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WINTER WATER QUALITY SURVEY ON THE ATHABASCA RIVER, FEBRUARY 1995

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WINTER WATER QUALITY SURVEY

ON THE ATHABASCA RIVER

FEBRUARY 1995

Prepared For:

ALBERTA NEWSPRINT COMPANY
WHITECOURT, ALBERTA

Prepared By:

SENTAR CONSULTANTS LTD.
CALGARY, ALBERTA

Bob M. Shelast
Kevin T. Brayford

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1.0 INTRODUCTION

As part of the license requirements of Alberta Environmental Protection, Alberta Newsprint Company (ANC) is required to conduct a winter water quality monitoring survey in the Athabasca River during the winter of 1994/1995. Previous winter water quality surveys were conducted in 1990 to 1994 inclusive and are part of the ongoing environmental monitoring programs established by ANC. The objective of the survey is to determine the water quality of the Athabasca River both upstream and downstream of existing effluent discharge points. 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

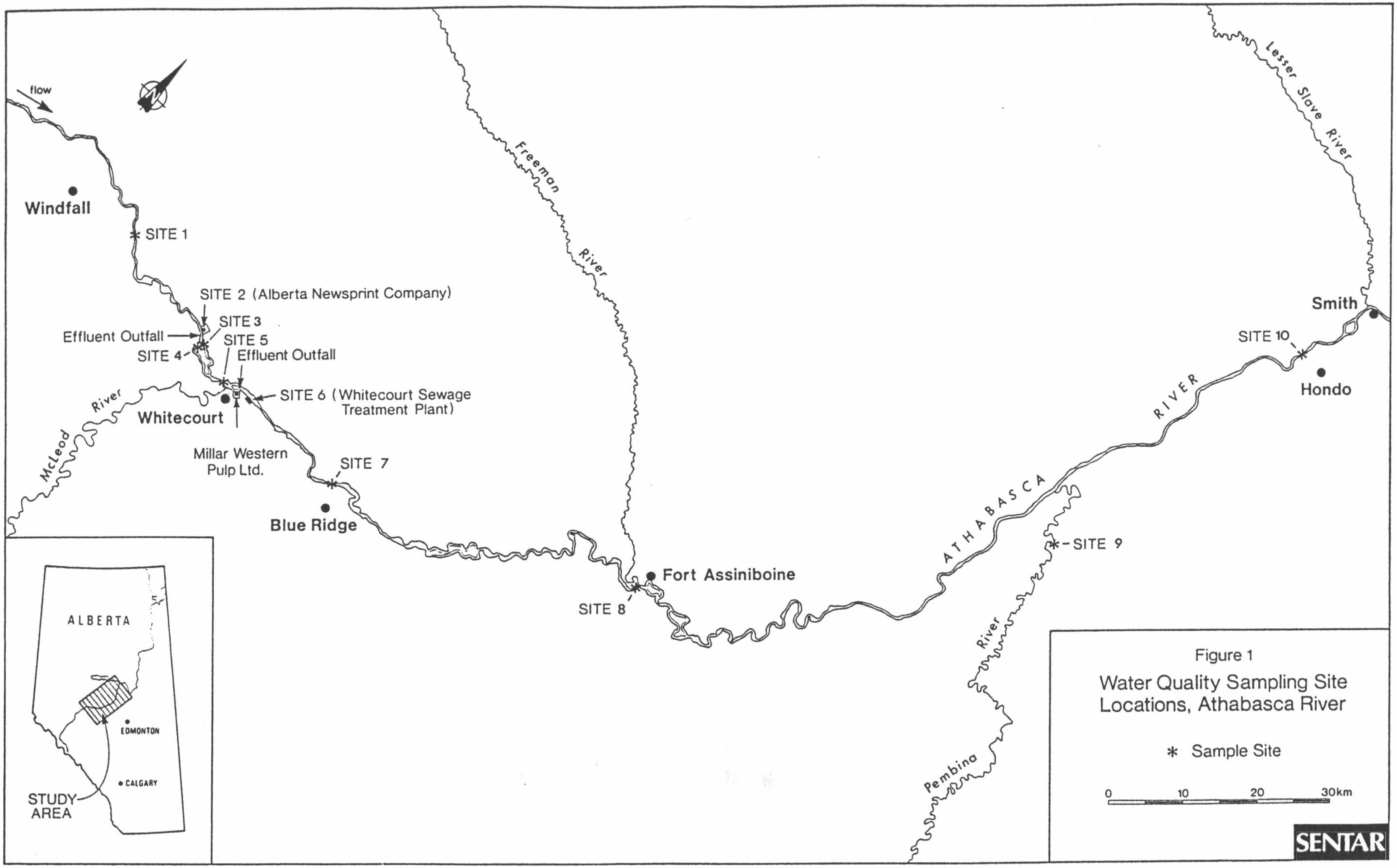
2.1 SITE LOCATIONS

Water quality sampling was conducted at 10 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. The sites were initially established and sampled during the 1990/1991 winter water quality program, the first year that such a program was undertaken by ANC (Beak 1991).

2.2 SAMPLE COLLECTION AND ANALYSES

The water quality survey was conducted on the 23 to 25 February 1995. 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 1995 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 Site 3 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. Samples were taken about 20 cm below the water surface. Field observations indicated that a large amount of frazil ice was present throughout the water column at Site 8 (Fort Assiniboine) at the time of sampling; all other sites were free of frazil ice. Effluent samples were taken directly from the ANC effluent pumphouse and the Whitecourt sewage treatment plant. River time of travel between sites was incorporated into the sampling regime, where logistically possible. In previous winter water quality surveys, a joint program was done with Millar Western Pulp Ltd.. In these programs, samples were also taken from the Millar Western effluent pumphouse, the McLeod River and at a site on the Athabasca River located approximately 0.5 km below the efffluent outfall. However, under their current License to Operate issued by Alberta Environmental Protection, Millar Western was not required to conduct a winter water quality program in 1995.


flow
Windfall
SITE 1
SITE 2 (Alberta Newsprint Company)
SITE 3
Effluent Outfall
SITE 5
SITE 4
Effluent Outfall
SITE 6 (Whitecourt Sewage Treatment Plant)
McLeod River
Whitecourt
Millar Western Pulp Ltd.
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Fort Assiniboine
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ATHABASCA RIVER
SITE 9
Pembina River
Lesser Slave River
Smith
SITE 10
Hondo
ALBERTA
EDMONTON
CALGARY
STUDY AREA
Figure 1
Water Quality Sampling Site Locations, Athabasca River
* Sample Site
0 10 20 30km
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Table 1. **Sample site and sampling point locations, February 1995.**

Site	Location	Date and Time Sampled	Sampling Point[a]
1	Windfall bridge	23/02, 1645	60 m below bridge, 20 m from right bank
2	ANC effluent	24/02, 1005	effluent pumphouse
3	0.5 km downstream of ANC outfall (north channel)	24/02, 1310	mid-channel
4	0.5 km downstream of ANC outfall (south channel)	24/02, 1330	15 m from left bank
5	Whitecourt (upstream of the McLeod River)	24/02, 1055	750 m below bridge, 25 m from right bank
9	Whitecourt sewage treatment plant effluent	24/02, 1150	treatment plant
10	Blue Ridge	24/02, 1530	35 m above bridge, 45 m from left bank
11	Fort Assiniboine	25/02, 1045	15 m above Freeman R. mouth 20 m from left bank
12	Pembina River near Flatbush	16/02, 1450	15 m below bridge, 15 m from right bank
13	Near Hondo (Highway #2)	16/02, 1605	15 m above bridge, 45 m from right bank

a Left and right banks were determined looking downstream

All samples were preserved in the field by standard methods, stored on ice, and forwarded within 24 hours to the laboratory for analysis.

The sampling regime for each site for the various water quality parameters is shown on Table 2. Field measurements for temperature, pH, 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 Myron L 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 chelates were conducted by Alpha Laboratory Services of Edmonton using standard methods (Appendix 1). Resin acid analyses were done by Enviro-Test Laboratories of Edmonton using GC/SIM-MS, in accordance with Alberta Environment method AE 129.0 (Appendix 1). Chelate analyses were performed by Chemex Labs of Calgary using standard methods.

In addition to the water quality sampling, the ice-free zone due to ANC effluent discharge 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.

2.3 QUALITY ASSURANCE/QUALITY CONTROL

A Quality Assurance/Quality Control (QA/QC) program was implemented during this study. Standard Operating Procedures (SOP's) or ptotocols were used for all procedures (such as sample collection, sample shipping, sample storage, chain of custody forms), laboratory procedures (such as laboratory duplicates, surrogate spikes and/or internal standards) and reporting data (including data entry checks). Documentation regarding QA/QC is provided in Appendix 2.

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 Whitecourt STP	7 Blue Ridge	8 Fort Assiniboine	9 Pembina R.	10 Hondo
Temperature [a]	X	X	X	X	X	X	X	X	X	X
pH [a]	X	X	X	X	X	X	X	X	X	X
Dissolved Oxygen [a]	X	X	X	X	X	X	X	X	X	X
Conductivity [a]	X	X	X	X	X	X	X	X	X	X
BOD_5	X	X	X	X	X	X	X	X	X	X
Sodium	X	X	X	X	X		X	X		X
Sulphate	X	X	X	X	X		X	X		X
Chloride	X	X	X	X	X		X	X		X
Manganese	X	X	X	X	X		X	X		X
Zinc	X	X	X	X	X		X	X		X
Total Phosphorus	X	X	X	X	X	X	X	X		X
Dissolved Phosphorus	X	X	X	X	X	X	X	X		X
Nitrate and Nitrite Nitrogen	X	X	X	X	X	X	X	X		X
Total Kjeldahl Nitrogen	X	X	X	X	X	X	X	X		X
Ammonia Nitrogen	X	X	X	X	X	X	X	X		X
Total Organic Carbon	X	X	X	X	X		X	X		X
Total Suspended Solids	X	X	X	X	X	X	X	X	X	X
True Color	X	X	X	X	X		X	X		X
Total Phenols	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
Klebsiella	X	X	X	X	X		X	X		X
Resin Acids	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 1995 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 2.8 to 11.3 mg/L which represents 22 to 91% saturation (Figure 2). The lowest level recorded was at Site 4 which was located 0.5 km below the ANC effluent outfall in the south channel of the river. Previous winter water quality studies undertaken by ANC indicated that generally there is little or no flow in the south channel during the winter months. Field observations at this site indicated that water depth under ice was only 16 cm at the time of sampling. Based on the water chemistry at this site (discussion to follow), it is likely that the flow at this site was comprised of groundwater discharge rather than of "Athabasca River" water and/or ANC efffluent. Dissolved oxygen concentrations measured in the field for the ANC effluent and Whitecourt sewage effluent were 7.4 and 2.4 mg/L, respectively, which represents 91 and 22% saturation, respectively. The Pembina River, a major tributary to the Athabasca River within the study area, had a dissolved oxygen concentration and saturation level of 2.3 mg/L and 17%, respectively.

Dissolved oxygen concentrations at sites on the Athabasca River below effluent outfalls were lower than the background level recorded at Site 1 (Windfall). Dissolved oxygen concentrations decreased progressively downstream and were below the background concentration of 11.3 mg/L. A similar trend was observed in past winter water quality studies. The dissolved oxygen sag at Blue Ridge (Site 7), Fort Assiniboine (Site 8) and Hondo (Site 10) has been documented in previous winter water quality studies on the

Table 3. Water quality results for the Athabasca River, tributary streams and effluent sources, 23 - 25 February 1995 (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 Whitecourt STP	7 Blue Ridge	8 Fort Assiniboine	9 Pembina R.	10 Hondo	AASWQIG[a]	CWQG[a]
Temperature (°C)	0	23	3	1	0	8	0	0	0	0	Increase of 3°C	-
pH (units)	7.7	7.7	8.2	7.9	8.1	7.5	8.1	8.1	7.9	8.1	6.5 - 8.5	6.5 - 9.0
Dissolved Oxygen (field)	11.3	7.4	11.2	2.8	11.0	2.4	10.0	8.8	2.3	8.7	5.0	5.0 - 9.5
DO Saturation (%)(field)	84	94	91	22	82	22	74	65	17	64	-	-
BOD_5	2.0	8.3	1.2	2.0	1.0	13.0	<1.0	2.6	<1.0	<1.0	-	-
Conductivity (μmhos/cm)	455	1,380	450	375	420	1,050	455	420	445	435	-	-
Sodium	14	170	14	9.1	14	130	21	22	-	23	-	-
Sulphate	89	376	83	48	85	46	81	76	-	66	-	-
Chloride	5.6	42	5.5	2.8	5.5	122	5.4	5.4	-	4.3	-	-
Manganese (dissolved)	0.009	1.59	<0.005	0.177	<0.005	-	0.010	0.006	-	<0.005	-	-
Zinc (dissolved)	<0.001	0.110	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	0.05	0.03
Total Phosphorus (as P)	0.058	8.340	0.078	0.062	0.080	4.270	0.075	0.250	-	0.054	0.05	-
Dissolved Phosphorus (as P)	0.008	6.290	0.041	0.010	0.029	3.210	0.032	0.027	-	0.018	-	-
Nitrate/Nitrite Nitrogen	0.16	1.50	0.16	0.10	0.15	8.60	0.14	0.20	-	0.20	-	-
Total Kjeldahl Nitrogen	0.2	3.3	0.2	0.3	0.2	8.6	0.2	0.4	-	0.3	1.0	-
Total Ammonia Nitrogen	<0.10	1.15	0.14	0.12	<0.10	6.10	0.14	<0.10	-	0.15	-	1.53[b]
Total Organic Carbon	<1	39	<1	<1	2	-	3	3	-	3	-	-
Total Suspended Solids	<1	16	<1	68	1	8	1	132	3	1	Increase of 10	-
True Color (units)	5	250	7.5	5	7.5	25	12.5	20	-	17.5	Increase of 30	-
Phenols	0.001	0.007	0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	0.005	0.001
Chelates - EDTA	<0.1	0.3	<0.1	<0.1	<0.1	-	<0.1	<0.1	-	<0.1	-	-
Chelates - DTPA	<0.2	1.8	<0.2	<0.2	<0.2	-	<0.2	<0.2	-	<0.2	-	-
Fecal Coliforms (CFU/100mL)	<1	155,000	330	5	190	29,000	80	8	-	5	<5,000/100 mL	-
Klebsiella (CFU/100mL)	<1	60,00	470	5	80	11,000	40	40	-	5	-	-
Resin Acids												
Abietic acid	<0.001	0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Dehydroabietic acid	<0.001	0.002	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Isopimaric	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Levopimaric acid	<0.001	0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Neoabietic acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Palustric acid	<0.001	0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Pimaric acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-

(continued)

Table 3. (concluded)

Parameter	Site										AASWQIG[a]	CWQG[a]
	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 Whitecourt STP	7 Blue Ridge	8 Fort Assiniboine	9 Pembina R.	10 Hondo		
Resin Acids												
Sandaracopimaric acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Dichlorodehydroabietic acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
12-Chlorodehydroabietic acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
14-Chlorodehydroabietic acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
TOTAL	<0.001	0.005	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	0.1	-
Fatty Acids												
Arachidic acid	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Dichlorostearic acid	<0.001	0.003	<0.001	<0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Linoleic acid	<0.001	<0.001	<0.001	0.001	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Linolenic acid	<0.001	0.001	<0.001	0.002	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Myristic acid	<0.001	0.011	0.001	0.003	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Oleic acid	<0.001	0.014	0.002	0.003	<0.001	-	<0.001	<0.001	-	<0.001	-	-
Palmitic acid	<0.001	0.002	0.002	0.008	0.001	-	0.003	0.002	-	0.002	-	-
Stearic acid	<0.001	<0.001	<0.001	0.001	0.001	-	0.001	0.001	-	0.001	-	-
TOTAL	<0.001	0.031	0.005	0.018	0.002	-	0.004	0.003	-	0.003	-	-

a AASWQIG - Alberta Ambient Surface Water Quality Interim Guidelines (Alberta Environmental Protection 1993)
CWQG - Canadian Water Quality Guideline for Freshwater Aquatic Life (CCREM 1987)

b CWQG of 1.53 for ammonia nitrogen is at a pH of 8.0 and a temperature of 0°C.

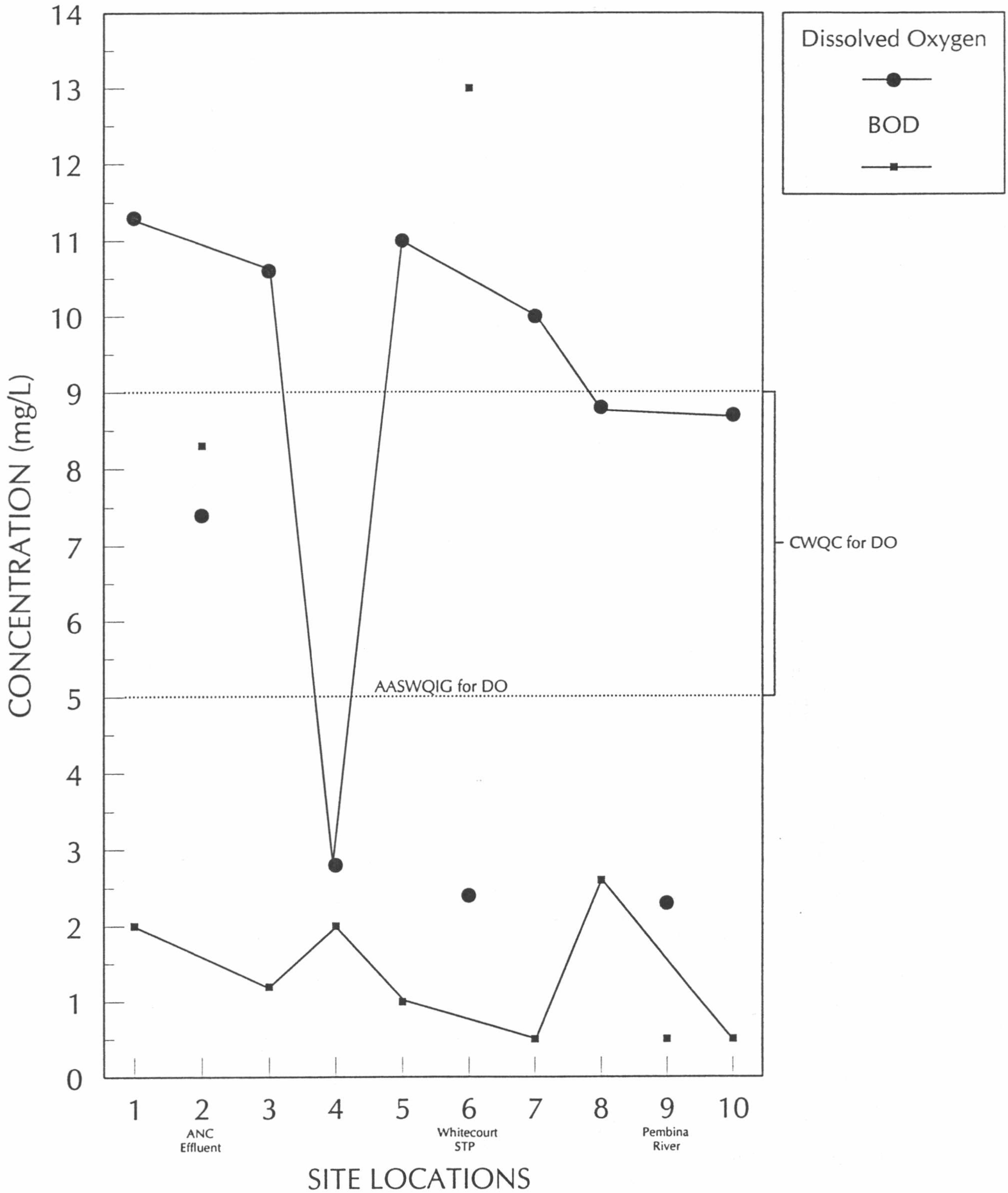

Figure 2. **Dissolved oxygen and BOD_5 concentrations for the Athabasca River, effluent sources and tributary streams, 23 to 25 Februrary 1995.**

Athabasca River (Noton and Shaw 1989, Beak 1990, 1991, SENTAR 1992, 1993, Shelast and Brayford 1994). 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 probably related to several factors including flow conditions, time of freeze-up, frazil ice formation and associated bed scour, 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, it is apparent that the three lowermost sites at Blue Ridge (Site 7), Fort Assiniboine (Site 8) and Hondo (Site 10) exhibited an appreciable decrease in dissolved oxygen saturation. The site immediately below the ANC effluent outfall had a higher dissolved oxygen saturation level 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 Ambient Surface Water Quality Interim Guideline (AASWIG) of a minimum of 5.0 mg/L. Dissolved oxygen concentrations at Sites 8 and 10 were 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 the Pembina River were low ranging from <1.0 to 2.6 mg/L with the highest value recorded at Site 8 at Fort Assiniboine (Figure 2). BOD_5 concentrations in ANC effluent and the Whitecourt sewage treatment plant (STP) effluent were 8.3 and 13.0 mg/L, respectively. Effluent discharge from these sources did not elevate BOD_5 concentrations at sites on the Athabasca River since levels were below the background value of 2.0 mg/L. The elevated BOD_5 concentration recorded at Site 8 (Fort Assiniboine) was likely due to the resuspension of organic sediment from the scouring affect of the large amount of frazil ice observed in the water column at this site. A similar situation has been recorded during previous winter water quality surveys conducted by ANC.

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 375 to 455 µmhos/cm. The lowest value was recorded at Site 4 in the south channel of the river below ANC. With the exception of this value, the conductivity readings at all other site on the river were very similar to the background site. The atypically low level at Site 4 suggests that the source of flow at this site is from localized groundwater discharge with little or no contribution from the mainstem river or ANC effluent. Effluents from ANC and the Whitecourt sewage treatment plant were substantially higher in conductivity with values of 1,380 and 1,050 µmhos/cm, respectively. However, effluent discharge from these sources did not affect specific conductance values at sites below the effluent outfalls.

Sodium concentrations in the Athabasca River downstream of ANC were not affected by effluent discharge from the ANC mill. Sodium concentrations at Site 3 immediately below ANC and at Site 5 at Whitecourt were 14 mg/L which is identical to the value recorded at the background site at Windfall. The relatively low sodium level recorded at Site 4 reinforces the conclusion that flow in the south channel originates from localized groundwater discharge. ANC effluent had a sodium concentration of 170 mg/L. The highest sodium concentrations recorded at sites on the Athabasca River occurred at the three lowermost sites suggesting sodium inputs from other sources. Sodium cooncentrations in the river below Whitecourt were above background levels (21 - 23 mg/L cf. 14 mg/L) likely as a result of effluent discharge from the Millar Western pulp mill at Whitecourt as well as inputs from the McLeod River. Although no samples were taken from the McLeod River and Millar Western's effluent during this study, previous winter water quality studies have shown that these two sources are contributors to sodium levels in the Athabasca River. Although the ANC effluent contained higher concentrations of sulphate and chloride than the background site on the Athabasca River, concentrations of these parameters in the river were not affected by effluent discharge. Sulphate and chloride concentrations in the ANC effluent were 376 and 42 mg/L, respectively. Sulphate and chloride concentrations of 89 and 5.6 mg/L, respectively, were recorded at the background site. Sulphate concentrations at sites on the Athabasca River below effluent discharge points ranged from 48 to 85 mg/L while chloride concentrations at these sites ranged from 2.8 to 5.5 mg/L. Sulphate and chloride concentrations in the Whitecourt sewage effluent were 46 and 122 mg/L, respectively.

Manganese concentrations at sites on the Athabasca River were not affected by effluent discharge from ANC. A manganese concentration of 0.009 mg/L, was recorded at background Site 1. The ANC effluent had a manganese concentration of 1.59 mg/L. At sites below the ANC effluent outfall, manganese concentrations ranged between <0.005 to 0.010 mg/L except for Site 3 which had an atypically high concentration of 0.177 mg/L. This high value reflects the groundwater inputs at this site. Although the ANC effluent contained a substantially higher concentration of zinc than the background site, effluent discharge did not result in increased zinc levels at the sites on the river. A zinc concentration of 0.110 mg/L was recorded in the ANC effluent while concentrations at all Athabasca River sites including the background site, were below the detection limit of 0.001. All zinc values recorded at the Athabasca River sites were below the AASWQIG of 0.05 mg/L and the CWQG of 0.03 mg/L.

3.3 NUTRIENTS

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

Total phosphorus concentrations at most sites on the Athabasca River were higher than the background level of 0.058 mg/L. The highest total phosphorus concentration occurred at Site 8 (Fort Assiniboine) where a value of 0.250 mg/L was recorded. This high value was due to frazil ice scour resulting in high concentrations of suspended solids (particulate matter) to which phosphorus is bound; dissolved phosphorus concentrations at this site formed only a small portion of the total phosphorus concentration. The total phosphorus concentration in ANC effluent was 8.340 mg/L most of which was in dissolved form (6.290 mg/L). Compared to previous surveys, total phosphorus concentrations of both the Athabasca River and effluent were substantially higher than those recorded during previous surveys. These higher values were due to the difference in analytical techniques between years where a stronger acid was used to digest the samples collected during the 1995 survey. Data collected by ANC as part of their effluent monitoring program indicated that in February 1995 the average total and dissolved phosphorus concentrations in the effluent were 5.29 and 5.06 mg/L, respectively. The analytical method used for these effluent samples called for digestion using a weaker acid. The Whitecourt sewage treatment effluent had a total phosphorus concentration of 4.270 mg/L, most of which was in dissolved form. Effluent discharge from ANC and the Whitecourt sewage treatment plant as well as inputs from the Millar Western mill, resulted in increased total phosphorous concentrations in the Athabasca River above the background level. This condition persisted until the lowermost site on the river (Site 10) where total phosphorus concentrations approached background levels. Total phosphorus concentrations at all sites on the Athabasca River were above the AASWQIG 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, the Whitecourt sewage treatment plant and probably Millar Western has resulted in elevated dissolved phosphorus concentrations in the Athabasca River. A dissolved phosphorus concentration of 0.008 mg/L was recorded at the background site while levels at all sites on the Athabasca River receiving effluent ranged from 0.010 to 0.041 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 similar to the background level of 0.16 mg/L. Nitrate and nitrite nitrogen concentrations in the ANC and the Whitecourt sewage treatment plant were 1.50 and 8.60 mg/L, respectively.

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 and Whitecourt sewage treatment plant effluents were 3.3 and 8.6 mg/L, respectively. Total Kjeldahl nitrogen concentrations in the Athabasca River were similar to the background concentration of 0.2 mg/L and were not affected by effluent discharge. TKN concentrations at sites below effluent outfalls ranged from 0.2 to 0.4 mg/L. All total Kjeldahl nitrogen concentrations in the Athabasca River were well below the AASWQIG 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 slightly exceeded the background level of <0.10 mg/L at all sites except Site 8. The ammonia nitrogen concentration in ANC effluent was 1.15 mg/L while the ammonia concentration in the Whitecourt sewage effluent was 6.10 mg/L which was considerably higher than the background level. Effluent discharge from ANC and the Whitecourt sewage treatment plant resulted in a slight increase in ammonia concentrations at downstream sites on the Athabasca River.

Total organic carbon is composed of both dissolved and particulate organic carbon and is directly related with both biochemical and chemical oxygen demand. Sources of total organic carbon include runoff from agricultural land and municipal and industrial waste discharges (McNeely et al. 1979). Total organic carbon concentrations were identical to the background level of <1 mg/L at the sites immediately below the ANC effluent outfall. A total organic carbon concentrations of 39 mg/L was recorded in the ANC effluent. However, by Site 5 at Whitecourt and below, total carbon concentrations were elevated above the background level and ranged from 2 - 3 mg/L. This slight increase in organic carbon levels is likey due to inputs from Millar Western's mill and possibly the McLeod 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 (TSS) concentrations were low at most sites on the Athabasca River with values ranging from <1 to 1 mg/L. The site in the south channel of the river below ANC (Site 4) had a TSS concentration of 68 mg/L which was likely due to the flow characteristics at this site. The high TSS concentration at Site 8 was due to the large amounts of frazil ice in the water column which scoured the river bed resulting in the resuspension of bottom sediments. Total suspended solids concentrations in the ANC effluent was 16 mg/L while the Whitecourt sewage effluent had a TSS concentration of 8 mg/L. 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 all sites on the Athabasca River were elevated above the background level of 5 units. True color values at Athabasca River sites ranged from 7.5 to 20 units. A true color value of 250 units was recorded in the ANC effluent while the Whitecourt sewage effluent had a true color of 25 units. True color values at all sites below effluent discharge points were within the AASWQIG 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 were <0.001 mg/L except at Site 3 where the toatl phenol concentration was identical to the background level. A total phenol concentration of 0.007 mg/L was recorded for the ANC effluent. Both the AASWQIG 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, the ANC pulp mill does not 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 for EDTA and <0.2 mg/L for DTPA. Although chelate concentrations in the ANC effluent were 0.3 mg/L for EDTA and 1.8 mg/L for DTPA, effluent discharge did not have any effect on chelate concentrations in the Athabasca River.

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* concentrations in the Athabasca River were affected by effluent discharge. A concentration of < 1 CFU/100 mL was recorded for both these parameters at the background Site 1. Immediately downstream of the ANC mill, fecal coliforms levels increased substantially to between 190 and 330 CFU/100 mL. A fecal coliform concentration of 155,000 CFU/100mL was recorded for the ANC effluent. Effluent discharge from the Whitecourt sewage treatment plant, with a fecal coliform concentration of 29,000 CFU/100 mL, appeared to contribute to the increased levels in the river. Although not measured during this survey, previous surveys have shown that Miilar Western effluent discharge also contributes to elevated fecal coliform levels in the Athabasca River below their effluent outfall. Fecal coliform levels remained elevated above the background level at Site 7 at Blue Ridge and Site 8 at Fort Assiniboine where concentrations were 80 and 8 CFU/100mL, respectively. By Site 10 (Hondo) fecal coliforms concentrations were approaching the background level with a value of 5 CFU/100 mL.

Klebsiella concentrations also increased substantially at sites below ANC and the Whitecourt sewage treatment plant. *Klebsiella* levels in ANC and Whitecourt sewage effluents were 60,000 and 11,000 CFU/100 mL, respectively. *Klebsiella* levels at sites in the Athabasca River below the effluent outfalls were above background levels with concentrations ranging from 5 to 470 CFU/100 mL. Similar to the situation for fecal coliforms, Millar Western effluent discharge was likely a contributor to these elevated levels. By Site 10, the concentration was similar to that recorded at the background site.

A 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, dichlorostearic 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 acids were not detected (detection limit 0.001 mg/L) at any Athabasca River sites. ANC effluent had a total resin acid concentration of 0.005 mg/L which was comprised of abietic acid (0.001 mg/L), dehydroabietic acid (0.002 mg/L), levopimaric acid (0.001 mg/L), and palustric acid (0.001 mg/L). Fatty acids were not detected at the background site but were found at all Athabasca River sites. At Site 3, myristic (0.001 mg/L), oleic (0.002mg/L) and palmitic (0.002 mg/L) acids, were detected. At Sites 5, 7, 8, and 10, palmitic (0.001 - 0.003 mg/L) and stearic (0.001 mg/L) acid were detected. At Site 4, linoleic (0.001 mg/L), linolenic (0.002 mg/L), myristic (0.003 mg/L), oleic (0.003 mg/L), palmitic (0.008 mg/L), and stearic (0.001 mg/L) acid were detected. The source of the fatty acids at this site is unknown since other water chemistry parameters strongly suggest that ANC effluent did not contribute to the flows at this site. It is possible that the fatty acids may be of natural origin since some of them (e.g. palmitic acid) were found in higher concentrations than in the ANC effluent. Dichlorostearic (0.003 mg/L), linolenic (0.001 mg/L), myristic (0.011 mg/L) oleic (0.014 mg/L), and palmitic (0.002 mg/L) acid were the only fatty acids found in the ANC effluent.

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; however the south channel was entirely ice-bound at the time of sampling. The open-water lead in the north channel extended for about 3.3 km and was about 5 to 15 m wide. Water

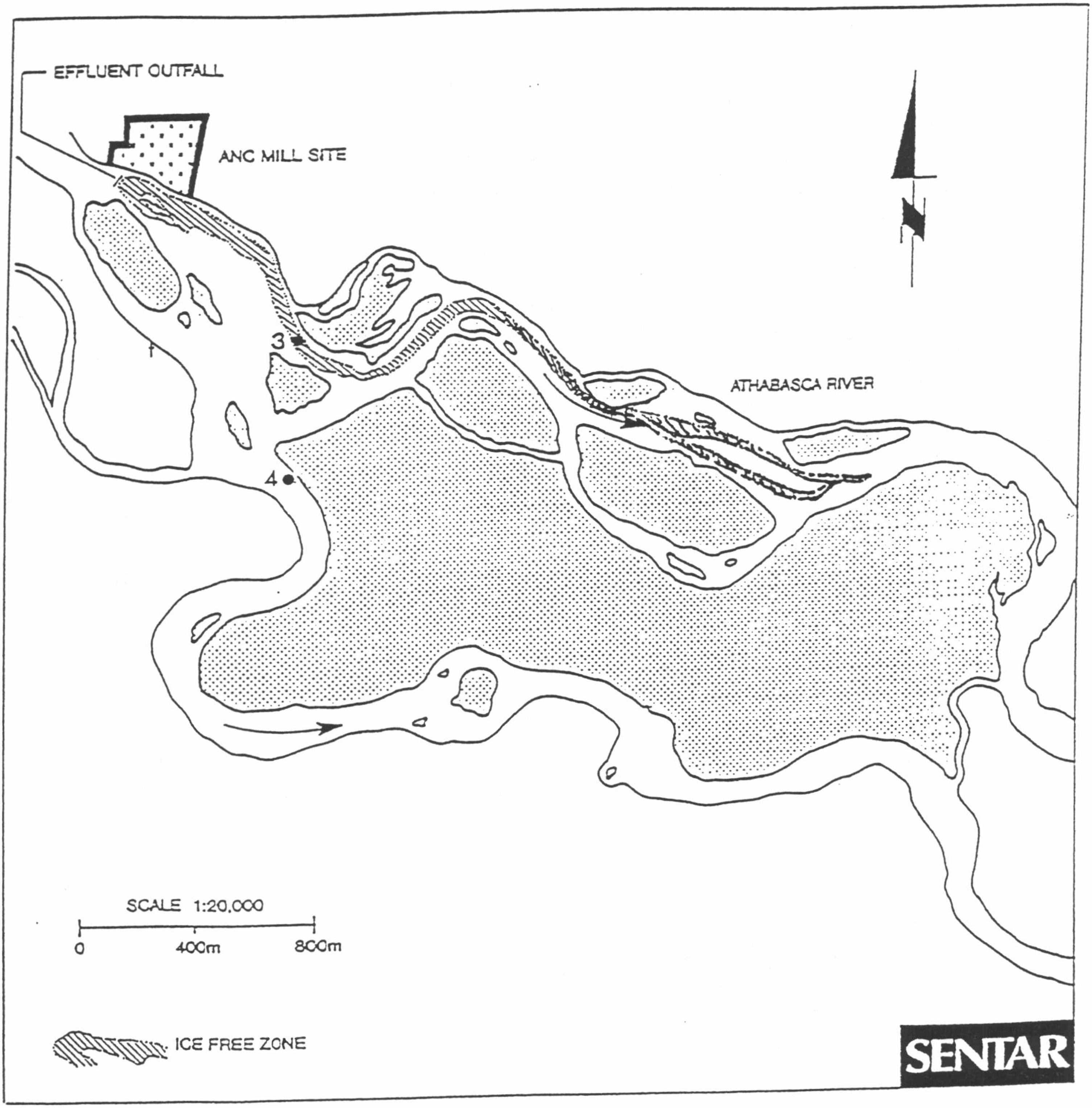

Figure 3. **Ice-free zone on the Athabasca River downstream of the ANC effluent outfall, February 1995.**

temperature in the north channel was 3.0°C and 23.0°C in the ANC effluent. The surface water temperature at the background site was 0°C.

The nearest operating gauge staion on the Athabsca River is at Hinton; Environment Canada no longer operates a gauge station at Windfall during the winter months. An incidental flow measurement taken at the Windfall station by Alberta Environmental Protection on February 14, 1995 was 38.1 m^3/s. Allowing for travel time, the flow at Hinton on a comparable date was 30.2 m^3/s, a difference of about 8 m^3/s. Flow in the Athabasca River at Hinton during this study was 31.4 to 31.9 m^3/s (Water Survey of Canada, pers. comm.). Assuming the same trend occurred during the sampling dates of this study, flow in the Athabasca River at Windfall, approximately 20 km upstream of the ANC effluent outfall, would have been about 40 m^3/s. Flow in the McLeod River near Rosevear during the sampling period was about 5 m^3/s giving a combined flow of about 45 m^3/s for the Athabasca River below Whitecourt. Treated effluent was discharged from the ANC mill at a rate of 15,328 m^3/day (0.18 m^3/s) during February 1995.

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 slightly below the 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 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 1995. 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 1995 survey were typical of those recorded during the past several years. Dissolved oxygen concentrations at all sites on the Athabasca River were above the AASWQIG but slightly lower than the upper minimum limit of the CWQG for the protection of freshwater aquatic life. BOD inputs from ANC and the Whitecourt sewage treatment plant did not have any effect on BOD concentrations measured in the Athabasca River. Sodium, sulphate, chloride, manganese, and zinc levels in the Athabasca River were not affected by effluent discharges.

As a result of effluent discharge, total and dissolved phosphorus concentrations were elevated above background levels at sites below the ANC mill and the Whitecourt sewage treatment plant. Phosphorus concentrations measured in the ANC effluent during this study were higher than the monthly average recorded in February 1995 during ANC's ongoing effluent monitoring program. These higher values were due to the difference in analytical techniques where a stronger acid was used to digest the samples collected during the 1995 survey. Effluent discharge from ANC and the Whitecourt sewage treatment plant also resulted in an increase in ammonia and TKN concentrations at downstream sites on the Athabasca River. Although not measured during this survey, it is likely that effluent discharge from the Millar Western mill was also a contributor to elevated nutrient levels in the Athabasca River since a similar trend was observed during previous winter water quality studies. Suspended solids in the Athabasca River were not affected by effluent discharge. Total phenol concentrations were below detection limits at most 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. Although resin acids were not detected at any of the Athabasca River sites, some fatty acids were detected at several sites. The origin of these fatty acids is unknown but may be due to natural sources.

Effluent discharge from ANC resulted in a 3.3 km ice-free zone in the north channel immediately below the effluent outfall. The south channel was completely ice covered with very little flow. It is suspected that most of the flow in the south channel is from localized groundwater discharge. Flows in the Athabasca and McLeod rivers during the sampling period were slightly below the historical average streamflows for February.

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6.0 SENTAR QUALITY MANAGEMENT PROGRAM

This report, entitled "**Winter Water Quality Survey on the Athabasca River, February 1995**", was produced by the following individuals:

Bob M. Shelast	**Kevin T. Brayford**
Name	Name
Signature	Signature

This report was reviewed by the following individual:

Robert C. Scace
Name

Signature

Approval to transmit to client:

Robert C. Scace
Office Manager/Senior Consultant

Signature

APPENDIX 1

LABORATORY ANALYTICAL METHODS AND RESULTS

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ALPHA LABORATORY SERVICES LTD.

Analytical and Consulting Services

17212 - 106 A Avenue
Edmonton, Alberta T5S 1M7
Phone: (403) 489-9100 Fax: (403) 489-9700

TECHNICAL REPORT

To: **Sentar Consultants Ltd.**
10160 112 Street
Edmonton AB T5K 2L6

File: **7348**
Date: **March 15, 1995**
Client PO:
Attention: **Bob Shelast**

Project: **ANC #09-805-00**

Parameter	Unit	Sample ID: **Site 1 River Water** Date Sampled: **Feb. 23/95**	Date Analyzed	Analyst Initials
Biochemical Oxygen Demand	mg/L	2.0	Feb. 24/95	T.H.
Sodium	mg/L	14	Feb. 27/95	B.L.
Sulphate	mg/L	89	Feb. 24/95	B.L.
Chloride	mg/L	5.6	Feb. 24/95	B.L.
Manganese - Dissolved	mg/L	0.009	Mar. 1/95	L.R.
Zinc - Dissolved	mg/L	<0.001	Mar. 1/95	L.R.
Total Phosphorus	mg/L P	0.058	Mar. 3/95	G.M.
Dissolved Phosphorus	mg/L P	0.008	Mar. 9/95	G.M.
Nitrate & Nitrite	mg/L N	0.16	Feb. 24/95	B.L.
Total Kjeldahl Nitrogen	mg/L N	0.2	Mar. 1/95	G.M.
Ammonia	mg/L N	<0.10	Feb. 28/95	G.M.
Total Organic Carbon	mg/L	<1	Mar. 1/95	B.L.
Total Suspended Solids	mg/L	<1	Mar. 7/95	T.H.
True Colour	TCU	5	Feb. 27/95	G.M.
Total Phenols	mg/L	0.001	Mar. 6/95	E.W.
Fecal Coliforms	CFU/100mL	<1	Feb. 24/95	B.D.
Klebsiella spp.	CFU/100mL	<1	Feb. 24/95	B.D.

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TECHNICAL REPORT

To: **Sentar Consultants Ltd.** File: **7348**

Project: **ANC #09-805-00**

	Sample ID:	**Site 2 Mill Effluent**	**Site 3 River Water**		
	Date Sampled:	**Feb. 24/95**	**Feb. 24/95**		
Parameter	Unit			Date Analyzed	Analyst Initials
Biochemical Oxygen Demand	mg/L	8.3	1.2	Feb. 25/95	B.D.
Sodium	mg/L	170	14	Feb. 27/95	B.L.
Sulphate	mg/L	376	83	Mar. 7/95	B.L.
Chloride	mg/L	42	5.5	Mar. 7/95	B.L.
Manganese - Dissolved	mg/L	1.59	<0.005	Mar. 1/95	L.R.
Zinc - Dissolved	mg/L	0.110	<0.001	Mar. 1/95	L.R.
Total Phosphorus	mg/L P	8.34	0.078	Mar. 13/95	G.M.
Dissolved Phosphorus	mg/L P	6.29	0.041	Mar. 9/95	G.M.
Nitrate & Nitrite	mg/L N	1.5	0.16	Mar. 8/95	B.L.
Total Kjeldahl Nitrogen	mg/L N	3.3	0.2	Mar. 1/95	G.M.
Ammonia	mg/L N	1.15	0.14	Feb. 28/95	G.M.
Total Organic Carbon	mg/L	39	<1	Mar. 1/95	B.L.
Total Suspended Solids	mg/L	16	<1	Mar. 7/95	T.H.
True Colour	TCU	250	7.5	Feb. 27/95	G.M.
Total Phenols	mg/L	0.007	0.001	Mar. 6/95	E.W.
Fecal Coliforms	CFU/100mL	155000	330	Feb. 25/95	B.D.
Klebsiella spp.	CFU/100mL	60000	470	Feb. 25/95	B.D.

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To: **Sentar Consultants Ltd.** File: **7348**

Project: **ANC #09-805-00**

Parameter	Unit	Sample ID: **Site 4 River Water** Date Sampled: **Feb. 24/95**	**Site 5 River Water** **Feb. 24/95**	Date Analyzed	Analyst Initials
Biochemical Oxygen Demand	mg/L	2.0	1.3	Feb. 25/95	B.D.
Sodium	mg/L	9.1	14	Feb. 27/95	B.L.
Sulphate	mg/L	48	85	Mar. 7/95	B.L.
Chloride	mg/L	2.8	5.5	Mar. 7/95	B.L.
Manganese - Dissolved	mg/L	0.177	<0.005	Mar. 1/95	L.R.
Zinc - Dissolved	mg/L	<0.001	<0.001	Mar. 1/95	L.R.
Total Phosphorus	mg/L P	0.062	0.080	Mar. 13/95	G.M.
Dissolved Phosphorus	mg/L P	0.010	0.029	Mar. 9/95	G.M.
Nitrate & Nitrite	mg/L N	0.10	0.15	Mar. 8/95	B.L.
Total Kjeldahl Nitrogen	mg/L N	0.3	0.2	Mar. 1/95	G.M.
Ammonia	mg/L N	0.12	<0.10	Feb. 28/95	G.M.
Total Organic Carbon	mg/L	<1	2	Mar. 1/95	B.L.
Total Suspended Solids	mg/L	68	1	Mar. 7/95	T.H.
True Colour	TCU	5	7.5	Feb. 27/95	G.M.
Total Phenols	mg/L	<0.001	<0.001	Mar. 6/95	E.W.
Fecal Coliforms	CFU/100mL	5	190	Feb. 25/95	B.D.
Klebsiella spp.	CFU/100mL	5	80	Feb. 25/95	B.D.

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Analytical and Consulting Services
17212 - 106 A Avenue
Edmonton, Alberta T5S 1M7
Phone: (403) 489-9100 Fax: (403) 489-9700

TECHNICAL REPORT

To: **Sentar Consultants Ltd.** File: **7348**

Project: **ANC #09-805-00**

Parameter	Unit	Sample ID: / Date Sampled: **Site 9 Sewage Effluent Feb. 24/95**	**Site 10 River Water Feb. 24/95**	Date Analyzed	Analyst Initials
Biochemical Oxygen Demand	mg/L	13	<1.0	Feb. 25/95	B.D.
Sodium	mg/L	130	21	Feb. 27/95	B.L.
Sulphate	mg/L	46	81	Mar. 7/95	B.L.
Chloride	mg/L	122	5.4	Mar. 7/95	B.L.
Manganese - Dissolved	mg/L	--	0.010	Mar. 1/95	L.R.
Zinc - Dissolved	mg/L	--	<0.001	Mar. 1/95	L.R.
Total Phosphorus	mg/L P	4.27	0.075	Mar. 13/95	G.M.
Dissolved Phosphorus	mg/L P	3.21	0.032	Mar. 13/95	G.M.
Nitrate & Nitrite	mg/L N	8.6	0.14	Mar. 8/95	B.L.
Total Kjeldahl Nitrogen	mg/L N	8.6	0.2	Mar. 1/95	G.M.
Ammonia	mg/L N	6.10	0.14	Feb. 28/95	G.M.
Total Organic Carbon	mg/L	--	3	Mar. 1/95	B.L.
Total Suspended Solids	mg/L	8	1	Mar. 7/95	T.H.
True Colour	TCU	25	12.5	Feb. 27/95	G.M.
Total Phenols	mg/L	--	<0.001	Mar. 6/95	E.W.
Fecal Coliforms	CFU/100mL	29000	80	Feb. 25/95	B.D.
Klebsiella spp.	CFU/100mL	11000	40	Feb. 25/95	B.D.

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ALPHA LABORATORY SERVICES LTD.

Analytical and Consulting Services

17212 - 106 A Avenue
Edmonton, Alberta T5S 1M7
Phone: (403) 489-9100 Fax: (403) 489-9700

TECHNICAL REPORT

To: **Sentar Consultants Ltd.** File: **7348**

Project: **ANC #09-805-00**

Parameter	Sample ID: / Date Sampled: / Unit	**Site 11 River Water Feb. 25/95**	**Site 12 River Water Feb. 25/95**	Date Analyzed	Analyst Initials
Biochemical Oxygen Demand	mg/L	2.6	<1.0	Feb. 25/95	B.D.
Sodium	mg/L	22	--	Feb. 27/95	B.L.
Sulphate	mg/L	76	--	Mar. 7/95	B.L.
Chloride	mg/L	5.4	--	Mar. 7/95	B.L.
Manganese - Dissolved	mg/L	0.006	--	Mar. 1/95	L.R.
Zinc - Dissolved	mg/L	<0.001	--	Mar. 1/95	L.R.
Total Phosphorus	mg/L P	0.25	--	Mar. 13/95	G.M.
Dissolved Phosphorus	mg/L P	0.027	--	Mar. 13/95	G.M.
Nitrate & Nitrite	mg/L N	0.20	--	Mar. 8/95	B.L.
Total Kjeldahl Nitrogen	mg/L N	0.4	--	Mar. 1/95	G.M.
Ammonia	mg/L N	<0.10	--	Feb. 28/95	G.M.
Total Organic Carbon	mg/L	3	--	Mar. 1/95	B.L.
Total Suspended Solids	mg/L	132	3	Mar. 7/95	T.H.
True Colour	TCU	20	--	Feb. 27/95	G.M.
Total Phenols	mg/L	<0.001	--	Mar. 6/95	E.W.
Fecal Coliforms	CFU/100mL	8	--	Feb. 25/95	B.D.
Klebsiella spp.	CFU/100mL	40	--	Feb. 25/95	B.D.

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Analytical and Consulting Services

17212 - 106 A Avenue
Edmonton, Alberta T5S 1M7
Phone: (403) 489-9100 Fax: (403) 489-9700

TECHNICAL REPORT

To: **Sentar Consultants Ltd.** File: **7348**

Project: **ANC #09-805-00**

Parameter	Unit	Sample ID: **Site 13 River Water** Date Sampled: **Feb. 25/95**	Date Analyzed	Analyst Initials
Biochemical Oxygen Demand	mg/L	<1.0	Feb. 25/95	B.D.
Sodium	mg/L	23	Feb. 27/95	B.L.
Sulphate	mg/L	66	Mar. 8/95	B.L.
Chloride	mg/L	4.3	Mar. 8/95	B.L.
Manganese - Dissolved	mg/L	<0.005	Mar. 1/95	L.R.
Zinc - Dissolved	mg/L	<0.001	Mar. 1/95	L.R.
Total Phosphorus	mg/L P	0.054	Mar. 3/95	G.M.
Dissolved Phosphorus	mg/L P	0.018	Mar. 3/95	G.M.
Nitrate & Nitrite	mg/L N	0.20	Mar. 8/95	B.L.
Total Kjeldahl Nitrogen	mg/L N	0.3	Mar. 1/95	G.M.
Ammonia	mg/L N	0.15	Feb. 28/95	G.M.
Total Organic Carbon	mg/L	3	Mar. 1/95	B.L.
Total Suspended Solids	mg/L	1	Mar. 7/95	T.H.
True Colour	TCU	17.5	Feb. 27/95	G.M.
Total Phenols	mg/L	<0.001	Mar. 6/95	E.W.
Fecal Coliforms	CFU/100mL	5	Feb. 25/95	B.D.
Klebsiella spp.	CFU/100mL	5	Feb. 25/95	B.D.

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Analytical and Consulting Services

17212 - 106 A Avenue
Edmonton, Alberta T5S 1M7
Phone: (403) 489-9100 Fax: (403) 489-9700

TECHNICAL REPORT

To: **Sentar Consultants Ltd.** File: **7348**

Project: **ANC #09-805-00**

Chemical Analysis Verified by:

Lisa Reinbolt
Supervisor, Chemical Services

Biological Analysis Verified by:

Bill Durnford
Supervisor, Biological Services

Report Authorized by:

Bob Lickacz, B.Sc., P.Biol
President

Note: All samples will be disposed of 30 days after analysis. Please advise the laboratory if you require additional sample storage time.

ALPHA LABORATORY SERVICES LTD.

QA REPORT FOR: Sentar

ATTENTION: Mr. B. Shelast

SAMPLE INFORMATION:
Project: ANC # 09-805-00
Date : 25-Feb

REFERENCE:
Client P.O.:
Alpha Job #: 7348

REPORT:
Date: 14-Mar-95
Verified By: LR
Filename: Cust16.rpt

DESCRIPTION	DATE	QC CHECK				DUPLICATE CHECK			SPIKE CHECK			
PARAMETER -- METHOD	ANALYSED	RESULT	MEAN	95% CONFIDENCE LIMITS		a	b	Diff. 95% C.L.	%RECOV.	MEAN	95% CONFIDENCE LIMITS	
B.O.D. - BOD5	25-Feb	9.20	7.59	5.70	9.48	182.00	168.00	20.79	Spike Check	Not Applicable		
Sodium - ICP High Level	27-Feb	52.17	48.76	45.38	52.13	22.91	23.14	1.38	102.80	90.56	68.16	112.96
Sulphate - I.C	8-Mar	78.34	78.74	73.95	83.53	372.82	375.78	4.13	96.51	94.38	87.85	100.92
Chloride - I.C.	8-Mar	3.58	3.68	3.46	3.91	0.57	0.52	0.22	106.88	100.01	86.31	113.72
Manganese - ICP Low Level	1-Mar	0.24	0.24	0.22	0.27	0.18	0.18	0.01	97.80	96.10	82.84	109.35
Zinc - ICP Low Level	1-Mar	0.04	0.05	0.04	0.06	0.01	0.01	0.01	103.08	103.48	69.87	137.09
Total Phosphate - Stannous Chl	3-Mar	0.13	0.14	0.12	0.16	0.03	0.03	0.01	136.00	113.93	86.94	140.91
Ortho-Phosphate - Stannous Chl	3-Mar	0.05	0.05	0.04	0.06	0.03	0.03	0.01	92.00	99.59	86.60	112.59
Nitrate - I.C	8-Mar	1.76	1.78	1.71	1.86	1.20	1.24	0.03	96.40	97.90	87.10	108.70
Nitrite - I.C	8-Mar	0.44	0.46	0.42	0.51	0.05	0.05	0.00	102.50	102.44	92.48	112.39
TKN - Ion Specific Electrode	1-Mar	0.24	0.24	0.21	0.26	1.66	1.61	0.06	75.16	91.89	67.29	116.49
Ammonia Nitrogen - Ion Specific	28-Feb	0.21	0.20	0.18	0.22	6.10	6.10	0.01	110.28	102.79	80.32	125.26
TOC - Auto sampler	1-Mar	4.70	4.91	4.33	5.50	1.30	0.80	5.01	Spike Check	Not Applicable		
Total Suspended Solids - Gravin	7-Mar	98.00	95.73	90.74	100.72	367.00	355.00	408.60	Spike Check	Not Applicable		
Color - Vision	27-Feb	15.00	15.00	15.00	15.00	2.50	2.50	0.00	Spike Check	Not Applicable		
Phenol - Chloroform Extraction	6-Mar	QC Check	Not Applicable			Duplicate Check	Not Applicable		98.00	93.74	79.06	108.42

ETL Enviro·Test
LABORATORIES
A DIVISION OF ETL CHEMSPEC ANALYTICAL LIMITED

9936 - 67 Avenue, Edmonton, Alberta T6E 0P5 Telephone: (403) 434-9509 Fax: (403) 437-2311
1313 - 44 Avenue N.E., Calgary, Alberta T2E 6L5 Telephone: (403) 291-9897 Fax: (403) 291-0298
Suite 406, 3700 Gilmore Way, Burnaby, British Columbia V5G 4M1 Telephone: (604) 451-9317 Fax: (604) 436-0565
107 - 111 Research Drive, Saskatoon, Saskatchewan S7N 3R2 Telephone: (306) 966-6901 Fax: (306) 966-6900

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CHEMICAL ANALYSIS REPORT

SENTAR CONSULTANTS
SUITE 200, 1122-4 STREET S.W.
CALGARY, ALBERTA
T2R 1M1

DATE: **March 21, 1995**

ATTN: **BOB SHELAST**

Lab Work Order #: E502333

Sampled By: BOB SHELAST

Project Reference: 09-805-00

Date Received: 02/28/95

Project P.O.#: QUOTE JH3045

Comments:

Chealate results will be forwarded and billed direct from Chemex Laboratories.

APPROVED BY: [signature]

D.A. Birkholz, PhD
Project Manager

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

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

PROJECT : SENTAR CONSULTANTS
MATRIX : WATER
LAB SAMPLE# : E5-02-333-01A
CLIENT I.D. : SITE 1
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 02-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 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
MATRIX : WATER
LAB SAMPLE# : SITE 2
CLIENT I.D. : E5-02-333-02A
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 02-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
	ARACHIDIC ACID	ND
	LINOLEIC ACID	0.003
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.001
FATTY ACIDS	OLEIC ACID	0.011
	PALMITIC ACID	0.014
	STEARIC ACID	0.002
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.031
	ABIETIC ACID	0.001
	DEHYDROABIETIC ACID	0.002
	ISOPIMARIC ACID	ND
	LEVOPIMARIC ACID	0.001
	NEOABIETIC ACID	ND
	PALUSTRIC ACID	0.001
RESIN ACIDS	PIMARIC ACID	ND
	SANDARACOPIMARIC ACID	ND
	12,14-DICHLORODEHYDROABIETIC ACID	ND
	12-CHLORODEHYDROABIETIC ACID [#2]	ND
	14-CHLORODEHYDROABIETIC ACID [#1]	ND
	TOTAL RESIN ACIDS :	0.005
	TOTAL RESIN AND FATTY ACIDS :	0.036

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	INSTRUMENT	: HEWLETT PACKARD 5971A GC/MSD
MATRIX	: WATER	ANALYSIS DATE	: 02-Mar-95
LAB SAMPLE#	: E5-02-333-03A	ANALYST	: Greg McCoy, Residue Analyst
CLIENT I.D.	: SITE 3		
SAMPLE SIZE	: 800 mL	DETECTION LIMIT:	0.001 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	ND
	LINOLENIC ACID	ND
	MYRISTIC ACID	0.001
	OLEIC ACID	0.002
	PALMITIC ACID	0.002
	STEARIC ACID	ND
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.005
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 :	0.005

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
MATRIX : WATER
LAB SAMPLE# : E5-02-333-04A
CLIENT I.D. : SITE 4
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 02-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 mg/L (ppm)

	COMPOUND	CONCENTRATION mg/L (ppm)
FATTY ACIDS	ARACHIDIC ACID	ND
	LINOLEIC ACID	0.001
	LINOLENIC ACID	0.002
	MYRISTIC ACID	0.003
	OLEIC ACID	0.003
	PALMITIC ACID	0.008
	STEARIC ACID	0.001
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.018
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 :	0.018

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
MATRIX : WATER
LAB SAMPLE# : E5-02-333-05A
CLIENT I.D. : SITE 5
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 02-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 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	0.001
	STEARIC ACID	0.001
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.002
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 :	0.002

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
MATRIX : WATER
LAB SAMPLE# : E5-02-333-06A
CLIENT I.D. : SITE 10
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 02-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 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	0.003
	STEARIC ACID	0.001
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.004
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 :	0.004

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
MATRIX : WATER
LAB SAMPLE# : E5-02-333-07A
CLIENT I.D. : SITE 11
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 03-Mar-95
ANALYST : Greg McCoy, Residue Analyst
DETECTION LIMIT: 0.001 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	0.002
	STEARIC ACID	0.001
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.003
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 :	0.003

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
MATRIX : WATER
LAB SAMPLE# : E5-02-333-08A
CLIENT I.D. : SITE 13
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 03-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 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	0.002
	STEARIC ACID	0.001
	9,10-DICHLOROSTEARIC ACID	ND
	TOTAL FATTY ACIDS :	0.003
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 :	0.003

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
MATRIX : DEIONIZED WATER
LAB SAMPLE# : WATER SPIKE
CLIENT I.D. : E5-02-333-SPK
SAMPLE SIZE : 800 mL

INSTRUMENT : HEWLETT PACKARD 5971A GC/MSD
ANALYSIS DATE : 02-Mar-95
ANALYST : Greg McCoy, Residue Analyst

DETECTION LIMIT: 0.001 mg/L (ppm)

	COMPOUND	PERCENT RECOVERY (%)	SPIKING LEVEL (ug/L)
FATTY ACIDS	ARACHIDIC ACID	96%	3.5
	LINOLEIC ACID	101%	6.2
	LINOLENIC ACID	97%	6.9
	MYRISTIC ACID	102%	5.1
	OLEIC ACID	97%	6.2
	PALMITIC ACID	107%	4.6
	STEARIC ACID	103%	2.8
	9,10-DICHLOROSTEARIC ACID	97%	4.3
RESIN ACIDS	ABIETIC ACID	83%	3.2
	DEHYDROABIETIC ACID	104%	4.0
	ISOPIMARIC ACID	97%	4.5
	LEVOPIMARIC ACID	9%	4.9
	NEOABIETIC ACID	25%	1.4
	PALUSTRIC ACID	69%	3.0
	PIMARIC ACID	95%	4.2
	SANDARACOPIMARIC ACID	95%	4.1
	12,14-DICHLORODEHYDROABIETIC ACID	104%	3.1
	12-CHLORODEHYDROABIETIC ACID [#2]	100%	1.3
	14-CHLORODEHYDROABIETIC ACID [#1]	98%	1.4

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 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%

Appendix A Test Methodologies

Resin Acids in Water

Resin and Fatty Acids Method Reference: Alberta Environment AE 129.0

CHEMEX Labs Alberta Inc.

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

SENTAR CONSULTANTS LTD.
BOB SHELAST

DATE : March 7, 1995
CHEMEX PROJECT NO.: SENT010-0501-94-04960
CLIENT REFERENCE :
CLIENT JOB NO. : PROJ.#09-805-00

Analytical Data Reviewed By : ____________________

QA/QC Reviewed By : ____________________

The above signatures indicate that the individuals identified have reviewed the enclosed documents.

NOTE : Soil samples and water samples (for stable parameters) will be retained for a period of 60 days after completion of analysis.
Retention beyond this period can be arranged for a fee.

CHEMEX Labs Alberta Inc. is accredited by both the Canadian Association for Environmental Analytical Laboratories and the Standards Council of Canada for specific parameters registered with the Association and the Council.

CHEMEX Labs Alberta Inc.

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SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

PROJ.#09-805-00

Sample Description : SITE #1
Sample Date & Time : 23-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-1
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	RESULTS	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.2	0.2

CHEMEX Labs Alberta Inc.

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #1
Sample Date & Time : 23-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-1
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	% RECOV	SPIKES CONT LOWER	LIMIT UPPER	% RECOV	CHECK CONT LOWER	LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

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

SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

PROJ.#09-805-00

Sample Description : SITE #2
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-2
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	0.3	0.1
D.T.P.A. (IC)		mg/L	1.8	0.2

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BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #2
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-2
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES CONT LIMIT LOWER	SPIKES CONT LIMIT UPPER	CHECK % RECOV	CHECK CONT LIMIT LOWER	CHECK CONT LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

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

SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

PROJ.#09-805-00

Sample Description : SITE #3
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-3
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.2	0.2

CHEMEX Labs Alberta Inc.

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #3
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-3
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES CONT LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK CONT LOWER	CHECK LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

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SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

PROJ.#09-805-00

Sample Description : SITE #4
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-4
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	RESULTS		DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	<	0.1	0.1
D.T.P.A. (IC)		mg/L	<	0.2	0.2

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #4
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-4
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES CONT LIMIT LOWER	SPIKES CONT LIMIT UPPER	CHECK % RECOV	CHECK CONT LIMIT LOWER	CHECK CONT LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

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

SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

PROJ.#09-805-00

Sample Description : SITE #5
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-5
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	RESULTS	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.2	0.2

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #5
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-5
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	% RECOV	SPIKES CONT LOWER	LIMIT UPPER	% RECOV	CHECK CONT LOWER	LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

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SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

PROJ.#09-805-00

Sample Description : SITE #10
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-10
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	RESULTS	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.2	0.2

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #10
Sample Date & Time : 24-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-10
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES CONT LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK CONT LOWER	CHECK LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST

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

PROJ.#09-805-00

Sample Description : SITE #11
Sample Date & Time : 25-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-11
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	RESULTS	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.2	0.2

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #11
Sample Date & Time : 25-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-11
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES CONT LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK CONT LOWER	CHECK LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

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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

PROJ.#09-805-00

Sample Description : SITE #13
Sample Date & Time : 25-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-13
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER DESCRIPTION	NAQUADAT CODE	UNITS	R E S U L T S	DETECTION LIMIT
E.D.T.A. (IC)	969001	mg/L	< 0.1	0.1
D.T.P.A. (IC)		mg/L	< 0.2	0.2

CHEMEX Labs Alberta Inc.

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

BATCH SPECIFIC QUALITY ASSURANCE REPORT FOR :
SENTAR CONSULTANTS LTD.
ATTENTION : BOB SHELAST
PROJ.#09-805-00

Sample Description : SITE #13
Sample Date & Time : 25-02-95
Sampled By : BS
Sample Type : GRAB
Sample Station Code :

Chemex Worksheet Number : 94-04960-13
Chemex Project Number : SENT010-0501
Sample Access :
Sample Matrix : WATER
Report Date : March 7, 1995

PARAMETER	DATE ANALYZED (DD-MM-YY)	QA/QC BATCH NUMBER	DUP Rr	SPIKES % RECOV	SPIKES CONT LOWER	SPIKES LIMIT UPPER	CHECK % RECOV	CHECK CONT LOWER	CHECK LIMIT UPPER
E.D.T.A. (IC)	03-03-95	10	N.A.	101.1	72.8	116.8	99.6	86.9	117.2
D.T.P.A. (IC)	03-03-95	10	N.A.	99.0	72.2	122.7	101.9	77.4	129.5

APPENDIX 2

QA/QC

STATEMENT OF SENTAR'S QUALITY ASSURANCE/QUALITY CONTROL

The basis of SENTAR's Quality Assurance/Quality Control (QA/QC) program is the adherence to a Quality Management Plan. SENTAR's QA/QC program is practiced for all types of studies. The QA program consists of externally imposed technical and management practices which ensure that the generation of quality and defensible data commensurate with the intended use of the data. The QC program consists of internal techniques which are used to measure and assess data quality and remedial actions to be taken when the data quality objectives are not realized. The assurance of adequate data is provided through Data Quality Objectives, which encompass all components of uncertainty in data generation.

Objective

The objective of SENTAR's QA/QC program is to ensure that data generated for our clients is of known and defensible quality.

Organization

Project Manager:

- Communicates committment to and delegates responsibility for quality assurance.
- Allocates funds and resources for effective quality assurance.
- Establishes Standard Operating Procedures (SOPs).

Quality Assurance Officer:

- Responsible for approval of all procedures.
- Authority for corrective action.
- Plans and evaluates QA/QC program.
- Reports any plans or problems of QA/QC to management.

Field Supervisor:

- Supervises compliance to QA/QC program.
- Helps establish SOPs.
- Follows approved field, sample and data analyses procedures and reporting of data as outlined in SOPs.

Field/Office Technicians:

- Have appropriate education and experience for the job.
- Follow approved field, sample and data analyses procedures and reporting of data as outlined in SOPs.

Standard Operating Procedures

SOPs are developed to meet Data Quality Objectives. SENTAR's SOPs outline detailed protocols for sample collection, field procedures, laboratory procedures and reporting of data. Any changes to SOPs during a project are documented and justified.

All SOPs include meticulous record-keeping, proper collection of samples, adequate replication, preservation, shipping and storage of samples, instrument calibration and maintenance and the use of chain-of-custody forms to ensure sample continuity.

Analytical Laboratories

The operations of any analytical laboratories used by SENTAR include the following Quality Control requirements as appropriate to the specific analysis: method blanks, laboratory duplicates, matrix spikes, analysis of reference materials, calibration control, surrogate spikes and internal standards.