SENTAR
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Environmental Services

WINTER WATER QUALITY SURVEY ON THE ATHABASCA RIVER, FEBRUARY 1994

JULY 1994

WINTER WATER QUALITY SURVEY

ON THE ATHABASCA RIVER

FEBRUARY 1994

Prepared For:

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AND
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1.0 INTRODUCTION

As part of the license requirements of Alberta Environmental Protection, 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 1993/1994. Previous winter water quality surveys were conducted in 1990 to 1993 inclusive 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 15 and 16 February 1994. 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 1994 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 and frozen to the bed. Samples were taken about 20 cm below the water surface. Field observations indicated that moderate amounts of frazil ice were present at Sites 1 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.

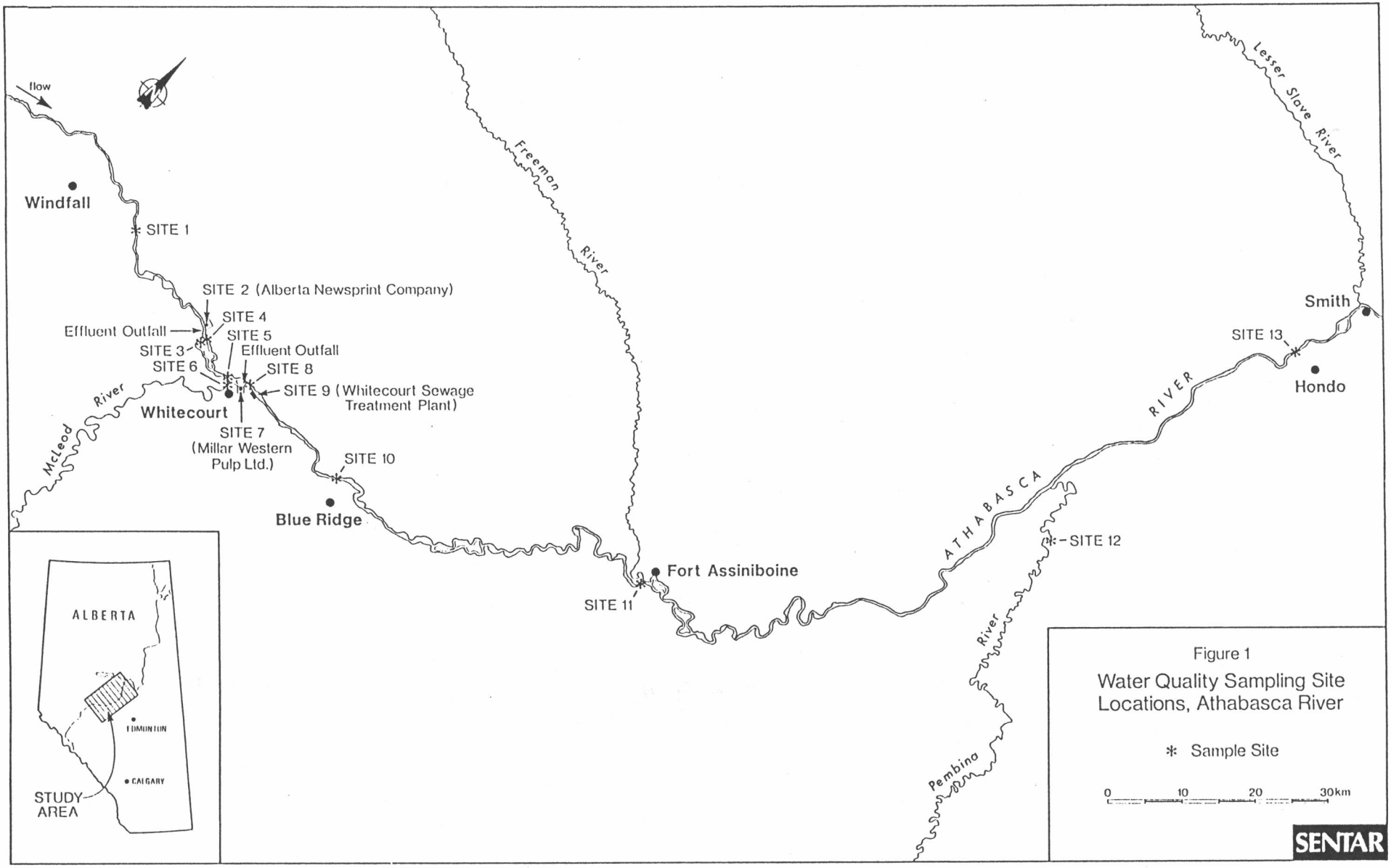

flow
Windfall
SITE 1
SITE 2 (Alberta Newsprint Company)
SITE 4
Effluent Outfall
SITE 5
SITE 3
Effluent Outfall
SITE 6
SITE 8
SITE 9 (Whitecourt Sewage Treatment Plant)
Whitecourt
SITE 7 (Millar Western Pulp Ltd.)
McLeod River
SITE 10
Blue Ridge
Freeman River
Fort Assiniboine
SITE 11
ATHABASCA RIVER
SITE 12
Lesser Slave River
Smith
SITE 13
Hondo
Pembina River
ALBERTA
EDMONTON
CALGARY
STUDY AREA
Figure 1
Water Quality Sampling Site Locations, Athabasca River
* Sample Site
0 10 20 30km
SENTAR

Table 1. Sample site and sampling point locations, February 1994.

Site	Location	Date and Time Sampled	Sampling Point[a]
1	Windfall bridge	15/02, 940	20 m from right bank
2	ANC effluent	15/02, 1100	effluent pumphouse
3	0.5 km downstream of ANC outfall (north channel)	15/02, 1145	mid-channel
4	0.5 km downstream of ANC outfall (south channel)	15/02, 1230	Frozen to the bed
5	Whitecourt (upstream of the McLeod River)	15/02, 1410	30 m from right bank
6	McLeod River at mouth	15/02, 1610	40 m from left bank
7	Millar Western effluent	15/02, 1650	effluent pumphouse
8	1 km downstream of Millar Western outfall	15/02, 1210	mid-channel
9	Whitecourt sewage treatment plant effluent	15/02, 1515	treatment plant
10	Blue Ridge	16/02, 1010	45 m from left bank
11	Fort Assiniboine	16/02, 1155	20 m from left bank
12	Pembina River near Flatbush	16/02, 1450	20 m from right bank
13	Near Hondo (Highway #2)	16/02, 1605	60 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 and bacteria were conducted by Chemex Labs of Edmonton (BOD samples only) and Calgary using standard methods (Appendix 1). 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 1). Bacteriological analyses were performed by Bio-Chem Consulting of Calgary using standard 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 (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	N	X	X	X	X	X	X	X	X	X
pH [a]	X	X	X	O	X	X	X	X	X	X	X	X	X
Dissolved Oxygen [a]	X	X	X	T	X	X	X	X	X	X	X	X	X
Conductivity [a]	X	X	X		X	X	X	X	X	X	X	X	X
BOD_5	X	X	X	S	X	X	X	X	X	X	X	X	X
Sodium	X	X	X	A	X	X	X	X		X	X		X
Sulphate	X	X	X	M	X	X	X	X		X	X		X
Chloride	X	X	X	P	X		X	X		X	X		X
Manganese	X	X	X	L	X		X	X		X	X		X
Zinc	X	X	X	E	X		X	X		X	X		X
Silicon	X	X	X	D	X	X	X	X		X	X		X
Total Phosphorus	X	X	X		X		X	X	X	X	X		X
Dissolved Phosphorus	X	X	X	F	X		X	X	X	X	X		X
Nitrate and Nitrite Nitrogen	X	X	X	R	X		X	X	X	X	X		X
Total Kjeldahl Nitrogen	X	X	X	O	X		X	X	X	X	X		X
Ammonia Nitrogen	X	X	X	Z	X		X	X	X	X	X		X
Total Organic Carbon	X	X	X	E	X		X	X		X	X		X
Total Suspended Solids	X	X	X	N	X	X	X	X	X	X	X	X	X
True Color	X	X	X		X		X	X		X	X		X
Total Phenols	X	X	X		X		X	X		X	X		X
Chelates (EDTA and DTPA)	X	X	X		X		X	X		X	X		
Fecal Coliforms	X	X	X		X		X	X	X	X	X		X
Klebsiella	X	X	X		X		X	X		X	X		X
Resin Acids	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 1994 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 7.8 to 10.8 mg/L which represents 57 to 84% saturation (Figure 2). Dissolved oxygen concentrations measured in the field for the ANC effluent, Millar Western effluent and Whitecourt sewage effluent were 7.7, 4.9 and 4.0 mg/L, respectively, which represents 94, 60 and 36% 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 5.8 and 1.4 mg/L respectively, which represents 43 and 10% saturation, respectively.

Dissolved oxygen concentrations at sites on the Athabasca River below effluent outfalls were higher than the background level recorded at Site 1 (Windfall). However, dissolved concentrations decreased progressively downstream at the two lowermost sites on the Athabasca River and were below the background concentration of 10.0 mg/L. A similar trend was observed in past winter water quality studies although the dissolved oxygen concentrations recorded in 1994 at all sites on the Athabasca River were the lowest compared to any of the previous winter surveys. The dissolved oxygen sag at Fort Assiniboine (Site 11) and Hondo (Site 13) has been documented in previous winter water quality studies on the Athabasca River (Noton and Shaw 1989, Beak 1990, 1991, SENTAR 1992, 1993). This decrease in dissolved oxygen is likely the result of increased oxygen demand by decompositional processes. The magnitude of the decrease from year to year is

Table 3. Water quality results for the Athabasca River, tributary streams and effluent sources, 15 and 16 February 1994 (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 (^{o}C)	0	21.5	2.0	-	0	0	22.0	2.0	7.0	0	0	0	0	Increase of 3^{o}C	-
pH (units)	8.3	7.7	8.2	-	8.4	7.9	7.7	8.2	7.7	8.4	8.2	7.9	8.2	6.5 - 8.5	6.5 - 9.0
Dissolved Oxygen (field)	10.0	7.7	10.6	-	10.7	5.8	4.9	10.8	4.0	9.9	9.4	1.4	7.8	5.0	5.0 - 9.5
DO saturation (%) (field)	75	94	82	-	79	43	60	84	36	73	69	10	57	-	-
BOD_5	1.0	8.0	3.0	-	1.0	<0.1	16.0	2.0	16.0	0.4	<0.1	<0.1	0.5	-	-
Specific Conductance (μmhos/cm)	445	1,240	505	-	490	460	3,920	520	1,075	515	505	510	500	-	-
Sodium	12.6	140.0	15.3	-	14.9	22.1	1,020.0	15.4	-	18.5	17.9	-	18.3	-	-
Sulphate	68.4	328.0	81.6	-	83.4	16.5	570.0	83.2	-	75.0	64.2	-	59.4	-	-
Chloride	5.2	48.6	5.7	-	5.5	-	47.0	5.5	-	5.1	4.5	-	4.2	-	
Manganese (dissolved)	0.004	0.771	0.007	-	0.006	-	2.160	0.009	-	0.007	0.012	-	0.008	-	-
Zinc (dissolved)	0.005	0.212	0.022	-	0.005	-	0.569	0.024	-	0.004	0.004	-	0.004	0.05	0.03
Silica (dissolved)	6.42	21.40	5.99	-	6.33	9.91	149.80	6.48	-	6.23	7.34	-	7.32	-	-
Total Phosphorus (as P)	0.003	7.800	0.035	-	0.033	-	6.750	0.043	3.05	0.043	0.032	-	0.006	0.05	-
Dissolved Phosphorus (as P)	0.003	7.500	0.030	-	0.028	-	6.700	0.040	3.00	0.040	0.030	-	0.005	-	-
Nitrate and Nitrite Nitrogen	0.142	0.520	0.149	-	0.149	-	0.030	0.150	0.636	0.165	0.166	-	0.169	-	-
Total Kjeldahl Nitrogen	0.28	14.90	0.44	-	0.36	-	9.50	0.48	9.76	0.28	0.40	-	0.36	1.0	-
Total Ammonia Nitrogen	0.04	10.30	0.09	-	0.08	-	<0.01	0.09	9.76	0.09	0.06	-	0.03	-	1.53[b]
Total Organic Carbon	3.3	40.5	4.4	-	4.4	-	406.0	4.4	-	15.0	5.1	-	5.4	-	-
Total Suspended Solids	<0.4	20.0	<0.4	-	<0.4	<0.4	108.0	<0.4	1.0	<0.4	<0.4	<0.4	<0.4	Increase of 10	-
True Color (units)	10	150	10	-	10	-	540	10	-	10	10	-	10	Increase of 30	-
Phenols	<0.001	<0.001	<0.001	-	<0.001	-	0.021	<0.001	-	<0.001	<0.001	-	<0.001	0.005	0.001
Chelates - EDTA	<0.1	<1	<0.1	-	<0.1	-	<1	<0.1	-	<0.1	<0.1	-	<0.1	-	-
Chelates - DTPA	<0.1	<1	<0.1	-	<0.1	-	14.3	<0.1	-	<0.1	<0.1	-	<0.1		
Fecal Coliforms (MPN per 100 mL)	<1	1,000	90	-	150	-	700	80	9200	150	11	-	3	<5,000/100 mL	-
Klebsiella (MPN per 100 mL)	<1	1,200,000	1,200	-	480	-	9,700	770	21,000	520	67	-	3	-	-
Resin and Fatty Acids														100	-
Abietic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Dehydroabietic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Isopimaric	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Levopimaric acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006		
Neoabietic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Palustric acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Pimaric acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-

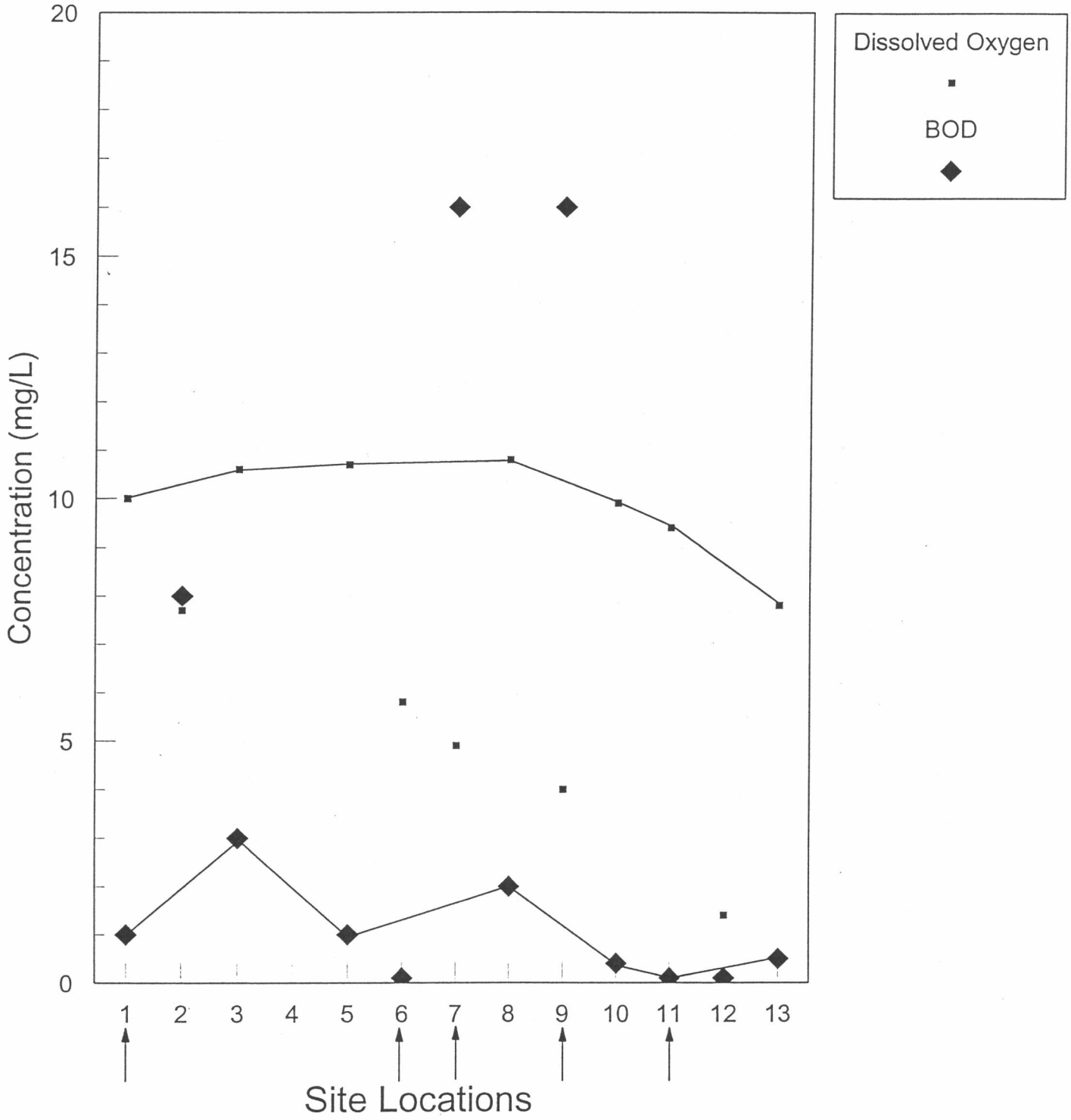
(continued)

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	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Chlorodehydroabietic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Dichlorodehydroabietic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Arachidic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Dichlorostearic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Linoleic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	0.0740	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Linolenic acid	<0.0006	<0.0100	<0.0006	-	<0.0006	-	<0.0100	<0.0006	-	<0.0006	<0.0006	-	<0.0006	-	-
Myristic acid	<0.0006	0.0110	0.0010	-	<0.0006	-	0.0200	<0.0006	-	0.0010	<0.0006	-	0.0016	-	-
Oleic acid	<0.0006	<0.0100	0.0011	-	<0.0006	-	0.0250	<0.0006	-	0.0013	<0.0006	-	0.0019	-	
Palmitic acid	<0.0006	<0.0100	0.0020	-	<0.0006	-	<0.0100	<0.0006	-	0.0026	<0.0006	-	0.0035	-	-
Stearic acid	<0.0006	0.01300	<0.0006	-	<0.0006	-	0.0160	<0.0006	-	0.0008	<0.0006	-	0.0017	-	-

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 $0^{o}C$.



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, 15 and 16 February 1994.**

probably related to several factors including flow conditions, time of freeze-up, and the severity of the winter in terms of the amount of snow cover and ice thickness. Since the solubility of oxygen in water is temperature dependent and there were water temperature differences between sites during field measurements for dissolved oxygen, a comparison of saturation levels provides a relative indication of dissolved oxygen levels between sites. When saturation levels are compared, only the two lowermost sites at Fort Assiniboine (Site 11) and Hondo (Site 13) exhibited any appreciable decrease in dissolved oxygen saturation. 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 either naturally or 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 a minimum of 5.0 mg/L. Only one site, Site 13 was below the upper limit of 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 <0.1 to 3.0 mg/L (Figure 2). BOD_5 concentrations in ANC effluent, Millar Western effluent and the Whitecourt sewage treatment plant (STP) effluent were 8.0, 16.0 and 16.0 mg/L, respectively. Effluent discharge from these sources resulted in a slight increase in BOD_5 concentrations at sites immediately below the effluent outfalls where concentrations were 2.0 to 3.0 mg/L compared to the background value of 1.0 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 lower than the background site.

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 and base flow conditions 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 445 to 520 μmhos/cm. Effluent from ANC, Millar Western and the Whitecourt sewage treatment plant were substantially higher in conductivity with values of 1,240, 3,920 and 1,075 μmhos/cm, respectively. Effluent discharge from these sources resulted in elevated specific conductance values 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 12.6 mg/L was recorded at the background site at Windfall. Discharge of ANC and Millar Western effluents, with concentrations of 140.0 and 1,020 mg/L, respectively, resulted in a slight increase in concentrations at sites in the Athabasca River immediately below the effluent outfall. The McLeod River with a sodium concentration of 22.1 mg/L, was also a contributor of sodium to the Athabasca River. The highest sodium concentrations recorded at sites on the Athabasca River occurred at the three lowermost sites suggesting sodium inputs from other sources. Although the ANC and Millar Western effluents generally contained higher concentrations of sulphate and chloride than the background site 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 328.0 and 570.0 mg/L, respectively, while chloride concentrations in these effluents were 48.6 and 47.0 mg/L respectively. Sulphate and chloride concentrations of 68.4 and 5.2 mg/L, respectively, were recorded at the background site. Sulphate concentrations at sites on the Athabasca River below effluent discharge points ranged from 59.4 to 83.4 mg/L while chloride concentrations at these sites ranged from 4.2 to 5.7 mg/L.

Manganese concentrations at sites on the Athabasca River were affected by effluent discharge from ANC or Millar Western. A manganese concentration of 0.004 mg/L, was recorded at background Site 1. The ANC and Millar Western effluents had manganese concentrations of 0.771 and 2.160 mg/L, respectively. At sites between the ANC and Millar Western effluent outfalls, manganese concentrations ranged between 0.006 and 0.007 mg/L while at sites below Millar Western, concentrations ranged between 0.007 and 0.012 mg/L. The highest value was recorded at Site 11 at Fort Assiniboine. It should be noted that moderate 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 was the prime contributor to the elevated level of manganese at this site. Both

the ANC and Millar Western effluents contained substantially higher concentrations of zinc than the background site where a concentration of 0.005 mg/L was recorded. Zinc concentrations in the ANC and Millar Western effluents were 0.212 and 0.569 mg/L, respectively. Effluent discharge resulted in elevated zinc levels at the sites immediately below the effluent outfalls where concentrations of 0.022 to 0.024 mg/L were recorded. These increased concentrations were spatially limited to the sites within 0.5 km of the outfalls since levels at the lower sites were below the background level. 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 all sites on the Athabasca River were higher than the background level of 0.003 mg/L. The highest total phosphorus concentration occurred at Site 8 (0.5 km below Millar Western) and Site 10 (Blue Ridge) where a value of 0.043 mg/L was recorded. The total phosphorus concentration in ANC effluent was 7.800 mg/L most of which was in dissolved form (7.500 mg/L). It should be noted that the effluent treatment system was in upset conditions at the time of sampling and that phosphorus concentrations in the effluent were atypically high. Phosphorus concentrations in the ANC effluent for the two weeks prior to sampling and the week following sampling were much lower, ranging from 2.07 to 5.09 mg/L (B. Steinback pers comm.). The Millar Western effluent had a total phosphorus concentration of 6.75 mg/L most of which was in dissolved form. Not unlike ANC, the Millar Western effluent treatment system was also in upset conditions at the time of sampling resulting in unusually high concentrations of residual phosphorus. Under normal operating conditions, total phosphorus in Millar Western's effluent ranges from 1.5 to 3.4 mg/L. The Whitecourt sewage treatment effluent had a total phosphorus

concentration lower than the ANC and Millar Western effluents with a value of 3.050 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 the background level. Concentrations were elevated by about 10-fold at sites on the Athabasca River. This condition persisted until the lowermost site on the river (Site 13) where total phosphorus concentrations approached background levels. 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. Not surprisingly, dissolved phosphorus concentrations followed a similar trend to that exhibited by total phosphorus. When comparing dissolved phosphorus concentrations between the background and downstream sites, it appears that effluent discharge from ANC, Millar Western and the Whitecourt sewage treatment plant has resulted in elevated dissolved phosphorus concentrations in the Athabasca River. A dissolved phosphorus concentration of 0.003 mg/L was recorded at the background site while levels at all sites on the Athabasca River receiving effluent ranged from 0.005 to 0.040 mg/L.

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 slightly higher than the background level of 0.142 mg/L, primarily the result of effluent discharge from the ANC mill and the Whitecourt sewage treatment plant. Nitrate and nitrite nitrogen concentrations in both the ANC and Millar Western effluents were 0.520 and 0.030 mg/L, respectively, while the Whitecourt sewage treatment plant had a concentration of 0.636 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 were 14.90, 9.50 and 9.76 mg/L, respectively. Total Kjeldahl nitrogen concentrations in the Athabasca River were above the background concentration of 0.28 mg/L as a result of effluent discharge. TKN concentrations at sites below effluent outfalls ranged from 0.28 to 0.48 mg/L. 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 similar among sites on the Athabasca River and exceeded the background level of 0.04 mg/L at all sites except Site 13. The ammonia nitrogen concentration in the ANC effluent was 10.30 mg/L which was considerably higher than the background level. As mentioned previously, the ANC effluent treatment system was in upset conditions at the time of sampling. Under normal operating conditions, ammonia concentrations in ANC's effluent are typically <1 mg/L. The ammonia concentration in the Whitecourt sewage treatment plant was 9.76 mg/L while ammonia nitrogen in the Millar Western effluent was below the detection limit of 0.01 mg/L. Effluent discharge from ANC and the Whitecourt sewage treatment plant resulted in an increase in ammonia concentrations at downstream sites on the Athabasca River. Concentrations were at the background level by Site 13 near Hondo.

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 3.3 mg/L at all sites below the ANC and Millar Western effluent outfalls. Total organic carbon concentrations of 40.5 and 406.0 mg/L were recorded in the ANC and Millar Western treated effluents, respectively. At sites below the effluent outfalls, total organic carbon concentrations ranged from 4.4 to 5.4 mg/L.

Silica concentrations at sites on the Athabasca River ranged from 5.99 to 7.34 mg/L compared to the background value of 6.42 mg/L. Slightly elevated silica concentrations were observed at the two lowermost sites on the river. Discharge of effluents from ANC and Millar Western, with silica concentrations of 21.40 and 149.80 mg/L, respectively, did not appear to affect silica concentrations in the Athabasca River. The McLeod River, with a concentration of 9.91 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 identical at all sites on the Athabasca River with a value of <0.4 mg/L. Total suspended solids concentrations in ANC and Millar Western effluent were 20.0 and 108.0 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 identical to the background level of 10 units and were unaffected by effluent discharge from both ANC and Millar Western. A true color value of 150 units was recorded in the ANC effluent while the Millar Western effluent had a true color of 540 units. True color values at all sites below effluent discharge points were 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 not affected by effluent discharge. A total phenol concentration of <0.001 mg/L was recorded at the background site while concentrations at sites in the Athabasca River below the effluent outfalls were identical. Total phenol concentrations in the ANC and Millar Western effluents were <0.001 and 0.021 mg/L, respectively. Both the ASWQO for total phenols of 0.005 mg/L and the CWQG of 0.001 mg/L were not exceeded at any river sites.

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 (both EDTA and DTPA) at all sites on the Athabasca River were identical to the background value of <0.1 mg/L. Chelate concentrations in the ANC effluent were below the detection limit of 1.0 mg/L; the Millar Western effluent had an EDTA concentration of <1 mg/L and DPTA concentration of 14.3 mg/L.

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. Immediately downstream of ANC and Millar Western, fecal coliforms levels increased substantially to between 80 and 150 MPN/100 mL. Fecal coliform concentrations in ANC and Millar Western effluents were 1,000 and 700 MPN/100 mL, respectively. Effluent discharge from the Whitecourt sewage treatment plant, with a fecal coliform concentration of 9,200 MPN/100 mL, appeared to contribute to the increased levels in the river. By Site 13 (Hondo) fecal coliforms concentrations were similar to the background level with a value of 3 MPN/100 mL.

Klebsiella concentrations increased substantially at sites below ANC and Millar Western. *Klebsiella* levels in ANC and Millar Western effluents were 1,200,000 and 9,700 MPN/100 mL, respectively. The unusually high concentration in the ANC effluent is likely due to the upset conditions in the effluent treatment plant at the time of sampling. A *Klebsiella* concentration of 21,000 MPN/100mL was recorded in the Whitecourt sewage treatment plant effluent. *Klebsiella* levels at sites in the Athabasca River below the effluent outfalls were above background levels with concentrations ranging from 67 to 1,200 MPN/100 mL were recorded. ANC effluent discharge appeared to be the prime contributor to these elevated levels. By Site 13, the concentration was similar to that recorded at the background site.

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 than 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 most Athabasca River sites were below the detection limit of 0.0006 mg/L. At Site 3, myristic (0.0010 mg/L), oleic (0.0011mg/L) and palmitic (0.0020 mg/L), all fatty acids, were detected. At Site 10, myristic (0.0010 mg/L), oleic (0.0013 mg/L), palmitic (0.0026 mg/L), and stearic (0.0008 mg/L) acid were detected. Myristic (0.0016 mg/L), oleic (0.0019 mg/L), palmitic (0.0035 mg/L), and stearic (0.0017 mg/L) acid were detected at Site 13. The occurrence of these fatty acids was likely from natural sources since these fatty acids were either not detected in the treated effluents, were not found at sites immediately below the effluent outfalls or were in lower concentrations in the effluents than recorded in the Athabasca River. Myristic (0.0110 mg/L) and stearic (0.0130 mg/L) acid were the only resin or fatty acids found in the ANC effluent. Duplicate analysis of the same sample, as part of the laboratory QA/QC, found all resin and fatty acids below detection limits (Appendix 1). Millar Western effluent contained detectable amounts of linoleic (0.0740 mg/L), myristic (0.0200 mg/L), oleic (0.0025 mg/L), and stearic (0.0160 mg/L) acid.

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 2.6 km and was about 15 m wide. Water temperature in the north channel was 2.0°C and 21.5°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 2.0°C compared to a temperature of 0°C at the site above the lead; Millar Western effluent had a temperature of 22.0°C.

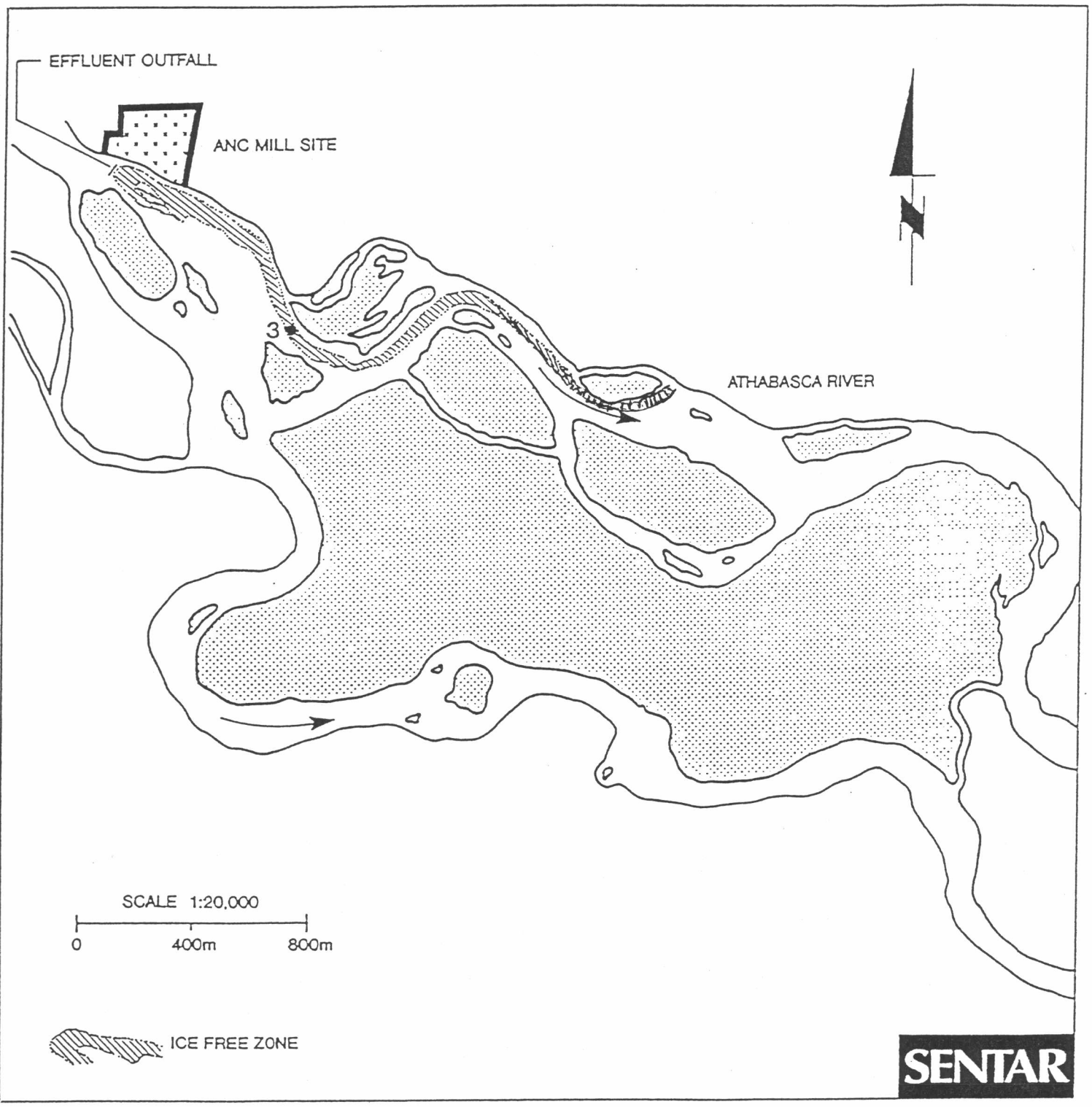


Figure 3. Ice-free zone on the Athabasca River downstream of the ANC effluent outfall, February 1994.

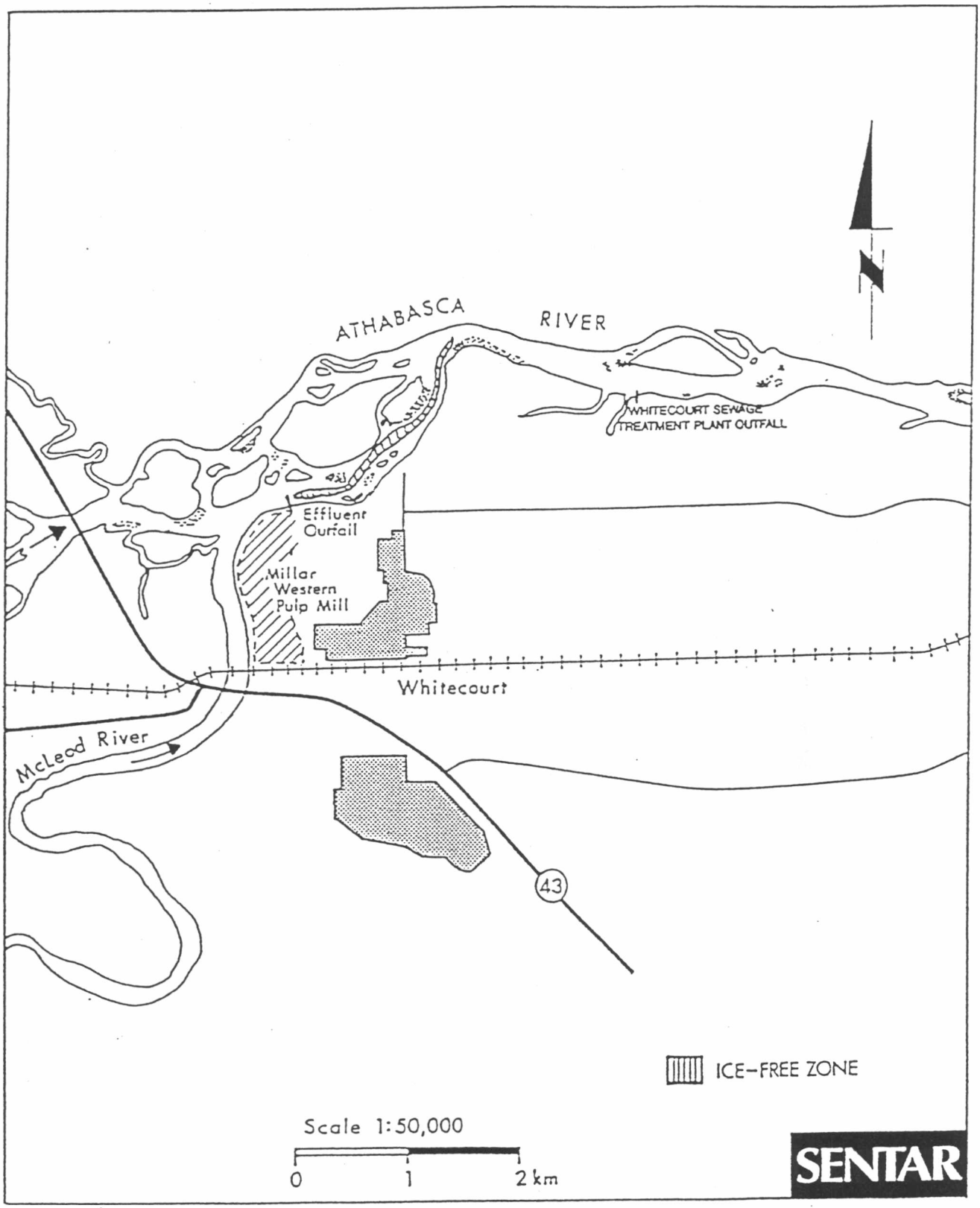


Figure 4. Ice-free zone on the Athabasca River downstream of the Millar Western effluent outfall, February 1994.

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 33.0 to 33.6 m^3/s (Water Survey of Canada, 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 52 m^3/s. Flow in the McLeod River near Whitecourt during the sampling period was 7.8 m^3/s giving a combined flow of about 60 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 13,147 m^3/day (0.152 m^3/s) during February 1994 while mean monthly discharge from the Millar Western mill during this time was 10,822 m^3/day (0.125 m^3/s).

Historical streamflow data for the Athabasca River near Windfall indicated an average monthly discharge for February (1960 - 1993) of 50.2 m^3/s and an average monthly discharge (1985 - 1993) for the McLeod River at Rosevear of 7.0 m^3/s (Environment Canada 1992, unpublished). 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 1994. Dissolved oxygen concentrations were decreased below the background level at the three lowermost sites on the Athabasca River. The dissolved oxygen sag was first evident at the site at Blue Ridge and persisted up to Hondo. The dissolved oxygen concentrations observed during the 1994 survey were the lowest recorded during the past few years and were probably related to flow conditions and the severity of the winter. However, dissolved oxygen concentrations at all sites on the Athabasca River were above the ASWQO but slightly lower than the upper minimum limit of the CWQG for the protection of freshwater aquatic life. BOD inputs from ANC and Millar Western resulted in a slight increase in BOD concentrations at the sites immediately below the outfalls. 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. The highest sodium concentrations were recorded at the lower sites suggesting sodium inputs from other sources. Sulphate, chloride and zinc levels in the Athabasca River were slightly increased above background levels at sites below 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.

As a result of effluent discharge, total and dissolved phosphorus concentrations were elevated above background levels at sites below the ANC mill, Millar Western mill and the Whitecourt sewage treatment plant. Nitrate and nitrite concentrations were slightly higher than background levels primarily the result of inputs from ANC and the Whitecourt sewage treatment plant. Effluent discharge from ANC and the Whitecourt sewage treatment plant resulted in an increase in ammonia and TKN concentrations at downstream sites on the Athabasca River. Suspended solids and color in the Athabasca River were not affected by effluent discharge. Total phenol concentrations were below detection limits at all Athabasca River sites. Concentrations of chelators (EDTA and DTPA) were below detection limits at all sites on the Athabasca River. Fecal coliforms and *Klebsiella* levels in the river increased as result of effluent discharges but approached background levels at the lowermost site at Hondo. Fatty acids were detected at Sites 3 and 10; however,concentrations were not affected by effluent discharge and appear to be related to natural sources.

Effluent discharge from ANC resulted in a 2.6 km ice-free zone in the north channel immediately below the effluent outfall. The south channel was completely ice covered and frozen to the bed. 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

CHEMEX Labs Alberta Inc.

Calgary : 2021 - 41st Avenue N.E., T2E 6P2. Telephone (403) 291-3077, FAX (403) 291-9468
Edmonton : 9331 - 48th Street, T6B 2R4. Telephone (403) 465-9877, FAX (403) 466-3332

SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 1
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-1
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	12.6	0.2
Chloride - Dissolved	17206L	mg/L	5.2	0.5
Sulphate - (IC)	16309L	mg/L	68.4	0.1
Silicon - Dissolved (ICP)		mg/L	3.00	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	1.	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	3.3	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.04	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.28	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.142	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.003	0.001
Total Phosphorus as P	15406L	mg/L	0.003	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.004	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.005	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 1
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-1
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	1	0.5	97.8	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 2
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-2
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	140.	0.2
Chloride - Dissolved	17206L	mg/L	48.6	0.5
Sulphate - (IC)	16309L	mg/L	328.	0.1
Silicon - Dissolved (ICP)		mg/L	10.0	0.02
Colour (True)	02021L	PtCo Units	150.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	8.	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	40.5	0.2
Total Ammonia Nitrogen	07505L	mg/L	10.3	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	14.9	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.520	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	7.50	0.001
Total Phosphorus as P	15406L	mg/L	7.80	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	20.0	0.4
E.D.T.A. (IC)	969001	mg/L	< 1	1.
D.T.P.A. (IC)		mg/L	< 1	1.
Manganese - Dissolved (ICP)	25109L	mg/L	0.771	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.212	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR : SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 2
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-2
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	25-02-94	10	N.A.	102.0	86.4	104.2	101.8	88.6	128.3
D.T.P.A. (IC)	25-02-94	10	N.A.	100.0	88.7	112.5	111.2	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 3
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-3
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	15.3	0.2
Chloride - Dissolved	17206L	mg/L	5.7	0.5
Sulphate - (IC)	16309L	mg/L	81.6	0.1
Silicon - Dissolved (ICP)		mg/L	2.80	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	3.	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	4.4	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.09	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.44	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.149	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.030	0.001
Total Phosphorus as P	15406L	mg/L	0.035	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.007	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.022	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 3
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-3
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 13
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-4
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	18.3	0.2
Chloride - Dissolved	17206L	mg/L	4.2	0.5
Sulphate - (IC)	16309L	mg/L	59.4	0.1
Silicon - Dissolved (ICP)		mg/L	3.42	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	0.5	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	5.4	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.03	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.36	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.169	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.005	0.001
Total Phosphorus as P	15406L	mg/L	0.006	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.008	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.004	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 13
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-4
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Biochemical Oxygen Demand (5 days)	22-02-94	1	N.A.	NOT APPLICABLE			NOT APPLICABLE		
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 5
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-5
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	14.9	0.2
Chloride - Dissolved	17206L	mg/L	5.5	0.5
Sulphate - (IC)	16309L	mg/L	83.4	0.1
Silicon - Dissolved (ICP)		mg/L	2.96	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	1.	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	4.4	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.08	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.36	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.149	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.028	0.001
Total Phosphorus as P	15406L	mg/L	0.033	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.006	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.005	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR : SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 5
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-5
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 6
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-6
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	22.1	0.2
Sulphate - (IC)	16309L	mg/L	16.5	0.1
Silicon - Dissolved (ICP)		mg/L	4.63	0.02
Biochemical Oxygen Demand (5 days)	08202L	mg/L	< 0.1	0.1
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR : SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 6
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-6
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		

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Edmonton : 9331 - 48th Street, T6B 2R4. Telephone (403) 465-9877, FAX (403) 466-3332

SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 9
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-8
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	1020.	0.2
Chloride - Dissolved	17206L	mg/L	47.0	0.5
Sulphate - (IC)	16309L	mg/L	570.	0.1
Silicon - Dissolved (ICP)		mg/L	70.0	0.02
Colour (True)	02021L	PtCo Units	540.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	16.	0.1
Phenols	06537L	mg/L	0.021	0.001
Total Organic Carbon	06005L	mg/L	406.	0.2
Total Ammonia Nitrogen	07505L	mg/L	< 0.01	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	9.50	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.030	0.03
Total Dissolved Phosphorus as P	15423L	mg/L	6.70	0.001
Total Phosphorus as P	15406L	mg/L	6.75	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	108.	0.4
E.D.T.A. (IC)	969001	mg/L	< 1	1.
D.T.P.A. (IC)		mg/L	14.3	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	2.16	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.569	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE #1
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-8
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	18-02-94	2	0.1	100.7	95.0	106.1	103.1	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	25-02-94	10	N.A.	102.0	86.4	104.2	101.8	88.6	128.3
D.T.P.A. (IC)	25-02-94	10	N.A.	100.0	88.7	112.5	111.2	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 18
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-7
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	15.4	0.2
Chloride - Dissolved	17206L	mg/L	5.5	0.5
Sulphate - (IC)	16309L	mg/L	83.2	0.1
Silicon - Dissolved (ICP)		mg/L	3.03	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	2.	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	4.4	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.09	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.48	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.150	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.040	0.001
Total Phosphorus as P	15406L	mg/L	0.043	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.009	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.024	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 7 8
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-7
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 9
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-9
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Biochemical Oxygen Demand (5 days)	08202L	mg/L	16.	0.1
Total Ammonia Nitrogen	07505L	mg/L	9.76	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	9.76	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.636	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	3.00	0.001
Total Phosphorus as P	15406L	mg/L	3.05	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	1.0	0.4

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 9
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-9
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 10
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-10
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	18.5	0.2
Chloride - Dissolved	17206L	mg/L	5.1	0.5
Sulphate - (IC)	16309L	mg/L	75.0	0.1
Silicon - Dissolved (ICP)		mg/L	2.91	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	0.4	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	15.0	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.09	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.28	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.165	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.040	0.001
Total Phosphorus as P	15406L	mg/L	0.043	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.007	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.004	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 10
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-10
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Biochemical Oxygen Demand (5 days)	22-02-94	1	N.A.	NOT APPLICABLE			NOT APPLICABLE		
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 11
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-11
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Sodium - (Flame Photometer) Dis	11103L	mg/L	17.9	0.2
Chloride - Dissolved	17206L	mg/L	4.5	0.5
Sulphate - (IC)	16309L	mg/L	64.2	0.1
Silicon - Dissolved (ICP)		mg/L	3.43	0.02
Colour (True)	02021L	PtCo Units	10.	5.
Biochemical Oxygen Demand (5 days)	08202L	mg/L	< 0.1	0.1
Phenols	06537L	mg/L	< 0.001	0.001
Total Organic Carbon	06005L	mg/L	5.1	0.2
Total Ammonia Nitrogen	07505L	mg/L	0.06	0.01
Total Kjeldahl Nitrogen	07015L	mg/L	0.40	0.02
Nitrite plus Nitrate Nitrogen as N	07110L	mg/L	0.166	0.003
Total Dissolved Phosphorus as P	15423L	mg/L	0.030	0.001
Total Phosphorus as P	15406L	mg/L	0.032	0.001
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.1	0.1
Manganese - Dissolved (ICP)	25109L	mg/L	0.012	0.001
Zinc - Dissolved (ICP)	30501D	mg/L	0.004	0.001

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 11
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-11
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Sodium - (Flame Photometer) Dis	17-02-94	2	0.5	100.6	92.4	106.8	100.0	97.6	104.5
Chloride - Dissolved	17-02-94	2	0.0	102.8	88.7	107.9	103.7	85.2	115.4
Sulphate - (IC)	23-02-94	10	1.7	101.7	94.1	105.5	96.9	93.0	102.4
Silicon - Dissolved (ICP)	22-02-94	10	0.0	102.9	78.0	125.7	108.0	80.2	150.1
Biochemical Oxygen Demand (5 days)	22-02-94	1	N.A.	NOT APPLICABLE			NOT APPLICABLE		
Phenols	22-02-94	1	0.0	96.0	83.2	111.2	97.8	85.6	110.9
Total Organic Carbon	23-02-94	1	1.7	100.0	95.0	106.1	103.7	95.0	111.2
Total Ammonia Nitrogen	17-02-94	1	0.8	100.0	86.8	108.2	99.4	90.2	105.8
Total Kjeldahl Nitrogen	22-02-94	1	0.0	104.5	88.7	112.9	104.0	90.2	114.5
Nitrite plus Nitrate Nitrogen as N	17-02-94	1	1.3	97.7	93.2	106.7	102.1	90.7	113.0
Total Dissolved Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Total Phosphorus as P	23-02-94	1	1.3	96.8	89.6	112.5	114.3	90.0	113.2
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		
E.D.T.A. (IC)	24-02-94	10	N.A.	100.0	86.4	104.2	102.0	88.6	128.3
D.T.P.A. (IC)	24-02-94	10	N.A.	90.0	88.7	112.5	102.0	88.5	119.3
Manganese - Dissolved (ICP)	22-02-94	10	0.0	94.1	89.3	110.9	97.3	82.7	118.0
Zinc - Dissolved (ICP)	22-02-94	10	2.7	95.0	89.3	117.8	97.9	96.1	121.0

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SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

ANL/MW WINTER WATER QUALITY

Sample Description : SITE 12
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-12
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
Biochemical Oxygen Demand (5 days)	08202L	mg/L	< 0.1	0.1
Non-Filterable Residue (TSS)	10401L	mg/L	< 0.4	0.4

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD
ATTENTION : BOB SHELAST

Sample Description : SITE 12
Sample Date & Time : February 17, 1994
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 93-04232-12
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 3, 1994

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES WARN LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK WARN LOWER	CHECK LIMIT UPPER
Biochemical Oxygen Demand (5 days)	22-02-94	1	N.A.	NOT APPLICABLE			NOT APPLICABLE		
Non-Filterable Residue (TSS)	22-02-94	1	0.0	NOT APPLICABLE			NOT APPLICABLE		

bio-chem consulting SERVICES (1980) LTD.

ANALYTICAL REPORT

Sentar Consultants Ltd.
(BC3431)

Sample Number	Location	Fecal Coliforms (cells/100ml)	*Klebsiella sp.* (cells/100ml)
1	Site 1	<1	<1
2	Site 2	1000	1200000
3	Site 3	90	1200
4	Site 5	150	480
5	Site 8	80	770
6	Site 7	700	9700
7	Site 9	9200	21000
8	Site 10	150	520
9	Site 11	11	67
10	Site13	3	3

Michael Sheppard, BSc.
Microbiologist

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: RIVER WATER	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-01A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 1		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	ND
	OLEIC ACID	ND
	PALMITIC ACID	ND
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	ND
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.
2.) NDR = Not Detected due to incorrect ion ratios.
3.) The detection limit applies to all compounds listed.

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: EFFLUENT	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-02A-D1	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 2		
SAMPLE SIZE	: 50 mL	DETECTION LIMIT:	0.0100 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.011
	OLEIC ACID	ND
	PALMITIC ACID	ND
	STEARIC ACID	0.013
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.024
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	0.024

NOTES:

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

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: EFFLUENT	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-02A-D2	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 2		
SAMPLE SIZE	: 50 mL	DETECTION LIMIT:	0.0100 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	ND
	OLEIC ACID	ND
	PALMITIC ACID	ND
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	ND
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	ND

NOTES:

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2.) NDR = Not Detected due to incorrect ion ratios.
3.) The detection limit applies to all compounds listed.

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: RIVER WATER	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-03A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 3		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.0010
	OLEIC ACID	0.0011
	PALMITIC ACID	0.0020
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.0041
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	0.0041

NOTES:

1.) ND = Not Detected, less than detection limit listed.
2.) NDR = Not Detected due to incorrect ion ratios.
3.) The detection limit applies to all compounds listed.

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: RIVER WATER	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-04A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 5		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	ND
	OLEIC ACID	ND
	PALMITIC ACID	ND
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	ND
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	ND

NOTES:

1.) ND = Not Detected, less than detection limit listed.
2.) NDR = Not Detected due to incorrect ion ratios.
3.) The detection limit applies to all compounds listed.

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: EFFLUENT	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-06A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 7		
SAMPLE SIZE	: 50 mL	DETECTION LIMIT:	0.01 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	0.074
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.020
	OLEIC ACID	0.025
	PALMITIC ACID	ND
	STEARIC ACID	0.016
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.14
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	0.14

NOTES:

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

QA/QC:

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

O-methylpodocarpic acid 95% ± 11%

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% ± 16%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: RIVER WATER	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-05A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 78		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	ND
	OLEIC ACID	ND
	PALMITIC ACID	ND
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	ND
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	ND

NOTES:

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2.) NDR = Not Detected due to incorrect ion ratios.
3.) The detection limit applies to all compounds listed.

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: RIVER WATER	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-07A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 10		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.0010
	OLEIC ACID	0.0013
	PALMITIC ACID	0.0026
	STEARIC ACID	0.0008
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.0057
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	0.0057

NOTES:

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QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT : SENTAR CONSULTANTS LTD.
MATRIX : RIVER WATER
LAB SAMPLE# : E4-02-183-08A
CLIENT I.D. : SITE 11
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 06-Mar-94
ANALYST : Mahir Sidra, M.Sc.
DETECTION LIMIT: 0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	ND
	OLEIC ACID	ND
	PALMITIC ACID	ND
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	ND
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	ND

NOTES:

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

QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%

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

PROJECT	: SENTAR CONSULTANTS LTD.	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: RIVER WATER	ANALYSIS DATE	: 06-Mar-94
LAB SAMPLE#	: E4-02-183-09A	ANALYST	: Mahir Sidra, M.Sc.
CLIENT I.D.	: SITE 13		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.0006 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.0016
	OLEIC ACID	0.0019
	PALMITIC ACID	0.0035
	STEARIC ACID	0.0017
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.0087
RESIN ACIDS	ABIETIC ACID	ND
	DEHYDROABIETIC ACID	ND
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	ND
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	ND
	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	ND
	TOTAL RESIN AND FATTY ACIDS :	0.0087

NOTES:

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QA/QC:

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

O-Methylpodocarpic Acid is: 95% ± 10%

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 is: 103% ± 6.2%