beak
associates
consulting ltd.

file copy
300-020-025

WINTER WATER QUALITY SURVEY ON THE ATHABASCA RIVER, FEBRUARY 1991

WINTER WATER QUALITY SURVEY ON THE ATHABASCA RIVER, FEBRUARY 1991

Prepared For:

MILLAR WESTERN PULP LTD.
AND
ALBERTA NEWSPRINT COMPANY
WHITECOURT, ALBERTA

Prepared By:

BEAK ASSOCIATES CONSULTING LTD.
CALGARY, ALBERTA

June 1991
Project No.: 09-055-01-01

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

As part of the license requirements of Alberta Environment, Millar Western Pulp Ltd. (Millar Western) and Alberta Newsprint Company (ANC) are required to conduct a winter water quality monitoring survey in the Athabasca River during the winter of 1990/1991. The objectives of the survey are to determine the water quality of the Athabasca River, both upstream and downstream of existing effluent discharge points. The Millar Western bleached chemithermomechanical pulp (BCTMP) mill became operational in August 1988 and discharges treated effluent to the Athabasca River at an average rate of about 12,000 to 14,000 m^3/day. The ANC CTMP newsprint mill became operational in August 1990 and discharges treated effluent to the Athabasca River at a rate of about 12,000 to 16,000 m^3/day. The Town of Whitecourt discharges treated sewage effluent to the Athabasca River at a continuous rate of about 3,300 m^3/day during the winter months.

2.0 METHODOLOGY

2.1 SITE LOCATIONS

Water quality sampling was conducted at 13 locations on the Athabasca River, tributary streams and from effluent sources (Figure 1, Table 1). These sites were selected partly based on the winter water quality program conducted by Alberta Environment (Noton and Shaw 1989) when the oxygen sag in the Athabasca River was found to be greatest at the site near Hondo. Eleven of these sites were initially established and sampled during the 1989/1990 winter water quality program (Beak 1990). Additional sites for this program were the ANC effluent and the south channel 0.5 km downstream of the ANC outfall.

2.2 SAMPLE COLLECTION AND ANALYSES

The water quality survey was conducted from 20 to 21 February 1991. Previous studies on the Athabasca River by Alberta Environment indicated that dissolved oxygen concentrations were generally at their lowest levels during the latter part of February.

Grab samples were collected from most sites on the Athabasca River and tributary streams by immersing a PVC sampler below the ice surface in the channel thalweg. The samples collected at Sites 3, 4 and 8 were taken in the mid-channel of the open water lead. It should be noted that this point in the river was still within the mixing zone and that the effluent was not completely mixed. The samples were taken about 20 cm below the water surface. Effluent samples were taken directly from the ANC and Millar Western effluent pumphouses and the Whitecourt sewage treatment plant. All samples were preserved in the field by standard methods, stored on ice, and forwarded within 24 hours to the laboratory for analysis.

The sampling regime for each site for the various water quality parameters is shown on Table 2. Field measurements for temperature, pH and dissolved oxygen were taken at all sites using a pocket thermometer ($\pm$ 0.5°C), a pHep Hanna Instruments pH meter ($\pm$ 0.1 unit) and a YS1 Model 54A dissolved oxygen meter ($\pm$ 0.2 ppm).

Chemical analyses for all parameters, except resin acids were conducted by Norwest Labs of Edmonton using standard methods (Appendix A). Dissolved oxygen samples were preserved in the field using the azide modification of the Winkler method where 1 mL of

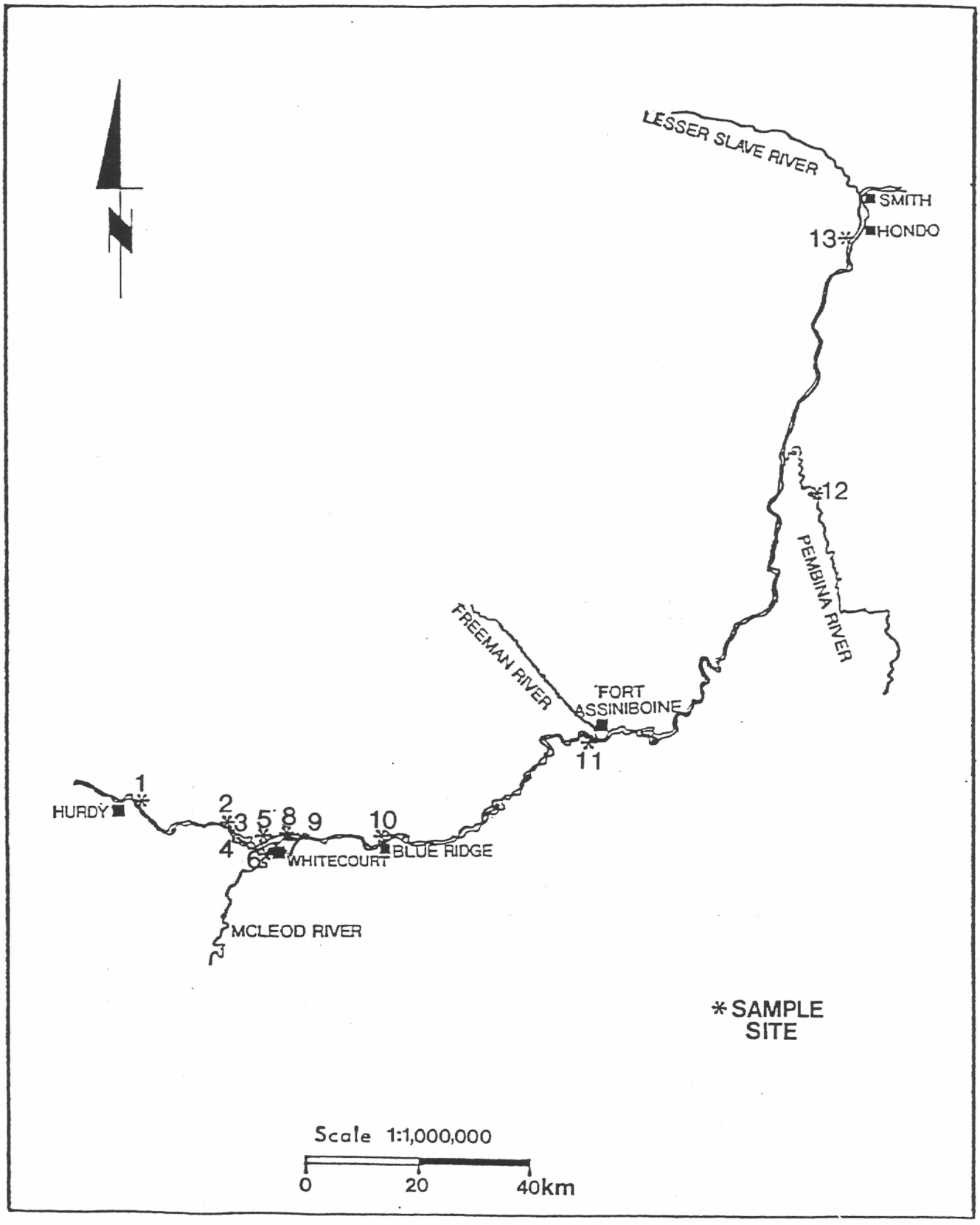

Figure 1. Water quality sampling site locations, Athabasca River.

Table 1. Sample site and sampling point locations.

Site	Location	Sampling Point[a]
1	Windfall bridge	20 m from right bank
2	ANC effluent	effluent pumphouse
3	0.5 km downstream of ANC outfall (north channel)	mid-channel
4	0.5 km downstream of ANC outfall (south channel)	mid-channel
5	Whitecourt (upstream of the McLeod River)	15 m from right bank
6	McLeod River at mouth	25 m from left bank
7	Millar Western effluent	effluent pumphouse
8	1 km downstream of Millar Western outfall	mid-channel
9	Whitecourt sewage treatment plant effluent	treatment plant
10	Blue Ridge	15 m from left bank
11	Fort Assiniboine	20 m from left bank
12	Pembina River near Flatbush	10 m from right bank
13	Hondo	60 m from right bank

a Left and right banks were determined looking downstream

Table 2. Sampling regime for water quality parameters.

Parameter	Site												
	1 Windfall	2 ANC Effluent	3 0.5 km d/s of ANC (North)	4 0.5 km d/s of ANC (South)	5 Whitecourt	6 McLeod R.	7 MW Effluent	8 1 km d/s of MW	9 Whitecourt STP	10 Blue Ridge	11 Fort Assiniboine	12 Pembina R.	13 Hondo
Temperature [a]	X	X	X	X	X	X	X	X	X	X	X	X	X
pH [a]	X	X	X	X	X	X	X	X	X	X	X	X	X
Dissolved Oxygen [b]	X	X	X	X	X	X	X	X	X	X	X	X	X
BOD_5	X	X	X	X	X	X	X	X	X	X	X	X	X
Sodium	X	X	X	X	X	X	X	X		X	X		X
Sulphate	X	X	X	X	X	X	X	X		X	X		X
Chloride	X	X	X	X	X		X	X		X	X		X
Manganese	X	X	X	X	X		X	X		X	X		X
Zinc	X	X	X	X	X		X	X		X	X		X
Silicon	X	X	X	X	X	X	X	X		X	X		X
Total Phosphorus	X	X	X	X	X		X	X	X	X	X		X
Dissolved Phosphorus	X	X	X	X	X		X	X	X	X	X		X
Nitrate and Nitrite Nitrogen	X	X	X	X	X		X	X	X	X	X		X
Total Kjeldahl Nitrogen	X	X	X	X	X		X	X	X	X	X		X
Ammonia Nitrogen	X	X	X	X	X		X	X	X	X	X		X
Total Organic Carbon	X	X	X	X	X		X	X		X	X		X
Total Suspended Solids	X	X	X	X	X	X	X	X	X	X	X	X	X
True Color	X	X	X	X	X		X	X		X	X		X
Total Phenols	X	X	X	X	X		X	X		X	X		X
Chelates (EDTA and DTPA)	X	X	X	X	X		X	X		X	X		X
Fecal Coliforms	X	X	X	X	X		X	X	X	X	X		X
Klebsiella	X	X	X	X	X		X	X		X			
Resin Acids	X	X	X	X	X		X	X		X	X		X

a Measured in the field

b Measured in the field and laboratory

x Sample taken at site

manganese sulphate was added to the sample followed by a 1 mL addition of alkali-iodide azide. Resin acid analyses were done by Enviro-Test Laboratories of Edmonton using GC/MS, in accordance with the Pulp and Paper Research Institute of Canada (PAPRICAN) methods.

In addition to the water quality sampling, the ice-free zone due to ANC and Millar Western effluent discharges was determined and mapped. Discharge data were obtained for the sampling period from Water Survey of Canada stations at Windfall on the Athabasca River (Station No. 07AE001) and at Rosevear on the McLeod River (Station No. 07AG007).

3.0 RESULTS AND DISCUSSION

3.1 DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Dissolved oxygen concentrations at sites on the Athabasca River ranged from 10.0 to 12.2 mg/L which represents 72 to 98% saturation (Table 3). Dissolved oxygen concentrations in the ANC effluent, Millar Western effluent and Whitecourt sewage effluent were 7.2, 1.9 and 3.9 mg/L, respectively, which represents 91, 25 and 35% saturation, respectively. Dissolved oxygen measurements taken in Millar Western effluent samples by both Millar Western personnel and Alberta Environment in February 1991, typically averaged about 4.0 mg/L (W. Lyka pers. comm.). The lower value recorded in the effluent during this survey may have been the result of insufficient flushing of effluent through the pumphouse pipeline when a sample was drawn for the field measurement for dissolved oxygen. Two of the major tributaries to the Athabasca River, the McLeod and Pembina rivers, had dissolved oxygen concentrations of 10.2 and 2.3 mg/L, respectively. Dissolved oxygen concentrations at most of the sites on the Athabasca were at background levels. At the two lowermost sites at Fort Assiniboine and Hondo, concentrations decreased by about 1 to 2 mg/L. A similar trend was observed by Alberta Environment (Noton and Shaw 1989) where the lowest dissolved oxygen concentrations in the Athabasca River within the study area occurred at the site near Hondo. Concentrations at Smith, downstream of Hondo, increase due to dissolved oxygen loading from the Lesser Slave River. Laboratory measurements for dissolved oxygen were higher at all sites compared to field measurements. Generally, laboratory results were about 1 mg/L higher than field measurements except at Site 11 (Fort Assiniboine) where the laboratory value was 6.4 mg/L higher than the field value. It was noted during the field sampling program that the water column at this site contained a lot of frazil ice. It is possible that the presence of frazil ice in the sample created an air space that "reaerated" the sample resulting in a higher, anomalous value.

All dissolved oxygen concentrations recorded in the field and laboratory at sites on the Athabasca River were above the Alberta Surface Water Quality Objective (ASWQO) of 5.0 mg/L and the Canadian Water Quality Guideline (CWQG) for the protection of freshwater aquatic life of 5.0 to 9.5 mg/L.

Biochemical oxygen demand (BOD) values at sites on the Athabasca River and tributary streams were low ranging from < 1 to 3 mg/L. BOD concentrations in ANC effluent,

Table 3. Water quality results for water samples collected from the Athatbasca River, 20 to 21 February 1991 (all values as mg/L unless indicated otherwise).

Parameter	Site 1 Windfall	2 ANC Effluent	3 0.5 km d/s of ANC (North)	4 0.5 km d/s of ANC (South)	5 Whitecourt	6 McLeod R.	7 MW Effluent	8 1 km d/s of MW	9 Whitecourt STP	10 Blue Ridge	11 Fort Assiniboine	12 Pembina R.	13 Hondo	ASWQO[a]	CWQG[a]
Temperature (°C)	0	23.0	1.5	0	0	0	26.0	4.0	7.0	0	0	0	0	Increase of 3°C	-
pH (units)	8.4	7.5	8.4	8.5	8.5	8.2	8.0	8.3	7.7	8.5	8.6	7.9	8.3	6.5 - 8.5	6.5 - 9.0
Dissolved Oxygen (field)	12.1	7.2	12.0	12.2	12.1	10.2	1.9	12.0	3.9	12.1	11.2	2.3	10.0	5.0	5.0 - 9.5
Dissolved Oxygen (laboratory)	12.7	9.0	12.8	12.3	12.8	12.3	2.6	12.5	5.3	12.7	17.6	4.6	11.0	-	-
DO saturation (%) (field)	88	91	88	89	88	74	25	98	35	88	81	17	72	-	-
BOD_5	<1	7	<1	<1	<1	<1	46	<1	34	<1	3	2	2	-	-
Sodium	12	81	11	11	11	23	1510	21	-	17	17	-	19	-	-
Sulphate	72	210	71	74	72	27	592	71	-	64	68	-	61	-	-
Chloride	3.9	50.8	3.8	4.0	3.6	-	49.6	3.4	-	2.6	3.0	-	3.3	-	-
Manganese (dissolved)	0.017	2.430	0.013	0.027	0.015	-	2.020	0.022	-	0.092	0.360	-	0.009	0.05	-
Zinc (dissolved)	0.009	0.140	<0.005	<0.005	<0.005	-	0.463	<0.005	-	0.011	0.026	-	<0.005	0.05	0.03
Silicon (dissolved)	3	3	3	3	3	5	87	3	-	3	4	-	3	-	-
Total Phosphorus (as P)	<0.005	10.1	<0.005	<0.005	<0.005	-	0.680	0.070	3.67	0.040	0.260	-	<0.005	0.05	-
Dissolved Phosphorus (as P)	<0.005	10.1	<0.005	<0.005	<0.005	-	<0.005	<0.005	3.37	<0.005	<0.005	-	<0.005	-	-
Nitrate and Nitrite Nitrogen	0.10	0.52	0.10	0.10	0.09	-	<0.05	0.09	4.97	0.10	0.19	-	0.17	-	-
Total Kjeldahl Nitrogen	0.31	1.99	0.13	0.13	0.38	-	7.73	<0.05	6.42	0.38	0.75	-	0.19	1.0	-
Ammonia Nitrogen	0.170	0.180	0.130	0.120	0.080	-	0.170	0.100	5.20	0.120	0.100	-	0.120	-	1.53[b]
Total Organic Carbon	2.1	21.6	3.5	2.5	2.8	-	341	3.4	-	3.9	4.2	-	4.2	-	-
Total Suspended Solids	8	19	6	4	5	6	192	6	20	7	300	10	11	Increase of 10	-
True Color (units)	15	150	15	15	15	-	900	15	-	15	15	-	15	Increase of 30	-
Total Phenols	0.002	0.045	0.003	0.002	0.002	-	0.890	0.007	-	0.004	0.003	-	0.003	0.005	0.001
Chelates (EDTA and DTPA)	4.28	15.82	4.28	3.91	3.72	-	44.67	3.72	-	3.54	3.54	-	1.86	-	-
Fecal Coliforms (MPN per 100 mL)	<1	20,000	60	160	25	-	10,000	25	60	20	<1	-	-	<5,000/100 mL	-
Klebsiella (MPN per 100 mL)	<1	5,000	30	90	30	-	6,000	90	-	70	-	-	-	-	-
Resin Acids (ug/L)														100	-
Linoleic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Oleic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Pimaric acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Sandaracopimaric acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Isopimaric acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Palustric acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Dehydroabietic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-

(continued)

Table 3. (concluded).

Parameter	Site 1 Windfall	2 ANC Effluent	3 0.5 km d/s of ANC (North)	4 0.5 km d/s of ANC (South)	5 Whitecourt	6 McLeod R.	7 MW Effluent	8 1 km d/s of MW	9 Whitecourt STP	10 Blue Ridge	11 Fort Assiniboine	12 Pembina R.	13 Hondo	ASWQO[a]	CWQG[a]
Abietic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Neoabietic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Chlorodehydroabietic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-
Dichlorodehydroabietic acid	<10	<10	<10	<10	<10	-	<10	<10	-	<10	<10	-	<10	-	-

a ASWQO - Alberta Surface Water Quality Objective (Alberta Environment 1977)
CWQG - Canadian Water Quality Guideline for Freshwater Aquatic Life (CCREM 1987)

b CWQG of 1.53 for ammonia nitrogen is at a pH of 8.0 and a temperature of $0^{o}C$.

Millar Western effluent and the Whitecourt sewage treatment plant (STP) effluent were 7, 46 and 34 mg/L, respectively. The discharge of these effluents did not have any effect on BOD concentrations at sites below the effluent outfalls where values were identical to the value (< 1 mg/L) at background Site 1. The slight increase at Site 11 (Fort Assiniboine) was probably due to the re-suspension of organic sediment from the scouring effect of the large amount of frazil ice noted at this site.

3.2 MAJOR IONS AND METALS

Sodium concentrations in the Athabasca River downstream of Whitecourt increased above background levels due to effluent discharge from the Millar Western mill. A background sodium value of 12 mg/L was recorded at the Windfall site. ANC effluent had a concentration of 81 mg/L but effluent discharge did not affect concentrations in the Athabasca River. The Millar Western effluent had a sodium concentration of 1510 mg/L and effluent discharge resulted in sodium concentrations of 17 to 21 mg/L at sites on the Athabasca River below Whitecourt. The McLeod River with a sodium concentration of 23 mg/L, was also a minor contributor of sodium to the Athabasca River. Although both the ANC and Millar Western effluents contained higher concentrations of sulphate and chloride than the background sites on the Athabasca River, concentrations of these parameters in the river were not affected by effluent discharges.

Manganese concentrations at sites on the Athabasca River were slightly elevated due to effluent discharges. A concentration of 0.017 mg/L was recorded at background Site 1 while concentrations at the sites immediately below the ANC effluent outfall were 0.013 and 0.027 mg/L. ANC effluent contained 2.430 mg/L manganese. A manganese concentration of 0.015 mg/L was recorded in the Athabasca River at Site 5, just above the Millar Western effluent outfall. At Site 8, 1 km downstream of Millar Western, a manganese concentration of 0.022 mg/L was recorded. Millar Western effluent had a manganese concentration of 2.020 mg/L. Manganese concentrations at sites immediately below both the ANC and Millar Western effluent outfalls were within the ASWQO of 0.05 mg/L. The highest manganese concentration values at sites on the Athabasca River occurred at Sites 10 and 11 (Blue Ridge and Fort Assiniboine) where concentrations of 0.092 and 0.360 mg/L, respectively, were recorded. It is considered that these elevated concentrations are from natural sources since manganese is a common element in soils and sediments. Zinc concentrations were not affected by effluent discharge from either ANC or Millar Western. The highest concentration (0.026 mg/L) in the Athabasca River

was recorded at the site at Fort Assiniboine and is probably from natural sources. All zinc values recorded at the Athabasca River sites were below the ASWQO of 0.05 mg/L and the CWQG of 0.03 mg/L.

3.3 NUTRIENTS

Total phosphorus concentrations were elevated above the background level of < 0.005 mg/L at sites below Millar Western and the Whitecourt sewage treatment plant effluent outfalls. Although the ANC effluent had a total phosphorus concentration of 10.1 mg/L, all of which was in dissolved form, concentrations at sites below the ANC effluent outfall were not affected. At Site 8, 1 km downstream of Millar Western, a total phosphorus concentration of 0.070 mg/L was recorded. Millar Western's effluent had a total phosphorus concentration of 0.680 mg/L, most of which was adsorbed to particulate organic matter (i.e. was not in dissolved form). Due to the relatively high concentration of suspended solids (particulate matter) in Millar Western effluent, to which phosphorus is bound, total phosphorus concentrations at Site 8 increased above background levels. Whitecourt sewage effluent had a total phosphorus concentration of 3.67 mg/L which was primarily in dissolved form. Total phosphorus concentrations remained above background levels at Site 10 at Blue Ridge where a value of 0.040 mg/L was recorded. The maximum concentration recorded at any Athabasca River site occurred at Site 11 (Fort Assiniboine) with a value of 0.260 mg/L. This high value was due to the re-suspension of phosphorus-bound particulate matter from frazil ice scour. Total phosphorus concentrations were at background levels at the lowermost site on the Athabasca River (Site 13). With the exception of Sites 8 and 11, all total phosphorus concentrations were below the ASWQO of 0.05 mg/L. Dissolved phosphorus concentrations in the Athabasca River were unaffected by effluent discharges from ANC, Millar Western and the Whitecourt sewage treatment plant.

Nitrate and nitrite nitrogen concentrations at most sites on the Athabasca River were similar to the background level of 0.10 mg/L and were not affected by effluent discharge. Concentrations were elevated to 0.19 and 0.17 mg/L at the two lowermost sites on the river, Sites 11 and 13 respectively, and appear to be the result of natural sources. Total Kjeldahl nitrogen concentrations were generally below the background concentrations of 0.31 mg/L and did not appear to be affected by effluent discharge. The maximum concentration recorded for the Athabasca River occurred at Site 11 and was probably the result of the re-suspension of organic sediments. However, all total Kjeldahl nitrogen

concentrations in the Athabasca River were below the ASWQO of 1.0 mg/L. Ammonia nitrogen concentrations were below background levels at all sites and were unaffected by effluent discharges. Total organic carbon concentrations were increased above the background concentration of 2.1 mg/L at all sites due to effluent discharge from ANC and Millar Western. At the sites below the ANC effluent outfall, total organic carbon concentrations ranged from 2.5 to 3.5 mg/L; ANC effluent had a concentration of 21.6 mg/L. Total organic carbon concentrations below Millar Western ranged from 3.4 to 4.2 mg/L; Millar Western's effluent had a concentration of 341 mg/L. Silicon concentrations ranged from 3 to 4 mg/L at all Athabasca River sites and were unaffected by effluent discharges.

3.4 SUSPENDED SOLIDS AND COLOR

Total suspended solids concentrations were low at most sites on the Athabasca River, ranging from 4 to 11 mg/L. An anomalous value of 300 mg/L was recorded at Site 11 (Fort Assiniboine) as a result of the re-suspension of sediments due to frazil ice scour. As previously stated, field observations at this site indicated the presence of large amounts of frazil ice throughout the water column. Total suspended solids concentrations in ANC and Millar Western effluent were 19 and 192 mg/L, respectively. Effluent discharge had no effect on suspended solids concentrations in the Athabasca River.

True color values at all sites on the Athabasca River, including the background site, were identical with a concentration of 15 units. Although true color concentrations in the ANC and Millar Western effluents were 150 and 900 units, respectively, no increase in Athabasca River levels due to effluent discharge was observed.

3.5 PHENOLS

Effluent discharge from the Millar Western mill resulted in an increase in total phenols concentrations at sites below the effluent outfall. A concentration of 0.002 mg/L was recorded at the background site (Site 1) on the Athabasca River, while a concentration of 0.007 mg/L was recorded at the site 1 km downstream of Millar Western. The Millar Western effluent had a total phenols concentration of 0.890 mg/L. Concentrations at other downstream sites on the Athabasca River were similar to background values. ANC effluent contained a total phenols concentration of 0.045 mg/L but effluent discharge did not have a discernible effect on concentrations at downstream sites. The ASWQO for total

phenols of 0.005 mg/L was exceeded at Site 8. The CWQG of 0.001 mg/L was exceeded at all sites on the Athabasca River including the background site.

Phenols are of concern because of their propensity to taint fish and their toxicity to aquatic life. Total phenols is a measure of the total concentration of phenols (monohydric, dihydric and polyhydric) and substituted phenols (e.g. chlorophenols, nitrophenols) (Cirrus Consultants 1989). However, the specific forms of phenolics are important in determining the potential effects on the aquatic environment. Chlorophenolics, for example, have a greater relative toxicity than monohydric phenols. Chlorophenolics are produced in the chlorine bleaching process in pulp production; however, neither the Millar Western or ANC pulp mill use this process.

3.6 CHELATORS

EDTA (Ethylenediaminetetraacetic acid) and DPTA (Diethylenetri-aminepentaacetic acid) are chelators with a strong affinity for transition metals, which they bind permanently into a metal-chelator complex (Cirrus Consultants 1989). The chelated metal is highly soluble, and therefore much more available for absorption by plants or animals. In open-water seasons, chelators are rapidly decayed by photolysis and bacterial metabolism. However, under ice conditions, decomposition is much slower.

Chelate concentrations at all sites on the Athabasca River were equal to or below the value of 4.28 mg/L recorded at background Site 1. Chelate concentrations in ANC and Millar Western effluent were 15.82 and 44.67 mg/L, respectively. However, chelate concentrations in the Athabasca River were unaffected by effluent discharge.

3.7 COLIFORMS

Pulp mill effluents commonly contain bacteria of the genus *Klebsiella* which show a positive response in both the standard total and fecal coliform tests. Fecal coliforms and *Klebsiella* (a fecal coliform) concentrations in the Athabasca River were affected by effluent discharge. A concentration of < 1 MPN/100 ml was recorded for both these parameters at the background Site 1. Downstream of ANC and Millar Western, fecal coliforms levels increased between 25 to 160 MPN/100 ml. Fecal coliform concentrations in ANC and Millar Western effluents were 20,000 and 10,000 MPN/100 ml, respectively. By Site 11 (Fort Assiniboine) fecal coliforms concentrations were at the background level of < 1

MPN/100 ml. All concentrations in the Athabasca River were below the ASWQO of 5,000/100 ml.

Klebsiella concentrations increased between 30 to 90 MPN/100 ml at sites below ANC and Millar Western. *Klebsiella* levels in ANC and Millar Western effluents were 5,000 and 6,000 MPN/100 ml, respectively. Elevated *Klebsiella* levels in the Athabasca River persisted to at least Site 10 (Blue Ridge).

A recent study of the health significance of *Klebsiella* in the environment concluded that the presence of *Klebsiella* in lakes and streams does not produce human disease (Duncan 1988).

3.8 RESIN ACIDS

Resin acids concentrations at all Athabasca River sites and in both ANC and Millar Western effluent, were below the detection limit of 10 μg/L.

3.9 ICE-FREE ZONE AND ATHABASCA RIVER DISCHARGE

Effluent discharge from the ANC mill resulted in an ice-free zone in both the north and south channels of the Athabasca River below the effluent outfall (Figure 2). The open-water lead in the north channel extended for about 1.8 km, while in the south channel, the lead extended for a distance of about 2.0 km. The width of the ice-free zone in both channels was variable but generally was about 15 m wide. Water temperature in the north channel was 1.5 ^{o}C and 0 ^{o}C in the south channels; ANC effluent had a temperature of 23.0 ^{o}C.

Effluent discharge from the Millar Western mill resulted in an ice-free zone of about 2 km downstream of the effluent outfall (Figure 3). The ice-free zone varied in width but was generally about 10 m wide. Water temperature in the open-water lead was 4.0 ^{o}C; Millar Western effluent has a temperature of 26.0 ^{o}C.

Due to gauge malfunction, flow data for the Athabasca River near Windfall during the sampling period is not available. However, flow in the Athabasca River at Hinton during the sampling period was 40 m^3/s (Flow Forecasting, Alberta Environment). Based on historical data, flow in the river near Windfall is about 19 m^3/s higher than at Hinton.

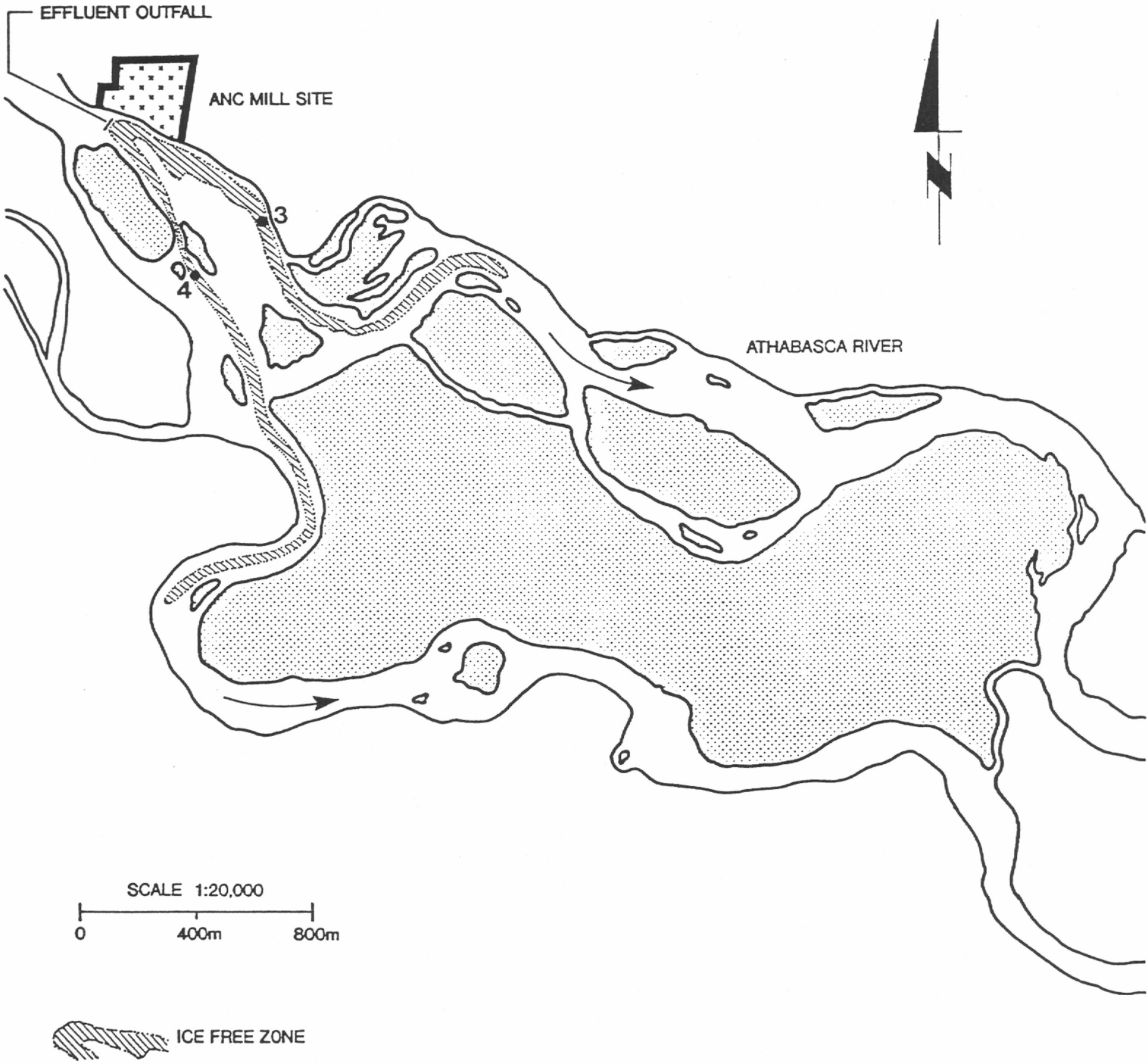

Figure 2. **Ice-free zone on the Athabasca River downstream of the ANC effluent outfall, February 1991.**

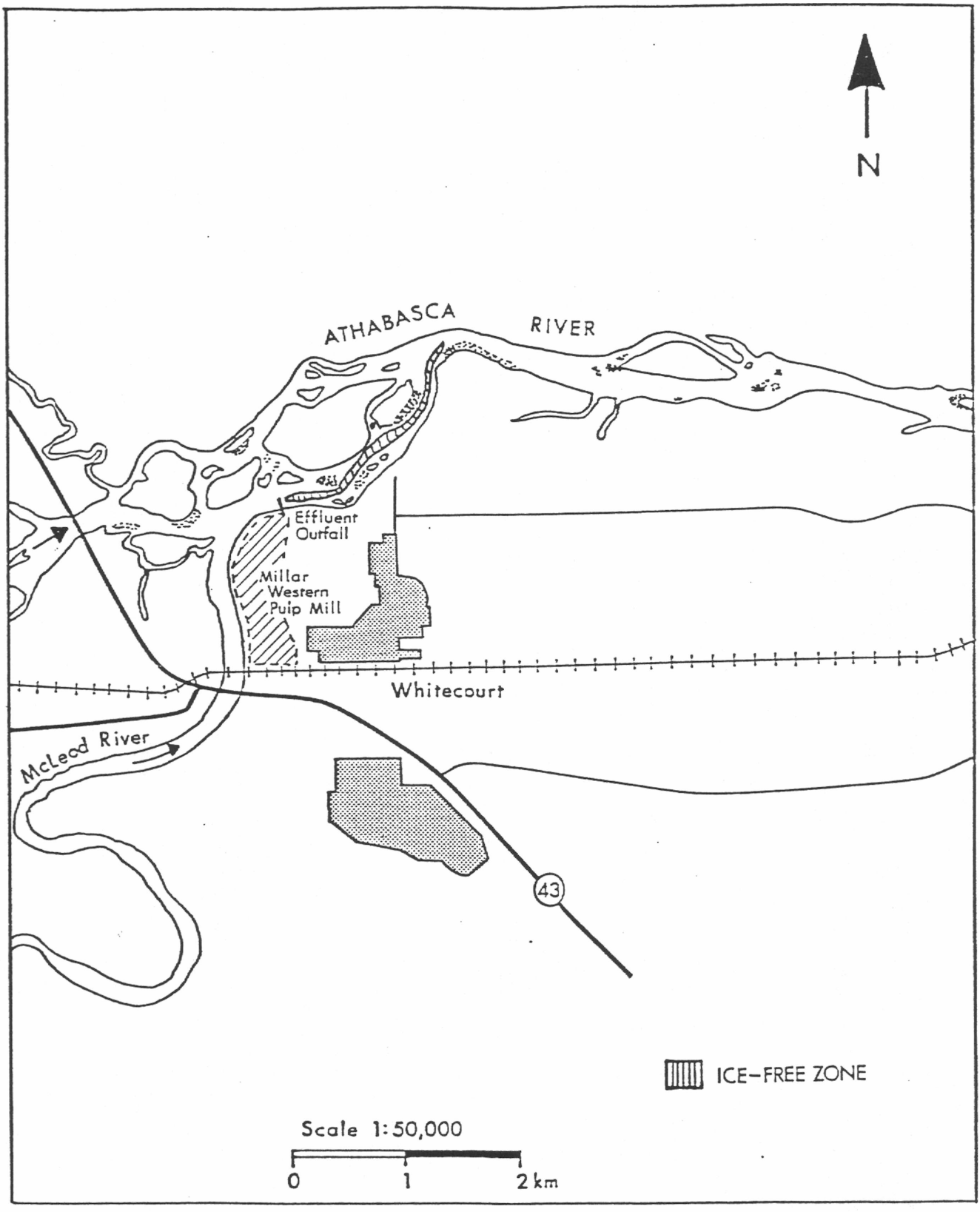

Figure 3. **Ice-free zone on the Athabasca River downstream of the Millar Western effluent outfall, February 1991.**

Assuming the same trend occurred during this study, flow in the Athabasca River at Windfall, approximately 20 km upstream of the ANC effluent outfall, would have been about 59 m^3/s. Flow in the McLeod River near Rosevear during the sampling period averaged 9.3 m^3/s giving a combined flow of about 68 m^3/s for the Athabasca River at the Millar Western pulp mill.

Historical streamflow data for the Athabasca River near Windfall indicated an average monthly discharge for February (1960 - 1988) of 50.2 m^3/s and an average monthly discharge (1985 - 1988) for the McLeod River at Rosevear of 7.2 m^3/s (Environment Canada 1989). Based on this data, the flow conditions during this study were typical of historical averages. The winter 7Q10 low flow for the Athabasca River at Windfall is about 33.6 m^3/s (BEAK 1989).

4.0 SUMMARY AND CONCLUSIONS

Effluent discharge from the ANC pulp mill, Millar Western pulp mill and, to a lesser extent, effluent from the Whitecourt sewage treatment plant, had affected a few water quality parameters in the Athabasca River during the winter 1991. Dissolved oxygen concentrations in the river below Whitecourt decreased due to BOD inputs from ANC, Millar Western and the Whitecourt sewage treatment plant. The dissolved oxygen sag was first evident at the site at Fort Assiniboine and persisted up to Hondo. However, dissolved oxygen concentrations at all sites on the Athabasca River were still above the ASWQO and CWQG for the protection of freshwater aquatic life. Sodium concentrations in the river were elevated due to inputs from the Millar Western mill and, to a minor extent, by the McLeod River. Sulphate and chloride levels in the Athabasca River were unaffected by any effluent discharges. Manganese concentrations were slightly elevated due to ANC and Millar Western effluent discharge while zinc levels were similar to background values.

Total phosphorus and total organic carbon concentrations were elevated above background levels at sites below the Millar Western mill and the Whitecourt sewage treatment plant. Total phenols concentration increased above background levels at the site immediately below the Millar Western effluent outfall and was in exceedence of the ASWQO of 0.005 mg/L. All sites on the river, including the background sites, were higher than the CWQG for total phenols of 0.001 mg/L. Although concentrations of total suspended solids, color and chelators (EDTA and DTPA) were higher than background levels in both ANC and Millar Western effluent, concentrations in the Athabasca River were unaffected by effluent discharge. Fecal coliforms and *Klebsiella* levels in the river increased as result of effluent discharges; fecal coliform concentrations did, however, return to background levels at the Fort Assiniboine site while *Klebsiella* levels persisted to at least Blue Ridge. Resin acids were not detected at either Athabasca River sites or in effluent samples.

Anomalous values for several parameters (manganese, zinc, total phosphorus, TKN and suspended solids) were recorded at the site at Fort Assiniboine due to the large amounts of frazil ice observed at this site which resulted in scour and re-suspension of bottom sediments.

Effluent discharge from ANC resulted in a 1.8 km ice-free zone in the north channel immediately below the effluent outfall and a 2.0 km ice-free zone in the south channel. Millar Western effluent discharge resulted in a 2.0 km open-water lead below the effluent

outfall. Flows in the Athabasca and MacLeod Rivers during the sampling period were similar to historical average streamflows for February.

5.0 LITERATURE CITED

Alberta Environment. 1977. Alberta surface water quality objectives. Water Quality Branch, Alberta Environment, Edmonton, Alberta. 17 pp.

Beak. 1989. Mixing characteristics of the Athabasca River below the proposed ANC mill. Prepared for Alberta Newsprint Company Ltd., Whitecourt, Alberta by Beak Associates Consulting Ltd., Edmonton, Alberta.

Beak. 1990. Winter water quality survey on the Athabasca River, February 1990. Prepared for Millar Western Pulp Ltd. and Alberta Newsprint Company, Whitecourt, Alberta by Beak Associates Consulting Ltd., Calgary, Alberta.

CCREM. 1987. Canadian water quality guidelines. Prepared by the Task Force on Water Quality Guidelines, Canadian Council of Resource and Environment Ministers, Environment Canada, Ottawa, Ontario.

Cirrus Consultants. 1989. Meadow Lake CTMP Mill, Environmental Impact Statement. Prepared for Millar Western Pulp Ltd. by Cirrus Consultants. 255 pp.

Duncan, I. B. R. 1988. Health significance of *Klebsiella* in the environment. Prepared for Ontario Ministry of the Environment. Queen's Printer for Ontario.

Environment Canada. 1989. Historical streamflow summary, Alberta. To 1988. Water Survey of Canada, Environment Canada, Ottawa, Ontario. 595 pp.

Noton, L.R. and R.D. Shaw. 1989. Winter water quality in the Athabasca River system 1988 and 1989. Environmental Quality Monitoring Branch, Alberta Environment, Edmonton, Alberta. 132 pp.

APPENDIX A

LABORATORY ANALYTICAL METHODS AND RESULTS

NORWEST LABS

9938-67 Avenue
Edmonton, AB
T6E 0P5
(403) 438-5522

DATE	01 MAR 91 16:48
P.O. NO.	
W.O. NO.	3 41113

BEAK ASSOC. CONSULTING
155, 2635-37AVE. NE
CALGARY, AB
T1N 5Z6

BOB SHELAST

The following published METHODS OF ANALYSIS were used:

5071 07557 AMMONIA-N
DISS. COLORIMETRY, AUTOMATED

5074* 07003P TOTAL KJEHL NIT

5076 NWL 5076 PHOSPHORUS(TOT)
TOTLA, PERSULPHATE AUTOCLAVE;
AUTOMATED COLORIMETRY, ASCORBIC ACID

5078 NWL 5078 PHOSPHORUS(DISS)
DISS, AUTOMATED COLORIMETRY,
ASCORBIC ACID

5025*11102L SODIUM
ICP SPECTROSCOPY

5028*16306L SULPHATE
ICP SPECTROSCOPY

5029*17203L CHLORIDE
AUTOMATED COLORIMETRY

5032*07105L NITRATE&NITRITE
AUTOMATED COLORIMETRY Cd REDUCTION

4123 14120 SILICON

4130 30304 ZINC

5038*06005L TOTAL ORG CARBON

5035*08202 BIOCHEM O2 DEM'D
FIVE DAY INCUBATION AT 20 DEGREES C,
ANALYSIS WITH OXYGEN METER

5042*06537P PHENOLS
AUTOMATED, DISTILLATION AND COLORIMETRY
WITH 4-AAP

5064*10401L RESIDUE NON-FILT
FILTRATION THROUGH GF/C FILTER AND
GRAVIMETRIC ANALYSIS OF RESIDUE
RETAINED ON FILTER

NORWEST SOIL RESEARCH LTD has been accredited by the STANDARDS COUNCIL of CANADA for these analytical methods.

ANALYST

NORWEST LABS

9938-67 Avenue
Edmonton, AB
T6E 0P5
(403) 438-5522

DATE	01 MAR 91 16:48
P.O. NO.	
W.O. NO.	3 41113

BEAK ASSOC. CONSULTING
155, 2635-37AVE. NE
CALGARY, AB
T1N 5Z6

BOB SHELAST

WATER NUTRIENTS

	SAMPLE DESCRIPTION	07557 NH_3- N mg/L	07003P TKN mg/L	NWL 5076 P(TOTAL) mg/L	NWL 5078 P (DISS) mg/L	DISSOLVD OXYGEN mg/L
1	SITE-1 WINDFALL	0.170	0.31	< 0.005	< 0.005	12.7
2	SITE-2 ANC EFFLUENT	0.180	1.99	10.1	10.1	9.0
3	SITE-3 0.5KM D/S ANC	0.130	0.13	< 0.005	< 0.005	12.8
4	SITE-4 0.5KM SOUTH	0.120	0.13	< 0.005	< 0.005	12.3
5	SITE-5 WHITECOURT	0.080	0.38	< 0.005	< 0.005	12.8
6	SITE-6 MCLEOD R.					12.3
7	SITE-7 MW EFFLUENT	0.170	7.73	0.680	< 0.005	2.6
8	SITE-8 1KM D/S MW	0.100 <	0.05	0.070	< 0.005	12.5
9	SITE-9 WHITECOURT STP	5.20	6.42	3.67	3.37	5.3
10	SITE-10 BLUE RIDGE	0.120	0.38	0.040	< 0.005	12.7
11	SITE-11 FT. ASSINIBOINE	0.100	0.75	0.260	< 0.005	17.6
12	SITE-12 PEMBINA RIVER					4.6
13	SITE-13 HONT	0.120	0.19	< 0.005	< 0.005	11.0

ROUTINE WATER

	SAMPLE DESCRIPTION	11102L Na mg/L	16306L SO_4 mg/L	17203L Cl mg/L	07105L NO_3& NO_2 mg/L
1	SITE-1 WINDFALL	12	72	3.9	0.10
2	SITE-2 ANC EFFLUENT	81	210	50.8	0.52
3	SITE-3 0.5KM D/S ANC	11	71	3.8	0.10
4	SITE-4 0.5KM SOUTH	11	74	4.0	0.10
5	SITE-5 WHITECOURT	11	72	3.6	0.09
6	SITE-6 MCLEOD R.	23	27		
7	SITE-7 MW EFFLUENT	1510	592	49.6	< 0.05
8	SITE-8 1KM D/S MW	21	71	3.4	0.09
9	SITE-9 WHITECOURT STP				4.97
10	SITE-10 BLUE RIDGE	17	64	2.6	0.10
11	SITE-11 FT. ASSINIBOINE	17	68	3.0	0.19
12	SITE-12 PEMBINA RIVER				
13	SITE-13 HONT	19	61	3.3	0.17

DISSOLVED METALS

	SAMPLE DESCRIPTION	Mn mg/L	14120 Si mg/L	30304 Zn mg/L
1	SITE-1 WINDFALL	0.017	3	0.009
2	SITE-2 ANC EFFLUENT	2.43	3	0.140
3	SITE-3 0.5KM D/S ANC	0.013	3	< 0.005
4	SITE-4 0.5KM SOUTH	0.027	3	< 0.005
5	SITE-5 WHITECOURT	0.015	3	< 0.005
6	SITE-6 MCLEOD R.		5	
7	SITE-7 MW EFFLUENT	2.02	87	0.463
8	SITE-8 1KM D/S MW	0.022	3	< 0.005
9	SITE-9 WHITECOURT STP			
10	SITE-10 BLUE RIDGE	0.092	3	0.011
11	SITE-11 FT. ASSINIBOINE	0.360	4	0.026
12	SITE-12 PEMBINA RIVER			
13	SITE-13 HONT	0.009	4	< 0.005

ORGANICS

	SAMPLE DESCRIPTION	06005L ORGANIC CARBON mg/L	08202 BOD mg/L	06537P PHENOL mg/L
1	SITE-1 WINDFALL	2.1	< 1	0.002
2	SITE-2 ANC EFFLUENT	21.6	7	0.045
3	SITE-3 0.5KM D/S ANC	3.5	< 1	0.003
4	SITE-4 0.5KM SOUTH	2.5	< 1	0.002
5	SITE-5 WHITECOURT	2.8	< 1	0.002
6	SITE-6 MCLEOD R.		< 1	
7	SITE-7 MW EFFLUENT	341	46	0.890
8	SITE-8 1KM D/S MW	3.4	< 1	0.007
9	SITE-9 WHITECOURT STP		34	
10	SITE-10 BLUE RIDGE	3.9	< 1	0.004
11	SITE-11 FT. ASSINIBOINE	4.2	3	0.003
12	SITE-12 PEMBINA RIVER		2	
13	SITE-13 HONT	4.2	2	0.003

PHYSICAL ANALYSIS

	SAMPLE DESCRIPTION	10401L NFR mg/L	COLOR CO.UNITS
1	SITE-1 WINDFALL	8	15
2	SITE-2 ANC EFFLUENT	19	150
3	SITE-3 0.5KM D/S ANC	6	15
4	SITE-4 0.5KM SOUTH	4	15
5	SITE-5 WHITECOURT	5	15
6	SITE-6 MCLEOD R.	6	
7	SITE-7 MW EFFLUENT	192	900
8	SITE-8 1KM D/S MW	6	15
9	SITE-9 WHITECOURT STP	20	
10	SITE-10 BLUE RIDGE	7	15
11	SITE-11 FT. ASSINIBOINE	300	15
12	SITE-12 PEMBINA RIVER	10	
13	SITE-13 HONT	11	15

ANALYST R K Weiman

NORWEST LABS

9938 - 67 Avenue
Edmonton, AB
T6E 0P5
(403) 438-5522

DATE	5 MAR 91
P.O. NO.	
W.O. NO.	41113

BEAK ASSOC. CONSULTING
155, 2635 - 37 AVE NE
CALGARY, AB
T1N 5Z6

BOB SHELAST

CHELATE ANALYSIS

Sample #	Sample ID	Chelate, mg/L
41113-1	1 Windfall	4.28
41113-2	2 Anc Effluent	15.82
41113-3	3 0.5 km d/s ANC	4.28
41113-4	4 0.5 km South	3.91
41113-5	5 Whitecourt	3.72
41113-7	7 MW Effluent	44.67
41113-8	8 1 km d/s MW	3.72
41113-10	10 Blue Ridge	3.54
41113-11	11 Ft. Assiniboine	3.54
41113-13	13 Hont	1.86

ANALYST

NORWEST LABS

9938 - 67 Avenue
Edmonton, AB
T6E 0P5
(403) 438-5522

DATE	5 MAR 91
P.O. NO.	
W.O. NO.	41113

BEAK ASSOC. CONSULTING
155, 2635 - 37 AVE NE
CALGARY, AB
T1N 5Z6

BOB SHELAST

ANALYSIS

Sample #	Description	Fecal Coliforms (per 100 mls)	Klebsiella (per 100 mls)
41113-1	1 Windfall	<1	<1
41113-2	2 Anc Effluent	20,000	5000
41113-3	3 0.5 km d/s ANC	60	30
41113-4	4 0.5 km South	160	90
41113-5	5 Whitecourt	25	30
41113-7	7 MW Effluent	10,000	6000
41113-8	8 1 km d/s MW	25	90
41113-9	9 Whitecourt STP	60	-
41113-10	10 Blue Ridge	20	70
41113-11	11 Ft. Assiniboine	<1	-

ANALYST Original report sent out was signed by Rhonda

Enviro-Test Laboratories
A Division of ETL Chemspec Analytical Limited

9936 - 67th Avenue — Edmonton, Alberta T6E 0P5 Telephone: (403) 434-9509 FAX: (403) 437-2311

CHEMICAL ANALYSIS REPORT

BEAK ASSOCIATES CONSULTING
#155, 2635-37 AVE N.E.
CALGARY, ALBERTA
T1Y 5Z6 ATTN: BOB SHELAST

Date: May 7th, 1991

Lab Sample #: 91-D1052 Revision Sampled By: Client

Customer #: _____ Date Received: February 22, 1991

Sample Description: 10 water samples for Resin Acid analysis.

METHOD REFERENCE: Official Pulp and Paper Research Insititute of Canada "Method for Resin and Fatty Acids", Point Claire, Quebec (GC/MS)

RESULTS:

LAB SAMPLE#:	91-D1052-1	91-D1052-2	91-D1052-3
SAMPLE I.D.:	Site # 1	Site # 3	Site # 4
PARAMETER:	ppm, mg/L	ppm, mg/L	ppm, mg/L
Linoleic Acid	N.D.	N.D.	N.D.
Oleic Acid	N.D.	N.D.	N.D.
Pimaric Acid	N.D.	N.D.	N.D.
Sandaracopimaric Acid	N.D.	N.D.	N.D.
Isopimaric Acid	N.D.	N.D.	N.D.
Palustric Acid	N.D.	N.D.	N.D.
Dehydroabietic Acid	N.D.	N.D.	N.D.
Abietic Acid	N.D.	N.D.	N.D.
Neoabietic Acid	N.D.	N.D.	N.D.
Chlorodehydroabietic Acid	N.D.	N.D.	N.D.
Dichlorodehydroabietic Acid	N.D.	N.D.	N.D.

N.D. - Not detected, less than 0.010 ppm

91-D1052 Cont'd

LAB SAMPLE#:	91-D1052-4	91-D1052-5A	91-D1052-5B
SAMPLE I.D.:	Site # 5	Site # 7 (Duplicate)	Site # 7 (Duplicate)
PARAMETER:	ppm, mg/L	ppm, mg/L	ppm, mg/L
Linoleic Acid	N.D.	N.D.	N.D.
Oleic Acid	N.D.	N.D.	N.D.
Pimaric Acid	N.D.	N.D.	N.D.
Sandaracopimaric Acid	N.D.	N.D.	N.D.
Isopimaric Acid	N.D.	N.D.	N.D.
Palustric Acid	N.D.	N.D.	N.D.
Dehydroabietic Acid	N.D.	N.D.	N.D.
Abietic Acid	N.D.	N.D.	N.D.
Neoabietic Acid	N.D.	N.D.	N.D.
Chlorodehydroabietic Acid	N.D.	N.D.	N.D.
Dichlorodehydroabietic Acid	N.D.	N.D.	N.D.

N.D. - Not detected, less than 0.010 ppm

91-D1052 Cont'd

LAB SAMPLE#:	91-D1052-6	91-D1052-7	91-D1052-8
SAMPLE I.D.:	Site # 8	Site # 10	Site # 11
PARAMETER:	ppm, mg/L	ppm, mg/L	ppm, mg/L
Linoleic Acid	N.D.	N.D.	N.D.
Oleic Acid	N.D.	N.D.	N.D.
Pimaric Acid	N.D.	N.D.	N.D.
Sandaracopimaric Acid	N.D.	N.D.	N.D.
Isopimaric Acid	N.D.	N.D.	N.D.
Palustric Acid	N.D.	N.D.	N.D.
Dehydroabietic Acid	N.D.	N.D.	N.D.
Abietic Acid	N.D.	N.D.	N.D.
Neoabietic Acid	N.D.	N.D.	N.D.
Chlorodehydroabietic Acid	N.D.	N.D.	N.D.
Dichlorodehydroabietic Acid	N.D.	N.D.	N.D.

N.D. - Not detected, less than 0.010 ppm

91-D1052 Cont'd

LAB SAMPLE#:	91-D1052-9	91-D1052-10A	91-D1052-10B
SAMPLE I.D.:	Site # 13	Site #2 (Duplicate)	Site #2 (Duplicate)
PARAMETER:	ppm, mg/L	ppm, mg/L	ppm, mg/L
Linoleic Acid	N.D.	N.D.	N.D.
Oleic Acid	N.D.	N.D.	N.D.
Pimaric Acid	N.D.	N.D.	N.D.
Sandaracopimaric Acid	N.D.	N.D.	N.D.
Isopimaric Acid	N.D.	N.D.	N.D.
Palustric Acid	N.D.	N.D.	N.D.
Dehydroabietic Acid	N.D.	N.D.	N.D.
Abietic Acid	N.D.	N.D.	N.D.
Neoabietic Acid	N.D.	N.D.	N.D.
Chlorodehydroabietic Acid	N.D.	N.D.	N.D.
Dichlorodehydroabietic Acid	N.D.	N.D.	N.D.

N.D. - Not detected, less than 0.010 ppm

Surrogate recovery: 88% (n=13)

91-D1052 Cont'd

LAB SAMPLE#:	91-D1052-Spike
SAMPLE I.D.:	Fortified Sample
PARAMETER:	**% Recovery**
Linoleic Acid	86%
Oleic Acid	92%
Pimaric Acid	98%
Sandaracopimaric Acid	94%
Isopimaric Acid	108%
Palustric Acid	69%
Dehydroabietic Acid	104%
Abietic Acid	106%
Neoabietic Acid	66%
Chlorodehydroabietic Acid	105%
Dichlorodehydroabietic Acid	102%

N.D. - Not detected, less than 0.010 ppm

Surrogate recovery: 88% (n=13)

CERTIFIED BY: _____
Doug Johnson, Residue Analyst

APPROVED BY: Leanne Lawrence
Leanne Lawrence, Project Manager

ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.