recorded from the Muskeg River in 1976-77 (Appendix 3) are likely the result of the limited accuracy and contamination that is generally believed to have occurred in mercury analysis prior to the 1990s. The ASWQG for total mercury is 13 ng•L^{-1} for acute exposure and 5 ng•L^{-1} for chronic exposure. Mercury does not appear to be a problem in the Muskeg River at this time.

5.5.13 Molybdenum

Other than natural sources, molybdenum loading occurs primarily from fertilizers containing the element. Molybdenum is essential for algal photosynthesis but is toxic at high concentrations. CCME guidelines for molybdenum are 73 µg•L^{-1} and are under review. Average total recoverable molybdenum concentrations at the WSC, ditch and upstream sites were 0.13, 0.29 and 0.07 µg•L^{-1} with no data below detection (Figure 5.29). Molybdenum concentrations were higher at the ditch site compared to both WSC and upstream sites ($P << 0.01$, df ≥ 8.5) and higher at the WSC site compared to the upstream site ($P < 0.01$). Flow from the Alsands drain appears to be a source of molybdenum, the signature of which can be seen downstream at the WSC site. However, concentrations were more than 250-fold lower than the CCME guideline.

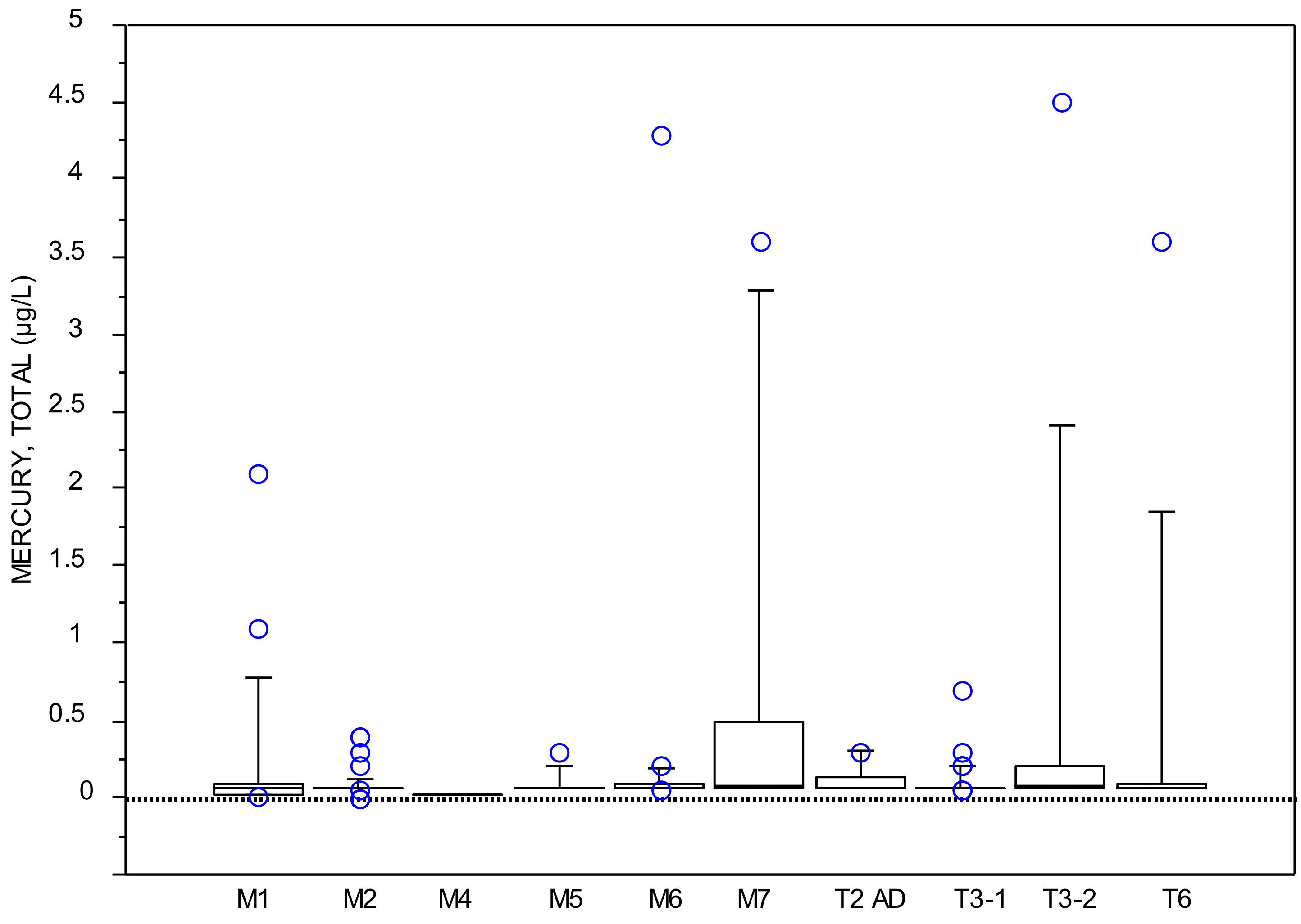


Figure 5.28 Total mercury concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

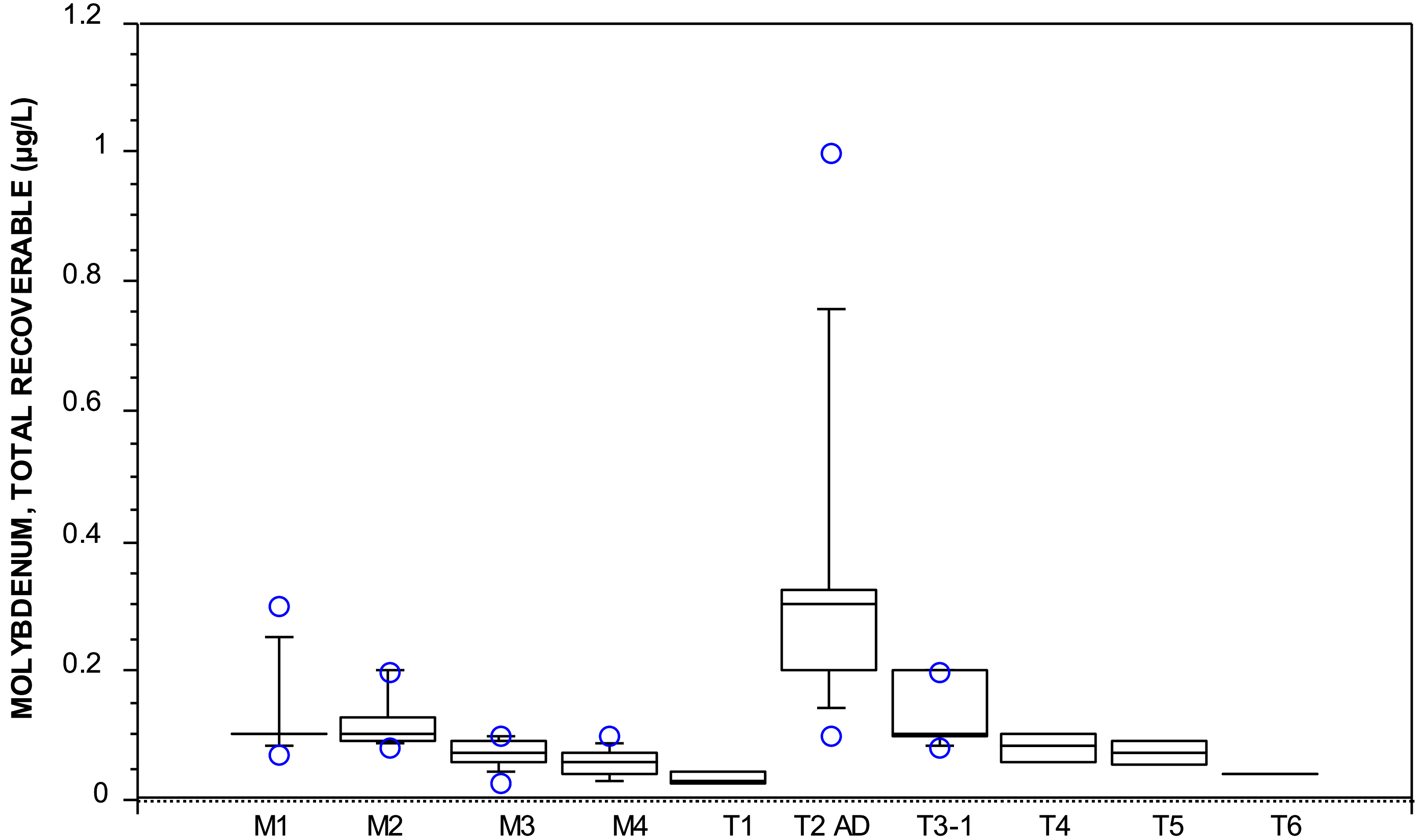


Figure 5.29 Total recoverable molybdenum concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

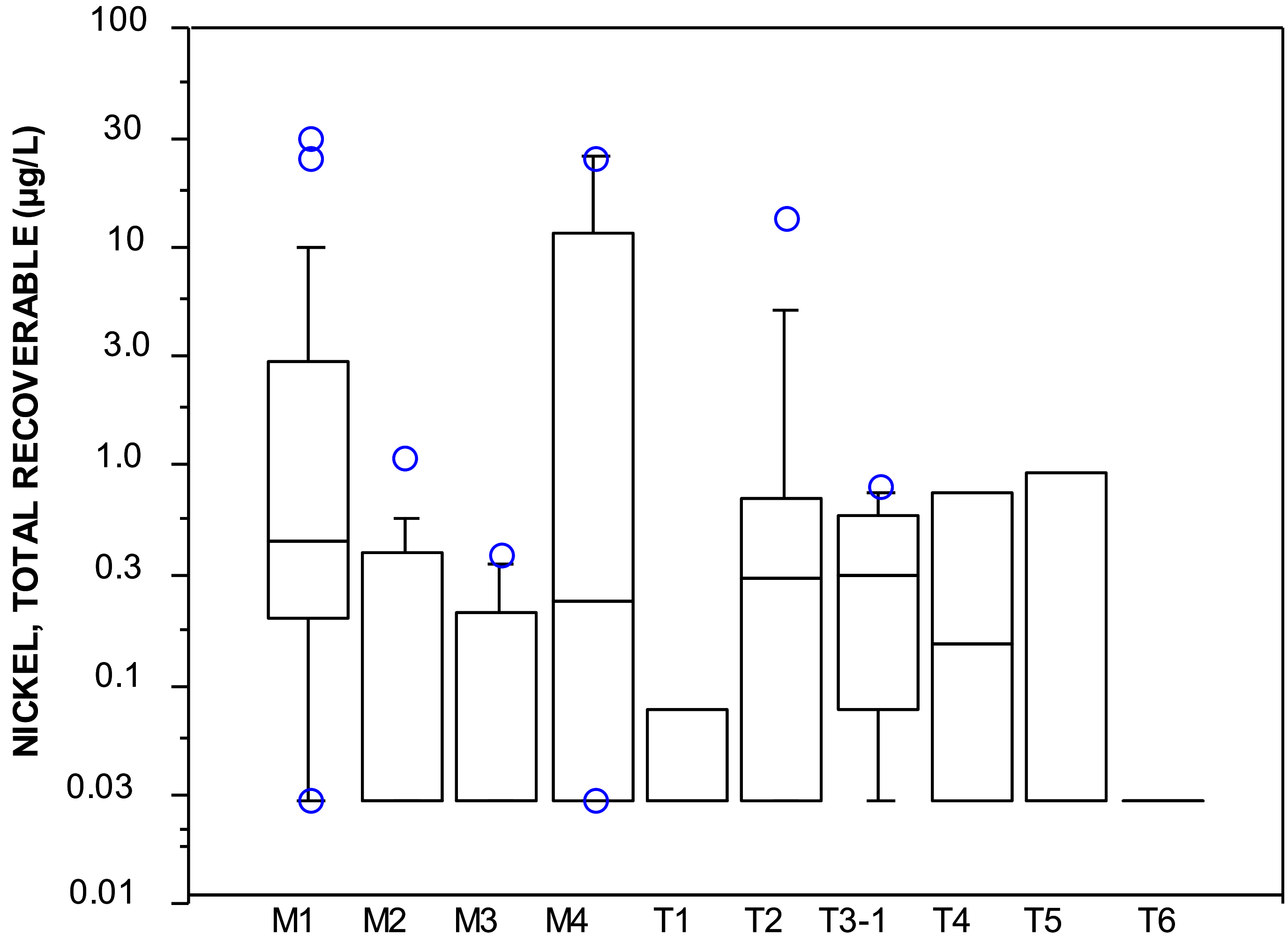


Figure 5.30 Total recoverable nickel concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

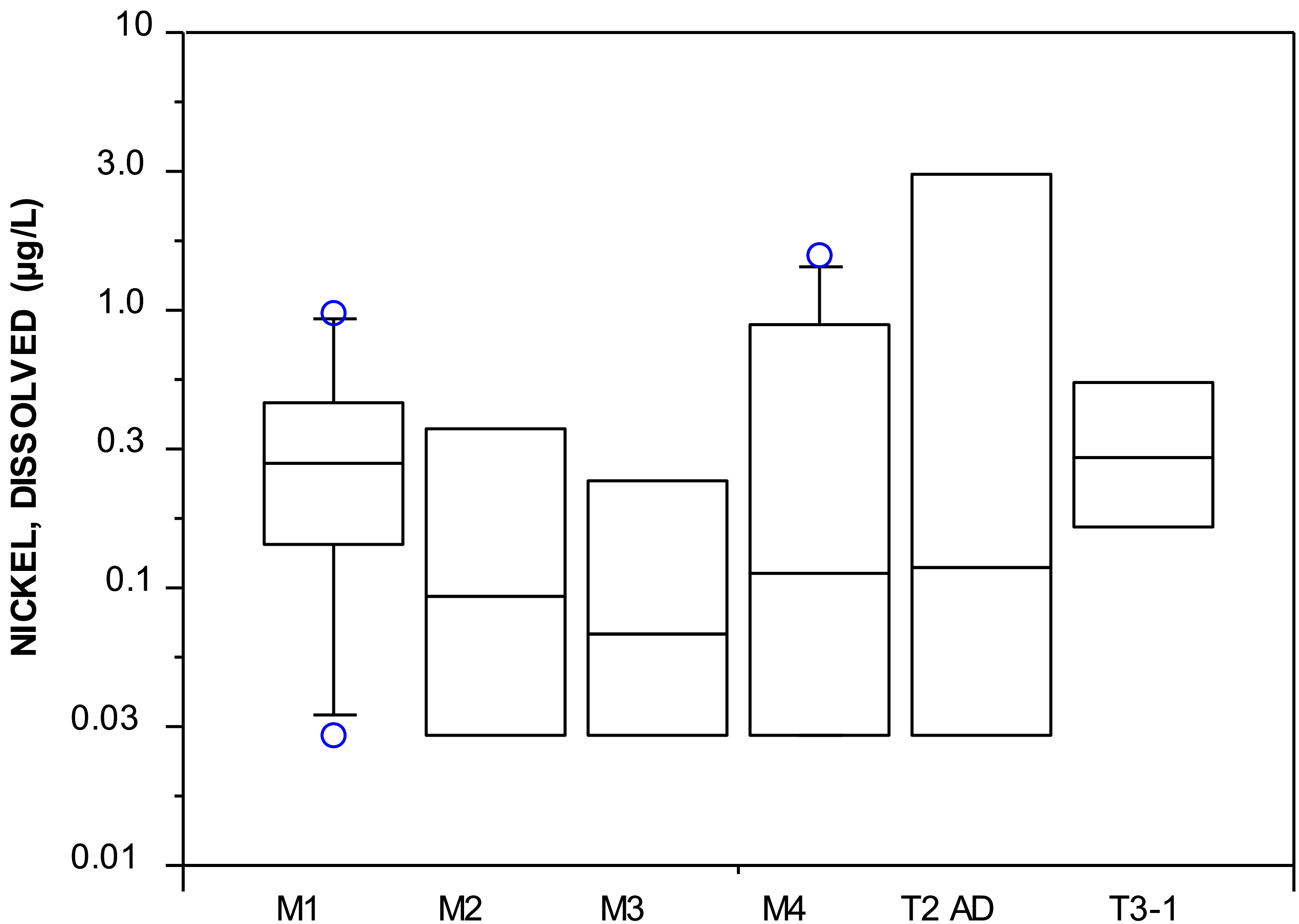


Figure 5.31 Dissolved nickel concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

5.5.14 Nickel

Natural loading of nickel from weathering can be significantly enhanced by depositional sources from the burning of fossil fuels (CCREM 1987). The ASWQG for nickel is dependant on water hardness and ranges from 65 to 150 $\mu g \bullet L^{-1}$ for hardness values typical in the Muskeg River and its tributaries (100 to 325 $mg \bullet L^{-1}$ $CaCO_3$). Mean total recoverable nickel concentrations at the WSC, ditch and upstream sites were 0.24, 1.77 and 0.12 $\mu g \bullet L^{-1}$, respectively. The mean concentration of total recoverable and dissolved nickel for water from the ditch site was not significantly different from the WSC and M3 sites ($P > 0.4$). Concentrations of nickel in waters from all three sites were usually below 0.6 $\mu g \bullet L^{-1}$ although periodic high concentrations were recorded (Figure 5.30, 5.31).

Like manganese, mean dissolved nickel concentrations reported in Table 5.3 are higher than total recoverable concentrations for the upstream and ditch sites. In the case of nickel this occurred because fewer samples were analyzed from open water periods when concentrations were low. In addition, dissolved nickel analyses returned higher concentrations than total recoverable analyses on two occasions possibly because of sample dilution effects or interference in turbid water samples.

5.5.15 Selenium

Both total and dissolved selenium concentrations were below the limit of detection (0.5 µg/L), except one sample (May 1999) at the WSC site (0.6 µg/L). The ASWQG for selenium is 1 µg/L. Selenium does not appear to be a concern in the Muskeg River at this time.

5.5.16 Strontium

Strontium is a radionuclide that occurs as a weathering product of uranium ore. The only guidelines for strontium are for radioactivity of its isotope strontium-90, a product of fallout from atomic bomb testing. No strontium-90 data were collected in the Muskeg River surveys. Total strontium was measured in total recoverable and dissolved forms for which no guidelines are currently available. Mean concentrations of total recoverable strontium at the WSC, ditch and upstream sites were 186, 308 and 170 $\mu g \bullet L^{-1}$, respectively. Strontium concentrations at the ditch site were elevated compared to the WSC and upstream sites ($P << 0.01$, $df \geq 8.6$), perhaps reflecting overburden drainage from oil sands mining since strontium can be abundant in groundwater. Shelly Creek also had a high strontium concentration relative to other sites (Figure 5.32), again possibly reflecting groundwater discharge. Dissolved strontium was only measured at the drain site and indicated 97% of total recoverable strontium was in dissolved form.

5.5.17 Uranium

Uranium is a naturally occurring element with potential for environmental release from mining activities in uranium-containing geologic formations. The only guideline for uranium is the CCME guideline for irrigation water of 10 $\mu g \bullet L^{-1}$. Mean concentrations of total recoverable uranium at the WSC, ditch and upstream sites were 0.16, 0.69 and 0.07 $\mu g \bullet L^{-1}$, respectively

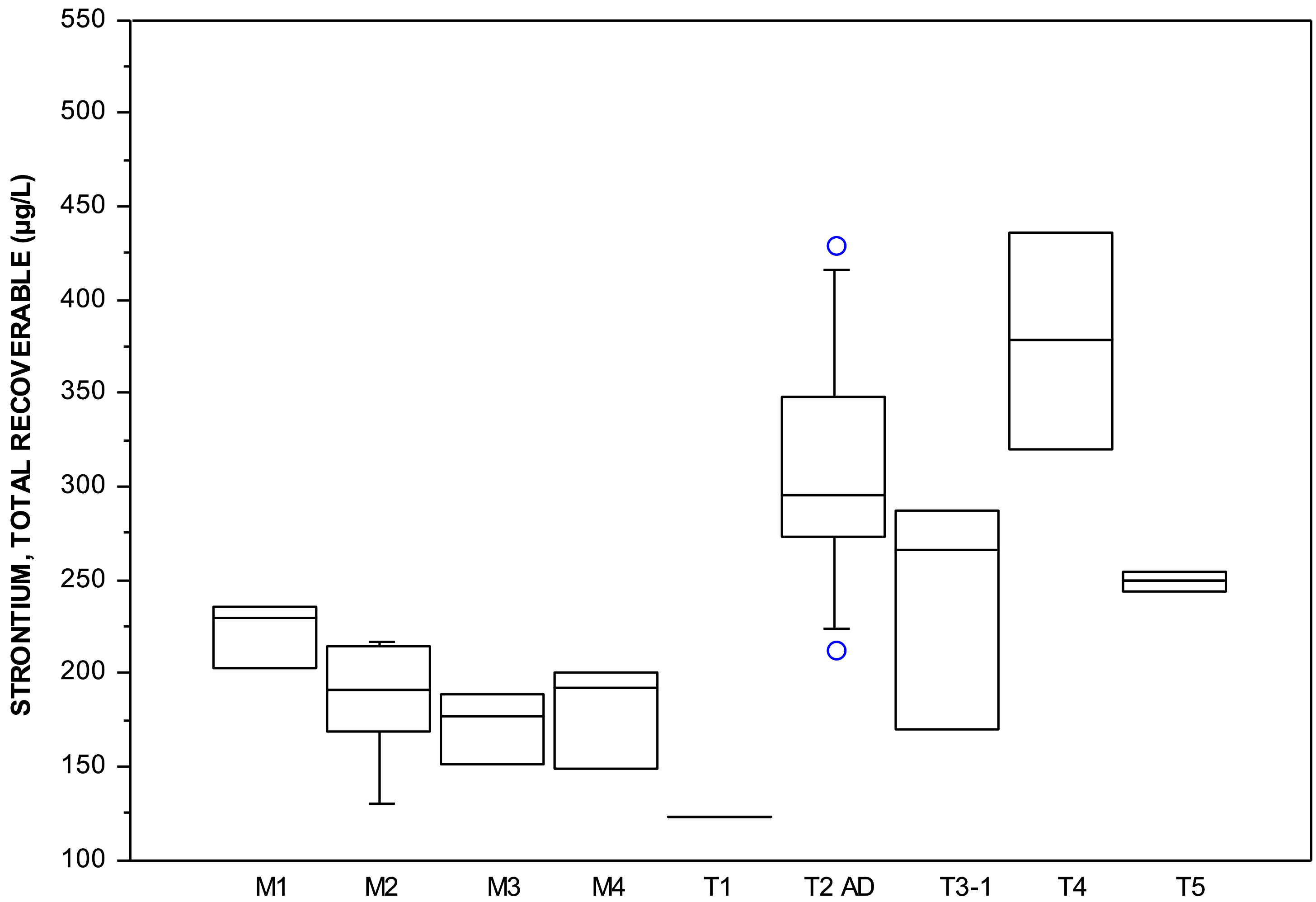


Figure 5.32 Total recoverable strontium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

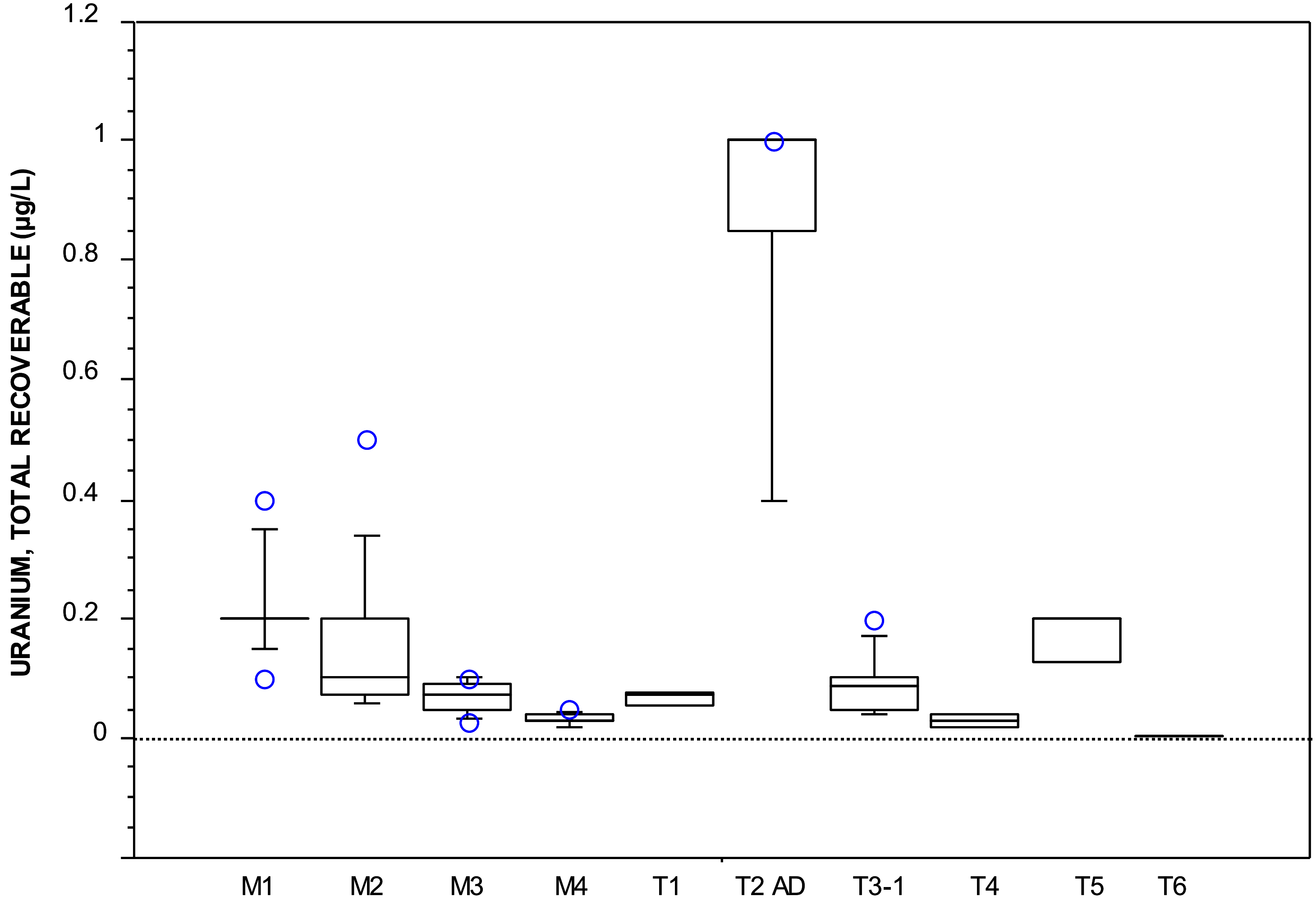


Figure 5.33 Total recoverable uranium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

(Figure 5.33). Total recoverable and dissolved uranium concentrations were higher at the ditch site compared to the WSC and upstream sites ($P << 0.01$, df $\geq$ 8.5). The higher uranium in the Alsands Ditch may reflect overburden drainage, although concentrations were still well below the CCME guideline. The implication for aquatic life of uranium in stream water is not well understood, although there does not appear to be evidence of uranium toxicity to aquatic life at these concentrations.

5.5.18 Vanadium

Although vanadium is released into the aquatic environment from clays and seepage from carbonaceous deposits, it is also relatively abundant in oil sands. Surface water quality guidelines for vanadium are not included in the ASWQG. Total recoverable vanadium concentrations at the WSC, ditch and upstream sites were 0.36, 0.42 and 0.34 $\mu g \bullet L^{-1}$, respectively (Table 5.3). Mean dissolved vanadium concentrations were 0.24, 0.26 and 0.20 $\mu g \bullet L^{-1}$ at the WSC, ditch and upstream sites, respectively. The mean concentration of total recoverable and dissolved vanadium of water from the ditch site was not different from the WSC and upstream sites ($P > 0.3$). Contributions of vanadium from the Alsands ditch appear to be minimal at this time. Dissolved vanadium concentrations did not increase at upstream sites. However, total recoverable concentrations were elevated in Shelley and Jackpine Creeks (Figure 5.34, 5.35) possibly in association with suspended sediments.

5.5.19 Zinc

Zinc has both natural and industrial sources. Sources of zinc from oil sands development would likely be due to enhanced weathering of exposed zinc containing minerals. The ASWQG for zinc is 30 $\mu g \bullet L^{-1}$. Mean concentrations of total recoverable zinc at the WSC, ditch and upstream sites were 3.3, 5.6 and 1.5 $\mu g \bullet L^{-1}$. Total recoverable zinc concentrations were elevated at the ditch site compared to the upstream site ($P = 0.04$, df 9.1). Dissolved zinc samples were too few to determine if concentrations were higher at the ditch site. Mean dissolved zinc concentrations reported in Table 5.3 are elevated compared to total zinc because the limited number of samples focused on periods of higher concentration. Total recoverable zinc concentrations at the ditch site had a maximum of 18.5 $\mu g \bullet L^{-1}$ (Figure 5.36). Enhanced monitoring for zinc is needed to determine if site drainage will contribute zinc in quantities that might exceed the ASWQG.

5.6 Trace Organic Pollutants

Alberta Environment has monitored polycyclic aromatic hydrocarbons (PAH) at several sites in the Muskeg River system. As well, two samples from the mouth site (1996, 97) and one sample from the WSC site (2001) were analyzed for adsorbable organic halides (AOX), and USEPA volatile priority pollutants (VPP) and extractable priority pollutants (EPP). Concentrations of AOX were 5 and 33 μg/L. All EPP and VPP analytes were below limits of detection.

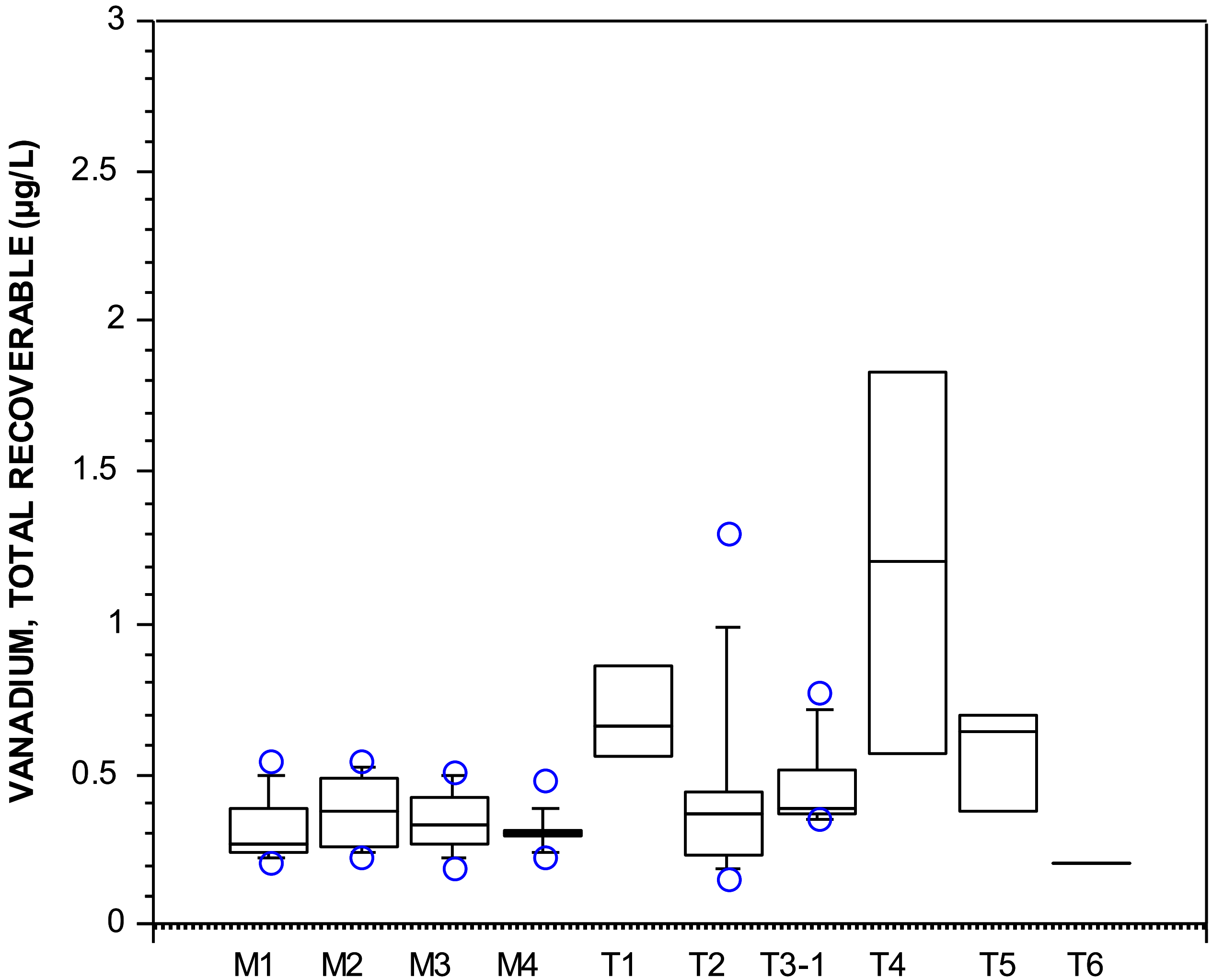


Figure 5.34 Total recoverable vanadium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

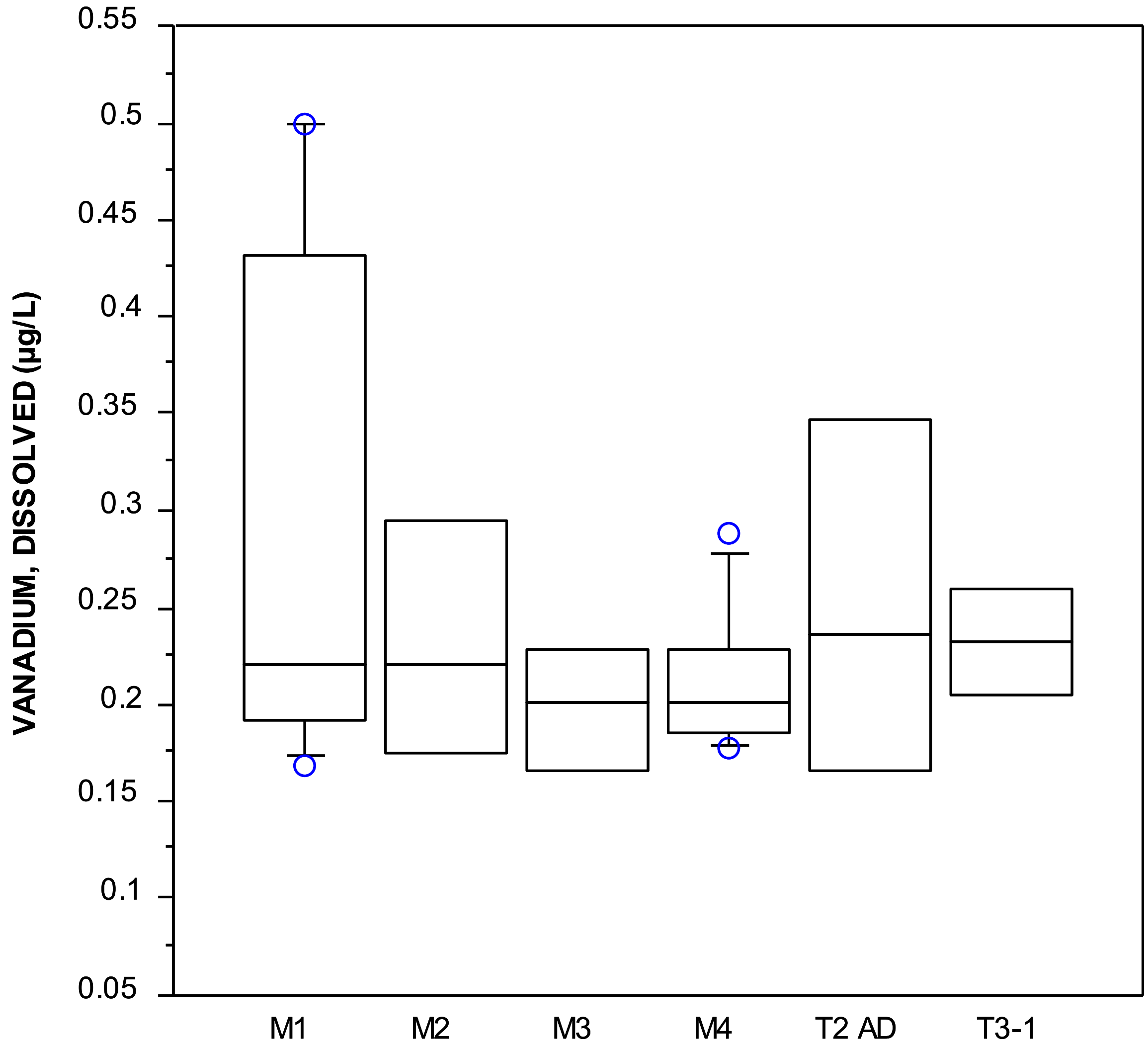


Figure 5.35 Dissolved vanadium concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

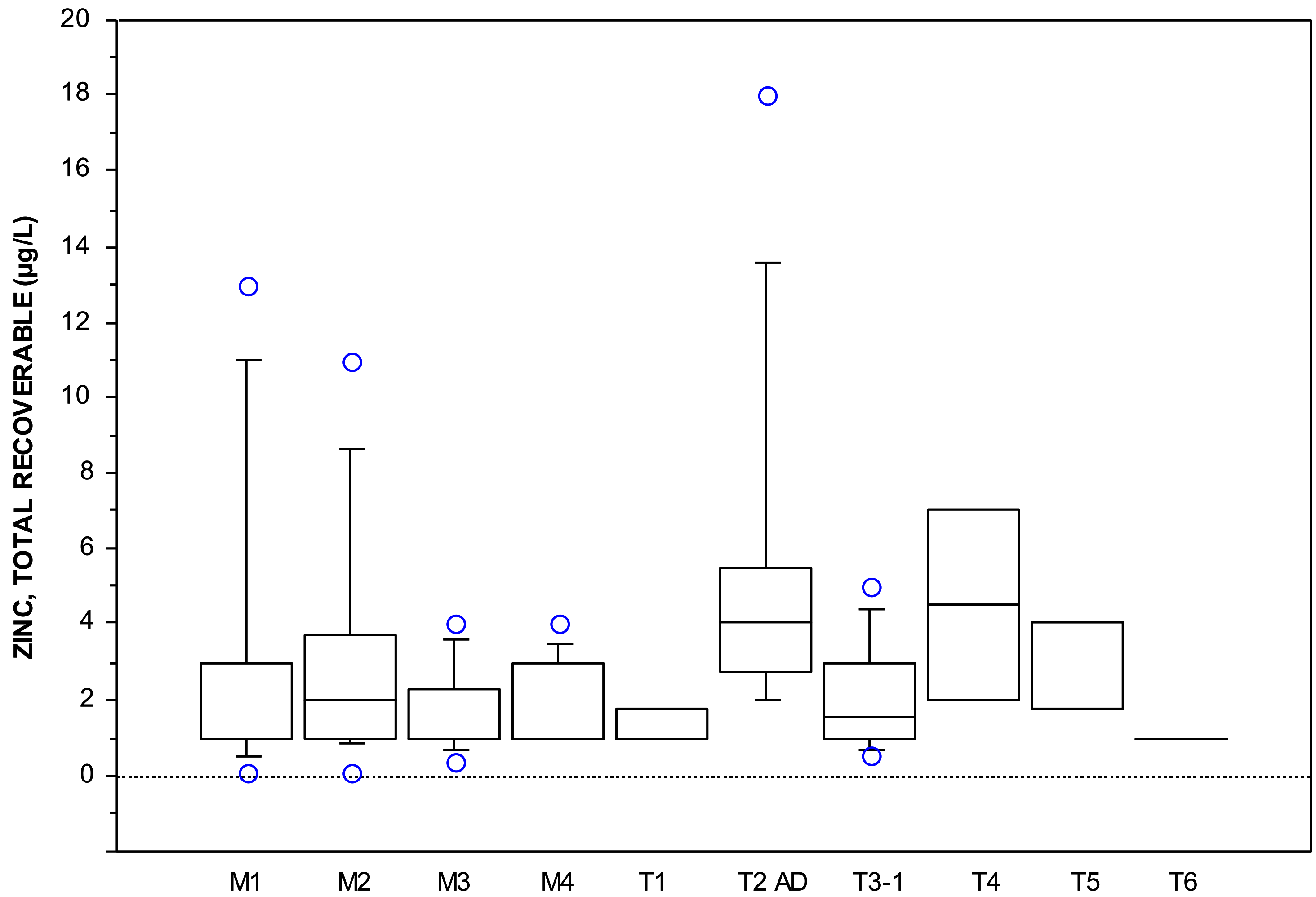


Figure 5.36 Total recoverable zinc concentrations at Muskeg River sites from mouth (M1) towards headwaters (M4) and tributaries aligned from downstream (T1) to headwaters (T6)
Sites labels follow map (Figure 3.1). See Fig. 5.1 for legend explaining box plots.

Table 5.4 Polycyclic Aromatic Hydrocarbon concentrations at sites where concentrations exceeded detection limits
Guideline values are from Alberta Environment (1999)

Site	Date	PAH Detected	Concentration (µg/L)	Guideline (µg/L)
Muskeg Mouth	Feb. 2000	Acenaphthylene	0.035	5.8[1]
		Phenanthrene	0.012	0.4
		Napthalene	0.89	1.1
		Fluorene	0.016	3.0
Muskeg WSC	July 1999	Benzo(a)anthracene	0.003	0.018
		Benzo(b,j,k)fluoranthene	0.009	ng
		Benzo(g,h,i)perylene	0.002	0.015[2]
		Chrysene	0.004	ng
		Fluoranthene	0.004	0.04
		Indeno(1,2,3-c,d)pyrene	0.004	ng
		Phenanthrene	0.003	0.4
		Pyrene	0.004	0.025
Alsands Ditch	July 1999	Benzo(b,j,k)fluoranthene	0.009	ng
		Benzo(g,h,i)perylene	0.004	0.015[2]
		Chrysene	0.004	ng
		Dibenz(a,h)anthracene	0.002	ng
		Fluoranthene	0.002	0.04
		Indeno(1,2,3-c,d)pyrene	0.005	ng
		Phenanthrene	0.002	0.4
		Pyrene	0.003	0.025
	May 1999	Acenaphthene	0.004	5.8
		Chrysene	0.002	ng
		Fluorene	0.002	3.0

[1] Guideline for related compound, Acenaphthene.
[2] Guideline for related compound, Benzo (*a*) pyrene.
ng = no guideline

5.6.1 Polycyclic Aromatic Hydrocarbons (PAHs)

The complete analytical results for PAHs are compiled in Appendix 4. A total of 37 water samples from the Muskeg River system have been analyzed for PAHs under this program, and only four samples had detectable levels of PAHs. The method detection limit (MDL) has been 0.01 µg/L, although the ARCV laboratory regularly provides estimates of concentrations lower than that, if they are confidant of the analyte's identity. The detected PAHs and their concentrations are summarized in Table 5.4. Note that most of the concentrations are estimated values, less than the MDL. Also, detected PAH concentrations at all sites were one to two orders of magnitude below current guidelines except napthalene at the mouth site, which was 82% of the current guideline. The detection of PAHs at the ditch and WSC sites but not at upstream sites in July 1999, suggests that the Alsands Ditch may have been the source for the PAHs detected downstream in the Muskeg River. Samples were not collected at the mouth site during July 1999.

5.6.2 Odour

Observations of water odour are routinely recorded by field crews. Care is taken to evaluate water odour in fresh samples in clean glass sample jars. Odour is generally rated as nil, low, medium, or high (relative to most surface waters), and the quality described. These are qualitative observations, as opposed to lab analyses, and are subject to individual abilities and interpretation. Nonetheless, they are pertinent to water quality and relevant to what recreational and other users may perceive. Compounds causing odour may taint the flesh of fish.

Most field evaluations of odour in this work found that when odour was detectable in the Muskeg River system, it was of a musty or swampy nature, and appeared natural. However, a more petroleum-like odour was noted in the Alsands Ditch on some occasions. Samples for volatile priority pollutants were collected from the Ditch site, but no compounds were detected. It may be that the ditch system draining oil sands leases and feeding the Alsands Ditch intersected the top of the oil sands formations, and thus receives some odorous compounds. The oil sands formations are near the ground surface in this area. Odour was not detected downstream of the Alsands Ditch in the Muskeg River in the 1998-2000 work, but has been subsequently. Follow-up work is occurring on this.

6.0 DISCUSSION

The Muskeg River basin drains peatlands and mixedwood forests and derives its water primarily from shallow groundwater passing through organic deposits, till, and alluvium. Runoff contains high concentrations of organic carbon and major ions, which is typical for boreal streams in Alberta and is high relative to rivers elsewhere in the world. Oil sands mining activities will intersect and influence flow paths for surface and groundwater that, in addition to contributions from reclamation waters, have the potential to significantly alter water chemistry in the Muskeg River.

Several general characteristics of the Muskeg River and its tributaries appear to be important in determining the surface water chemistry at various sites along the river. Peatlands form a large component of the entire drainage basin, accounting for 50 to 90% of the area in some of the sub-basins. In the headwaters, the peatlands are elevated above the surrounding landscape. These peatlands receive most of their water from precipitation and discharge water characteristic of mineral poor bogs. The water may have relatively high concentrations of phosphorus, and low concentrations of nitrogen and mineral ions, compared to other sources in the Muskeg Basin. Water in upper areas of the Muskeg River and its tributaries reflect the influence of mineral poor peatwater contributions. Both mineral poor and rich peatlands exist in lowland locations closer to the Muskeg River mainstem. Sodium and calcium signatures, as well as ion concentrations, suggest a majority of water discharged from either peatlands or groundwater first interact at the peat-mineral interface before moving laterally to surface channels.

Thus discharge from mid-basin tributaries can contain relatively high concentrations of mineral ions and nitrogen from groundwater and relatively high concentrations of phosphorus and dissolved organic carbon from peatlands. In the headwaters we hypothesize that interflow travels through shallow peat, whereas in lowlands interflow travels along the peat-mineral interface. Subsurface geology contributes to the dichotomy between upland and lowland surface water chemistry. The uplands are underlain by >100 m of glacial and post-glacial deposits of till, silt and sand (Schwartz and Milne-Home 1982). The lowlands are influenced by groundwater produced from lithic sands and sandstone. The two distinct groundwater sources may be separated by shale which does not promote vertical exchange of groundwater (Schwartz and Milne-Home 1982). Water infiltrates in upland areas dissolving mineral ions from easily weathered till which is discharged in upland and midsection reaches of high soil permeability. Lower river sections are influenced by deeper groundwater draining the sandstones below shale deposits. As the river intersects deeper geologic strata such as the Clearwater formation, the influence of groundwater discharge with relatively high ion concentration can be observed in surface water samples at the river mouth (Akena 1979).

Gradient along the Muskeg River mainstem appears to be important to surface water quality in the various reaches. In the headwaters below peatland plateaus, gradient is high resulting in rapid drainage without modification by biotic processes in the stream. Along the mid section of the river below Wapasu Creek, the river channel gradient is shallow and pools are formed by beaver dams. The low gradient and beaver ponds combine to produce low current velocities, extensive macrophyte growth and possibly higher oxygen demand in the organic-rich ponds. Sedimentation and biotic activity reduce phosphorus, nitrogen and dissolved organic carbon concentrations in stream water along this reach. Decomposition of organic matter in the low gradient reach also results in increased ammonia (reduction of nitrate and denitrification during organic decomposition) and reduced dissolved oxygen concentration and pH, particularly during winter ice-cover. The channel gradient of the Muskeg River increases again after the confluence of Jackpine Creek and downstream from there, a general increase in dissolved oxygen concentration occurs relative to upstream sites.

Flow paths and the residence time of groundwater in soils change seasonally, with the result that water chemistry in streams receiving groundwater inputs also fluctuates seasonally. The major seasonal events are snowmelt, the thawing of peatlands, declining flows during the late open water season and ice cover during winter months. Snowmelt causes a pulse in runoff, which is usually dilute in base cations and other constituents from geologic sources, but which may be high in organic compounds. Peak total cation concentrations in January and February were followed by minimum concentrations between April and May as a result of snowmelt runoff. Snowmelt in the Muskeg River basin appears to flow largely through shallow frozen soil systems, because declining winter DOC concentrations increased marginally in spring. However, thawing of most peatlands probably occurred by June when DOC concentrations in the Muskeg River stabilized between 20 and 30 $mg{\bullet}L^{-1}$. Declining flow after October, resulted in a greater proportion of groundwater in the total streamflow. As a result, ions from mineral sources including phosphorus tended to increase in concentration. Once the river was covered by ice, chemical constituents underwent changes typical for the anoxic and reducing conditions that followed in the middle to upper reaches. Oxidized compounds were reduced; for example nitrate was reduced to ammonium, pH declined, and metals concentrations increased. Seasonal fluctuations in water chemistry were important in the Muskeg River and should be considered when assessing its assimilative capacity. High concentrations of some inorganic variables can occur during winter, to the point of exceeding water quality guidelines. Mitigating this could depend on other seasonal factors such as removal of sediment during peak discharges occurring in spring and summer.

Water discharge responded rapidly to storm events in the Muskeg River and discharge depended closely on changes in the annual water budget. Major fluctuations in discharge may be important in aquatic ecosystem function in the Muskeg River. Peak discharge events may serve to purge the system of accumulated sediments, particularly flocculated organic carbon, iron and adsorbed colloids, and are often required to maintain fish spawning habitat (Junk et al. 1989). Field observations suggest ferric hydroxide precipitate may be common in the Muskeg River. Ferric hydroxide can be toxic to *Daphnia magna* and is widely thought to impair ecosystems due to smothering (Soucek et al. 2001). Additional analyses are currently on-going to determine the composition of winter suspended sediments in the Muskeg River.

Discharge was not closely correlated with the concentrations of constituents in the stream except in the case of dissolved oxygen. Dissolved oxygen concentrations were often below Alberta surface water quality guidelines, a condition that may be exacerbated in low flow years. Although historic winter data are few, low DO seems to have occurred naturally during winters with low flow (e.g., 1982). As a preliminary estimate, we suggest a 7.2 m^3/s minimum discharge requirement in the spring and 2.6 m^3/s during the summer if the system is managed to maintain DO concentrations above the ASWQG. These values assume BOD will not increase substantially as mining activities progress. Pulses in BOD occur, however, more data is required to determine if these are natural and under what conditions they occur.

Currently, the Muskeg River is not at risk of acidification. It is well buffered and could ameliorate spikes in loading from acidic sources. The acid neutralizing capacity remained above 1.2 meq•L^{-1}, 16-fold above recommended minimum values for lakes. However, two findings were pertinent here. The first was the contribution of sulfate from the Alsands ditch, which may represent overburden and muskeg drainage waters. Sulfate concentrations in the ditch averaged over 40 times that in the Muskeg River and the sulfate contributions had a clear effect (eight-fold increase) on sulfate concentrations at downstream sites. High sulfate concentrations, typical for acid mine drainage, may initially be balanced by cations and water will often remain neutral in buffered systems until the ANC is surpassed (Morin and Hutt 1997). Increased drainage from peatlands may exacerbate sulfate loading (Gorham 1991). The production of sulfate from peat drainage can be a significant source of acidification in surface waters (Gorham 1991). Sulfate derived from the weathering of gypsum does not produce the protons that are derived when sulfides are oxidized, however, the ANC of receiving waters can be reduced by the sulfate load when calcium precipitates with carbonates. The second concern was an apparent decline in pH from 1997 to 2001. Water in the Muskeg River remains neutral at this point but the situation could change if proton activity continues to rise. Additional effort may be needed on determining the sources of sulfates and the ANC limits of open waters in the Muskeg basin.

Regarding nutrients, both total phosphorus and total nitrogen concentrations were high but do not appear to have changed appreciably since 1976. Muskeg and organic soils were likely the largest sources of phosphorus to surface waters. Mineral groundwater seems to be the larger source for nitrogen. Stream water concentrations of both nitrogen and phosphorus dropped considerably in the slow moving reach upstream of Jackpine Creek, likely due to retention in beaver ponds. Denitrification, biotic assimilation and sedimentation are all processes known to occur in beaver ponds that cause lower concentrations of nutrients in water below beaver dams (Margolis et al. 2001). Occasional peaks in ammonium concentration occur but fell within guidelines for the pH and temperature conditions at the time. However, ammonium concentrations appear correlated with low oxygen conditions and the latter have been more prevalent in recent years. Mining activities will undoubtedly cause changes in the flow regime of the Muskeg River and may influence ammonia concentrations through changes in dissolved oxygen. In addition, peatland and overburden drainage may result in the elevated nutrient concentrations observed in the upper river reaches where source waters derive from peatland systems.

Drainage waters contained elevated concentrations of the metals, barium, copper, iron, strontium, uranium and zinc compared to the Muskeg River. Except for iron, all concentrations were below the ASWQG. Iron has a large natural background source some of which is related to anoxic conditions in minerotrophic peatlands. Drainage of these sites could substantially increase iron loading. Mercury is an additional concern because peatlands can be large sinks for mercury deposited from the atmosphere. Drainage of peatlands can result in both mercury loading to surface waters and the methylation of mercury to more toxic and bioavailable forms (Branfireun et al. 1996).

Trace organic pollutants were rarely detected. When detected, polycyclic aromatic hydrocarbon (PAH) concentrations were below the ASWQG. Some PAH compounds were exported from the Alsands ditch resulting in their detection at downstream sites Odour was noted by field personnel at several sites, occasionally with a petroleum taint. We are currently following up on these observations with assessments of volatile organic compounds at these sites. The source of odour may be from drainage ditches that intersect bitumen-containing sands located in the upper 2 meters of soil.

The Alsands Ditch received drainage from muskeg and overburden. Some of the ditches in its system may intersect the top of the oil sands formation, which is near the ground surface in the area. Waters from the overburden are probably of greater age, and concentration, than those expected from natural runoff. The contribution of deeper groundwater was apparent in its high concentrations of total cations and anions. The influence of peat dewatering was less apparent as DOC concentrations were often low compared to natural drainage at sites along the Muskeg River. In Alsands drainage, the oxidation of sulfide minerals may be a source for high concentrations of sulfate in discharge waters. This process is usually a problem if alkalinity levels are low which was not the case in the Muskeg River. However, several concerns do exist with sulfate ion loading to surface waters; one is that at some point on a large scale, the acid neutralizing capacity of the water may be outstripped by the acidifying potential of sulfide oxidation, another is that sulfate reduction by bacteria may increase under winter low oxygen conditions. Increased sulfate reduction promotes the methylation of mercury and mercury toxicity in the aquatic environment. The Alsands ditch was also a source of some metals and trace elements. It also seems to have been a source of PAHs, although concentrations were low compared to guideline values.

The work reported here did not assess in detail all possible influences of oil sands development in the Muskeg River basin. Effort was focused on the Alsands ditch as one of the main, and readily monitored, anthropogenic factors in the river system. Some other development influences include atmospheric deposition, site drainage ditches (routed through sedimentation ponds), changes in groundwater supply, and impacts from roads and stream crossings. Other than a possible influence on pH, obvious effects from these additional factors were not apparent up to spring 2001.

This report compiles and interprets AENV water quality data for the Muskeg River system. Water quality, groundwater, and other data are also being collected on the Muskeg River system by the Regional Aquatic Monitoring Program (RAMP) and by operating oil sands companies (Syncrude Aurora and Albian Muskeg River Mine). As well, water quality modeling of the system is being funded by proponents of additional oil sands developments. A full integration of data from all parties, as well as enhanced monitoring and investigations on the river system, would further the understanding of its water quality and aid the protection and reclamation of the basin as development occurs. Significant gaps in our understanding that may warrant further investigation appear to be:

- Sulfate and acidifying load: The sources and dynamics of sulfate, vis-a vis acidic interactions, and the apparent decline in pH, need further investigation.

- Groundwater dynamics and input to the Muskeg River system: Full integration of data from groundwater monitoring with surface water quality data, should be done. The adequacy of the groundwater data, for supporting understanding of Muskeg River water quality, should also be assessed and further data collection done if required.
- In-stream processes: Data and understanding are lacking regarding the behavior and fate of some variables (nutrients, metals), particularly with respect to sedimentation and in-sediment reactions. The nature of winter suspended solids and factors controlling winter DO, is also not fully understood.
- Upstream/downstream monitoring: Integrate industry and AENV monitoring of surface waters so that samples are collected above and below mining activities that are paired in time. This will allow differentiation between changes that may occur due to mining from those that occur naturally, for example due to climate.

7.0 REFERENCES

Akena, A. M. (1979). An intensive surface water quality study of the Muskeg River watershed. Volume 1, Water Chemistry. Edmonton, Alberta Environment**:** 187.

Alberta Environment (1994). Evaporation and Evapotranspiration in Alberta (1912-1996). Alberta Environment Water Sciences Branch. Ed. C. Abraham.

Alberta Environment (1999). Surface Water Quality Guidelines for use in Alberta. Environmental Service Pub T/483. Available at: http://www.gov.ab.ca/env/protenf/publications/SurfWtrQual-Nov99.pdf

Alberta Environment, Hydrology Branch (2001). Discharge data for the Muskeg River.

Andrews, D. (2000). Critical loads of acidity to 162 lakes sampled by Alberta-Pacific Forest Industries during 1998. Calgary, Western Resource Solutions.

APHA (1992). Standard Methods for the Examination of Water and Wastewater.

Bayley, S. E., D. W. Schindler, et al. (1992). "Effects of multiple fires on nutrient yields from streams draining boreal forest and fen watersheds nitrogen and phosphorus." Can. J. Fish. Aquat. Sci. **49**(3): 584-596.

Branfireun, B.A., A. Heyes and N.T. Roulet (1996). The hydrology and methylmercury dynamics of a Precambrian Shield headwater peatland. Water Resour. Res. 32: 1785-1794.

Corkum, L.D. (1985). Water quality of the Athabasca oil sands area: A regional study. Alberta Environment, AOSERP Report L-85.

CCME - CWQG (1999) Canadian Council of Ministers of the Environment, Canadian Water Quality Guidelines. Environment Canada Pub. No. 1299.

Energy and Utilities Board. 2000. Oil Sands Regional Review Status 2000 Map.

Environment Canada (2000). Daily Canadian climate normals. CDROM.

Garcia, E. and R. Carignan (2000). "Mercury concentrations in northern pike (Esox lucius) from boreal lakes with logged, burned, or undisturbed catchments." Can. J. Fish. Aquat. Sci. **57**(Supp/2): 129-135.

Golder (2001). Oil Sands Regional Aquatics Monitoring Program (RAMP) 2000. Volumes 1 and 2. Calgary, Golder Associates.

Golder (1997) Muskeg River Mine Project: Environmental Impact Assessment, Vol. 2. Calgary, Golder Associates.

Gorham, E. (1991). "Northern peatlands role in the carbon cycle and probable responses to climatic warming." Ecological Applications **1**(2): 182-195.

Harms, T. E. and D. S. Chanasyk (1998). "Variability of snowmelt runoff and soil moisture recharge." Nord. Hydrol. **29**(3): 179-198.

Hudon, C., R. Morin, J. Bunch and R. Harland (1996). Carbon and nutrient output from the Great Whale River (Hudson Bay) and a comparison with other rivers around Quebec. Can. J. Fish. Aquat. Sci. **53**: 1513-1525.

Hope, D., M.F. Billet, M.S. Cresser (1994) A review of the export of carbon in river water: fluxes and processes. Environmental Pollution 84: 301-324.

Ingram, H. A. P. (1983). Hydrology. Ecosystems of the world 4A. Mires: Swamp, bog, fen and moor. A. J. Gore. Oxford, Elsevier**:** 67-158.

Junk, W. J., P. B. Bayley. (1989). The flood pulse concept in river-floodplain systems. Proceedings of the International Large River Symposium, Canadian Special Publication of Fisheries and Aquatic Sciences.

Koertelainen, P. (1999). Occurrence of humic waters. Limnology of humic waters. J. Keskitalo and P. Eloranta. Leiden, Backhuys Publishers.

Komex (1997). Muskeg River Mine Project: Volume 2 EIA, Biophysical and historical resources, Baseline conditions. Section D3: Hydrogeologic Setting. Calgary, Alberta Environment.

Kukkonen, J. V. K. (1999). Toxicity and bioavailability of contaminants. Limnology of humic waters. J. Keskitalo and P. Eloranta. Leiden, Backhuys Publishers**:** 117-124.

Margolis, B. E., M. S. Castro, and R.L. Raesly (2001). "The impact of beaver impoundments on the chemistry of two Appalachian streams." Can. J. Fish. Aquat. Sci. **58**: 2271-2283.

McEachern, P., E. E. Prepas, J.J. Gibson, W.P. Dinsmore (2000). "Forest fire induced impacts on phosphorus, nitrogen and chlorophyll a concentrations in boreal subarctic lakes of northern Alberta." Can. J. Fish. Aquat. Sci. **57**(SUPP/2): 73-81.

Metcalfe, R.A. and J.M. Buttle (2001). Soil partitioning and surface store controls on spring runoff from a boreal forest peatland basin in north-central Manitoba, Canada. Hydrol. Process 15: 2305-2324.

Morin, K.A. and N.M. Hutt (1997). Environmental Geochemistry of Minesite Drainage: Practical theory and case studies. © held by Authors. MDAG Publishing, Vancouver B.C. Canada.

Neill, C. R. and B. J. Evans (1979). Synthesis of surface water hydrology. Edmonton, Alberta Oil Sands Environmental Research Program**:** 84.

Pietroniro, A., T. Prowse, L. Hamlin, N. Kouwen, and E. Soulis (1996). Application of a grouped response unit hydrological model to a northern wetland region. Hydrol. Process. **14**: 1245-1261.

Prepas, E.E., D. Planas, J.J. Gibson, D.H. Vitt, T.D. Prowse, W.P. Dinsmore, L.A. Halsey, P.M. McEachern, S. Paquet, G.J. Scrimgeour, W.M. Tonn, C.A. Paszkowski, K. Wolfstein (2001). "Landscape variables influencing nutrients and phytoplankton communities in Boreal Plain lakes of northern Alberta: A comparison of wetland- and upland-dominated catchments." Can. J. Fish. Aquat. SCi. **58**: 1286 - 1299.

Rask, M. and T.-R. Metsala (1991). "Mercury concentrations in northern pike, Essox lucius L. in small lakes of Evo area, southern Finland." Wat. Air. Soil. Pollut. **56**: 369-378.

Reuss, J., N. Christophersen and H.M Siep (1986). "A critique of models for freshwater and soil acidification." Water, Air and Soil Pollution **30**: 909-930.

Saffran, K. A. and D. O. Trew (1996). Sensitivity of Alberta lakes to acidifying deposition: An update of sensitivity maps with emphasis on 109 northern lakes. Edmonton, Alberta Environment**:** 75.

Schnoor, J. L. (1996). Environmental Modeling: fate and transport of pollutants in water , air, and soil. New York, John Wiley & Sons.

Schwartz, F. W. and W. A. Milne-Home (1982a). "Watersheds in Muskeg Terrain. 1. The Chemistry of Water Systems." J. Hydrol. **57**(3-4): 267-290.

Schwartz, F. W. and W. A. Milne-Home (1982b). "Watersheds in Muskeg Terrain. 2. Evaluations Based on Water Chemistry." Journal of Hydrology **57**(3): 291-305.

Soucek, D.J., D.S. Cherry and C.E. Zipper (2001). Aluminum-dominated acute toxicity to the cladoceran *Ceriodaphnia dubia* in natural waters downstream of an acid mine drainage discharge. Can. J. Fish. Aquat. Sci. **58:** 2396-2404.

Verta, M. (1990). "Mercury in Finnish forest lakes and reservoirs: anthropogenic contributions to the load and accumulation in fish." Publ. Wat. Envir. Res. Inst. **6**: 1-34.

Vitt, D. H., L. A. Halsey and S.c. Zoltai (1994). "The bog landforms of continental western Canada in relation to climate and permafrost patterns." Arct. Antarct. Alp. Res. **26**(1): 1-13.

Walder, G. L., P. L. Strankman, et al. (1980). Aquatic biophysical inventory of the major tributaries in the AOSERP study area. Edmonton, Alberta Oil Sands Environmental Research Program. **2**.

Wetzel, R. G. (1983). "Limnology (Second Edition ed.). New York: Saunders College Publishing."

APPENDICES

Appendix 1 List of AOSERP Research Reports

AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta - 1975
3.	HE 1.1.1	Structure of Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North - The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs within the Albert Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigations into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather: “A Feasibility Study”
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.		
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21.		AOSERP Second Annual Report, 1976-77
22.		Alberta Oil Sands Environmental Research Program Interim Report to 1978 Covering the Period April 1975 to November 1978
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water of Trout Perch and Rainbow Trout
24.	ME 1.5.2	Air System Winter Field Study in the AOSERP Study Area, February 1977
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
31.	VE 2.3	Ecological Habitat Mapping of the AOSERP Study Area: Phase 1
32.		AOSERP Third Annual Report, 1977-78
33.	TF 1.2	Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in Northern Alberta. Part 1: Moose Preferences for Habitat Strata and Forages
34.	HY 2.4	Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35.	AF 4.9.1	The Effects of Sedimentation on the Aquatic Biota
36.	AF 4.8.1	Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume 1
37.	HE 2.2.2	Community Studies: Fort McMurray, Anzac, Fort MacKay
38.	VE 7.1.1	Techniques for the Control of Small Mammals: A Review
39.	ME 1.0	The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40.	WS 3.3	Mixing Characteristics of the Athabasca River below Fort McMurray – Winter Conditions
41.	AF 3.5.1	Acute and Chronic Toxicity of Vanadium in Fish
42.	TF 1.1.4	Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-75
43.	TF 6.1	A Socioeconomic Evaluation of the Recreational Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. Volume 1: Summary and Conclusions
44.	VE 3.1	Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978
45.	VE 3.3	Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978
46.	VE 3.4	Interim Report on Ecological Benchmarking and Biomonitoring for Detection of air-borne Pollutant Effects on Vegetation and Soils, 1975 to 1978
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48.	HG 1.1	Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49.	WS 1.3.3	The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50.	ME 3.6	Literature Review of Pollution Deposition Processes
51.	HY 1.3	Interim Compilation of 1976 Suspended Sediment Data in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53. HY 3.1.2 Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54. WS 2.3 A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55. HY 2.6 Microbial Populations in the Athabasca River
56. AF 3.2.1 The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57. LS 2.3.1 Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase 1
58. AF 2.0.2 Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers within the Alberta Oil Sands Environmental Research Program Study Area
59. TF 3.1 Semi-Aquatic Mammals: Annotated Bibliography
60. WS 1.1.1 Synthesis of Surface Water Hydrology
61. AF 4.5.2 An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
62. TF 5.1 Amphibians and Reptiles in the AOSERP Study Area
63. ME 3.8.3 Analysis of AOSERP Plume Sigma Data
64. LS 21.6.1 A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area
65. LS 21.6.2 A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area
66. AS 4.3.2 An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67. WS 1.3.2 Aquatic Biological Investigations of the Muskeg River Watershed
68. AS 1.5.3 AS 3.5.2 Air Systems Summer Field Study in the AOSERP Study Area, June 1977
69. HS 40.1 Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70. LS 28.1.2 An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71. HY 2.2 Lake Acidification Potential in the Alberta Oils Sands Environmental Research Program Study Area
72. LS 7.1.2 The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
73. LS 23.2 Distribution, Abundance and Habitat Associations of Beavers, Muskrats, Mink and River Otters in the AOSERP Study Area, Northeastern Alberta
--. -- Interim Report to 1978
74. AS 4.5 Air Quality Modelling and User Needs
75. WS 1.3.4 Interim Report on a Comparative Study of Benthic Algal Primary Productivity in the AOSERP Study Area
76. AF 4.5.1 An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
77. HS 20.1 Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961
78. LS 22.1.1 Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta
79. AF 3.6.1 The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish

80. LS 22.3.1 Biology and Management of Peregrin Falcons (*Falco peregrinus anatum*) in Northeastern Alberta
81. LS 22.1.2 Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta
82. LS 22.2 Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area
83. LS 22.2 The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area

These reports are not available upon request. For further information about the availability and location of depositories, please contact:

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Appendix 2 Variable names, brief analytical method description and method detection limits

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
NUTRIENTS AND ROUTINE						
AMMONIA DISSOLVED	604	7562	0.005	MG/L	219	Colorimetrically (Berthelot method)
BICARBONATE (CALCD.)	545	6201		MG/L	135	Calculated value
CARBON DISSOLVED ORGANIC	478	6107	0.4	MG/L	119	Colourimetric analysis
CARBON PARTICULATE TOTAL	491	100533	0.2	MG/L	2700	Carbon, particulate: thermal combustion & analysis by CHNS instrument.
CARBONATE (CALCD.)	431	6301		MG/L	137	Calculated value
COLOUR TRUE	443	2024		TCU	27	Klett-Somerson spectrophotometric method
HARDNESS TOTAL (CALCD.) CACO3	542	10602		MG/L	423	Calculated method
DISSOLVED NO3 & NO2	628	7105		MG/L	2359	Colourimetry on an autoanalyzer. The sample; after filtration through
NITROGEN TOTAL KJELDAHL (TKN)	626	7021	0.05	MG/L	235	Colorimetry on autoanalyzer
OXYGEN BIOCHEMICAL DEMAND	647	8202	1	MG/L	331	BOD measurement using a DO meter
OXYGEN DISSOLVED (FIELD METER)	3361	100922	0.01	MG/L	2730	Oxygen, dissolved: measured by electronic meter with a polarograph.
OXYGEN DISSOLVED (WINKLER)	3362	8101	0.01	MG/L	324	Winkler method (azide modification)
PH (FIELD)	3359	100923		PH UNITS	2731	pH: measured by electronic meter with a glass ph reference electrode.
PH (LAB)	3360	10301		PH UNITS	389	Electrometric method
PHOSPHORUS PARTICULATE (CALCD.)	725	15901		MG/L	598	Part.phosp.=total phosp.- total dissolved(soluble) phosp.
PHOSPHORUS TOTAL (P)	730	15421	0.006	MG/L	582	Colourimetry with ammon.molyb.;antimony; ascorbic acid
PHOSPHORUS TOTAL DISSOLVED	731	103464	0.002	MG/L	582	Colourimetry with ammon.molyb.;antimony; ascorbic acid
RESIDUE NONFILTRABLE	749	10401	10	MG/L	396	Gravimetric method
RESIDUE TOTAL	750	10471		MG/L	407	Gravimetric method
SPECIFIC CONDUCTANCE (FIELD)	3357	100924	1	US/CM	2732	Specific conductance: measured by electronic meter with nickel cell.
SPECIFIC CONDUCTANCE (LAB)	3358	2041		US/CM	32	Conductivity meter; platinum electrodes

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
TEMPERATURE WATER	840	100925		DEG C	2733	Temperature, water: measured by electronic meter with a thermistor.
TOTAL DISSOLVED SOLIDS	836	207		MG/L	14	Calculated value
TOTAL DISSOLVED SOLIDS (CALCD.)	837	100536		MG/L	2703	Solids total dissolved: dissolved solids are calculated from ion conc.
IONS, MAJOR IONS						
ALKALINITY PHENOLPHTHALEIN CACO3	366	10151	0.1	MG/L	379	Potentiometric titration
ALKALINITY TOTAL CACO3	364	10101	0.5	MG/L	363	Potentiometric titration
CALCIUM DISSOLVED/FILTERED	404	20111	0.006	MG/L	1516	Inductively coupled argon plasma emission spectroscopy
CHLORIDE DISSOLVED	426	102087	0.3	MG/L	2862	Analysis of chloride by flame photometry (flow injection analysis).
FLUORIDE DISSOLVED	532	9107	0.02	MG/L	358	Automated potentiometric method
MAGNESIUM DISSOLVED/FILTERED	581	12111	0.002	MG/L	1516	Inductively coupled argon plasma emission spectroscopy
POTASSIUM DISSOLVED/FILTERED	565	102086	0.1	MG/L	2861	Analysis by flame photometry (flow injection analysis).
SILICA REACTIVE	786	102616	0.1	MG/L	2885	Reactive silica by flow injection analysis
SODIUM DISSOLVED/FILTERED	600	11111	0.03	MG/L	1516	Inductively coupled argon plasma emission spectroscopy
SULPHATE DISSOLVED	814	16306	0.2	MG/L	615	Colourimetry on autoanalyzer with bacl2 & methylthymol blue
SULPHATE DISSOLVED	814	102965	0.06	MG/L	2912	Analysis of anions and cations by suppressed ion chromatography
SUM OF ANIONS	829	125		MEQ/L	4	Calculated value
SUM OF CATIONS	830	120		MEQ/L	4	Calculated value
METALS						
ALUMINUM EXTRACTABLE	371	100582		MG/L	2709	Metals, Extractable: By inductively coupled argon plasma spectrometry (ICP-MS)
ALUMINUM DISSOLVED - AL	2882	101776		UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
ALUMINUM TOTAL RECOVERABLE - AL	2973	101888	8	UG/L	2845	Total recoverable and total metals were combined. Total recoverable metals were preserved with nitric acid. Total metals were digested with nitric acid. Both were analyzed by ICP-MS.
ANTIMONY DISSOLVED - SB	2904	101802	0.03	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
ANTIMONY TOTAL RECOVERABLE - SB	2998	101914	0.03	UG/L	2845	See aluminum, total recoverable
ARSENIC DISSOLVED - AS	2883	101777	0.15	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
ARSENIC TOTAL RECOVERABLE - AS	2974	101889	0.2	UG/L	2845	See aluminum, total recoverable
BARIUM DISSOLVED - BA	2885	101779	0.04	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
BARIUM TOTAL RECOVERABLE - BA	2976	101891	1	UG/L	2845	See aluminum, total recoverable

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
BERYLLIUM DISSOLVED - BE	2886	101780	0.1	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
BERYLLIUM TOTAL RECOVERABLE - BE	2977	101892	0.1	UG/L	2845	See aluminum, total recoverable
BORON DISSOLVED - B	2915	101813	2	UG/L	2838	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
BORON TOTAL RECOVERABLE - B	3009	101925	2	UG/L	2846	See aluminum, total recoverable
CADMIUM DISSOLVED - CD	2889	101783	0.05	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
CADMIUM TOTAL RECOVERABLE - CD	2980	101895	0.05	UG/L	2845	See aluminum, total recoverable
CHROMIUM DISSOLVED - CR	2916	101814	0.4	UG/L	2838	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
CHROMIUM TOTAL RECOVERABLE - CR	3010	101926	0.4	UG/L	2846	See aluminum, total recoverable
COBALT DISSOLVED - CO	2891	101828	0.04	UG/L	2840	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
COBALT TOTAL RECOVERABLE - CO	2982	101937	0.04	UG/L	2847	See aluminum, total recoverable
COPPER DISSOLVED - CU	2893	101787	0.2	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
COPPER TOTAL RECOVERABLE - CU	2984	101899	0.2	UG/L	2845	See aluminum, total recoverable
IRON (FE) EXTRACTABLE	517	102082	0.01	MG/L	2729	Metals, Extractable: By inductively coupled argon plasma spectrometry (ICP-MS)
IRON DISSOLVED	516	102090	0.01	MG/L	2725	Dissolved elements by ICP-MS: Samples filtered and then analyzed. Some samples run by Atomic Emission Spectrometry.
IRON TOTAL RECOVERABLE - FE	2985	101936	0.025	MG/L	2847	See aluminum, total recoverable
LEAD DISSOLVED	678	101800	0.1	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
LEAD TOTAL RECOVERABLE - PB	684	101912	0.1	UG/L	2845	See aluminum, total recoverable
LITHIUM DISSOLVED - LI	2896	101790	0.7	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
LITHIUM TOTAL RECOVERABLE - LI	2987	101902	0.7	UG/L	2845	See aluminum, total recoverable
MANGANESE DISSOLVED - MN	2898	101792	0.1	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
MANGANESE TOTAL RECOVERABLE - MN	2989	101904	0.1	UG/L	2845	See aluminum, total recoverable

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
MERCURY TOTAL	549	101980	0.002	UG/L	2859	Hg analysis by flow injection, samples preserved with HCll.
MOLYBDENUM DISSOLVED - MO	2899	101793	0.1	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
MOLYBDENUM TOTAL RECOVERABLE - MO	2990	101905	0.1	UG/L	2845	See aluminum, total recoverable
NICKEL DISSOLVED - NI	2901	101829		UG/L	2840	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
NICKEL TOTAL RECOVERABLE - NI	2992	101938	0.3	UG/L	2847	See aluminum, total recoverable
SELENIUM DISSOLVED - SE	2920	101818	0.7	UG/L	2838	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
SELENIUM TOTAL RECOVERABLE - SE	3014	101930	0.7	UG/L	2846	See aluminum, total recoverable
SILVER DISSOLVED - AG	2841	101775	0.03	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
SILVER TOTAL RECOVERABLE - AG	2972	101887	0.03	UG/L	2845	See aluminum, total recoverable
STRONTIUM DISSOLVED - SR	2921	101819	0.02	UG/L	2838	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
STRONTIUM TOTAL RECOVERABLE - SR	3015	101931	0.02	UG/L	2846	See aluminum, total recoverable
URANIUM DISSOLVED - U	2912	101810	0.03	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
URANIUM TOTAL RECOVERABLE - U	3006	101922	0.03	UG/L	2845	See aluminum, total recoverable
VANADIUM DISSOLVED - V	2913	101811	0.1	UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
VANADIUM TOTAL RECOVERABLE - V	3007	101923	0.1	UG/L	2845	See aluminum, total recoverable
VANADIUM TOTAL RECOVERABLE - V	3007	101935	0.2	UG/L	2847	See aluminum, total recoverable
ZINC DISSOLVED - ZN	2914	101812		UG/L	2837	Dissolved elements by ICP-MS: Samples filtered and then analyzed.
ZINC TOTAL RECOVERABLE - ZN	3008	101924	0.5	UG/L	2845	See aluminum, total recoverable
PHENOLS						
2,4,6-TRICHLOROPHENOL	308	100708	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
2,4-DICHLOROPHENOL	96	100700	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
2,4-DIMETHYLPHENOL	62	100701	2	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
2,4-DINITROPHENOL	205	100703	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
2-CHLOROPHENOL	330	100699	2	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
2-METHYL-4,6-DINITROPHENOL	213	100702	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
2-NITROPHENOL	309	100704	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
4-CHLORO-3-METHYLPHENOL	231	100698	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
4-NITROPHENOL	51	100705	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
PENTACHLOROPHENOL	307	100706	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
PHENOL	75	100707	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
ESTERS						
BIS(2-ETHYLHEXYL) PHTHALATE	88	100748	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
BUTYLBENZYL PHTHALATE	300	100743	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
DIETHYL PHTHALATE	295	100745	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
DIMETHYL PHTHALATE	108	100746	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
DI-N-BUTYL PHTHALATE	297	100744	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
DI-N-OCTYL PHTHALATE	90	100747	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
4-BROMOPHENYL PHENYL ETHER	59	100738	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
4-CHLOROPHENYL PHENYL ETHER	253	100742	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
BIS(2-CHLOROETHOXY) METHANE	2801	100739	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
BIS(2-CHLOROETHYL) ETHER	78	100740	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
BIS(2-CHLOROISOPROPYL) ETHER	71	100741	1	UG/L	2722	Extractable priority pollutants in water: Analysis by GC-MS.
MTBE (METHYL TERTIARY BUTYL ETHER)	3052	102608	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectrometry.
HYDROCARBONS						
HYDROCARBONS EXTRACTABLE (C8 AND UP)	9028	900029		MG/L	167	Gas chromatography
HYDROCARBONS,VOLATILE SCAN(C3-C9)	3136	103343	100	UG/L	2959	Photoionization detector and flame ionization detector
HEXACHLOROCYCLOPENTADIE NE	282	100728	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
ISOPHORONE	284	100749	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
3-METHYLCHOLANTHRENE	3069	103142	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
7,12-DIMETHYLBENZ(A)ANTHRA CENE	3070	103143	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
ACENAPHTHENE	292	103144	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
ACENAPHTHYLENE	148	103145	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
ANTHRACENE	93	103147	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZENE	256	95200	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
BENZO(A)ANTHRACENE	219	103148	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZO(A)PYRENE	204	103149	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZO(B,J,K)FLUORANTHENE	3071	103150	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZO(C)PHENANTHRENE	3076	103151	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZO(E)PYRENE	137	103152	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZO(G,H,I)PERYLENE	132	103153	0.01	UG/L	2933	PAH's in water samples: analysis by GC-MS.
BENZO(K)FLUORANTHENE	147	100714	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
CHRYSENE	155	103154	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
DIBENZ(A,H)ANTHRACENE	212	103158	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
DIBENZO(A,H)PYRENE	3072	103155	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
DIBENZO(A,I)PYRENE	3073	103156	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
DIBENZO(A,L)PYRENE	3074	103157	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
FLUORANTHENE	146	103159	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
FLUORENE	303	103160	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
INDENO(1,2,3-C,D)PYRENE	140	103161	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
NAPHTHALENE	312	103162	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
N-BUTYLBENZENE	2704	100637	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
PHENANTHRENE	299	103163	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
P-ISOPROPYLTOLUENE	2715	100648	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
PYRENE	107	103164	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.
SEC-BUTYLBENZENE	2702	100635	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass
TERT-BUTYLBENZENE	2703	100636	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,1,1,2-TETRACHLOROETHANE	2716	100651	5	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,1,1-TRICHLOROETHANE	257	95227	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,1,2,2-TETRACHLOROETHANE	290	95224	5	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,1,2-TRICHLOROETHANE	288	95228	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
1,1-DICHLOROETHANE	275	95214	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,1-DICHLOROETHYLENE	276	95216	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,1-DICHLOROPROPYLENE	2714	100645	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2,3-TRICHLOROPROPANE	2717	100655	I	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2-DIBROMO-3-CHLOROPROPANE	2707	100640	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2-DIBROMOETHANE	898	100641	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2-DICHLOROETHANE	66	95215	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2-DICHLOROPROPANE	285	95218	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,3-DICHLOROPROPANE	2713	100644	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
2,2-DICHLOROPROPANE	2712	100643	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
2-CHLOROETHYLVINYLETHER	917	95207	4	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
BROMOFORM	273	95202	5	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
BROMOMETHANE	266	95203	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
CARBON TETRACHLORIDE	217	95204	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
CHLOROETHANE	270	95206	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
CHLOROFORM	250	95208	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
CIS-1,2-DICHLOROETHENE	929	100642	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
CIS-1,3-DICHLOROPROPENE	54	95219	3	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
DIBROMOCHLOROMETHANE	103	95209	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
DIBROMOMETHANE	267	95210	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
DICHLOROBROMOMETHANE	274	95201	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
HEXACHLOROBUTADIENE	306	100646	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
HEXACHLOROBUTADIENE	306	100727	5	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
HEXACHLOROETHANE	251	100729	5	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
METHYLENE CHLORIDE	272	95222	2	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
TETRACHLOROETHYLENE	106	95225	3	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
TRANS-1,2-DICHLOROETHENE	120	95217	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
TRANS-1,3-DICHLOROPROPENE	55	95220	3	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
TRICHLOROETHYLENE	289	100654	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
TRICHLOROFLUOROMETHANE	277	95229	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
VINYL CHLORIDE	271	95232	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
2-CHLOROTOLUENE	2705	100638	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
4-CHLOROTOLUENE	2706	100639	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2,3-TRICHLOROBENZENE	304	100652	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2,4-TRICHLOROBENZENE	95	100653	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2-DICHLOROBENZENE	329	95211	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,3-DICHLOROBENZENE	215	95212	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,4-DICHLOROBENZENE	64	95213	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
BROMOBENZENE	907	100634	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
CHLOROBENZENE	74	95205	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
2-CHLORONAPHTHALENE	315	100725	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
ACRIDINE	3075	103146	0.01	UG/L	2933	PAH’s in water samples: analysis by GC-MS.

Variable name	Variable	VMV	Method detection limit	Units	Method	Description
1,2,4-TRIMETHYLBENZENE	905	100656	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
1,2-DIPHENYLHYDRAZINE	102	100734	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
1,3,5-TRIMETHYLBENZENE	904	100657	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
2,4-DINITROTOLUENE	97	100732	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
2,6-DINITROTOLUENE	236	100733	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
BENZIDENE	316	100731	2	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
ETHYL BENZENE	52	95221	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
ISOPROPYLBENZENE	903	100647	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
M- + P-XYLENE	113	95234	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
NITROBENZENE	339	100735	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
N-NITROSODIPHENYLAMINE	301	100736	2	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
N-PROPYLBENZENE	914	100650	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
O-XYLENE	328	95233	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass
STYRENE	53	95223	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
TOLUENE	73	95226	1	UG/L	2321	Batch purge and trap/capillary column gas chromatography/mass spectroscopy
OTHER						
N-NITROSODI-N-PROPYLAMINE	242	100737	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.
HEXACHLOROBENZENE	91	100726	1	UG/L	2722	Extractable priority pollutants in water: analysis by GC-MS.

Appendix 2 Continued: Concentrations reported from blank samples

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
100533 CARBON PARTICULATE TOTAL MG/L	L0.02	L0.02								
100754 PHOSPHORUS TOTAL MG/L			L0.1	L0.1						
100755 SULPHUR TOTAL MG/L			0.6	0.7						
100757 SILICON TOTAL MG/L			2.71	2.81						
100768 LITHIUM TOTAL MG/L			L0.001	L0.001						
POTASSIUM TOTAL MG/L			L0.2	L0.2						
100775 MANGANESE TOTAL (MN) MG/L			0.009	0.006						
100776 IRON TOTAL (FE) MG/L			L0.01	L0.01						
100783 PHOSPHORUS DISSOLVED MG/L			L0.1	L0.1						
100784 SULPHUR DISSOLVED MG/L			L0.2	L0.2						
100786 SILICON DISSOLVED MG/L			2.53	2.72						
100797 LITHIUM DISSOLVED MG/L			L0.001	L0.001						
10101 ALKALINITY TOTAL CACO3 MG/L	2	2								
101484 SULPHIDE DISSOLVED MG/L									L0.001	
10151 ALKALINITY PHENOLPHTHALEIN CACO3 MG/L	L1	L1								
101775 SILVER_107 DISSOLVED - AG UG/L			L0.005	L0.005	L0.005	L0.005	L0.005	L0.005		
101776 ALUMINUM_27 DISSOLVED - AL UG/L			0.21	0.27	0.32	L0.1	0.15	14.2		
ARSENIC_75 DISSOLVED - AS UG/L			0.02	L0.02	L0.02	L0.02	L0.02	L0.02		
BARIUM_137 DISSOLVED - BA UG/L			0.24	0.43	0.15	L0.02	1.03	L0.02		
101780 BERYLLIUM_9 DISSOLVED - BE UG/L			L0.04	L0.04	L0.04	L0.04	L0.04	L0.04		
101781 BISMUTH_209 DISSOLVED - BI UG/L			L0.005	L0.005	L0.005	L0.005	L0.005	L0.005		

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
CALCIUM_43 DISSOLVED - CA MG/L			0.127	0.141	L0.01	L0.01	0.46	0.021		
101783 CADMIUM_114 DISSOLVED - CD UG/L			L0.01	L0.01	L0.01	L0.01	0.011	0.012		
101784 CHLORINE_35 DISSOLVED - CL MG/L			0.72	L0.2	L0.2	L0.2	L0.2	L0.2		
101786 CHROMIUM_53 DISSOLVED - CR UG/L			0.7	L0.1	L0.1	L0.1				
101787 COPPER_65 DISSOLVED - CU			0.08	0.13	L0.08	0.1	L0.08	L0.08		
101790 LITHIUM_7 DISSOLVED - LI UG/L			L0.1	L0.1	L0.1	L0.1	0.27	L0.1		
101792 MANGANESE_55 DISSOLVED - MN UG/L	0.05	0.06	0.019	0.08	0.47	0.52	8.2	0.39		0.12
101793 MOLYBDENUM_98 DISSOLVED - MO UG/L			L0.02	L0.02	L0.02	L0.02	L0.02	L0.02		
101800 LEAD DISSOLVED UG/L			0.272	0.428	0.096	0.093	L0.01	L0.01		
101802 ANTIMONY_121 DISSOLVED - SB UG/L			L0.004	L0.004	2.78	5.9	0.59	2.43		
101805 TIN_118 DISSOLVED - SN UG/L			L0.1	L0.1	L0.1	L0.1	L0.1	L0.1		
101807 THORIUM_232 DISSOLVED - TH UG/L			L0.003	L0.003	L0.003	L0.003	L0.003	L0.003		
101808 TITANIUM_47 DISSOLVED - TI UG/L			L0.2	0.3	L0.2	L0.2	L0.2	L0.2		
101809 THALLIUM_205 DISSOLVED - TL UG/L			L0.003	L0.003	L0.003	L0.003	L0.003	L0.003		
URANIUM_238 DISSOLVED - U UG/L			L0.003	L0.003	L0.003	L0.003	0.005	0.004		

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
101811 VANADIUM_51 DISSOLVED - V UG/L			0.179	0.016	L0.008	L0.008	0.09	0.033		
101812 ZINC_66 DISSOLVED - ZN UG/L			L0.2		3.86	0.36	0.32	0.25		
101813 BORON_11 DISSOLVED - B UG/L			0.8	L0.08	L0.08	L0.08	0.16	L0.08		
101814 CHROMIUM_52 DISSOLVED - CR UG/L							L0.08	L0.08		
101818 SELENIUM_77 DISSOLVED - SE UG/L			L0.5	L0.5	L0.5	L0.5	L0.5	L0.5		
101819 STRONTIUM_88 DISSOLVED - SR UG/L			0.087	0.097	0.116	L0.004				
101827 IRON_57 DISSOLVED - FE UG/L	L3	L3	L3	L3	L3	L3	58	L3		9
101828 COBALT_59 DISSOLVED - CO UG/L			L0.02	L0.02	L0.02	L0.02	L0.02	L0.02		
101829 NICKEL_60 DISSOLVED - NI UG/L			L0.06	0.07	0.11	L0.06	L0.06	L0.06		
101887 SILVER_107 TOTAL RECOVERABLE - AG UG/L	L0.005	L0.005	0.013	L0.005	L0.005		L0.005	L0.005		L0.005
101888 ALUMINUM_27 TOTAL RECOVERABLE - AL UG/L	1.37	L1	1.66	L1	23.5		L1	1.42		L1
101889 ARSENIC_75 TOTAL RECOVERABLE -	L0.02	0.02	L0.02	L0.02	L0.02		L0.02	0.03		0.04
101891 BARIUM_137 TOTAL RECOVERABLE - BA UG/L	0.75	L0.1	L0.1	L0.1	0.51		L0.1	L0.1		L0.1
101892 BERYLLIUM_9 TOTAL RECOVERABLE - BE UG/L	L0.04	L0.04	L0.04	L0.04	L0.04		0.05	L0.04		L0.04

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
101893 BISMUTH_209 TOTAL RECOVERABLE - BI UG/L	L0.005	L0.005	L0.005	L0.005	L0.005		L0.005	L0.005		L0.005
101894 CALCIUM_43 TOTAL RECOVERABLE -	0.013	L0.01	0.117	0.14	0.053		0.013	L0.01		0.108
101895 CADMIUM_114 TOTAL RECOVERABLE - CD UG/L	L0.02	L0.02	L0.02	L0.02	L0.02		L0.02	L0.02		L0.02
101896 CHLORINE_35 TOTAL RECOVERABLE - CL MG/L	L0.6	L0.6	1.43	1.12	L0.6		L0.6	L0.6		L0.6
101898 CHROMIUM_53 TOTAL RECOVERABLE - CR UG/L	0.29	1.5	0.3	L0.1	0.12					0.3
101899 COPPER_65 TOTAL RECOVERABLE - CU UG/L	0.08	0.27	1.19	0.11	0.35		0.12	0.08		L0.08
101902 LITHIUM_7 TOTAL RECOVERABLE - LI UG/L	0.18	L0.1	L0.1	L0.1	L0.1		L0.1	L0.1		L0.1
101904 MANGANESE_55 TOTAL RECOVERABLE - MN UG/L	0.31	0.19	0.015	0.053	0.57		L0.01	0.065		L0.01
101905 MOLYBDENUM_98 TOTAL RECOVERABLE - MO UG/L	0.027	L0.02	L0.02	L0.02	L0.02		L0.02	L0.02		L0.02
101912 LEAD TOTAL RECOVERABLE - PB UG/L	0.02	0.013	0.101	0.056	0.351		L0.01	L0.01		L0.01
101914 ANTIMONY_121 TOTAL RECOVERABLE - SB UG/L	L0.004	L0.004	0.005	L0.004	0.016		0.019	L0.004		0.0043

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
101915 SELENIUM_82 TOTAL RECOVERABLE - SE UG/L										L0.4
101917 TIN_118 TOTAL RECOVERABLE - SN UG/L	L0.1	L0.1	L0.1	L0.1			L0.1	L0.1		L0.1
101918 STRONTIUM_86 TOTAL RECOVERABLE - SR UG/L		L0.5								
101919 THORIUM_232 TOTAL RECOVERABLE - TH UG/L	L0.003	L0.003	L0.003	L0.003			L0.003	L0.003		L0.003
101920 TITANIUM_47 TOTAL RECOVERABLE - TI UG/L	L0.2	L0.2	L0.2	0.3			L0.2	L0.2		0.4
101921 THALLIUM_205 TOTAL RECOVERABLE - TL UG/L	L0.003	0.0058	L0.003	L0.003			0.027	0.0076		L0.003
101922 URANIUM_238 TOTAL RECOVERABLE - U UG/L	L0.003	L0.003	L0.003	L0.003			0.005	0.005		L0.003
101923 VANADIUM_51 TOTAL RECOVERABLE - V UG/L	0.39	0.028	0.104	0.018			0.09	0.09		0.034
101924 ZINC_66 TOTAL RECOVERABLE - ZN UG/L	L0.2	1.07	0.25	0.55			0.51	L0.2		0.74
101925 BORON_11 TOTAL RECOVERABLE - B UG/L	0.7	2.5	1.9	L0.08			L0.08	L0.08		L0.08
101926 CHROMIUM_52 TOTAL RECOVERABLE - CR UG/L							L0.08	L0.08		

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
101930 SELENIUM_77 TOTAL RECOVERABLE - SE UG/L	L0.5	L0.5	L0.5	L0.5			L0.5	L0.5		
101931 STRONTIUM_88 TOTAL RECOVERABLE - SR UG/L	0.11		0.078	0.091			0.011	0.034		0.068
101936 IRON_57 TOTAL RECOVERABLE - FE UG/L	L3	5	L3	L3			L3	L3		L3
101937 COBALT_59 TOTAL RECOVERABLE - CO UG/L	L0.02	0.04	L0.02	L0.02			L0.02	L0.02		L0.02
101938 NICKEL_60 TOTAL RECOVERABLE - NI UG/L	0.09	1.23	0.12	0.09			L0.06	L0.06		0.11
101990 URANIUM TOTAL MGL			L0.0004	L0.0004						
[illegible] STRONTIUM TOTAL MG/L			0.029	0.027						
101992 BARIUM TOTAL MG/L			0.0562	0.0572						
101993 ARSENIC TOTAL MG/L			L0.005	L0.005						
101994 VANADIUM TOTAL MG/L			L0.001	L0.001						
101995 MOLYBDENUM TOTAL MG/L			L0.0002	L0.0002						
101996 ALUMINUM TOTAL MG/L			0.426	0.472						
101997 BERYLLIUM TOTAL MG/L			L0.0002	L0.0002						
101998 ZINC TOTAL (ZN) MG/L			0.002	0.0032						
101999 COPPER TOTAL (CU) MG/L			0.0025	0.0031						
102000 SILVER TOTAL MG/L			0.0001	L0.0001						
102001 LEAD TOTAL MG/L			L0.0003	L0.0003						
102003 TITANIUM TOTAL MG/L			L0.001	L0.001						
102004 CADMIUM TOTAL MG/L			L0.0002	L0.0002						
102005 COBALT TOTAL MG/L			L0.0003	0.0004						

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
102006 NICKEL TOTAL MG/L			0.0015	0.0018						
102007 BORON TOTAL MG/L			L0.01	0.02						
102009 SELENIUM TOTAL MG/L			0.013	L0.007						
102010 CHROMIUM TOTAL (CR) MG/L			0.001	L0.001						
102011 ANTIMONY TOTAL MG/L			L0.0002	L0.0002						
102012 TIN TOTAL MG/L			L0.001	L0.001						
102015 THALLIUM TOTAL MG/L			L0.0002	L0.0002						
102017 ZIRCONIUM TOTAL MG/L			L0.0002	0.0044						
102018 URANIUM DISSOLVED MG/L			L0.0004	L0.0004						
STRONTIUM DISSOLVED MG/L			0.023	0.024						
102020 BARIUM DISSOLVED MG/L			0.0556	0.0449						
102021 ARSENIC DISSOLVED MG/L			L0.005	L0.005						
102022 VANADIUM DISSOLVED MG/L			L0.001	L0.001						
102023 MOLYBDENUM DISSOLVED MG/L			L0.0002	L0.0002						
102024 ALUMINUM DISSOLVED MG/L			0.014	0.01						
102025 BERYLLIUM DISSOLVED MG/L			L0.0002	L0.0002						
102026 ZINC DISSOLVED MG/L			L0.0006	0.0009						
102027 COPPER DISSOLVED MG/L			L0.0002	0.0004						
102028 SILVER DISSOLVED MG/L			L0.0001	L0.0001						
102029 LEAD DISSOLVED MG/L			L0.0003	L0.0003						
102031 TITANIUM DISSOLVED MG/L			L0.001	L0.001						
102032 CADMIUM DISSOLVED MG/L			L0.0002	L0.0002						
102033 COBALT DISSOLVED MG/L			L0.0003	L0.0003						
102034 NICKEL DISSOLVED MG/L			0.0015	0.0012						
102035 BORON DISSOLVED MG/L			L0.01	L0.01						
102037 SELENIUM DISSOLVED MG/L			L0.007	L0.007						

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
102038 CHROMIUM DISSOLVED MG/L			L0.001	L0.001						
102039 ANTIMONY DISSOLVED MG/L			L0.0002	L0.0002						
102040 TIN DISSOLVED MG/L			L0.001	L0.001						
102043 THALLIUM DISSOLVED MG/L			L0.0002	L0.0002						
102045 ZIRCONIUM DISSOLVED MG/L			L0.0002	L0.0002						
102085 SODIUM DISSOLVED/FILTE RED MG/L	1.3	1.7								
POTASSIUM DISSOLVED/FILTE RED MG/L	L0.1	L0.1								
102087 CHLORIDE DISSOLVED MG/L	1.5	1.5								
102089 MANGANESE DISSOLVED MG/L			0.005	0.005						
102090 IRON DISSOLVED MG/L			L0.01	L0.01						
102616 SILICA REACTIVE MG/L	0.1	0.1								
10301 PH (LAB) PH UNITS	5.33	5.51								
10401 RESIDUE NONFILTRABLE MG/L	L1	L1							L1	
10471 RESIDUE TOTAL MG/L	16	2								
10602 HARDNESS TOTAL (CALCD_) CACO3 MG/L	L1	L1								
11005 SODIUM TOTAL (NA) MG/L			0.4	0.3						
11111 SODIUM DISSOLVED/FILTE RED MG/L			L0.1	L0.1						
120 SUM OF CATIONS MEQ/L	0.06	0.08								
12005 MAGNESIUM TOTAL MG/L			L0.1	L0.1						
12111 MAGNESIUM DISSOLVED/FILTE RED MG/L	0.019	0.008	L0.1	L0.1						
125 SUM OF ANIONS MEQ/L	0.15	0.13								
15105 PHOSPHORUS TOTAL DISSOLVED MG/L	L0.001	0.001								

Appendix 2 Continued

Collection Date	9/22/98	1/12/99	6/22/99	6/22/99	7/13/99	7/13/99	10/19/99	10/19/99	12/14/99	2/17/99
15421 PHOSPHORUS TOTAL (P) MG/L	L0.001	0.003								
15901 PHOSPHORUS PARTICULATE (CALCD_) MG/L	L0.001	0.002								
16306 SULPHATE DISSOLVED MG/L	3	L3								
19111 POTASSIUM DISSOLVED/FILTERED MG/L			L0.2	L0.2						
20005 CALCIUM TOTAL MG/L			1.3	1.2						
20111 CALCIUM DISSOLVED/FILTERED MG/L	0.02	0.02	1	1						
2024 COLOUR TRUE TCU	3	L1								
2041 SPECIFIC CONDUCTANCE (LAB) US/CM	1.2	3.4								
DISSOLVED SOLIDS (CALCD_) MG/L	7.2	6.6								
207 TOTAL DISSOLVED SOLIDS MG/L	16	2								
6107 CARBON DISSOLVED ORGANIC MG/L	L0.2	L0.2							L0.2	
BICARBONATE (CALCD_) MG/L	3	3								
7021 NITROGEN TOTAL KJELDAHL (TKN) MG/L	L0.01	L0.01								
7105 NITROGEN DISSOLVED NO3 & NO2 MG/L	L0.005	L0.005								
7562 AMMONIA DISSOLVED MG/L	0.005	0.002							0.001	
8202 OXYGEN BIOCHEMICAL DEMAND MG/L	0.5	0.3							L0.2	
9107 FLUORIDE DISSOLVED MG/L	L0.01	L0.01								

Appendix 3. Inorganic chemistry for the Muskeg River and tributaries, 1997 to 2001.

SAMPLE NO.	DATE/TIME	Water Temp	Chloro phyll a	TKN	NO3+2 - N	NH3+4-N	TP	TDP	TPP	DOC	TPC	TOC	Tannin & Lignin	True Colour
	Variable Code:	840	414	626	628	604	730	731	725	478	491	487	834	443
	Unit Code:	Deg C	mg/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCU
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)														
98SWE02763	20-Oct-98 11:30	2.11		0.96	0.014	0.016	0.079	0.017	0.062	13.9	4.78			45
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)														
98SWE00807	27-May-98 11:15	18.09		0.78	L0.005	0.017	0.037	0.014	0.023	20.7	0.7			93
98SWE00808	27-May-98 11:20			0.79	L0.005	0.015	0.036	0.015	0.021	20.1	0.78			89
98SWE00809	27-May-98 11:25			0.78	L0.005	0.011	0.037	0.017	0.02	20.1	0.74			91
98SWE01026	25-Jun-98 08:00	20.71								20.9	1.71			83
98SWE01368	15-Jul-98 10:35	15.97		0.9	0.042	0.032	0.039	0.022	0.017	25.4	0.5			114
98SWE01964	19-Aug-98 10:30	18.01								19.9	0.23			68
98SWE02537	22-Sep-98 12:15	9.8		0.58	L0.005	0.008	0.02	0.009	0.011	16	0.43			33
98SWE02757	20-Oct-98 14:10	4.12		0.65	0.051	0.063	0.025	0.004	0.021	15.4	0.41			36
98SWE02953	18-Nov-98 11:45	0.13				0.28				15.6	1.01			44
98SWE03027	15-Dec-98 09:40	0.07				0.51				14.3	0.94			39
99SWE00027	13-Jan-99 11:10	-0.02		1.36	0.016	0.65	0.049	0.006	0.043	17.5	1.61			42
99SWE00190	17-Feb-99 13:00	0.01				0.57				16	1.09			26
99SWE00425	16-Mar-99 12:45	-0.01				0.68				18	1.14			49
99SWE02055	18-May-99 12:45	8.82		0.68	L0.005	0.011	0.036	0.018	0.018	16.6	0.5			88
99SWE02668	22-Jun-99 10:15	19.51				0.039				21.3				
99SWE03351	13-Jul-99 13:00	20.9		0.8	L0.005	0.014	0.035	0.018	0.017	21.5				75
99SWE04065	11-Aug-99 10:30	16.94				0.009				24				
99SWE04909	15-Sep-99 09:30	9.89		0.87	0.011	0.014	0.037	0.016	0.021	21.4				61
99SWE05461	19-Oct-99 12:00	3.25			L0.005	0.008				18				49
99SWE05686	16-Nov-99 11:05	-0.08				0.067				18				
99SWE05770	15-Dec-99 10:45	0.52				0.35				16.2				
00SWE00089	26-Jan-00 09:45	0.33				0.56				15.9				
00SWE00333	23-Feb-00 12:30	0.01				0.67				17.5				
00SWE00879	05-Apr-00 09:50	-0.32												
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)														
98SWE00805	27-May-98 11:40	17.16		0.74	L0.005	0.009	0.027	0.015	0.012	21.9	0.43			102
98SWE01027	25-Jun-98 08:30	19.66								24.3	0.29			110
98SWE01369	15-Jul-98 10:15	14.61		0.88	0.023	0.018	0.037	0.026	0.011	28.3	0.37			129
98SWE01965	19-Aug-98 09:45	17.07								26.5	0.46			87
98SWE02758	20-Oct-98 13:15	4.47		0.61	L0.005	0.009	0.037	0.006	0.031	18.3	0.72			41
98SWE02954	18-Nov-98 11:30	0.23				0.019				17.9	0.71			41
98SWE03028	15-Dec-98 11:00	0.08				0.014				16.7	1.03			39

SAMPLE NO.	DATE/TIME	Water Temp	Chloro phyll a	TKN	NO3+2 - N	NH3+4-N	TP	TDP	TPP	DOC	TPC	TOC	Tannin & Lignin	True Colour
	Variable Code:	840	414	626	628	604	730	731	725	478	491	487	834	443
	Unit Code:	Deg C	mg/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCU
99SWE00026	13-Jan-99 12:15	-0.03		0.91	0.02	0.21	0.052	0.006	0.046	18.2	1.77			42
99SWE00194	17-Feb-99 13:45	0.04				0.115				17.1	1.13			22
99SWE00426	16-Mar-99 13:15	0.32				0.106				13.9	1.44			25
99SWE00427	16-Mar-99 13:20					0.107				15	0.9			28
99SWE00428	16-Mar-99 13:25					0.106				14.7	0.87			28
99SWE02056	18-May-99 13:00	8.59		0.73	L0.005	0.01	0.029	0.016	0.013	18.4	0.26			88
99SWE02670	22-Jun-99 10:30	18.69				0.021				20.2				
99SWE03350	13-Jul-99 12:30	20.67		0.87	L0.005	0.008	0.031	0.015	0.016	26.1				77
99SWE04066	11-Aug-99 10:00	16.15				0.008				26.4				
99SWE04910	15-Sep-99 12:00	9.27		0.78	0.005	0.011	0.042	0.017	0.025	18.9				57
99SWE05460	19-Oct-99 12:30	3.6			L0.005	0.009				18.6				49
99SWE05774	15-Dec-99 11:45	0.52				0.01				17				
00SWE00088	26-Jan-00 10:10	0.19				0.058				19.1				
00SWE00336	23-Feb-00 12:00	0.28				0.135				18.9				
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)														
98SWE00803	27-May-98 11:50	18.25		0.53	L0.005	0.016	0.021	0.004	0.017	11.4	0.66			24
98SWE01028	25-Jun-98 08:35	18.4								9.8	0.53			24
98SWE01371	15-Jul-98 10:55	13.42		0.39	0.01	0.021	0.01	0.003	0.007	10.6	0.32			22
98SWE01963	19-Aug-98 11:00	15.73								9.2	0.13			19
98SWE02536	22-Sep-98 12:45	9.51		0.31	0.007	0.008	0.006	0.001	0.005	9.6	0.15			12
98SWE02756	20-Oct-98 14:00	3.95		0.29	L0.005	0.004	0.008	0.002	0.006	8.8	1.09			14
98SWE02952	18-Nov-98 12:00	0.13				0.15				11.5	0.17			20
98SWE03029	15-Dec-98 12:00	-0.02				0.28				9.3	0.14			19
99SWE00028	13-Jan-99 12:45	-0.08		0.5	0.012	0.168	0.006	0.004	0.002	8.2	0.24			12
99SWE00192	17-Feb-99 14:20	0.01				0.31				7.7	0.36			4
99SWE00424	16-Mar-99 14:00	0.02				0.11				7.5	0.28			10
99SWE02049	18-May-99 13:20	11.48		0.44	0.052	0.012	0.015	0.003	0.012	10	0.44			19
99SWE02667	22-Jun-99 11:15	21.07				0.011				12.4				
99SWE03349	13-Jul-99 13:30	22.49		0.55	L0.005	0.008	0.01	0.005	0.005	14.4				16
99SWE04070	11-Aug-99 10:45	18.47				0.012				13				
99SWE04913	15-Sep-99 10:30	13.76		0.75	0.005	0.011	0.01	0.006	0.004	16				32
99SWE05464	19-Oct-99 14:00	3.46			0.005	0.43				14				28
99SWE05687	16-Nov-99 11:40	0.01				0.092				9.5				
99SWE05773	15-Dec-99 12:15	0.31				0.099				7.4				
00SWE00087	26-Jan-00 10:40	0.11				0.114				7.4				
00SWE00339	23-Feb-00 12:00	0.18				0.156				9				
00SWE00880	05-Apr-00 10:00	-0.44												

SAMPLE NO.	DATE/TIME	Water Temp	Chloro phyll a	TKN	NO3+2 - N	NH3+4-N	TP	TDP	TPP	DOC	TPC	TOC	Tannin & Lignin	True Colour
	Variable Code:	840	414	626	628	604	730	731	725	478	491	487	834	443
	Unit Code:	Deg C	mg/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCU
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)														
98SWE02760	20-Oct-98 15:30	5.45		0.43	0.008	0.02	0.015	0.003	0.012	12.3	0.67			29
99SWE00198	17-Feb-99 15:00	0.64				0.139				11.9	0.54			15
99SWE05459	19-Oct-99 13:15	6.24			L0.005	0.022				13.4				28
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)														
98SWE00263	30-Mar-98 18:30	0.03			0.048	0.23								33
98SWE00405	15-Apr-98 11:15	1.93			0.011	0.046								59
98SWE00552	29-Apr-98 14:30	10.67			0.007	0.026								63
98SWE00804	27-May-98 12:15	18.74		0.72	L0.005	0.007	0.029	0.014	0.015	19.1	0.58			84
98SWE00952	16-Jun-98 11:30	15.72			L0.005	0.009								81
98SWE01029	25-Jun-98 09:00	20.78								19.5	1.11			71
98SWE01335	14-Jul-98 14:00	17.23		0.88	L0.005	0.014	0.035	0.016	0.019	23.5	0.94			96
98SWE01935	18-Aug-98 14:30	19.45								16.4	0.35			53
98SWE01936	18-Aug-98 14:45									16.1	0.26			52
98SWE01937	18-Aug-98 15:00									16.2	0.26			52
98SWE02571	23-Sep-98 09:00	8.6		0.42	L0.005	0.004	0.011	0.004	0.007	12.8	0.25			33
98SWE02755	20-Oct-98 16:00	4.03		0.48	L0.005	0.004	0.014	0.004	0.01	12.8	0.41			29
98SWE02950	17-Nov-98 16:30	0.07				0.041				13.8	0.23			37
98SWE03030	15-Dec-98 12:35	-0.08				0.29				13.3	0.44			36
99SWE00029	13-Jan-99 14:50	-0.08		0.95	0.074	0.37	0.022	0.005	0.017	14.2	0.75			32
99SWE00239	17-Feb-99 09:15	0.18				0.38				14.3	0.89			15
99SWE00470	18-Mar-99 09:20	-0.01				0.34				15.4	1.16			40
99SWE02119	19-May-99 08:15	8.7		0.68	L0.005	0.01	0.035	0.016	0.019	16.5	0.53			87
99SWE02669	22-Jun-99 09:30	19.38				0.018				20.2				
99SWE03348	13-Jul-99 11:00	21.13		0.74	L0.005	0.009	0.02	0.01	0.01	21				64
99SWE04069	11-Aug-99 08:45	16.77				0.008				21.5				
99SWE04912	15-Sep-99 11:45	12.31		0.58	0.006	0.01	0.009	0.005	0.004	15.9				44
99SWE05472	20-Oct-99 10:00	3.45			L0.005	0.007				17				35
99SWE05677	15-Nov-99 16:45	-0.17				0.014				15.9				
99SWE05772	15-Dec-99 13:45	0.21				0.19				15				
00SWE00086	26-Jan-00 11:30	-0.01				0.33				15.2				
00SWE00337	23-Feb-00 15:45	0.01				0.46				16.3				
00SWE00877	05-Apr-00 07:45	-0.32												
00SWE01255	10-May-00 07:15	8.74		0.61	L0.005	0.01	0.033	0.016	0.017	15.7				
00SWE01634	08-Jun-00 09:30	12.25				0.011				25.2				
00SWE02306	13-Jul-00 13:30	20.65		1.21	0.006	0.038	0.065	0.047	0.018	34.6				

SAMPLE NO.	DATE/TIME	Water Temp	Chloro phyll a	TKN	NO3+2 - N	NH3+4-N	TP	TDP	TPP	DOC	TPC	TOC	Tannin & Lignin	True Colour
	Variable Code:	840	414	626	628	604	730	731	725	478	491	487	834	443
	Unit Code:	Deg C	mg/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCU
00SWE03081	23-Aug-00 07:20	15.94				0.017				30.2				
00SWE03277	13-Sep-00 14:45	10.78		0.86	L0.005	0.018	0.028	0.018	0.01	30.3				
00SWE03697	18-Oct-00 11:00	3.12				0.013				23.5				
00SWE03921	16-Nov-00 09:30	-0.19								23.7				
00SWE03940	13-Dec-00 11:45	-0.18				0.26				23.2				
01SWE00029	10-Jan-01 12:45	-0.02		1.16	0.015	0.52	0.045	0.012	0.033	19.2				
01SWE00536	22-Feb-01 15:20	-0.2												
01SWE00339	13-Mar-01 09:20	-0.21				0.51				16.8				
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)														
97SWE00045	25-Feb-97 14:30	0.17	L0.1	0.89	0.174	0.28	0.017	0.005		16.9		17.2	1.15	20
98SWE00802	27-May-98 12:45	20.11		0.67	L0.005	0.009	0.028	0.012	0.016	19.1	0.73			75
98SWE01030	25-Jun-98 09:15	19.82								19.3	0.78			69
98SWE01334	14-Jul-98 13:00	16.91		0.85	0.022	0.012	0.035	0.011	0.024	22.8	1.11			90
98SWE01962	19-Aug-98 11:25	18.13								15.9	0.17			52
98SWE02570	23-Sep-98 09:40	7.72		0.4	L0.005	0.008	0.007	0.002	0.005	12.7	0.18			33
98SWE02754	20-Oct-98 16:20	4.32		0.44	0.006	0.007	0.01	0.004	0.006	12.7	0.27			29
98SWE02949	17-Nov-98 16:00	0.03				0.139				15.1	0.48			36
98SWE03031	15-Dec-98 13:20	-0.1				0.21				12.6	0.24			36
99SWE00018	12-Jan-99 15:15	-0.07		0.85	0.147	0.28	0.022	0.005	0.017	14	0.34			26
99SWE00191	17-Feb-99 16:20	-0.01				0.32				14.7	0.49			20
99SWE00469	18-Mar-99 10:15	0.02				0.22				16.1				40
99SWE02050	18-May-99 13:45	10.28		0.65	0.02	0.017	0.029	0.013	0.016	14.9	0.55			67
99SWE02678	22-Jun-99 12:00	20.47				0.016				18.6				
99SWE04068	11-Aug-99 12:00	18.69				0.008				20.4				
99SWE04911	15-Sep-99 12:15	11.74		0.76	0.005	0.011	0.015	0.008	0.007	19.9				51
99SWE05462	20-Oct-99 07:45	3.93			L0.005	0.006				15.7				35
99SWE05476	20-Oct-99 08:00				L0.005	0.007				16.4				35
99SWE05475	20-Oct-99 08:15				L0.005	0.006				16.4				35
99SWE05688	16-Nov-99 12:15	-0.29				0.005				15.2				
99SWE05771	15-Dec-99 15:15	0.19				0.124				14.8				
00SWE00085	26-Jan-00 12:45	-0.06				0.22				14.5				
00SWE00332	23-Feb-00 16:45	-0.05				0.25				15.6				
00SWE00876	05-Apr-00 10:35	-0.31												
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)														
98SWE02765	20-Oct-98 09:30	3.08		1.08	0.011	0.47	0.055	0.006	0.049	17.7	1.66			38
99SWE00197	17-Feb-99 09:45	0.19				1.06				15.3	2.81			17
99SWE05465	19-Oct-99 08:15	2.45			L0.005	0.33				19.5				45

SAMPLE NO.	DATE/TIME	Water Temp	Chloro phyll a	TKN	NO3+2 - N	NH3+4-N	TP	TDP	TPP	DOC	TPC	TOC	Tannin & Lignin	True Colour
	Variable Code:	840	414	626	628	604	730	731	725	478	491	487	834	443
	Unit Code:	Deg C	mg/m3	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	TCU
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)														
98SWE02764	20-Oct-98 08:30	2.53		1.84	0.006	0.91	0.116	0.031	0.085	26.6	2.83			163
99SWE00196	17-Feb-99 10:15	0.68				1.83				32.5	6.06			95
99SWE05467	19-Oct-99 07:30	1.96			0.043	0.101				19.1				75
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)														
97SWE00046	25-Feb-97 10:00	0.26	L0.1	1.47	0.012	0.75	0.065	0.004		15.1		16	1.32	20
98SWE00810	27-May-98 10:50	16.68		0.81	0.017	0.047	0.046	0.018	0.028	19.4	1.07			86
98SWE01025	25-Jun-98 07:45	18.83								20.6	1.45			89
98SWE01370	15-Jul-98 08:30	14.63		0.93	0.083	0.114	0.051	0.029	0.022	21.1	0.48			102
98SWE01933	18-Aug-98 13:30	17.58								20.3	1.9			80
98SWE02569	23-Sep-98 08:10	8.72		0.64	0.024	0.039	0.032	0.006	0.026	17.2	0.75			50
98SWE02759	20-Oct-98 11:50	3.41		0.89	0.027	0.33	0.035	0.006	0.029	16.3	1.04			39
98SWE02955	18-Nov-98 09:30	0.44				0.53				15.9	1.05			40
98SWE03026	14-Dec-98 15:40	0.12				0.67				14.3	1.42			39
99SWE00030	13-Jan-99 09:45	0.02		1.46	L0.005	0.9	0.039	0.003	0.036	14.4	1.16			30
99SWE00195	17-Feb-99 11:05	0.02				0.97				14.3	2.14			20
99SWE00471	18-Mar-99 08:45	-0.01				1				14.4	2.04			40
99SWE02054	18-May-99 12:15	7.52		0.62	0.014	0.015	0.033	0.017	0.016	16	0.43			88
99SWE02672	22-Jun-99 08:15	17.85				0.32				21				
99SWE02675	22-Jun-99 09:00							L0.1						
99SWE02676	22-Jun-99 09:15							L0.1						
99SWE02677	22-Jun-99 09:30							L0.1						
99SWE03352	13-Jul-99 08:40	18.78		0.88	0.099	0.084	0.045	0.026	0.019	21.8				86
99SWE04067	11-Aug-99 08:00	16.54				0.014				22.4				
99SWE04908	15-Sep-99 08:10	10.38		0.82	0.009	0.024	0.033	0.011	0.022	18.5				54
99SWE05458	19-Oct-99 09:30	2.39			0.014	0.156				17.7				58
99SWE05676	15-Nov-99 15:45	0.16				0.28				16.3				
99SWE05758	14-Dec-99 15:30	0.33				0.49				15.6				
00SWE00093	27-Jan-00 09:30	0.83				0.82				15.7				
00SWE00338	23-Feb-00 11:00	0.07				0.9				15.6				
00SWE00878	05-Apr-00 08:45	-0.32												
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)														
98SWE02762	20-Oct-98 12:10	4.1		1.01	0.008	0.16	0.06	0.028	0.032	22.7	1.04			59
99SWE00193	17-Feb-99 11:45	0.01				0.102				30.8	0.35			61
99SWE05466	19-Oct-99 10:30	2.76			L0.005	0.085				20.6				68
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)														
98SWE02761	20-Oct-98 12:50	6.39		1.26	L0.005	0.39	0.048	0.018	0.03	27.7	5.29			65
99SWE05463	19-Oct-99 11:00	4.25			0.008	0.63				28.6				165

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Ca	Mg	Na	K	Phenol phthalein Alkalinity	Total Alkalinity	Total Hardness	HCO3	CO3	Cl-	SO4
	Variable Code:	404	581	600	565	366	364	541	545	431	426	814
	Unit Code:	mg/L	mg/L	mg/L	mg/L	CaCO3, mg/L	CaCO3, mg/L	CaCO3, mg/L	mg/L	mg/L	mg/L	mg/L
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)												
98SWE02763	20-Oct-98 11:30	40.9	9.72	2.4	0.8	L1	145	142	176		0.7	L3
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)												
98SWE00807	27-May-98 11:15	36.2	9	8.6	0.7	L1	145	127	177		3.3	3
98SWE00808	27-May-98 11:20	36.4	9.1	8.9	0.7	L1	146	128	177		3.4	4
98SWE00809	27-May-98 11:25	36.8	9.18	9	0.7	L1	145	130	177		2.7	4
98SWE01026	25-Jun-98 08:00											
98SWE01368	15-Jul-98 10:35	50	11.8	10.3	0.6	L1	180	174	219		3.3	L3
98SWE01964	19-Aug-98 10:30											
98SWE02537	22-Sep-98 12:15	89.2	16.2	10.9	1.4	L1	288	289	351		5.2	15
98SWE02757	20-Oct-98 14:10	82.2	16.1	11.5	1.3	L1	276	271	336		7.5	L3
98SWE02953	18-Nov-98 11:45											
98SWE03027	15-Dec-98 09:40											
99SWE00027	13-Jan-99 11:10	82	18	12.9	1.5	L1	299	279	365		3.7	L3
99SWE00190	17-Feb-99 13:00	77.3	16.5	19.9	1.5	L1	275	261	336		2.5	6
99SWE00425	16-Mar-99 12:45											
99SWE02055	18-May-99 12:45	40	9.99	8.1	1.3	L1	152	141	185		3.4	5
99SWE02668	22-Jun-99 10:15											
99SWE03351	13-Jul-99 13:00	52.8	13	7.9	0.5	L1	196	185	239		3.2	L3
99SWE04065	11-Aug-99 10:30											
99SWE04909	15-Sep-99 09:30	70.3	17.3	13.8	1.3	L1	263	247	320		7.9	L3
99SWE05461	19-Oct-99 12:00	73	16	13.5	1.7	L1	272	248	331		6	L3
99SWE05686	16-Nov-99 11:05											
99SWE05770	15-Dec-99 10:45											
00SWE00089	26-Jan-00 09:45											
00SWE00333	23-Feb-00 12:30											
00SWE00879	05-Apr-00 09:50											
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)												
98SWE00805	27-May-98 11:40	23.7	6.25	10.5	0.6	L1	103	85	125		1.6	L3
98SWE01027	25-Jun-98 08:30											
98SWE01369	15-Jul-98 10:15	32.3	8.38	11.2	0.4	L1	125	115	152		1.9	L3
98SWE01965	19-Aug-98 09:45											
98SWE02758	20-Oct-98 13:15	62.1	16.4	18.2	1.1	L1	243	222	297		12.9	L3
98SWE02954	18-Nov-98 11:30											
98SWE03028	15-Dec-98 11:00											

SAMPLE NO.	DATE/TIME	Ca	Mg	Na	K	Phenol phthalein Alkalinity	Total Alkalinity	Total Hardness	HCO3	CO3	Cl-	SO4
	Variable Code:	404	581	600	565	366	364	541	545	431	426	814
	Unit Code:	mg/L	mg/L	mg/L	mg/L	CaCO3, mg/L	CaCO3, mg/L	CaCO3, mg/L	mg/L	mg/L	mg/L	mg/L
99SWE00026	13-Jan-99 12:15	86.7	20.5	23.5	1.8	L1	331	301	403		10	L3
99SWE00194	17-Feb-99 13:45	94.9	23.7	6.7	2	L1	371	334	452		15.1	L3
99SWE00426	16-Mar-99 13:15											
99SWE00427	16-Mar-99 13:20											
99SWE00428	16-Mar-99 13:25											
99SWE02056	18-May-99 13:00	26.4	6.83	15.2	2.1	L1	111	94	135		4	13
99SWE02670	22-Jun-99 10:30											
99SWE03350	13-Jul-99 12:30	36.4	9.26	16.3	1	L1	154	129	188		2.9	L3
99SWE04066	11-Aug-99 10:00											
99SWE04910	15-Sep-99 12:00	48.8	13	18.1	1.2	L1	198	175	242		6	L3
99SWE05460	19-Oct-99 12:30	56.6	14.2	18	1.4	L1	227	200	276		5.6	L3
99SWE05774	15-Dec-99 11:45											
00SWE00088	26-Jan-00 10:10											
00SWE00336	23-Feb-00 12:00											
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)												
98SWE00803	27-May-98 11:50	93.4	12.6	6.3	1.4	L1	244	285	297		1.8	60
98SWE01028	25-Jun-98 08:35											
98SWE01371	15-Jul-98 10:55	129	16.8	6.8	1.7	L1	261	392	318		1.4	122
98SWE01963	19-Aug-98 11:00											
98SWE02536	22-Sep-98 12:45	146	20.2	7.3	1.8	L1	294	447	359		2.9	158
98SWE02756	20-Oct-98 14:00	147	20.6	7.1	1.7	L1	298	452	363		1.1	103
98SWE02952	18-Nov-98 12:00											
98SWE03029	15-Dec-98 12:00											
99SWE00028	13-Jan-99 12:45	242	28.9	8.4	2.6	L1	359	724	438		4.8	372
99SWE00192	17-Feb-99 14:20	315	32.1	9.4	3	L1	334	920	407		0.9	574
99SWE00424	16-Mar-99 14:00											
99SWE02049	18-May-99 13:20	174	22.4	7.3	1.9	1	289	526	349	2	2.7	252
99SWE02667	22-Jun-99 11:15											
99SWE03349	13-Jul-99 13:30	136	22.7	8.2	1.7	L1	215	432	263		0.8	207
99SWE04070	11-Aug-99 10:45											
99SWE04913	15-Sep-99 10:30	151	26.3	9.2	2.4	L1	243	484	297		1.6	252
99SWE05464	19-Oct-99 14:00	160	20.8	8.5	2.2	L1	328		400		1	198
99SWE05687	16-Nov-99 11:40											
99SWE05773	15-Dec-99 12:15											
00SWE00087	26-Jan-00 10:40											
00SWE00339	23-Feb-00 12:00											
00SWE00880	05-Apr-00 10:00											

SAMPLE NO.	DATE/TIME	Ca	Mg	Na	K	Phenol phthalein Alkalinity	Total Alkalinity	Total Hardness	HCO3	CO3	Cl-	SO4
	Variable Code:	404	581	600	565	366	364	541	545	431	426	814
	Unit Code:	mg/L	mg/L	mg/L	mg/L	CaCO3, mg/L	CaCO3, mg/L	CaCO3, mg/L	mg/L	mg/L	mg/L	mg/L
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)												
98SWE02760	20-Oct-98 15:30	73.9	12.6	6.9	1.2	L1	249	236	304		6.6	L3
99SWE00198	17-Feb-99 15:00	75.2	12.9	6.8	1.2	L1	247	241	301		2.7	L3
99SWE05459	19-Oct-99 13:15	77	13	8.6	1.4	L1	255	246	311		4.8	L3
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)												
98SWE00263	30-Mar-98 18:30	58.5	12	9.1	1.5	L1	214	195	261		4.2	7.7
98SWE00405	15-Apr-98 11:15	24	5.65	5.1	1.6	L1	91	83	111		2.6	4.69
98SWE00552	29-Apr-98 14:30	28.8	6.63	6.5	1.2	L1	109	99	133		1.1	5.06
98SWE00804	27-May-98 12:15	40.9	9.07	9.2	0.7	L1	152	140	185		2.7	6.22
98SWE00952	16-Jun-98 11:30	54.8	10.5	11.9	L0.1	2	187	180	224	2	7.7	12.6
98SWE01029	25-Jun-98 09:00											
98SWE01335	14-Jul-98 14:00	58.1	11.7	11	0.6	L1	185	193	226		3.1	12
98SWE01935	18-Aug-98 14:30											
98SWE01936	18-Aug-98 14:45											
98SWE01937	18-Aug-98 15:00											
98SWE02571	23-Sep-98 09:00	115	17.8	8.8	1.6	L1	283	361	345		4.6	86
98SWE02755	20-Oct-98 16:00	104	17.2	10	1.4	L1	284	329	346		4	28
98SWE02950	17-Nov-98 16:30											
98SWE03030	15-Dec-98 12:35											
99SWE00029	13-Jan-99 14:50	105	18.9	13.1	1.8	L1	318	341	387		4.1	48
99SWE00239	17-Feb-99 09:15	115	19.4	12.2	1.8	L1	289	368	352		3.1	89
99SWE00470	18-Mar-99 09:20											
99SWE02119	19-May-99 08:15	43.1	9.87	9.6	1.5	L1	152	148	185		2.9	4
99SWE02669	22-Jun-99 09:30											
99SWE03348	13-Jul-99 11:00	55.1	13	8.4	0.5	L1	191	191	233		2.1	L3
99SWE04069	11-Aug-99 08:45											
99SWE04912	15-Sep-99 11:45	85.8	18.8	14.1	1.4	L1	235	292	286		7.5	72
99SWE05472	20-Oct-99 10:00	108	18.8	12.4	1.9	L1	288	348	350		4.5	82
99SWE05677	15-Nov-99 16:45											
99SWE05772	15-Dec-99 13:45											
00SWE00086	26-Jan-00 11:30											
00SWE00337	23-Feb-00 15:45											
00SWE00877	05-Apr-00 07:45											
00SWE01255	10-May-00 07:15	50.5	11.5	9.9	1.8	L1	169	173	206		2.5	22
00SWE01634	08-Jun-00 09:30											
00SWE02306	13-Jul-00 13:30	35.6	9.31	11.5	1	L1	143	127	174		3.2	5

SAMPLE NO.	DATE/TIME	Ca	Mg	Na	K	Phenol phthalein Alkalinity	Total Alkalinity	Total Hardness	HCO3	CO3	Cl-	SO4
	Variable Code:	404	581	600	565	366	364	541	545	431	426	814
	Unit Code:	mg/L	mg/L	mg/L	mg/L	CaCO3, mg/L	CaCO3, mg/L	CaCO3, mg/L	mg/L	mg/L	mg/L	mg/L
00SWE03081	23-Aug-00 07:20											
00SWE03277	13-Sep-00 14:45	36.1	9.23	12	0.7	L1	137	128	167		4	5
00SWE03697	18-Oct-00 11:00											
00SWE03921	16-Nov-00 09:30											
00SWE03940	13-Dec-00 11:45											
01SWE00029	10-Jan-01 12:45			16.3	1.5	L1	284	254	347		6.4	L3
01SWE00536	22-Feb-01 15:20											
01SWE00339	13-Mar-01 09:20											
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)												
97SWE00045	25-Feb-97 14:30	73.7	16.4	14	1.2	L0.1	264	252	322	L0.5	5.2	2.6
98SWE00802	27-May-98 12:45	41.9	9.02	9.4	0.8	2	154	142	182	3	2.5	7
98SWE01030	25-Jun-98 09:15											
98SWE01334	14-Jul-98 13:00	57.9	11.5	11.5	0.7	3	184	192	218	3	2.8	14
98SWE01962	19-Aug-98 11:25											
98SWE02570	23-Sep-98 09:40	108	17.5	10	1.5	2	275	342	329	3	3.9	73
98SWE02754	20-Oct-98 16:20	104	17.3	10.6	1.5	6	282	330	330	7	3.6	21
98SWE02949	17-Nov-98 16:00											
98SWE03031	15-Dec-98 13:20											
99SWE00018	12-Jan-99 15:15	107	19.3	15.5	1.8	L1	333	348	406		8.4	47
99SWE00191	17-Feb-99 16:20	122	20.9	29.8	1.8	L1	312	390	380		4.1	97
99SWE00469	18-Mar-99 10:15											
99SWE02050	18-May-99 13:45	48.6	10.8	9.7	1.4	2	162	166	192	3	3.5	18
99SWE02678	22-Jun-99 12:00											
99SWE04068	11-Aug-99 12:00											
99SWE04911	15-Sep-99 12:15	87.7	19	12.3	1.6	L1	247	297	302		5.7	63
99SWE05462	20-Oct-99 07:45	106	18.9	13.3	1.9	L1	280	343	341		5.8	91
99SWE05476	20-Oct-99 08:00	107	19.3	13.1	1.9	L1	280	346	341		5.9	92
99SWE05475	20-Oct-99 08:15	106	19	13.1	1.9	L1	280	344	341		5.8	91
99SWE05688	16-Nov-99 12:15											
99SWE05771	15-Dec-99 15:15											
00SWE00085	26-Jan-00 12:45											
00SWE00332	23-Feb-00 16:45											
00SWE00876	05-Apr-00 10:35											
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)												
98SWE02765	20-Oct-98 09:30	76.8	19.4	6.8	1.2	L1	281	272	343		2.1	L3
99SWE00197	17-Feb-99 09:45	88	23.1	6.7	1.6	L1	328	315	400		1.7	L3
99SWE05465	19-Oct-99 08:15	76	18.6	6.7	1.4	L1	280	266	341		1.5	L3

SAMPLE NO.	DATE/TIME	Ca	Mg	Na	K	Phenol phthalein Alkalinity	Total Alkalinity	Total Hardness	HCO3	CO3	Cl-	SO4
	Variable Code:	404	581	600	565	366	364	541	545	431	426	814
	Unit Code:	mg/L	mg/L	mg/L	mg/L	CaCO3, mg/L	CaCO3, mg/L	CaCO3, mg/L	mg/L	mg/L	mg/L	mg/L
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)												
98SWE02764	20-Oct-98 08:30	69.2	12.8	9.9	1	L1	244	225	298		2.3	4
99SWE00196	17-Feb-99 10:15	89.1	15.2	7	1.4	L1	306	285	373		2.1	L3
99SWE05467	19-Oct-99 07:30	34.2	9.37	7.5	1.4	L1	132	124	161		1.6	4
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)												
97SWE00046	25-Feb-97 10:00	82.6	19.8	9.52	1.2	L0.1	299	288	364	L0.5	3.1	0.7
98SWE00810	27-May-98 10:50	40.7	9.94	5.5	0.6	L1	155	143	189		3.6	L3
98SWE01025	25-Jun-98 07:45											
98SWE01370	15-Jul-98 08:30	59.9	13.9	5.9	0.7	L1	205	207	250		2	L3
98SWE01933	18-Aug-98 13:30											
98SWE02569	23-Sep-98 08:10	74.4	16.4	8.8	1.2	L1	276	253	336		3	L3
98SWE02759	20-Oct-98 11:50	70.6	15.8	7.2	1.1	L1	256	242	312		2.9	26
98SWE02955	18-Nov-98 09:30											
98SWE03026	14-Dec-98 15:40											
99SWE00030	13-Jan-99 09:45	87.1	19.7	10	1.5	L1	316	298	386		2.8	L3
99SWE00195	17-Feb-99 11:05	84.8	19.4	6.8	1.5	L1	308	292	376		2.7	L3
99SWE00471	18-Mar-99 08:45											
99SWE02054	18-May-99 12:15	40.3	10.5	5.8	1.2	L1	150	144	183		1.6	4
99SWE02672	22-Jun-99 08:15											
99SWE02675	22-Jun-99 09:00	54.8	13.1	3.6	0.2							
99SWE02676	22-Jun-99 09:15	54.7	13.1	3.5	L0.2							
99SWE02677	22-Jun-99 09:30	56.1	13.4	3.5	L0.2							
99SWE03352	13-Jul-99 08:40	58.7	14.1	6.3	0.6	L1	205	205	250		1.3	L3
99SWE04067	11-Aug-99 08:00											
99SWE04908	15-Sep-99 08:10	73.3	16.4	8.1	1.1	L1	263	251	321		3.6	5
99SWE05458	19-Oct-99 09:30	70.4	15.1	8.4	1.6	L1	254	238	310		1.9	L3
99SWE05676	15-Nov-99 15:45											
99SWE05758	14-Dec-99 15:30											
00SWE00093	27-Jan-00 09:30											
00SWE00338	23-Feb-00 11:00											
00SWE00878	05-Apr-00 08:45											
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)												
98SWE02762	20-Oct-98 12:10	65.9	17.2	48.6	1.8	L1	299	235	364		20.2	L3
99SWE00193	17-Feb-99 11:45	39.2	12.8	11.2	1.7	L1	180	151	220		2	8
99SWE05466	19-Oct-99 10:30	66.2	17.3	44.2	2.1	L1	297	237	362		23.1	8
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)												
98SWE02761	20-Oct-98 12:50	70.1	11.9	45.9	0.7	L1	295	224	359		16.6	L3
99SWE05463	19-Oct-99 11:00	83.5	13.8	96.2	3.1	L1	354	265	432		80.2	10

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Sulfide	OH-	TA	TC	TC-TA	Silica	Cond (field)	Cond (lab)	pH (field)	pH (lab)	BOD	COD	DO (meter)	DO (Winkler)
	Variable Code:	831	641	829	830	556	786	3357	3358	3359	3360	647	657	3361	3362
	Unit Code:	mg/L	mg/L	meq/L	meq/L	%TC	mg/L	uS/cm	uS/cm	units	units	mg/L	mg/L	mg/L	mg/L
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)															
98SWE02763	20-Oct-98 11:30	0.002		2.95	2.97	-97	23.3	255	266	6.93	7.39	0.4		7.93	
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)															
98SWE00807	27-May-98 11:15			3.03	2.94	-100	4.5	268		7.63	8.03	1.5		7.8	7.4
98SWE00808	27-May-98 11:20			3.05	2.97	-100	4.5				8.04	1.5			
98SWE00809	27-May-98 11:25			3.01	3.00	-97	4.3				8.06	1.3			
98SWE01026	25-Jun-98 08:00							370		7.7		3		7.47	6.87
98SWE01368	15-Jul-98 10:35			3.73	3.93	-91	11.6	325		7.71	7.96	1.3		8.14	7.68
98SWE01964	19-Aug-98 10:30							476		7.83		1.4		7.16	6.69
98SWE02537	22-Sep-98 12:15			5.94	6.29	-88	12.5	547	548	7.49	8.03	1.7		9.09	8.18
98SWE02757	20-Oct-98 14:10	0.001		5.77	5.96	-91	13.5	511	519	7.3	7.93	0.8		10.93	
98SWE02953	18-Nov-98 11:45							511		7.51		1.5		9.75	
98SWE03027	15-Dec-98 09:40							574		7.67		1.9		4.13	4.03
99SWE00027	13-Jan-99 11:10			6.12	6.17	-93	16.8	527	545	6.88	7.42	1.3		3.68	2.54
99SWE00190	17-Feb-99 13:00	L0.001		5.60	6.12	-85		475		6.98	7.5	1.6		4.86	4.18
99SWE00425	16-Mar-99 12:45							495		6.75		1.9		4.86	3.96
99SWE02055	18-May-99 12:45			3.17	3.20	-96	6	292	292	7.6	7.95	1.4		10	
99SWE02668	22-Jun-99 10:15							376		7.62		1.5		6.35	
99SWE03351	13-Jul-99 13:00			4.04	4.06	-95	7.8	368	368	7.55	8.1	1.5		6.55	
99SWE04065	11-Aug-99 10:30							454		7.24		0.9		4.22	
99SWE04909	15-Sep-99 09:30			5.52	5.56	-94	11.1	487	491	7.79	7.82	1.2		7.35	
99SWE05461	19-Oct-99 12:00	0.001		5.64	5.59	-95	12.4	485	499	7.7	7.71	0.7		9.73	
99SWE05686	16-Nov-99 11:05							506		7.48		1.1		9.46	
99SWE05770	15-Dec-99 10:45	L0.001						500		6.75		0.7		6.91	
00SWE00089	26-Jan-00 09:45	L0.001						533		7.11		1.9		3.8	
00SWE00333	23-Feb-00 12:30							544		6.98				3.74	3.47
00SWE00879	05-Apr-00 09:50							249		7.68				10.28	
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)															
98SWE00805	27-May-98 11:40			2.14	2.17	-96	3.2	189		7.83	7.92	1.1		8.65	8.19
98SWE01027	25-Jun-98 08:30							223		7.64		L0.2		7.11	6.58
98SWE01369	15-Jul-98 10:15			2.59	2.80	-90	9.5	232		7.86	8.04	1.2		9.15	
98SWE01965	19-Aug-98 09:45							350		7.68		1.3		6.54	
98SWE02758	20-Oct-98 13:15	0.001		5.26	5.27	-95	7.3	451	460	7.1	7.8	0.9		9.48	9.13
98SWE02954	18-Nov-98 11:30							565		7.62		1.4		9.3	
98SWE03028	15-Dec-98 11:00							631		7.88		2.6		7.49	7.58

SAMPLE NO.	DATE/TIME	Sulfide	OH-	TA	TC	TC-TA	Silica	Cond (field)	Cond (lab)	pH (field)	pH (lab)	BOD	COD	DO (meter)	DO (Winkler)
	Variable Code:	831	641	829	830	556	786	3357	3358	3359	3360	647	657	3361	3362
	Unit Code:	mg/L	mg/L	meq/L	meq/L	%TC	mg/L	uS/cm	uS/cm	units	units	mg/L	mg/L	mg/L	mg/L
99SWE00026	13-Jan-99 12:15			6.94	7.08	-91	16.5	630	612	7.03	7.63	1.5		4.46	2.83
99SWE00194	17-Feb-99 13:45	L0.001		7.88	7.03	-105		598		7.29	7.83	1.6		5.18	4.88
99SWE00426	16-Mar-99 13:15							625		7.11		1.8		7.78	
99SWE00427	16-Mar-99 13:20											1.3			
99SWE00428	16-Mar-99 13:25											1.7			
99SWE02056	18-May-99 13:00			2.37	2.59	-89	5.2	235	236	7.84	8.06	1.4		10.65	
99SWE02670	22-Jun-99 10:30							303		7.7		1.4		7.08	
99SWE03350	13-Jul-99 12:30			3.19	3.31	-93	4.3	297	299	7.54	8.04	1.3		5.84	
99SWE04066	11-Aug-99 10:00							337		7.33		1.1		6	
99SWE04910	15-Sep-99 12:00			4.16	4.32	-92	3.2	372	379	7.69	7.8	2.1		8.06	
99SWE05460	19-Oct-99 12:30	0.002		4.73	4.81	-94	6.3	413	429	7.77	7.92	1.5		10.36	
99SWE05774	15-Dec-99 11:45	L0.001						549		7.25		0.6		10.47	
00SWE00088	26-Jan-00 10:10	L0.001						535		7.36		0.7		7.43	
00SWE00336	23-Feb-00 12:00							578		7.16				6.26	
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)															
98SWE00803	27-May-98 11:50			4.96	6.01	-77	9.1	548		7.87	8.13	1.3		9.4	
98SWE01028	25-Jun-98 08:35							621		7.81		1		7.88	
98SWE01371	15-Jul-98 10:55			5.29	8.16	-57	11.9	687		7.85	8.1	0.9		9.92	
98SWE01963	19-Aug-98 11:00							748		7.79		0.8		8.67	
98SWE02536	22-Sep-98 12:45			5.99	9.31	-55	12.3	820	802	7.78	8.07	1		10.62	
98SWE02756	20-Oct-98 14:00	0.001		6.02	9.38	-55	12.8	776	771	7.65	8.08	0.5		12.54	
98SWE02952	18-Nov-98 12:00							1149		7.51		1		9.49	
98SWE03029	15-Dec-98 12:00							1183		7.77		1.9		9.41	
99SWE00028	13-Jan-99 12:45			7.35	14.89	-34	14.8	1172	1230	7.06	7.61	1.1		9.2	
99SWE00192	17-Feb-99 14:20	L0.001		6.74	18.85	-17		1246		7.02	7.53	0.9		9.98	
99SWE00424	16-Mar-99 14:00							1019		7.13		0.8		9.11	
99SWE02049	18-May-99 13:20			5.89	10.89	-43	9.8	917	926	8.06	8.3	1.3		10.5	
99SWE02667	22-Jun-99 11:15							892		8.08		1.6		8.81	
99SWE03349	13-Jul-99 13:30			4.35	9.05	-39	7.1	781	777	8.02	8.25	1.1		8.89	
99SWE04070	11-Aug-99 10:45							889		7.78		1.1		9.55	
99SWE04913	15-Sep-99 10:30			4.94	10.16	-38	10.9	897	887	7.94	8.21	1.3		10.3	
99SWE05464	19-Oct-99 14:00	0.001		6.62	10.12	-55	14.4	887	905	7.86	7.97	0.9		12.54	
99SWE05687	16-Nov-99 11:40							1031		7.57		1		13.4	
99SWE05773	15-Dec-99 12:15	L0.001						886		6.94		0.3		13.69	
00SWE00087	26-Jan-00 10:40	L0.001						986		7.26		0.3		9.75	
00SWE00339	23-Feb-00 12:00							893		7.22				11.45	
00SWE00880	05-Apr-00 10:00							968		7.43				11.52	

SAMPLE NO.	DATE/TIME	Sulfide	OH-	TA	TC	TC-TA	Silica	Cond (field)	Cond (lab)	pH (field)	pH (lab)	BOD	COD	DO (meter)	DO (Winkler)
	Variable Code:	831	641	829	830	556	786	3357	3358	3359	3360	647	657	3361	3362
	Unit Code:	mg/L	mg/L	meq/L	meq/L	%TC	mg/L	uS/cm	uS/cm	units	units	mg/L	mg/L	mg/L	mg/L
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)															
98SWE02760	20-Oct-98 15:30	0.001		5.20	5.06	-98	8	447	456	7.5	7.99	0.4		10.78	
99SWE00198	17-Feb-99 15:00	0.001		5.05	5.14	-93		420		7.4	7.85	1.5		9.91	
99SWE05459	19-Oct-99 13:15	0.001		5.27	5.32	-94	6.7	457	473	7.88	8.08	0.8		11.52	
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)															
98SWE00263	30-Mar-98 18:30			4.43	4.34	-98	11.4	395	409	7.2	8.28			7.99	
98SWE00405	15-Apr-98 11:15			1.93	1.93	-98	4.8	174	184	7.58	7.93			11.97	11.61
98SWE00552	29-Apr-98 14:30			2.24	2.30	-95		212	214	7.77	8.04			10.02	9.38
98SWE00804	27-May-98 12:15			3.15	3.21	-95	4.2	290	292	7.85	8.11	1.4		8.37	7.9
98SWE00952	16-Jun-98 11:30			3.99	4.12	-93	6.1	371	364	7.9	8.3			8.82	
98SWE01029	25-Jun-98 09:00							383		7.82		2		7.24	6.84
98SWE01335	14-Jul-98 14:00			3.82	4.36	-83	9.2	361		7.9	8.08	1.5		8.81	8.19
98SWE01935	18-Aug-98 14:30							556		8		1.1		8.61	8.56
98SWE01936	18-Aug-98 14:45											1.1			
98SWE01937	18-Aug-98 15:00											1.1			
98SWE02571	23-Sep-98 09:00			5.82	7.63	-69	10.7	673	666	7.93	8.1	0.6		10.51	9.81
98SWE02755	20-Oct-98 16:00	0.001		5.83	7.08	-75	12	608	617	7.76	8.09	0.6		11.84	11.66
98SWE02950	17-Nov-98 16:30							591		7.67		1.3		10.53	10.71
98SWE03030	15-Dec-98 12:35							645		7.73		1.6		7.3	6.89
99SWE00029	13-Jan-99 14:50			6.51	7.41	-80	15.6	661	654	6.97	7.55	1.2		5.62	5.11
99SWE00239	17-Feb-99 09:15	L0.001		5.90	7.91	-67		650		7.28	7.58	1.6		6.19	5.78
99SWE00470	18-Mar-99 09:20							613		7.05		1.6		6.74	
99SWE02119	19-May-99 08:15			3.15	3.42	-89	5.3	312	322	7.83	8.11	1.5		10.3	
99SWE02669	22-Jun-99 09:30							379		7.83		1.5		7.05	
99SWE03348	13-Jul-99 11:00			3.91	4.20	-89	7.2	365	366	7.87	8.15	0.8		7.65	
99SWE04069	11-Aug-99 08:45							488		7.7		0.7		7.62	
99SWE04912	15-Sep-99 11:45			4.95	6.48	-70	5	578	573	7.85	8.29	1.1		9.18	
99SWE05472	20-Oct-99 10:00	0.001		5.92	7.52	-71	11.5	655	665	7.89	7.92	1.2		11.44	10.55
99SWE05677	15-Nov-99 16:45							651		7.5		0.9		10.9	
99SWE05772	15-Dec-99 13:45	L0.001						579		6.94		0.5		8.87	
00SWE00086	26-Jan-00 11:30	L0.001						628		7.24		0.9		4.19	
00SWE00337	23-Feb-00 15:45							598		7.08				2.93	
00SWE00877	05-Apr-00 07:45							373		7.44				10.62	
00SWE01255	10-May-00 07:15			3.48	3.94	-84	6.5	352	358	7.78	8.08			10.39	
00SWE01634	08-Jun-00 09:30							264		7.6				8.3	8.6
00SWE02306	13-Jul-00 13:30			2.98	3.07	-94	9.3	280	275	7.39	7.69			5.96	5.47

SAMPLE NO.	DATE/TIME	Sulfide	OH-	TA	TC	TC-TA	Silica	Cond (field)	Cond (lab)	pH (field)	pH (lab)	BOD	COD	DO (meter)	DO (Winkler)
	Variable Code:	831	641	829	830	556	786	3357	3358	3359	3360	647	657	3361	3362
	Unit Code:	mg/L	mg/L	meq/L	meq/L	%TC	mg/L	uS/cm	uS/cm	units	units	mg/L	mg/L	mg/L	mg/L
00SWE03081	23-Aug-00 07:20							344.8		7.53				8.04	
00SWE03277	13-Sep-00 14:45	0.005		2.89	3.10	-90	7.9	257	247	7.54	8.01			9.96	9.05
00SWE03697	18-Oct-00 11:00							257		7.58				11.91	
00SWE03921	16-Nov-00 09:30							333		6.89				7.99	
00SWE03940	13-Dec-00 11:45							452.1		6.8				3.26	
01SWE00029	10-Jan-01 12:45	0.002		5.89			14.8	515	514	7.55	7.8			2.35	1.64
01SWE00536	22-Feb-01 15:20							489		7				4.43	
01SWE00339	13-Mar-01 09:20	0.002						641		7				4.75	4.62
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)															
97SWE00045	25-Feb-97 14:30	L0.005	L0.5	5.46	5.67	-91	13	472	506	7.08	7.42	0.9	49	11.06	11.05
98SWE00802	27-May-98 12:45			3.18	3.26	-94	4.3	292		8.12	8.31	1.3		9.04	8.54
98SWE01030	25-Jun-98 09:15							384		8.15		1		8.46	8.08
98SWE01334	14-Jul-98 13:00			3.79	4.35	-83	8.4	355		8.51	8.35	1.5		9.56	9.11
98SWE01962	19-Aug-98 11:25							543		8.26		1		9.3	8.76
98SWE02570	23-Sep-98 09:40			5.64	7.30	-70	9.8	635	629	8.22	8.31	0.6		11.47	11.02
98SWE02754	20-Oct-98 16:20	0.001		5.77	7.11	-74	11.5	604	615	8.06	8.37	0.4		12.56	
98SWE02949	17-Nov-98 16:00							701		7.82		1.2		11.89	11.93
98SWE03031	15-Dec-98 13:20							678		7.82		1.8		11.09	10.59
99SWE00018	12-Jan-99 15:15			6.93	7.65	-83	15.3	649	696	7	7.58	1		9.59	8.59
99SWE00191	17-Feb-99 16:20	L0.001		6.39	9.15	-61		686		7.04	7.59	1.5		6.38	5.56
99SWE00469	18-Mar-99 10:15							619		7.09				6.94	
99SWE02050	18-May-99 13:45			3.37	3.77	-86	5.7	335	336	8.21	8.31	1.5		10.64	
99SWE02678	22-Jun-99 12:00							380		8.42		1.4		9.66	
99SWE04068	11-Aug-99 12:00							464		8.04		0.8		9.97	
99SWE04911	15-Sep-99 12:15			5.13	6.52	-72	4.7	574	575	8.02	8.13	1		10.3	
99SWE05462	20-Oct-99 07:45	0.001		5.80	7.47	-70	10.4	655	666	8.02	8.21	0.9		12.3	
99SWE05476	20-Oct-99 08:00	0.001		5.80	7.55	-69	10.3		671		8.23	0.7			
99SWE05475	20-Oct-99 08:15	L0.001		5.80	7.47	-70	10.2		671		8.23	0.9			
99SWE05688	16-Nov-99 12:15							640		7.86		1.1		13.64	
99SWE05771	15-Dec-99 15:15	L0.001						595		7.08		0.5		13.88	10.12
00SWE00085	26-Jan-00 12:45	L0.001						635		7.28		0.7		10.67	
00SWE00332	23-Feb-00 16:45							640		7.23				7.27	6.94
00SWE00876	05-Apr-00 10:35							444		7.71				13.43	
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)															
98SWE02765	20-Oct-98 09:30	0.001		5.71	5.75	-93	15.1	493	505	6.98	7.45	1.3		5.01	4.26
99SWE00197	17-Feb-99 09:45	L0.001			6.62			541		7.12	7.66	2.1		2.33	
99SWE05465	19-Oct-99 08:15	0.001		5.67	5.65	-95	15.4	481	506	7.55	7.47	1.3		5.78	

SAMPLE NO.	DATE/TIME	Sulfide	OH-	TA	TC	TC-TA	Silica	Cond (field)	Cond (lab)	pH (field)	pH (lab)	BOD	COD	DO (meter)	DO (Winkler)
	Variable Code:	831	641	829	830	556	786	3357	3358	3359	3360	647	657	3361	3362
	Unit Code:	mg/L	mg/L	meq/L	meq/L	%TC	mg/L	uS/cm	uS/cm	units	units	mg/L	mg/L	mg/L	mg/L
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)															
98SWE02764	20-Oct-98 08:30	0.002		4.98	4.96	-95	12.6	433	445	6.54	7.09	3.05		3.39	
99SWE00196	17-Feb-99 10:15	0.002			6.04			540		7.04	7.42	1.5		1.25	
99SWE05467	19-Oct-99 07:30	0.002		2.72	2.84	-93	10.7	395	246	7.41	7.33	0.9		6.54	
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)															
97SWE00046	25-Feb-97 10:00	L0.005	L0.5				15.4	514	553	6.76	7.14	1.9	40	0.75	
98SWE00810	27-May-98 10:50			3.23	3.10	-101	5.6	281		7.54	7.6	1.5		6	5.48
98SWE01025	25-Jun-98 07:45							404		7.31		2		5.11	4.41
98SWE01370	15-Jul-98 08:30			4.19	4.41	-91	13	364		7.48	7.76	1.3		6.76	6.45
98SWE01933	18-Aug-98 13:30							462		7.52		1.7		5.94	7.14
98SWE02569	23-Sep-98 08:10			5.64	5.48	-97	13.9	487	493	7.4	7.83	1.2		6.81	6.28
98SWE02759	20-Oct-98 11:50	0.002		5.23	5.16	-96	14.9	452	463	6.8	7.62	0.8		8.67	7.85
98SWE02955	18-Nov-98 09:30							488		6.93		1.8		3.7	
98SWE03026	14-Dec-98 15:40							527		7.61		2.7		1.65	
99SWE00030	13-Jan-99 09:45			6.43	6.44	-93	16.9	569	565	6.92	7.42	1.2		0.73	0.3
99SWE00195	17-Feb-99 11:05	L0.001			6.16			513		7.02	7.53	3.4		2.49	
99SWE00471	18-Mar-99 08:45							530		6.93		1.4		3.26	
99SWE02054	18-May-99 12:15			3.08	3.16	-94	5.8	279	281	7.35	7.79	1.4		9.32	
99SWE02672	22-Jun-99 08:15							379		7.41		1.8		4.45	
99SWE02675	22-Jun-99 09:00														
99SWE02676	22-Jun-99 09:15														
99SWE02677	22-Jun-99 09:30														
99SWE03352	13-Jul-99 08:40			4.17	4.38	-91	9.6	379	378	7.4	7.84	1.3		4.93	
99SWE04067	11-Aug-99 08:00							431		7.41		1		6.68	
99SWE04908	15-Sep-99 08:10			5.39	5.39	-95	13	470	474	7.7	7.85	1.7		6.75	
99SWE05458	19-Oct-99 09:30	0.001		5.17	5.16	-95	15.8	439	459	7.68	7.78	0.9		8.57	
99SWE05676	15-Nov-99 15:45							475		7.5		1.1		8.6	
99SWE05758	14-Dec-99 15:30							334		7.01		1.5		3.15	3.1
00SWE00093	27-Jan-00 09:30	L0.001						522		7.16		1.7		2.7	
00SWE00338	23-Feb-00 11:00							540		6.94				2.05	
00SWE00878	05-Apr-00 08:45							284		7.7				9.6	
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)															
98SWE02762	20-Oct-98 12:10	0.002		6.59	6.86	-89	8.8	580	595	7.09	7.54	1.2		6.32	5.89
99SWE00193	17-Feb-99 11:45	L0.001			3.54			314		7.02	7.57	1.4		6.01	5.52
99SWE05466	19-Oct-99 10:30	0.002		6.63	6.70	-92	8.1	585	584	7.59	7.76	1.4		7.21	
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)															
98SWE02761	20-Oct-98 12:50	0.002		6.40	6.49	-92	14.7	627	557	6.68	7.11	1.9		5.27	
99SWE05463	19-Oct-99 11:00	0.023		9.40	9.57	-89	15.8	1172	890	7.23	7.16	10.4		0.92	

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Phenols	Non-filterable Residue (TSS)	Total Residue (TS)	Filterable Residue (difference)	Turbidity	Cyanide	Fluoride, diss.	Fecal Coliforms	Total Coliforms
	Variable Code:	689	749	750	836	864	427	532	433	434
	Unit Code:	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	no./dL	no./100 mL
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)										
98SWE02763	20-Oct-98 11:30		13	214	201			0.16		
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)										
98SWE00807	27-May-98 11:15		6	216	210			0.12		
98SWE00808	27-May-98 11:20		6	216	210			0.12		
98SWE00809	27-May-98 11:25		5	220	215			0.13		
98SWE01026	25-Jun-98 08:00		45							
98SWE01368	15-Jul-98 10:35		3	274	271			0.13		
98SWE01964	19-Aug-98 10:30		L1							
98SWE02537	22-Sep-98 12:15		L1	388	388			0.17		
98SWE02757	20-Oct-98 14:10		4	544	540			0.18		
98SWE02953	18-Nov-98 11:45		5							
98SWE03027	15-Dec-98 09:40		6							
99SWE00027	13-Jan-99 11:10		9	374	365			0.21		
99SWE00190	17-Feb-99 13:00		8							
99SWE00425	16-Mar-99 12:45		2							
99SWE02055	18-May-99 12:45		L1					0.12		
99SWE02668	22-Jun-99 10:15		3							
99SWE03351	13-Jul-99 13:00		2	262	260			0.15		
99SWE04065	11-Aug-99 10:30		1							
99SWE04909	15-Sep-99 09:30		2	342	340			0.17		
99SWE05461	19-Oct-99 12:00		2					0.18		
99SWE05686	16-Nov-99 11:05		2							
99SWE05770	15-Dec-99 10:45		5							
00SWE00089	26-Jan-00 09:45		40							
00SWE00333	23-Feb-00 12:30		7							
00SWE00879	05-Apr-00 09:50									
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)										
98SWE00805	27-May-98 11:40		3	170	167			0.09		
98SWE01027	25-Jun-98 08:30		2							
98SWE01369	15-Jul-98 10:15		3	220	217			0.1		
98SWE01965	19-Aug-98 09:45		1							
98SWE02758	20-Oct-98 13:15		5	472	467			0.15		
98SWE02954	18-Nov-98 11:30		5							
98SWE03028	15-Dec-98 11:00		5							

SAMPLE NO.	DATE/TIME	Phenols	Non-filterable Residue (TSS)	Total Residue (TS)	Filterable Residue (difference)	Turbidity	Cyanide	Fluoride, diss.	Fecal Coliforms	Total Coliforms
	Variable Code:	689	749	750	836	864	427	532	433	434
	Unit Code:	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	no./dL	no./100 mL
99SWE00026	13-Jan-99 12:15		11	420	410			0.21		
99SWE00194	17-Feb-99 13:45		8							
99SWE00426	16-Mar-99 13:15		5							
99SWE00427	16-Mar-99 13:20		3							
99SWE00428	16-Mar-99 13:25		4							
99SWE02056	18-May-99 13:00		L1					0.1		
99SWE02670	22-Jun-99 10:30		3							
99SWE03350	13-Jul-99 12:30		1	224	223			0.13		
99SWE04066	11-Aug-99 10:00		2							
99SWE04910	15-Sep-99 12:00		13	276	263			0.15		
99SWE05460	19-Oct-99 12:30		8					0.15		
99SWE05774	15-Dec-99 11:45		2							
00SWE00088	26-Jan-00 10:10		3							
00SWE00336	23-Feb-00 12:00		10							
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)										
98SWE00803	27-May-98 11:50		11	398	387			0.14		
98SWE01028	25-Jun-98 08:35		9							
98SWE01371	15-Jul-98 10:55		5	508	503			0.13		
98SWE01963	19-Aug-98 11:00		10							
98SWE02536	22-Sep-98 12:45		7	574	567			0.12		
98SWE02756	20-Oct-98 14:00		13	732	719			0.11		
98SWE02952	18-Nov-98 12:00		3							
98SWE03029	15-Dec-98 12:00		2							
99SWE00028	13-Jan-99 12:45		4	992	988			0.11		
99SWE00192	17-Feb-99 14:20		2							
99SWE00424	16-Mar-99 14:00		2							
99SWE02049	18-May-99 13:20		7					0.11		
99SWE02667	22-Jun-99 11:15		4							
99SWE03349	13-Jul-99 13:30		4	620	616			0.11		
99SWE04070	11-Aug-99 10:45		4							
99SWE04913	15-Sep-99 10:30		3	706	703			0.09		
99SWE05464	19-Oct-99 14:00		10					0.11		
99SWE05687	16-Nov-99 11:40		2							
99SWE05773	15-Dec-99 12:15		L1							
00SWE00087	26-Jan-00 10:40		L1							
00SWE00339	23-Feb-00 12:00		L1							
00SWE00880	05-Apr-00 10:00									

SAMPLE NO.	DATE/TIME	Phenols	Non-filterable Residue (TSS)	Total Residue (TS)	Filterable Residue (difference)	Turbidity	Cyanide	Fluoride, diss.	Fecal Coliforms	Total Coliforms
	Variable Code:	689	749	750	836	864	427	532	433	434
	Unit Code:	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	no./dL	no./100 mL
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)										
98SWE02760	20-Oct-98 15:30		4	266	262			0.11		
99SWE00198	17-Feb-99 15:00		7							
99SWE05459	19-Oct-99 13:15		6					0.1		
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)										
98SWE00263	30-Mar-98 18:30		25					0.13		
98SWE00405	15-Apr-98 11:15		13					0.07		
98SWE00552	29-Apr-98 14:30		8							
98SWE00804	27-May-98 12:15		3	228	225			0.11		
98SWE00952	16-Jun-98 11:30		6					0.13		
98SWE01029	25-Jun-98 09:00		8							
98SWE01335	14-Jul-98 14:00		5	298	293			0.13		
98SWE01935	18-Aug-98 14:30		2							
98SWE01936	18-Aug-98 14:45		3							
98SWE01937	18-Aug-98 15:00		3							
98SWE02571	23-Sep-98 09:00		2	484	482			0.1		
98SWE02755	20-Oct-98 16:00		3	598	595			0.15		
98SWE02950	17-Nov-98 16:30		3							
98SWE03030	15-Dec-98 12:35		4							
99SWE00029	13-Jan-99 14:50		4	452	449			0.19		
99SWE00239	17-Feb-99 09:15		7							
99SWE00470	18-Mar-99 09:20		8							
99SWE02119	19-May-99 08:15		2					0.11		
99SWE02669	22-Jun-99 09:30		4							
99SWE03348	13-Jul-99 11:00		1	260	259			0.14		
99SWE04069	11-Aug-99 08:45		1							
99SWE04912	15-Sep-99 11:45		1	408	407			0.15		
99SWE05472	20-Oct-99 10:00		15					0.15		
99SWE05677	15-Nov-99 16:45		1							
99SWE05772	15-Dec-99 13:45		L1							
00SWE00086	26-Jan-00 11:30		3							
00SWE00337	23-Feb-00 15:45		2							
00SWE00877	05-Apr-00 07:45									
00SWE01255	10-May-00 07:15		L1	252	251			0.12		
00SWE01634	08-Jun-00 09:30		L1							
00SWE02306	13-Jul-00 13:30		3	264	261			0.1		

SAMPLE NO.	DATE/TIME	Phenols	Non-filterable Residue (TSS)	Total Residue (TS)	Filterable Residue (difference)	Turbidity	Cyanide	Fluoride, diss.	Fecal Coliforms	Total Coliforms
	Variable Code:	689	749	750	836	864	427	532	433	434
	Unit Code:	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	no./dL	no./100 mL
00SWE03081	23-Aug-00 07:20		L1							
00SWE03277	13-Sep-00 14:45		2	224	222			0.1		
00SWE03697	18-Oct-00 11:00		2							
00SWE03921	16-Nov-00 09:30		3							
00SWE03940	13-Dec-00 11:45		L1							
01SWE00029	10-Jan-01 12:45		6	364	358			0.15		
01SWE00536	22-Feb-01 15:20									
01SWE00339	13-Mar-01 09:20		5							
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)										
97SWE00045	25-Feb-97 14:30	L0.001	3	313	310	7.2	0.002	0.2	L4	23
98SWE00802	27-May-98 12:45		6	228	223			0.12		
98SWE01030	25-Jun-98 09:15		5							
98SWE01334	14-Jul-98 13:00		5	292	288			0.13		
98SWE01962	19-Aug-98 11:25		1							
98SWE02570	23-Sep-98 09:40		1	454	453			0.14		
98SWE02754	20-Oct-98 16:20		2	462	460			0.14		
98SWE02949	17-Nov-98 16:00		1							
98SWE03031	15-Dec-98 13:20		2							
99SWE00018	12-Jan-99 15:15		2	476	474			0.16		
99SWE00191	17-Feb-99 16:20		3							
99SWE00469	18-Mar-99 10:15									
99SWE02050	18-May-99 13:45		2					0.13		
99SWE02678	22-Jun-99 12:00		4							
99SWE04068	11-Aug-99 12:00		2							
99SWE04911	15-Sep-99 12:15		4	406	402			0.15		
99SWE05462	20-Oct-99 07:45		3					0.14		
99SWE05476	20-Oct-99 08:00		4					0.14		
99SWE05475	20-Oct-99 08:15		4					0.14		
99SWE05688	16-Nov-99 12:15		1							
99SWE05771	15-Dec-99 15:15		2							
00SWE00085	26-Jan-00 12:45		L1							
00SWE00332	23-Feb-00 16:45		L1							
00SWE00876	05-Apr-00 10:35									
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)										
98SWE02765	20-Oct-98 09:30		9	368	359			0.16		
99SWE00197	17-Feb-99 09:45		17							
99SWE05465	19-Oct-99 08:15		7					0.14		

SAMPLE NO.	DATE/TIME	Phenols	Non-filterable Residue (TSS)	Total Residue (TS)	Filterable Residue (difference)	Turbidity	Cyanide	Fluoride, diss.	Fecal Coliforms	Total Coliforms
	Variable Code:	689	749	750	836	864	427	532	433	434
	Unit Code:	mg/L	mg/L	mg/L	mg/L	NTU	mg/L	mg/L	no./dL	no./100 mL
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)										
98SWE02764	20-Oct-98 08:30		13	350	337			0.13		
99SWE00196	17-Feb-99 10:15		33							
99SWE05467	19-Oct-99 07:30		2					0.08		
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)										
97SWE00046	25-Feb-97 10:00	L0.001	10	342		28	0.003	0.23		8
98SWE00810	27-May-98 10:50		5	216	212			0.13		
98SWE01025	25-Jun-98 07:45		10							
98SWE01370	15-Jul-98 08:30		3	292	289			0.16		
98SWE01933	18-Aug-98 13:30		2							
98SWE02569	23-Sep-98 08:10		5	346	342			0.17		
98SWE02759	20-Oct-98 11:50		5	356	351			0.17		
98SWE02955	18-Nov-98 09:30		6							
98SWE03026	14-Dec-98 15:40		9							
99SWE00030	13-Jan-99 09:45		9	376	367			0.21		
99SWE00195	17-Feb-99 11:05		14							
99SWE00471	18-Mar-99 08:45		9							
99SWE02054	18-May-99 12:15		L1					0.13		
99SWE02672	22-Jun-99 08:15		5							
99SWE02675	22-Jun-99 09:00									
99SWE02676	22-Jun-99 09:15									
99SWE02677	22-Jun-99 09:30									
99SWE03352	13-Jul-99 08:40		2	272	270			0.16		
99SWE04067	11-Aug-99 08:00		2							
99SWE04908	15-Sep-99 08:10		5	358	353			0.19		
99SWE05458	19-Oct-99 09:30		3					0.17		
99SWE05676	15-Nov-99 15:45		2							
99SWE05758	14-Dec-99 15:30		11							
00SWE00093	27-Jan-00 09:30		7							
00SWE00338	23-Feb-00 11:00		13							
00SWE00878	05-Apr-00 08:45									
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)										
98SWE02762	20-Oct-98 12:10		5	422	417			0.23		
99SWE00193	17-Feb-99 11:45		2							
99SWE05466	19-Oct-99 10:30		7					0.2		
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)										
98SWE02761	20-Oct-98 12:50		8	488	480			0.14		
99SWE05463	19-Oct-99 11:00		39					0.21		

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Al-tot.	Al-ext.	Al-diss.	As-tot.	As-diss.	Ba-tot.	Ba-diss.	Ba-ext.	B-tot.	B-diss.	Cd-tot.	Cd-diss.	Cr-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)														
98SWE02763	20-Oct-98 11:30	36.9			0.11		41			15				0.22
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)														
98SWE00807	27-May-98 11:15													
98SWE00808	27-May-98 11:20													
98SWE00809	27-May-98 11:25													
98SWE01026	25-Jun-98 08:00													
98SWE01368	15-Jul-98 10:35	24.3			0.45		47.6			47				0.31
98SWE01964	19-Aug-98 10:30													
98SWE02537	22-Sep-98 12:15	111			0.25		80.2			46.4				0.4
98SWE02757	20-Oct-98 14:10	21.6			0.22		71			43.8				0.41
98SWE02953	18-Nov-98 11:45													
98SWE03027	15-Dec-98 09:40													
99SWE00027	13-Jan-99 11:10	125			0.21		92			48.4				1.7
99SWE00190	17-Feb-99 13:00	56			L0.2		84			49				0.79
99SWE00425	16-Mar-99 12:45													
99SWE02055	18-May-99 12:45	74		4.95	0.24	0.23	44.4	42.8		36.1	36.9		0.014	0.3
99SWE02668	22-Jun-99 10:15													
99SWE03351	13-Jul-99 13:00	14.1		2.63	0.35	0.28	57.6	56.4		40.6	40		L0.01	0.4
99SWE04065	11-Aug-99 10:30													
99SWE04909	15-Sep-99 09:30	65		4.36	0.41	0.37	65.4	61.7		40.7	43.5		L0.01	
99SWE05461	19-Oct-99 12:00	21.5		2.65	0.3	0.27	57	54.8		44.5	40.1		L0.01	
99SWE05686	16-Nov-99 11:05													
99SWE05770	15-Dec-99 10:45													
00SWE00089	26-Jan-00 09:45													
00SWE00333	23-Feb-00 12:30													
00SWE00879	05-Apr-00 09:50													
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)														
98SWE00805	27-May-98 11:40													
98SWE01027	25-Jun-98 08:30													
98SWE01369	15-Jul-98 10:15	35.6			0.68		26.5			45.9				0.45
98SWE01965	19-Aug-98 09:45													
98SWE02758	20-Oct-98 13:15	42.6			0.43		49			59.3				
98SWE02954	18-Nov-98 11:30													
98SWE03028	15-Dec-98 11:00													

SAMPLE NO.	DATE/TIME	Al-tot.	Al-ext.	Al-diss.	As-tot.	As-diss.	Ba-tot.	Ba-diss.	Ba-ext.	B-tot.	B-diss.	Cd-tot.	Cd-diss.	Cr-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
99SWE00026	13-Jan-99 12:15	197			0.41		93.8			73.2				0.9
99SWE00194	17-Feb-99 13:45	53			0.24		91.6			91.3				1.1
99SWE00426	16-Mar-99 13:15													
99SWE00427	16-Mar-99 13:20													
99SWE00428	16-Mar-99 13:25													
99SWE02056	18-May-99 13:00	64.7		4.32	0.39	0.32	36.6	35.9		67	67		0.011	0.2
99SWE02670	22-Jun-99 10:30													
99SWE03350	13-Jul-99 12:30	38		3.94	0.62	0.59	48.8	47.3		75	77		L0.01	0.25
99SWE04066	11-Aug-99 10:00													
99SWE04910	15-Sep-99 12:00	27.4		3.25	0.52	0.46	50.3	47.7		65.2	64.6		L0.01	
99SWE05460	19-Oct-99 12:30	160		3.55	0.48	0.37	55.6	51.2		65	59.2		L0.01	
99SWE05774	15-Dec-99 11:45													
00SWE00088	26-Jan-00 10:10													
00SWE00336	23-Feb-00 12:00													
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)														
98SWE00803	27-May-98 11:50													
98SWE01028	25-Jun-98 08:35													
98SWE01371	15-Jul-98 10:55	38.2			0.33		190			38.6				0.21
98SWE01963	19-Aug-98 11:00													
98SWE02536	22-Sep-98 12:45	66			0.29		163			36.6				0.25
98SWE02756	20-Oct-98 14:00	21.1			0.21		162			36.4				0.16
98SWE02952	18-Nov-98 12:00													
98SWE03029	15-Dec-98 12:00													
99SWE00028	13-Jan-99 12:45	28.9			0.26		265			40.4				5.9
99SWE00192	17-Feb-99 14:20	10.9			0.32		185			39.8				0.4
99SWE00424	16-Mar-99 14:00													
99SWE02049	18-May-99 13:20	92		3.3	0.32	0.26	151	144		40.3	39		0.015	0.3
99SWE02667	22-Jun-99 11:15													
99SWE03349	13-Jul-99 13:30	21.6		1.72	0.4	0.39	128	126		57.9	59		L0.01	0.16
99SWE04070	11-Aug-99 10:45													
99SWE04913	15-Sep-99 10:30	18.8		2.24	0.3	0.3	140	139		54	52.4		L0.01	L0.1
99SWE05464	19-Oct-99 14:00	578		4.42	0.35	0.26	175	175		57.4	53		0.011	
99SWE05687	16-Nov-99 11:40													
99SWE05773	15-Dec-99 12:15													
00SWE00087	26-Jan-00 10:40													
00SWE00339	23-Feb-00 12:00													
00SWE00880	05-Apr-00 10:00													

SAMPLE NO.	DATE/TIME	Al-tot.	Al-ext.	Al-diss.	As-tot.	As-diss.	Ba-tot.	Ba-diss.	Ba-ext.	B-tot.	B-diss.	Cd-tot.	Cd-diss.	Cr-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)														
98SWE02760	20-Oct-98 15:30	10.4			0.11		57			34.1				0.36
99SWE00198	17-Feb-99 15:00	85			L0.2		63.4			31.3				1.06
99SWE05459	19-Oct-99 13:15	72.3			0.17		62.4			39.5				
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)														
98SWE00263	30-Mar-98 18:30		190						81					
98SWE00405	15-Apr-98 11:15		60						30					
98SWE00552	29-Apr-98 14:30		40						34					
98SWE00804	27-May-98 12:15		L30											
98SWE00952	16-Jun-98 11:30		L30											
98SWE01029	25-Jun-98 09:00													
98SWE01335	14-Jul-98 14:00	74			0.47		58.2			50				0.41
98SWE01935	18-Aug-98 14:30													
98SWE01936	18-Aug-98 14:45													
98SWE01937	18-Aug-98 15:00													
98SWE02571	23-Sep-98 09:00	135			0.28		115			43.7				0.42
98SWE02755	20-Oct-98 16:00	14.7			0.21		102			43.6				0.25
98SWE02950	17-Nov-98 16:30													
98SWE03030	15-Dec-98 12:35													
99SWE00029	13-Jan-99 14:50	62.2			0.2		102			50.1				2.8
99SWE00239	17-Feb-99 09:15	94			L0.2		89.4			45.9				0.69
99SWE00470	18-Mar-99 09:20													
99SWE02119	19-May-99 08:15	72.3		4.8	0.3	0.28	48	44.9		43	44.8		L0.01	0.5
99SWE02669	22-Jun-99 09:30													
99SWE03348	13-Jul-99 11:00	15.5		2.65	0.35	0.29	54.4	53.5		40.8	41		L0.01	0.17
99SWE04069	11-Aug-99 08:45													
99SWE04912	15-Sep-99 11:45	29.8		2.74	0.3	0.27	64.7	63.4		58	53.1		L0.01	0.17
99SWE05472	20-Oct-99 10:00	19		2.56	0.29	0.28	89.5	88.8		45.5	44.4		0.024	0.1
99SWE05677	15-Nov-99 16:45													
99SWE05772	15-Dec-99 13:45													
00SWE00086	26-Jan-00 11:30													
00SWE00337	23-Feb-00 15:45													
00SWE00877	05-Apr-00 07:45													
00SWE01255	10-May-00 07:15	20			L0.2		49			43.2				
00SWE01634	08-Jun-00 09:30													
00SWE02306	13-Jul-00 13:30	42			0.74		37.7			59				

SAMPLE NO.	DATE/TIME	Al-tot.	Al-ext.	Al-diss.	As-tot.	As-diss.	Ba-tot.	Ba-diss.	Ba-ext.	B-tot.	B-diss.	Cd-tot.	Cd-diss.	Cr-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
00SWE03081	23-Aug-00 07:20													
00SWE03277	13-Sep-00 14:45	43			0.44		27.8			43.1				0.28
00SWE03697	18-Oct-00 11:00													
00SWE03921	16-Nov-00 09:30													
00SWE03940	13-Dec-00 11:45													
01SWE00029	10-Jan-01 12:45	39.6			0.32		69.8			54.1				0.5
01SWE00536	22-Feb-01 15:20													
01SWE00339	13-Mar-01 09:20													
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)														
97SWE00045	25-Feb-97 14:30											L0.2		
98SWE00802	27-May-98 12:45													
98SWE01030	25-Jun-98 09:15													
98SWE01334	14-Jul-98 13:00	56.5			0.49		56.2			52.5				0.4
98SWE01962	19-Aug-98 11:25													
98SWE02570	23-Sep-98 09:40	181			0.26		94			44.5				0.43
98SWE02754	20-Oct-98 16:20	10.7			0.19		94.4			41.8				0.35
98SWE02949	17-Nov-98 16:00													
98SWE03031	15-Dec-98 13:20													
99SWE00018	12-Jan-99 15:15	53			0.22		96			56				1.3
99SWE00191	17-Feb-99 16:20	31			0.25		93.2			53				0.58
99SWE00469	18-Mar-99 10:15	55		8.2	0.28	0.21	48.3	46		43.2	44.5		0.01	0.2
99SWE02050	18-May-99 13:45													
99SWE02678	22-Jun-99 12:00													
99SWE04068	11-Aug-99 12:00													
99SWE04911	15-Sep-99 12:15	14.3		1.84	0.34	0.33	78.5	76.8		48.5	48.1		L0.01	
99SWE05462	20-Oct-99 07:45	18		1.97	0.29	0.24	79.7	77.6		46.2	47		L0.01	0.2
99SWE05476	20-Oct-99 08:00	15.3		1.8	0.3	0.27	79.1	78.7		47.5	46.9		L0.01	
99SWE05475	20-Oct-99 08:15	15.3		2.09	0.27	0.23	78.6	78.4		48.6	45.8		0.011	
99SWE05688	16-Nov-99 12:15													
99SWE05771	15-Dec-99 15:15													
00SWE00085	26-Jan-00 12:45													
00SWE00332	23-Feb-00 16:45													
00SWE00876	05-Apr-00 10:35													
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)														
98SWE02765	20-Oct-98 09:30	9.9			0.21		82.7			33				0.84
99SWE00197	17-Feb-99 09:45	2.2			L0.2		107			41.6				1.64
99SWE05465	19-Oct-99 08:15	14.7			0.18		80.6			35.9				

SAMPLE NO.	DATE/TIME	Al-tot.	Al-ext.	Al-diss.	As-tot.	As-diss.	Ba-tot.	Ba-diss.	Ba-ext.	B-tot.	B-diss.	Cd-tot.	Cd-diss.	Cr-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)														
98SWE02764	20-Oct-98 08:30	8.8			0.41		68.2			35.6				1.63
99SWE00196	17-Feb-99 10:15	23.1			0.53		105			46				3.4
99SWE05467	19-Oct-99 07:30	8.6			0.2		22.3			21.5				
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)														
97SWE00046	25-Feb-97 10:00											L0.2		
98SWE00810	27-May-98 10:50													
98SWE01025	25-Jun-98 07:45													
98SWE01370	15-Jul-98 08:30	15.9			0.29		64.8			34.7				0.5
98SWE01933	18-Aug-98 13:30													
98SWE02569	23-Sep-98 08:10	141			0.23		76			46				0.63
98SWE02759	20-Oct-98 11:50	24.8			0.19		72.4			35.9				0.62
98SWE02955	18-Nov-98 09:30													
98SWE03026	14-Dec-98 15:40													
99SWE00030	13-Jan-99 09:45	16			0.14		97.1			57				8.1
99SWE00195	17-Feb-99 11:05	5.4			L0.2		97			45.5				1.37
99SWE00471	18-Mar-99 08:45	36.5		3.8	0.25	0.22	40.4	41.4		28.1	27.5		0.01	0.4
99SWE02054	18-May-99 12:15													
99SWE02672	22-Jun-99 08:15	13.2		3.5	0.33	0.31	73.9	72.3		42.2	42.5		0.025	0.8
99SWE02675	22-Jun-99 09:00					L5						L0.2	L0.2	
99SWE02676	22-Jun-99 09:15					L5						L0.2	L0.2	
99SWE02677	22-Jun-99 09:30					L5						L0.2	L0.2	
99SWE03352	13-Jul-99 08:40	10.5		3.54	0.29	0.28	64.4	64		34.7	33.5		L0.01	0.36
99SWE04067	11-Aug-99 08:00													
99SWE04908	15-Sep-99 08:10	45		2.92	0.21	0.2	71.4	77.1		38	37.7		L0.01	
99SWE05458	19-Oct-99 09:30	10.3		2.51	0.22	0.21	69.3	63.3		35.6	32.2		L0.01	
99SWE05676	15-Nov-99 15:45													
99SWE05758	14-Dec-99 15:30													
00SWE00093	27-Jan-00 09:30													
00SWE00338	23-Feb-00 11:00													
00SWE00878	05-Apr-00 08:45													
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)														
98SWE02762	20-Oct-98 12:10	20			0.47		53.5			141				
99SWE00193	17-Feb-99 11:45	21			0.41		29.2			65				0.46
99SWE05466	19-Oct-99 10:30	129			0.3		52.1			126				
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)														
98SWE02761	20-Oct-98 12:50	14.2			0.7		93			223				
99SWE05463	19-Oct-99 11:00	84.3			0.45		171			213				

Note: Comb. = Combined Variable Codes

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Cr-diss.	Cr-ext.	Cu-tot.	Cu-diss.	Cu-ext.	Fe-tot.	Fe-diss.	Fe-ext.	Hg-tot.	Li-tot.	Li-diss.	Mn-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	2989
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)													
98SWE02763	20-Oct-98 11:30			0.2			0.656	0.194			6.6		83.3
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)													
98SWE00807	27-May-98 11:15							0.553					
98SWE00808	27-May-98 11:20							0.491					
98SWE00809	27-May-98 11:25							0.509					
98SWE01026	25-Jun-98 08:00												
98SWE01368	15-Jul-98 10:35			0.32			1.106	0.657			8.5		29.9
98SWE01964	19-Aug-98 10:30												
98SWE02537	22-Sep-98 12:15			0.4			0.393	0.093			11.1		26.1
98SWE02757	20-Oct-98 14:10			0.3			0.824	0.096			12.2		44.9
98SWE02953	18-Nov-98 11:45												
98SWE03027	15-Dec-98 09:40												
99SWE00027	13-Jan-99 11:10			0.42			2.709	0.113			13.1		934
99SWE00190	17-Feb-99 13:00			0.45			1.519	0.288			11.8		543
99SWE00425	16-Mar-99 12:45												
99SWE02055	18-May-99 12:45			0.46	0.41		1.368	0.815			7	6.9	38.9
99SWE02668	22-Jun-99 10:15												
99SWE03351	13-Jul-99 13:00			0.26	0.13		0.887	0.534			8.1	8.2	64.3
99SWE04065	11-Aug-99 10:30												
99SWE04909	15-Sep-99 09:30			0.31	0.43		0.828	0.297			10	10.2	82.6
99SWE05461	19-Oct-99 12:00	0.11		0.22	0.19		0.678	0.263			11.4	11.8	96.8
99SWE05686	16-Nov-99 11:05												
99SWE05770	15-Dec-99 10:45												
00SWE00089	26-Jan-00 09:45												
00SWE00333	23-Feb-00 12:30							0.096					
00SWE00879	05-Apr-00 09:50												
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)													
98SWE00805	27-May-98 11:40							0.398					
98SWE01027	25-Jun-98 08:30												
98SWE01369	15-Jul-98 10:15			0.26			0.767	0.591			8.6		36.2
98SWE01965	19-Aug-98 09:45												
98SWE02758	20-Oct-98 13:15			0.37			1.207	0.168			14.3		67.4
98SWE02954	18-Nov-98 11:30												
98SWE03028	15-Dec-98 11:00												

SAMPLE NO.	DATE/TIME	Cr-diss.	Cr-ext.	Cu-tot.	Cu-diss.	Cu-ext.	Fe-tot.	Fe-diss.	Fe-ext.	Hg-tot.	Li-tot.	Li-diss.	Mn-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	2989
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L
99SWE00026	13-Jan-99 12:15			0.42			2.134	0.121			19		516
99SWE00194	17-Feb-99 13:45			0.33			1.014	0.027			22.4		228
99SWE00426	16-Mar-99 13:15												
99SWE00427	16-Mar-99 13:20												
99SWE00428	16-Mar-99 13:25												
99SWE02056	18-May-99 13:00			0.77	0.27		0.626	0.418			10.2	10.6	22.5
99SWE02670	22-Jun-99 10:30												
99SWE03350	13-Jul-99 12:30			0.44	0.21		0.585	0.323			13.2	13.2	59.9
99SWE04066	11-Aug-99 10:00												
99SWE04910	15-Sep-99 12:00			0.26	0.29		0.952	0.345			12.6	12.7	77.3
99SWE05460	19-Oct-99 12:30	0.19		0.35	0.39		1.374	0.394			13.8	13.7	48.7
99SWE05774	15-Dec-99 11:45												
00SWE00088	26-Jan-00 10:10												
00SWE00336	23-Feb-00 12:00							0.027					
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)													
98SWE00803	27-May-98 11:50							0.036					
98SWE01028	25-Jun-98 08:35												
98SWE01371	15-Jul-98 10:55			0.54			0.036	0.031			8.2		61.9
98SWE01963	19-Aug-98 11:00												
98SWE02536	22-Sep-98 12:45			0.86			0.369	0.065			8		20.1
98SWE02756	20-Oct-98 14:00			0.8			0.423	0.096			8.6		54.4
98SWE02952	18-Nov-98 12:00												
98SWE03029	15-Dec-98 12:00												
99SWE00028	13-Jan-99 12:45			0.74			0.44	0.228			11		1374
99SWE00192	17-Feb-99 14:20			1.88			0.759	L0.03			12.2		1401
99SWE00424	16-Mar-99 14:00												
99SWE02049	18-May-99 13:20			1.1	0.89		0.576	L0.003			9	8.8	182
99SWE02667	22-Jun-99 11:15												
99SWE03349	13-Jul-99 13:30			0.89	0.83		0.289	0.123			10.9	11.4	23.7
99SWE04070	11-Aug-99 10:45												
99SWE04913	15-Sep-99 10:30			1.26	0.97		0.099	L0.003			12.9	12.6	22.4
99SWE05464	19-Oct-99 14:00	2.91		2.2	2.27		1.081	0.151			12.9	12.4	248
99SWE05687	16-Nov-99 11:40												
99SWE05773	15-Dec-99 12:15												
00SWE00087	26-Jan-00 10:40												
00SWE00339	23-Feb-00 12:00							L0.003					
00SWE00880	05-Apr-00 10:00												

SAMPLE NO.	DATE/TIME	Cr-diss.	Cr-ext.	Cu-tot.	Cu-diss.	Cu-ext.	Fe-tot.	Fe-diss.	Fe-ext.	Hg-tot.	Li-tot.	Li-diss.	Mn-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	**2989**
	Unit Code:	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**mg/L**	**mg/L**	**mg/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)													
98SWE02760	20-Oct-98 15:30			0.19			0.881	0.084			6.5		72
99SWE00198	17-Feb-99 15:00			0.38			1.918	0.264			6.3		291
99SWE05459	19-Oct-99 13:15			0.31			1.532	0.194			6.8		126
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)													
98SWE00263	30-Mar-98 18:30		L2			L3			1.9				
98SWE00405	15-Apr-98 11:15		L2			L3			1.23				
98SWE00552	29-Apr-98 14:30		L2			L3			0.718				
98SWE00804	27-May-98 12:15							0.412					
98SWE00952	16-Jun-98 11:30								1.2				
98SWE01029	25-Jun-98 09:00												
98SWE01335	14-Jul-98 14:00			0.36			0.858	0.397			8.9		47.9
98SWE01935	18-Aug-98 14:30												
98SWE01936	18-Aug-98 14:45												
98SWE01937	18-Aug-98 15:00												
98SWE02571	23-Sep-98 09:00			0.65			0.373	0.101			9.2		22.1
98SWE02755	20-Oct-98 16:00			0.5			0.428	0.078			10.3		28.1
98SWE02950	17-Nov-98 16:30												
98SWE03030	15-Dec-98 12:35												
99SWE00029	13-Jan-99 14:50			0.41			1.12	0.134			12.6		549
99SWE00239	17-Feb-99 09:15			0.63			1.132	0.045			11.5		538
99SWE00470	18-Mar-99 09:20												
99SWE02119	19-May-99 08:15			0.58	0.47		1.215	0.631			8.2	8.2	51.5
99SWE02669	22-Jun-99 09:30												
99SWE03348	13-Jul-99 11:00			0.38	0.25		0.435	0.264			7.8	7.7	35.8
99SWE04069	11-Aug-99 08:45												
99SWE04912	15-Sep-99 11:45			0.53	0.43		0.159	0.034			11.7	11.7	33.9
99SWE05472	20-Oct-99 10:00	0.12		0.66	0.61		0.379	0.146			11.6	12.1	19.5
99SWE05677	15-Nov-99 16:45												
99SWE05772	15-Dec-99 13:45												
00SWE00086	26-Jan-00 11:30												
00SWE00337	23-Feb-00 15:45							0.084					
00SWE00877	05-Apr-00 07:45												
00SWE01255	10-May-00 07:15			0.22			0.962			L0.005	8.4		44.6
00SWE01634	08-Jun-00 09:30												
00SWE02306	13-Jul-00 13:30			0.28			1.18		1.33	L0.005	8		87.8

SAMPLE NO.	DATE/TIME	Cr-diss.	Cr-ext.	Cu-tot.	Cu-diss.	Cu-ext.	Fe-tot.	Fe-diss.	Fe-ext.	Hg-tot.	Li-tot.	Li-diss.	Mn-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	2989
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L
00SWE03081	23-Aug-00 07:20												
00SWE03277	13-Sep-00 14:45			0.32			0.632		0.603	L0.005	7.9		36.1
00SWE03697	18-Oct-00 11:00												
00SWE03921	16-Nov-00 09:30												
00SWE03940	13-Dec-00 11:45												
01SWE00029	10-Jan-01 12:45			0.35			2.197		2.2	L0.005	12.8		1061
01SWE00536	22-Feb-01 15:20												
01SWE00339	13-Mar-01 09:20												
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)													
97SWE00045	25-Feb-97 14:30						1.12			L0.005			81
98SWE00802	27-May-98 12:45							0.335					
98SWE01030	25-Jun-98 09:15												
98SWE01334	14-Jul-98 13:00			0.64			0.704	0.344			8.9		58.9
98SWE01962	19-Aug-98 11:25												
98SWE02570	23-Sep-98 09:40			0.76			0.232	0.078			9.3		29.8
98SWE02754	20-Oct-98 16:20			0.62			0.248	0.072			9.9		22.4
98SWE02949	17-Nov-98 16:00												
98SWE03031	15-Dec-98 13:20												
99SWE00018	12-Jan-99 15:15			0.71			0.655	0.149			13.9		154
99SWE00191	17-Feb-99 16:20			0.68			0.69	0.114			12.9		286
99SWE00469	18-Mar-99 10:15			0.4	0.21		1.088	0.587			8	8.1	49.7
99SWE02050	18-May-99 13:45												
99SWE02678	22-Jun-99 12:00												
99SWE04068	11-Aug-99 12:00												
99SWE04911	15-Sep-99 12:15			0.45	0.43		0.104	0.021			10.4	10.1	15.5
99SWE05462	20-Oct-99 07:45			0.62	0.55		0.226	0.115			11.9	11.5	16.8
99SWE05476	20-Oct-99 08:00	L0.08		0.83	0.8		0.212	0.097			11.8	12.1	16.6
99SWE05475	20-Oct-99 08:15	L0.08		0.71	0.68		0.202	0.106			11.6	11.2	17.3
99SWE05688	16-Nov-99 12:15												
99SWE05771	15-Dec-99 15:15												
00SWE00085	26-Jan-00 12:45												
00SWE00332	23-Feb-00 16:45							0.055					
00SWE00876	05-Apr-00 10:35												
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)													
98SWE02765	20-Oct-98 09:30			0.24			2.436	0.098			11.1		317
99SWE00197	17-Feb-99 09:45			0.35			5.151	0.072			14		470
99SWE05465	19-Oct-99 08:15			2.89			2.308	0.236			11.1		296

SAMPLE NO.	DATE/TIME	Cr-diss.	Cr-ext.	Cu-tot.	Cu-diss.	Cu-ext.	Fe-tot.	Fe-diss.	Fe-ext.	Hg-tot.	Li-tot.	Li-diss.	Mn-tot.
	Variable Code:	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.	2989
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	mg/L	ug/L	ug/L	ug/L	ug/L
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)													
98SWE02764	20-Oct-98 08:30			0.2			6.078	0.742			8.1		516
99SWE00196	17-Feb-99 10:15			0.17			14.841	0.62			9.6		677
99SWE05467	19-Oct-99 07:30			0.22			0.98	0.654			6.6		119
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)													
97SWE00046	25-Feb-97 10:00						4.09			L0.005			426
98SWE00810	27-May-98 10:50							0.62					
98SWE01025	25-Jun-98 07:45												
98SWE01370	15-Jul-98 08:30			0.24			1.772	1.034			7.9		71.2
98SWE01933	18-Aug-98 13:30												
98SWE02569	23-Sep-98 08:10			0.38			1.409	0.152			11.6		89
98SWE02759	20-Oct-98 11:50			0.2			1.341	0.125			10.6		162
98SWE02955	18-Nov-98 09:30												
98SWE03026	14-Dec-98 15:40												
99SWE00030	13-Jan-99 09:45			0.23			2.484	0.114			12.2		817
99SWE00195	17-Feb-99 11:05			0.18			3.743	0.068			12		532
99SWE00471	18-Mar-99 08:45			0.48	0.47		1.255	0.852			6.1	6	
99SWE02054	18-May-99 12:15												33.4
99SWE02672	22-Jun-99 08:15			0.19	0.15		1.919	1.178			7.7	7.8	224
99SWE02675	22-Jun-99 09:00						1.62	0.73					200
99SWE02676	22-Jun-99 09:15						1.66	0.75					200
99SWE02677	22-Jun-99 09:30						1.69	0.78					207
99SWE03352	13-Jul-99 08:40			0.23	L0.08		1.751	1.066			7.1	7	68.1
99SWE04067	11-Aug-99 08:00												
99SWE04908	15-Sep-99 08:10			0.42	0.24		0.943	0.258			9.7	9.6	68.4
99SWE05458	19-Oct-99 09:30	0.17		0.12	0.1		1.793	0.275			10.1	10.3	206
99SWE05676	15-Nov-99 15:45												
99SWE05758	14-Dec-99 15:30												
00SWE00093	27-Jan-00 09:30												
00SWE00338	23-Feb-00 11:00							0.094					
00SWE00878	05-Apr-00 08:45												
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)													
98SWE02762	20-Oct-98 12:10			0.26			1.376	0.351			23.5		261
99SWE00193	17-Feb-99 11:45			0.3			0.426	0.433			10.3		54.9
99SWE05466	19-Oct-99 10:30			0.53			1.539	0.478			22.9		350
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)													
98SWE02761	20-Oct-98 12:50			0.28			14.81	1.066			35.7		1343
99SWE05463	19-Oct-99 11:00			0.45			4.985	0.012			42.9		1463

Note: Comb. = Combined Variable Codes

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Mn-diss.	Mn-ext.	Mo-tot.	Mo-diss.	Ni-tot.	Ni-diss.	Ni-ext.	Pb-tot.	Pb-diss.	Pb-ext.	Se-tot.	Se-diss.	Sr-tot.
	Variable Code:	2898	589	Comb.	Comb.	2992	2901	608	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)														
98SWE02763	20-Oct-98 11:30	23.4		0.039		L0.06						L0.5		
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)														
98SWE00807	27-May-98 11:15													
98SWE00808	27-May-98 11:20													
98SWE00809	27-May-98 11:25													
98SWE01026	25-Jun-98 08:00													
98SWE01368	15-Jul-98 10:35	20.7		0.085		L0.06						L0.5		
98SWE01964	19-Aug-98 10:30													
98SWE02537	22-Sep-98 12:15	12		0.07		L0.06						L0.5		
98SWE02757	20-Oct-98 14:10	36.1		0.06		L0.06						L0.5		174
98SWE02953	18-Nov-98 11:45													
98SWE03027	15-Dec-98 09:40													
99SWE00027	13-Jan-99 11:10	939		0.06		0.3						L0.5		200
99SWE00190	17-Feb-99 13:00	520		0.08		L0.06								178
99SWE00425	16-Mar-99 12:45													
99SWE02055	18-May-99 12:45	26.4		0.089	0.097	L0.06	L0.06			0.076		L0.5	L0.5	
99SWE02668	22-Jun-99 10:15													
99SWE03351	13-Jul-99 13:00	12.3		0.058	0.06	L0.06	L0.06			L0.01		L0.5	L0.5	130
99SWE04065	11-Aug-99 10:30													
99SWE04909	15-Sep-99 09:30	71.4		0.102	0.082	0.4	0.39			L0.01		L0.5	L0.5	
99SWE05461	19-Oct-99 12:00	76.7		0.034	0.03	0.19	0.15			0.121		L0.5	L0.5	
99SWE05686	16-Nov-99 11:05													
99SWE05770	15-Dec-99 10:45													
00SWE00089	26-Jan-00 09:45													
00SWE00333	23-Feb-00 12:30	1155												
00SWE00879	05-Apr-00 09:50													
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)														
98SWE00805	27-May-98 11:40													
98SWE01027	25-Jun-98 08:30													
98SWE01369	15-Jul-98 10:15	26.6		0.157		0.56						L0.5		
98SWE01965	19-Aug-98 09:45													
98SWE02758	20-Oct-98 13:15	46.3		0.11		L0.06						L0.5		
98SWE02954	18-Nov-98 11:30													
98SWE03028	15-Dec-98 11:00													

SAMPLE NO.	DATE/TIME	Mn-diss.	Mn-ext.	Mo-tot.	Mo-diss.	Ni-tot.	Ni-diss.	Ni-ext.	Pb-tot.	Pb-diss.	Pb-ext.	Se-tot.	Se-diss.	Sr-tot.
	Variable Code:	2898	589	Comb.	Comb.	2992	2901	608	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
99SWE00026	13-Jan-99 12:15	464		0.09		0.2						L0.5		266
99SWE00194	17-Feb-99 13:45	221		0.08		L0.06								294
99SWE00426	16-Mar-99 13:15													
99SWE00427	16-Mar-99 13:20													
99SWE00428	16-Mar-99 13:25													
99SWE02056	18-May-99 13:00	4.13		0.161	0.14	0.25	0.15			0.047		L0.5	L0.5	
99SWE02670	22-Jun-99 10:30													
99SWE03350	13-Jul-99 12:30	7.03		0.21	0.152	0.4	0.19			0.016		L0.5	L0.5	139
99SWE04066	11-Aug-99 10:00													
99SWE04910	15-Sep-99 12:00	26.7		0.127	0.148	0.82	0.65			0.024		L0.5	L0.5	
99SWE05460	19-Oct-99 12:30	31		0.11	0.091	0.66	0.46			0.125		L0.5	L0.5	
99SWE05774	15-Dec-99 11:45													
00SWE00088	26-Jan-00 10:10													
00SWE00336	23-Feb-00 12:00	106												
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)														
98SWE00803	27-May-98 11:50													
98SWE01028	25-Jun-98 08:35													
98SWE01371	15-Jul-98 10:55	53.8		0.53		1.2						L0.5		
98SWE01963	19-Aug-98 11:00													
98SWE02536	22-Sep-98 12:45	17.6		0.36		L0.06						L0.5		
98SWE02756	20-Oct-98 14:00	49.6		0.21		L0.06						L0.5		212
98SWE02952	18-Nov-98 12:00													
98SWE03029	15-Dec-98 12:00													
99SWE00028	13-Jan-99 12:45	1391		0.34		L0.6						L0.5		359
99SWE00192	17-Feb-99 14:20	1428		0.24		L0.6								429
99SWE00424	16-Mar-99 14:00													
99SWE02049	18-May-99 13:20	157		0.3	0.3	L0.06	L0.06			0.051		L0.5	L0.5	272
99SWE02667	22-Jun-99 11:15													
99SWE03349	13-Jul-99 13:30	3.35		0.27	0.26	L0.06	L0.06			0.024		L0.5	L0.5	275
99SWE04070	11-Aug-99 10:45													
99SWE04913	15-Sep-99 10:30	7.13		0.15	0.14	0.59	0.45			L0.01		L0.5	L0.5	316
99SWE05464	19-Oct-99 14:00	232		0.2	0.19	13.4	21.5			0.496		L0.5	L0.5	296
99SWE05687	16-Nov-99 11:40													
99SWE05773	15-Dec-99 12:15													
00SWE00087	26-Jan-00 10:40													
00SWE00339	23-Feb-00 12:00	779												
00SWE00880	05-Apr-00 10:00													

SAMPLE NO.	DATE/TIME	Mn-diss.	Mn-ext.	Mo-tot.	Mo-diss.	Ni-tot.	Ni-diss.	Ni-ext.	Pb-tot.	Pb-diss.	Pb-ext.	Se-tot.	Se-diss.	Sr-tot.
	Variable Code:	2898	589	Comb.	Comb.	2992	2901	608	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)														
98SWE02760	20-Oct-98 15:30	58.6		0.023		L0.06						L0.5		124
99SWE00198	17-Feb-99 15:00	240		0.027		L0.06								
99SWE05459	19-Oct-99 13:15	69.4		0.05		0.11						L0.5		
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)														
98SWE00263	30-Mar-98 18:30		192					L5			L20			
98SWE00405	15-Apr-98 11:15		72					L5			L20			
98SWE00552	29-Apr-98 14:30		41					L5			L20			
98SWE00804	27-May-98 12:15													
98SWE00952	16-Jun-98 11:30													
98SWE01029	25-Jun-98 09:00													
98SWE01335	14-Jul-98 14:00	22.1		0.17		0.17						L0.5		
98SWE01935	18-Aug-98 14:30													
98SWE01936	18-Aug-98 14:45													
98SWE01937	18-Aug-98 15:00													
98SWE02571	23-Sep-98 09:00	14.5		0.243		L0.06						L0.5		
98SWE02755	20-Oct-98 16:00	19.3		0.13		L0.06						L0.5		191
98SWE02950	17-Nov-98 16:30													
98SWE03030	15-Dec-98 12:35													
99SWE00029	13-Jan-99 14:50	516		0.08		1.11						L0.5		217
99SWE00239	17-Feb-99 09:15	516		0.095		L0.06						L0.5		213
99SWE00470	18-Mar-99 09:20													
99SWE02119	19-May-99 08:15	31.5		0.12	0.087	L0.06	L0.06			0.057		0.6	0.6	
99SWE02669	22-Jun-99 09:30													
99SWE03348	13-Jul-99 11:00	13.4		0.087	0.092	L0.06	L0.06			0.022		L0.5	L0.5	130
99SWE04069	11-Aug-99 08:45													
99SWE04912	15-Sep-99 11:45	28.7		0.11	0.14	0.41	0.45			L0.01		L0.5	L0.5	
99SWE05472	20-Oct-99 10:00	11.2		0.12	0.1	0.4	0.3			0.093		L0.5	L0.5	
99SWE05677	15-Nov-99 16:45													
99SWE05772	15-Dec-99 13:45													
00SWE00086	26-Jan-00 11:30													
00SWE00337	23-Feb-00 15:45	674												
00SWE00877	05-Apr-00 07:45													
00SWE01255	10-May-00 07:15			0.12		L0.06								
00SWE01634	08-Jun-00 09:30													
00SWE02306	13-Jul-00 13:30			0.19		0.49						L0.5		

SAMPLE NO.	DATE/TIME	Mn-diss.	Mn-ext.	Mo-tot.	Mo-diss.	Ni-tot.	Ni-diss.	Ni-ext.	Pb-tot.	Pb-diss.	Pb-ext.	Se-tot.	Se-diss.	Sr-tot.
	Variable Code:	2898	589	Comb.	Comb.	2992	2901	608	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
00SWE03081	23-Aug-00 07:20													
00SWE03277	13-Sep-00 14:45			0.09		0.32						L0.5		
00SWE03697	18-Oct-00 11:00													
00SWE03921	16-Nov-00 09:30													
00SWE03940	13-Dec-00 11:45													
01SWE00029	10-Jan-01 12:45			0.091		L0.06						L0.5		181
01SWE00536	22-Feb-01 15:20													
01SWE00339	13-Mar-01 09:20													
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)														
97SWE00045	25-Feb-97 14:30					L0.5			0.9					
98SWE00802	27-May-98 12:45													
98SWE01030	25-Jun-98 09:15													
98SWE01334	14-Jul-98 13:00	20		0.32		0.1						L0.5		
98SWE01962	19-Aug-98 11:25													
98SWE02570	23-Sep-98 09:40	22.6		0.21		L0.06						L0.5		
98SWE02754	20-Oct-98 16:20	14.2		0.12		L0.06						L0.5		194
98SWE02949	17-Nov-98 16:00													
98SWE03031	15-Dec-98 13:20													
99SWE00018	12-Jan-99 15:15	158		0.089		0.2						L0.5		230
99SWE00191	17-Feb-99 16:20	276		0.07		0.15								237
99SWE00469	18-Mar-99 10:15	22		0.11	0.09	L0.06	L0.06			0.064		L0.5	L0.5	
99SWE02050	18-May-99 13:45													
99SWE02678	22-Jun-99 12:00													
99SWE04068	11-Aug-99 12:00													
99SWE04911	15-Sep-99 12:15	8.1		0.13	0.103	0.49	0.46			L0.01		L0.5	L0.5	
99SWE05462	20-Oct-99 07:45	11.6		0.1	0.118	0.42	0.14			0.125		L0.5	L0.5	
99SWE05476	20-Oct-99 08:00	11.5		0.12	0.1	0.4	0.21			0.146		L0.5	L0.5	
99SWE05475	20-Oct-99 08:15	11.7		0.14	0.1	0.43	0.36			0.11		L0.5	L0.5	
99SWE05688	16-Nov-99 12:15													
99SWE05771	15-Dec-99 15:15													
00SWE00085	26-Jan-00 12:45													
00SWE00332	23-Feb-00 16:45	85.3												
00SWE00876	05-Apr-00 10:35													
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)														
98SWE02765	20-Oct-98 09:30	292		0.038		L0.06						L0.5		
99SWE00197	17-Feb-99 09:45	446		0.041		L0.06								205
99SWE05465	19-Oct-99 08:15	273		0.07		13.6						L0.5		

SAMPLE NO.	DATE/TIME	Mn-diss.	Mn-ext.	Mo-tot.	Mo-diss.	Ni-tot.	Ni-diss.	Ni-ext.	Pb-tot.	Pb-diss.	Pb-ext.	Se-tot.	Se-diss.	Sr-tot.
	Variable Code:	2898	589	Comb.	Comb.	2992	2901	608	Comb.	Comb.	Comb.	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)														
98SWE02764	20-Oct-98 08:30	477		0.033		L0.06						L0.5		
99SWE00196	17-Feb-99 10:15	573		0.05		L0.06								209
99SWE05467	19-Oct-99 07:30	114		0.084		0.24						L0.5		
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)														
97SWE00046	25-Feb-97 10:00					L0.5			0.8					
98SWE00810	27-May-98 10:50													
98SWE01025	25-Jun-98 07:45													
98SWE01370	15-Jul-98 08:30	61.4		0.067		L0.06						L0.5		
98SWE01933	18-Aug-98 13:30													
98SWE02569	23-Sep-98 08:10	75.7		0.069		L0.06						L0.5		
98SWE02759	20-Oct-98 11:50	146		0.054		L0.06						L0.5		
98SWE02955	18-Nov-98 09:30													
98SWE03026	14-Dec-98 15:40													
99SWE00030	13-Jan-99 09:45	821		0.07		2						L0.5		202
99SWE00195	17-Feb-99 11:05	509		0.039		L0.06								192
99SWE00471	18-Mar-99 08:45			0.11	0.066					0.076		L0.5	L0.5	
99SWE02054	18-May-99 12:15	28.4				L0.06	L0.06							
99SWE02672	22-Jun-99 08:15	198		0.063	0.06	L0.06	L0.06			0.04		L0.5	L0.5	
99SWE02675	22-Jun-99 09:00	197				26.1	1.6		1.7	L0.3			L7	
99SWE02676	22-Jun-99 09:15	196				26.1	0.7		0.5	L0.3			L7	
99SWE02677	22-Jun-99 09:30					26.1	1.1		0.5	L0.3			L7	
99SWE03352	13-Jul-99 08:40	50.6		0.06	0.045	L0.06	L0.06			L0.01		L0.5	L0.5	133
99SWE04067	11-Aug-99 08:00													
99SWE04908	15-Sep-99 08:10	48.3		0.028	0.026	0.24	0.13			L0.01		L0.5	L0.5	
99SWE05458	19-Oct-99 09:30	170		0.03	0.03	L0.06	0.1			0.035		L0.5	L0.5	
99SWE05676	15-Nov-99 15:45													
99SWE05758	14-Dec-99 15:30													
00SWE00093	27-Jan-00 09:30													
00SWE00338	23-Feb-00 11:00	639												
00SWE00878	05-Apr-00 08:45													
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)														
98SWE02762	20-Oct-98 12:10	232		0.052		L0.06						L0.5		244
99SWE00193	17-Feb-99 11:45	58		0.15		L0.06								
99SWE05466	19-Oct-99 10:30	271		0.07		2.95								255
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)														
98SWE02761	20-Oct-98 12:50	627		0.06		L0.06						L0.5		320
99SWE05463	19-Oct-99 11:00	1.04		0.1		0.76								436

Note: Comb. = Combined Variable Codes

Appendix 3. Continued.

SAMPLE NO.	DATE/TIME	Sr-diss.	U-tot.	U-diss.	V-tot.	V-tot.	V-diss.	V-ext.	Zn-tot.	Z-diss.	Z-ext.
	Variable Code:	Comb.	Comb.	Comb.	878	3007	2913	877	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)											
98SWE02763	20-Oct-98 11:30		0.006			0.209			1.1		
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)											
98SWE00807	27-May-98 11:15										
98SWE00808	27-May-98 11:20										
98SWE00809	27-May-98 11:25										
98SWE01026	25-Jun-98 08:00										
98SWE01368	15-Jul-98 10:35		0.048			0.323			1.71		
98SWE01964	19-Aug-98 10:30										
98SWE02537	22-Sep-98 12:15		0.141			0.4			0.72		
98SWE02757	20-Oct-98 14:10		0.088			0.272			0.82		
98SWE02953	18-Nov-98 11:45										
98SWE03027	15-Dec-98 09:40										
99SWE00027	13-Jan-99 11:10		0.056			0.48			4.2		
99SWE00190	17-Feb-99 13:00		0.067			0.32			3.2		
99SWE00425	16-Mar-99 12:45										
99SWE02055	18-May-99 12:45		0.033	0.041		0.51	0.24		1.03	0.85	
99SWE02668	22-Jun-99 10:15										
99SWE03351	13-Jul-99 13:00		0.044	0.044		0.253	0.184		0.62		
99SWE04065	11-Aug-99 10:30										
99SWE04909	15-Sep-99 09:30		0.097	0.101		0.36	0.219		0.4	0.36	
99SWE05461	19-Oct-99 12:00		0.089	0.08		0.19	0.15		0.74	0.52	
99SWE05686	16-Nov-99 11:05										
99SWE05770	15-Dec-99 10:45										
00SWE00089	26-Jan-00 09:45										
00SWE00333	23-Feb-00 12:30										
00SWE00879	05-Apr-00 09:50										
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)											
98SWE00805	27-May-98 11:40										
98SWE01027	25-Jun-98 08:30										
98SWE01369	15-Jul-98 10:15		0.038			0.348			2.85		
98SWE01965	19-Aug-98 09:45										
98SWE02758	20-Oct-98 13:15		0.13			0.4			0.96		
98SWE02954	18-Nov-98 11:30										
98SWE03028	15-Dec-98 11:00										

SAMPLE NO.	DATE/TIME	Sr-diss.	U-tot.	U-diss.	V-tot.	V-tot.	V-diss.	V-ext.	Zn-tot.	Z-diss.	Z-ext.
	Variable Code:	Comb.	Comb.	Comb.	**878**	**3007**	**2913**	**877**	Comb.	Comb.	Comb.
	Unit Code:	**ug/L**	**ug/L**	**ug/L**	**mg/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**	**ug/L**
99SWE00026	13-Jan-99 12:15		0.12			0.77			5.4		
99SWE00194	17-Feb-99 13:45		0.155			0.43			2.28		
99SWE00426	16-Mar-99 13:15										
99SWE00427	16-Mar-99 13:20										
99SWE00428	16-Mar-99 13:25										
99SWE02056	18-May-99 13:00		0.037	0.038		0.363	0.206		1.02	1.1	
99SWE02670	22-Jun-99 10:30										
99SWE03350	13-Jul-99 12:30		0.059	0.053		0.36	0.26		0.9		
99SWE04066	11-Aug-99 10:00										
99SWE04910	15-Sep-99 12:00		0.08	0.074		0.36	0.26		0.46	L0.2	
99SWE05460	19-Oct-99 12:30		0.087	0.085		0.59	0.204		3	0.83	
99SWE05774	15-Dec-99 11:45										
00SWE00088	26-Jan-00 10:10										
00SWE00336	23-Feb-00 12:00										
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)											
98SWE00803	27-May-98 11:50										
98SWE01028	25-Jun-98 08:35										
98SWE01371	15-Jul-98 10:55		0.97			0.41			2.5		
98SWE01963	19-Aug-98 11:00										
98SWE02536	22-Sep-98 12:45		0.79			0.38			4.95		
98SWE02756	20-Oct-98 14:00		0.57			0.358			2.04		
98SWE02952	18-Nov-98 12:00										
98SWE03029	15-Dec-98 12:00										
99SWE00028	13-Jan-99 12:45		0.76			0.22			6.72		
99SWE00192	17-Feb-99 14:20		0.86			0.161			5.39		
99SWE00424	16-Mar-99 14:00										
99SWE02049	18-May-99 13:20	266	0.787	0.633		0.51	0.173		3.66	2.6	
99SWE02667	22-Jun-99 11:15										
99SWE03349	13-Jul-99 13:30		0.61	0.61		0.234	0.3		3.09	3.86	
99SWE04070	11-Aug-99 10:45										
99SWE04913	15-Sep-99 10:30	315	0.402	0.411		0.24	0.16		3.4	2.48	
99SWE05464	19-Oct-99 14:00	274	0.437	0.41		1.3	0.394		18.5	23.7	
99SWE05687	16-Nov-99 11:40										
99SWE05773	15-Dec-99 12:15										
00SWE00087	26-Jan-00 10:40										
00SWE00339	23-Feb-00 12:00										
00SWE00880	05-Apr-00 10:00										

SAMPLE NO.	DATE/TIME	Sr-diss.	U-tot.	U-diss.	V-tot.	V-tot.	V-diss.	V-ext.	Zn-tot.	Z-diss.	Z-ext.
	Variable Code:	Comb.	Comb.	Comb.	878	3007	2913	877	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)											
98SWE02760	20-Oct-98 15:30		0.076			0.52			2.46		
99SWE00198	17-Feb-99 15:00		0.053			0.93			1.03		
99SWE05459	19-Oct-99 13:15		0.075			0.66			0.84		
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)											
98SWE00263	30-Mar-98 18:30							L4			2
98SWE00405	15-Apr-98 11:15							L4			L2
98SWE00552	29-Apr-98 14:30							L4			L2
98SWE00804	27-May-98 12:15										
98SWE00952	16-Jun-98 11:30										
98SWE01029	25-Jun-98 09:00										
98SWE01335	14-Jul-98 14:00		0.143			0.49			2.01		
98SWE01935	18-Aug-98 14:30										
98SWE01936	18-Aug-98 14:45										
98SWE01937	18-Aug-98 15:00										
98SWE02571	23-Sep-98 09:00		0.474			0.51			2.17		
98SWE02755	20-Oct-98 16:00		0.27			0.26			1.11		
98SWE02950	17-Nov-98 16:30										
98SWE03030	15-Dec-98 12:35										
99SWE00029	13-Jan-99 14:50		0.19			0.38			8.33		
99SWE00239	17-Feb-99 09:15		0.174			0.38			5.6		
99SWE00470	18-Mar-99 09:20										
99SWE02119	19-May-99 08:15		0.075	0.083		0.485	0.33		3.16	2.4	
99SWE02669	22-Jun-99 09:30										
99SWE03348	13-Jul-99 11:00		0.072	0.059		0.25	0.18		0.89		
99SWE04069	11-Aug-99 08:45										
99SWE04912	15-Sep-99 11:45		0.192	0.189		0.23	0.26		L0.2	L0.2	
99SWE05472	20-Oct-99 10:00		0.23	0.217		0.25	0.17		1.44	0.82	
99SWE05677	15-Nov-99 16:45										
99SWE05772	15-Dec-99 13:45										
00SWE00086	26-Jan-00 11:30										
00SWE00337	23-Feb-00 15:45										
00SWE00877	05-Apr-00 07:45										
00SWE01255	10-May-00 07:15		0.085			0.256			1.95		
00SWE01634	08-Jun-00 09:30										
00SWE02306	13-Jul-00 13:30		0.064			0.54			1.02		

SAMPLE NO.	DATE/TIME	Sr-diss.	U-tot.	U-diss.	V-tot.	V-tot.	V-diss.	V-ext.	Zn-tot.	Z-diss.	Z-ext.
	Variable Code:	Comb.	Comb.	Comb.	878	3007	2913	877	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
00SWE03081	23-Aug-00 07:20										
00SWE03277	13-Sep-00 14:45		0.055			0.32			1.28		
00SWE03697	18-Oct-00 11:00										
00SWE03921	16-Nov-00 09:30										
00SWE03940	13-Dec-00 11:45										
01SWE00029	10-Jan-01 12:45		0.074			0.39			10.6		
01SWE00536	22-Feb-01 15:20										
01SWE00339	13-Mar-01 09:20										
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)											
97SWE00045	25-Feb-97 14:30				L0.002						
98SWE00802	27-May-98 12:45										
98SWE01030	25-Jun-98 09:15										
98SWE01334	14-Jul-98 13:00		0.151			0.46			2.72		
98SWE01962	19-Aug-98 11:25										
98SWE02570	23-Sep-98 09:40		0.43			0.54			0.83		
98SWE02754	20-Oct-98 16:20		0.33			0.236			13.1		
98SWE02949	17-Nov-98 16:00										
98SWE03031	15-Dec-98 13:20										
99SWE00018	12-Jan-99 15:15		0.221			0.273			9.36		
99SWE00191	17-Feb-99 16:20		0.25			0.26			3.25		
99SWE00469	18-Mar-99 10:15		0.097	0.083					1.11	1.37	
99SWE02050	18-May-99 13:45					0.387	0.23				
99SWE02678	22-Jun-99 12:00										
99SWE04068	11-Aug-99 12:00										
99SWE04911	15-Sep-99 12:15		0.179	0.174		0.27	0.22		L0.2	L0.2	
99SWE05462	20-Oct-99 07:45		0.248	0.244		0.25	0.17		1.03	0.88	
99SWE05476	20-Oct-99 08:00		0.248	0.2		0.24	0.19		0.99	0.76	
99SWE05475	20-Oct-99 08:15		0.23	0.25		0.201	0.2		0.88	0.58	
99SWE05688	16-Nov-99 12:15										
99SWE05771	15-Dec-99 15:15										
00SWE00085	26-Jan-00 12:45										
00SWE00332	23-Feb-00 16:45										
00SWE00876	05-Apr-00 10:35										
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)											
98SWE02765	20-Oct-98 09:30		0.031			0.24			0.66		
99SWE00197	17-Feb-99 09:45		0.017			0.32			L0.2		
99SWE05465	19-Oct-99 08:15		0.029			0.211			17.4		

SAMPLE NO.	DATE/TIME	Sr-diss.	U-tot.	U-diss.	V-tot.	V-tot.	V-diss.	V-ext.	Zn-tot.	Z-diss.	Z-ext.
	Variable Code:	Comb.	Comb.	Comb.	878	3007	2913	877	Comb.	Comb.	Comb.
	Unit Code:	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)											
98SWE02764	20-Oct-98 08:30		0.018			1.06			0.72		
99SWE00196	17-Feb-99 10:15		0.01			1.63			2.7		
99SWE05467	19-Oct-99 07:30		L0.003			0.14			1.55		
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)											
97SWE00046	25-Feb-97 10:00				L0.002						
98SWE00810	27-May-98 10:50										
98SWE01025	25-Jun-98 07:45										
98SWE01370	15-Jul-98 08:30		0.04			0.298			4.11		
98SWE01933	18-Aug-98 13:30										
98SWE02569	23-Sep-98 08:10		0.051			0.48			2.61		
98SWE02759	20-Oct-98 11:50		0.025			0.23			0.54		
98SWE02955	18-Nov-98 09:30										
98SWE03026	14-Dec-98 15:40										
99SWE00030	13-Jan-99 09:45		0.025			0.272			3.2		
99SWE00195	17-Feb-99 11:05		0.02			0.349			1.03		
99SWE00471	18-Mar-99 08:45		0.033	0.031		0.324	0.29		0.82	0.21	
99SWE02054	18-May-99 12:15										
99SWE02672	22-Jun-99 08:15		0.038	0.04	0.007	0.3	0.225		0.93	4.25	
99SWE02675	22-Jun-99 09:00								8.3	3.5	
99SWE02676	22-Jun-99 09:15				0.006	0.303	0.2		3.6	0.6	
99SWE02677	22-Jun-99 09:30				0.006	0.31	0.23		2.7	2.4	
99SWE03352	13-Jul-99 08:40		0.029	0.035		0.305	0.201		1.1	1.77	
99SWE04067	11-Aug-99 08:00										
99SWE04908	15-Sep-99 08:10		0.039	0.04		0.31	0.178		3.28	2.4	
99SWE05458	19-Oct-99 09:30		0.02	0.013		0.24	0.18		0.64	L0.2	
99SWE05676	15-Nov-99 15:45										
99SWE05758	14-Dec-99 15:30										
00SWE00093	27-Jan-00 09:30										
00SWE00338	23-Feb-00 11:00										
00SWE00878	05-Apr-00 08:45										
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)											
98SWE02762	20-Oct-98 12:10		0.206			0.64			0.82		
99SWE00193	17-Feb-99 11:45		0.106			0.28			3.52		
99SWE05466	19-Oct-99 10:30		0.18			0.7			4.5		
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)											
98SWE02761	20-Oct-98 12:50		0.016			0.566			7.03		
99SWE05463	19-Oct-99 11:00		0.036			1.83			2.5		

Note: Comb. = Combined Variable Codes

Appendix 4. Polyaromatic hydrocarbons (PAHs) in the Muskeg River and tributaries, 1998-2001. All values in µg/L.

SAMPLE NO.	DATE/TIME VMV Code:	3-METHYL CHLORAN THRENE 103142	7,12-DIMETHYL BENZ(A) ANTHRA CENE 103143	ACE NAPH THENE 103144	ACE NAPH THYLENE 103145	ACRI DINE 103146	ANTHRA CENE 103147	BENZO(A) ANTHRA CENE 103148	BENZO(A) PYRENE 103149	BENZO (B,J,K) FLUOR ANTHENE 103150
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)										
98SWE02763	20-Oct-98 11:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)										
98SWE02757	20-Oct-98 14:10	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02055	18-May-99 12:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03351	13-Jul-99 13:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04909	15-Sep-99 09:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00333	23-Feb-00 12:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)										
98SWE02758	20-Oct-98 13:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02056	18-May-99 13:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03350	13-Jul-99 12:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04910	15-Sep-99 12:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00336	23-Feb-00 12:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)										
98SWE02756	20-Oct-98 14:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02049	18-May-99 13:20	L0.01	L0.01	**0.0038**	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03349	13-Jul-99 13:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	**0.0093**
99SWE04913	15-Sep-99 10:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00339	23-Feb-00 12:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)										
98SWE02760	20-Oct-98 15:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)										
98SWE02755	20-Oct-98 16:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02119	19-May-99 08:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03348	13-Jul-99 11:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	**0.0027**	L0.01	**0.0091**
99SWE04912	15-Sep-99 11:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00337	23-Feb-00 15:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE01255	10-May-00 07:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
01SWE00029	10-Jan-01 12:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01

SAMPLE NO.	DATE/TIME VMV Code:	3-METHYL CHLORAN THRENE 103142	7,12-DIMETHYL BENZ(A) ANTHRA CENE 103143	ACE NAPH THENE 103144	ACE NAPH THYLENE 103145	ACRI DINE 103146	ANTHRA CENE 103147	BENZO(A) ANTHRA CENE 103148	BENZO(A) PYRENE 103149	BENZO (B,J,K) FLUOR ANTHENE 103150
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)										
98SWE02754	20-Oct-98 16:20	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02050	18-May-99 13:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04911	15-Sep-99 12:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00332	23-Feb-00 16:45	L0.01	L0.01	L0.01	**0.035**	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)										
98SWE02765	20-Oct-98 09:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)										
98SWE02764	20-Oct-98 08:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)										
98SWE02759	20-Oct-98 11:50	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02054	18-May-99 12:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03352	13-Jul-99 08:40	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04908	15-Sep-99 08:10	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00338	23-Feb-00 11:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)										
98SWE02762	20-Oct-98 12:10	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)										
98SWE02761	20-Oct-98 12:50	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01

Appendix 4. Continued.

SAMPLE NO.	DATE/TIME VMV Code:	BENZO(C) PHENAN THRENE 103151	BENZO(E) PYRENE 103152	BENZO (G,H,I) PERYLENE 103153	CHRY SENE 103154	DIBENZO (A,H) PYRENE 103155	DIBENZO (A,I) PYRENE 103156	DIBENZO (A,L) PYRENE 103157	DIBENZ (A,H) ANTHRA CENE 103158	FLUOR ANTHENE 103159
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)										
98SWE02763	20-Oct-98 11:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)										
98SWE02757	20-Oct-98 14:10	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02055	18-May-99 12:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03351	13-Jul-99 13:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04909	15-Sep-99 09:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00333	23-Feb-00 12:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)										
98SWE02758	20-Oct-98 13:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02056	18-May-99 13:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03350	13-Jul-99 12:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04910	15-Sep-99 12:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00336	23-Feb-00 12:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)										
98SWE02756	20-Oct-98 14:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02049	18-May-99 13:20	L0.01	L0.01	L0.01	**0.0022**	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03349	13-Jul-99 13:30	L0.01	L0.01	**0.0039**	**0.0045**	L0.01	L0.01	L0.01	**0.0024**	**0.0025**
99SWE04913	15-Sep-99 10:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00339	23-Feb-00 12:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)										
98SWE02760	20-Oct-98 15:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)										
98SWE02755	20-Oct-98 16:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02119	19-May-99 08:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03348	13-Jul-99 11:00	L0.01	L0.01	**0.0022**	**0.0041**	L0.01	L0.01	L0.01	L0.01	**0.0037**
99SWE04912	15-Sep-99 11:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00337	23-Feb-00 15:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE01255	10-May-00 07:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
01SWE00029	10-Jan-01 12:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01

SAMPLE NO.	DATE/TIME VMV Code:	BENZO(C) PHENAN THRENE 103151	BENZO(E) PYRENE 103152	BENZO (G,H,I) PERYLENE 103153	CHRY SENE 103154	DIBENZO (A,H) PYRENE 103155	DIBENZO (A,I) PYRENE 103156	DIBENZO (A,L) PYRENE 103157	DIBENZ (A,H) ANTHRA CENE 103158	FLUOR ANTHENE 103159
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)										
98SWE02754	20-Oct-98 16:20	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02050	18-May-99 13:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04911	15-Sep-99 12:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00332	23-Feb-00 16:45	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)										
98SWE02765	20-Oct-98 09:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)										
98SWE02764	20-Oct-98 08:30	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)										
98SWE02759	20-Oct-98 11:50	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02054	18-May-99 12:15	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03352	13-Jul-99 08:40	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04908	15-Sep-99 08:10	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00338	23-Feb-00 11:00	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)										
98SWE02762	20-Oct-98 12:10	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)										
98SWE02761	20-Oct-98 12:50	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01	L0.01

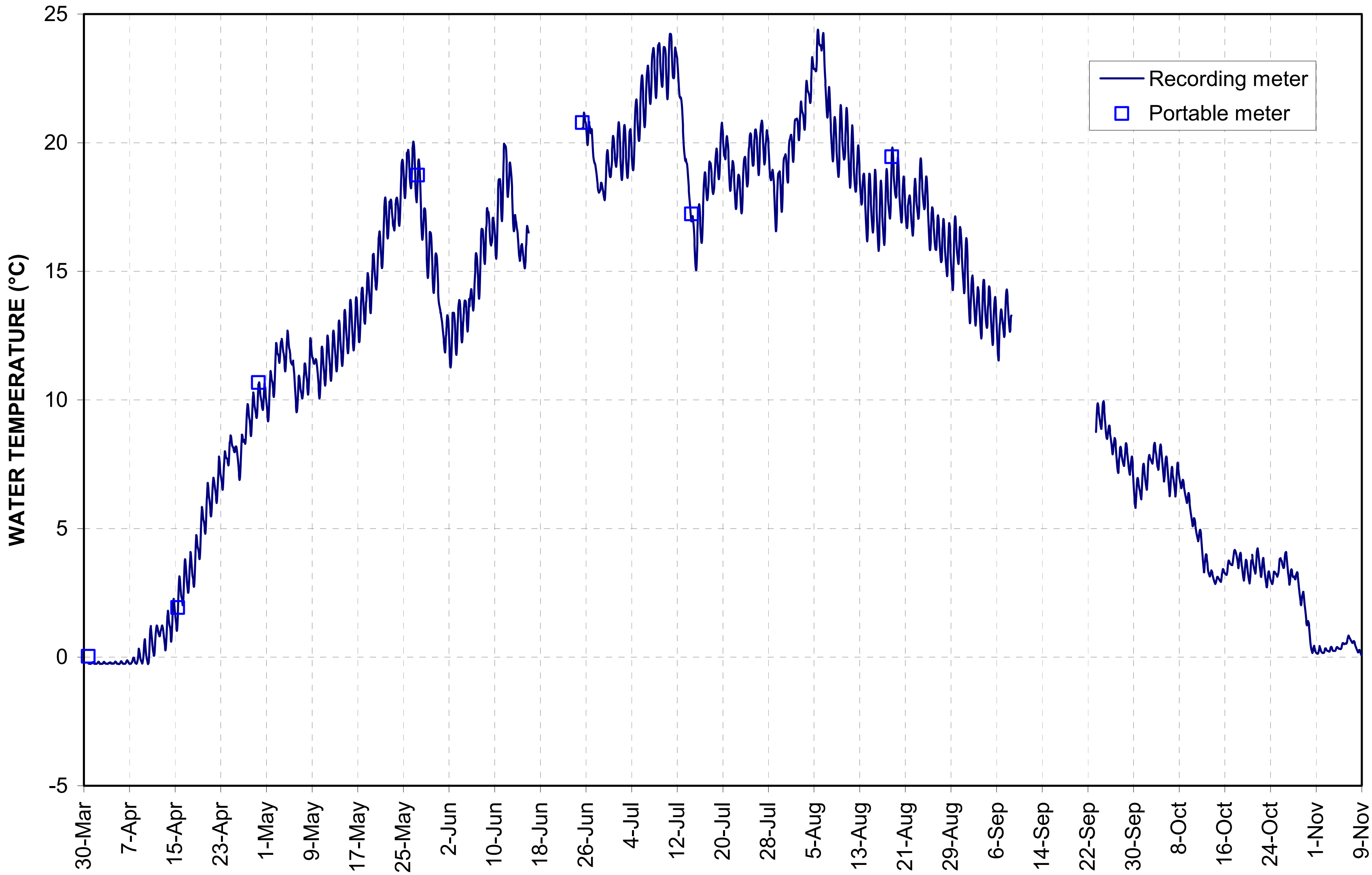
Appendix 4. Continued.

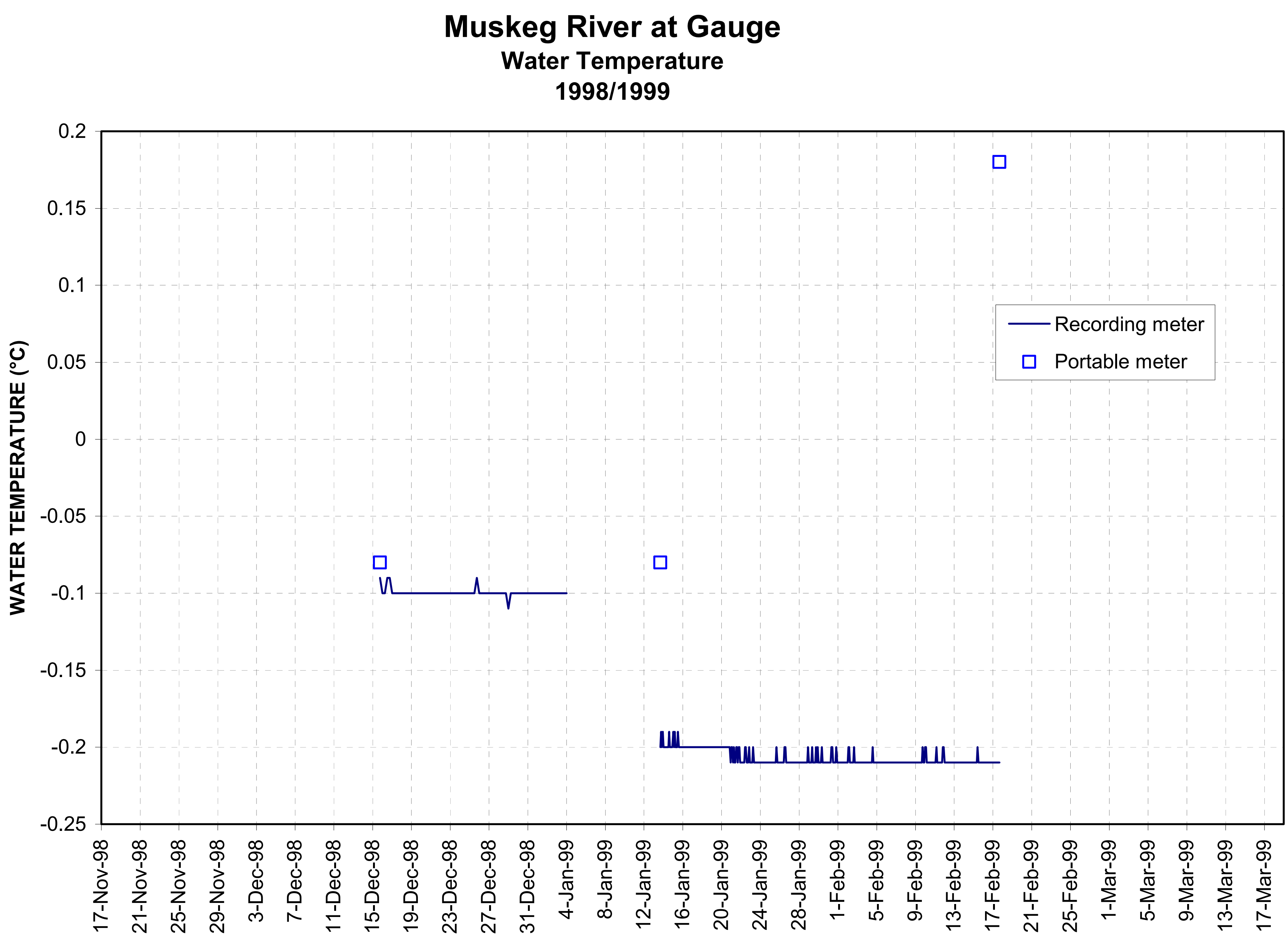
SAMPLE NO.	DATE/TIME VMV Code:	FLUOR ENE 103160	INDENO (1,2,3-C,D) PYRENE 103161	NAPH THALENE 103162	PHENAN THRENE 103163	PYRENE 103164
STANLEY CRK 1.5 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0490)						
98SWE02763	20-Oct-98 11:30	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. UPSTREAM OF JACKPINE CRK (AB07DA0595)						
98SWE02757	20-Oct-98 14:10	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02055	18-May-99 12:45	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03351	13-Jul-99 13:00	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04909	15-Sep-99 09:30	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00333	23-Feb-00 12:30	L0.01	L0.01	L0.01	L0.01	L0.01
HARTLEY (JACKPINE) CRK 0.25 MILES ABOVE CONFLUENCE WITH MUSKEG R. - AOSERP (AB07DA0600)						
98SWE02758	20-Oct-98 13:15	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02056	18-May-99 13:00	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03350	13-Jul-99 12:30	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04910	15-Sep-99 12:00	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00336	23-Feb-00 12:00	L0.01	L0.01	L0.01	L0.01	L0.01
ALSANDS DITCH AT ROAD 90 METERS BEFORE ENTERING MUSKEG R. (AB07DA0605)						
98SWE02756	20-Oct-98 14:00	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02049	18-May-99 13:20	**0.0016**	L0.01	L0.01	L0.01	L0.01
99SWE03349	13-Jul-99 13:30	L0.01	**0.0054**	L0.01	**0.0023**	**0.0032**
99SWE04913	15-Sep-99 10:30	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00339	23-Feb-00 12:00	L0.01	L0.01	L0.01	L0.01	L0.01
TRIBUTARY ONE DRAINING 3 PONDS NEAR MUSKEG R. (AB07DA0606)						
98SWE02760	20-Oct-98 15:30	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. 2.2 MILES NE OF FORT MACKAY AT WSC GAUGE - AOSERP (AB07DA0610)						
98SWE02755	20-Oct-98 16:00	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02119	19-May-99 08:15	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03348	13-Jul-99 11:00	L0.01	**0.0036**	L0.01	**0.0027**	**0.0042**
99SWE04912	15-Sep-99 11:45	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00337	23-Feb-00 15:45	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE01255	10-May-00 07:15	L0.01	L0.01	L0.01	L0.01	L0.01
01SWE00029	10-Jan-01 12:45	L0.01	L0.01	L0.01	L0.01	L0.01

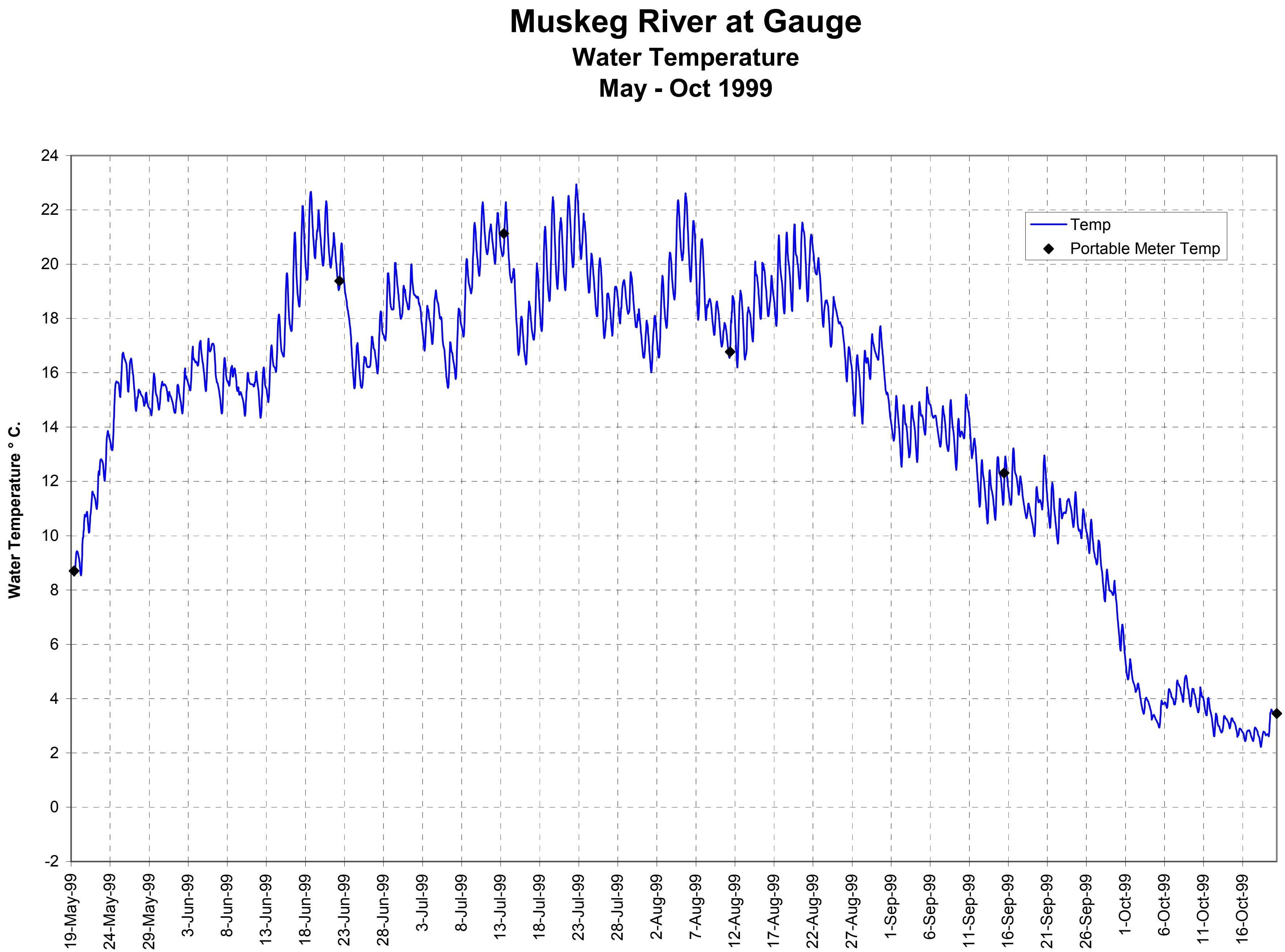
SAMPLE NO.	DATE/TIME	FLUORENE	INDENO (1,2,3-C,D) PYRENE	NAPHTHALENE	PHENANTHRENE	PYRENE
	VMV Code:	103160	103161	103162	103163	103164
MUSKEG R. NEAR THE MOUTH - ARC ATH R KM 244.5 (AB07DA0620)						
98SWE02754	20-Oct-98 16:20	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02050	18-May-99 13:45	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04911	15-Sep-99 12:15	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00332	23-Feb-00 16:45	**0.012**	L0.01	**0.89**	**0.016**	L0.01
MUSKEG R. LOCATED 0.25 KM ABOVE WAPASU CRK CONFLUENCE (AB07DA1125)						
98SWE02765	20-Oct-98 09:30	L0.01	L0.01	L0.01	L0.01	L0.01
WAPASU CRK .1 KM ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA1126)						
98SWE02764	20-Oct-98 08:30	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG R. DOWNSTREAM OF STANLEY CRK (AB07DA2750)						
98SWE02759	20-Oct-98 11:50	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE02054	18-May-99 12:15	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE03352	13-Jul-99 08:40	L0.01	L0.01	L0.01	L0.01	L0.01
99SWE04908	15-Sep-99 08:10	L0.01	L0.01	L0.01	L0.01	L0.01
00SWE00338	23-Feb-00 11:00	L0.01	L0.01	L0.01	L0.01	L0.01
MUSKEG CRK AT CONFLUENCE WITH MUSKEG R. (AB07DA2755)						
98SWE02762	20-Oct-98 12:10	L0.01	L0.01	L0.01	L0.01	L0.01
SHELLY CRK ABOVE CONFLUENCE WITH MUSKEG R. (AB07DA2756)						
98SWE02761	20-Oct-98 12:50	L0.01	L0.01	L0.01	L0.01	L0.01

Appendix 5. Water temperature recordings (hourly) and spot checks (portable meter), Muskeg River basin sites, open-water seasons, 1998-2001

Muskeg River at Gauge
Water Temperature
1998

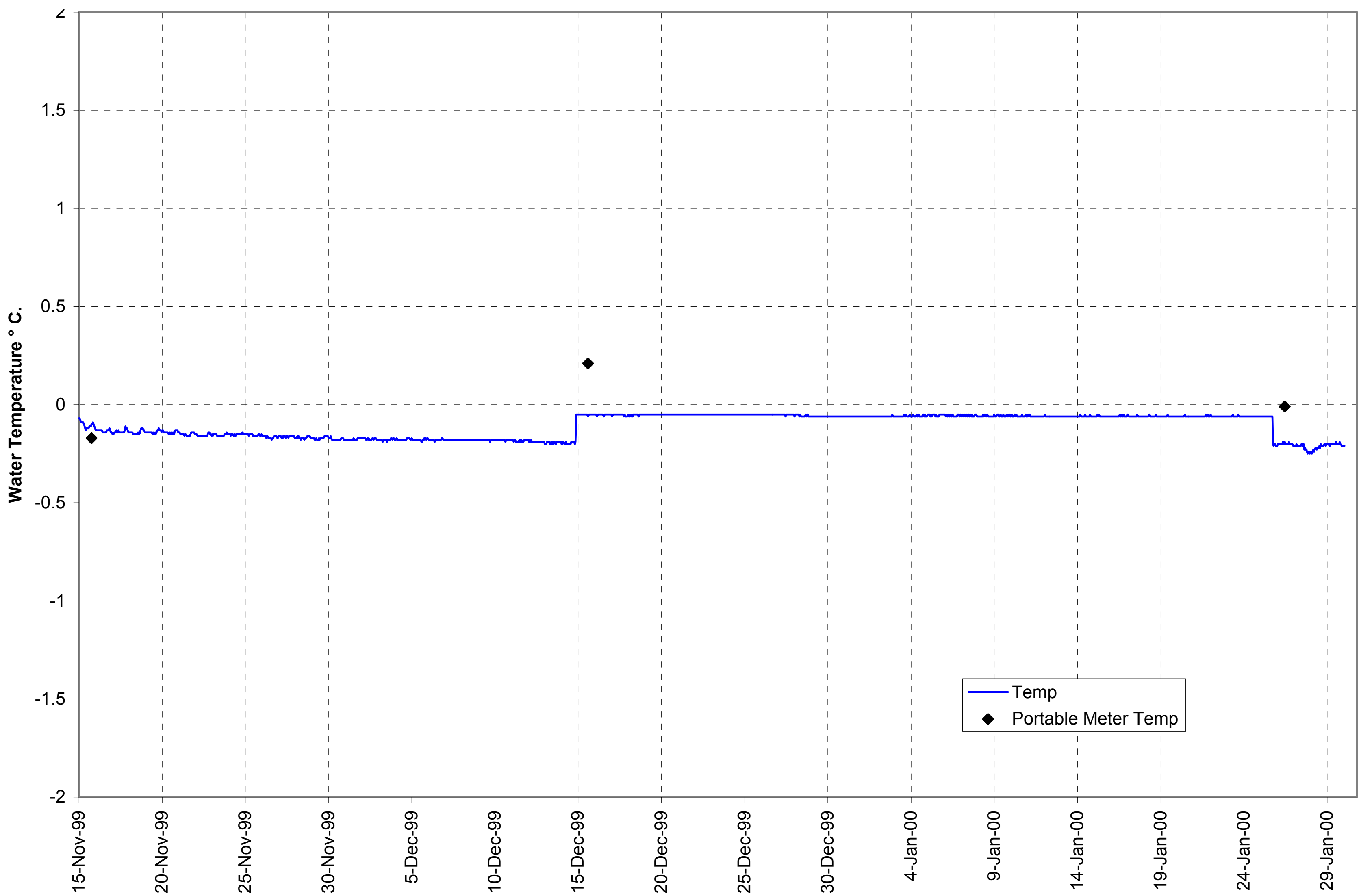



Muskeg River at Gauge
Water Temperature
1998/1999
WATER TEMPERATURE (°C)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99



Muskeg River at Gauge
Water Temperature
May - Oct 1999
Water Temperature ° C.
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
Temp
Portable Meter Temp
19-May-99
24-May-99
29-May-99
3-Jun-99
8-Jun-99
13-Jun-99
18-Jun-99
23-Jun-99
28-Jun-99
3-Jul-99
8-Jul-99
13-Jul-99
18-Jul-99
23-Jul-99
28-Jul-99
2-Aug-99
7-Aug-99
12-Aug-99
17-Aug-99
22-Aug-99
27-Aug-99
1-Sep-99
6-Sep-99
11-Sep-99
16-Sep-99
21-Sep-99
26-Sep-99
1-Oct-99
6-Oct-99
11-Oct-99
16-Oct-99

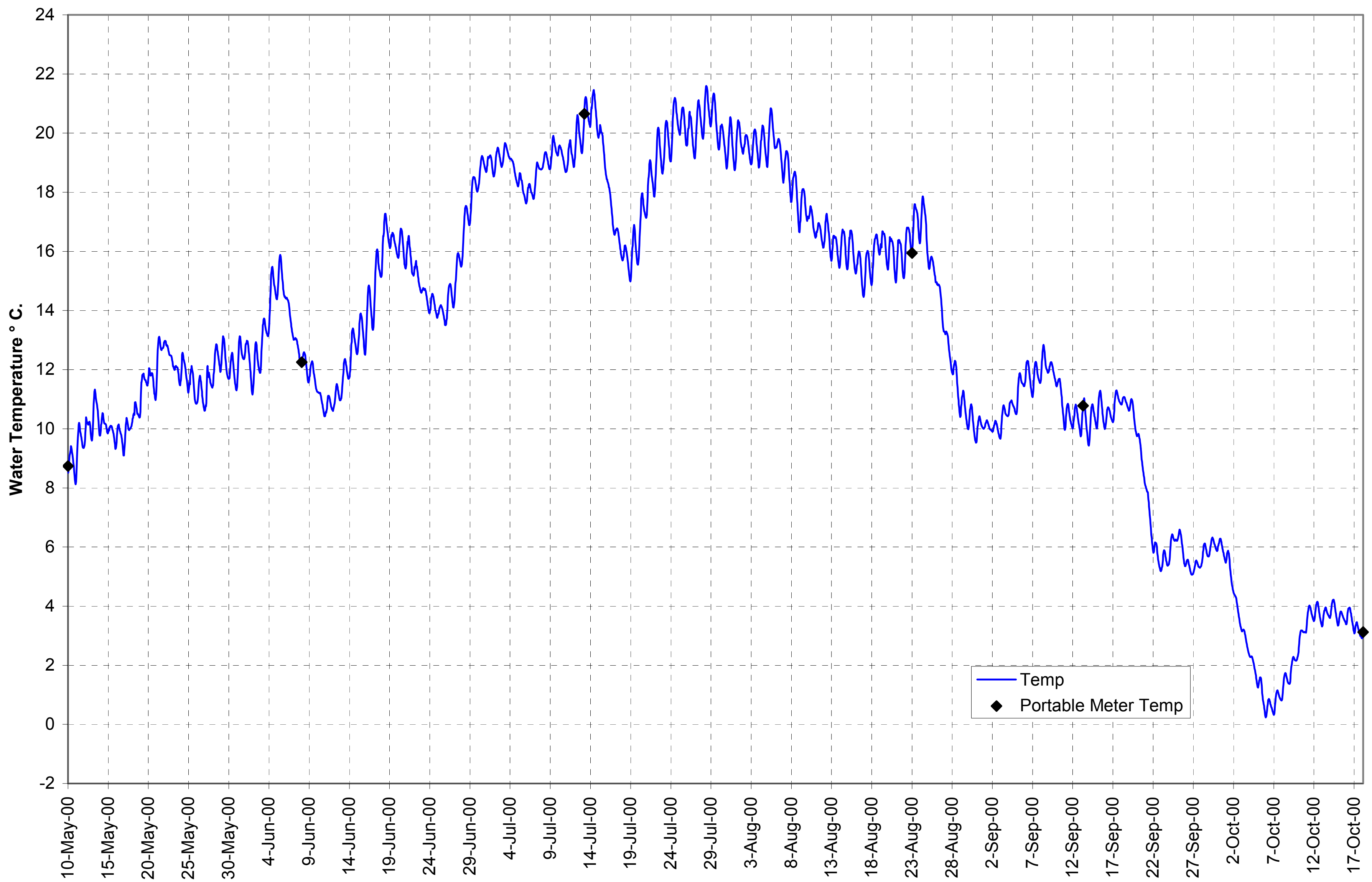
Muskeg River at Gauge
Water Temperature
Winter 1999-2000

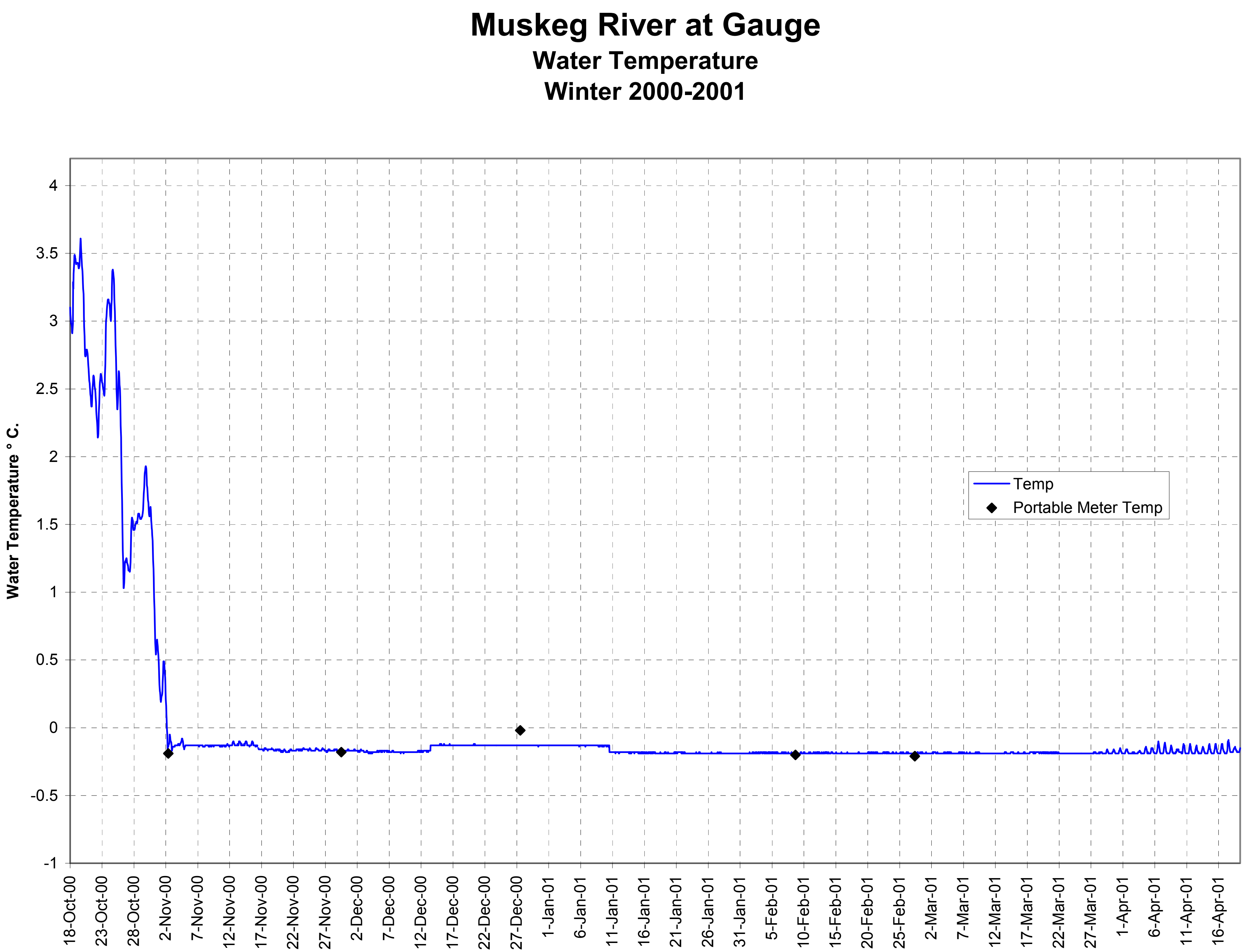


Muskeg River at Gauge

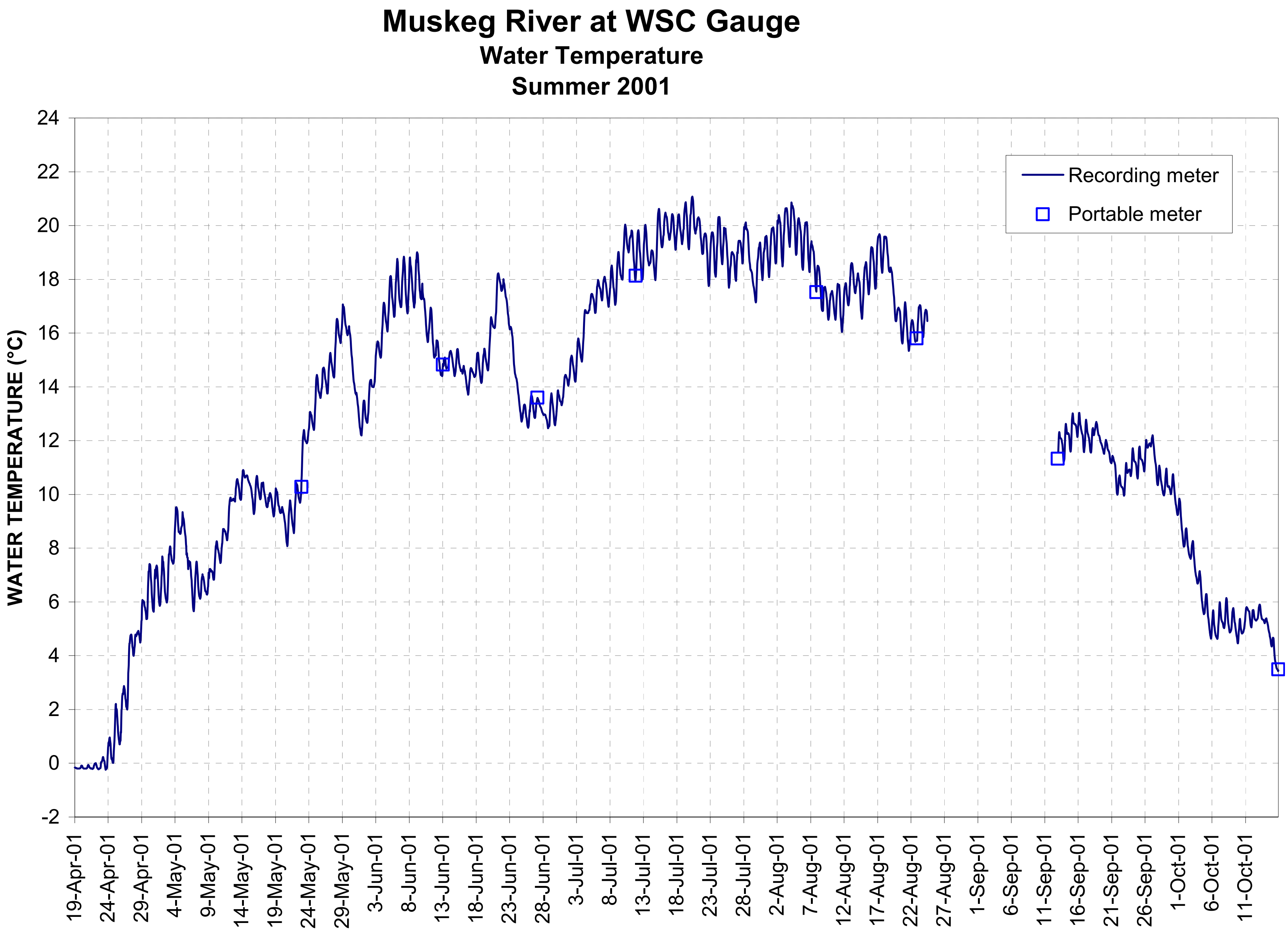
Water Temperature

May-Oct 2000

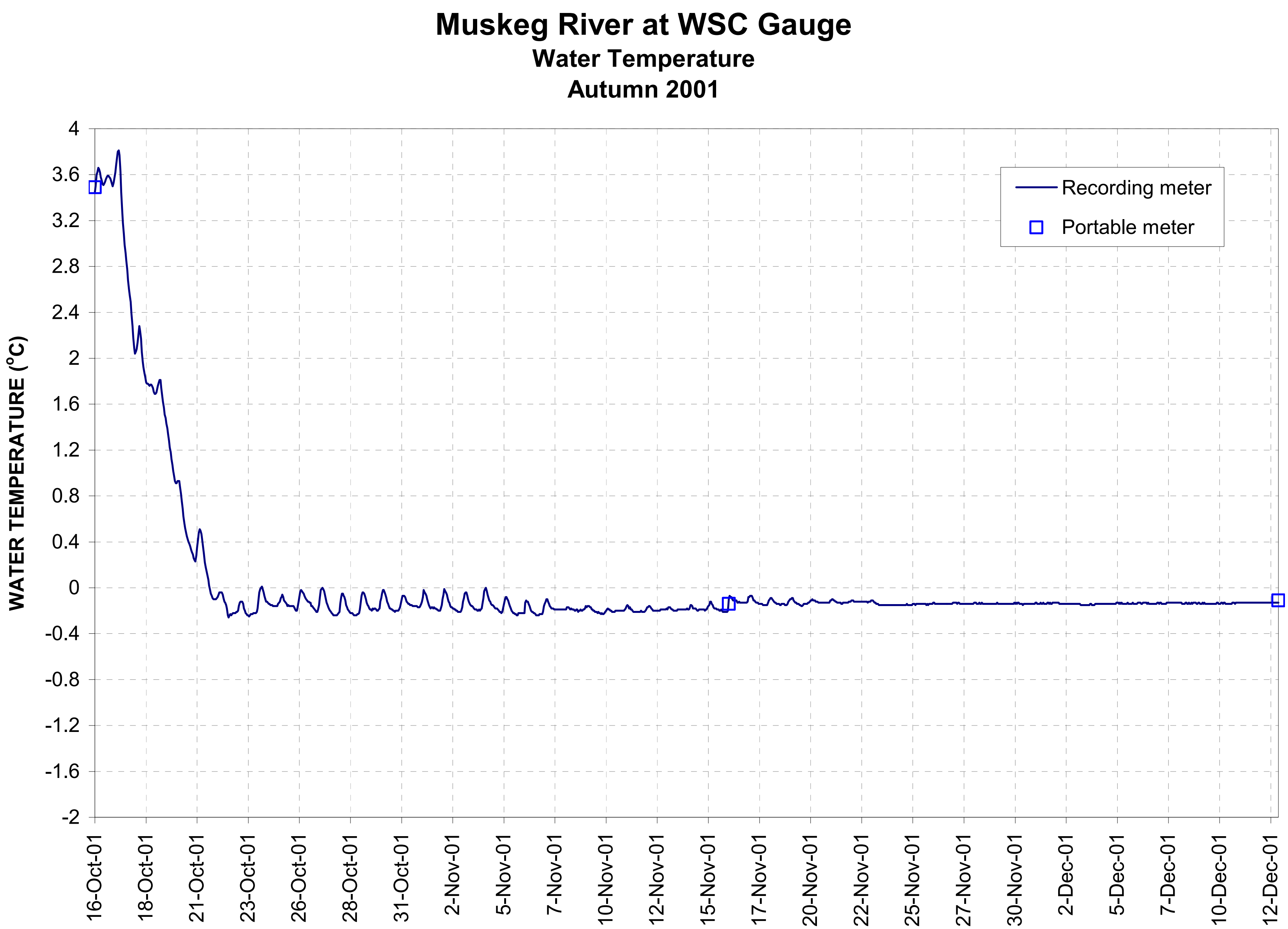




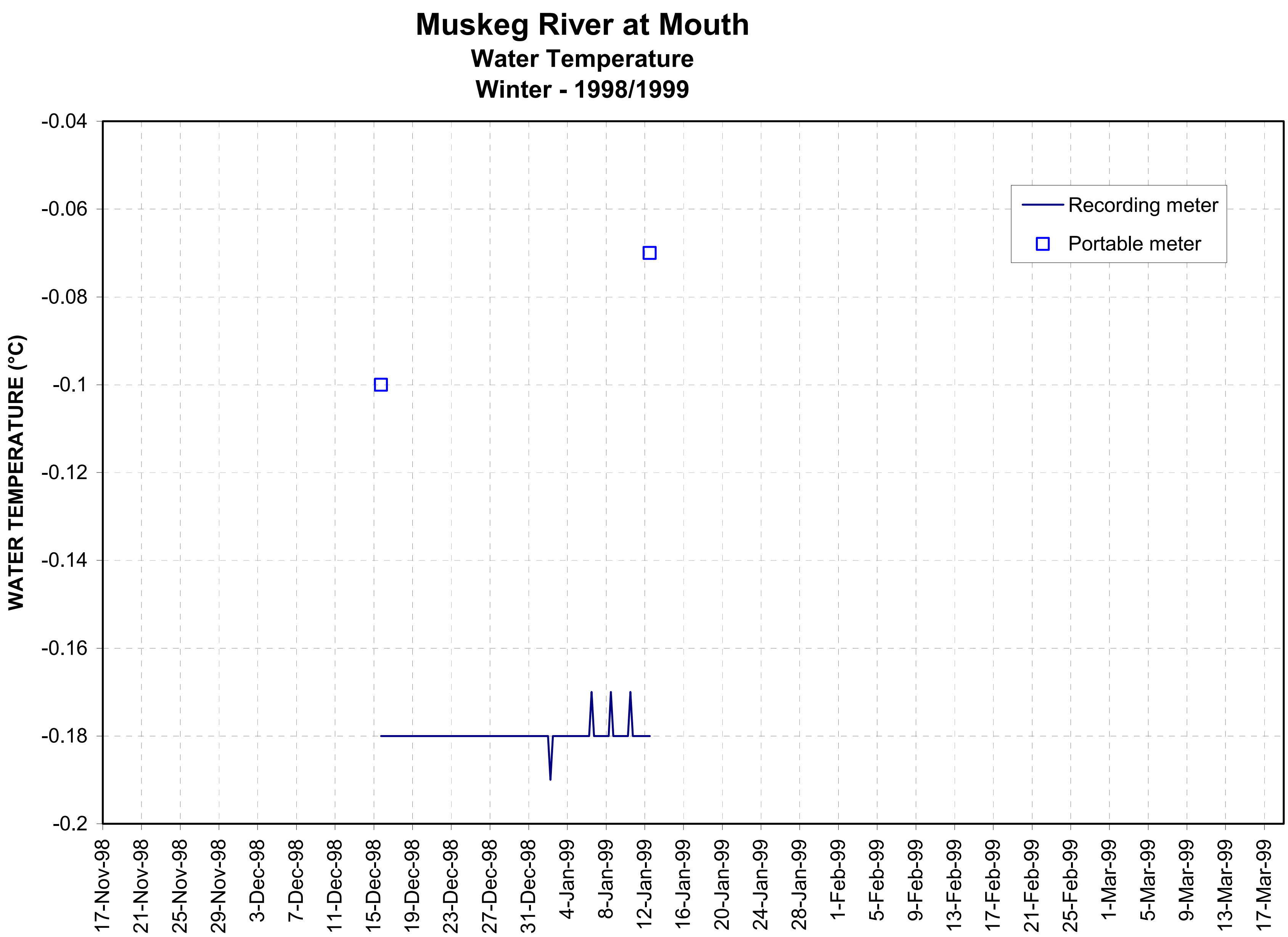
Muskeg River at Gauge
Water Temperature
Winter 2000-2001
Water Temperature ° C.
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
Temp
Portable Meter Temp
18-Oct-00
23-Oct-00
28-Oct-00
2-Nov-00
7-Nov-00
12-Nov-00
17-Nov-00
22-Nov-00
27-Nov-00
2-Dec-00
7-Dec-00
12-Dec-00
17-Dec-00
22-Dec-00
27-Dec-00
1-Jan-01
6-Jan-01
11-Jan-01
16-Jan-01
21-Jan-01
26-Jan-01
31-Jan-01
5-Feb-01
10-Feb-01
15-Feb-01
20-Feb-01
25-Feb-01
2-Mar-01
7-Mar-01
12-Mar-01
17-Mar-01
22-Mar-01
27-Mar-01
1-Apr-01
6-Apr-01
11-Apr-01
16-Apr-01



Muskeg River at WSC Gauge
Water Temperature
Summer 2001
WATER TEMPERATURE (°C)
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
Recording meter
Portable meter
19-Apr-01
24-Apr-01
29-Apr-01
4-May-01
9-May-01
14-May-01
19-May-01
24-May-01
29-May-01
3-Jun-01
8-Jun-01
13-Jun-01
18-Jun-01
23-Jun-01
28-Jun-01
3-Jul-01
8-Jul-01
13-Jul-01
18-Jul-01
23-Jul-01
28-Jul-01
2-Aug-01
7-Aug-01
12-Aug-01
17-Aug-01
22-Aug-01
27-Aug-01
1-Sep-01
6-Sep-01
11-Sep-01
16-Sep-01
21-Sep-01
26-Sep-01
1-Oct-01
6-Oct-01
11-Oct-01

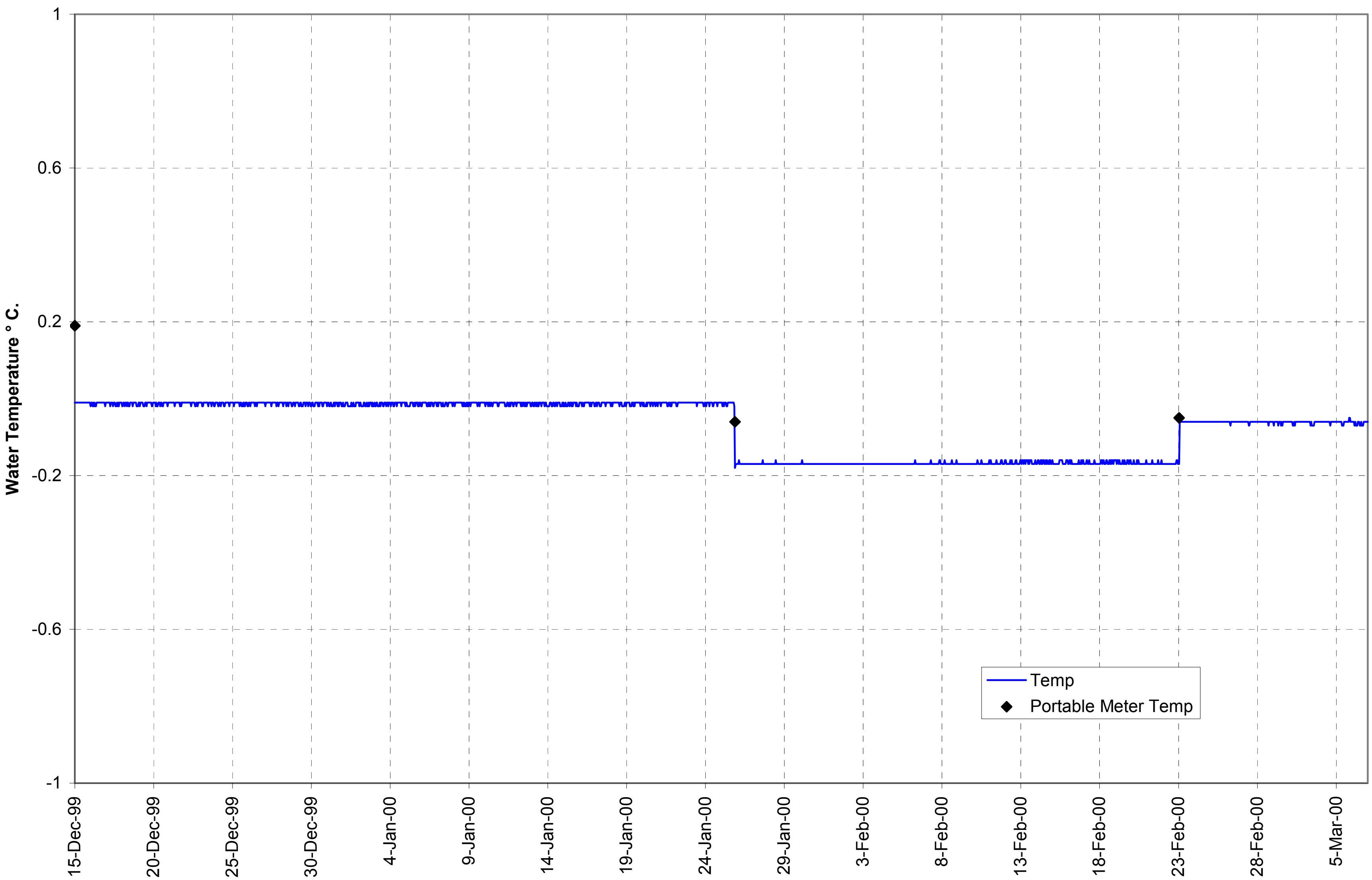


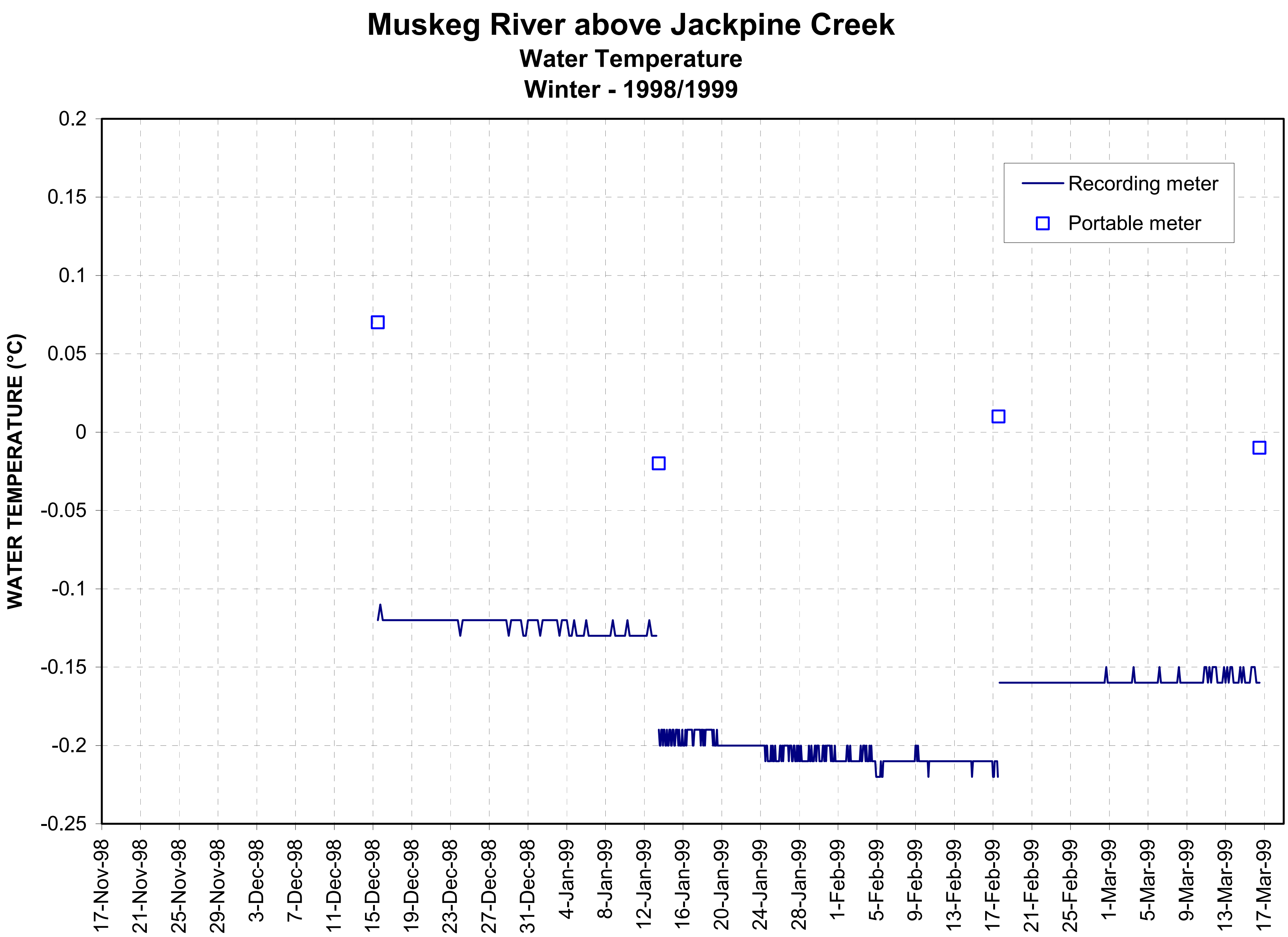
Muskeg River at WSC Gauge
Water Temperature
Autumn 2001
WATER TEMPERATURE (°C)
4
3.6
3.2
2.8
2.4
2
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
-2
Recording meter
Portable meter
16-Oct-01
18-Oct-01
21-Oct-01
23-Oct-01
26-Oct-01
28-Oct-01
31-Oct-01
2-Nov-01
5-Nov-01
7-Nov-01
10-Nov-01
12-Nov-01
15-Nov-01
17-Nov-01
20-Nov-01
22-Nov-01
25-Nov-01
27-Nov-01
30-Nov-01
2-Dec-01
5-Dec-01
7-Dec-01
10-Dec-01
12-Dec-01



Muskeg River at Mouth
Water Temperature
Winter - 1998/1999
WATER TEMPERATURE (°C)
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
-0.2
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

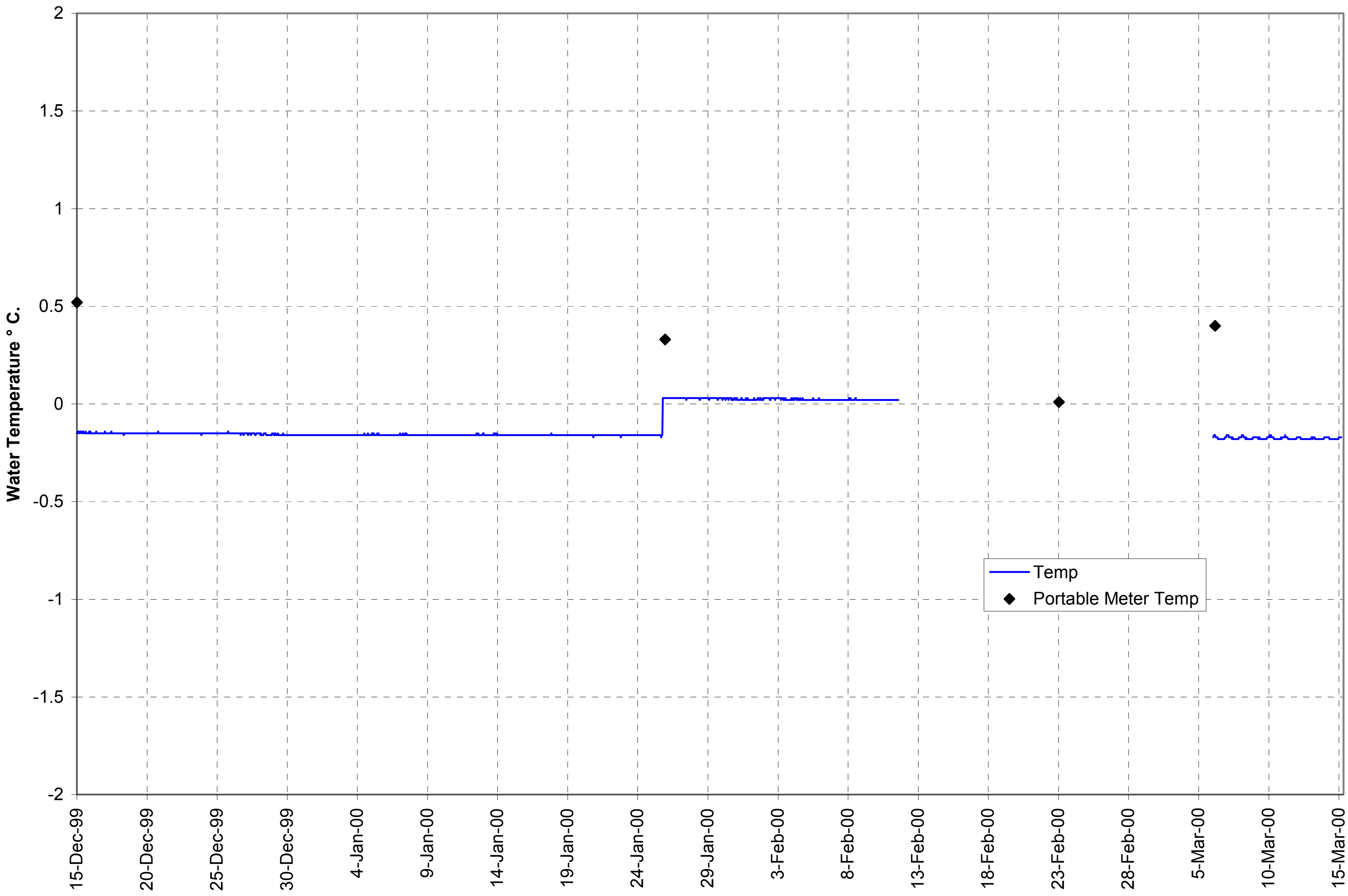
Muskeg River at confluence
Water Temperature
Winter 1999-2000

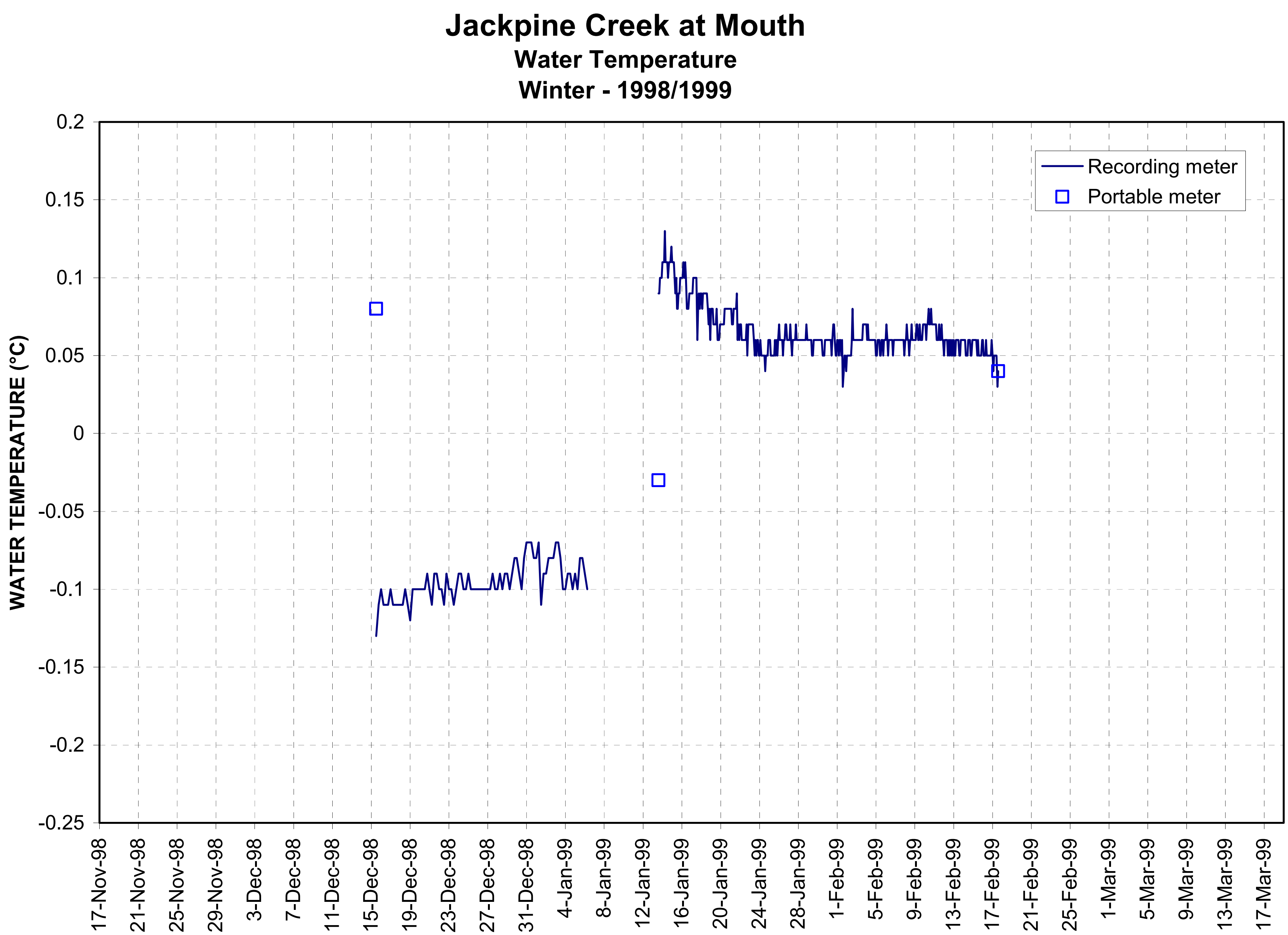




Muskeg River above Jackpine Creek
Water Temperature
Winter - 1998/1999
WATER TEMPERATURE (°C)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

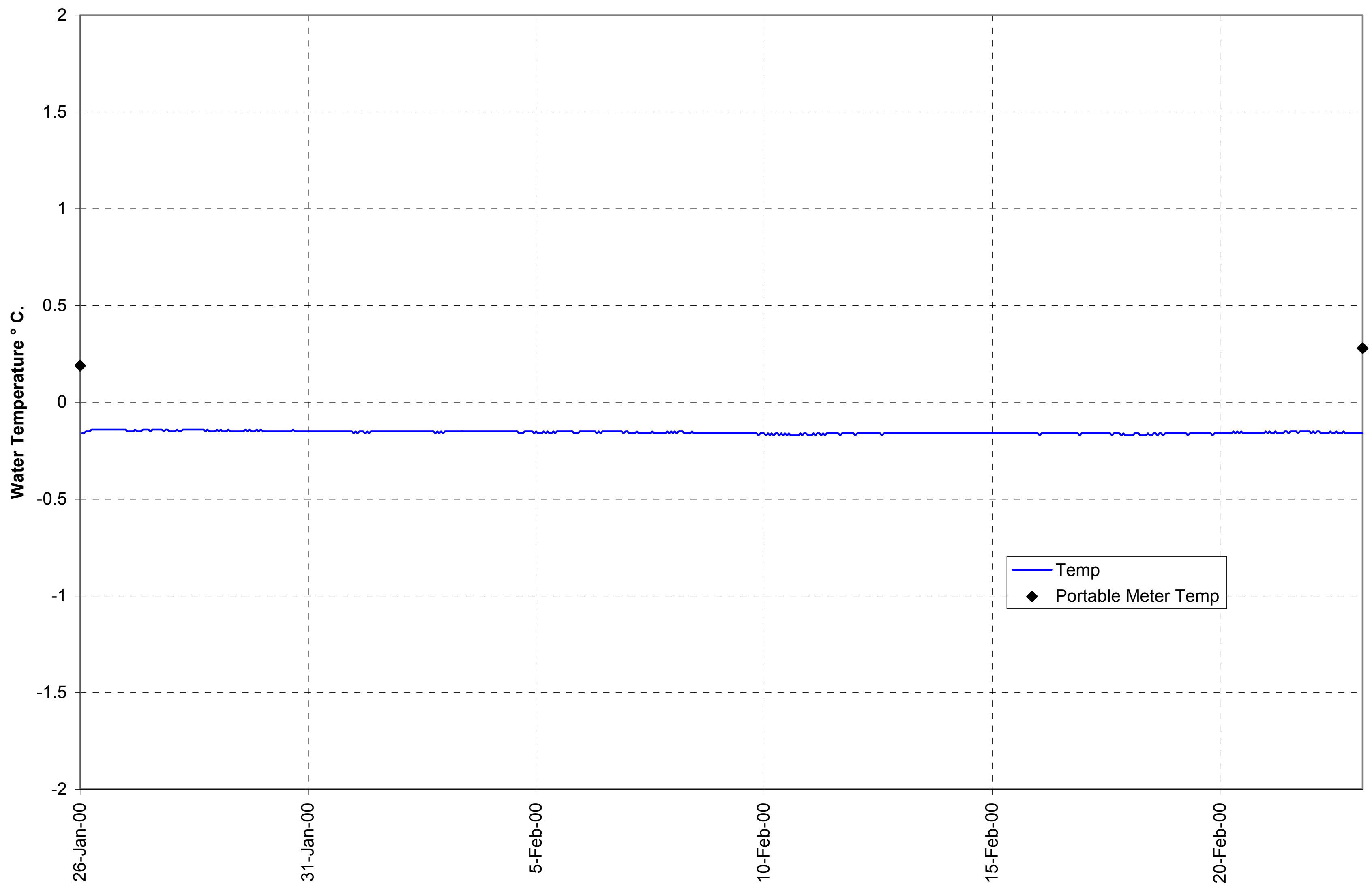
Muskeg River above Jackpine Creek
Water Temperature
Winter 1999-2000



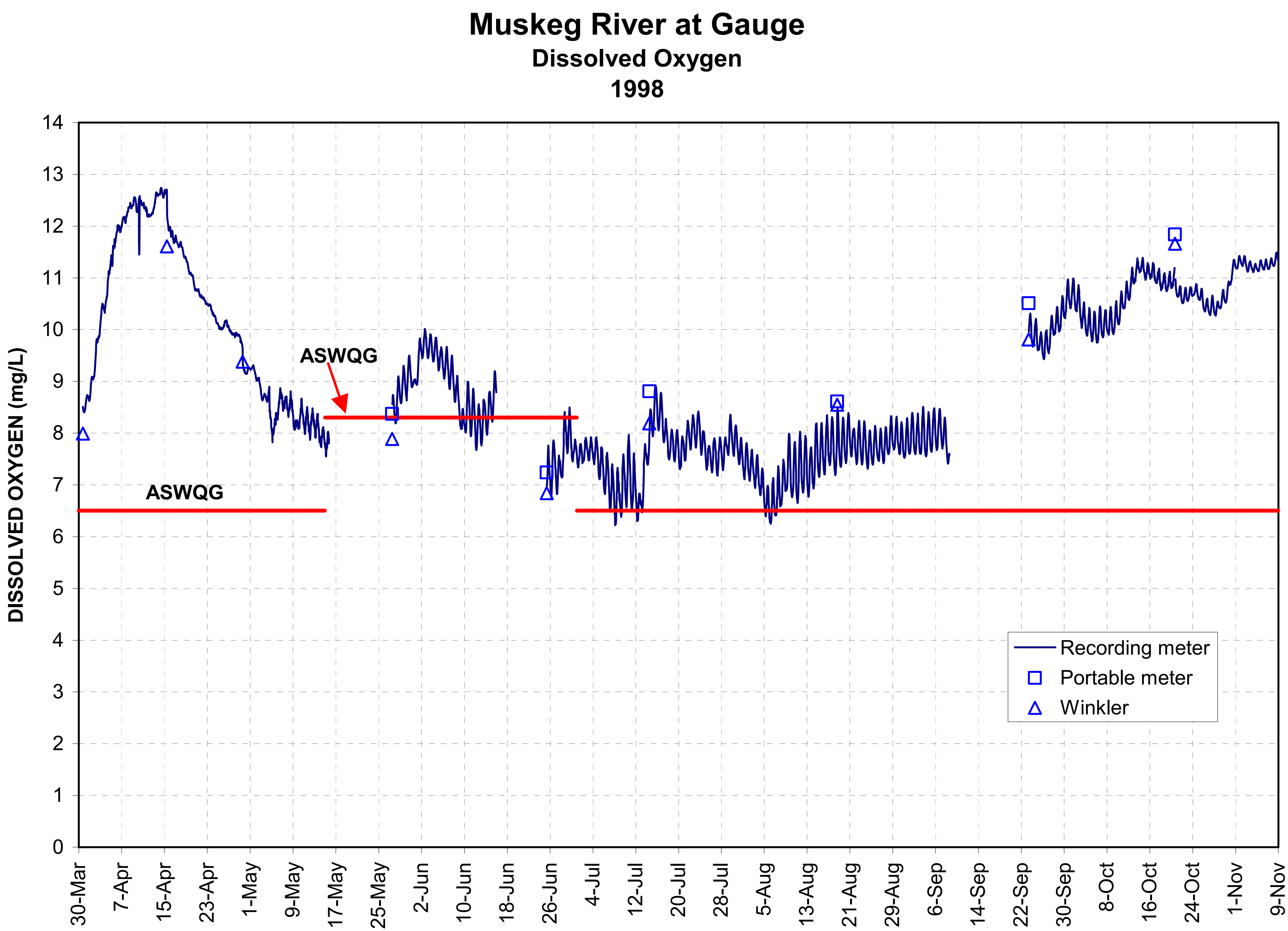


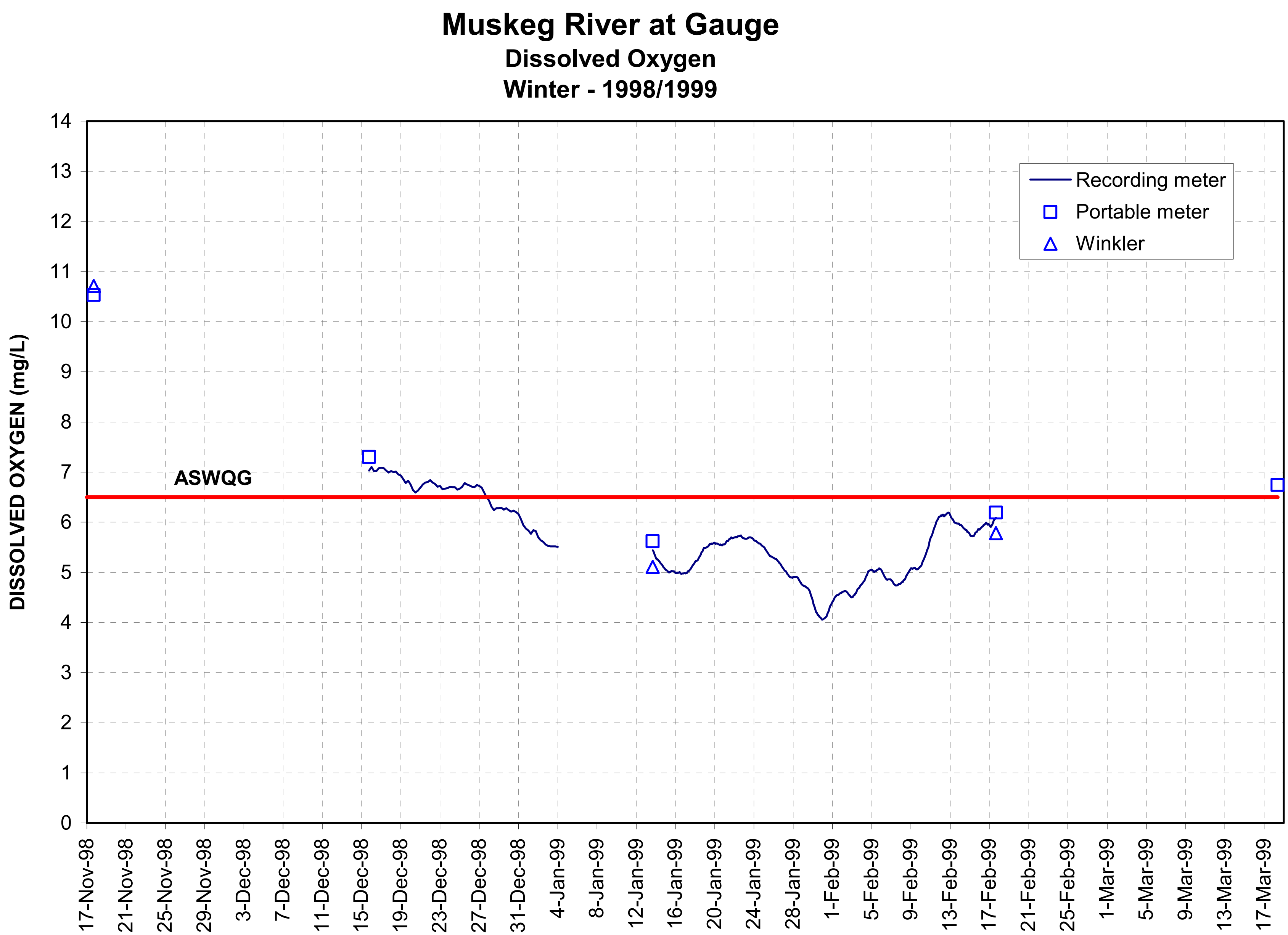
Jackpine Creek at Mouth
Water Temperature
Winter - 1998/1999
WATER TEMPERATURE (°C)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

Jackpine Creek at Mouth
Water Temperature
Winter 1999-2000



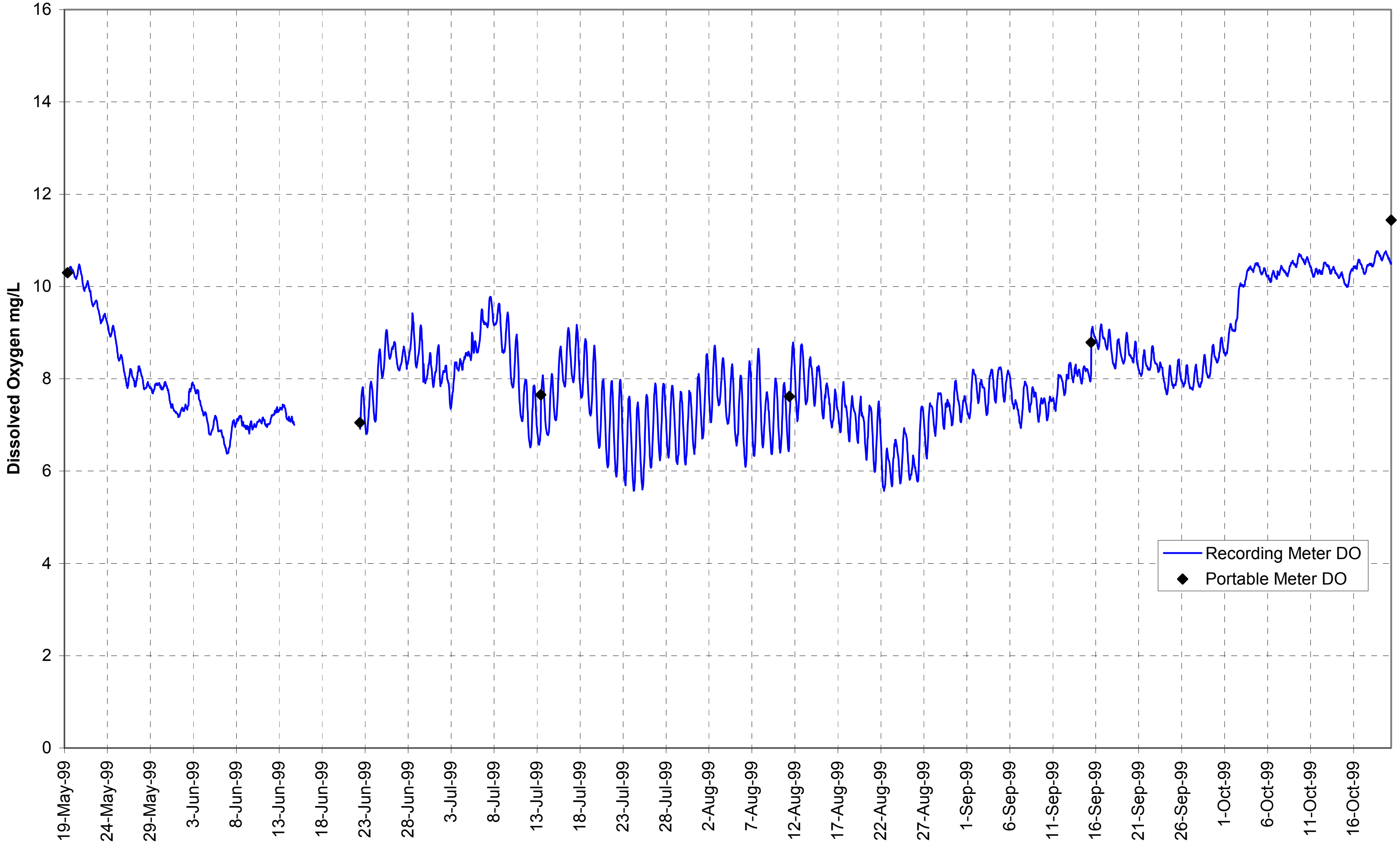
Appendix 6. Dissolved oxygen recordings (hourly) and spot checks (portable meter), Muskeg River basin sites, open-water seasons, 1998-2001


Muskeg River at Gauge
Dissolved Oxygen
1998
DISSOLVED OXYGEN (mg/L)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
ASWQG
ASWQG
30-Mar
7-Apr
15-Apr
23-Apr
1-May
9-May
17-May
25-May
2-Jun
10-Jun
18-Jun
26-Jun
4-Jul
12-Jul
20-Jul
28-Jul
5-Aug
13-Aug
21-Aug
29-Aug
6-Sep
14-Sep
22-Sep
30-Sep
8-Oct
16-Oct
24-Oct
1-Nov
9-Nov
Recording meter
Portable meter
Winkler

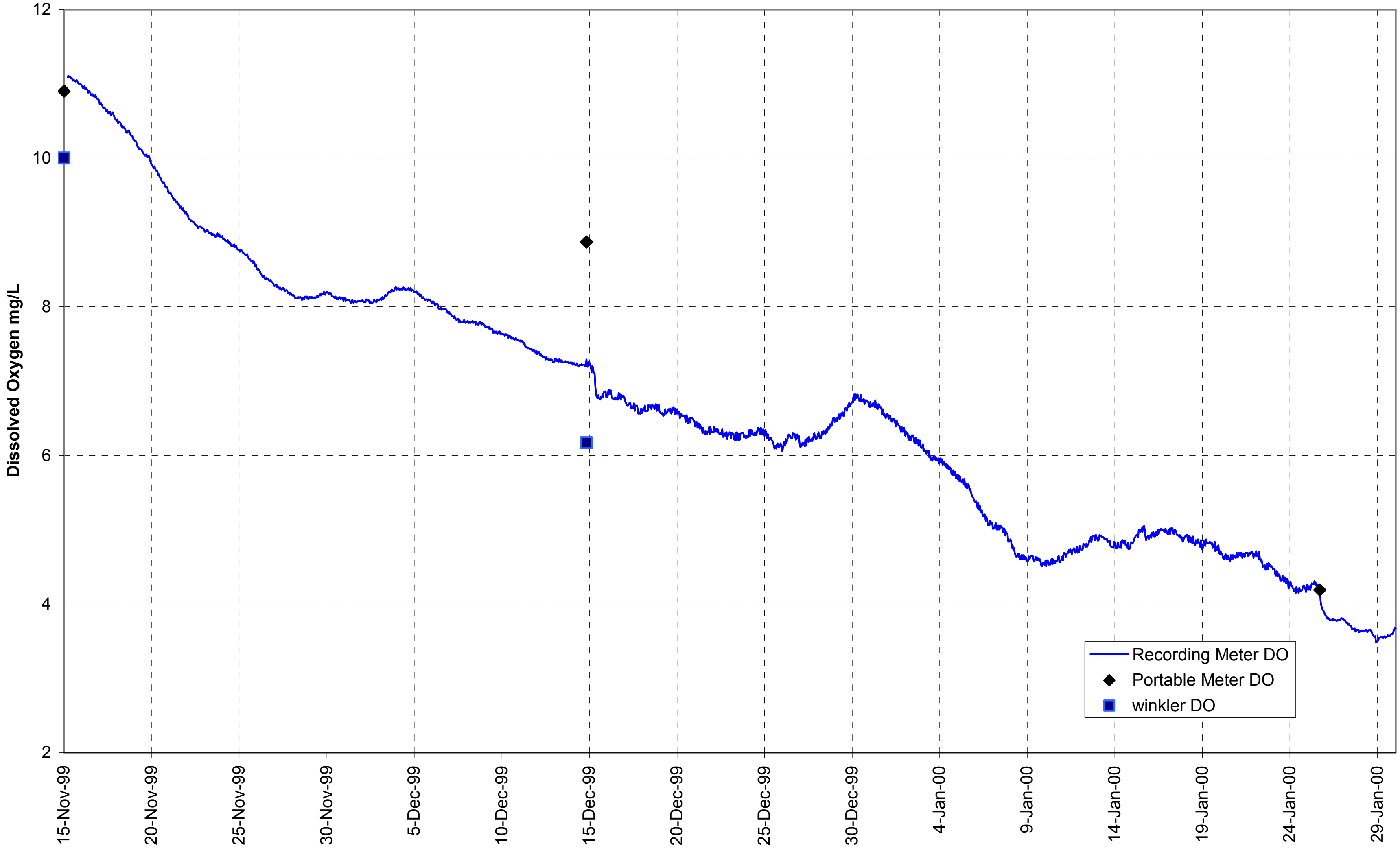


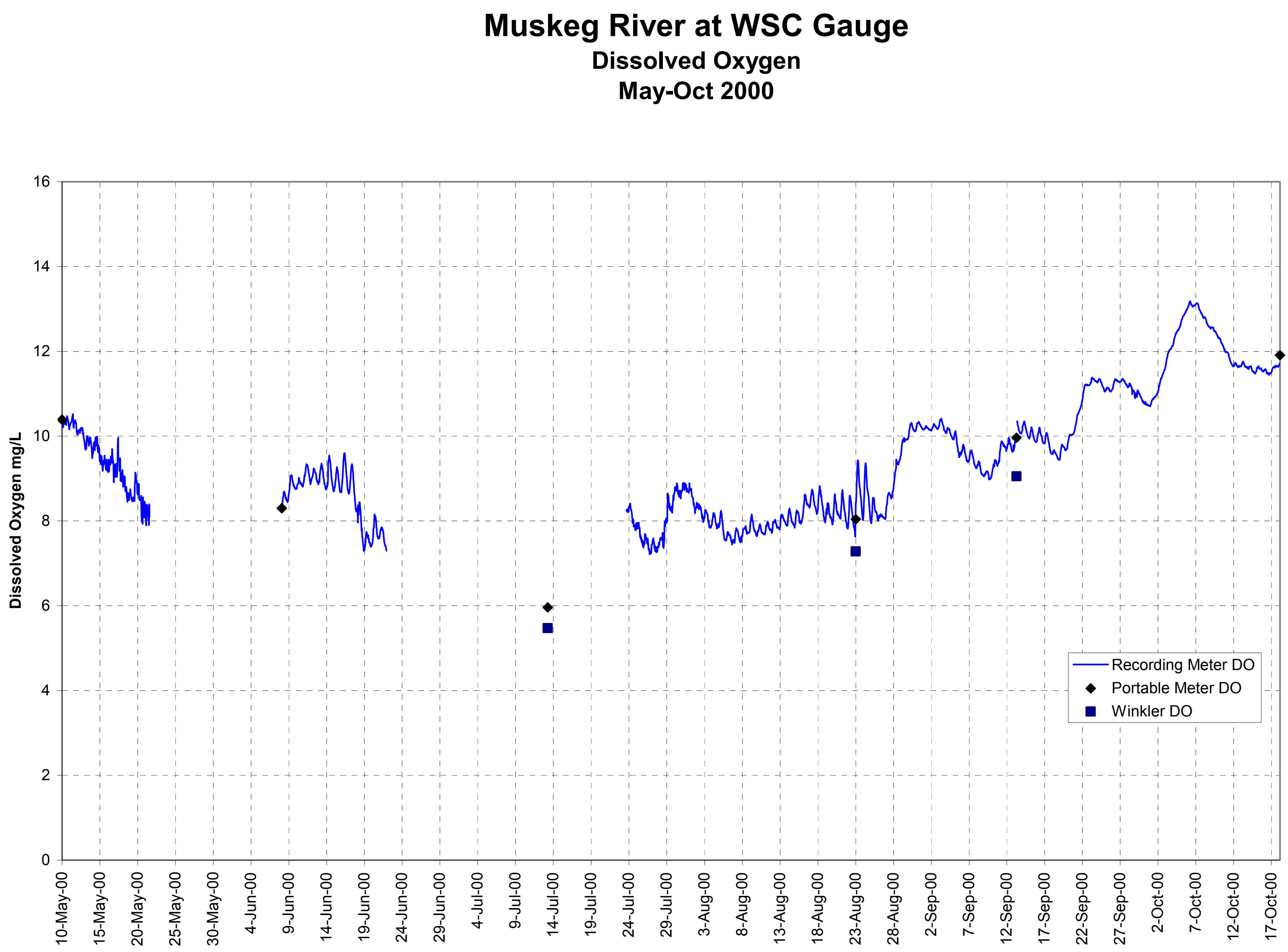
Muskeg River at Gauge
Dissolved Oxygen
Winter - 1998/1999
DISSOLVED OXYGEN (mg/L)
ASWQG
Recording meter
Portable meter
Winkler
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

Muskeg River at Gauge
Dissolved Oxygen
May-Oct 1999

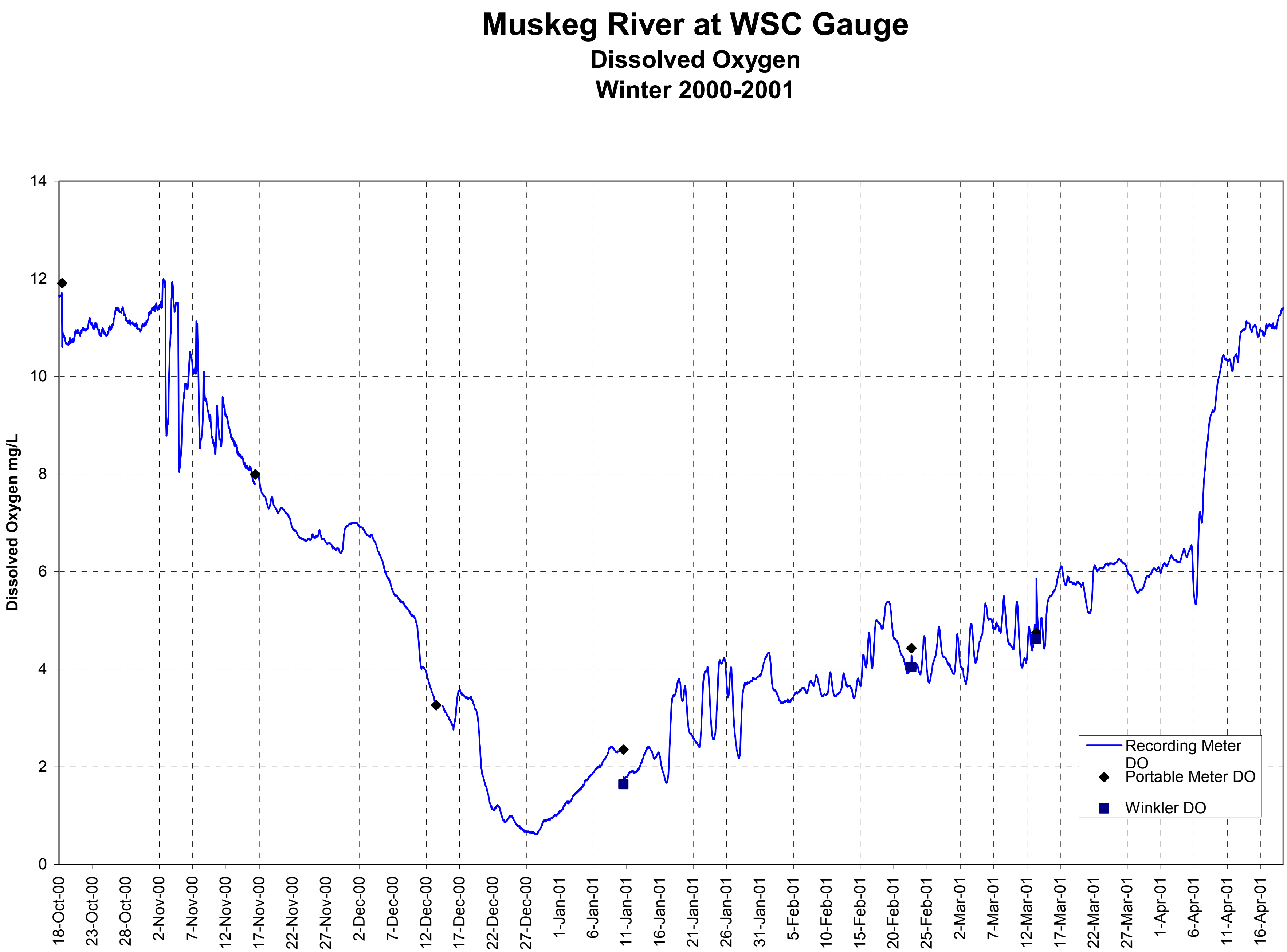


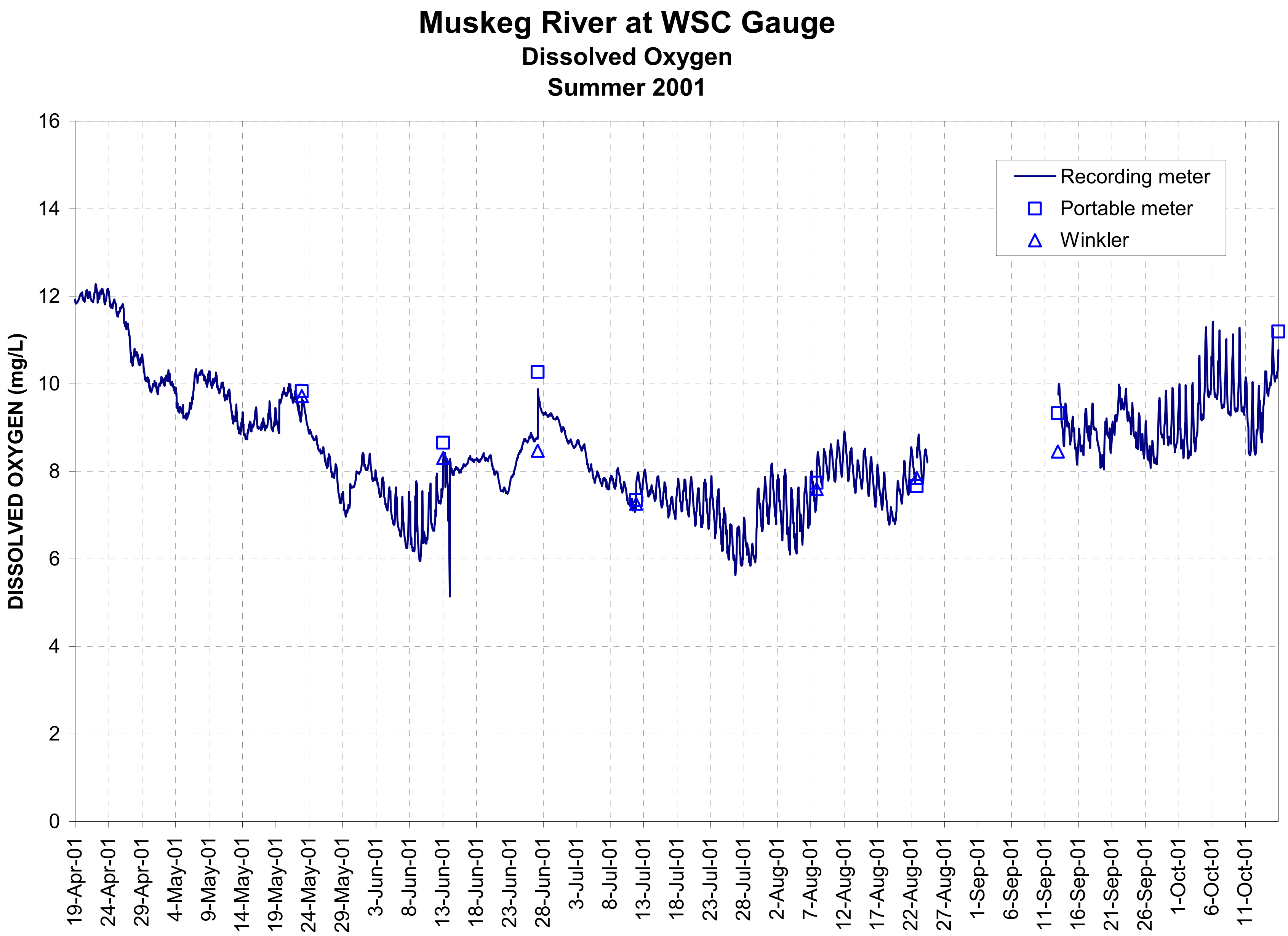
Muskeg River at WSC Gauge
Dissolved Oxygen
Winter 1999-2000





Muskeg River at WSC Gauge
Dissolved Oxygen
May-Oct 2000
Dissolved Oxygen mg/L
0
2
4
6
8
10
12
14
16
10-May-00
15-May-00
20-May-00
25-May-00
30-May-00
4-Jun-00
9-Jun-00
14-Jun-00
19-Jun-00
24-Jun-00
29-Jun-00
4-Jul-00
9-Jul-00
14-Jul-00
19-Jul-00
24-Jul-00
29-Jul-00
3-Aug-00
8-Aug-00
13-Aug-00
18-Aug-00
23-Aug-00
28-Aug-00
2-Sep-00
7-Sep-00
12-Sep-00
17-Sep-00
22-Sep-00
27-Sep-00
2-Oct-00
7-Oct-00
12-Oct-00
17-Oct-00
Recording Meter DO
Portable Meter DO
Winkler DO


Muskeg River at WSC Gauge
Dissolved Oxygen
Winter 2000-2001
Dissolved Oxygen mg/L
0
2
4
6
8
10
12
14
18-Oct-00
23-Oct-00
28-Oct-00
2-Nov-00
7-Nov-00
12-Nov-00
17-Nov-00
22-Nov-00
27-Nov-00
2-Dec-00
7-Dec-00
12-Dec-00
17-Dec-00
22-Dec-00
27-Dec-00
1-Jan-01
6-Jan-01
11-Jan-01
16-Jan-01
21-Jan-01
26-Jan-01
31-Jan-01
5-Feb-01
10-Feb-01
15-Feb-01
20-Feb-01
25-Feb-01
2-Mar-01
7-Mar-01
12-Mar-01
17-Mar-01
22-Mar-01
27-Mar-01
1-Apr-01
6-Apr-01
11-Apr-01
16-Apr-01
Recording Meter DO
Portable Meter DO
Winkler DO


Muskeg River at WSC Gauge
Dissolved Oxygen
Summer 2001
DISSOLVED OXYGEN (mg/L)
16
14
12
10
8
6
4
2
0
Recording meter
Portable meter
Winkler
19-Apr-01
24-Apr-01
29-Apr-01
4-May-01
9-May-01
14-May-01
19-May-01
24-May-01
29-May-01
3-Jun-01
8-Jun-01
13-Jun-01
18-Jun-01
23-Jun-01
28-Jun-01
3-Jul-01
8-Jul-01
13-Jul-01
18-Jul-01
23-Jul-01
28-Jul-01
2-Aug-01
7-Aug-01
12-Aug-01
17-Aug-01
22-Aug-01
27-Aug-01
1-Sep-01
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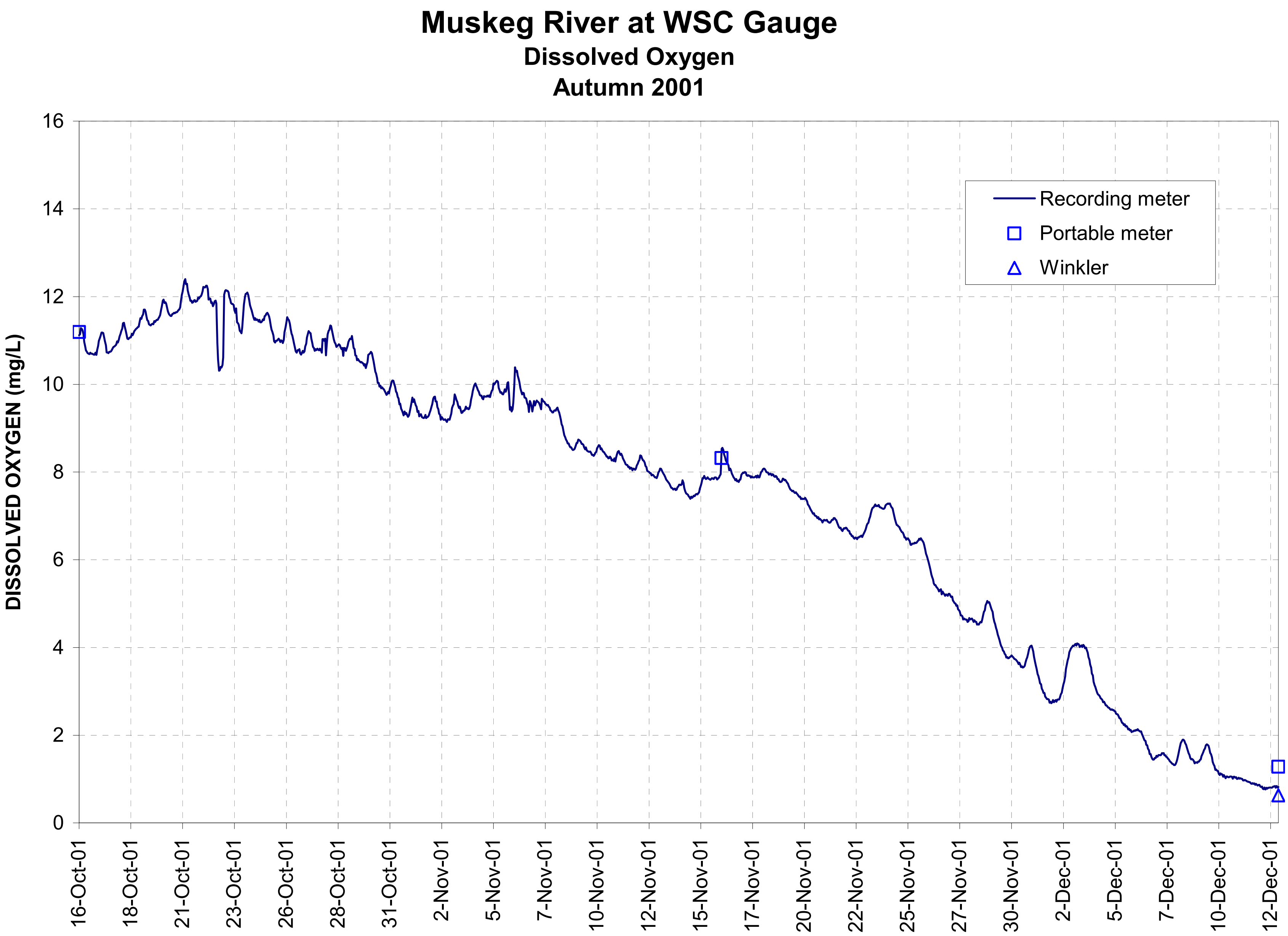
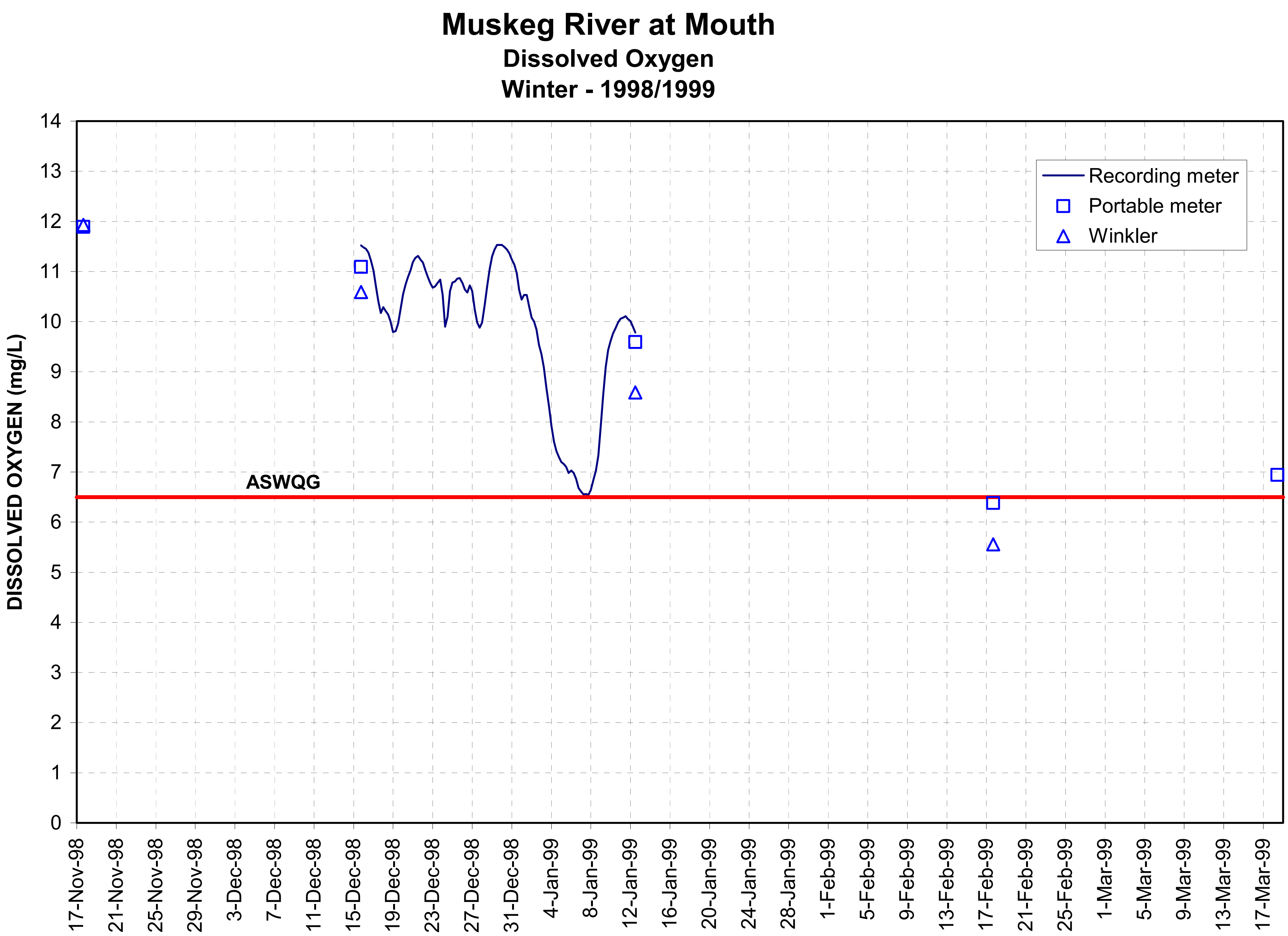
26-Sep-01
1-Oct-01
6-Oct-01
11-Oct-01



Muskeg River at WSC Gauge
Dissolved Oxygen
Autumn 2001
DISSOLVED OXYGEN (mg/L)
16
14
12
10
8
6
4
2
0
Recording meter
Portable meter
Winkler
16-Oct-01
18-Oct-01
21-Oct-01
23-Oct-01
26-Oct-01
28-Oct-01
31-Oct-01
2-Nov-01
5-Nov-01
7-Nov-01
10-Nov-01
12-Nov-01
15-Nov-01
17-Nov-01
20-Nov-01
22-Nov-01
25-Nov-01
27-Nov-01
30-Nov-01
2-Dec-01
5-Dec-01
7-Dec-01
10-Dec-01
12-Dec-01



Muskeg River at Mouth
Dissolved Oxygen
Winter - 1998/1999
DISSOLVED OXYGEN (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
ASWQG
Recording meter
Portable meter
Winkler
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
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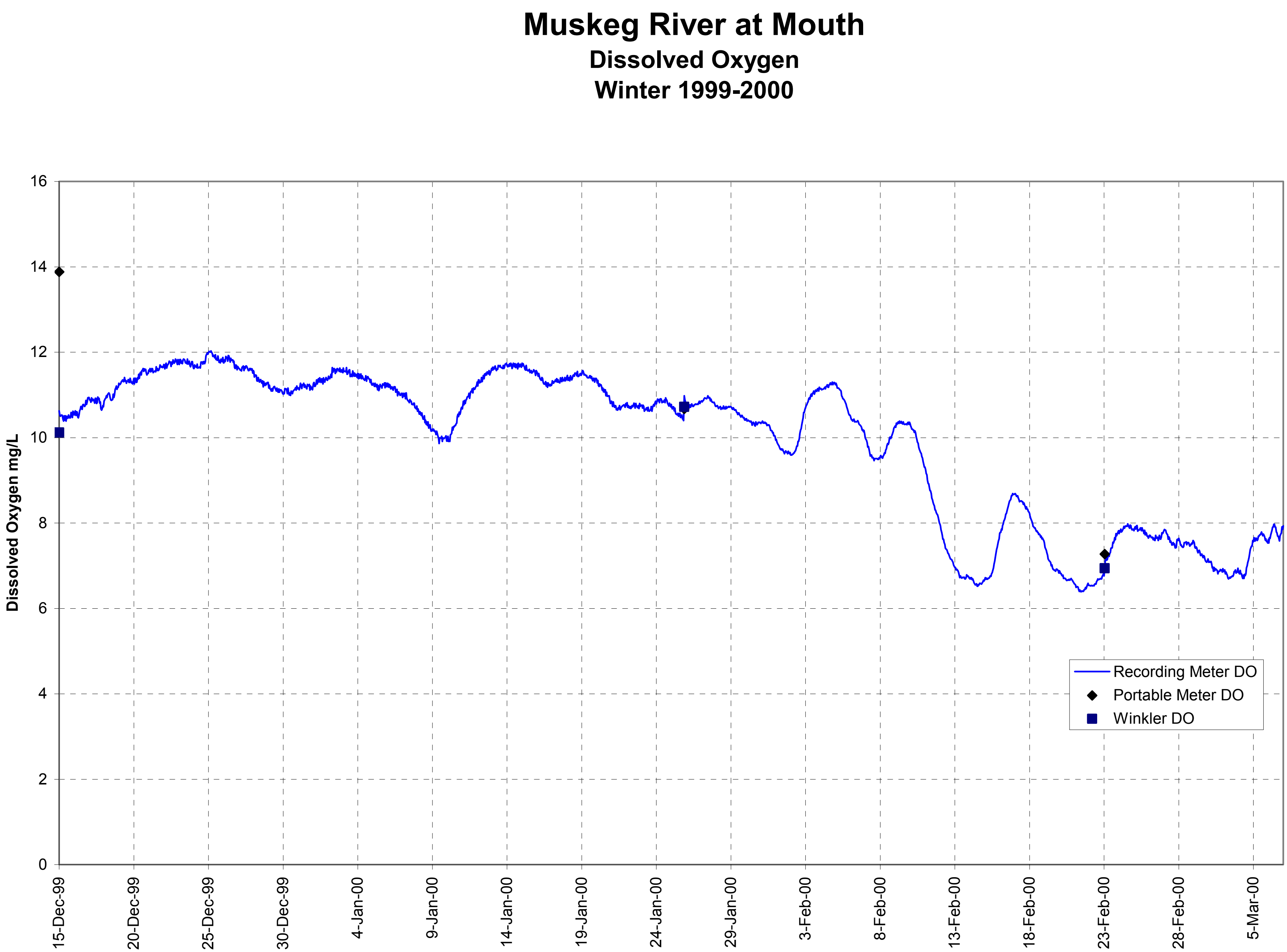
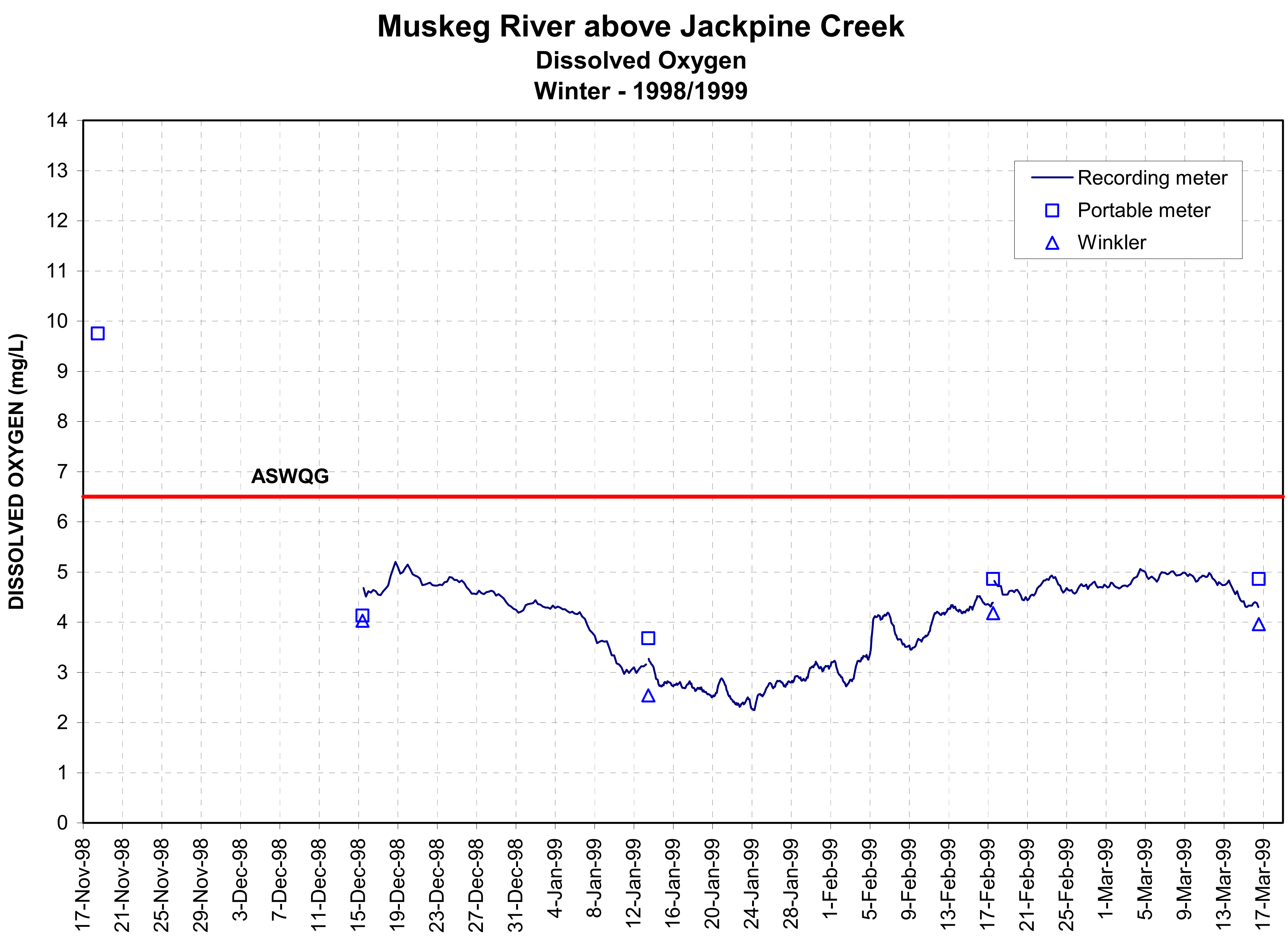
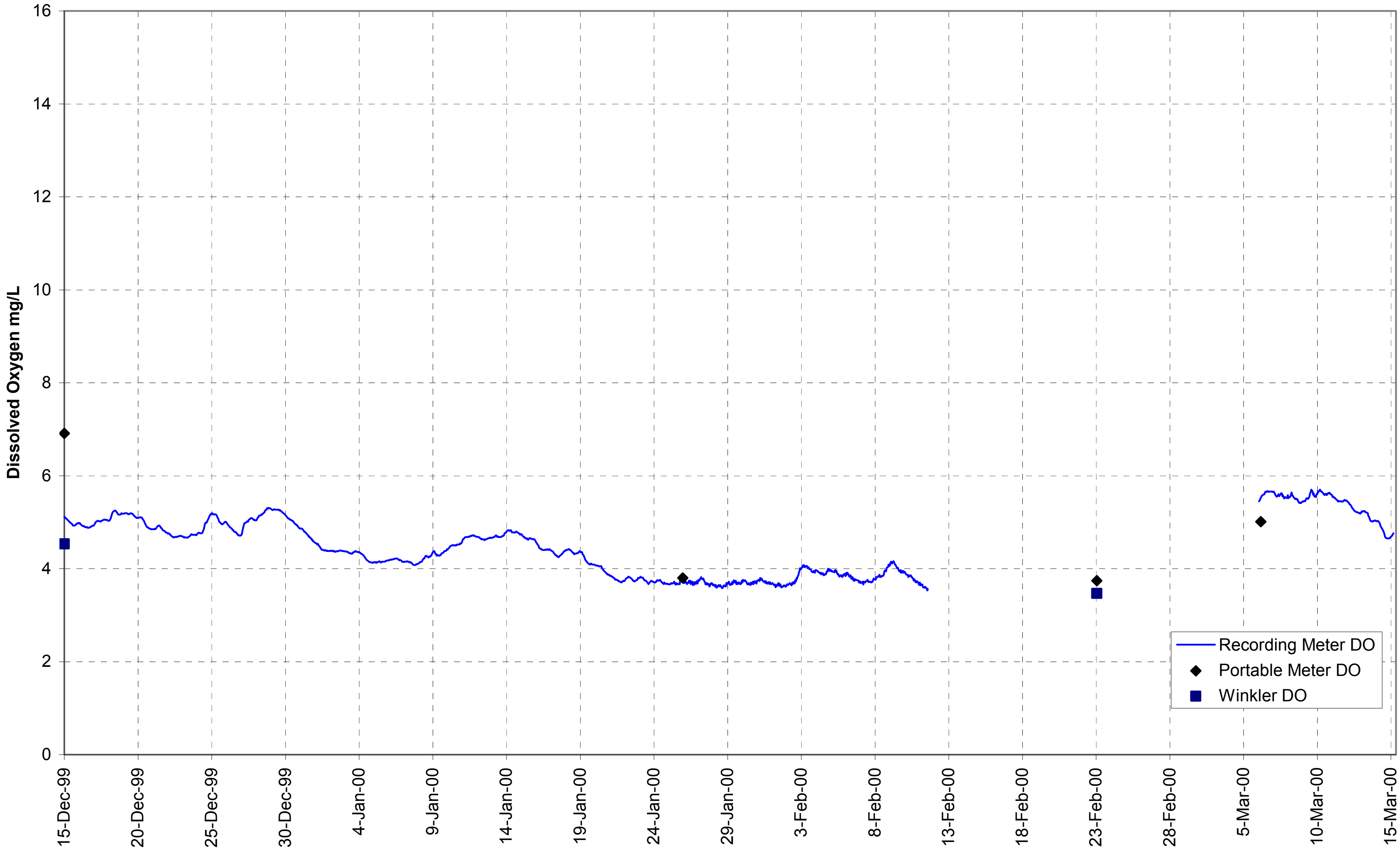
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

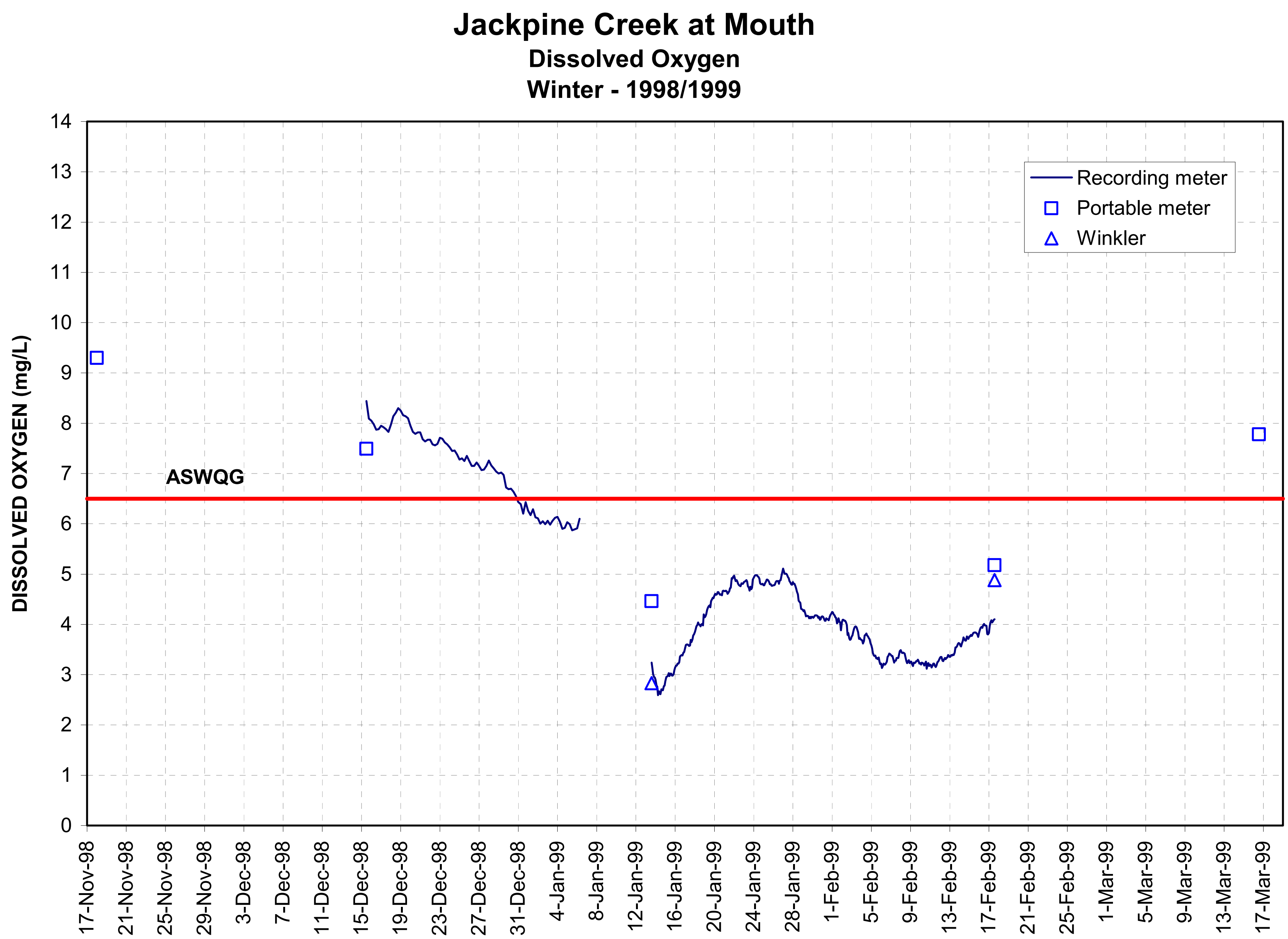


Muskeg River at Mouth
Dissolved Oxygen
Winter 1999-2000
Dissolved Oxygen mg/L
0
2
4
6
8
10
12
14
16
15-Dec-99
20-Dec-99
25-Dec-99
30-Dec-99
4-Jan-00
9-Jan-00
14-Jan-00
19-Jan-00
24-Jan-00
29-Jan-00
3-Feb-00
8-Feb-00
13-Feb-00
18-Feb-00
23-Feb-00
28-Feb-00
5-Mar-00
Recording Meter DO
Portable Meter DO
Winkler DO

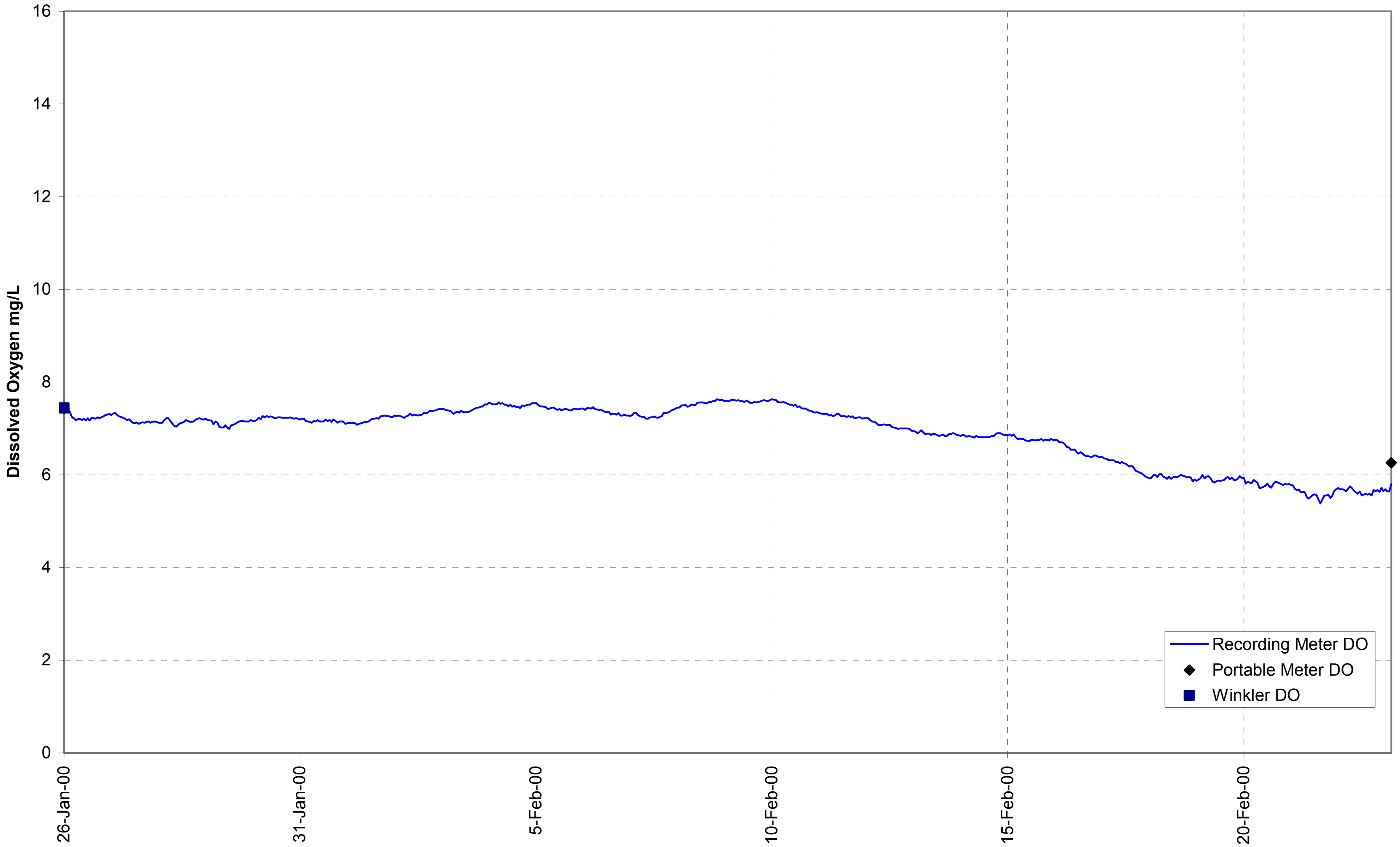

Muskeg River above Jackpine Creek
Dissolved Oxygen
Winter - 1998/1999
DISSOLVED OXYGEN (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
ASWQG
Recording meter
Portable meter
Winkler
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

Muskeg River above Jackpine Creek
Dissolved Oxygen
Winter 1999-2000

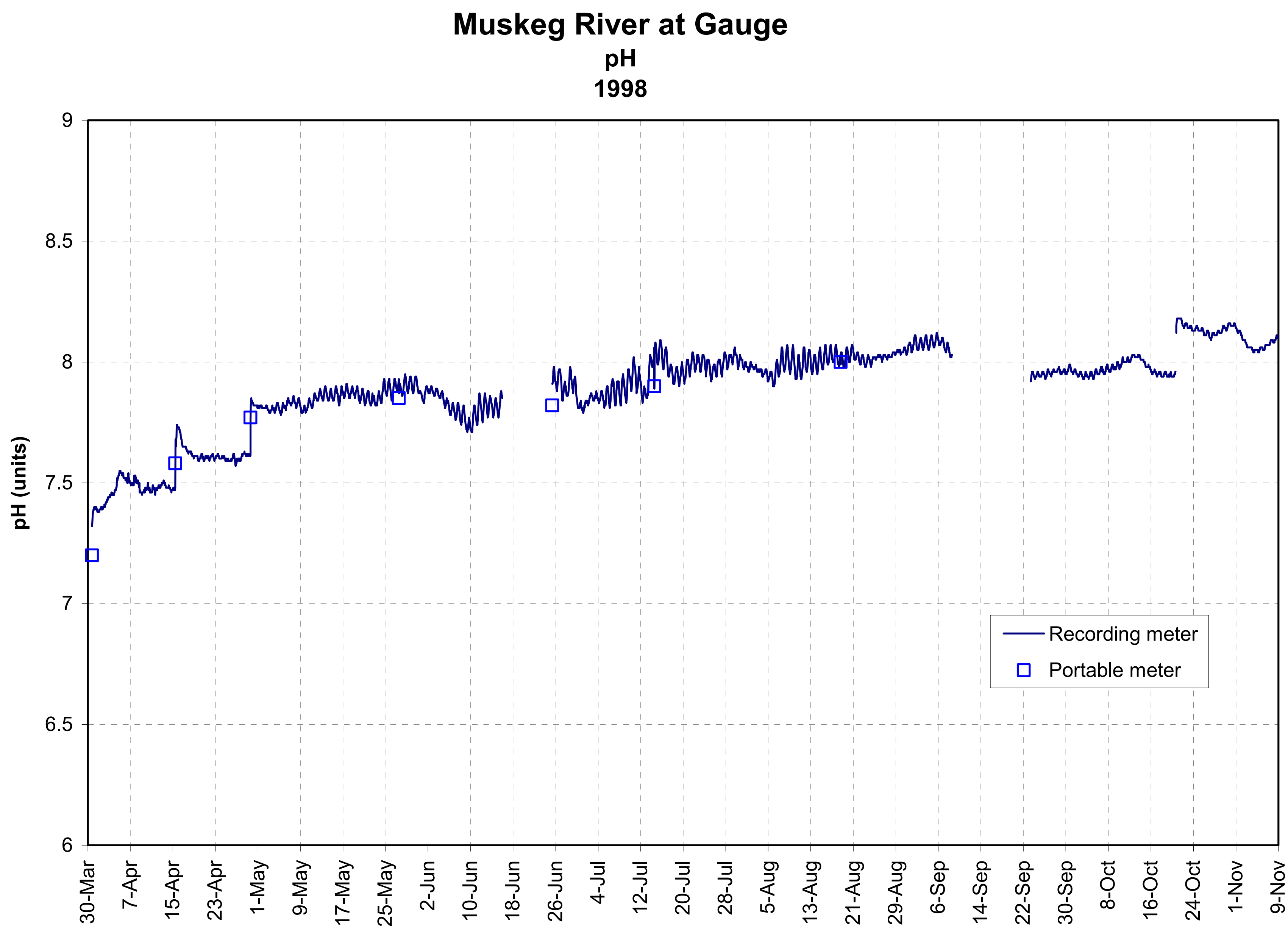


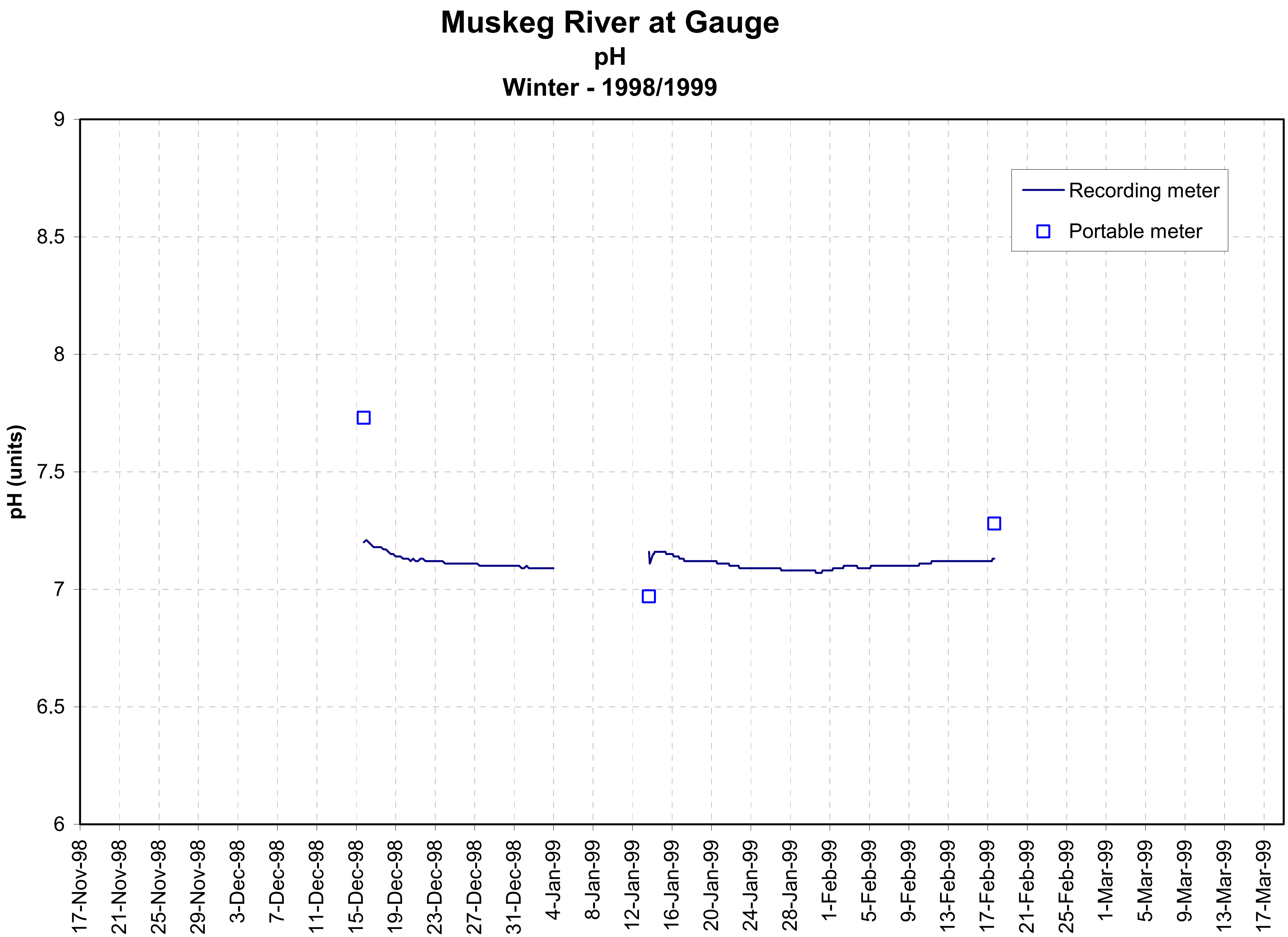

Jackpine Creek at Mouth
Dissolved Oxygen
Winter - 1998/1999
DISSOLVED OXYGEN (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
ASWQG
Recording meter
Portable meter
Winkler
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

Jackpine Creek at Mouth
Dissolved Oxygen
Winter 1999-2000



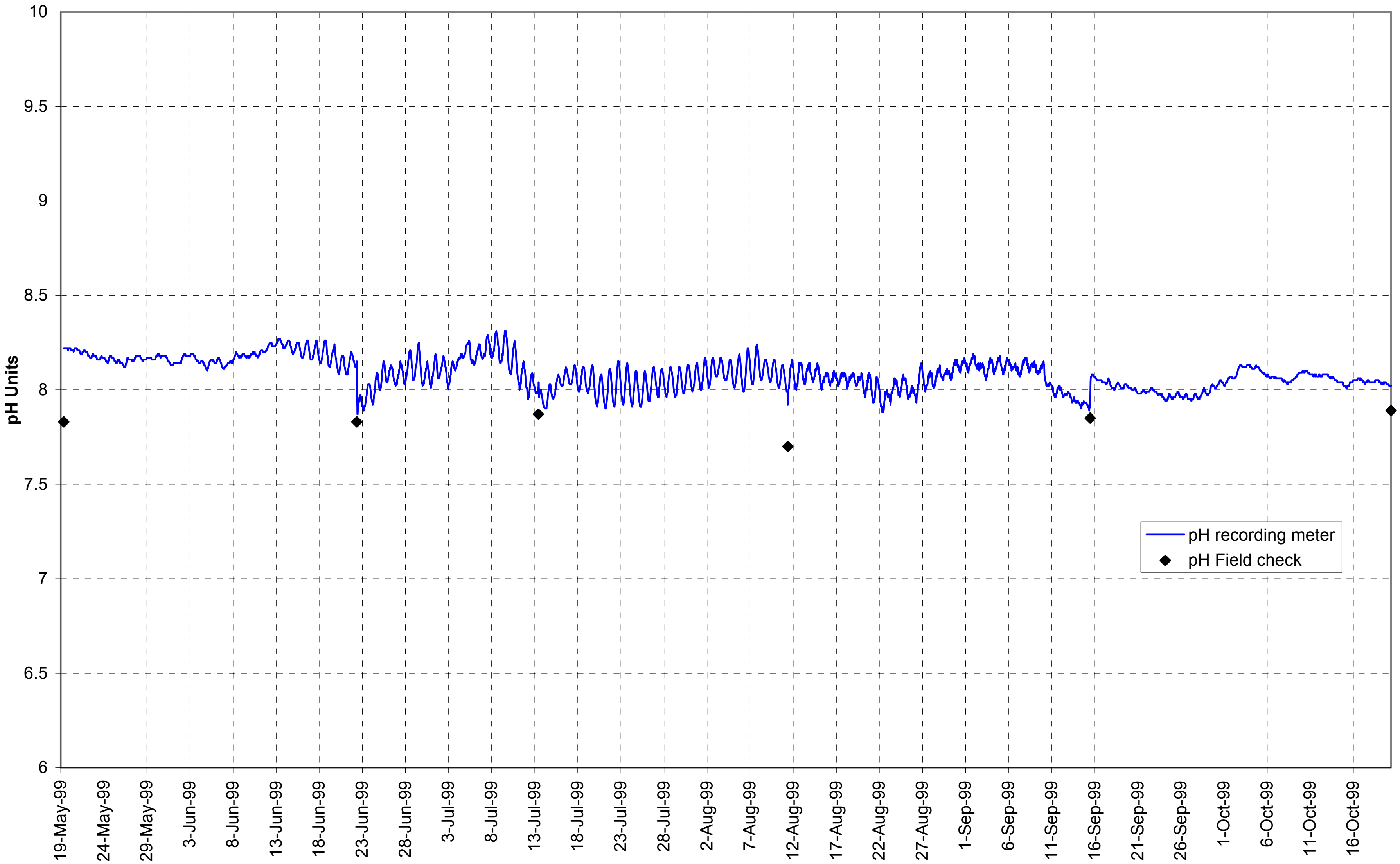
Appendix 7. pH recordings (hourly) and spot checks (portable meter), Muskeg River basin sites, open-water seasons, 1998-2001

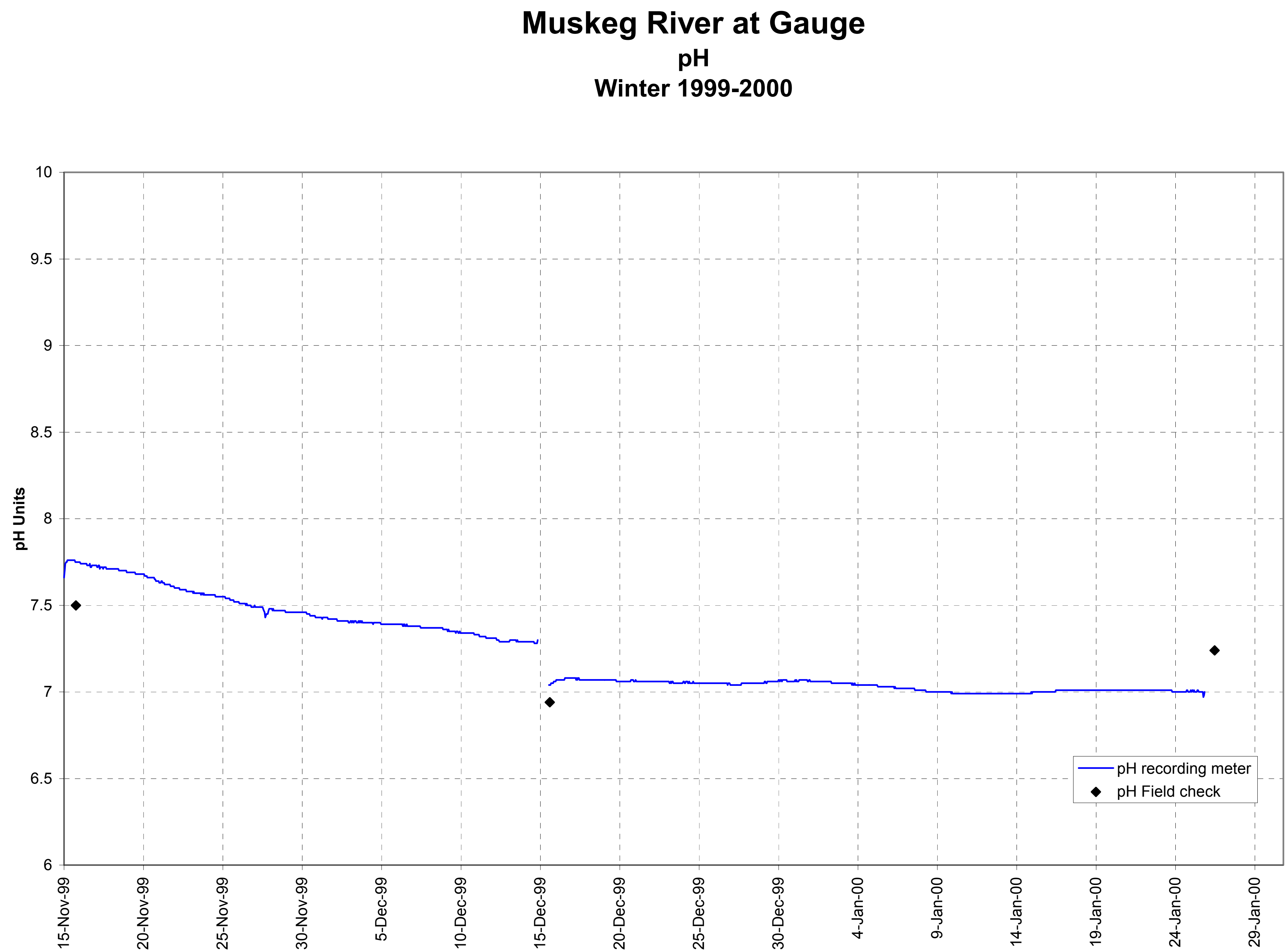

Muskeg River at Gauge
pH
1998
pH (units)
9
8.5
8
7.5
7
6.5
6
30-Mar
7-Apr
15-Apr
23-Apr
1-May
9-May
17-May
25-May
2-Jun
10-Jun
18-Jun
26-Jun
4-Jul
12-Jul
20-Jul
28-Jul
5-Aug
13-Aug
21-Aug
29-Aug
6-Sep
14-Sep
22-Sep
30-Sep
8-Oct
16-Oct
24-Oct
1-Nov
9-Nov
Recording meter
Portable meter



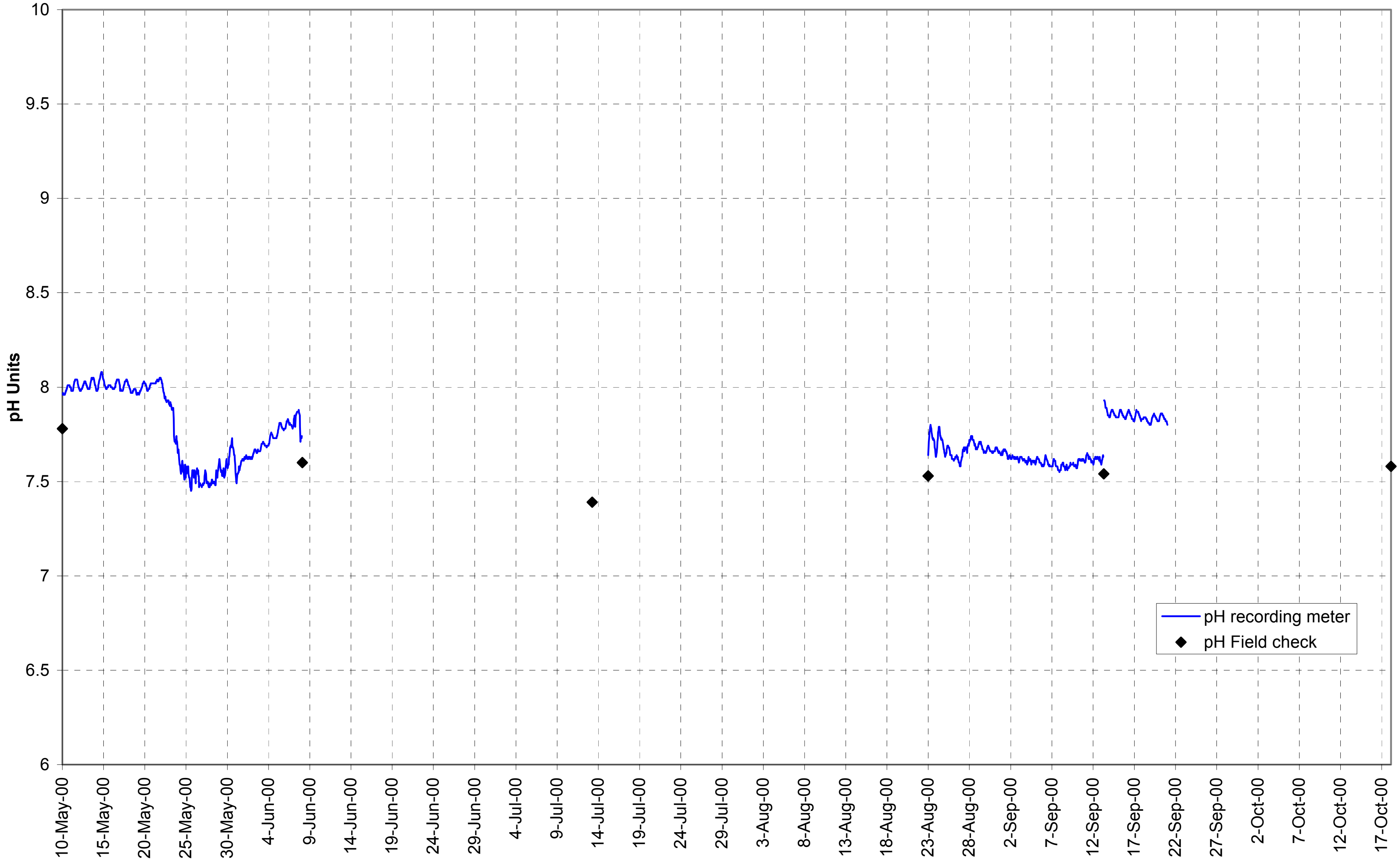
Muskeg River at Gauge
pH
Winter - 1998/1999
pH (units)
9
8.5
8
7.5
7
6.5
6
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

Muskeg River at Gauge
pH
May-Oct 1999

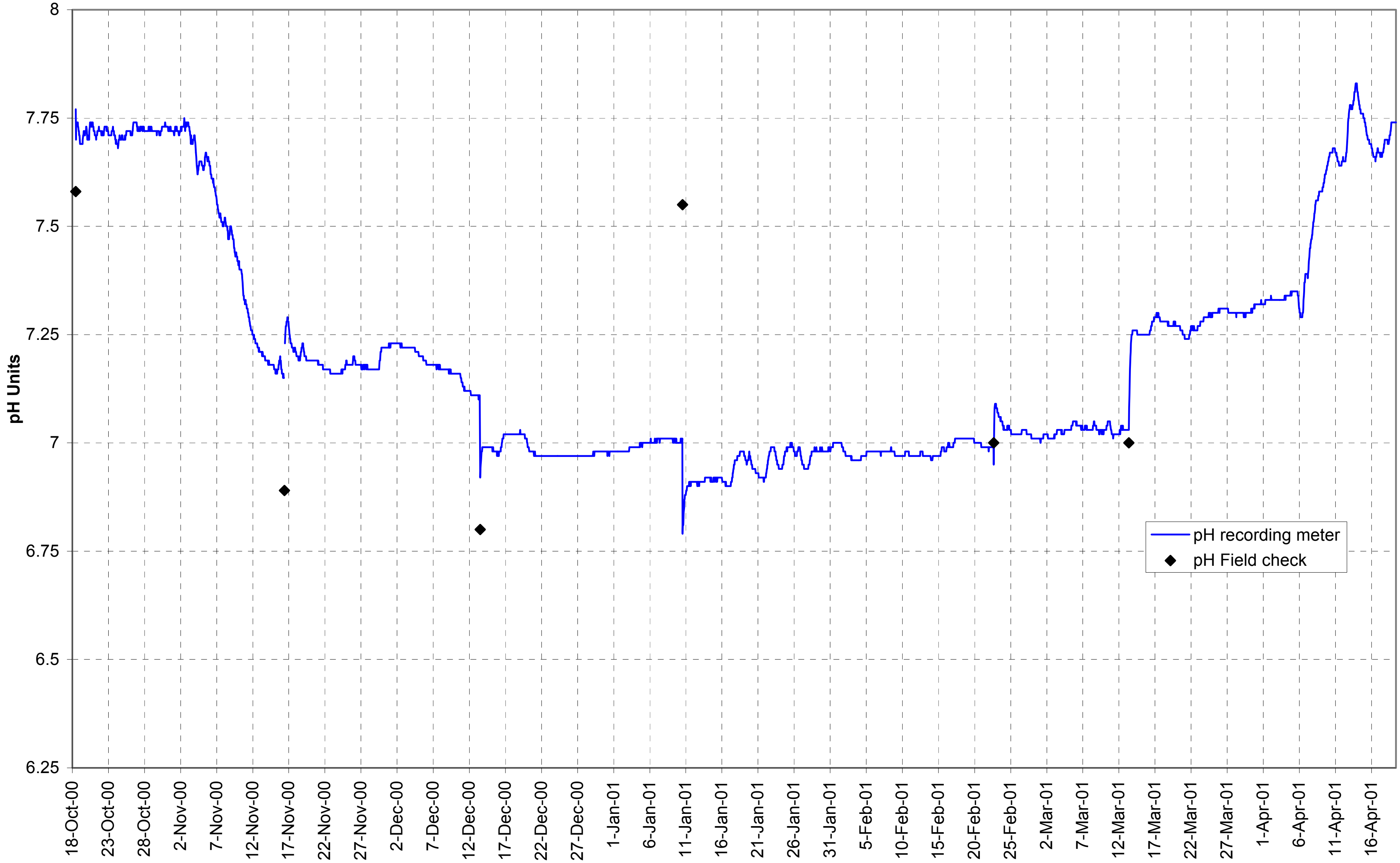


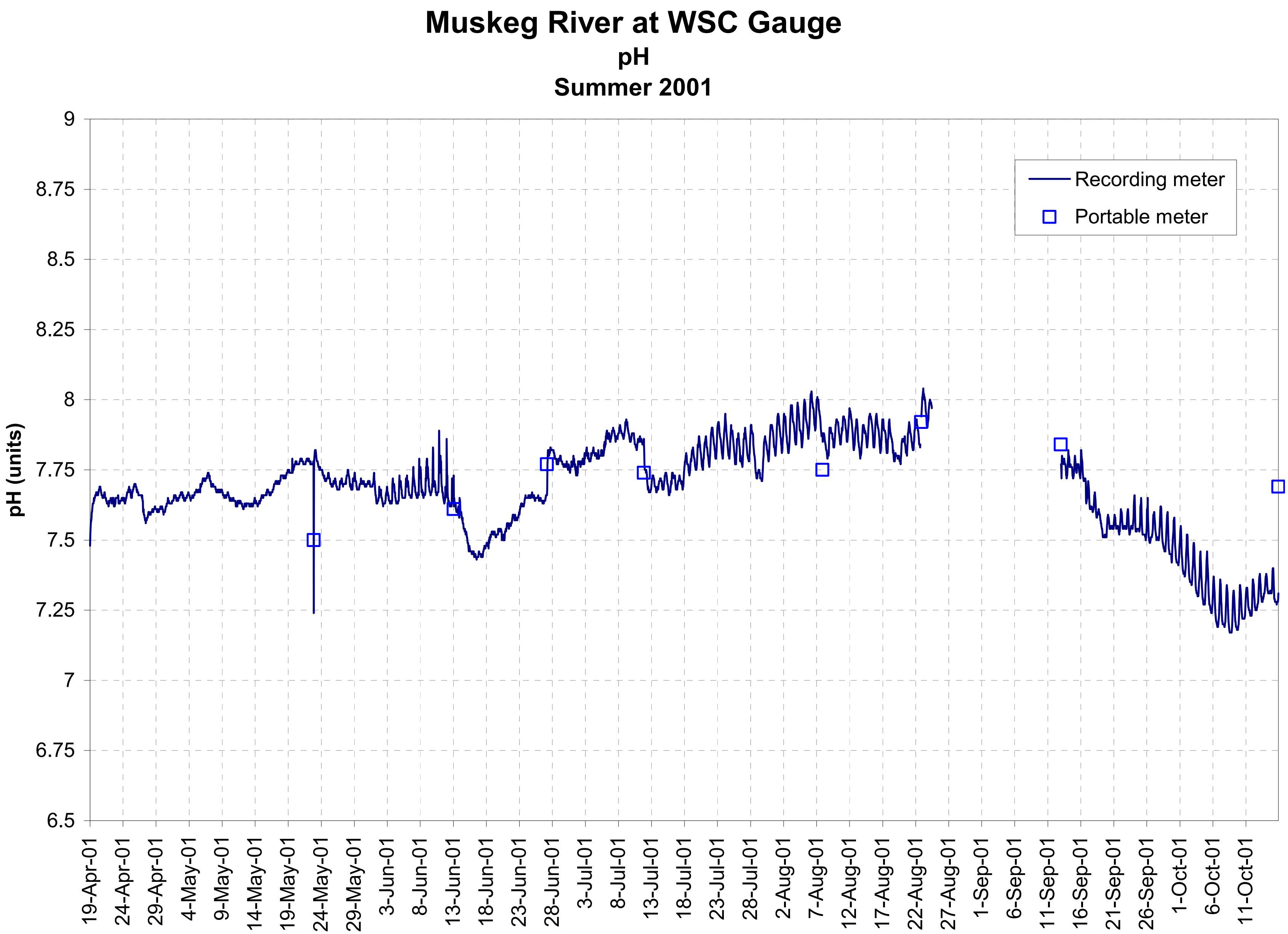

Muskeg River at Gauge
pH
Winter 1999-2000
pH Units
10
9.5
9
8.5
8
7.5
7
6.5
6
15-Nov-99
20-Nov-99
25-Nov-99
30-Nov-99
5-Dec-99
10-Dec-99
15-Dec-99
20-Dec-99
25-Dec-99
30-Dec-99
4-Jan-00
9-Jan-00
14-Jan-00
19-Jan-00
24-Jan-00
29-Jan-00
pH recording meter
pH Field check

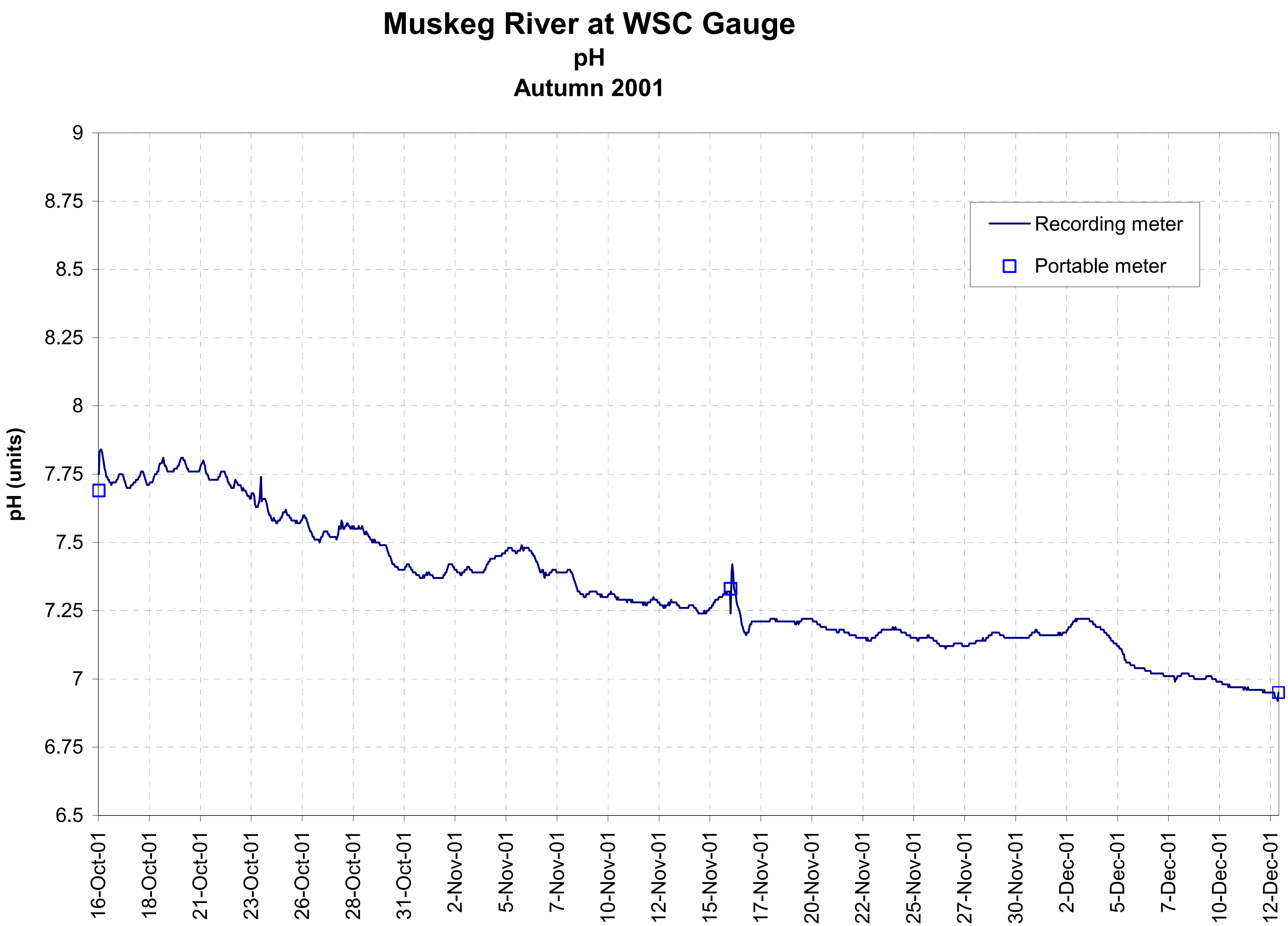
Muskeg River at WSC Gauge
pH
May-Oct 2000

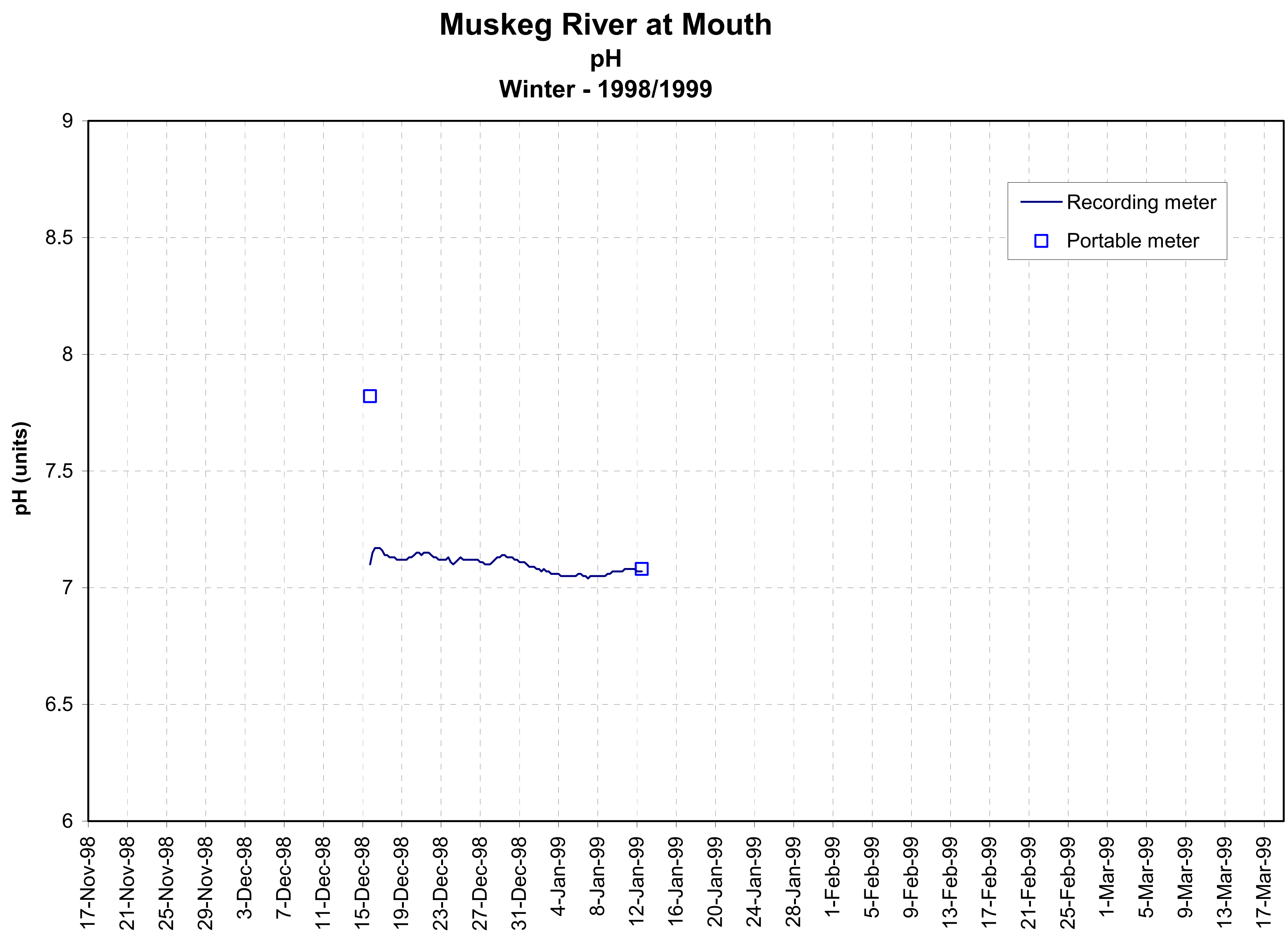


Muskeg River at Gauge
pH
Winter 2000-2001



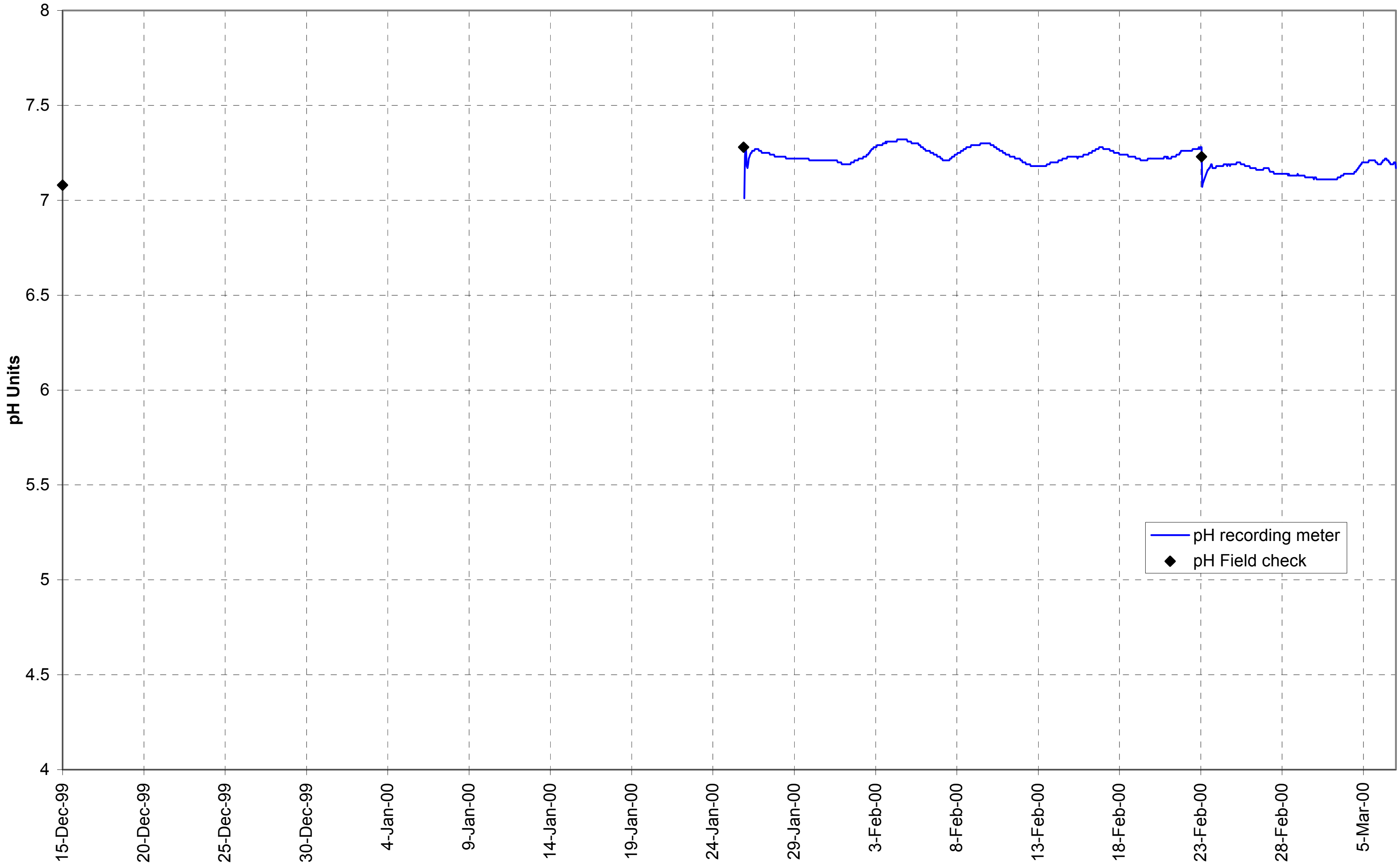

Muskeg River at WSC Gauge
pH
Summer 2001
pH (units)
9
8.75
8.5
8.25
8
7.75
7.5
7.25
7
6.75
6.5
Recording meter
Portable meter
19-Apr-01
24-Apr-01
29-Apr-01
4-May-01
9-May-01
14-May-01
19-May-01
24-May-01
29-May-01
3-Jun-01
8-Jun-01
13-Jun-01
18-Jun-01
23-Jun-01
28-Jun-01
3-Jul-01
8-Jul-01
13-Jul-01
18-Jul-01
23-Jul-01
28-Jul-01
2-Aug-01
7-Aug-01
12-Aug-01
17-Aug-01
22-Aug-01
27-Aug-01
1-Sep-01
6-Sep-01
11-Sep-01
16-Sep-01
21-Sep-01
26-Sep-01
1-Oct-01
6-Oct-01
11-Oct-01

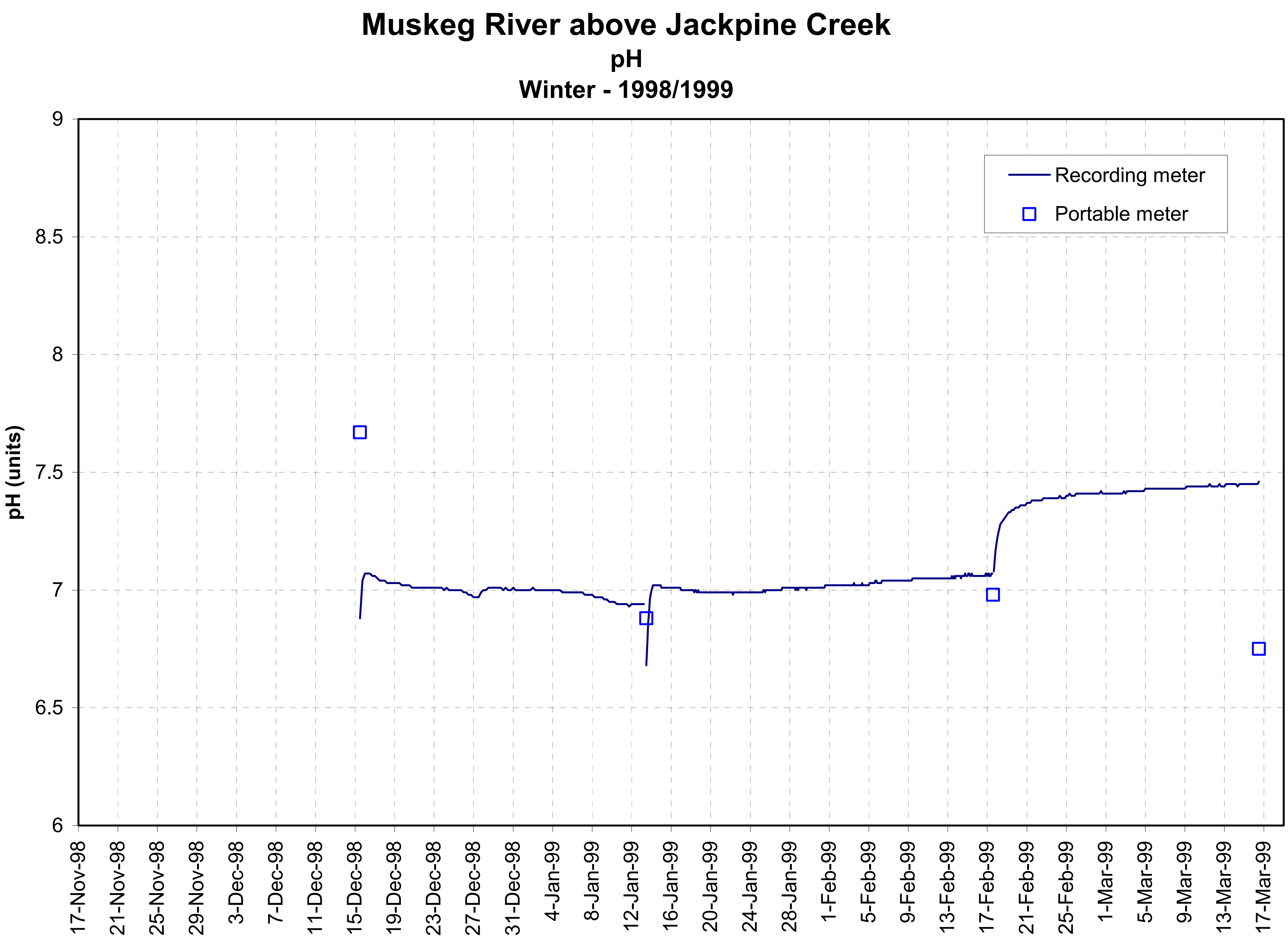

Muskeg River at WSC Gauge
pH
Autumn 2001
pH (units)
9
8.75
8.5
8.25
8
7.75
7.5
7.25
7
6.75
6.5
Recording meter
Portable meter
16-Oct-01
18-Oct-01
21-Oct-01
23-Oct-01
26-Oct-01
28-Oct-01
31-Oct-01
2-Nov-01
5-Nov-01
7-Nov-01
10-Nov-01
12-Nov-01
15-Nov-01
17-Nov-01
20-Nov-01
22-Nov-01
25-Nov-01
27-Nov-01
30-Nov-01
2-Dec-01
5-Dec-01
7-Dec-01
10-Dec-01
12-Dec-01



Muskeg River at Mouth
pH
Winter - 1998/1999
pH (units)
9
8.5
8
7.5
7
6.5
6
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

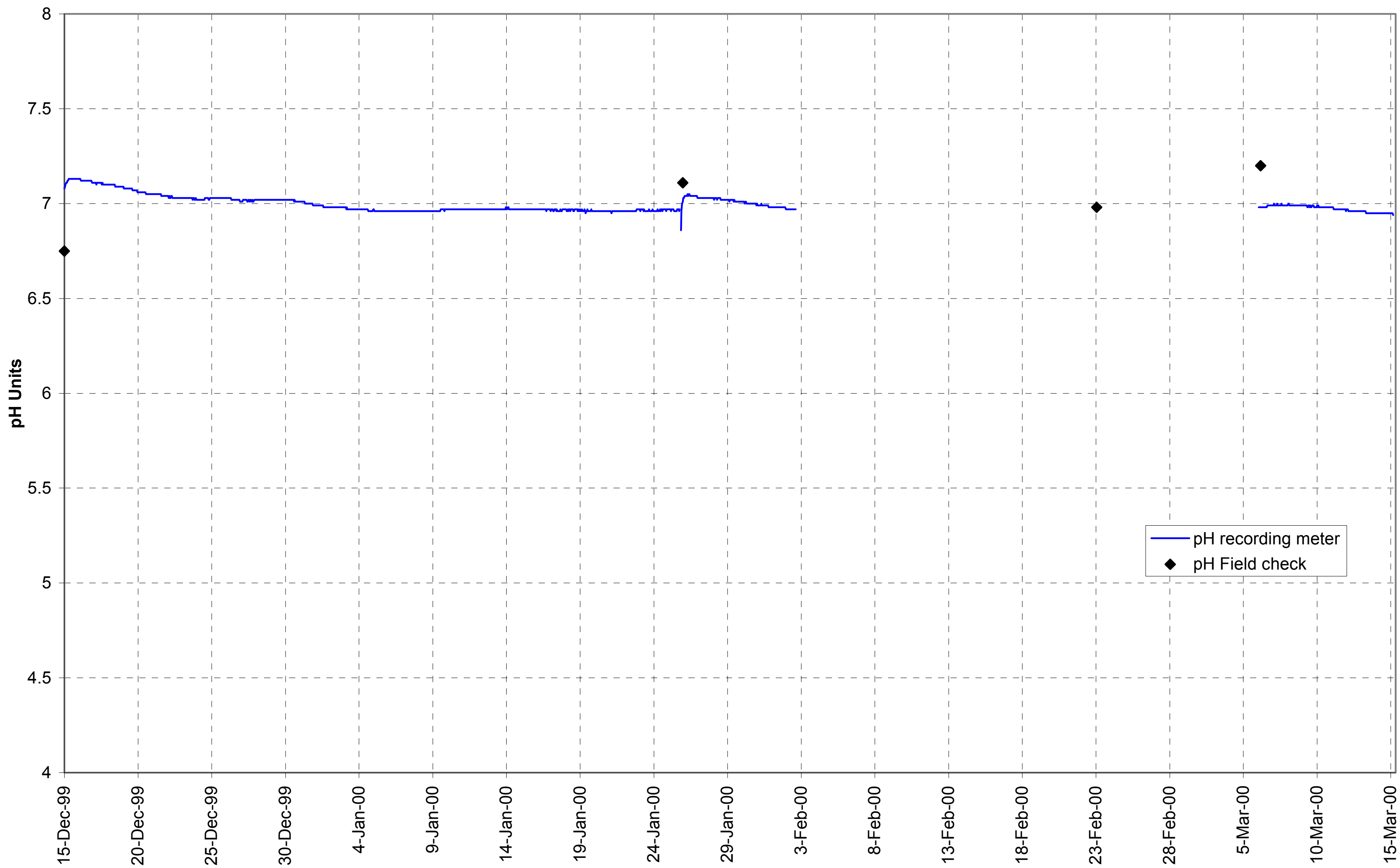
Muskeg River at Mouth
pH
Winter 1999-2000

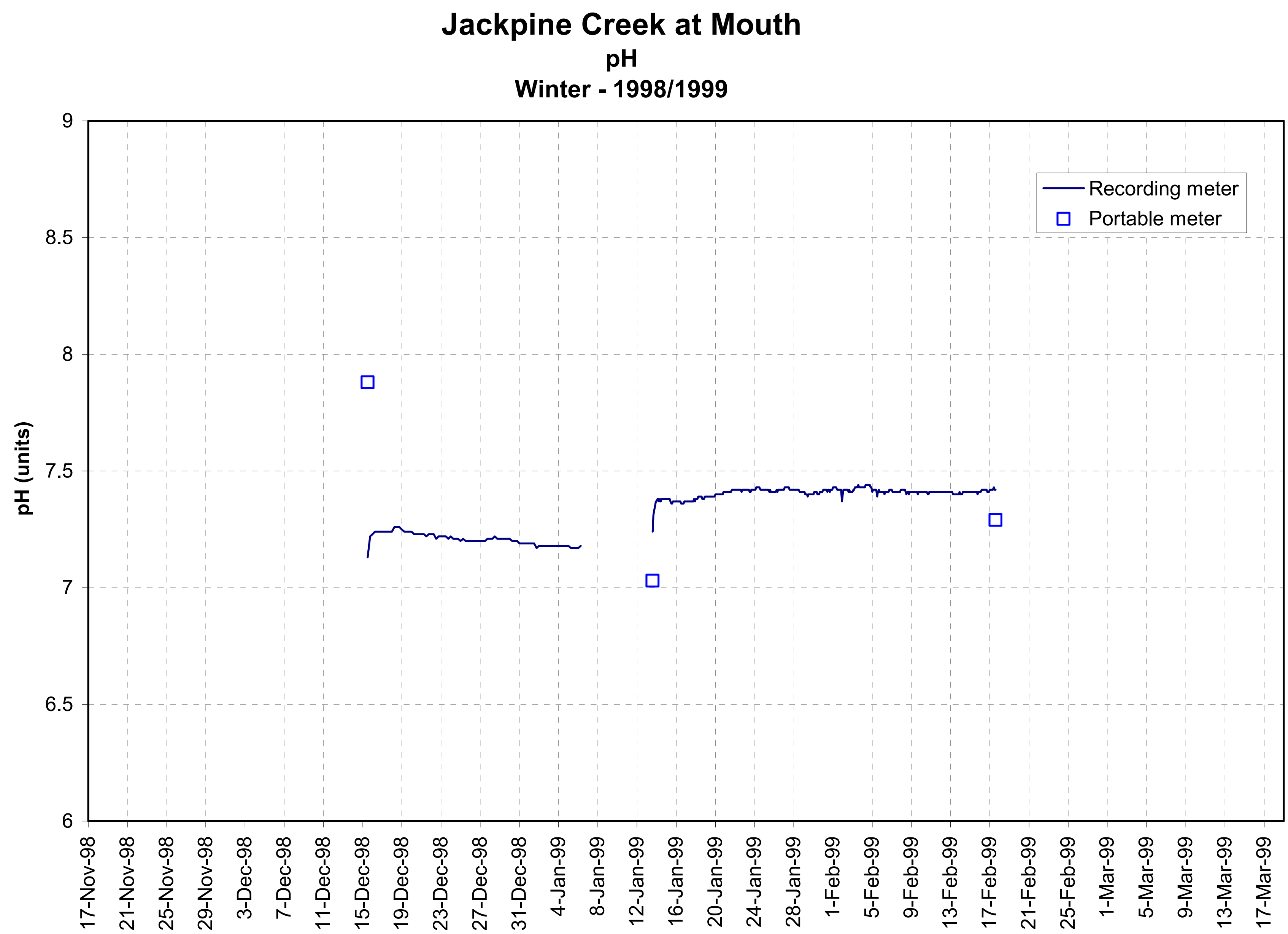




Muskeg River above Jackpine Creek
pH
Winter - 1998/1999
pH (units)
9
8.5
8
7.5
7
6.5
6
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

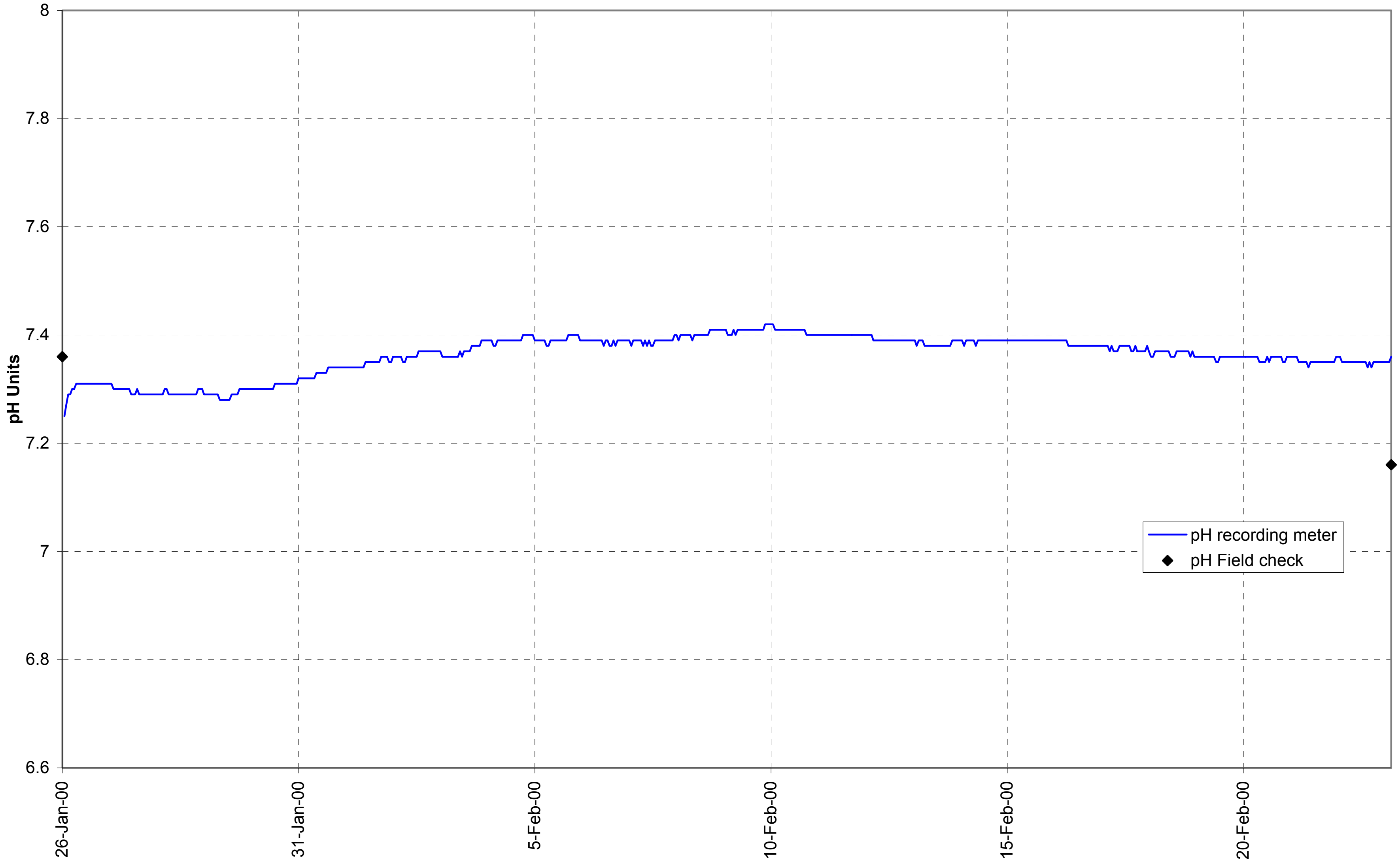
Muskeg River above Jackpine Creek
pH
Winter 1999-2000





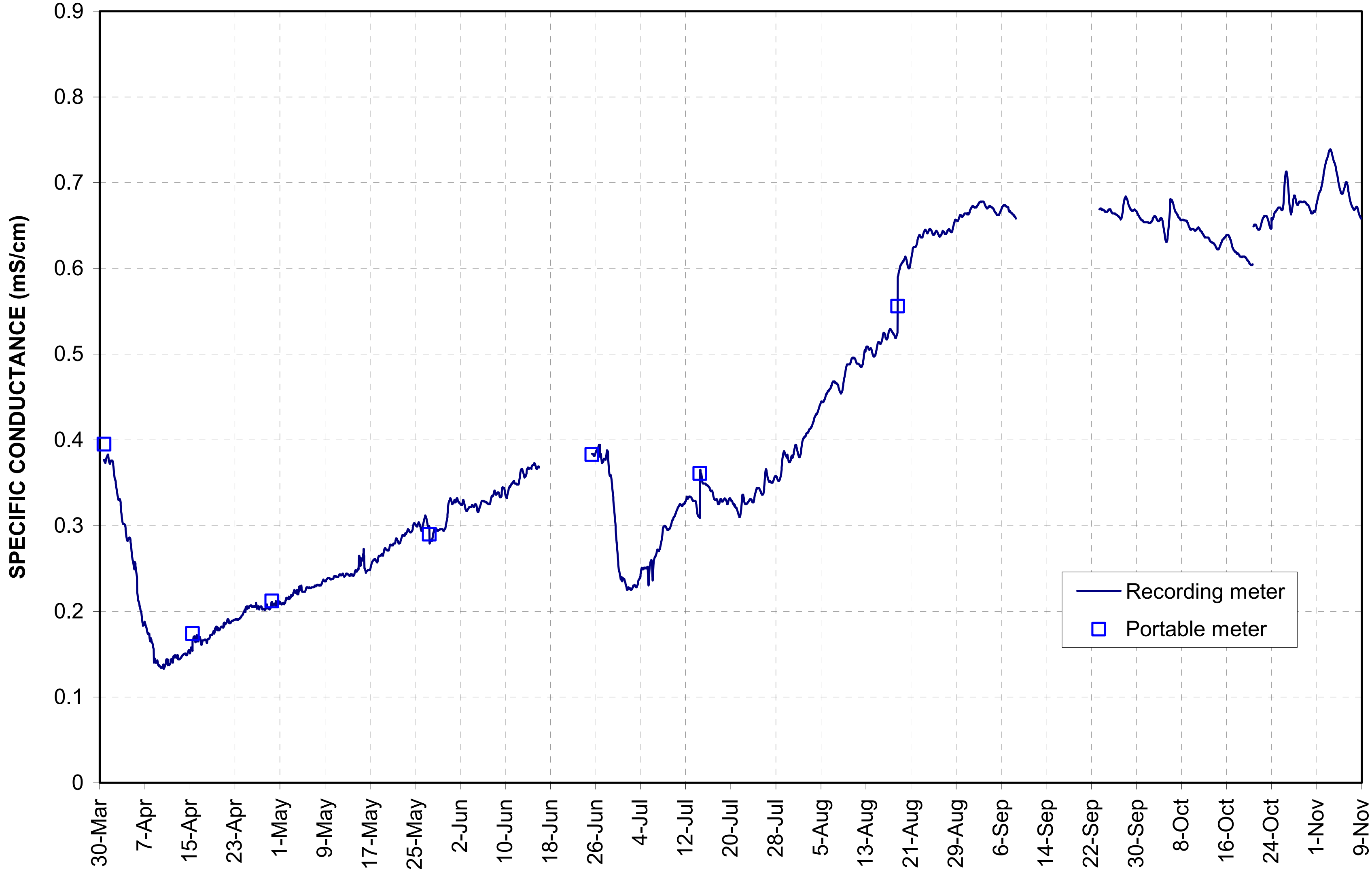
Jackpine Creek at Mouth
pH
Winter - 1998/1999
pH (units)
9
8.5
8
7.5
7
6.5
6
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

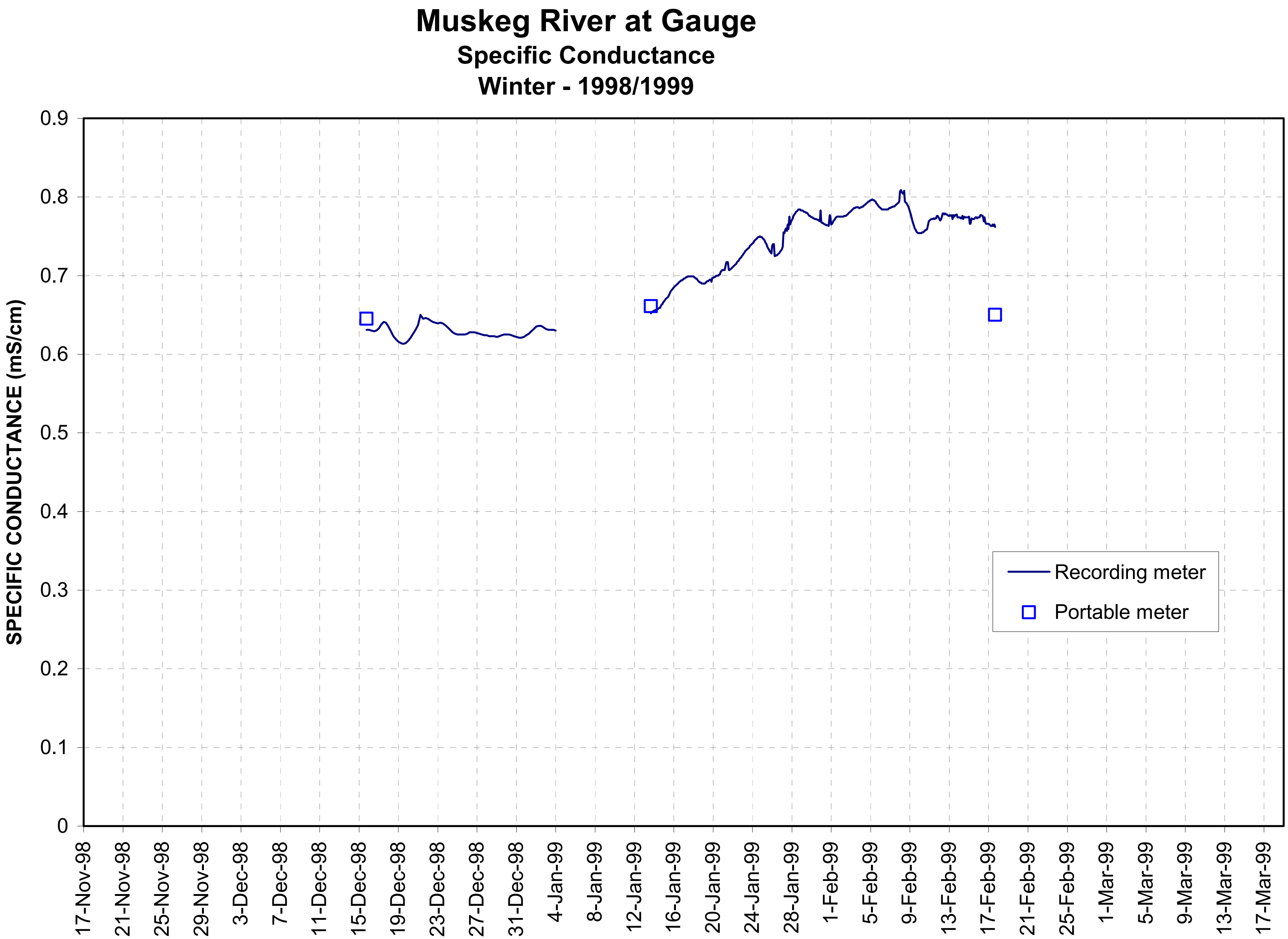
Jackpine Creek at Mouth
pH
Winter 1999-2000



Appendix 8. Specific conductance recordings (hourly) and spot checks (portable meter), Muskeg River basin sites, open-water seasons, 1998-2001

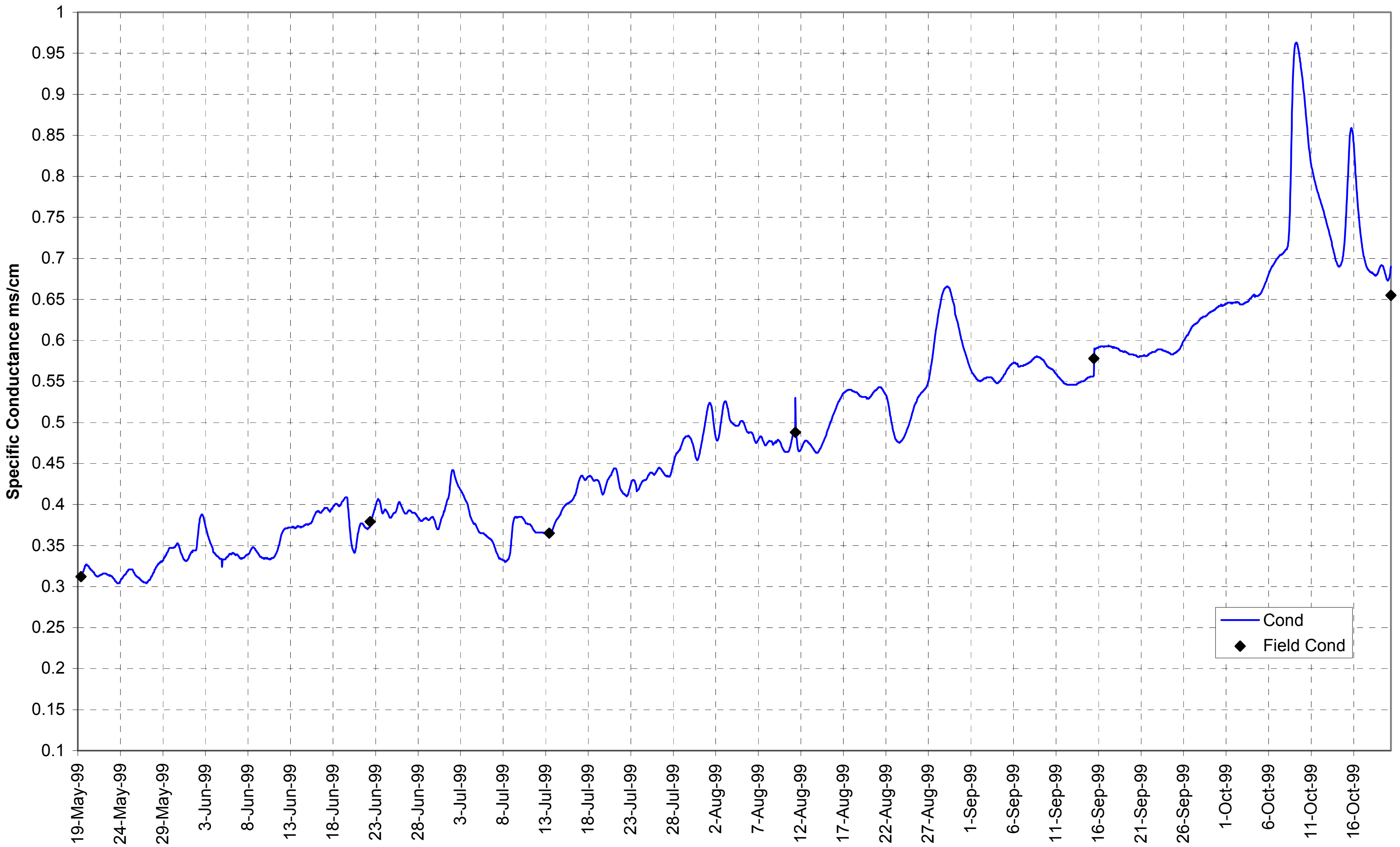
Muskeg River at Gauge
Specific Conductance
1998

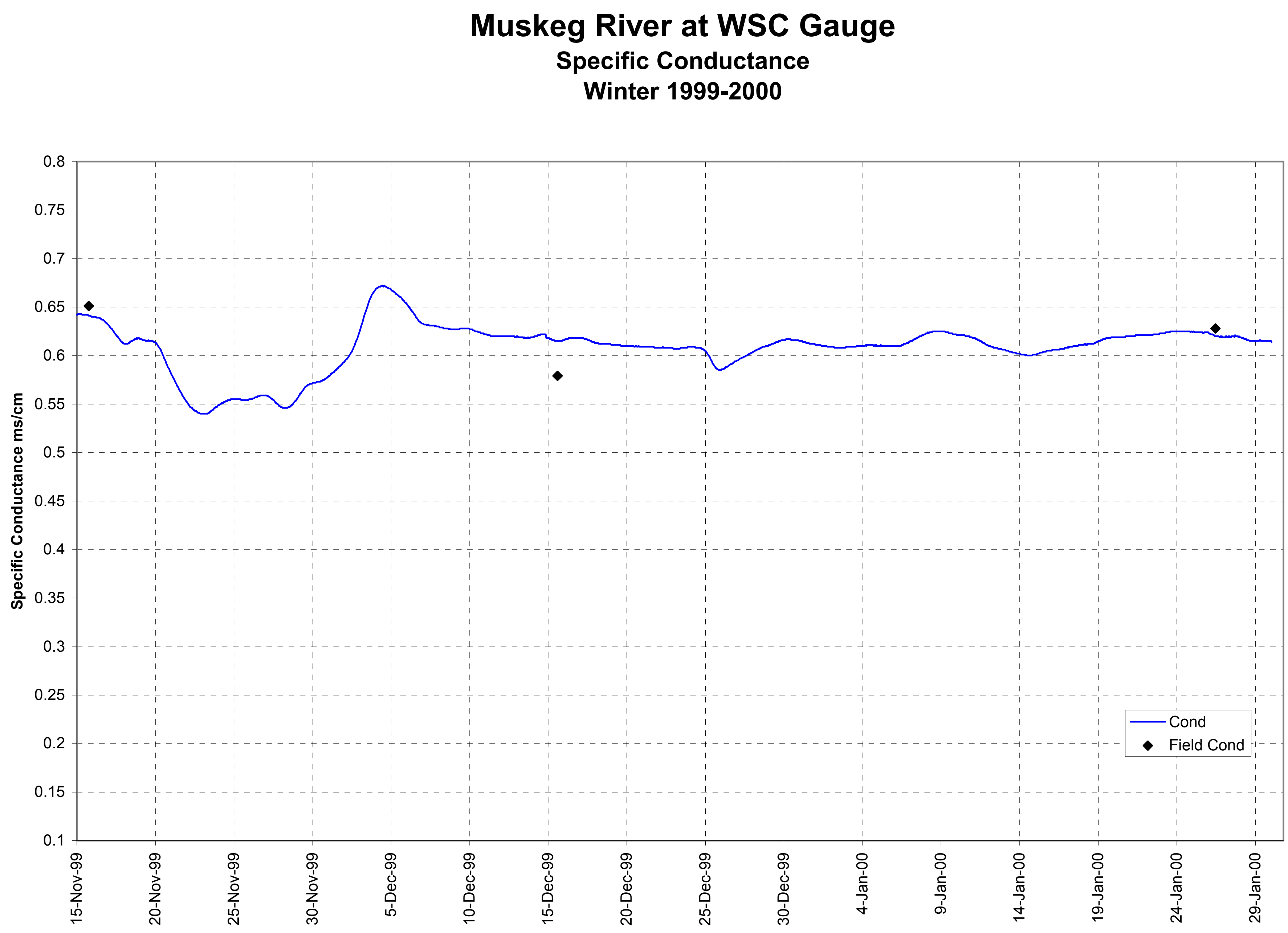




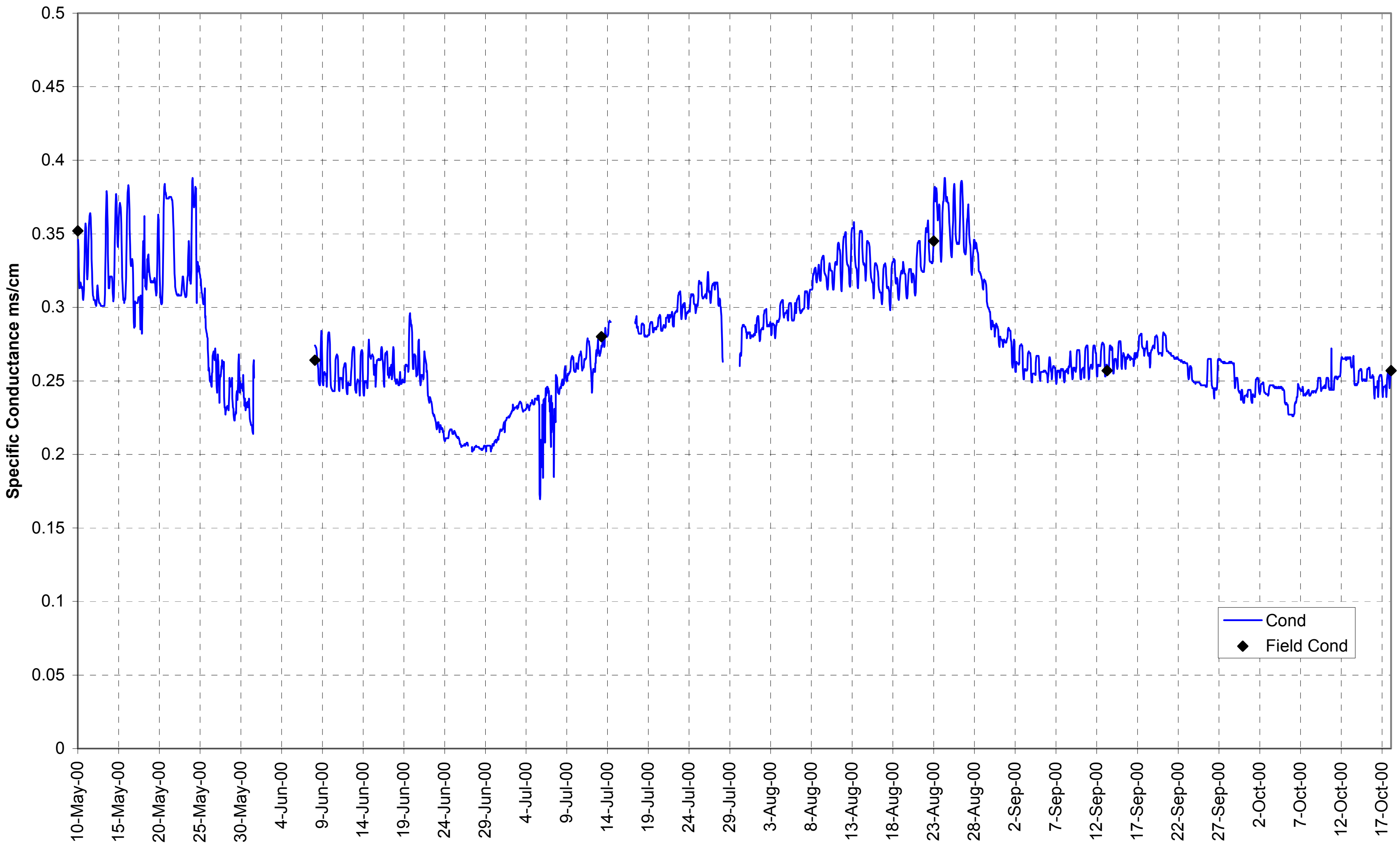
Muskeg River at Gauge
Specific Conductance
Winter - 1998/1999
SPECIFIC CONDUCTANCE (mS/cm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99
Recording meter
Portable meter

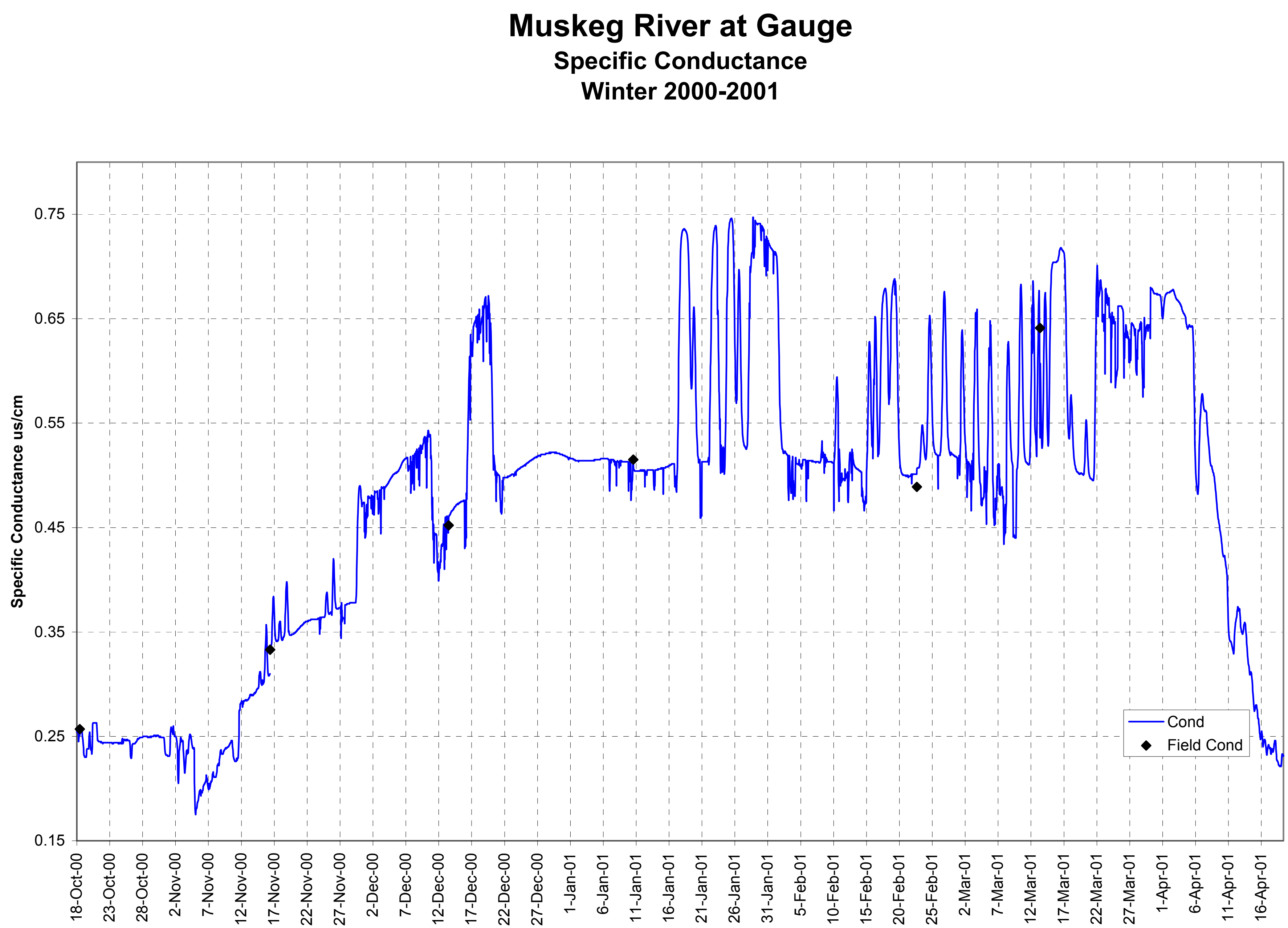
Muskeg River at Gauge
Specific Conductance
May-Oct 1999



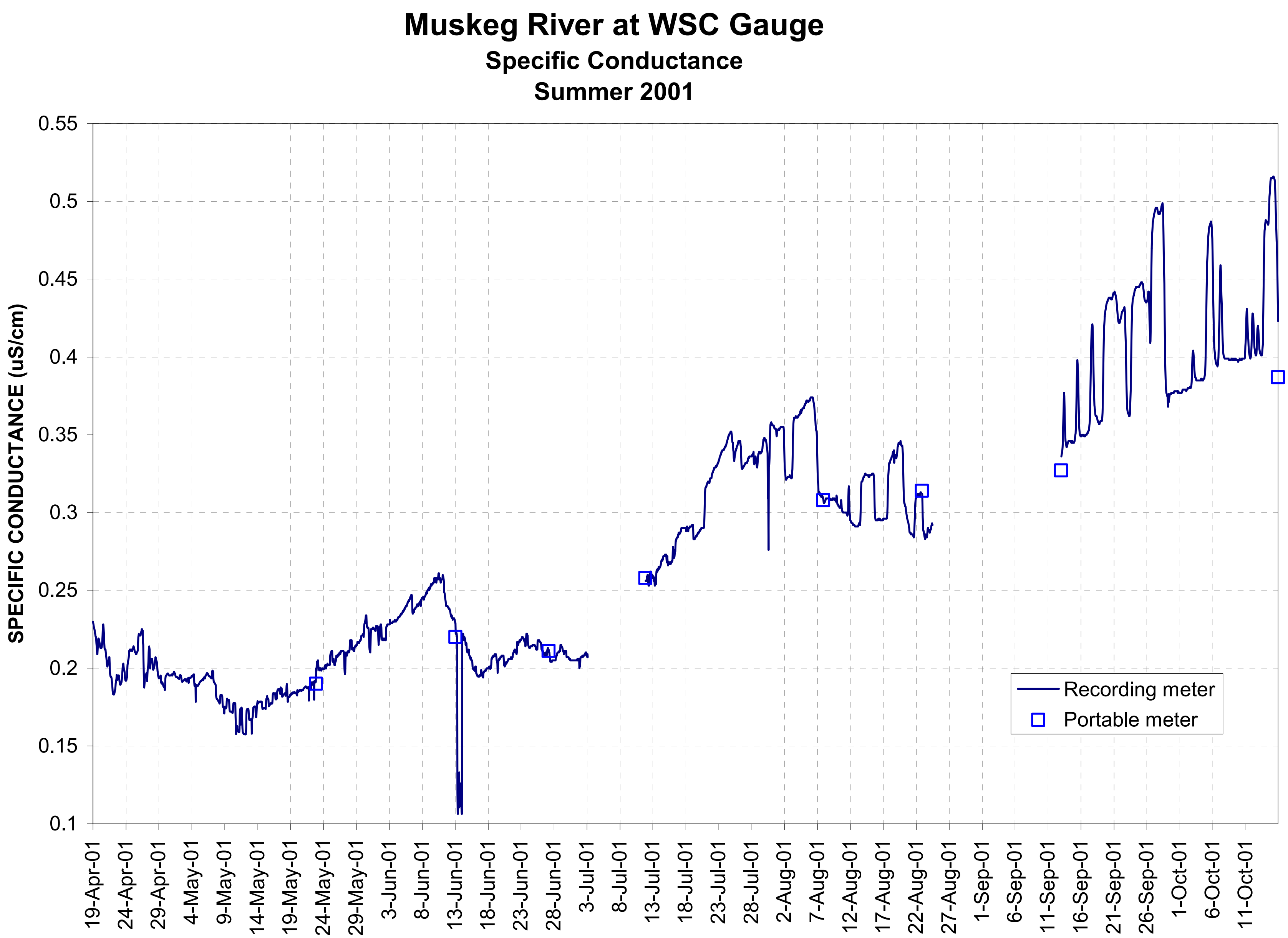

Muskeg River at WSC Gauge
Specific Conductance
Winter 1999-2000
Specific Conductance ms/cm
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
15-Nov-99
20-Nov-99
25-Nov-99
30-Nov-99
5-Dec-99
10-Dec-99
15-Dec-99
20-Dec-99
25-Dec-99
30-Dec-99
4-Jan-00
9-Jan-00
14-Jan-00
19-Jan-00
24-Jan-00
29-Jan-00
Cond
Field Cond

Muskeg River at WSC Gauge
Specific Conductance
May-Oct 2000

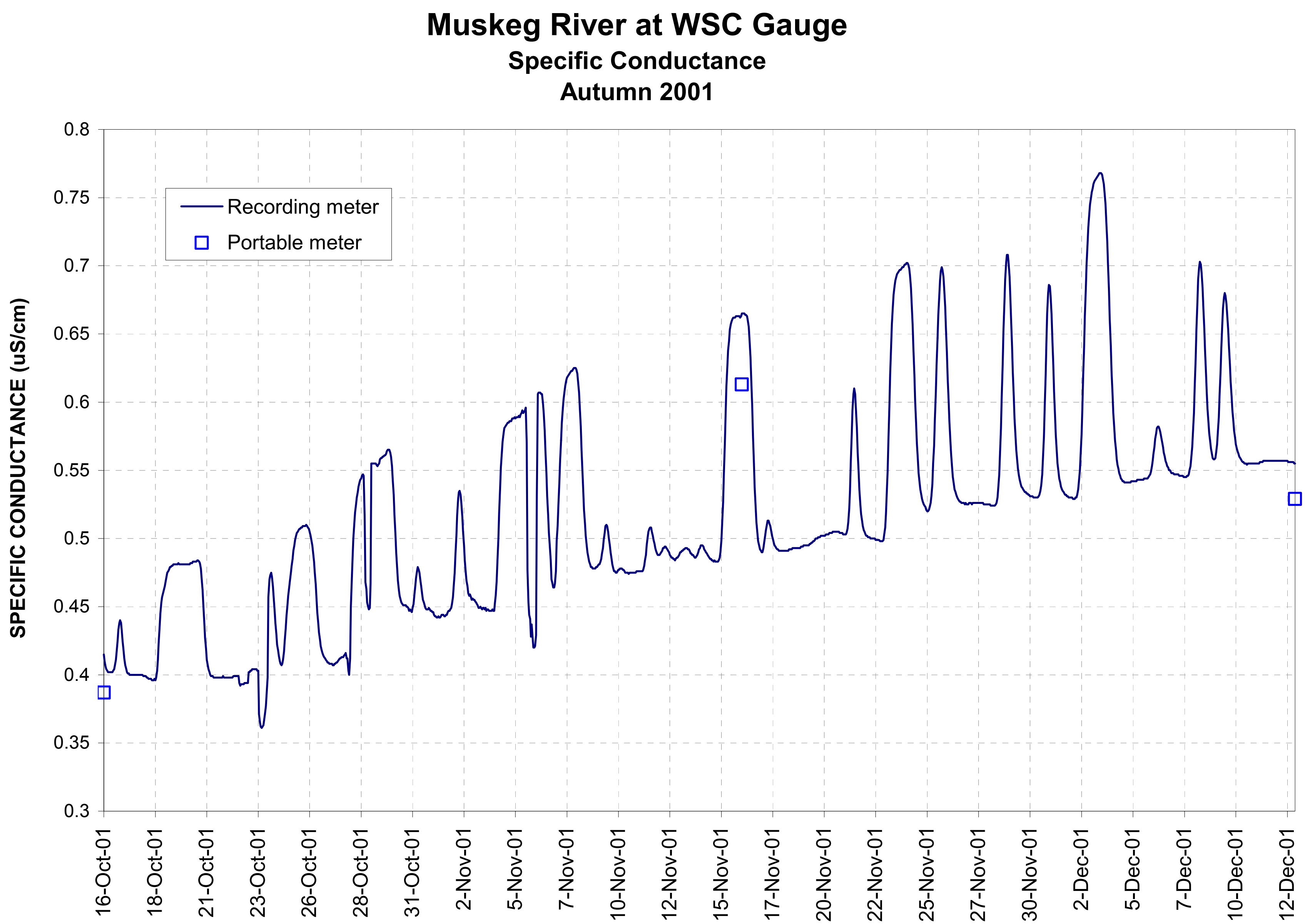




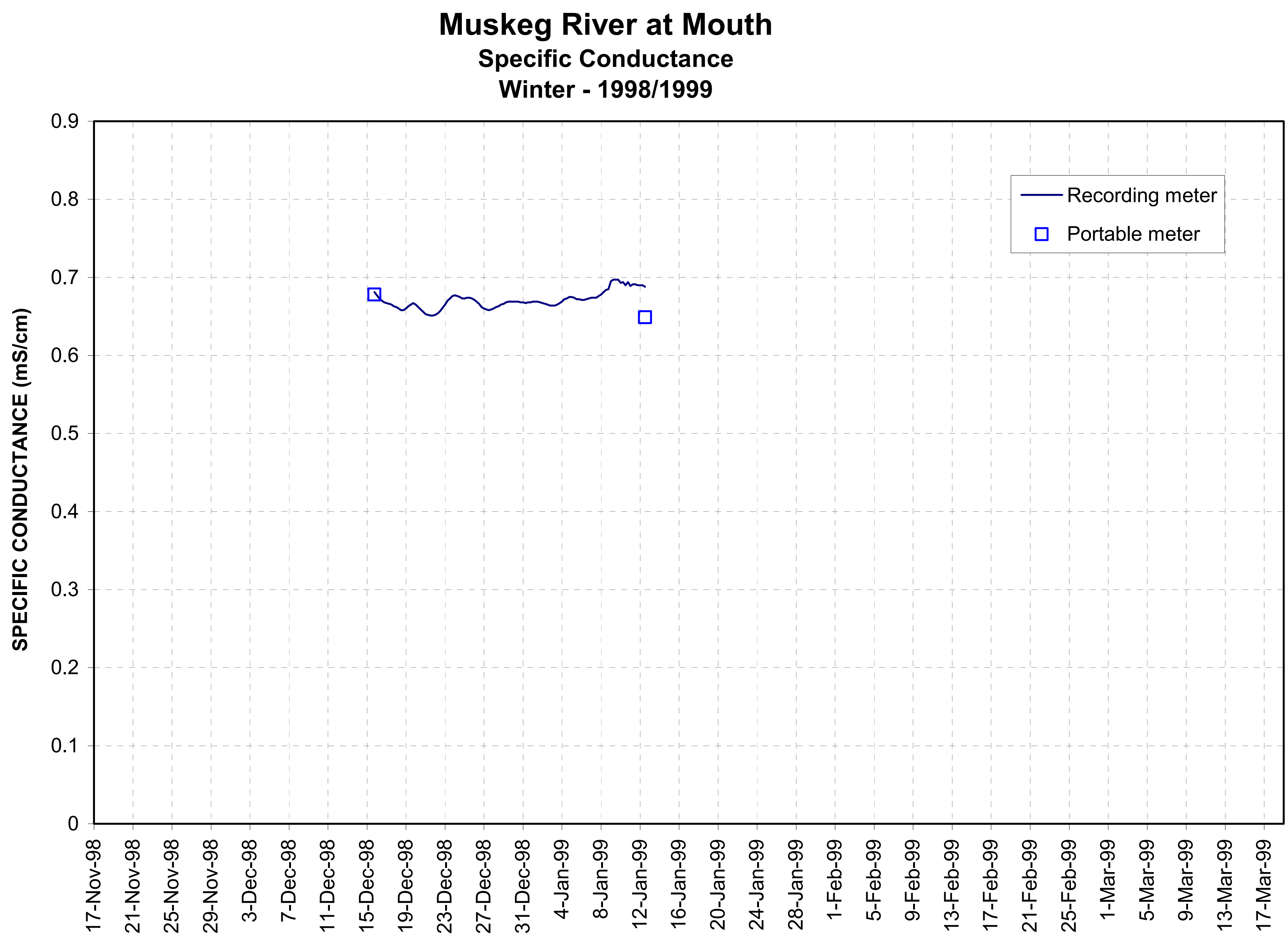
Muskeg River at Gauge
Specific Conductance
Winter 2000-2001
Specific Conductance us/cm
0.75
0.65
0.55
0.45
0.35
0.25
0.15
18-Oct-00
23-Oct-00
28-Oct-00
2-Nov-00
7-Nov-00
12-Nov-00
17-Nov-00
22-Nov-00
27-Nov-00
2-Dec-00
7-Dec-00
12-Dec-00
17-Dec-00
22-Dec-00
27-Dec-00
1-Jan-01
6-Jan-01
11-Jan-01
16-Jan-01
21-Jan-01
26-Jan-01
31-Jan-01
5-Feb-01
10-Feb-01
15-Feb-01
20-Feb-01
25-Feb-01
2-Mar-01
7-Mar-01
12-Mar-01
17-Mar-01
22-Mar-01
27-Mar-01
1-Apr-01
6-Apr-01
11-Apr-01
16-Apr-01
Cond
Field Cond

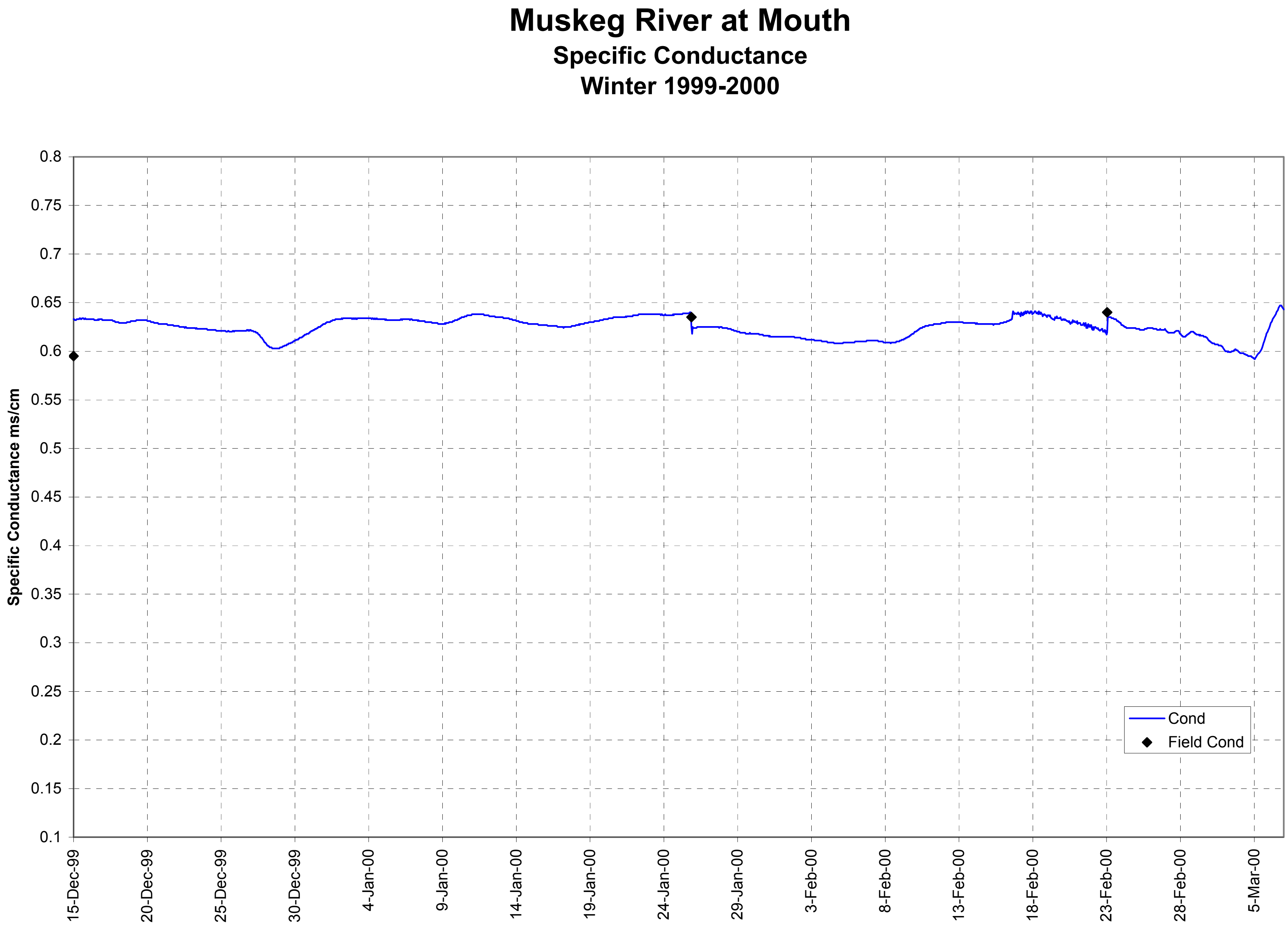


Muskeg River at WSC Gauge
Specific Conductance
Summer 2001
SPECIFIC CONDUCTANCE (uS/cm)
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
19-Apr-01
24-Apr-01
29-Apr-01
4-May-01
9-May-01
14-May-01
19-May-01
24-May-01
29-May-01
3-Jun-01
8-Jun-01
13-Jun-01
18-Jun-01
23-Jun-01
28-Jun-01
3-Jul-01
8-Jul-01
13-Jul-01
18-Jul-01
23-Jul-01
28-Jul-01
2-Aug-01
7-Aug-01
12-Aug-01
17-Aug-01
22-Aug-01
27-Aug-01
1-Sep-01
6-Sep-01
11-Sep-01
16-Sep-01
21-Sep-01
26-Sep-01
1-Oct-01
6-Oct-01
11-Oct-01
Recording meter
Portable meter

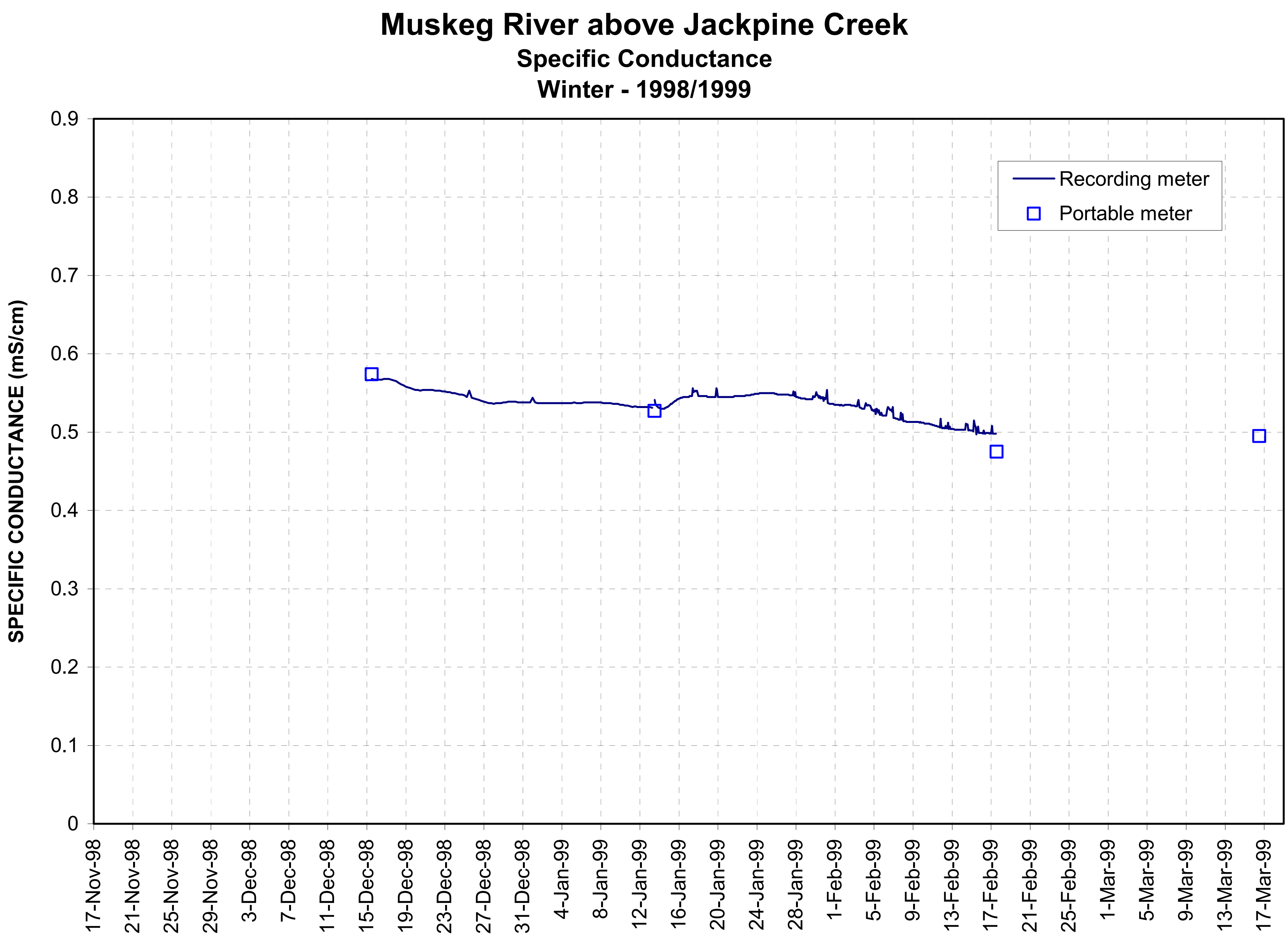


Muskeg River at WSC Gauge
Specific Conductance
Autumn 2001
SPECIFIC CONDUCTANCE (uS/cm)
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
Recording meter
Portable meter
16-Oct-01
18-Oct-01
21-Oct-01
23-Oct-01
26-Oct-01
28-Oct-01
31-Oct-01
2-Nov-01
5-Nov-01
7-Nov-01
10-Nov-01
12-Nov-01
15-Nov-01
17-Nov-01
20-Nov-01
22-Nov-01
25-Nov-01
27-Nov-01
30-Nov-01
2-Dec-01
5-Dec-01
7-Dec-01
10-Dec-01
12-Dec-01

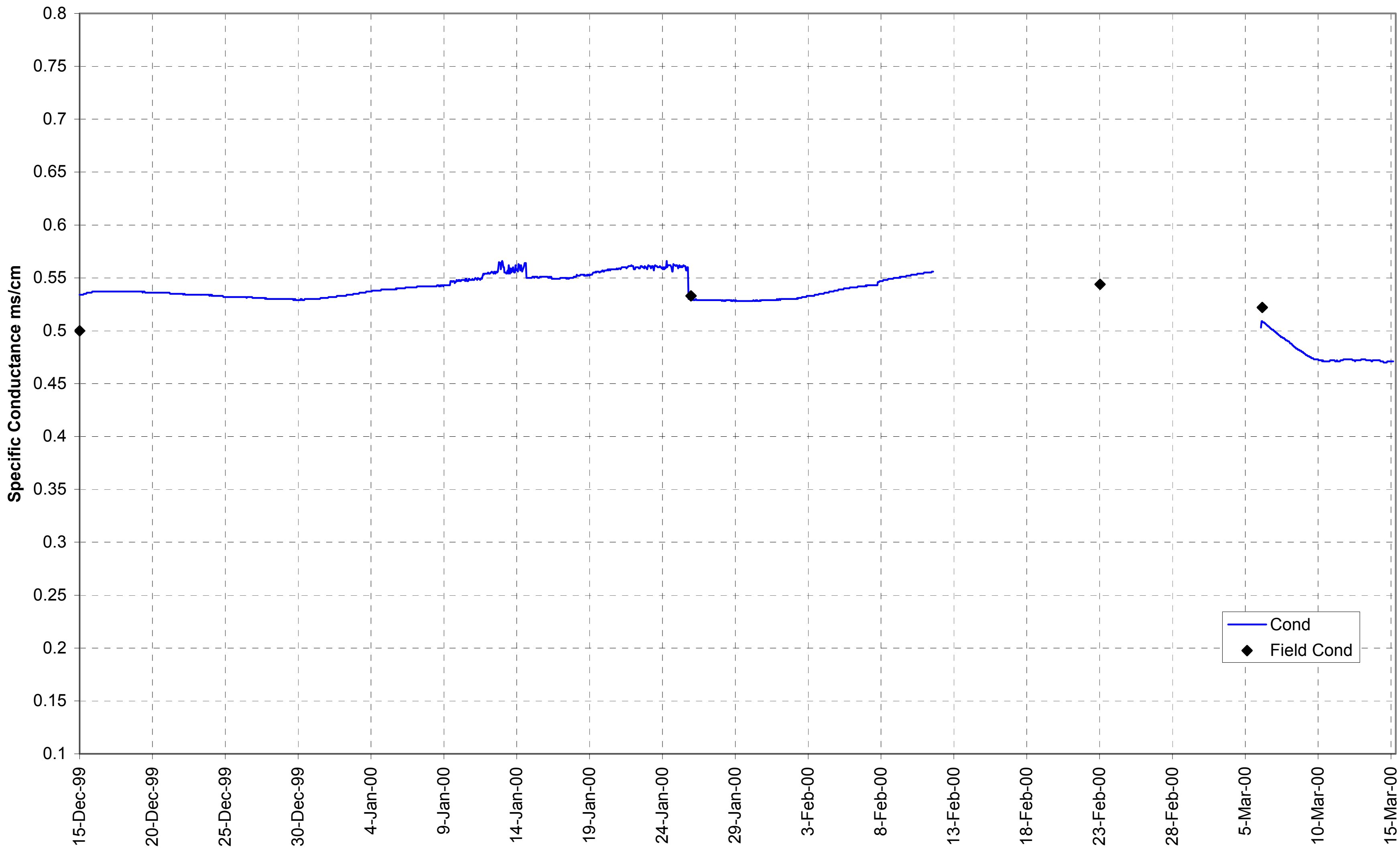

Muskeg River at Mouth
Specific Conductance
Winter - 1998/1999
SPECIFIC CONDUCTANCE (mS/cm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99



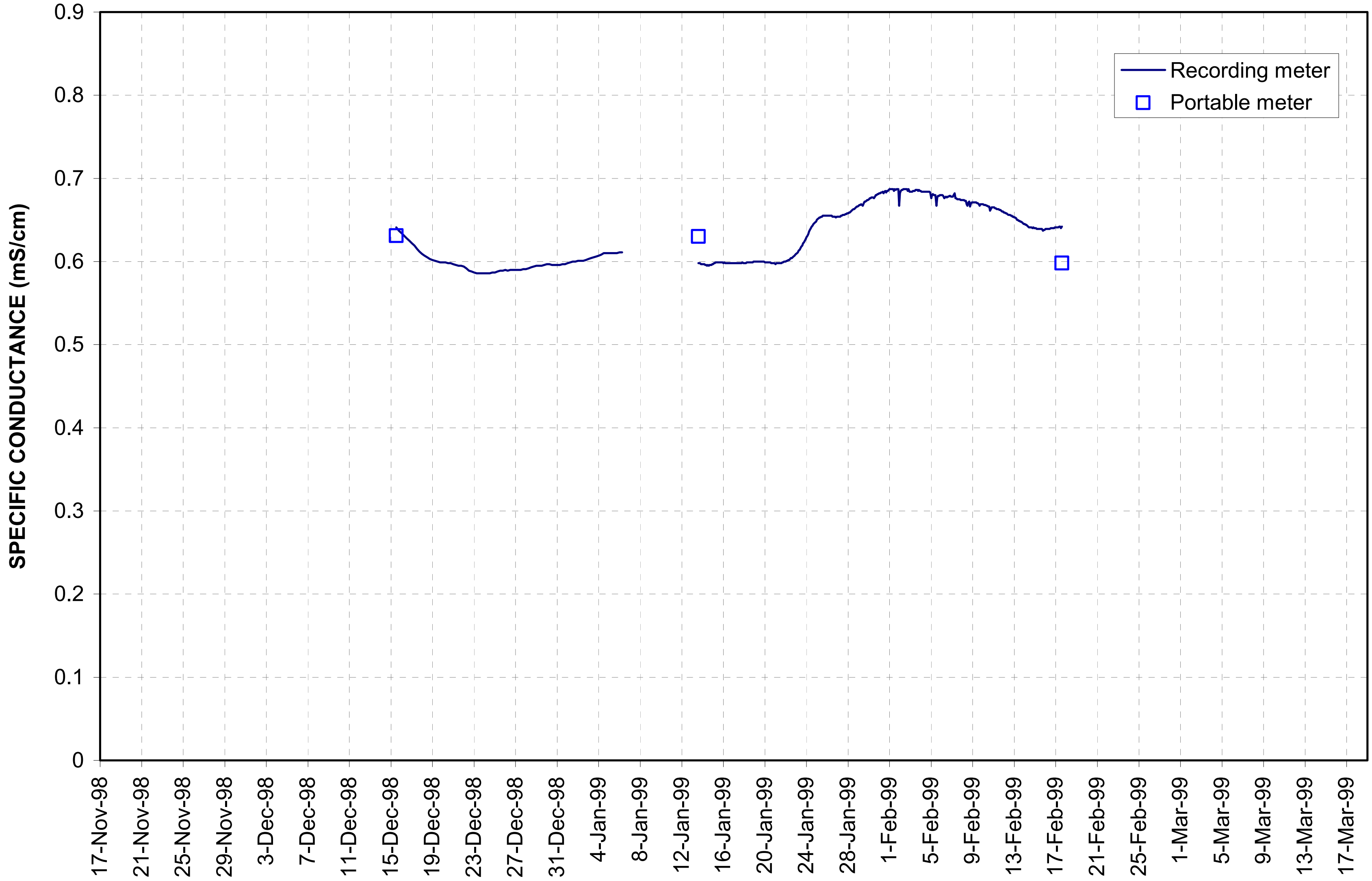
Muskeg River at Mouth
Specific Conductance
Winter 1999-2000
Specific Conductance ms/cm
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
15-Dec-99
20-Dec-99
25-Dec-99
30-Dec-99
4-Jan-00
9-Jan-00
14-Jan-00
19-Jan-00
24-Jan-00
29-Jan-00
3-Feb-00
8-Feb-00
13-Feb-00
18-Feb-00
23-Feb-00
28-Feb-00
5-Mar-00
Cond
Field Cond


Muskeg River above Jackpine Creek
Specific Conductance
Winter - 1998/1999
SPECIFIC CONDUCTANCE (mS/cm)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Recording meter
Portable meter
17-Nov-98
21-Nov-98
25-Nov-98
29-Nov-98
3-Dec-98
7-Dec-98
11-Dec-98
15-Dec-98
19-Dec-98
23-Dec-98
27-Dec-98
31-Dec-98
4-Jan-99
8-Jan-99
12-Jan-99
16-Jan-99
20-Jan-99
24-Jan-99
28-Jan-99
1-Feb-99
5-Feb-99
9-Feb-99
13-Feb-99
17-Feb-99
21-Feb-99
25-Feb-99
1-Mar-99
5-Mar-99
9-Mar-99
13-Mar-99
17-Mar-99

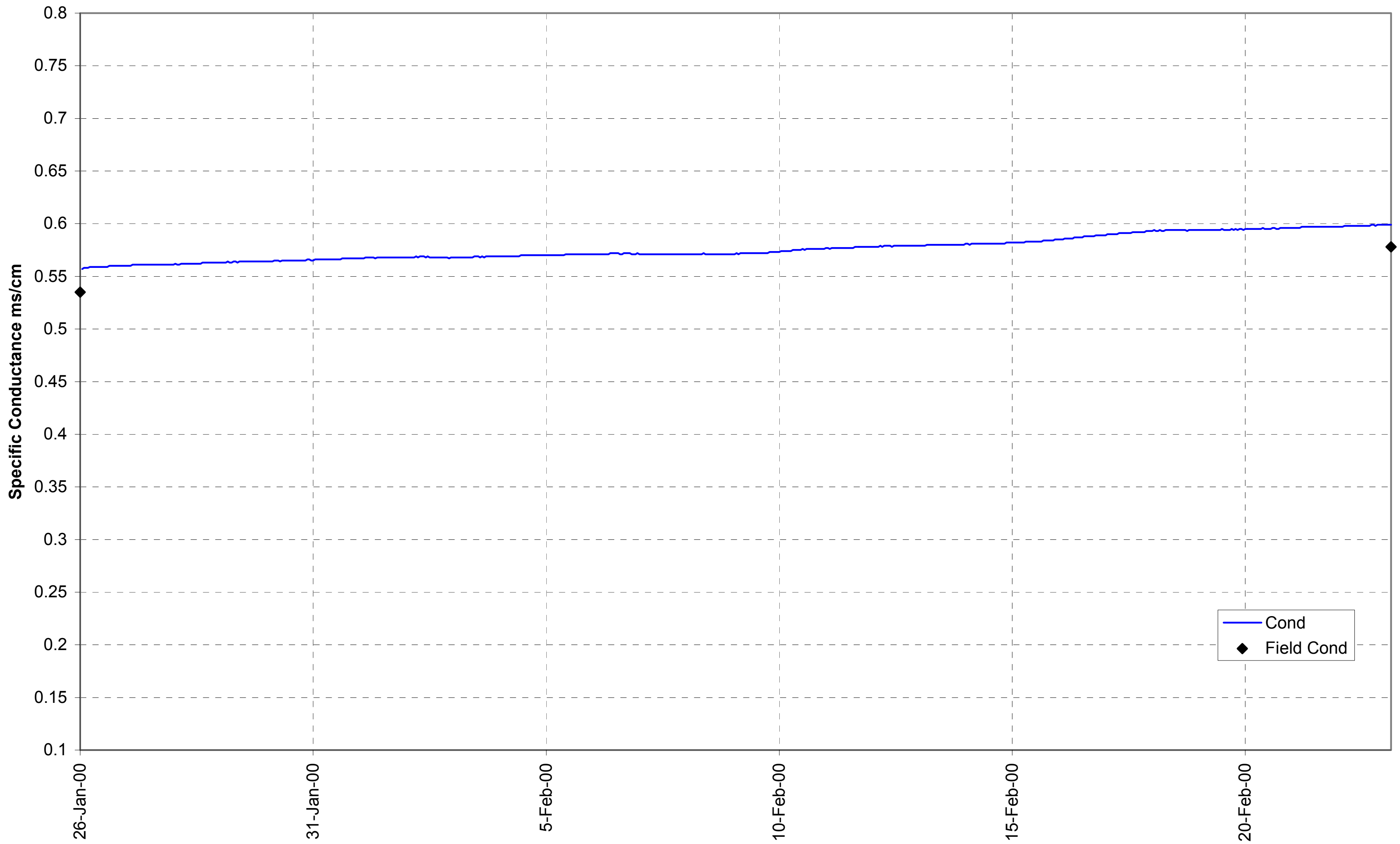
Muskeg River above Jackpine Creek
Specific Conductance
Winter 1999-2000



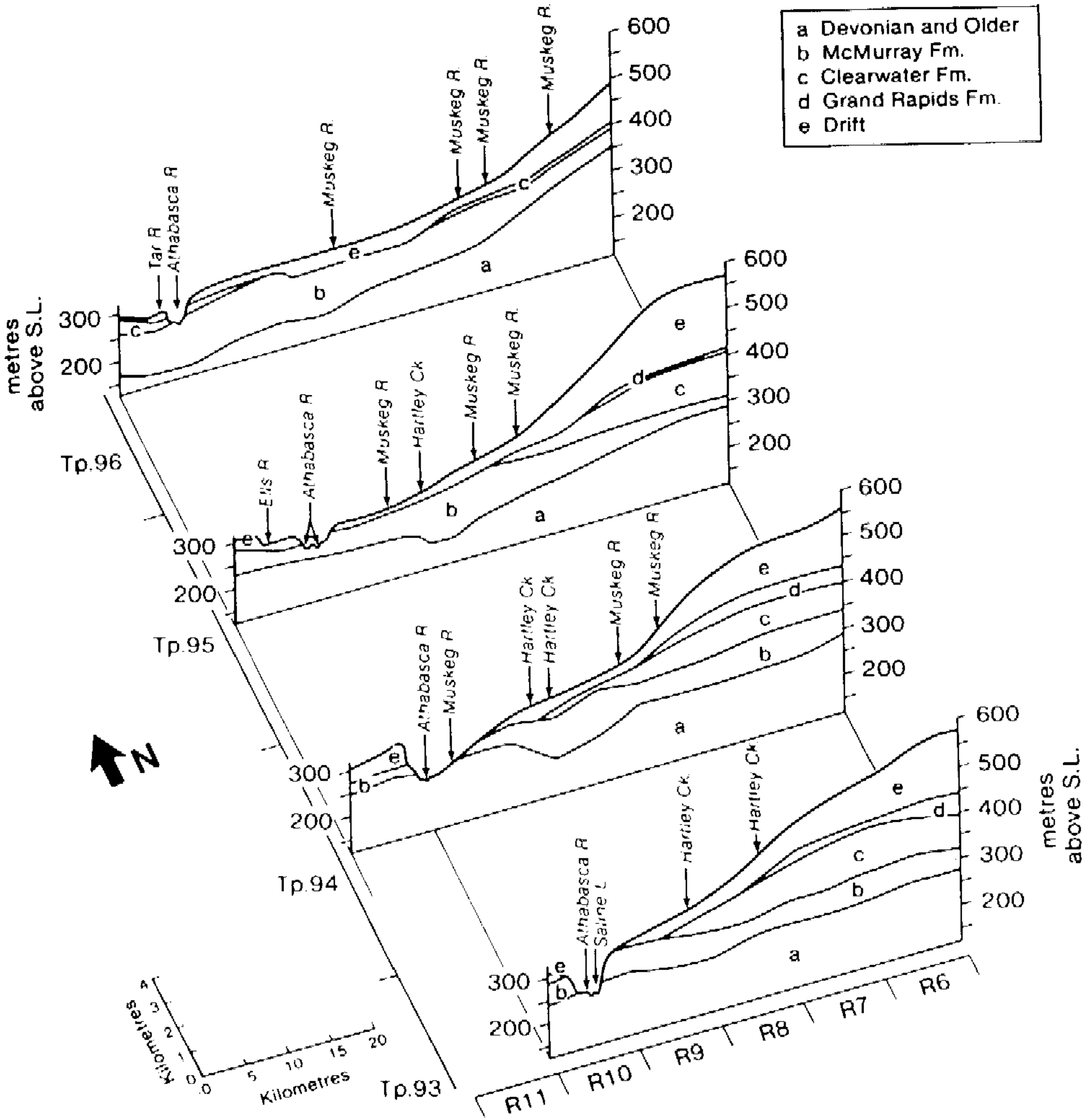
Jackpine Creek at Mouth
Specific Conductance
Winter - 1998/1999



Jackpine Creek at Mouth
Specific Conductance
Winter 1999-2000



Appendix 9 Geologic cross sections of the Muskeg Catchment (Schwartz and Milne-Home 1982)



Appendix 9 Continued: Channel slope profile for the Muskeg River mainstem (Sekarak and Walder 1980)