NORTHERN RIVER BASINS STUDY PROJECT REPORT NO. 138
BROAD SPECTRUM ANALYSIS OF MUNICIPAL AND INDUSTRIAL EFFLUENTS DISCHARGED INTO THE PEACE, ATHABASCA AND SLAVE RIVER BASINS: EVALUATION OF SURFACE WATERS
PREFACE:

The Northern River Basins Study was initiated through the "Canada-Alberta-Northwest Territories Agreement Respecting the Peace-Athabasca-Slave River Basin Study, Phase II - Technical Studies" which was signed September 27, 1991. The purpose of the Study is to understand and characterize the cumulative effects of development on the water and aquatic environment of the Study Area by coordinating with existing programs and undertaking appropriate new technical studies.

This publication reports the method and findings of particular work conducted as part of the Northern River Basins Study. As such, the work was governed by a specific terms of reference and is expected to contribute information about the Study Area within the context of the overall study as described by the Study Final Report. This report has been reviewed by the Study Science Advisory Committee in regards to scientific content and has been approved by the Study Board of Directors for public release.

It is explicit in the objectives of the Study to report the results of technical work regularly to the public. This objective is served by distributing project reports to an extensive network of libraries, agencies, organizations and interested individuals and by granting universal permission to reproduce the material.

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this publication be subjected to proper and responsible review and be considered for release to the public.

(Dr. Fred J. Wrona, Science Director) 

(Date) 14 May 96

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this publication has been reviewed for scientific content and that the scientific practices represented in the report are acceptable given the specific purposes of the project and subject to the field conditions encountered.

SUPPLEMENTAL COMMENTARY HAS BEEN ADDED TO THIS PUBLICATION: [ ] Yes [ ] No

(Dr. P. A. Larkin, Ph.D., Chair) 28 May 96

(Date)

Whereas the Study Board is satisfied that this publication has been reviewed for scientific content and for immediate health implications,

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this publication be released to the public, and that this publication be designated for: [ ] STANDARD AVAILABILITY [ ] EXPANDED AVAILABILITY

(Lucille Partington, Co-chair) May 29/96

(Date)

(Robert McLeod, Co-chair) May 21/96
BROAD SPECTRUM ANALYSIS OF MUNICIPAL AND INDUSTRIAL EFFLUENTS DISCHARGED INTO THE PEACE, ATHABASCA AND SLAVE RIVER BASINS: EVALUATION OF SURFACE WATERS

STUDY PERSPECTIVE

Under the Northern River Basins Study (NRBS), water, effluent, sediment, and biota have been sampled extensively and analyzed for specific contaminants known to be associated with developments within the study area, or known to be transported by aerial transport. To date, only "target compound" contaminant analyses have been conducted on these samples, and the results show generally low levels of these compounds. However, these types of specific analyses do not include other potential contaminants that are not currently known to be associated with man-made developments within the basins, or aerial transport, or for which there is little understanding of their environmental effects. Target compound analyses have been done with selected ion monitoring gas chromatography or mass spectrometry (GC/MS) with specific detectors. However, this method gives no indication of the other non-target compounds present, nor does it provide an "archive" record of chromatograms. An alternative experimental approach to characterizing the major effluents and receiving waters of the Athabasca and Peace river systems is by broad spectrum analysis.

The project conducted broad spectrum analyses of water and effluent samples upstream and downstream of major effluent sources on the Athabasca, Peace and Wapiti-Smoky River systems. Analytical methods to classify organic constituents in effluents were based on full scan coupled GC/MS, and all significant compounds were characterized with respect to mass spectra and GC retention indices. The task was accomplished in three stages: (1) summary of results and review of raw GC/MS data from previous effluent analyses conducted between 1989 and 1994, (2) collection and analysis of current effluents, and (3) collection and analysis of receiving water samples.

Routine priority pollutant data for the analyses of municipal and industrial effluents, produced between 1989 and 1994, were reevaluated. Searchable mass spectral libraries were prepared for the organic components that were characterized. During that time period, improvements in effluent quality were observed, particularly for conventional bleached kraft mills. Generally, only low concentrations of contaminants were observed in sewage treatment plant (STP) effluent. Under the second task, 260 compounds were characterized from 1994 effluent samples, and a comparison of results revealed that the improvement in pulp mill effluent quality has continued. The third task determined that none of the contaminants observed in the discharged effluents were observed in surface waters in significant concentrations. Some of the compounds observed are ubiquitous in nature, and their presence cannot be attributed solely to industrial and municipal effluents.

Based on these results, it was concluded that the scope of future investigations should be narrowed to lipophilic classes of compounds in effluents and receiving waters, eliminating the compromises necessary to include hydrophilic compounds in the analysis. These analytical results will provide a permanent record of GC/MS data, allowing researchers to revisit the data in future years if other compounds become of interest.

This report provides analytical results arising from the collection and analysis of receiving water samples (Task 3). A summary of the results and review of raw GC/MC data from previous effluent analysis conducted between 1989 and 1994 (Task 1) is provided in Northern River Basins Study Project Report No. 111. Northern River Basins Study Project Report No. 121 provides information on the collection and analysis of current effluents (Task 2).
REPORT SUMMARY

Northern river basin surface waters receiving industrial and municipal effluents were analyzed for compounds observed previously in the screening of the effluents by broad spectrum analysis of organic compounds using coupled gas chromatography-mass spectrometry (GC-MS). Only phthalate esters, aliphatic hydrocarbons and fatty acids, as their methyl esters, were observed in the surface waters. Analysis of characteristic traces constructed from single ion chromatograms extracted from GC-MS data showed no patterns consistent with those observed previously in effluents.
ACKNOWLEDGEMENTS

The authors gratefully to acknowledge the assistance of Doreen LeClair and the sampling crews of Alberta Environmental Protection for collecting the samples, Brian Brownlee of National Water Research Institute for useful discussions and assistance in the preparation of this report and the Northern River Basins Study Board for partial funding of this work.
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1.0 INTRODUCTION

Under the Northern River Basins Study Board, water, effluent, sediment, fish and benthic invertebrates have been sampled extensively and analyzed for a wide variety of specific contaminants known to be associated with the developments within the Northern Basins. To date only target compound analysis for specific contaminants has been undertaken. These analyses are for specific contaminants and yield no information regarding other contaminants which may be present. To observe these other compounds full scan GC-MS analysis of samples, followed by interpretation of the generated mass spectra is required.

The characterization of effluents currently discharged into the northern river basins is described in the second report of this series (Johnson et. al. 1996). Major classes of compounds, and the construction of characteristic chromatograms representative of each class, from coupled gas chromatography-mass spectrometry data, are described, as well as the characterization of 260 compounds. This report, the third and last of this series describes the application of these results to the evaluation of surface waters.

2.0 MATERIALS AND METHODS

2.1 Solvents, Reagents and Equipment

All solvents were distilled in glass reagent grade purchased from BDH Inc. (Omnisolv grade). Tetrahydrofuran (THF) was purchased with BHT (0.25%) present as preservative and was redistilled in glass and preserved with ethanol (0.25%) prior to use. Acetic anhydride was freshly distilled prior to use. Amberlite XAD-2 resin was purchased from Axys Environmental Systems Ltd. and used without modification or from the Aldrich Scientific Company and soxhlet extracted with methyl-r-butyl ether (4 hr) followed by methanol (4 hr) prior to use. Glass fibre filters used in the extraction apparatus were Gelman Type A/E 142 mm glass fiber filters prepared following AEC Environmental Chemistry SOP SB16.0, “Preparation of Gelman type A/E filters for Infiltrex II sampler”. Extractions were done with an Infiltrex II sampler purchased from Axys Environmental Systems Ltd.
2.2 Sample Collection, Transport, and Storage

Large volume samples were collected by \textit{in situ} solid phase extraction (SPE) using an Infiltrex II extractor fitted with an XAD-2 cartridge. Samples were collected using a pumping rate of 100 mL/min.

Grabs of effluents were collected, without preservation, in methyl-$t$-butyl ether rinsed 4L amber glass bottles fitted with PFTE lined screw caps. Samples were shipped by overnight courier to the Alberta Environmental Centre in Vegreville Alberta where they were stored at 4° C until analyzed.

2.3 Sample Extraction

Grab samples were extracted, without acidification, using an Infiltrex automatic sampler fitted with a Gelman Type A/E glass fiber filter and XAD-2 extraction cartridge. The 4.0 L of sample was pumped through the sampler at a rate of 40 mL/min. The glass fiber filter was removed from the filter assembly and extracted with 300 mL of freshly distilled tetrahydrofuran in a soxhlet extractor for 4 hr. The extraction cartridge was removed and excess water was expelled with a gentle stream of UHP grade nitrogen gas. The extraction column was then eluted with 150 mL THF which was collected and combined with the filter extract. The column was then eluted with nitrogen-purged methanol and stored for further use. The sample bottle was rinsed with 100 mL of tetrahydrofuran which was combined with the previous tetrahydrofuran extracts and concentrated by rotary evaporator and made up to 10 mL in freshly distilled THF. The extract was then dried by passing through 1 g of granular anhydrous sodium sulphate packed in a 6” Pasteur pipette.

Large volume SPE samples were handled in a similar manner. The glass fiber filter was removed from the filter assembly and extracted with 300 mL of freshly distilled tetrahydrofuran in a soxhlet extractor for 4 hr. The extraction cartridge was removed and excess water was expelled with a gentle stream of UHP grade nitrogen gas. The extraction column was then eluted with 150 mL tetrahydrofuran which was collected and combined with the filter extract. The column was then eluted with nitrogen-purged methanol and stored for further use. The THF extract was then concentrated by rotary evaporator and made up to 10 mL in methyl-$t$-butyl ether and methylated with diazomethane following AEC Environmental Chemistry SOP SB22.0,
“Methylation of organic acids with diazomethane generated from Diazald®” evaporated to 1 mL under a stream of nitrogen and stored at -20°C for analysis by coupled gas chromatography-mass spectroscopy.

2.4 **Fractionation of Low Molecular Weight Fraction of Effluent Extracts**

Extracts were fractionated repeatedly in 2 mL portions. A 2 mL portion of the low molecular weight fraction of extract was combined with 40 mL of distilled deionized water and 1.0 mL of aqueous potassium carbonate (75%) in a 50 mL Mixxor liquid/liquid extractor. The aqueous phase was extracted with 10 mL of pentane which was then dried by elution through a 1 g column of granular anhydrous sodium sulphate (fraction A).

Freshly distilled acetic anhydride, 0.3 mL, was then added to the aqueous solution which was then extracted with 10 mL pentane. The pentane was then dried by elution through a 1 g column of granular anhydrous sodium sulphate (fraction B).

The aqueous solution was then extracted with 10 mL of methyl-t-butyl ether, which was then dried by elution through a 1 g column of granular anhydrous sodium sulphate (fraction C). The remaining aqueous solution was acidified by dropwise addition of 30% sulphuric acid to adjust the pH to below 2 and then extracted with methyl-t-butyl ether. The extract was also dried by elution through a 1 g column of granular anhydrous sodium sulphate (fraction D). Dried fractions from the low molecular weight fraction were pooled, concentrated and then diluted to 10 mL with methyl-t-butyl ether. Fractions A and B were then concentrated to 1 mL under a stream of nitrogen and stored at -20°C for analysis by coupled gas chromatography-mass spectroscopy. Fraction C was methylated with diazomethane generated from Diazald® following AEC Environmental Chemistry SOP SB22.0, “Methylation of organic acids with diazomethane generated from Diazald®” evaporated to 1 mL under a stream of nitrogen and stored at -20°C for analysis by coupled gas chromatography-mass spectroscopy. Fraction D was methylated with diazomethane generated from Diazald® following AEC Environmental Chemistry SOP SB22.0, “Methylation of organic acids with diazomethane generated from Diazald®” evaporated to 1 mL under a stream of nitrogen and stored at -20°C for analysis by coupled gas chromatography-mass spectroscopy.
2.5 Coupled Gas Chromatography-Mass Spectroscopy Analysis

Effluent extract fractions to which d10 phenanthrene had been added as the internal standard (2.4 μg/mL) were analyzed using a Hewlett Packard 5890 gas chromatograph coupled to a Hewlett Packard 5970 mass selective detector. The gas chromatograph was equipped with an HP 7470 autosampler, a split/splitless injector run in the splitless mode, and a fused silica capillary column (30m x 0.20 mm i.d.) coated with DB-1 methylsilicone stationary phase (film thickness 0.25μ). The mass selective detector had been fitted with a high energy dynode electron multiplier to increase sensitivity. The mass spectrometer was tuned using perfluorotributylamine as calibrant, to give a 502 ion 25% of the 69 ion and a 219 ion 150% of the 69 ion. The injector was maintained at 290°C for 1.0 μL sample injections. The initial column oven temperature was 50°C, which was maintained for 2 minutes before being increased to 300°C at a rate of 5°C/min. and then maintained for 5 minutes at 300°C. The GC-MS interface was maintained at 280°C. GC-MS information was recorded and the analyzed on an Everdata 486 computer using Hewlett Packard G1045c MS Chemstation software.

2.6 Analysis of GC-MS Results

GC-MS data was analyzed using Hewlett Packard G1045c MS Chemstation software on an Everdata 486 computer. The retention times of n-alkanes (C9 to C34) were used to calculate retention times from the Kovats indices of compounds identified in effluents in the second report of this series (Johnson et al. 1996). Extracted ion chromatograms of a quantitation ion and one qualification ion spanning the expected retention time of each compound were integrated. Table 1 lists the Kovats indices, the expected retention time, the quantitation ion, the qualification ion, and the ratio of the two observed in effluent extract. When the ratio of the qualification ion abundance to quantitation can abundance agreed within 50% to that in Table 1 and the retention time agreed within 0.1 min. to that in Table 1 the compound was deemed to be present.

Method blanks for the large volume SPE samples were evaluated to determine the contribution of the extraction and chromatographic materials to those observed in the final extract fractions. The method blanks were used to subtract “background” for the large volume in situ SPE samples. Grab samples were fractionated and the results of individual fractions
summed for this report. These were no background subtracted because of the uncertainty in the measurement of the background for this complicated extraction fractionation scheme.

Concentrations of compounds were estimated using d_{10} phenanthrene as internal standard. No standards for the compounds reported were run in the course of the analysis so compound concentrations were calculated assuming similar response factors for quantitation ions of the compounds and the m/e 188 ion of internal standard. These estimates are approximate at best and should only be considered accurate to within an order of magnitude.

Characteristic traces were constructed as previously reported (Johnson et al. 1996) except the retention times were adjusted to accommodate the changes in retention times, using Kovats indices and the n-alkane retention times. Characteristic traces of mono- and dicarboxylic acids is the extracted ion chromatograms of m/e 74 and m/e 87 of the D fraction from 12 to 53 minutes added together. The extracted ion chromatogram of m/e 149 of the A fraction from 31 to 57 minutes is the characteristic trace of phthalate esters. The diterpene characteristic trace is the sum of the extracted ion chromatograms of m/e 272, m/e 270, m/e 257, m/e 255 and m/e 137 of the A fraction from 33 to 38 minutes. The characteristic trace of triterpenoids is the sum of the extracted ion chromatograms of m/e 380, m/e 382, m/e 384, m/e 394, m/e 396 and m/e 398 of the A fraction from 49 to 57 minutes merged with the sum of the extracted ion chromatograms of m/e 410 and m/e 412 of the A fraction from 53 to 57 minutes. The characteristic trace of nonylphenols is the sum of the extracted ion chromatograms of m/e 121, m/e 135, m/e 107 and m/e 149 of the A fraction from 27 to 32 minutes. The characteristic trace of the unidentified acids in the municipal STP effluents is the sum of the extracted ion chromatograms of m/e 117, m/e 251 and m/e 265 of the D fraction from 39 to 49 minutes.

3.0 RESULTS AND DISCUSSION

Surface water samples were collected from sites on the northern river systems as 4 L grab samples or as in situ extracts of greater than 10 L obtained using an Infiltrex II automated sampler with XAD-2 as the solid phase extractant. Table 2 lists the sample sites and type of sampling method employed. Grab samples were extracted by solid phase extraction in the laboratory and the fractionated by liquid/liquid partitioning following the scheme described in the
second report of this series (Johnson et. al. 1996) before analysis by GC-MS. The large volume in situ extracts were analyzed by GC-MS following methylation with diazomethane, without fractionation. Samples were collected above and below effluent discharges so the impact of the effluent(s) could be assessed.

3.1 Individual Compound Analysis

Each sample was analyzed for a list of 260 compounds, developed from the results of GC-MS analysis of effluents discharged into the northern rivers. These compounds are presented in Table 1. The results of analysis of the Athabasca River samples are presented in Table 4 and the results of analysis of the Wapiti/Smoky River system samples are presented in Table 5. The estimated concentrations are order of magnitude estimates, reported with one significant figure, based on the abundance of a quantitation ion relative to the abundance of the m/e 188 ion of d_{10} phenanthrene, added as a internal standard. The concentrations should not be regarded as accurate to more than one order of magnitude.

Very few of the compounds observed in effluents were observed in the surface waters. The compounds observed in the surface waters comprised linear alkanes, phthalate esters, and methyl esters of fatty acids. These compounds, which were observed in very low concentrations, are, although anthropogenic, ubiquitous in nature and cannot be attributed to any one source and may in fact be simply analytical background.

3.2 Analysis of Characteristic Traces

A more sensitive method described in the second report of this series involves the construction of GC traces characteristic of classes of compound by summing and merging single ion chromatograms. Characteristic traces of methyl esters of carboxylic acids, phthalate esters, diterpenes, nonylphenols, and a group of acids specific to STP effluents for each of the sample and a method blank are presented in Figures 1 through 65. Attempts were made to construct characteristic traces of tritepenoids but no significant peaks were observed so no traces are presented.

The characteristic traces of methyl esters of mono- and dicarboxylic acids in the Athabasca River samples did not differ significantly from the method blank. In the
Wapiti/Smoky River samples compounds with intense m/e 87 ions, observed previously in
method blank obscure this trace. Characteristic traces of phthalate esters did not vary much
between samples and blanks except for the Wapiti River sample taken upstream of Grande
Prairie. This contained a complicated mixture of phthalate esters not observed the subsequent
downstream samples. No significant diterpene peaks were present in the diterpene characteristic
traces of the Athabasca River sample. One large peak due to the methyl ester of hexadecanoic
acid was present. No peaks were observed in the characteristic traces of nonylphenols and the
methyl esters unidentified STP acids of the Athabasca River samples. The diterpene
characteristic traces of the Wapiti/Smoky River samples did contain significant peaks but did not
follow the profiles previously observed in effluents discharging to this system. Likewise the
nonylphenol traces did contain peaks but did not follow the pattern associated with nonylphenol
and were likely due to other compounds. The pattern of peaks associated with the methyl esters
of unidentified STP acids were not observed in the Wapiti/Smoky River samples.

4.0 CONCLUSIONS

None of the contaminants observed in effluents currently discharged into the northern
rivers, or those observed in past analysis of effluents discharged to the northern rivers were
observed in surface waters in significant concentrations. Compounds which were observed are
ubiquitous in nature and their presence cannot be attributed solely the industrial and municipal
effluents. They may in fact be artifactual background.

While the water column, and no other compartments were assessed the results indicated
that the target compound approach employed in the study did not miss other contaminants
present in significant concentrations (< 0.1 μg/L). Hydrophilic compounds, which this work was
specifically designed to include, were not observed, however, with the compromises which were
required to broaden the scope of the analysis, and the attention to only one environmental
compartment, it cannot be concluded that all organic contaminants in effluents have no
significant presence in the northern rivers basin. This would require further work focusing
specifically on lipophilic compounds and other environmental compartments.
5.0 SUGGESTIONS FOR FURTHER WORK

In further work the scope of the investigations should be narrowed to lipophlic classes of compounds in effluents and receiving waters, eliminating the need for compromises necessary to include hydrophilic compounds in the analysis, but which add to background. If such compounds are observed during the screening of effluents, but not receiving waters, the scope of the investigation should be extended to other environmental compartments. Also when focusing on these classes of compounds it is possible to employ fractionation procedures, such as preparative high performance liquid chromatography, which remove rather than add to background contamination.

6.0 REFERENCES

Table 1. Compound information of compounds identified in effluents discharged into the northern river basins.

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Table 1 continued. Compound information of compounds identified in effluents discharged into the northern river basins.

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### Table 1 continued. Compound information of compounds identified in effluents discharged into the northern river basins.

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<th>Compound Description</th>
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Table 1 continued. Compound information of compounds identified in effluents discharged into the northern river basins.

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Table 2. Sample types, sites and volumes.

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<th>Volume Extracted</th>
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<td><em>In situ</em> SPE</td>
<td>9-Feb-95</td>
<td>10</td>
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<td><em>In situ</em> SPE</td>
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<td><em>In situ</em> SPE</td>
<td>20-Jul-94</td>
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<tr>
<td>At town of Athabasca</td>
<td><em>In situ</em> SPE</td>
<td>20-Jul-94</td>
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<td>Upstream of Alberta Pacific Mill effluent.</td>
<td>Grab</td>
<td>20-Aug-95</td>
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<tr>
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<td>Upstream of Fort McMurray</td>
<td><em>In situ</em> SPE</td>
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<td>Wapiti/Smoky River System</td>
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<td>Wapiti R. upstream of Grande Prairie</td>
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<td>Wapiti R. downstream of sewage treatment plant.</td>
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<td>Wapiti R. at confluence with Smoky R.</td>
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<td>Smoky R. upstream of Wapiti R.</td>
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Table 3. Concentration of contaminants in Athabasca River samples (μg/L).

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<td>BSA 004</td>
<td>4-Acetylmorpholine</td>
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<td>BSA 005</td>
<td>Benzene acetic acid, methyl ester</td>
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<td>BSA 006</td>
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<td>BSA 007</td>
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Table 3 continued. Concentration of contaminants in Athabasca River samples (µg/L).

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<th>Upstream Weldwood intake</th>
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<th>21 km Downstream Weldwood effluent</th>
<th>At town of Athabasca</th>
<th>Upstream of Alberta Pacific discharge</th>
<th>Downstream of Alberta Pacific discharge</th>
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Table 3 continued. Concentration of contaminants in Athabasca River samples (μg/L).

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<th>Code</th>
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Table 3 continued. Concentration of contaminants in Athabasca River samples (µg/L).

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<th>BSA</th>
<th>Description</th>
<th>Upstream Weldwood intake.</th>
<th>1 km Downstream Weldwood effluent.</th>
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Table 3 continued. Concentration of contaminants in Athabasca River samples (µg/L).

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0.02

0.06
Table 3 continued. Concentration of contaminants in Athabasca River samples (μg/L).

| BSA 119 | 9-Octadecen(Z) oic acid methyl ester | 0.00 |
| BSA 120 | 9-Octadecen(E) oic acid methyl ester | 0.03 |
| BSA 121 | Heneicosane | 0.03 |
| BSA 122 | Unidentified Hydrocarbon | 0.03 |
| BSA 123 | Octadecanoic acid, methyl ester | 0.03 |
| BSA 124 | C18:1 Fatty acid | 0.03 |
| BSA 125 | C18:1 Fatty acid | 0.03 |
| BSA 126 | Unidentified | 0.03 |
| BSA 127 | C18:0 Fatty acid | 0.03 |
| BSA 128 | Octadecanoic acid, ethyl ester | 0.03 |
| BSA 129 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 130 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 131 | Branched alkane (C22H46) | 0.03 |
| BSA 132 | Nonadecanoic acid, methyl ester | 0.03 |
| BSA 133 | Docosane | 0.03 |
| BSA 134 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 135 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 136 | Unidentified Hydrocarbon | 0.03 |
| BSA 137 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 138 | Nonadecanoic acid, methyl ester | 0.03 |
| BSA 139 | Unidentified Diterpene (C20H28O) | 0.03 |
| BSA 140 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 141 | Unidentified alkene | 0.03 |
| BSA 142 | Phthalate Ester (di C6H13) | 0.03 |
| BSA 143 | Unidentified Hydrocarbon | 0.03 |
Table 3 continued. Concentration of contaminants in Athabasca River samples (µg/L).

| BSA 144 | Unidentified |
| BSA 145 | Phthalate Ester (di C6H13) |
| BSA 146 | Phthalate Ester (di C6H13) |
| BSA 147 | Phthalate Ester (di C6H13) |
| BSA 148 | Unidentified (mw 336) |
| BSA 149 | Phthalate Ester (di C6H13) |
| BSA 150 | Unidentified |
| BSA 151 | Unidentified (mw 336) |
| BSA 152 | Phthalate Ester (di C6H13) |
| BSA 153 | Unidentified (mw 336) |
| BSA 154 | Unidentified alkene |
| BSA 155 | Unidentified (mw 336) |
| BSA 156 | Phthalate Ester (butyl, methylphenyl) |
| BSA 157 | Phthalate Ester (di C6H13) |
| BSA 158 | Dehydroabietic acid. methyl ester |
| BSA 159 | Tricosane |
| BSA 160 | Unidentified |
| BSA 161 | Hexadecic acid, dioctyl ester |
| BSA 162 | Eicosanoic acid, methyl ester |
| BSA 163 | Phthalate Ester (di C6H13) |
| BSA 164 | Unidentified |
| BSA 165 | Phosphoric acid, triphenyl ester |
| BSA 166 | Unidentified |
| BSA 167 | Phthalate Ester |
| BSA 168 | Unidentified |
Table 3 continued. Concentration of contaminants in Athabasca River samples (µg/L).

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Table 3 continued. Concentration of contaminants in Athabasca River samples (µg/L).

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Table 3 continued. Concentration of contaminants in Athabasca River samples (μg/L).

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Table 4. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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<th>Smoky River at Watino</th>
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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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<th>Wapiti River downstream of Grande Prairie STP effluent</th>
<th>Wapiti River upstream of Grande Prairie</th>
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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (µg/L).

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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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32
Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (µg/L).

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<th>Wapiti River downstream of Grande Prairie STP effluent</th>
<th>Wapiti River mouth at Smoky River</th>
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<th>Smoky River at Walino</th>
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33
Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (µg/L).

| BSA 126 | Unidentified |
| BSA 127 | C18:0 Fatty acid |
| BSA 128 | Octadecanoic acid, ethyl ester |
| BSA 129 | Phthalate Ester (di C6H13) |
| BSA 130 | Phthalate Ester (di C6H13) |
| BSA 131 | Branched alkane (C22H46) |
| BSA 132 | Nonadecenoic acid, methyl ester |
| BSA 133 | Docosane |
| BSA 134 | Phthalate Ester (di C6H13) |
| BSA 135 | Phthalate Ester (di C6H13) |
| BSA 136 | Unidentified Hydrocarbon |
| BSA 137 | Phthalate Ester (di C6H13) |
| BSA 138 | Nonadecanoic acid, methyl ester |
| BSA 139 | Unidentified Diterpene (C20H28O) |
| BSA 140 | Phthalate Ester (di C6H13) |
| BSA 141 | Unidentified alkene |
| BSA 142 | Phthalate Ester (di C6H13) |
| BSA 143 | Unidentified Hydrocarbon |
| BSA 144 | Unidentified |
| BSA 145 | Phthalate Ester (di C6H13) |
| BSA 146 | Phthalate Ester (di C6H13) |
| BSA 147 | Phthalate Ester (di C6H13) |
| BSA 148 | Unidentified (mw 336) |

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<th>Wapiti River upstream of Grande Prairie</th>
<th>Wapiti River downstream of Grande Prairie STP effluent</th>
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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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<th>Wapiti River upstream of Grande Prairie</th>
<th>Wapiti River downstream of Grande Prairie</th>
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<th>Smoky River upstream of Wapiti River Confluenc.</th>
<th>Smoky River at Watino</th>
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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (µg/L).

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37
Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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Table 4 continued. Concentration of contaminants in Wapiti/Smoky River system samples (μg/L).

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Figure 1. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River upstream Weldwood intake.
Figure 2. Phthalate ester characteristic trace of the Athabasca River upstream Weldwood intake.
Figure 3. Diterpene characteristic trace of the Athabasca River upstream Weldwood intake.
Figure 4. Nonylphenol characteristic trace of the Athabasca River upstream Weldwood intake.
Figure 5. Unidentified STP acid esters characteristic trace of the Athabasca River upstream Weldwood intake.
Figure 6. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River 1 km downstream Weldwood effluent.
Figure 7. Phthalate ester characteristic trace of the Athabasca River 1 km downstream Weldwood effluent.
Figure 8. Diterpene characteristic trace of the Athabasca River 1 km downstream Weldwood effluent.
Figure 9. Nonylphenol characteristic trace of the Athabasca River 1 km downstream Weldwood effluent.
Figure 10. Unidentified STP acid esters characteristic trace of the Athabasca River 1 km downstream Weldwood effluent.
Figure 11. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River 21 km downstream Weldwood effluent.
Figure 12. Phthalate ester characteristic trace of the Athabasca River 21 km downstream Weldwood effluent.
Figure 13. Diterpene characteristic trace of the Athabasca River 21 km downstream Weldwood effluent.
Figure 14. Nonylphenol characteristic trace of the Athabasca River 21 km downstream Weldwood effluent.
Figure 15. Unidentified STP acid esters characteristic trace of the Athabasca River 21 km downstream Weldwood effluent.
Figure 16. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River at the town of Athabasca.
Figure 17. Phthalate ester characteristic trace of the Athabasca River at the town of Athabasca.
Figure 18. Diterpene characteristic trace of the Athabasca River at the town of Athabasca.
Figure 19. Nonylphenol characteristic trace of the Athabasca River at the town of Athabasca.
Figure 20. Unidentified STP acid esters characteristic trace of the Athabasca River at the town of Athabasca.
Figure 21. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River upstream of Alberta Pacific discharge.
Figure 22. Phthalate ester characteristic trace of the Athabasca River upstream of Alberta Pacific discharge.
Figure 23. Diterpene characteristic trace of the Athabasca River upstream of Alberta Pacific discharge.
Abundance

Ion 107.00 (106.70 to 107.70): 3601037.D (+,−)

Figure 24. Nonylphenol characteristic trace of the Athabasca River upstream of Alberta Pacific discharge.
Abundance

Ion 265.00 (264.70 to 265.70): 3901040.D (+,-)

Figure 25. Unidentified STP acid esters characteristic trace of the Athabasca River upstream of Alberta Pacific discharge.
Figure 26. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River downstream of Alberta Pacific discharge.
Figure 27. Phthalate ester characteristic trace of the Athabasca River downstream of Alberta Pacific discharge.
Figure 28. Diterpene characteristic trace of the Athabasca River downstream of Alberta Pacific discharge.
Figure 29. Nonylphenol characteristic trace of the Athabasca River downstream of Alberta Pacific discharge.
Figure 30. Unidentified STP acid esters characteristic trace of the Athabasca River downstream of Alberta Pacific discharge.
Figure 31. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Athabasca River upstream of Fort McMurray.
Figure 32. Phthalate ester characteristic trace of the Athabasca River upstream of Fort McMurray.
Figure 33. Diterpene characteristic trace of the Athabasca River upstream of Fort McMurray.
Figure 34. Nonylphenol characteristic trace of the Athabasca River upstream of Fort McMurray.
Figure 35. Unidentified STP acid esters characteristic trace of the Athabasca River upstream of Ft McMurray.
Figure 36. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Wapiti River upstream of Grande Prairie.
Abundance

Ion 149.00 (148.70 to 149.70): 2001021.D (+,-)

Figure 37. Phthalate ester characteristic trace of the Wapiti River upstream of Grande Prairie.
Figure 38. Diterpene characteristic trace of the Wapiti River upstream of Grande Prairie.
Figure 39. Nonylphenol characteristic trace of the Wapiti River upstream of Grande Prairie.
Figure 40. Unidentified STP acid esters characteristic trace of the Wapiti River upstream of Grande Prairie.
Figure 41. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Wapiti River downstream of Grande Prairie STP effluent.
Figure 42. Phthalate ester characteristic trace of the Wapiti River downstream of Grande Prairie STP effluent.
Ion 137.00 (136.70 to 137.70): 1201013.D (+,-)

Figure 43. Diterpene characteristic trace of the Wapiti River downstream of Grande Prairie STP effluent.
Figure 44. Nonylphenol characteristic trace of the Wapiti River downstream of Grande Prairie STP effluent.
Ion 265.00 (264.70 to 265.70): 1501016.D (+,-)

Figure 45. Unidentified STP acid esters characteristic trace of the Wapiti River downstream of Grande Prairie STP effluent.
Figure 46. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Wapiti River mouth at Smoky River.
Figure 47. Phthalate ester characteristic trace of the Wapiti River mouth at Smoky River.
Figure 48. Diterpene characteristic trace of the Wapiti River mouth at Smoky River.
Figure 49. Nonylphenol characteristic trace of the Wapiti River mouth at Smoky River.
Figure 50. Unidentified STP acid esters characteristic trace of the Wapiti River mouth at Smoky River.
Figure 51. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Smoky River upstream of Wapiti River confluence.
Figure 52. Phthalate ester characteristic trace of the Smoky River upstream of Wapiti River confluence.
Figure 53. Diterpene characteristic trace of the Smoky River upstream of Wapiti River confluence.
Figure 54. Nonylphenol characteristic trace of the Smoky River upstream of Wapiti River confluence.
Figure 55. Unidentified STP acid esters characteristic trace of the Smoky River upstream of Wapiti River confluence.
Figure 56. Mono- and dicarboxylic acid, methyl ester characteristic trace of the Smoky River at Watino.
Figure 57. Phthalate ester characteristic trace of the Smoky River at Watino.
Figure 58. Diterpene characteristic trace of the Smoky River at Watino.
Figure 59. Nonylphenol characteristic trace of the Smoky River at Watino.
Figure 60. Unidentified STP acid esters characteristic trace of the Smoky River at Watino.
Figure 61. Mono- and dicarboxylic acid, methyl ester characteristic trace of blank.
Figure 62. Phthalate ester characteristic trace of blank.
Figure 63. Diterpene characteristic trace of blank.
Figure 64. Nonylphenol characteristic trace of blank.
Figure 65. Unidentified STP acid esters characteristic trace of blank.
I. BACKGROUND AND OBJECTIVES

Under the Northern River Basins Study, water, effluent, sediment, benthic invertebrates and fish have been sampled extensively and analyzed for a wide variety of specific contaminants known to be associated with developments within the Northern River Basins, or known to be transported into the study area by aerial transport. Aquatic systems that have been sampled include the Peace (including the Wapiti-Smoky systems) and Athabasca rivers (including the Athabasca Delta), in addition to sediment sampling from Lake Athabasca and other "reference" lakes. To date, only "target compound" contaminant analyses has been conducted on these samples. The list of target compounds includes: polychlorinated dioxins and furans (including di- and tri- and non-2,3,7,8-congeners), resin acids, polycyclic aromatic hydrocarbons, chlorophenolic compounds, polychlorinated biphenyls (congener specific), organochlorine pesticides including toxaphene, and metals. These results show generally low levels of these target contaminants for the samples analyzed. These types of specific analyses, however, do not include other potential contaminants that are not currently known to be associated with man-made developments within the basins, or aerial transport, or for which there is little understanding of their environmental effects.

The target compound analyses have been done using selected ion monitoring mass spectrometry or gas chromatography with specific detectors. This has two consequences: (1) as discussed above, it gives no indication of what other (non-target) compounds are present, and (2) there are no "archive" chromatograms such as the record provided by gas chromatography with a flame ionization detector (FID) or total ion mass chromatograms. Therefore, the most practical starting point in characterizing the major effluents and receiving waters of the Peace River and Athabasca River systems is by an experimental approach using broad spectrum analysis.

The purpose of this project is to conduct broad spectrum analyses of water and effluent samples upstream and downstream from major effluent sources on the Peace River (including the Wapiti-Smoky rivers) and the Athabasca River systems. These analyses will be used to identify other potential contaminants that may currently exist in the environment. They will also provide a permanent record, allowing researchers to revisit the data in future years if other compounds become of interest.

II. GENERAL REQUIREMENTS

Organic constituents in effluents and receiving waters within the study area will be rigorously characterized by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS).
Results are to be used to characterize current organic loads on the rivers from anthropogenic sources, and to evaluate future changes. All significant compounds (toxicants present in concentration > 1.0 \( \mu g/L \) in effluents) will be characterized with respect to mass spectra (electron impact, EI, and chemical ionization, CI) and GC retention indices (referenced to \( n \)-alkanes and aromatic ring size markers for the Suncor effluent). Mass spectra of significant compounds will be evaluated and, if possible, tentative structures proposed. When authentic standards are available, the tentative identifications will be confirmed. Effluent extracts and subfractions will be characterized for toxicity using the Microtox® test.

Over the past decade, effluents and receiving waters in northern Alberta have been analyzed at the Alberta Environmental Centre (AEC) as part of numerous surveys and monitoring programs of Alberta Environmental Protection. Organic constituents of these effluents and surface waters have been characterized by GC-MS following standard AEC Trace Organic Analysis Methods A105.1 for Extractable Priority Pollutants, and Method A102.1 for Automated Analysis of Volatile Priority Pollutants. These methods include a target compound analysis as well as a characterization of all organic constituents observed. The contractor is required to review this historical record, and incorporate it into this project.

A list of proposed river sampling sites and effluents is given in Schedule A. This table shows major effluent inputs from seven pulp mills and one oil sands plant, in addition to municipal inputs at Hinton (combined municipal and pulp mill), Whitecourt, Athabasca, Grande Prairie, Peace River and Fort McMurray. There are a total of 19 mainstream and 13 effluent sample sites where collections could be made.

### III. SPECIFIC REQUIREMENTS

The workplan is to be organized into three tasks or stages. The first is to involve a summary of results and a review of the raw GC-MS data from previous effluent analyses. The second task is the collection and analysis of current effluents listed in Schedule A. The third stage is the collection and analysis of surface water samples (upstream and downstream of effluents outfalls) listed in Schedule A. In each section, the results are to be compiled and interpreted in reports and catalogues which will be the products delivered to the Study Office.

**Task 1. Review Previous Effluent Results and Raw GC-MS Data Generated by the Trace Analysis Program from April 26, 1989, to July 1, 1994.**

The results of this review is intended to provide a record of what has been discharged to the northern rivers in the past, and a context in which to evaluate current effluents. Results should also help in the interpretation of GC-MS data from current effluents.

- a) Compile and review target compound analytical reports (EPP and VPP) for all relevant samples analyzed between April 26, 1989 and July 1, 1994.
- b) Retrieve EPP GC-MS data and convert to either HP Chemstation or HP UNIX format (this will be considered a product to be delivered to the Study Office).
c) Identify compounds present in concentrations greater than 10 µg/L and compile characteristic total ion chromatograms (TIC) and extracted ion profiles (EIP) for ions characteristic of classes of compounds (e.g. m/z 91 for alkylbenzenes).

The products of this task will be: (1) a report describing the chemical characterization of effluents from data generated by the Trace Analysis Program (1989-1994), (2) a catalogue of effluent TICs and characteristic EIPs and a mass spectral library of characteristic compounds, and (3) retrieved GC-MS data for the years 1989-1994.

Task 2. Characterization of 1994 Effluents by GC-MS and GC-FID

a) Collect, extract, cleanup by gel permeation chromatography (GPC), and fractionate effluent samples listed in Appendix A. Solid phase extraction (SPE) with XAD-2 will be used. DOC and AOX (if appropriate) balances will be done to validate extractions. If warranted, other extraction techniques may be substituted for the SPE. Effluent extracts will be fractionated into four fractions by: (1) partitioning the extract between aqueous potassium carbonate and pentane, (2) extracting and derivatizing in situ the phenols in the aqueous layer by adding acetic anhydride and extracting with pentane, (3) extracting the resulting aqueous layer with methyl-tert-butyl ether (MTBE), and (4) acidifying the resulting aqueous layer and extracting with MTBE. This entire scheme is shown in Appendix B. Operation 3 may be completed prior to 2 with hexane substituted for MTBE if this is found to improve the fractionation of some effluents.

b) Microtox® toxicity of each fraction will be measured and, if warranted, fractions will be fractionated chromatographically to isolate toxicants.

c) Fractions will be analyzed by GC-MS (electron impact and chemical ionization) and by GC-FID. n-Alkane retention indices will be determined for all fractions, and aromatic ring size retention indices will be determined for the Suncor effluent fraction.

The product of this task will be: (1) reports presenting the 1994 results and discussing the chemical characterization for each of the four types of effluents - kraft pulp mills, high yield pulp mills, municipal, and Suncor; (2) included in these reports will be a list and characterization of significant toxicants in effluents; and (3) a catalogue of current effluent fractions TICs and characteristic EIPs and a mass spectral library of characteristic compounds which can be used to evaluate surface waters in northern Alberta river basins.

Task 3. Characterization of Surface Water Above and Below Effluent Outfalls by GC-MS (EI only) and GC-FID.

Because contaminant concentrations in surface waters will be substantially lower than in effluent, the analysis of surface waters is to commence after the analysis of effluents has been completed. This will simplify the analysis of surface waters and the evaluation of the effects of effluents by identifying target areas where surface waters should be sampled. Sample sites for surface waters above and below effluent discharges are listed in Schedule A.
a) Collect, extract, cleanup by GPC and fractionate receiving water samples. SPE sample collection/extraction (Infiltrex, XAD-2) will be used if this method is found to be appropriate in Task 2 (a). Improvements to the fractionation procedure (if any) made in Task 2 (a) will be incorporated in the fractionation of surface water extracts.

b) GC-MS and GC-FID analysis of these extract fractions.

The product of this task will be a report discussing the effects of effluents on surface waters in northern Alberta river basins, including the contribution of these effluents to the organic composition in these waters. This report will refer to the results of the effluent analyses in Tasks 1 and 2.

IV. REPORTING REQUIREMENTS

1. Task 1 - ten copies of a Draft Report, catalogue and a mass spectral library along with an electronic disk copy are to be submitted to the Component Coordinator by November 30, 1994.

   Task 2 - ten copies each of four Draft Reports, catalogues and mass spectral libraries along with electronic disk copies are to be submitted to the Component Coordinator by January 31, 1995.

   Task 3 - ten copies of a Draft Report along with an electronic disk copy are to be submitted to the Component Coordinator by March 31, 1995.

2. Three weeks after the receipt of review comments on each of the draft reports, the Contractor is to provide the Component Coordinator with two unbound, camera ready copies and ten cerlox bound copies of each final report along with an electronic version.

3. The Contractor is to provide draft and final reports in the style and format outlined in the NRBS document, "A Guide for the Preparation of Reports," which will be supplied upon execution of the contract.

   The final report is to include the following: an acknowledgement section that indicates any local involvement in the project, Report Summary, Table of Contents, List of Tables, List of Figures and an Appendix with the Terms of Reference for this project.

   Text for the report should be set up in the following format:

   a) Times Roman 12 point (Pro) or Times New Roman (WPWIN60) font.
   b) Margins; are 1" at top and bottom, 7/8" on left and right.
c) Headings; in the report body are labelled with hierarchical decimal Arabic numbers.
d) Text; is presented with full justification; that is, the text aligns on both left and right margins.
e) Page numbers; are Arabic numerals for the body of the report, centred at the bottom of each page and bold.

- If photographs are to be included in the report text they should be high contrast black and white.
- All tables and figures in the report should be clearly reproducible by a black and white photocopier.
- Along with copies of the final report, the Contractor is to supply an electronic version of the report in Word Perfect 5.1 or Word Perfect for Windows Version 6.0 format.
- Electronic copies of tables, figures and data appendices in the report are also to be submitted to the Project Liaison Officer along with the final report. These should be submitted in a spreadsheet (Quattro Pro preferred, but also Excel or Lotus) or database (dBase IV) format. Where appropriate, data in tables, figures and appendices should be geo-referenced.

4. All figures and maps are to be delivered in both hard copy (paper) and digital formats. Acceptable formats include: DXF, uncompressed E00, VEC/VEH, Atlas, windows metafile (WMF) and ISIF. All digital maps must be properly geo-referenced.

5. All sampling locations presented in report and electronic format should be geo-referenced. This is to include decimal latitudes and longitudes (to six decimal places) and UTM coordinates. The first field for decimal latitudes / longitudes should be latitudes (10 spaces wide). The second field should be longitude (11 spaces wide).

6. A presentation package of 35 mm slides that can be used at public meetings to summarize the project is to comprise of one original and four duplicates of each slide.

V. DELIVERABLES

1. A report reviewing previous data for 1989-94, including the GC-MS data in appendices. The contractor will also provide a catalogue of effluent TICs and EIPs, and a mass spectral library of characteristic compounds.

2. Reports characterizing all of the industrial/municipal effluents in the study area for 1994, including characterization of significant toxicants. The contractor will also provide catalogues of current effluent fractions TICs and EIPs, and mass spectral libraries of characteristic compounds.
3. A report characterizing the surface waters above and below effluents in the study area, including the contribution of effluents to the organic composition in these waters.

4. Ten to twenty-five 35 mm slides that can be used at public meetings to summarize the project, methods and key findings.

VI. CONTRACT ADMINISTRATION

This project has been proposed by the Contaminants Component of the Northern Rivers Basins Study (Contaminants Component Leader - Dr. John Carey, NWRI)

The Scientific Authority for this project is:

Dr. Brian Brownlee
National Water Research Institute
867 Lakeshore Road
P.O. Box 5050
Burlington, Ontario
L7R 4A6
phone: (905) 336-4706
fax: (905) 336-4972

Questions of a technical nature should be directed to him.

The Component Coordinator for this project is:

Richard Chabaylo
Northern River Basins Study
690 Standard Life Centre
10405 Jasper Avenue
Edmonton, Alberta T5J 3N4
phone: (403) 427-1742
fax: (403) 422-3055

Questions of an administrative nature should be directed to him.
SCHEDULE A

RIVER AND EFFLUENT SAMPLING SITES

**Athabasca Mainstream:**
- upstream from Hinton
- downstream from Hinton
- upstream from Whitecourt
- downstream from Whitecourt
- upstream from Athabasca
- downstream from Athabasca and upstream from AlPac mill
- downstream from AlPac mill
- upstream from Fort McMurray
- downstream from Fort McMurray
- downstream from Suncor

**Athabasca Effluents:**
- Weldwood (Hinton Combined Effluent)
- Alberta Newsprint effluent (Whitecourt)
- Millar-Western effluent (Whitecourt)
- Whitecourt municipal effluent
- Slave Lake Pulp effluent (Lesser Slave River)
- Athabasca municipal effluent
- Alberta Pacific effluent (downstream from Athabasca)
- Fort McMurray municipal effluent
- Suncor effluent (downstream from Fort McMurray)

**Wapiti-Smoky-Peace Mainstream:**
- Wapiti R. upstream from Grande Prairie
- Wapiti R. downstream from municipal effluent and upstream from Weyerhaeuser mill
- Wapiti R. downstream from Weyerhaeuser mill
- Smoky R. upstream from confluence with Wapiti R.
- Smoky R. downstream from confluence with Wapiti R.
- Smoky R. at mouth
- Peace R. upstream from confluence with Smoky R.
- Peace R. downstream from Peace River
- Peace R. downstream from Daishowa mill

**Wapiti-Smoky-Peace Effluents:**
- Grande Prairie municipal effluent
- Weyerhaeuser effluent (Grande Prairie)
- Peace River municipal effluent
- Daishowa effluent
APPENDIX B: BROAD SPECTRUM ANALYSIS OF MUNICIPAL AND INDUSTRIAL EFFLUENT DISCHARGED INTO THE PEACE, ATHABASCA AND SLAVE RIVER BASINS - DATABASE FILES

The disks provided in this Appendix contains the electronic versions of Northern River Basins Study’s (NRBS) Project Report No’s 138, 121 and 111 and their appendices (where electronic copies exist). This information is being provided to facilitate use by researchers. Users are encouraged to contact the authors of these reports for additional background information.

**Disk No. 1** contains three files, using 990,161 bytes.
1. INSTALL.BAT; being 74 bytes in size.
2. PR138.EXE; being 989,601 bytes in size.
3. DISCLAIM.TXT; being 486 bytes in size.

To install the text, copy the three files on this disk to a directory on your hard drive and type install.bat. The result will be 4 files totalling 6,326,371 bytes; these files contain the text for NRBS Project Report No’s 138, 121 and 111. To use these files requires Word Perfect 5.1 for DOS.

**Disk No. 2** contains three files, using 1,209,794 bytes.
1. INSTALL.BAT; being 80 bytes in size.
2. PR121APP.EXE; being 1,209,228 bytes in size.
3. DISCLAIM.TXT; being 486 bytes in size.

To install the text, copy the three files on this disk to a directory on your hard drive and type install.bat. The result will be 5 files totalling 5,770,174 bytes; this file contains Appendices 1 through 6 from NRBS Project Report No. 121. To use this file requires Word Perfect 5.1 for DOS.

**Disk No. 3** contains Appendices 4 through 11 from NRBS Project Report No. 111 (Appendices 1 through 3 are not available in electronic form). To use these files requires Hewlett Packard Chem Station Software (HPG1034C MS Chem Station). The files in directory “REVIEWLB” are from the 1989 to 1994 review and the files in directory “ANAL1994” are from the analysis of 1994 samples.

There is no warranty expressed or implied for the use of this database; the Northern River Basins Study does not guarantee the accuracy of the data. The NRBS does not assume any liability for actions or consequences resulting from the use of the data; individuals using this data do so entirely at their own risk. The NRBS will not update the data except as deemed necessary for its own purpose.