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WINTER WATER QUALITY SURVEY ON THE ATHABASCA RIVER, FEBRUARY 1993

JUNE 1993

WINTER WATER QUALITY SURVEY
ON THE ATHABASCA RIVER
FEBRUARY 1993

Prepared For:

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

Prepared By:

SENTAR CONSULTANTS LTD.
CALGARY, ALBERTA

June 1993
Project No.: 09-682-01-01

SENTAR

June 7, 1993
File No.: 09-682-01-01

Mr. Brian Steinback
Alberta Newsprint Company
P.O. Bag 9000
Whitecourt, Alberta
T0E 2L0

Dear Brian:

Reference: 1993 Winter Water Quality Survey on the Athabasca River

Please find enclosed our final report on the 1993 Winter Water Quality Survey on the Athabasca River. We have incorporated your review comments on an earlier draft into the final report.

We trust that the report fulfills your requirements to Alberta Environmental Protection. If you have any further questions or comments on the report, please call the undersigned.

Yours truly,

SENTAR CONSULTANTS LTD.

Bob Shelast

Bob Shelast, P.Biol.
Senior Aquatic Biologist

BS/bs
Enclosure

SENTAR CONSULTANTS LTD.
STANLEY TECH CENTRE, 200, 1122 - 4th Street S.W., Calgary, Alberta, Canada T2R 1M1 Phone (403)269-9300 Fax (403)269-1527

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1.0 INTRODUCTION

As part of the license requirements of Alberta Environment, Millar Western Pulp Ltd. (Millar Western) and Alberta Newsprint Company (ANC) were required to conduct a winter water quality monitoring survey in the Athabasca River during the winter of 1992/1993. Previous winter water quality surveys were conducted in 1990, 1991 and 1992 and are part of the ongoing environmental monitoring programs established by both Millar Western and ANC. 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 11,000 to 14,000 m^3/day. The ANC TMP newsprint mill became operational in August 1990 and discharges treated effluent to the Athabasca River at a rate of about 13,000 to 18,000 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). Two additional sites, the ANC effluent and the south channel 0.5 km downstream of the ANC outfall, were established during the 1990/1991 sampling program (Beak 1991).

2.2 SAMPLE COLLECTION AND ANALYSES

The water quality survey was conducted on the 17 and 18 February 1993. 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. Additionally, this time frame was chosen because it coincided with Alberta Environmental Protection's 1993 synoptic survey as well as work done by the Northern River Basins Study.

Grab samples were collected from most sites on the Athabasca River and tributary streams by immersing a stainless steel sampler affixed with the sample bottle below the ice surface in the channel thalweg. The samples collected at Sites 3 and 8 were taken via helicopter 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. In previous years, Site 4 was also sampled in the open water lead created by ANC effluent discharge; however, during this survey, Site 4 was completely ice-covered. The samples were taken about 20 cm below the water surface. Field observations indicated that large amounts of frazil ice were present at Sites 4 and 11 at the time of sampling. Effluent samples were taken directly from the ANC and Millar Western effluent pumphouses and the Whitecourt sewage treatment plant. River time of travel between sites was incorporated into the sampling regime, where logistically possible. All samples were preserved in the field by standard methods, stored on ice, and forwarded within 24 hours to the laboratory for analysis.

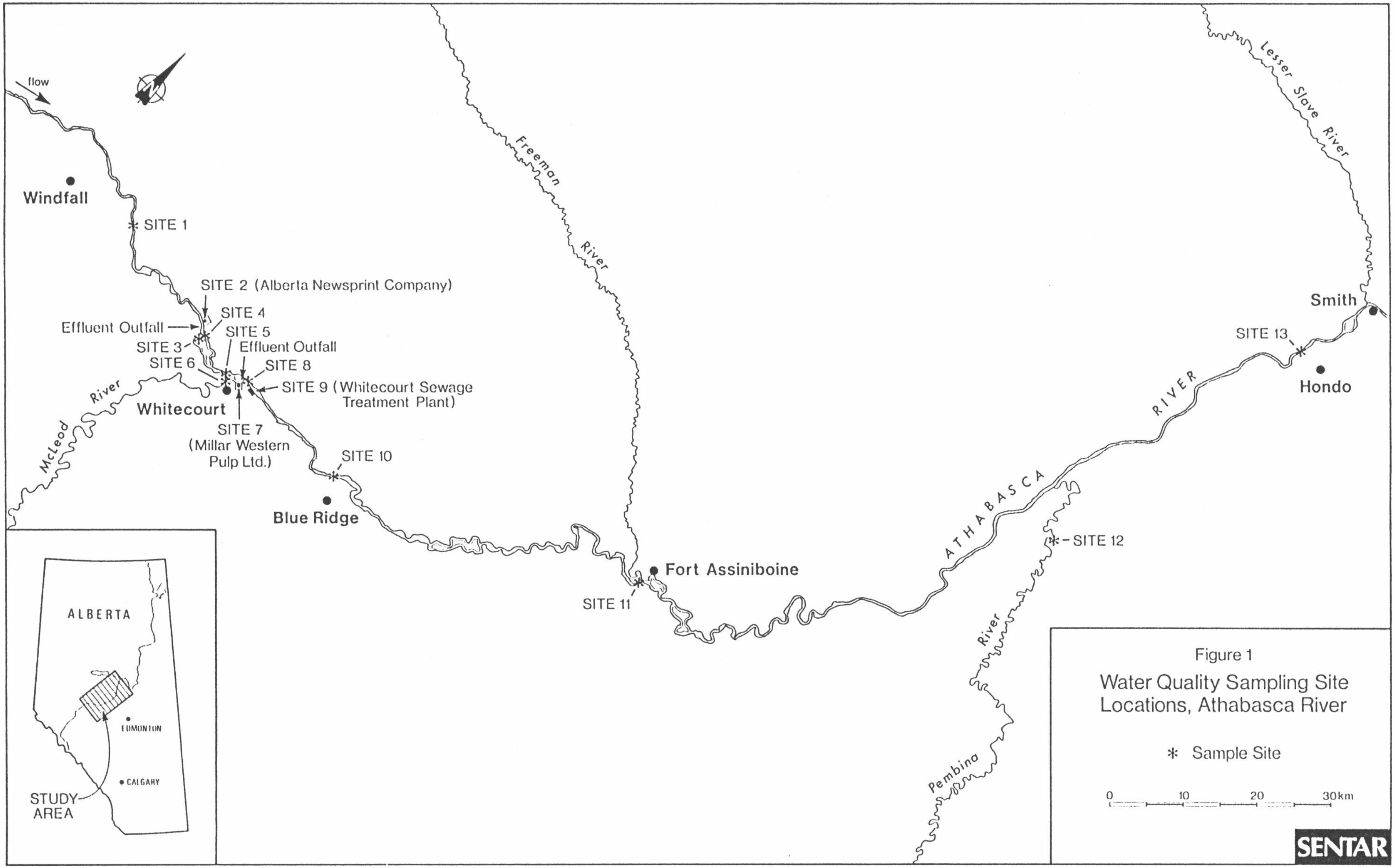


Figure 1
Water Quality Sampling Site Locations, Athabasca River

Table 1. **Sample site and sampling point locations.**

Site	Location	Date and Time Sampled	Sampling Point[a]
1	Windfall bridge	17/02, 900	40 m from right bank
2	ANC effluent	17/02, 1050	effluent pumphouse
3	0.5 km downstream of ANC outfall (north channel)	17/02, 1100	mid-channel
4	0.5 km downstream of ANC outfall (south channel)	17/02, 1140	15 m from left bank
5	Whitecourt (upstream of the McLeod River)	17/02, 1415	10 m from right bank
6	McLeod River at mouth	17/02, ~~150~~5	60 m from left bank
7	Millar Western effluent	17/02, 1650	effluent pumphouse
8	1 km downstream of Millar Western outfall	17/02, 1125	mid-channel
9	Whitecourt sewage treatment plant effluent	17/02, 1550	treatment plant
10	Blue Ridge	18/02, 1005	30 m from left bank
11	Fort Assiniboine	18/02, 1150	20 m from left bank
12	Pembina River near Flatbush	18/02, 1455	15 m from right bank
13	Hondo	18/02, 1605	65 m from right bank

[a] Left and right banks were determined looking downstream

The sampling regime for each site for the various water quality parameters is shown on Table 2. Field measurements for temperature, pH, conductivity and dissolved oxygen were taken at all sites using a pocket thermometer (± 0.5 °C), a pHep Hanna Instruments pH meter (± 0.1 unit) , a Hach Model 16300 portable conductivity meter (± 10 μmhos/cm) and a YS1 Model 54A dissolved oxygen meter (± 0.2 ppm), respectively.

Chemical analyses for all parameters, except resin acids were conducted by Norwest Labs of Edmonton using standard methods (Appendix I). Resin acid analyses were done by Enviro-Test Laboratories of Edmonton using GC/SIM-MS, in accordance with the Pulp and Paper Research Institute of Canada (PAPRICAN) methods (Appendix I). Dissolved oxygen samples were preserved in the field using the azide modification of the Winkler method where 1 mL of manganese sulphate was added to the sample followed by a 1 mL addition of alkali-iodide azide.

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 (WSC) stations at Hinton on the Athabasca River (Station No. 07AD002) and at Rosevear on the McLeod River (Station No. 07AG007). Discharge data for the WSC station at Windfall on the Athabasca River (Station No. 07AE001) was not available for the sampling period.

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 a	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	X		X
Resin Acids	X	X	X	X	X		X	X		X	X		X

a Measured in the field
x Sample taken at site

3.0 RESULTS AND DISCUSSION

Results for the water samples collected from each of the sites during the February 1993 survey are presented on Table 3.

3.1 DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

Dissolved oxygen at low concentrations can become a limiting factor for the maintenance of aquatic life. Dissolved oxygen concentrations in surface waters are affected by photosynthetic activity, biological respiration, temperature and reoxygenation from the atmosphere. During the winter months, under ice cover when atmospheric reaeration is limited or does not occur, bacterial decomposition of organic materials and chemical oxidation of inorganic and organic materials can reduce or totally deplete dissolved oxygen in rivers.

Field measurements of dissolved oxygen concentrations at sites on the Athabasca River ranged from 11.0 to 13.6 mg/L which represents 80 to 103% saturation (Figure 2). Dissolved oxygen concentrations measured in the field for the ANC effluent, Millar Western effluent and Whitecourt sewage effluent were 7.6, 5.5 and 6.7 mg/L, respectively, which represents 96, 76 and 57% saturation, respectively. Two of the major tributaries to the Athabasca River within the study area, the McLeod and Pembina rivers, had dissolved oxygen concentrations of 9.2 and 5.9 mg/L respectively, which represents 69 and 39% saturation, respectively. Laboratory measurements for dissolved oxygen varied greatly from the field measurements at some sites and are not considered reliable or indicative of actual dissolved oxygen levels. It is possible that some samples were not properly preserved due to the frazil ice in the sample.

Dissolved oxygen concentrations at most sites on the Athabasca River were slightly below the background level recorded at Site 1 (Windfall). However, a more appropriate comparison would be in saturation levels, since the solubility of oxygen in water is temperature dependent and there were water temperature differences between sites during field measurements for dissolved oxygen. When saturation levels are compared, only the three lowermost sites at Blue Ridge (Site 10), Fort Assiniboine (Site 11) and Hondo (Site 13) exhibited any appreciable decrease in dissolved oxygen saturation. The dissolved oxygen sag at Fort Assiniboine and Hondo has been documented in previous winter water quality studies on the Athabasca River (Noton and Shaw 1989, Beak 1990, 1991, SENTAR

Table 3. Water quality results for the Athabasca River, tributary streams and effluent sources, 17 and 18 February 1993 (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	23.5	2.5	0	0	0	28.0	2.0	5.0	0	0	0	0	Increase of 3°C	-
pH (units)	8.0	7.7	7.7	8.0	8.0	7.7	8.2	7.7	7.2	7.5	7.8	7.2	7.6	6.5 - 8.5	6.5 - 9.0
Dissolved Oxygen (field)	13.1	7.6	12.9	13.2	13.6	9.2	5.5	12.8	6.7	12.5	11.4	5.9	11.0	5.0	5.0 - 9.5
DO saturation (%) (field)	98	96	103	99	101	69	76	101	57	89	89	39	80	-	-
BOD$_5$	1.5	23.0	5.0	5.0	5.0	5.0	27.0	5.0	6.0	1.3	2.1	1.7	1.0	-	-
Specific Conductance (μmhos/cm)	260	1380	600	525	540	580	5300	555	960	520	540	880	590	-	-
Sodium	11.9	145.0	12.8	12.1	13.0	26.2	1230.0	16.2	-	17.4	19.7	-	20.1	-	-
Sulphate	79.1	401.0	81.9	81.6	81.2	22.0	583.0	80.3	-	75.3	76.9	-	73.9	-	-
Chloride	8.7	69.2	9.3	8.7	8.9	-	56.6	9.0	-	8.1	6.4	-	6.0	-	-
Manganese (total)	0.005	2.010	0.052	0.096	0.035	-	1.650	0.112	-	0.040	0.179	-	0.040	-	-
Zinc (total)	<0.005	0.381	<0.005	<0.005	<0.005	-	0.703	<0.005	-	<0.005	<0.005	-	<0.005	0.05	0.03
Silica (dissolved)	6.6	7.8	6.6	6.9	6.5	10.8	175.0	7.2	-	7.4	8.7	-	7.9	-	-
Total Phosphorus (as P)	<0.002	1.920	0.025	0.038	0.003	-	0.210	0.025	1.620	<0.002	0.100	-	0.014	0.05	-
Dissolved Phosphorus (as P)	<0.002	1.580	0.007	<0.002	0.003	-	0.037	<0.002	1.520	<0.002	0.054	-	0.010	-	-
Nitrate and Nitrite Nitrogen	0.22	3.15	0.27	0.20	0.20	-	0.22	0.20	13.80	0.14	0.29	-	0.21	-	-
Total Kjeldahl Nitrogen	0.29	4.34	0.29	0.71	0.14	-	9.69	0.57	3.35	0.21	0.50	-	0.07	1.0	-
Ammonia Nitrogen	0.030	0.005	0.026	0.026	0.021	-	1.800	0.046	1.800	0.036	<0.005	-	0.029	-	1.53[b]
Total Organic Carbon	2.9	30.8	3.0	3.0	2.8	-	195.0	4.0	-	3.3	3.5	-	3.8	-	-
Total Suspended Solids	7	49	4	78	6	4	45	7	10	6	87	5	4	Increase of 10	-
True Color (units)	25	290	25	20	20	-	780	30	-	15	10	-	10	Increase of 30	-
Total Phenols	0.004	0.082	0.006	0.005	0.005	-	0.039	0.007	-	0.005	0.005	-	0.004	0.005	0.001
Chelates (EDTA and DTPA)	6.5	24.8	6.1	8.0	8.0	-	62.0	6.1	-	5.8	5.7	-	8.0	-	-
Fecal Coliforms (MPN per 100 mL)	<1	1900	8	<1	36	-	150	10	30,000	150	14	-	28	<5,000/100 mL	-
Klebsiella (MPN per 100 mL)	<1	2,000	6	<1	48	-	40	<1	6200	22	14	-	18	-	-
Resin and Fatty Acids														100	-
Abietic acid	<0.0020	0.0033	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Dehydroabietic acid	<0.0020	0.0034	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Isopimaric	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Levopimaric acid	<0.0020	0.0030	<0.0020	<0.0020	<0.0020	-	0.0100	<0.0020	-	<0.0020	<0.0020	-	<0.0020		
Neoabietic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Palustric acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Pimaric acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-

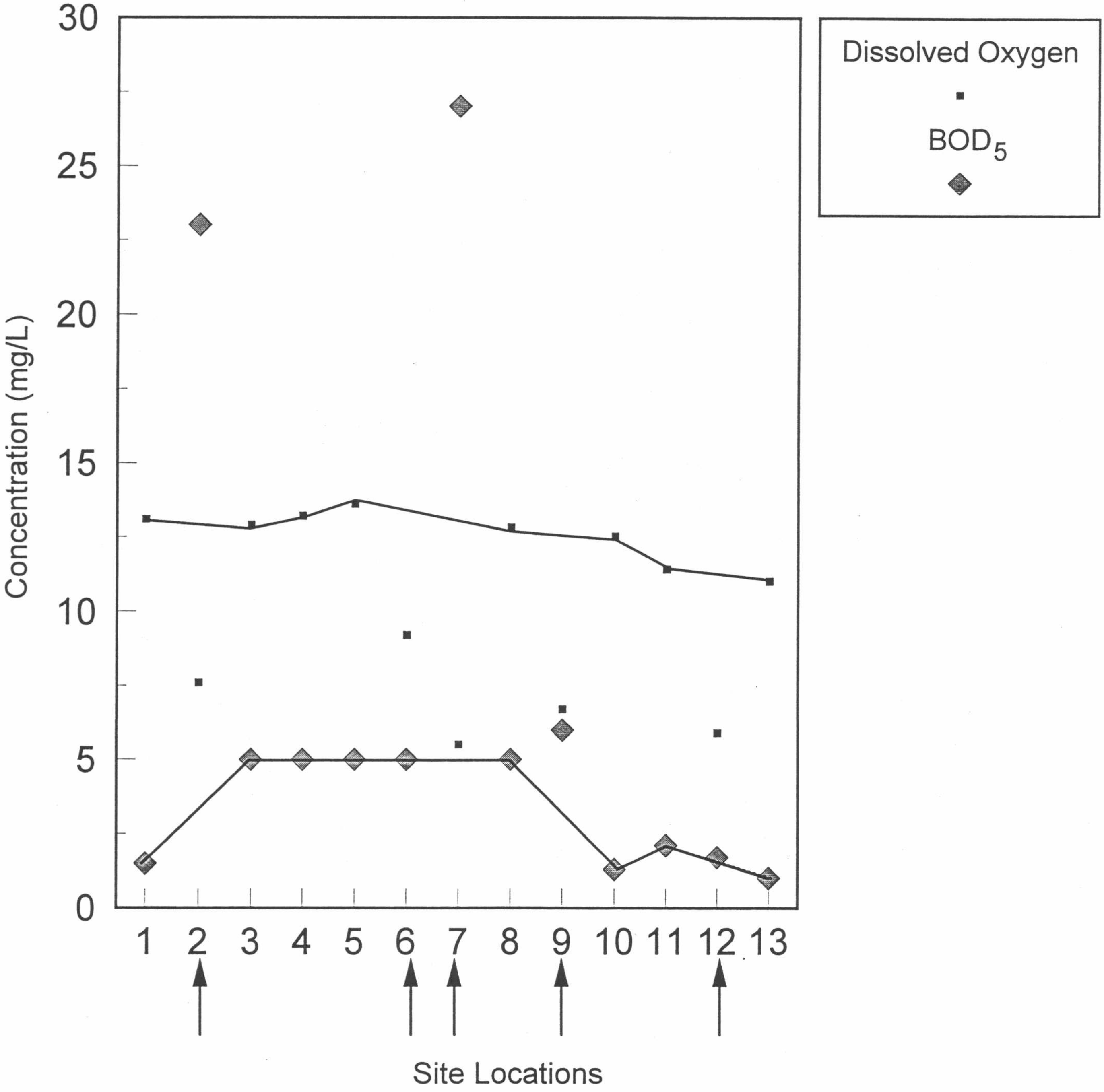
(continued)

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]
Sandaracopimaric acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Chlorodehydroabietic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Dichlorodehydroabietic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Arachidic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Dichlorostearic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Linoleic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Linolenic acid	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Myristic acid	<0.0020	<0.0020	0.0051	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	<0.0020	-	<0.0020	-	-
Oleic acid	<0.0020	<0.0020	0.0078	<0.0020	<0.0020	-	<0.0020	0.0027	-	<0.0020	<0.0020	-	<0.0020	-	-
Palmitic acid	<0.0020	0.0130	0.0180	<0.0020	<0.0020	-	0.0021	0.0055	-	<0.0020	<0.0020	-	<0.0020	-	-
Stearic acid	<0.0020	<0.0020	0.0070	<0.0020	<0.0020	-	<0.0020	0.0023	-	<0.0020	<0.0020	-	<0.0020	-	-

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°C.



Note: Arrows designate effluent outfall and tributary stream locations; solid lines represent Athabasca River sites

Figure 2. Dissolved Oxygen and BOD$_5$ concentrations for the Athabasca River, tributary streams and effluent sources, 17 and 18 February 1993.

1992). The sites immediately below the ANC and Millar Western effluent outfalls had higher dissolved oxygen saturation levels than the background site as a result of aeration in the open water leads created by effluent discharge.

All dissolved oxygen concentrations recorded in the field at sites on the Athabasca River were substantially 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) is a measure of the amount of oxygen required for aerobic microorganisms to oxidize organic matter to a stable inorganic form (CCREM 1987); BOD may also measure the oxygen used to oxidize forms of nitrogen. BOD_5 values at sites on the Athabasca River and tributary streams were low ranging from 1.0 to 5.0 mg/L (Figure 2). BOD_5 concentrations in ANC effluent, Millar Western effluent and the Whitecourt sewage treatment plant (STP) effluent were 23.0, 27.0 and 6.0 mg/L, respectively. Effluent discharge from these sources resulted in an increase in BOD_5 concentrations at sites below the effluent outfalls where concentrations were 5.0 mg/L compared to the background value of 1.5 mg/L. However, BOD_5 concentrations at the three lowermost sites on the Athabasca River, Site 10 (Blue Ridge), Site 11 (Fort Assiniboine) and Site 13 (Hondo), were similar to or lower than the background site. The slight increase at Site 11 was probably due to the resuspension of organic sediment from the scouring effect of the large amount of frazil ice in the water column at this site. This trend has been observed in all previous winter water quality studies done on the river for Millar Western and ANC.

BOD_{30} was determined for two sites on the Athabasca River, Site 11 at Fort Assiniboine and Site 13 at Hondo. BOD_{30} concentrations at these sites were 4.0 and 1.7 mg/L, respectively (Appendix 1). BOD_5 concentrations at Sites 11 and 13 during this time were 2.1 and 1.0 mg/L, respectively.

3.2 SPECIFIC CONDUCTANCE, MAJOR IONS AND METALS

Specific conductance is a measure of the ability of water to conduct an electrical current and provides an indication of the dissolved solids in water (McNeely et al. 1979). Typically specific conductance and dissolved solids are highest during periods of ice cover when dilution from surface flow is at a minimum and dissolved solids are concentrated through ice cover formation. Specific conductance at sites on the Athabasca River ranged from 560 to 600 μmhos/cm. Effluent from ANC, Millar Western and the Whitecourt sewage treatment plant were substantially higher in conductivity with values of 1380, 5300 and 960 μmhos/cm, respectively. However, effluent discharge from these sources did not have any effect on specific conductance values recorded at sites below the effluent outfalls.

Sodium concentrations in the Athabasca River downstream of Whitecourt increased above background levels due to effluent discharge from the ANC and Millar Western mills. A background sodium value of 11.9 mg/L was recorded at the Windfall site. Discharge of ANC effluent, with a concentration of 145.0 mg/L, resulted in a slight increase in concentrations at sites in the Athabasca River immediately below the effluent outfall. Discharge of Millar Western effluent, with a sodium concentration of 1230 mg/L, resulted in an increase of about 4 to 8 mg/L sodium at sites on the Athabasca River below Whitecourt. The McLeod River with a sodium concentration of 26.2 mg/L, was also a contributor of sodium to the Athabasca River. Although the ANC and Millar Western effluents generally contained higher concentrations of sulphate and chloride than the background sites on the Athabasca River, concentrations of these parameters in the river were only slightly affected by effluent discharges. Sulphate concentrations in the ANC and Millar Western effluents were 401.0 and 583.0 mg/L, respectively, while chloride concentrations in these effluents were 69.2 and 56.6 mg/L respectively. Sulphate and chloride concentrations of 79.1 and 8.7 mg/L, respectively, were recorded at the background site. Sulphate concentrations at sites on the Athabasca River below effluent discharge points ranged from 73.9 to 83.9 mg/L while chloride concentrations at these sites ranged from 6.0 to 9.3 mg/L.

Manganese concentrations at sites on the Athabasca River were affected by effluent discharge from ANC or Millar Western. A manganese concentrations of 0.005 mg/L, was recorded at background Site 1. The ANC and Millar Western effluents had manganese concentrations of 2.010 and 1.650 mg/L, respectively. At sites below the ANC effluent outfall, manganese concentrations ranged between 0.035 and 0.096 mg/L while at sites below Millar Western, concentrations ranged between 0.040 and 0.179 mg/L. The highest value was recorded at Site 11 at Fort Assiniboine. It should be noted that large amounts of frazil ice were present in the water column at this site. Streambed scour from the frazil ice and the associated resuspension of bottom sediment containing manganese is the probable source for these atypical, elevated levels of manganese. Although both ANC and Millar Western effluents contained zinc in concentrations above the background level of

<0.005 mg/L, effluent discharge did not affect concentrations at downstream sites in the river , where zinc levels were below the detection limit of 0.005 mg/l. 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

Phosphorus is the nutrient that limits productivity in most freshwater ecosystems (Wetzel 1983). Increasing concentrations of phosphorus often result in increased biomass of algae, aquatic macrophytes and associated biota. Phosphorus occurs in organic and inorganic forms and can be present in water as a dissolved or particulate species (McNeely et al. 1979). Phosphorus absorbs readily to suspended and bottom sediments. Phosphorus loads from sewage and pulp mills effluents can be high and agricultural drainage from fertilized land can contribute phosphorus to water. It is sometimes added to pulp mill effluents to enhance the biological degradation of the pulping wastes.

Total phosphorus concentrations at most sites on the Athabasca River were higher than the background level of <0.002 mg/L. The highest total phosphorus concentration ocurred at the site at Fort Assiniboine (Site 11) where a value of 0.100 mg/L was recorded. The relatively high total phosphorus concentration at this site was due to frazil ice scour resulting in high concentrations of suspended solids (particulate matter) to which phosphorus is bound; dissolved phosphorus concentrations at this site formed about half of the total phosphorus concentration. The total phosphorus concentration in ANC effluent was 1.920 mg/L most of which was in dissolved form (1.580 mg/L). This represents a substantial decrease in the amount of total phosphorus in ANC effluent, compared to previous winter surveys. The Millar Western effluent had a total phosphorus concentration of 0.210 mg/L most of which was absorbed to particulate organic matter. The Whitecourt sewage treatment effluent had a total phosphorus concentration intermediate to the ANC and Millar Western effluent with a value of 1.620 mg/L, most of which was in dissolved form. Effluent discharge from ANC, Millar Western and the Whitecourt sewage treatment plant did increase total phosphorous concentrations in the Athabasca River above background levels. However, both total and dissolved phosphorus concentrations were near background levels at the Whitecourt site (Site 5) below ANC and were at background levels at the site at Blue Ridge (Site 10). All total phosphorus concentrations at sites on the Athabasca River, with the exception of Site 11, were below the ASWQO of 0.05 mg/L. When comparing dissolved phosphorus concentrations between the background and downstream sites, it appears that effluent discharge from ANC and, to a lesser extent, Millar Western and the Whitecourt sewage treatment plant has resulted in slightly elevated dissolved phosphorus concentrations in the Athabasca River. A dissolved phosphorus concentration of <0.002 mg/L was recorded at the background site while levels at all sites on the Athabasca River receiving effluent ranged from <0.002 to 0.054 mg/L. As mentioned previously, the highest concentration was recorded at Site 11 and was probably the result of re-suspension of phosphorus-bound particulate matter.

Nitrate is the principal and most stable form of combined nitrogen found in surface waters. The highly soluble nitrate ion results from the complete oxidation of nitrogen compounds. Plants are capable of converting nitrates to organic nitrogen and since nitrates stimulate plant growth, algae can flourish in the presence of nitrates. Most surface waters contain some nitrates. Industrial and municipal discharges and waters draining agricultural lands where inorganic nitrate fertilizers are used, may contain substantial nitrate concentrations (McNeely et al. 1979). Nitrite is an intermediate, partly oxidized form of nitrogen that is usually found in minute quantities in surface waters, since it is rapidly oxidized to the more stable nitrate ion. The presence of nitrite in aquatic systems is usually the result of industrial effluents and is toxic to fish (CCREM 1987). Nitrate and nitrite nitrogen concentrations at most sites on the Athabasca River were similar to the background level of 0.22 mg/L and were not affected by effluent discharge. Nitrate and nitrite nitrogen concentrations in both the ANC and Millar Western effluents were 3.15 and 0.22 mg/L, respectively, while the Whitecourt sewage treatment plant had a concentration of 13.80 mg/L.

Total Kjeldahl nitrogen (TKN) measures both ammonia and organic nitrogen. Both of these forms of nitrogen are present in nitrogenous organic detritus from natural biological activities (McNeely et al. 1979). TKN may contribute to the overall abundance of nutrients in water and is important for assessing available nitrogen for biological activities. TKN concentrations in the ANC, Millar Western and Whitecourt sewage treatment plant effluents ranged from 3.35 to 9.69 mg/L. Total Kjeldahl nitrogen concentrations in the Athabasca River were generally below the background concentrations of 0.29 mg/L and did not appear to be affected by effluent discharge except at the site immediately below the Millar Western outfall (Site 8). The maximum concentrations recorded in the Athabasca River occurred at Sites 4 and 11 and were probably the result of the re-suspension of organic sediments, based on the relatively high suspended sediment concentrations at these sites. All total kejeldahl nitrogen concentrations in the Athabasca River were well below the ASWQO of 1.0 mg/L.

Ammonia is the most reduced inorganic form of nitrogen in water and includes dissolved ammonia and the ammonium ion. Nitrogen-fixing bacteria living in association with plants or in soil or water reduce nitrogen to ammonia and the ammonium ion (McNeely et al. 1979). Ammonia is produced naturally by the biological degradation of nitrogenous matter in soil and water or ammonia associated with clay minerals can enter the aquatic environment by soil erosion. Ammonia can enter the aquatic environment through the use of commercial fertilizers and from the discharge of municipal wastewater and pulp and paper mill effluents. Ammonia is a toxic substance and fish cannot tolerate large quantities of ammonia since it reduces the oxygen-carrying capacity of the blood. Ammonia toxicity is related to the amount of dissociated ammonium ion and is dependent upon both pH and dissolved oxygen (McNeely et al. 1979).

Ammonia concentrations were quite variable among sites on the Athabasca River and exceeded the background level of 0.030 mg/L at Sites 8 and 10 where values of 0.046 and 0.036 mg/L, respectively, were recorded. The ammonia nitrogen concentration in the ANC effluent was 0.005 mg/L which was considerably lower than the background level. The highest ammonia concentration in effluent sources was recorded at both Millar Western and the Whitecourt sewage treatment plant where a value of 1.800 mg/L ammonia nitrogen was recorded. Effluent discharge from these sources resulted in an increase in ammonia concentrations at downstream sites on the Athabasca River.

Total organic carbon is composed of both dissolved and particulate organic carbon and is directly related with both biochemical and chemical oxygen demand. Sources of total organic carbon include runoff from agricultural land and municipal and industrial waste discharges (McNeely et al. 1979). Total organic carbon concentrations were above the background level of 2.9 mg/L at sites below the Millar Western effluent outfall. A total organic carbon concentration of 195.0 mg/L was recorded in the Millar Western treated effluent. At sites below the Millar Western outfall, total organic carbon concentrations ranged from 3.3 to 4.0 mg/L. A total organic carbon concentration of 30.8 mg/L was recorded in the ANC effluent; however, concentrations at sites on the Athabasca River immediately below ANC were unaffected by effluent discharge.

Silica concentrations at sites on the Athabasca River ranged from 6.5 to 8.7 mg/L compared to the background value of 6.6 mg/L. Elevated silica concentrations were observed at the sites below Millar Western's effluent outfall. Discharge of effluent from Millar Western, with a silica concentration of 175.0 mg/L, was the probable source for the elevated silica values at these sites although the resuspension of bottom sediments from frazil ice scour was also a possible source at the Fort Assiniboine site. The McLeod River, with a concentration of 10.8 mg/L, was a minor contributor of silica to the Athabasca River.

3.4 SUSPENDED SOLIDS AND COLOR

Turbidity in water is caused by the presence of suspended matter such as clay, silt, organic matter, plankton and other microscopic organisms that are held in suspension (McNeely et al. 1979). Total suspended solids (TSS) are measured by the solids that are retained in a filter. TSS concentrations are highly variable in rivers and normally increase with flow rate as a result of scouring of river beds and banks and resuspension of particles. Particulate matter may act as a sorption surface for organic compounds, nutrients and heavy metals, and bacterial degradation of particulate organic matter may contribute to deoxygenation of the water (CCREM 1987).

Total suspended solids concentrations were low at most sites on the Athabasca River, ranging from 4 to 7 mg/L. Anomalous values of 78 and 87 mg/L were recorded at Site 4 and Site 11 (Fort Assiniboine) as a result of the resuspension of sediments due to frazil ice scour. As previously stated, field observations at these sites indicated the presence of large amounts of frazil ice throughout the water column. Total suspended solids concentrations in ANC and Millar Western effluent were 49 and 45 mg/L, respectively. Effluent discharge had no effect on suspended solids concentrations in the Athabasca River.

True color of water is the color of a filtered water sample and results from materials dissolved in the water. The color of water is derived from natural mineral components such as iron, and from dissolved organic matter such as humic acids, tannin and lignin (McNeely et al. 1979). Organic and inorganic compounds from industrial or agricultural uses may add color to water. Pulp mill effluents and tributary streams are sources of color to the Athabasca River.

True color values at sites on the Athabasca River were unaffected by effluent discharge from both ANC and Millar Western. A true color value of 240 units was recorded in the

ANC effluent while the Millar Western effluent had a true color of 780 units. True color values at all sites below effluent discharge points were well within the ASWQO which allows a maximum increase of 30 units above background values.

3.5 PHENOLS

Total phenol measurement is an attempt to determine the overall presence of the family of organic compounds which possess a benzene ring on which one or more hydroxyl groups are attached. Phenolic compounds can occur naturally in the environment as break-down products of biological decomposition (CCREM 1987). Industrial and municipal sources can increase the phenolic concentration, which in turn can create concerns regarding taste and odour of drinking water and fish tainting.

Total phenol concentrations in the Athabasca River were slightly affected by effluent discharge. A total phenol concentration of 0.004 mg/L was recorded at the background site while concentrations at sites in the Athabasca River below the effluent outfalls ranged from 0.004 to 0.007 mg/L. Most of these phenol values are within the standard error of the analytical technique used to determine phenol concentrations. Total phenol concentrations in the ANC and Millar Western effluents were 0.082 and 0.039 mg/L, respectively. The ASWQO for total phenols of 0.005 mg/L was exceeded at all sites except at Sites 1 and 13. The CWQG 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. 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 generally below the background value of 6.5 mg/L except at Sites 4 , 5 and 13 where a concentration of 8.0 mg/L was recorded. Chelate concentrations in the ANC and Millar Western effluents were 24.8 and 62.0 mg/L, respectively. It is suspected that the source of the elevated chelate level at Sites 4 and 5 was ANC 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 slightly to between 8 and 36 MPN/100 mL. Fecal coliform concentrations in ANC and Millar Western effluents were 1900 and 150 MPN/100 mL, respectively. Effluent discharge from the Whitecourt sewage treatment plant, with a fecal coliform concentration of 30,000 MPN/100 mL, appeared to increase levels at the Blue Ridge site where a concentration of 150 MPN/100mL was recorded. By Site 13 (Hondo) fecal coliforms concentrations were still above the background level with a value of 28 MPN/100 mL.

Klebsiella concentrations increased slightly at sites below ANC and Millar Western. *Klebsiella* levels in ANC and Millar Western effluents were 2,000 and 40 MPN/100 mL, respectively. A *Klebsiella* concentration of 6,200 MPN/100mL was recorded in the Whitecourt sewage treatment plant effluent. *Klebsiella* levels at sites in the Athabasca River below the treatment plant outfall were above background levels with concentrations of 14 to 18 MPN/100 mL were recorded.

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 AND FATTY ACIDS

Resin and fatty acids are naturally-occurring compounds whose concentrations and structure can change and/or increase as a result of pulping processes. These processes include debarking, kraft, sulfite or mechanical pulping and bleach-plant caustic extraction. The principal compounds are the following (Springer 1986):

Resin acids:	abietic, dehydroabietic, isopimaric, palustric, pimaric, sandaracopimaric, neoabietic (monochloro- and dichlorodehydroabietic from chlorine-based bleach plant)
Unsaturated fatty acids:	oleic, linoleic, palmitic (derivatives from chlorine-based bleach plant - epoxystearic acid, diclorostearic acid, 3, 4, 5-trichloroguaiacol, 3, 4, 5, 6 tetrachloroguaiacol)

Resin acid concentration entering a receiving water will depend upon the wood furnish in the mill, the age of wood chips used, the mill process and the extent of biological treatment before effluent is released. If the wood furnish includes species with high resin acid content (such as lodgepole pine), there will be greater resin acid production that if species such as white spruce dominate the furnish (Taylor et al. 1988). Resin acid content of wood chips declines with age and is highest in bark.

Thermomechanical or chemi-thermomechanical pulping processes solubilize resin acids, producing sharply higher total loadings (Taylor et al. 1988). Biological treatment of pulp mill wastes is very effective at degrading resin acids, usually reducing concentrations by 90 to 99% (Taylor et al. 1988).

Although these compounds are quite toxic and can also create taste and odour problems, it is unlikely that they are transported far downstream in the water column, because they are readily broken down by secondary treatment or by natural bacterial/fungal action in receiving waters. A large variety of bacteria and fungi have been isolated from natural receiving waters that have the ability to break down resin acids. The microbial transformation products of resin acids have been shown to be over ten times less toxic than the parent compounds (Taylor et al. 1988).

Resin and fatty acids concentrations at all Athabasca River sites were below the detection limit of 0.0020 mg/L, except at Site 3 where myristic (0.0051 mg/L), oleic (0.0078mg/L), palmitic (0.0180 mg/L) and stearic (0.0070 mg/L) acid were detected and at Site 8 where oleic (0.0027 mg/L), palmitic (0.0055 mg/L) and stearic (0.0023 mg/L) acid were detected. The occurrence of these fatty acids was likely from either a source upstream of the ANC and Millar Western effluent outfalls or from natural sources since these fatty acids were either not detected in the treated effluents or were in lower concentrations than recorded in the Athabasca River.

3.9 ICE-FREE ZONE AND ATHABASCA RIVER DISCHARGE

Effluent discharge from the ANC mill resulted in an ice-free zone in the north channel of the Athabasca River below the effluent outfall (Figure 3). Previous winter studies have shown that the south channel did at one time have an ice-free zone due to effluent discharge. The open-water lead in the north channel extended for about 2.1 km and was about 15 m wide. Water temperature in the north channel was 2.5 °C and 24.0 °C in the ANC effluent. The water temperature at the background site was 0 ° C.

Effluent discharge from the Millar Western mill resulted in an ice-free zone of about 2 km downstream of the effluent outfall (Figure 4). The ice-free zone varied in width but was generally about 10 m wide. Water temperature in the open-water lead was 4.0 °C compared to a temperature of 0 ° C at the site above the lead; Millar Western effluent had a temperature of 30.0 °C.

Due to gauge malfunction from frazil ice conditions, 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 about 41 m^3/s (Alberta Environmental Protection, River Forecast Centre, pers. comm.). Based on historical data, flow in the river near Windfall in February is about 19 m^3/s higher than at Hinton.

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 60 m^3/s. Flow in the McLeod River near Rosevear during the sampling period averaged 4.6 m^3/s giving a combined flow of about 65 m^3/s for the Athabasca River at the Millar Western pulp mill. Treated effluent was discharged from the ANC mill at a rate of

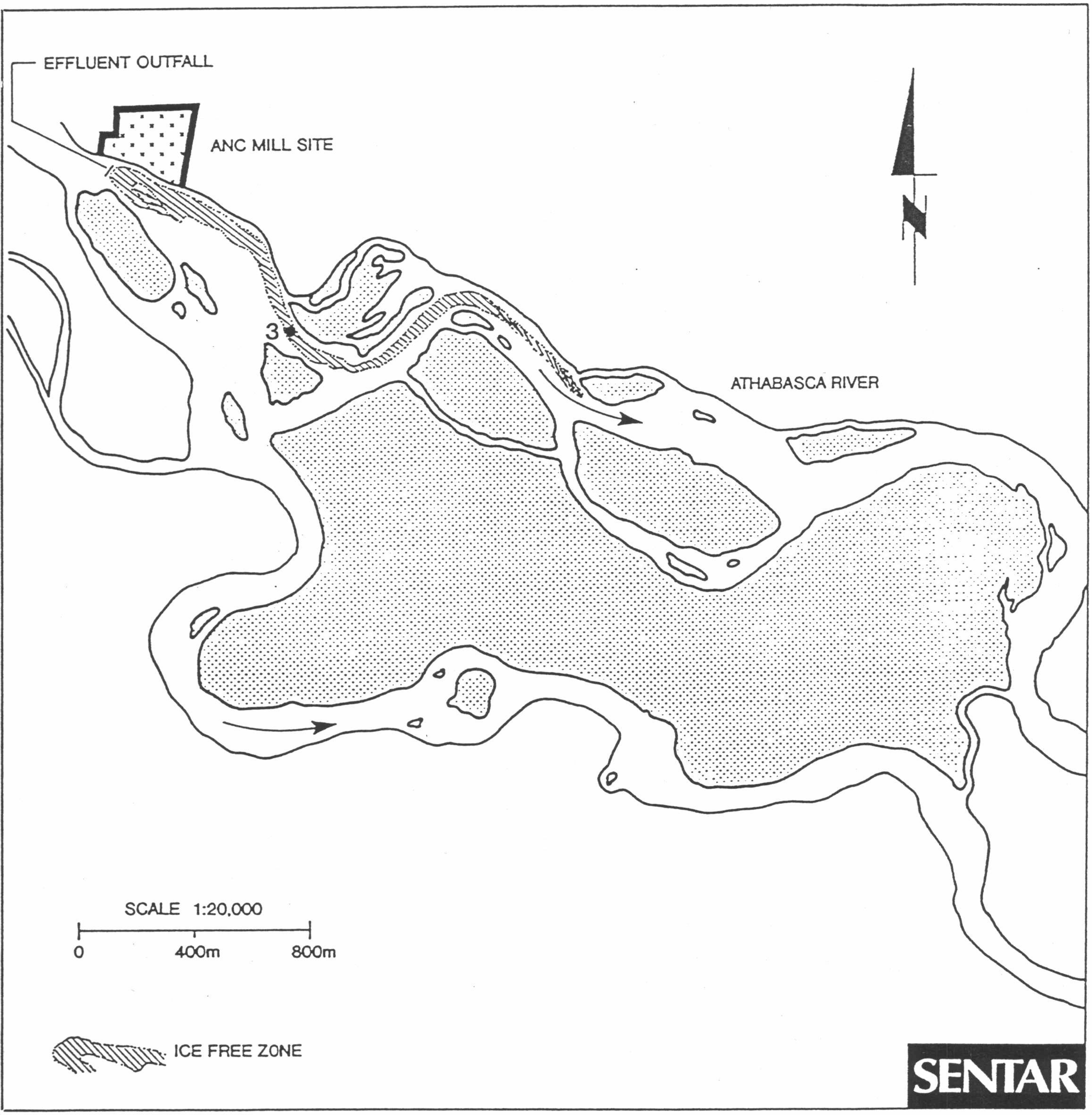


Figure 3. Ice-free zone on the Athabasca River downstream of the ANC effluent outfall, February 1993.

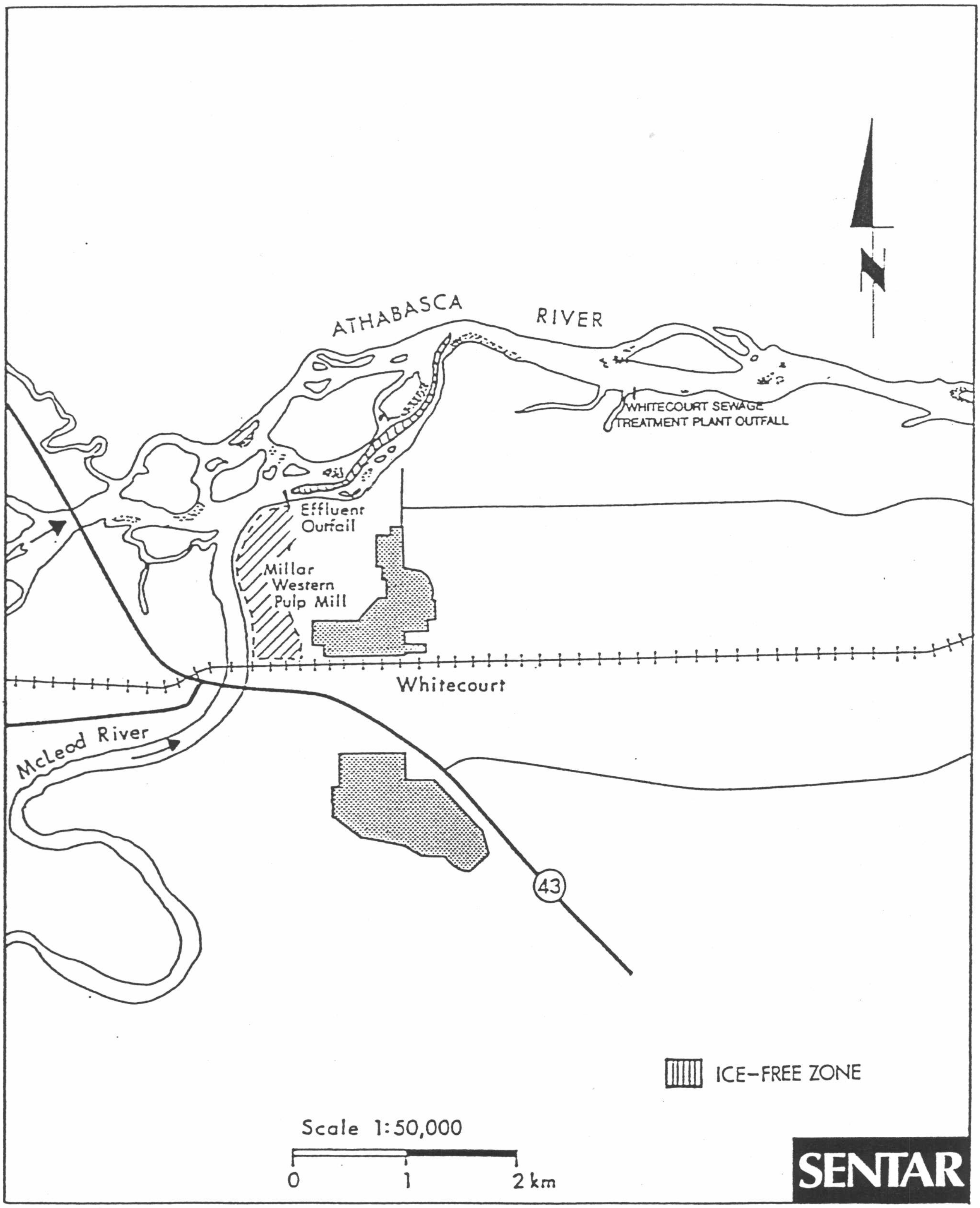


Figure 4. **Ice-free zone on the Athabasca River downstream of the Millar Western effluent outfall, February 1993.**

15,483 m^3/day (0.179 m^3/s) during February 1993 while mean monthly discharge from the Millar Western mill during this time was 11,387 m^3/day (0.132 m^3/s).

Historical streamflow data for the Athabasca River near Windfall indicated an average monthly discharge for February (1960 - 1990) of 50.2 m^3/s and an average monthly discharge (1985 - 1990) for the McLeod River at Rosevear of 6.9 m^3/s (Environment Canada 1992). 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 February 1993. Dissolved oxygen concentrations, based on saturation levels, in the river below Whitecourt decreased primarily 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 Blue Ridge and persisted up to Hondo. However, dissolved oxygen concentrations at all sites on the Athabasca River were still well above the ASWQO and CWQG for the protection of freshwater aquatic life. Sodium concentrations in the river were elevated due to inputs from Millar Western and the McLeod River and, to a minor extent, by the ANC mill. Sulphate, chloride and zinc levels in the Athabasca River were unaffected by any effluent discharges. Manganese concentrations at sites on the Athabasca River were elevated compared to the background site at Windfall as a result of effluent discharge from ANC and Millar Western.

Dissolved phosphorus concentrations were elevated above background levels at sites below the ANC mill, Millar Western mill and the Whitecourt sewage treatment plant. Effluent discharge from Millar Western and the Whitecourt sewage treatment plant resulted in an increase in ammonia concentrations at downstream sites on the Athabasca River. Total phenol concentrations were above background levels at all Athabasca River sites below the effluent outfalls. Total phenols at all sites on the river, including the background site, were higher than the CWQG for total phenols of 0.001 mg/L; phenol concentrations were above the ASWQO of 0.005 mg/L at all sites except Sites 1 and 13. Concentrations of chelators (EDTA and DTPA) were higher than background levels at a few sites on the Athabasca River due to effluent discharge from ANC. Fecal coliforms and *Klebsiella* levels in the river increased as result of effluent discharges but approached background levels at the lowermost site at Hondo. Resin acids were detected at Sites 3 and 8; however,concentrations were not affected by effluent discharge and appear to be related to either upstream inputs or natural sources.

Anomalous values for several parameters (manganese, total phosphorus and suspended solids) were recorded at the site at Fort Assiniboine due to the large amounts of frazil ice observed at these sites which resulted in scour and re-suspension of bottom sediments. A similar situation was observed in previous winter studies at this site.

Effluent discharge from ANC resulted in a 2.1 km ice-free zone in the north channel immediately below the effluent outfall. An ice-free zone was not present in the south channel, unlike previous years. Millar Western effluent discharge resulted in a 2.0 km open-water lead below the effluent outfall. Flows in the Athabasca and McLeod rivers during the sampling period were typical of the historical average streamflows for February.

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APPENDIX I

LABORATORY ANALYTICAL METHODS AND RESULTS

38-67 Avenue
Edmonton,AB
T6E 0P5

NORWEST LABS
(403) 438-5522 or 1-800-661-7645
(403) 438-0396 fax

DATE	29 MAR 93 15:47
P.O. NO.	WATERS
W.O. NO.	2 60272

SENTAR CONSULTANTS LTD.
200, 1122 - 4 ST.S.W.
CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

SAMPLE		1 SITE 1 WATER	2 SITE 2 WATER	3 SITE 3 WATER	4 SITE 4 WATER
TOTAL METALS					
MANGANESE	mg/L	0.005	2.01	0.052	0.096
SODIUM	mg/L	11.9	145	12.8	12.1
ZINC	mg/L	<0.005	0.381	<0.005	<0.005
ROUTINE WATER					
SULPHATE	mg/L	79.1	401	81.9	81.6
CHLORIDE	mg/L	8.7	69.2	9.3	8.7
NITRATE&NITRITE	mg/L	0.22	3.15	0.27	0.20
ATER NUTRIENTS					
AMMONIA-N	mg/L	0.030	0.005	0.026	0.026
TOTAL KJEHL NIT	mg/L	0.29	4.34	0.29	0.71
PHOSPHORUS(TOT)	mg/L	<0.002	1.92	0.025	0.038
PHOSPHORUS,DISS	mg/L	<0.002	1.58	0.007	<0.002
OXYGEN,DISS	mg/L		14.0		21.5
HELATES					
CHELATES	mg/L	6.5	24.8	6.1	8.0
RGANICS					
BIOCHEM O2 DEM	mg/L	1.5	23.0	5.0	5.0
PHENOLS	mg/L	0.004	0.082	0.006	0.005
TOT ORG CARBON	mg/L	2.9	30.8	3.0	3.0
ICP METALS,EXTR					
SILICON	mg/L	3.09	3.64	3.09	3.20
SILICA	mg/L	6.6	7.8	6.6	6.9
HYSIC ANALYSIS					
SOLIDS, SUSPEND	mg/L	7	49	4	78
COLOR H.5P	CO.UNITS	25	290	25	20

Lab Manager: E. Calli

8-67 Avenue
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200, 1122 - 4 ST.S.W.
CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

SAMPLE		5 SITE 5 WATER	6 SITE 6 WATER	7 SITE 7 WATER	8 SITE 8 WATER
TOTAL METALS					
MANGANESE	mg/L	0.035		1.65	0.112
SODIUM	mg/L	13.0	26.2	1230	16.2
ZINC	mg/L	<0.005		0.703	<0.005
ROUTINE WATER					
SULPHATE	mg/L	81.2	22.0	583	80.3
CHLORIDE	mg/L	8.9		56.6	9.0
NITRATE&NITRITE	mg/L	0.20		0.22	0.20
WATER NUTRIENTS					
AMMONIA-N	mg/L	0.021		1.80	0.046
TOTAL KJEHL NIT	mg/L	0.14		9.69	0.57
PHOSPHORUS(TOT)	mg/L	0.003		0.210	0.025
PHOSPHORUS,DISS	mg/L	0.003		0.037	<0.002
OXYGEN,DISS	mg/L	22.4	7.1	<0.1	12.5
CHELATES					
CHELATES	mg/L	8.0		62.0	6.1
ORGANICS					
BIOCHEM O2 DEM	mg/L	5.0	5.0	27.0	5.0
PHENOLS	mg/L	0.005		0.039	0.007
TOT ORG CARBON	mg/L	2.8		195	4.0
ICP METALS,EXTR					
SILICON	mg/L	3.04	5.05	81.8	3.36
SILICA	mg/L	6.5	10.8	175	7.2
PHYSIC ANALYSIS					
SOLIDS, SUSPEND	mg/L	6	4	45	7
COLOR H.5P	CO.UNITS	20		780	30

Lab Manager: ______________________

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CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

SAMPLE		9 SITE 9 WATER	10 SITE 10 WATER	11 SITE 11 WATER	12 SITE 12 WATER
TOTAL METALS					
MANGANESE	mg/L		0.040	0.179	
SODIUM	mg/L		17.4	19.7	
ZINC	mg/L		<0.005	<0.005	
ROUTINE WATER					
SULPHATE	mg/L		75.3	76.9	
CHLORIDE	mg/L		8.1	6.4	
NITRATE&NITRITE	mg/L	13.8	0.14	0.29	
ATER NUTRIENTS					
AMMONIA-N	mg/L	1.80	0.036	<0.005	
TOTAL KJEHL NIT	mg/L	3.35	0.21	0.50	
PHOSPHORUS(TOT)	mg/L	1.62	<0.002	0.100	
PHOSPHORUS,DISS	mg/L	1.52	<0.002	0.054	
OXYGEN,DISS	mg/L	3.0	10.0	12.0	3.3
HELATES					
CHELATES	mg/L		5.8	5.7	
RGANICS					
BIOCHEM O2 DEM	mg/L	6.0	1.3	2.1	1.7
PHENOLS	mg/L		0.005	0.005	
TOT ORG CARBON	mg/L		3.3	3.5	
CP METALS,EXTR					
SILICON	mg/L		3.44	4.09	
SILICA	mg/L		7.4	8.7	
HYSIC ANALYSIS					
SOLIDS, SUSPEND	mg/L	10	6	87	5
COLOR H.5P	CO.UNITS		15	10	

Lab Manager: ______________________

38-67 Avenue
Edmonton,AB
T6E 0P5

NORWEST LABS
(403) 438-5522 or 1-800-661-7645
(403) 438-0396 fax

DATE 29 MAR 93 15:47
P.O. NO. WATERS
W.O. NO. 2 60272

SENTAR CONSULTANTS LTD.
200, 1122 - 4 ST.S.W.
CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

SAMPLE		13 SITE 13 WATER	14 SITE 11	15 SITE 13
TOTAL METALS				
MANGANESE	mg/L	0.040		
SODIUM	mg/L	20.1		
ZINC	mg/L	<0.005		
ROUTINE WATER				
SULPHATE	mg/L	73.9		
CHLORIDE	mg/L	6.0		
NITRATE&NITRITE	mg/L	0.21		
WATER NUTRIENTS				
AMMONIA-N	mg/L	0.029		
TOTAL KJEHL NIT	mg/L	0.07		
PHOSPHORUS(TOT)	mg/L	0.014		
PHOSPHORUS,DISS	mg/L	0.010		
OXYGEN,DISS	mg/L	7.4		
CHELATES				
CHELATES	mg/L	8.0		
ORGANICS				
BIOCHEM O2 DEM	mg/L	1.0	4.0	1.7
PHENOLS	mg/L	0.004		
TOT ORG CARBON	mg/L	3.8		
ICP METALS,EXTR				
SILICON	mg/L	3.70		
SILICA	mg/L	7.9		
PHYSIC ANALYSIS				
SOLIDS, SUSPEND	mg/L	4		
COLOR H.5P	CO.UNITS	10		

note* NITRATE&NITRITE is expressed as nitrogen

38-67 Avenue
Edmonton,AB
T6E 0P5

NORWEST
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(403) 438-5522 or 1-800-661-7645
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DATE 29 MAR 93 15:47
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200, 1122 - 4 ST.S.W.
CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

SAMPLE 3, SAMPLE BOTTLE WAS BROKEN WHEN RECEIVED.
SAMPLE 8, SAMPLE BOTTLE WAS CRACKED WHEN RECEIVED.

Lab Manager: ______________________

38-67 Avenue
Edmonton,AB
T6E 0P5

NORWEST LABS
(403) 438-5522 or 1-800-661-7645
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DATE 29 MAR 93 15:47
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SENTAR CONSULTANTS LTD.
200, 1122 - 4 ST.S.W.
CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

--PARAMETER----	DATE OF- APPROVAL	------ANALYZED BY-------	---PARAMETER----	DATE OF- APPROVAL	------ANALYZED BY-------
ANGANESE	29Mar93	ERIC THOMSEN	SODIUM	29Mar93	ERIC THOMSEN
ZINC	29Mar93	ERIC THOMSEN	SULPHATE	29Mar93	ERIC THOMSEN
CHLORIDE	29Mar93	DIANE SMATHERS	NITRATE&NITRITE	29Mar93	DIANE SMATHERS
MMONIA-N	29Mar93	DIANE SMATHERS	TOTAL KJEHL NIT	29Mar93	DIANE SMATHERS
PHOSPHORUS(TOT)	29Mar93	DIANE SMATHERS	PHOSPHORUS,DISS	29Mar93	DIANE SMATHERS
OXYGEN,DISS	29Mar93	PHAT LAM	CHELATES	29Mar93	CATHY NGO
IOCHEM O2 DEM	29Mar93	PHAT LAM	PHENOLS	29Mar93	DIANE SMATHERS
OT ORG CARBON	29Mar93	DIANE SMATHERS	SILICON	29Mar93	ERIC THOMSEN
SILICA	29Mar93	ERIC THOMSEN	SOLIDS, SUSPEND	29Mar93	TO LUONG (NU)
OLOR H.5P	29Mar93	PHAT LAM			

Lab Manager: ______________________

38-67 Avenue
Edmonton,AB
T6E 0P5

NORWEST LABS
(403) 438-5522 or 1-800-661-7645
(403) 438-0396 fax

DATE 29 MAR 93 15:47
P.O. NO. WATERS
W.O. NO. 2 60272

SENTAR CONSULTANTS LTD.
200, 1122 - 4 ST.S.W.
CALGARY, AB
T2R 1M1

BOB SHELAST
09-682-01-01

The following published METHODS OF ANALYSIS were used:

16306L SULPHATE
ICP spectroscopy @ 180.7 nm
Ref. APHA 3120 B

17203L CHLORIDE
Automated colorimetry, Thiocyanate
Ref. APHA 4500 Cl-,E

07105L NITRATE&NITRITE
Automated colorimetry Cadmium reduction
Ref. APHA 4500-NO3-,F

07557 AMMONIA-N
Automated phenate colorimetry
Ref. APHA 4500 NH3,H

7021P TOTAL KJEHL NIT
Total, block digest with K2SO4/HgO
and H2SO4, auto phenate colorimetry.
Ref.US EPA 351.2;Crowther MOE

15406 PHOSPHORUS(TOT)
Total,Autoclave with persulphate/H2SO4
Auto. colorimetry with ascorbic acid
Ref. APHA 4500 P,E

15103 PHOSPHORUS,DISS
Diss.,Autoclave with persulphate/H2SO4
Auto. colorimetry with ascorbic acid
Ref. APHA 4500 P,E

3202 BIOCHEM O2 DEM
5 Day incubation at 20C. Analysis of
oxygen by DO meter.
Ref.APHA 5210,B

5537P PHENOLS
Automated, distillation and colorimetry
with 4-AAP
Ref. US EPA 420.2

06005L TOT ORG CARBON
Auto persulphate/UV digest. Colorimetric
Ref. MOE(Ontario Environment)

NWL 4523 SILICON
Acid extr.,ICP Spectro. Ref. APHA 3120 B

14111 SILICA
Dissolved by ICP spectroscopy @ 251.6 nm
Ref. APHA 3120 B

10401L SOLIDS, SUSPEND
Filter through GF/C filter, gravimetric
analysis of solids retained on filter
Ref. APHA 2540 D

02022L COLOR H.5P
Colour comparison, using chloroplatinate
Ref. APHA 2120 B

thod References:

1. APHA Standard Methods for the Examination of Water and Wastewater,
American Public Health Assoc., 17th ed.

EPA a. Test Methods for Evaluating Solid Waste, Physical/Chemical
Methods SW-846, 3rd ed., US EPA, 1986
b. Methods for Chemical Analysis ofWater and Wastewater, US EPA, 1983

MSS Manual on Soil Sampling and Methods of Analysis, Cdn. Soc. of
Soil Science, J. A. McKeague, 2nd ed.

NORWEST SOIL RESEARCH LTD has been accredited by the STANDARDS COUNCIL of CANADA
for specific tests registered with the COUNCIL.

Lab Manager: ______________________

[redacted]938-67 Avenue
Edmonton, Alberta
T6E 0P5

NORWEST
LABS
(403) 438-5522 PH OR 1-800-661-7645
(403) 438-0396 FAX

Date: 3/4/93
P.O. No:
W.O. No: 60272

SENTAR CONSULTANT LTD
SUITE 200, 1122 - 4 ST, SW
CALGARY, AB T2R 1M1

ATTN: BOB SHELAST

MICROBIOLOGICAL ANALYSIS REPORT
Coliforms/Other Parameters

Lab#	Sample Client ID	Sample Description	Results: CFU/100 mL Total Coliforms	Results: CFU/100 mL Fecal Coliforms	Results: CFU/100 mL Klebsiella
60272-1	Site No 1	Water		<1	<1
-2	Site No 2	Effluent		1900	2000
-3	Site No 3	Water		8	6
-4	Site No 4	Water		<1	<1
-5	Site No 5	Water		36	48
-7	Site No 7	Effluent		150	40
-8	Site No 8	Water		10	<1
-9	Site No 9	Effluent		30,000	6200
-10	Site No 10	Water		150	22
-11	Site No 11	Water		14	14
-13	Site No 13	Water		28	18

CFU: Colony Forming Units

RESULTS INTERPRETATION

1. Water and effluent samples were collected by Sentar from water quality sampling site locations in the Athabasca River as part of the annual river study.

2. Samples were received from all sites except the Sites #6 (McLeod River at mouth) and #12 (Pembina River near Flatbush).

3. All samples were analyzed using the membrane filter (MF) procedures (APHA Standard Methods, 1992) for the determination of levels of Fecal Coliforms (FC) and Klebsiella (KLEB). The FC counts were determined on m-FC agar with 24 h incubation at 44.5°C, while KLEB counts were determined on m-kleb agar with 24 h incubation at 35°C.

4. No FC and KLEB were detected in the water sample from Site 1 (Windfall bridge, 20 m from the right bank).

ANALYST ____________________

RESULTS INTERPRETATION CONT'D

5. Sample from Site 2 (ANC Effluent) produced counts of 1900 FC and 2000 KLEB CFU/100 mL. These levels are significantly lower than those observed during the 1992 survey.

6. Densities of both FC and KLEB declined in samples from Sites 3 and 4 (0.5 km downstream of ANC outfall) to very low levels of 8, <1 and 6 and <1/100 mL, respectively. At Site 5 (Upstream of the McLeod River), levels of both FC and KLEB increased slightly to 36 and 48/100 mL.

7. The Site 7 sample (Miller Western effluent) also produced significantly lower counts of both FC (150/100 mL) and KLEB (40/100 mL) than those recorded during the 1992 survey.

8. At Site 8 (1 km downstream of MW outfall), the levels of FC decreased to 10/100 mL and KLEB to <1/100 mL.

9. The highest densities of FC and KLEB were observed in Site 9 effluent (Whitecourt sewage treatment plant) sample with counts of 30,000 FC and 6,200 KLEB per 100 mL.

10. Levels of both FC and KLEB steadily declined in river water samples collected from downstream locations at Sites 10 (Blue Ridge), 11 (Fort Assiniboine) and 13 (Hondo). At these three sites the FC counts were 150, 14, and 28/100 mL and KLEB counts were 22, 14, and 18/100mL.

11. These results indicate that concentrations of both FC and KLEB at all sites were substantially lower than those recorded during the 1992 survey. The highest FC and KLEB counts were observed in Whitecourt sewage effluent, while the ANC effluent produced the next highest counts of FC and KLEB.

12. These data and results indicate that microbial parameters could serve as a valuable tool for determining and assessing the impact of pulp mill effluents in the mixing zones and in further downstream receiving waters. Furthermore, it is recommended to continue to use both FC and KLEB as pollution tracers in water quality surveys and environmental impact studies of pulp mill operations.

ANALYST ____________________

ETL 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

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CHEMICAL ANALYSIS REPORT

SENTAR CONSULTING LIMITED
C/O NORWEST LABS
9938 - 67 AVENUE
EDMONTON, ALBERTA
T6E 0P5

DATE: March 24, 1993

ATTN: BOB SHELAST

Lab Sample #: E3-02-232

Sampled By: Client

Customer #: WO# 60272

Date Received: February 19, 1993

Sample Description: 10 water samples for resin and fatty acids analysis.

LAB SAMPLE #	SAMPLE I.D.	RESULTS mg/L , ppm
E3-02-232-1	60772-1 SITE 1	Please see attached.
E3-02-232-2	60772-2 SITE 2	Please see attached.
E3-02-232-3	60772-3 SITE 3	Please see attached.
E3-02-232-4	60772-4 SITE 4	Please see attached.
E3-02-232-5	60772-5 SITE 5	Please see attached.
E3-02-232-6	60772-7 SITE 7	Please see attached.
E3-02-232-7	60772-8 SITE 8	Please see attached.
E3-02-232-8	60772-10 SITE 10	Please see attached.
E3-02-232-9	60772-11 SITE 11	Please see attached.
E3-02-232-10	60772-13 SITE 13	Please see attached.

METHOD REFERENCE: ETL MSOP # 26.04

Analysis performed by Lesley McFeeter, Residue Analyst.

APPROVED BY: ______________________
Detlef [Deib] Birkholz, MSc., PhD.
Manager, Environmental Services
Pulp and Paper Division

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-01A-1
CLIENT I.D. : 60272-1 SITE 1
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID ✓	ND
PALMITIC ACID ✓	ND
OLEIC ACID ✓	ND
LINOLEIC ACID ✓	ND
STEARIC ACID ✓	ND
LINOLENIC ACID ✓	ND
PIMARIC ACID ✓	ND
ARACHIDIC ACID ✓	ND
SANNDARACOPIMARIC ACID ✓	ND
LEVOPIMARIC ACID ✓	ND
ISOPIMARIC ACID ✓	ND
PALUSTRIC ACID ✓	ND
DEHYDROABIETIC ACID ✓	ND
ABIETIC ACID ✓	ND
NEOABIETIC ACID ✓	ND
9,10-DICHLOROSTEARIC ACID ✓	ND
14-CHLORODEHYDROABIETIC ACID (#1) ✓	ND
12-CHLORODEHYDROABIETIC ACID (#1) ✓	ND
12,14-DICHLORODEHYDROABIETIC ACID ✓	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-02A-1
CLIENT I.D. : 60272-2 SITE 2
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 22-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	0.013
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	0.0030
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	0.0034
ABIETIC ACID	0.0033
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid	83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid	102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-03A-1
CLIENT I.D. : 60272-3 SITE 3
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	0.0051
PALMITIC ACID	0.018
OLEIC ACID	0.0078
LINOLEIC ACID	ND
STEARIC ACID	0.0070
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-04A-1
CLIENT I.D. : 60272-4 SITE 4
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	0.0028
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-05A-1
CLIENT I.D. : 60272-5 SITE 5
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	ND
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-06A-1
CLIENT I.D. : 60272-7 SITE 7
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 22-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	0.0021
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	0.010
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-07A-1
CLIENT I.D. : 60272-8 SITE 8
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	0.0055
OLEIC ACID	0.0027
LINOLEIC ACID	ND
STEARIC ACID	0.0023
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-08A-1
CLIENT I.D. : 60272-10 SITE 10
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	ND
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.

2.) The detection limit applies to all compounds listed.

QA\QC:

1.) To ensure resin acid extraction efficiency, the effluent was fortified with a surrogate compound prior to extraction. Based on in-house data, the average % recovery for:

O-methylpodocarpic acid 83% ± 18%

2.) To ensure resin acid derivatization efficiency, the final extracts were fortified with tricosanoic acid prior to methylation with diazomethane. Based on in-house recovery data, the average % recovery for

Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-09A-1
CLIENT I.D. : 60272-11 SITE 11
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	ND
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

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Tricosanoic acid 102% ± 13%

RESIN AND FATTY ACIDS ANALYSIS REPORT
ENVIROTEST LABORATORIES
PULP AND PAPER DIVISION

PROJECT : NORWEST LABS (SENTAR)
MATRIX : EFFLUENT
LAB SAMPLE# : E3-02-232-10A-1
CLIENT I.D. : 60272-13 SITE 13
SAMPLE SIZE : 0.80 L

INSTRUMENT : HEWLETT PACKARD 5971A GC\MSD
ANAL. DATE : 4-MAR-93

DETECTION LIMIT : 0.0020 mg/L (ppm)

COMPOUND	CONCENTRATION mg/L (ppm)
MYRISTIC ACID	ND
PALMITIC ACID	ND
OLEIC ACID	ND
LINOLEIC ACID	ND
STEARIC ACID	ND
LINOLENIC ACID	ND
PIMARIC ACID	ND
ARACHIDIC ACID	ND
SANNDARACOPIMARIC ACID	ND
LEVOPIMARIC ACID	ND
ISOPIMARIC ACID	ND
PALUSTRIC ACID	ND
DEHYDROABIETIC ACID	ND
ABIETIC ACID	ND
NEOABIETIC ACID	ND
9,10-DICHLOROSTEARIC ACID	ND
14-CHLORODEHYDROABIETIC ACID (#1)	ND
12-CHLORODEHYDROABIETIC ACID (#1)	ND
12,14-DICHLORODEHYDROABIETIC ACID	ND

NOTES:

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2.) The detection limit applies to all compounds listed.

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