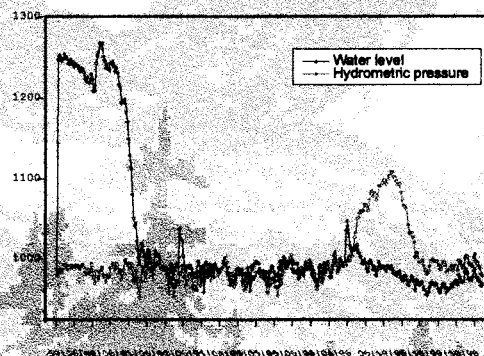
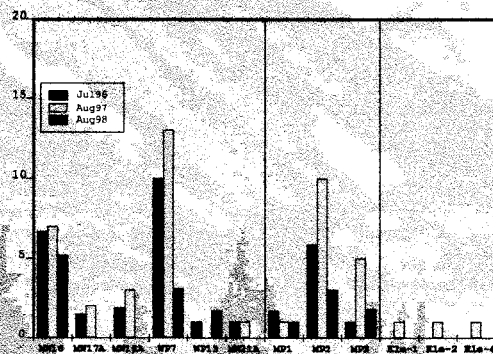


BORDER PUMP STATION AND RAINY HOLLOW, B.C., CANADA: 1997 & 1998 MONITORING PROGRAM



Prepared for:

**INDIAN AND NORTHERN AFFAIRS, CANADA
WASTE MANAGEMENT PROGRAM
YUKON REGION**

Prepared by:



Applied Research Division

February 1999

**ANNUAL MONITORING PROGRAM OF BORDER PUMP STATION
AND RAINY HOLLOW, BRITISH COLUMBIA, CANADA**

Prepared for:

Indian and Northern Affairs Canada
Waste Management Program, Whitehorse, Yukon

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EXECUTIVE SUMMARY

Border Station and Rainy Hollow are contiguous sites located in Northern British Columbia. The two sites were originally operated as a pump station along the Haines-Fairbanks pipeline from the mid 1950's until it was decommissioned in 1972. Following the discovery of DDT containing canisters buried in a dump at Rainy Hollow, a preliminary site investigation was conducted in 1994. This investigation indicated that hydrocarbons and DDT contamination was present in the soil and groundwater at Rainy Hollow. There was also some evidence of the migration of these contaminants into the adjacent Klehini River. In the following summer, hydrocarbon contamination of subsurface soil and groundwater at the Border Station site was also identified in a study, which was part of preliminary environmental assessments along the Haines-Fairbanks Pipeline.

A detailed site investigation and screening-level risk assessment of Border Station and Rainy Hollow was conducted in 1996 and this confirmed the presence of DDTs and hydrocarbons contamination in subsurface soils and groundwater at the sites. There was some evidence that both DDT and hydrocarbons were being introduced to the Klehini River through the discharge of contaminated groundwater. Remedial activities were conducted in the summer of 1997, based on the results of detailed site investigation and recommendations derived from an ecological and human health risk assessment.

The remediation plan and conclusions regarding risks to biota in the Klehini environment, however, were based on assumptions, which included the future fate of contaminants remaining in the subsurface environment of the upper and lower benches. In particular, results of the 1996 investigations indicated that the concentrations of DDTs (includes all the isomers p,p'-DDT, o,p'-DDT, p,p'-DDD, o,p'-DDD, p,p'-DDE, and o,p'-DDE) and hydrocarbon in groundwater across the site, at the outflow face into the Klehini River, and in the river itself did not constitute an elevated risk to aquatic life or piscivorous species. A groundwater model, including a monitoring program, was developed to determine if DDT concentrations entering the river would increase over time.

In order to validate the groundwater model and achieve the objectives outlined in the monitoring program, water samples were collected from Rainy Hollow and Border Station in August 1997 and 1998. Each field program was followed by laboratory analysis for DDTs, metals and hydrocarbons. The results obtained, which are presented in this report indicate that there has been no increase in the concentrations of the original contaminants of potential concern at the site since 1996 either in groundwater entering the Klehini River, or in river water collected adjacent to the site. This, along with the original risk assessment and subsequent risk management activities, suggest that the risk to wildlife or humans, at or near the site, of potential contaminants of concern at the site is minimal. A set of response triggers is recommended within the context of the original groundwater model used as well as risk to the Klehini River ecosystem.

TABLE OF CONTENTS

1.	INTRODUCTION.....	1
1.1	Overview.....	1
1.2	Previous Environmental Site Investigations and Risk Assessment.....	1
1.3	1997 Site Remedial Activities	2
1.4	Monitoring Program.....	3
1.5	Objectives of this Report	3
1.5.1	1997 Monitoring Program.....	4
1.5.2	1998 Monitoring Program.....	4
2.	METHODOLOGY.....	9
2.1	Sampling Locations.....	9
2.2	Sampling	9
2.3	Levellogger.....	10
2.4	Quality Assurance and Quality Control	10
2.5	Laboratory Analysis	11
3.	RESULTS AND DISCUSSION	14
3.1	Presentation of Analytical Results	14
3.2	Evaluation of Analytical Results.....	14
3.3	Groundwater Conditions	17
3.4	DDTs in Groundwater.....	19
3.4.1	DDTs in Monitoring Wells	19
3.4.2	DDTs in Mini-Piezometers	20
3.4.3	DDTs in Klehini River.....	21
3.5	Hydrocarbons	24
3.6	Metals.....	29
4.	CONCLUSIONS AND RECOMMENDATIONS	34
4.1	The Larger Context Re-visited.....	34
4.2	Overview of Monitoring Data to the Present Time.....	36
4.3	Recommended Response Triggers.....	37
4.4	Recommendations for Future Monitoring Programs	39
5.	REFERENCES	40

LIST OF APPENDICES

Appendix A: Groundwater Sampling Sheets

Appendix B: Chain of Custody Forms

Appendix C-1: 1997 Axys Data Reports for DDTs

Appendix C-2: 1998 Axys Data Reports for DDTs

Appendix C-3: 1997 ASL Chemical Analysis Report for Metals and Hydrocarbons

Appendix C-4: 1998 ASL Chemical Analysis Report for Metals and Hydrocarbons

LIST OF FIGURES

Figure 1-1: Border Pump Station and Rainy Hollow General Site Plan.....	6
Figure 1-2: Border Station and Rainy Hollow Locations of Monitoring Wells and Mini-Piezometers	7
Figure 1-3: Water Sampling Locations along the Klehini River	8
Figure 3.1: Groundwater Level and Hydrometric Pressure between August 1997 to August 1998 as Recorded by Automatic Solinst Levelloggers.....	18
Figure 3.2: DDT Concentration in Groundwater and Surface Water Samples Collected at Rainy Hollow in July 1996, Aug 1997 and Aug 1998	19
Figure 3.3: EPH (C10 – C18) Concentration in Groundwater and Surface Water Samples Collected at Rainy Hollow in July 1996, Aug 1997 and Aug 1998.....	24
Figure 3.4: Concentration of Total and Dissolved Iron and Aluminum in Groundwater and Surface Water Samples Collected at Rainy Hollow in August 1998Rainy Hollow	29
Figure 3.5: Zinc Concentration in Groundwater and Surface Water Samples Collected at Rainy Hollow in July 1997 and August 1998	30

LIST OF TABLES

Table 2.1: Summary of the 1997 Analytical Program	12
Table 2.2: Summary of the 1998 Analytical Program	13
Table 3.1: BC CSR Water Standards and CCME (1998) Canadian Environmental Quality Guidelines for DDTs (in µg/L)	14
Table 3.2: BC CSR Water Standards and CCME (1998) Canadian Environmental Quality Guidelines for Hydrocarbons (in mg/L).....	15
Table 3.3: BC CSR Water Standards and CCME (1998) Canadian Environmental Quality Guidelines for Metals (in mg/L unless otherwise stated).....	16
Table 3.4: Groundwater Levels for Monitoring Wells Measured in August 1998	17
Table 3.5: DDT Concentration (µg/L) in Water Samples Collected from Border Station and Rainy Hollow in August 1997.....	22
Table 3.6: DDT Concentration (µg/L) in Water Samples Collected from Border Station and Rainy Hollow in 1998.	23
Table 3.7: Concentration of Volatile, Light and Extractable Hydrocarbons (mg/L) in Water Samples Collected from Border Station and Rainy Hollow in 1997	26
Table 3.8: Concentration of Volatile, Light and Extractable Hydrocarbons in (mg/L) Water Samples Collected from Border Station and Rainy Hollow in 1998	27
Table 3.9: Concentration of Polycyclic Aromatic Hydrocarbons (PAHs) (mg/L) in Water Samples Collected from Border Station and Rainy Hollow in 1998	28
Table 3.10: Concentration of Total Metals (mg/L) in Water Samples Collected from Border Station and Rainy Hollow in 1998.....	31
Table 3.11: Concentration of Dissolved Metals (mg/L) in Water Samples Collected from Border Station and Rainy Hollow in 1997	32
Table 3.12: Concentration of Dissolved Metals (mg/L) in Water Samples Collected from Border Station and Rainy Hollow in 1998.....	33

1. INTRODUCTION

1.1 Overview

This report provides results of annual monitoring programs conducted at Rainy Hollow, British Columbia during the summers of 1997 and 1998. Rainy Hollow is situated near the Klehini River in Northern British Columbia, 8 km north of the Canada Customs Post at Pleasant Camp. The site was the lower bench of Border Pump Station, which was originally a pump station along the Haines-Fairbanks pipeline. A general layout of the site is given in Figure 1-1, located at the end of this chapter. The pump station was operated by the US military from the mid 1950's until it was decommissioned in 1972. A historical review of the pump station may be found in a report prepared for Indian and Northern Affairs by K. Bisset and Associates (1995). A number of clean-up activities were conducted on the site prior to 1994 and these have been summarized in a report by Royal Roads University (Royal Roads, 1996a).

An emergency response team consisting of representatives from CEDA Reactor Ltd. (Edmonton), BCMOE, EC and Golder Associates was assembled in September 1994 immediately following the discovery of DDT (dichloro-diphenyl-trichloroethane or 1,1-bis(4-chlorophenyl)-2,2,2-trichloroethane) containing canisters buried in a dump at Rainy Hollow (Golder, 1995). The DDT canisters, along with other materials which were suspected to contain contaminants (wastewater, empty barrels, transformer oil, and unknown solids) were excavated and placed in over-pack barrels and shipped off-site for treatment at a facility in the USA. After completion of the excavation, an Arctic grade polyethylene liner was placed in the bottom of the excavation and the "Trench" was filled with surface material. A reinforced polyethylene liner was placed over the backfilled material to prevent water infiltration and the area was fenced off. DDT contaminated soils removed from the Trench during excavation of the canisters were stored at a temporary storage facility constructed on the upper bench at Border Station. Contaminated materials in the Temporary Storage area was removed from the site in October 1996.

1.2 Previous Environmental Site Investigations and Risk Assessment

A preliminary environmental assessment was conducted by Golder Associates during the Emergency Response effort (Golder, 1995). The study concluded "both hydrocarbons and pesticides (DDT) are present in the soil and groundwater at the Trench and between the Trench and the River." Concentrations of most contaminants were either at or below the CCME or BC environmental criteria. The report also suggested that DDT was probably being moved towards the river dissolved in hydrocarbons, but no defensible conclusions could be derived on the issue of environmental impact(s). It was stressed that only a preliminary assessment had been performed at Rainy Hollow and "further detailed investigations and delineation sampling would be required to develop a remediation plan...consistent with the current and future uses of the site".

In a separate preliminary environmental assessment study conducted the following summer, hydrocarbon contamination of subsurface soil and groundwater at the Border

Station site was also identified. This study was part of preliminary environmental assessments along the Haines-Fairbanks Pipeline by UMA Engineering and Ambio Research Associates on behalf of Indian and Northern Affairs (UMA, 1995; Royal Roads, 1996b). The study also concluded with the possibility that this contamination may be passing with groundwater down through the Rainy Hollow site to the Klehini River.

A detailed site investigation and screening-level risk assessment of Border Station and Rainy Hollow was undertaken by Royal Roads University, in association with UMA Engineering Ltd., and Golder Associates Ltd. in 1996 (Royal Roads, 1997). This report confirmed the presence of DDTs and light hydrocarbons contamination in subsurface soils and groundwater near the Trench at Rainy Hollow. DDT contamination was also found in surface soils in the vicinity of the Trench at Rainy Hollow, near the Temporary Storage Facility at Border Station, and on access roads between the two areas.

There was some evidence that both DDT and hydrocarbons were being introduced to the Klehini River through the discharge of contaminated groundwater; however, the actual instantaneous concentrations of these substances in sediment, river water, or stream invertebrates was so low as to preclude any possibility of deleterious biological effects. DDT concentrations were indistinguishable from background levels for sediment and stream invertebrates. A conceptual model of DDT transport was developed.

The recommendations for remedial action included:

- The curtailment of the possible exposure pathways for DDTs in surface soils to wildlife and humans by the removal and off-site disposal of soils with total DDT concentrations exceeding 10 mg/kg.
- The encapsulation of the remaining DDT contaminated soils (with total DDT concentration in the range of 1 to 10 mg/kg) and hydrocarbon-contaminated soils (with concentrations exceeding 1000 mg/kg) by capping using a minimum of 0.5 m of clean granular material.
- The development of a long term groundwater monitoring program to validate and improve predictions of contaminant fate. This included monitoring of groundwater levels, the determination of DDT and hydrocarbon concentrations in a selected number of existing wells (with the emphasis on wells installed on the lower bench) and mini-piezometers, and verification of the conceptual model of DDT transport.

1.3 1997 Site Remedial Activities

The remedial action plan listed in the previous section was used by UMA Engineering to develop a construction specifications for the remediation of the site (UMA, 1997). Using the methodology presented in the construction specification, remedial activities were carried out between August 20 and September 14, 1997. Surface soils contaminated with DDTs at concentrations exceeding 10 mg/kg were excavated from the vicinity of the former Temporary Storage Facility and near the Trench at Rainy Hollow. The excavated soils were taken to the East Peace Industrial Waste Treatment and Disposal Site, Peace River, Alberta for disposal. The remaining DDT-contaminated soils (with total DDT

concentration in the range of 1 to 10 mg/kg) and hydrocarbon-contaminated soils (with concentrations exceeding 1000 mg/kg) were capped using a minimum of 0.5m of clean granular material (Royal Roads, 1998).

Eighteen monitoring wells required for the long-term monitoring program were reset to below ground surface as part of the remedial activity. The purpose of this task was to reduce the visibility of the monitoring wells at the site and minimize the potential for tampering. A hole was excavated around the well and the casing was removed. A section of the well was cut off. The PVC cap was replaced and the lower portion of the hole backfilled with clean sand. The well was then refit with the protective casing and sealed with bentonite pieces. It was then buried under approximately 0.3 - 0.5 m of soil. In addition, 11 wells, which were no longer needed for monitoring purposes, were cut off at a depth of 1m below ground surface and permanently sealed. The casing was removed from the upper- most portion of the well and the two inch PVC piezometer upriser was cut back to below grade. A PVC cap was placed on the top of the piezometer upriser, and the borehole was brought up to the surrounding grade with clean fill.

1.4 Monitoring Program

The monitoring program recommended in the Detailed Site Investigation and Risk Assessment report, including the conceptual model of contaminant transport, was expanded and evaluated in a follow up document entitled "Rainy Hollow Contaminant Transport Modeling" (Woodbury, 1997). Schedules and parameters recommended in this document included:

- Measurement of water levels at MW-19A using a continuous recorder (well locations are shown on Figure 1-2);
- Monitoring of the water levels at MW-18 and MW-22 on a twice per-month frequency from May to October;
- Annual sampling of water from monitoring wells WP-7, WP-13, MW-21A, MW-21B, MW-17A, MW-17B and MW-18, from mini-piezometers MP-1, MP-2 and MP-3, and at three points along the Klehini River (Figure 1-3).
- Field determination of the electrical conductivity, temperature and pH of the water samples and laboratory analysis for DDTs and BTEX in predefined subsets of the wells.
- In addition, pursuant to discussions at the Rainy Hollow Working Group meeting of March, 1998, it was deemed necessary to analyze these samples for dissolved metals as well as light extractable petroleum hydrocarbons (LEPHs - C10-C18).

1.5 Objectives of this Report

This report provides the results of both the 1997 and 1998 monitoring programs. The data obtained are also compared to results from the 1996 detailed site investigation (Royal

Roads, 1997). Finally a set of response triggers is recommended within the context of the original groundwater model used as well as risk to the Klehini River ecosystem.

1.5.1 1997 Monitoring Program

The 1997 monitoring program was designed to address issues presented in the Rainy Hollow Contaminant Transport Modeling report and evaluate the conceptual model. Specific objectives included:

- The installation of data loggers for the continuous measurement of water levels;
- The collection of surface water samples from three locations along the Klehini River;
- Sampling of groundwater from selected wells and the mini-piezometers;
- Laboratory analysis for DDTs, BTEX, volatile hydrocarbons, extractable hydrocarbons and dissolved metals

In order to achieve these objectives, a field sampling program was conducted between August 20 – 22, 1997. Activities undertaken by representatives from RRU, UMA and DIAND included the installation of two Solinst data loggers, collection of surface water samples along the Klehini River and sampling of groundwater samples from selected monitoring wells and mini-piezometers. As part of the 1997 remedial activities, the well heads were cut down to below the final grade and a well cap re-installed to protect the long-term integrity of the wells. The wells were then buried under approximately 0.3 - 0.5 m of soil. The purpose of this task was to reduce the visibility of the monitoring wells at the site and minimize the potential for tampering.

The field program was followed by laboratory analysis for DDTs, metals and hydrocarbons. A summary of the results was subsequently presented at the Rainy Hollow Working Group meeting in March 1998 at Royal Roads University.

1.5.2 1998 Monitoring Program

Objectives specific to the 1998 Sampling and Analytical Program included:

- Download data from the Solinst data loggers installed in 1997 ensuring that the data was adequately captured and properly archived. Re-set data loggers parallel to direction of groundwater flow (i.e. in MW-96-19A and MW-96-16).
- Excavate wells MW-16, 17A, 17B, 18, 19A, 21A, 21B, WP-7 and WP-13. (Locations are shown on Figure 1-2).
- Measure groundwater levels, temperature, pH and conductivity in the wells indicated above as well as the mini-piezometers MP-1, MP-2 and MP-3.
- Obtain water samples from the wells, the mini-piezometers and three locations along the Klehini River (Kle-1, Kle-2 and Kle-4).
- Re-bury wells with due regard for long-term integrity.
- Obtain data through the laboratory analysis for DDTs, BTEX, volatile hydrocarbons, extractable hydrocarbons and dissolved metals and total metals

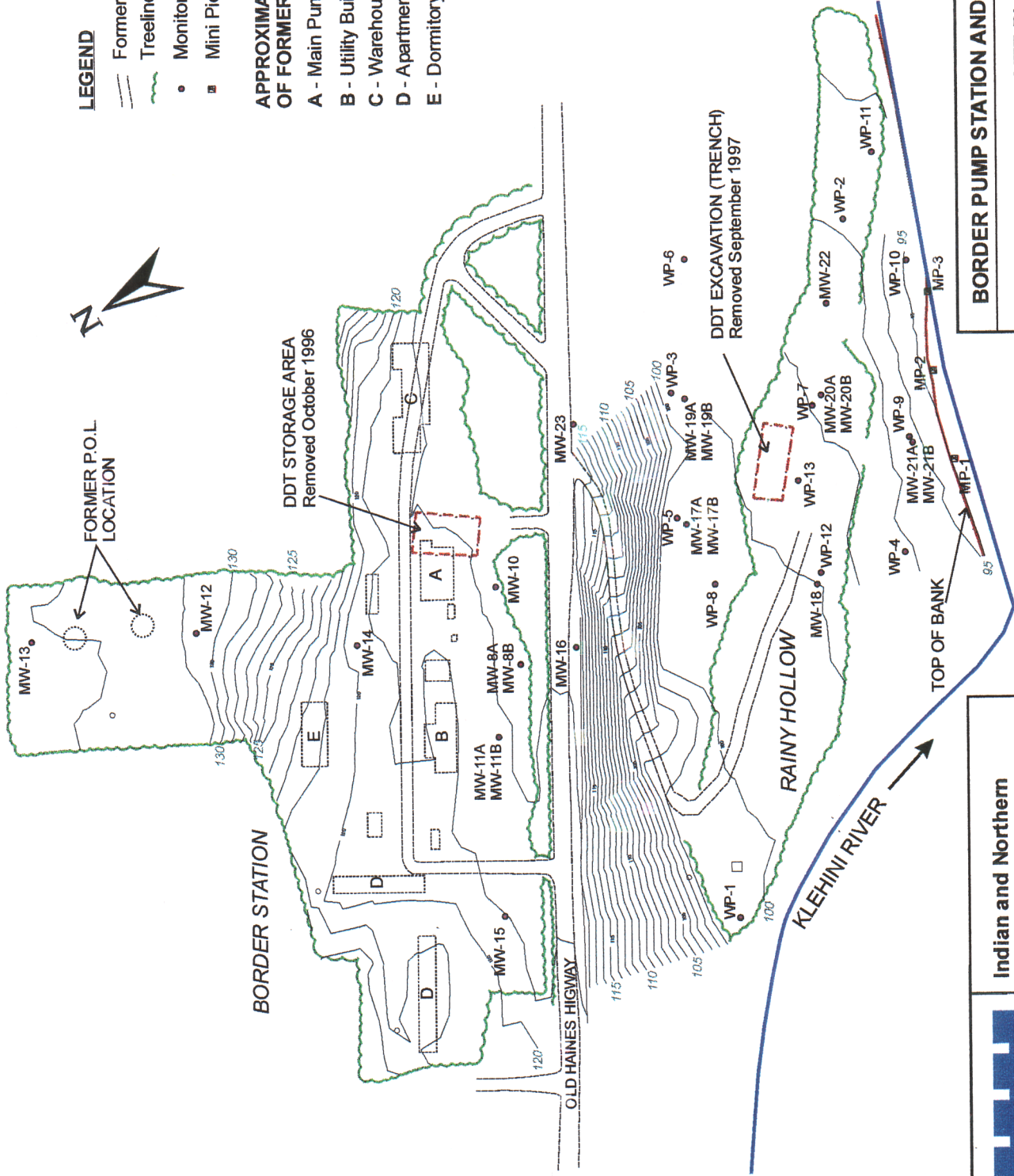
The field program was conducted between August 7 and 9, 1998 by representatives from RRU and DIAND Waste Management, Whitehorse. This was followed by laboratory analysis.

LEGEND

- Former Location of Roadway
- Treeline
- Monitoring well
- Mini Piezometer

APPROXIMATE LOCATION OF FORMER BUILDING

- A - Main Pump Line Building
- B - Utility Building
- C - Warehouse
- D - Apartment
- E - Dormitory



BORDER PUMP STATION AND RAINY HOLLOW

GENERAL SITE PLAN

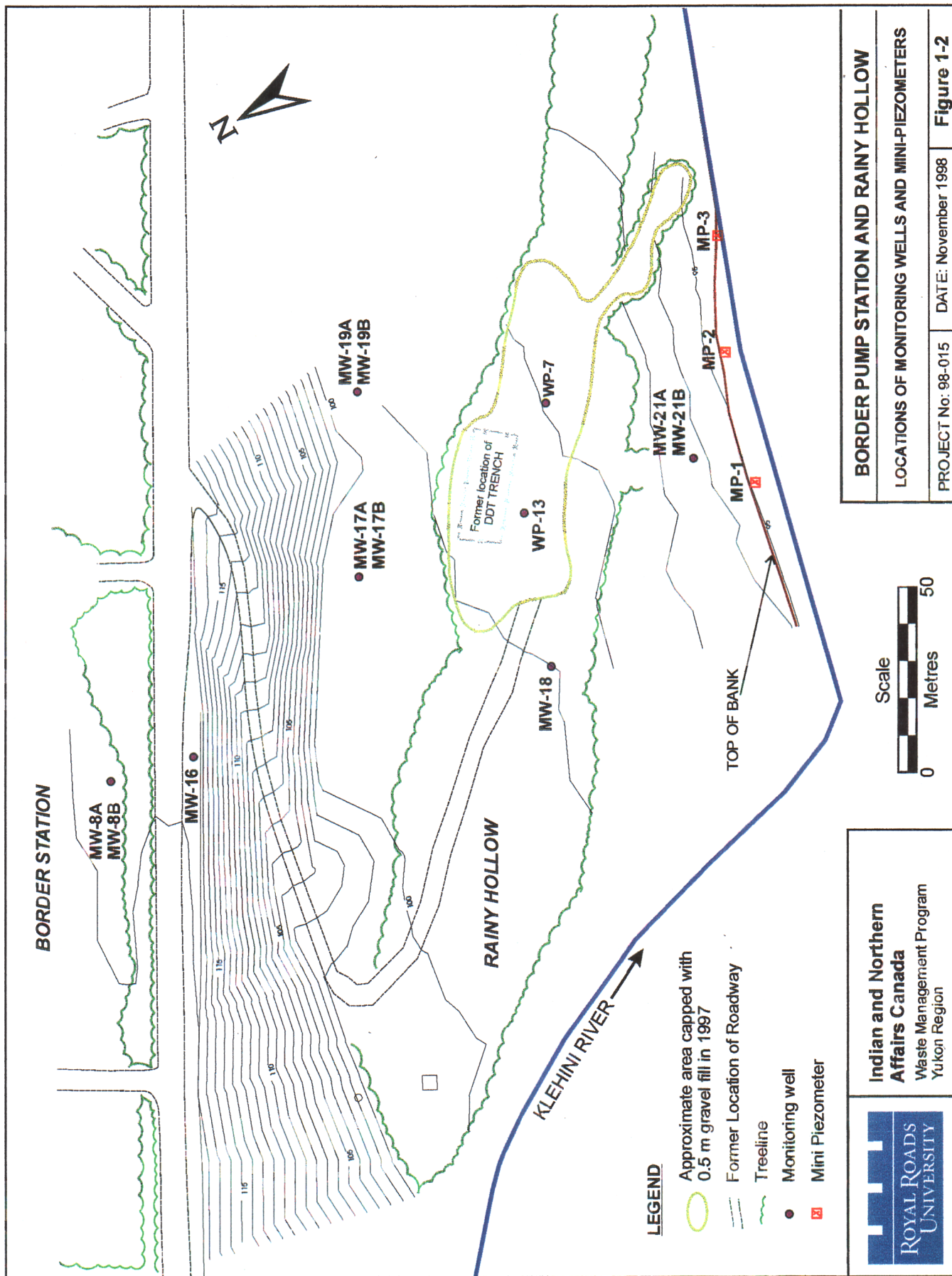
PROJECT No: 98-015

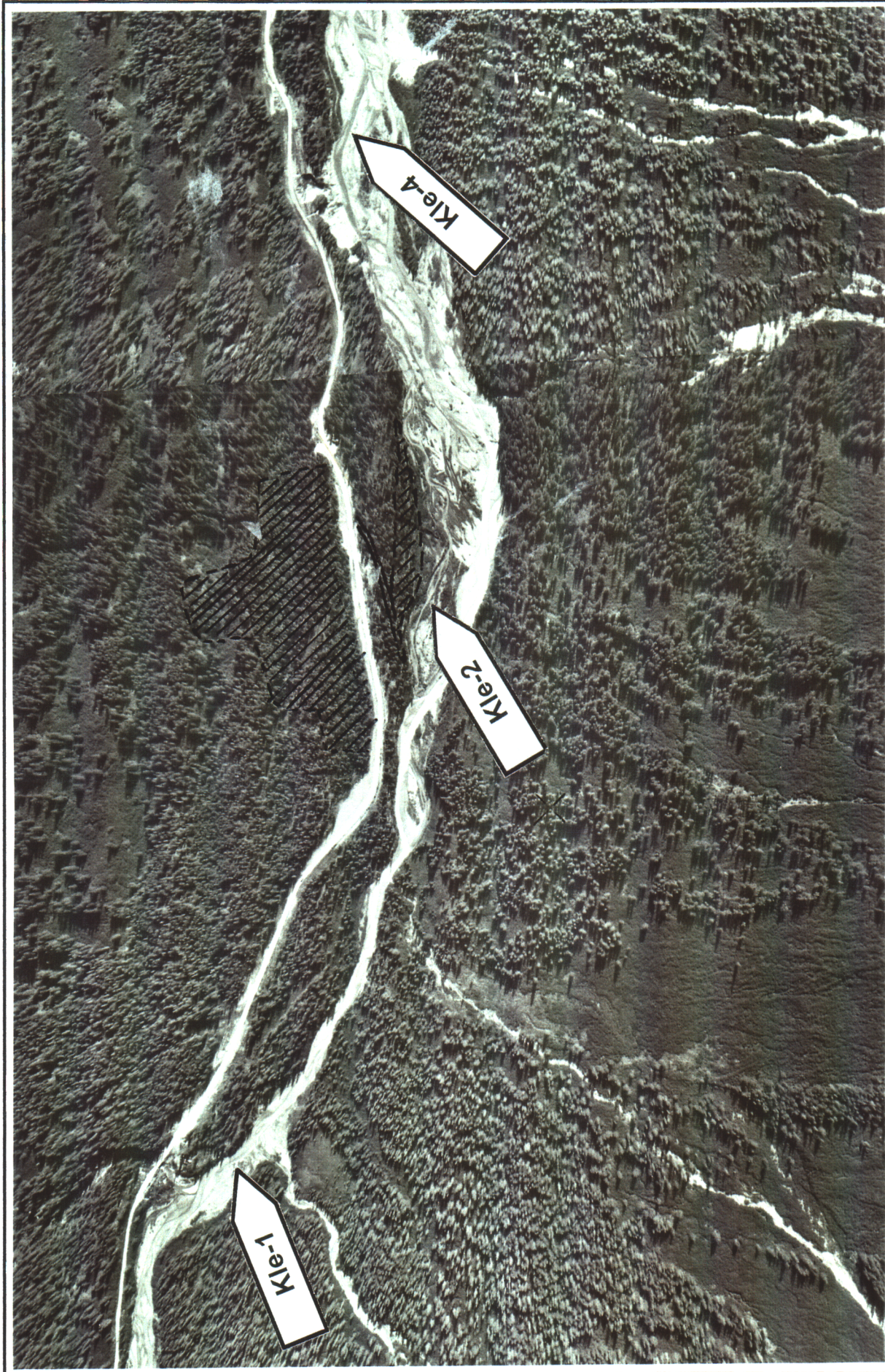
DATE: November 1998

Figure 1-1

Indian and Northern
Affairs Canada
Waste Management Program
Yukon Region







Indian and Northern
Affairs Canada
Waste Management Program
Yukon Region



Note: Aerial photograph was
taken in 1943 and predates
the construction of Border Station

BORDER PUMP STATION AND RAINY HOLLOW

WATER SAMPLING LOCATIONS ALONG THE KLEHINI RIVER

PROJECT No: 98-015

DATE: November 1998

Figure 1-3

2. METHODOLOGY

2.1 Sampling Locations

Eight locations were targeted for groundwater sampling and these are shown on Figure 1-2. The wells comprised:

- MW-8B¹ and MW-16 located on the upper bench to ascertain the migration of hydrocarbons towards Rainy Hollow;
- MW-17A&B and MW-19A&B which are two sets of nested wells situated along the groundwater flow path from the upper bench and up gradient from the DDT Trench at Rainy Hollow;
- WP-7, WP-13 and MW-21, which are located down gradient from the Trench; and,
- MW-18, which is not directly influenced by either the DDT Trench or hydrocarbon contamination from the upper bench and was therefore selected to provide data on the lower site background conditions.

Samples were also collected from the three mini-piezometers (MP-1, MP-2 and MP-3) situated along the bank of the Klehini River.

Surface water samples were obtained from three locations along the Klehini River as depicted on an aerial photograph presented in Figure 1.3. The three locations include:

- Kle-1: Downstream of the confluence of Seltat Creek and Klehini River, at approximately 1.1 km north of Rainy Hollow
- Kle-2: Inside of gravel bar adjacent to mini-piezometer MP-1
- Kle-4: South of Rainy Hollow, at approximately 1 km downstream of the site.

2.2 Sampling

Analytical Services Laboratory (ASL) and Axys Analytical Laboratories (Axys) provided appropriate pre-cleaned sampling jars and preservatives.

Groundwater samples were obtained from the wells prior to their burial in 1997. In 1998, the tops of the buried wells, which were down to 0.5 m below the surface, were located using a combination of reference maps and a metal detector. The wells were then excavated.

¹ In 1996, MW-8B (or TH-8B) was the only well that contained free-phase hydrocarbons (LNAPL – light non-aqueous phase liquids; up to 2 cm thick) on the groundwater surface. Where free product occurs, the groundwater concentration of various hydrocarbon fractions is assumed to approach the aqueous solubility limits of the product involved, with additions beyond solubility based on physical mixing and creation of micelles through the strong vertical motion created by the use of Waterra sampling systems. Therefore, where free product was observed, the analytical results for hydrocarbon fractions were not generally obtained.

The static water level in each well was measured using a Solinst Water level Meter equipped with an Interface Probe (Model No. 122). Each well was purged and sampled using the dedicated Waterra™ tubing and foot valve installed during the detailed site investigation as follows. At least three well volumes of water were withdrawn from the well and discarded. Following this, an aliquot of the purge water was placed into a 50 mL disposable Evergreen™ polyethylene vial and the pH, conductivity and temperature of the purge water were measured. Purging was continued until three consecutive measurements of pH, temperature and conductivity were within ten percent. Electrical conductivity measurements were performed with a Cole Parmer Model # 1481-60, which was calibrated with a 1413 µS standard solution while a Barnet Model 30 pH meter, calibrated with pH 7 and pH 4 standard solutions was used for the pH and temperature determinations. The pH, conductivity and thermal probes were rinsed with distilled water and wiped with Kimwipes™ after each determination.

Samples designated for either DDT or extractable hydrocarbon analyses were placed into 1 L amber glass jars. For volatile organic compound analysis an aliquot of groundwater was placed into a 40 mL vial containing copper sulfate preservative and sealed with a Teflon-lined septum lid.

Samples earmarked for dissolved metals analyses were field filtered using disposable in-line 700 cm² x 0.45 µm membrane filter (Gelman Sciences). The filtered sample was placed directly into a 250 mL plastic container and preserved with nitric acid. The sample for total metals analyses was placed directly into a 250 mL plastic container without filtration and preserved with nitric acid.

Groundwater Sampling Data Sheets, which provide static water levels, volumes of purge water, pH, temperature, conductivity and samples collected during the 1998 program are presented in Appendix A.

All the labeled sample containers were placed into coolers and shipped to the analytical laboratory via Canadian Air Cargo. Chain of custody forms accompanied the shipment. The list of samples submitted for analysis, and the parameters requested may be found in the chain of custody forms provided in Appendix B.

2.3 Levellogger

Two Solinst Model #3001 M5 Levelloggers (S/N# 3312 and 3313) were installed in monitoring well MW-19B on 23 August 1997. One Levellogger was set below the water level to measure the depth of water in the well. The second Levellogger was placed in the borehole above the highest expected water level to measure barometric pressure. The two loggers were set to record daily at 1200 hrs.

Data was retrieved from the Levelloggers during the 1998 program.

2.4 Quality Assurance and Quality Control

A field QA/QC program, which incorporate measures to ensure the integrity of the

groundwater samples collected was utilized. The QA/QC program included:

- Documentation of date, time, site identification, site conditions, sampling equipment, preservatives, etc.) on sampling sheets which are presented in Appendix A;
- The use of dedicated sampling equipment for each well to avoid cross-contamination;
- Collections of a field duplicate from MP-3 in 1997 and MP-2 in 1998.
- The use of chain of custody forms; and
- Transportation under conditions that retained the sample integrity.

2.5 Laboratory Analysis

The samples were analyzed at Analytical Services Laboratory (ASL), Vancouver, BC and Axys Analytical Services (Axys), Sidney, BC. Both ASL and Axys have been evaluated and accredited by the Canadian Association for Environmental Laboratories (CAEL).

The following substances were analyzed at ASL:

- Total metals;
- Dissolved metals;
- Light Extractable Petroleum Hydrocarbon (LEPH) and Heavy Extractable Petroleum Hydrocarbons (HEPH);

In order to achieve detection limits of less than 0.01 µg/L in groundwater samples (BC CSR standard for aquatic life, see Section 4.1), analysis for DDT and its metabolites (DDD and DDE) was carried out by high-resolution gas chromatography/mass spectrometry at Axys. The analytical methods are included in laboratory reports attached to Appendix C-1. A summary of the analytical program is provided in Tables 2.1 and 2.2.

Table 2.1: Summary of the 1997 Analytical Program

Sample #	Analysis Requested			
	DDT, DDE, & DDD ²	EPH ³ (C10-C18)	BTEX	Dissolved Metals
Monitoring Well				
WP-7	1	1	1	1
WP-13	1	1	1	1
MW-8A		1	1	1
MW-16		1		1
MW-17A		1		1
MW-17B		1		1
MW-18		1		1
MW-19A		1		1
MW-20 A		1		1
MW-21 A	1	1	1	1
MW-21 B		1		1
Mini-Piezometers				
MP-1	1	1	1	1
MP-2	1	1	1	1
MP-3	1	1	1	1
MP-3-2	1	1	1	1
(Field duplicate)				
Klehini River				
Kle-1	1	1		
Kle-2	1	1		
Kle-4	1	1		
Total No. of Samples	10	18	8	15

² Includes individual results for p,p'-DDT, o,p'-DDT, p,p'-DDD, o,p'-DDD, p,p'-DDE, o,p'-DDE.

³ EPH: Extractable petroleum hydrocarbons. This represents the fraction of hydrocarbons that elutes from the GC column (based on a boiling-point separation) from nC10 to C18, and includes the aliphatic, heterocyclic, and aromatic fractions (including PAHs); In the province of British Columbia, the presently accepted practice is to separately quantify the concentration of unsubstituted PAHs that fall in this range and subtract this from the total nC10 to C18 fraction to arrive at a concentration for "Light Extractable Petroleum Hydrocarbons", or LEPHs. For Rainy Hollow, it has been consistently demonstrated that the unsubstituted PAHs are an insignificant part of the EPH fraction. Rainy Hollow monitoring data for EPHs (C10-C18) and LEPHs are, therefore, directly comparable.

Table 2.2: Summary of the 1998 Analytical Program

Sample ID	Analysis Requested				
	DDT, DDD & DDE	LEPH/ HEPH ⁴	BTEX/ VPH	Total Metals	Dissolved Metals
<i>Monitoring Well</i>					
MW-16		1	1		
MW-17A	1		1	1	1
MW-18	1				
MW-19A				1	1
MW-21A	1		1	1	1
MW-21B	1		1	1	1
WP-7	1	1	1	1	1
WP-13	1	1	1	1	1
<i>Mini-Piezometer</i>					
MP-1	1	1	1	1	1
MP-2	1	1	1	1	1
MP-2 (Field Duplicate)	1	1	1	1	1
MP-3	1	1	1	1	1
<i>Klehini River</i>					
Kle-1	1			1	1
Kle-2	1			1	1
Kle-4	1			1	1
Total	13	7	10	13	13

⁴ Light Extractable Petroleum Hydrocarbons/Heavy Extractable Petroleum Hydrocarbons: In the province of British Columbia, the presently accepted practice is to separately quantify the concentration of unsubstituted PAHs that fall in the range and subtract this from the total nC10 to C18 fraction to arrive at a concentration for "Light Extractable Petroleum Hydrocarbons", or LEPHs. Similarly, HEPHs comprise the fraction from >C18 to C31, after subtracting concentrations of unsubstituted PAHs falling in this range. For Rainy Hollow, it has been consistently demonstrated that the unsubstituted PAHs are an insignificant part of the EPH fraction. Rainy Hollow monitoring data for EPHs (C10-C18) and LEPHs are, therefore, directly comparable. Similarly, data for EPHs (>C18 to C31) and HEPHs are directly comparable.

3. RESULTS AND DISCUSSION

3.1 Presentation of Analytical Results

Laboratory analytical results obtained are summarized in tables presented at the end of the respective sections in this chapter. Complete laboratory reports, which contain analytical methods and QA/QC data, are given in Appendix C.

3.2 Evaluation of Analytical Results

Data obtained for groundwater samples were evaluated using generic numerical water standards presented in Schedule 6 of the 1997 BC Contaminated Sites Regulations (BC CSR). The standards for aquatic life (AW) were employed. For surface waters collected from the Klehini River, the CCME (Canadian Council of Ministers of the Environment) Canadian Environmental Quality Guidelines for Freshwater (CCME, 1998) were used. Summaries of the standards and guidelines used are given in Tables 3.1, 3.2 and 3.3. The data was also evaluated with respect to the groundwater model.

Table 3.1: BC CSR Water Standards and CCME (1998) Canadian Environmental Quality Guidelines for DDTs (in µg/L)

Substance	BC CSR Aquatic Life (AW)	CCME (1998) Freshwater
DDT	0.010	0.001

Notes:

Includes DDT metabolites

All values are in µg/L

BC CSR Aquatic life standards assume minimum 1:10 dilution

Table 3.2: BC CSR Water Standards and CCME (1998) Canadian Environmental Quality Guidelines for Hydrocarbons (in mg/L)

Substance	BC CSR Aquatic Life (AW)	CCME (1998) Freshwater
<i>Non-halogenated Volatiles</i>		
Benzene	3	0.37
Ethylbenzene	7	0.09
Toluene	3	0.002
meta- para- & ortho-Xylene	---	---
<i>Volatiles</i>		
Light Hydrocarbons (C5-9)	---	---
VPH	---	---
<i>Extractables</i>		
EPH (C10-18)	---	---
EPH (C19-31)	---	---
LEPH	---	---
HEPH	---	---
<i>Polycyclic Aromatic Hydrocarbons</i>		
Acenaphthene	0.06	0.000058
Acenaphthylene	---	---
Acridine	0.0005	0.0044
Anthracene	0.001	0.000012
Benz(a)anthracene	0.001	0.018
Benzo(a)pyrene	0.0001	0.000015
Benzo(b)fluoranthene	---	---
Benzo(g,h,i)perylene	---	---
Benzo(k)fluoranthene	---	---
Chrysene	---	---
Dibenz(a,h)anthracene	---	---
Fluoranthene	0.002	0.00004
Fluorene	0.120	0.003
Indeno(1,2,3-c,d)pyrene	---	---
Naphthalene	---	0.0011
Phenanthrene	---	0.4
Pyrene	0.0002	0.000025

Notes: All values are in mg/L.

--- Value not established

Aquatic life standards assume minimum 1:10 dilution

Table 3.3: BC CSR Water Standards and CCME (1998) Canadian Environmental Quality Guidelines for Metals (in mg/L unless otherwise stated)

Substance	BC CSR Aquatic Life (AW) ¹	CCME (1998) Freshwater
<i>General parameters</i>		
pH	6.5 to 8.5	6.5 to 9
<i>Inorganics</i>		
aluminum	0.050 – 0.500 ²	0.005 to 0.100 ²
antimony	0.3	---
arsenic	0.5	0.005
barium	10	---
beryllium	0.053	---
boron	---	---
cadmium	0.002 – 0.018 ³	0.000017
chromium	0.020	---
cobalt	0.50	---
copper	0.020 – 0.090 ³	0.002 to 0.004 ³
iron	3	0.3
lead	0.040 – 0.160 ³	0.001 to 0.007 ³
manganese	1.0	---
mercury	0.001	0.0001
molybdenum	10	0.073
nickel	0.25 – 1.5	0.025 to 0.15 ³
selenium	0.10	0.001
silver	0.001	0.0001
thallium	0.003	0.0008
Uranium	3.0	---
zinc	0.30	0.03 ⁴

All values are in mg/L unless otherwise stated

--- Value not established

1. Aquatic life standards assume minimum 1:10 dilution
2. Guideline or standard varies with pH
3. Guideline or standard varies with water hardness
4. Tentative guideline because of insufficient evidence

3.3 Groundwater Conditions

Groundwater levels measured in August 1998 are summarized in Table 3.4. Groundwater elevations measured in 1996 are included in this table for comparison. The levels measured in August 1998 are in close agreement with levels measured in previous years. This suggests no dramatic change in horizontal gradient, which in turn means no significant change in the groundwater flux to the river.

Table 3.4: Groundwater Levels for Monitoring Wells Measured in August 1998

Well Number	Date/Time	Depth to Water Level from Top of Rim (m)	Depth to Bottom of Well from Top of Rim (m)	Ground- water Elevation (m)	1996 Ground- water Elevation (m)
WP-7	Aug 8/2:55PM	1.95	2.54	96.05	96.11
WP-13	Aug 8/2:10PM	2.60	3.89	96.18	96.08
MW-16	Aug 7/1:45 PM	19.00	21.50	98.80	98.20
MW-17A	Aug 7/3:15 PM	1.77	8.65	97.28	97.39
MW-18	Aug 8/9:20AM	2.10	7.39	96.10	96.30
MW19A	Aug 7/3:55 PM	2.26	4.47	95.95	96.22
MW-21A	Aug 8/9:20AM	0.32	1.70	93.98	93.85
MW-21B	Aug 8/9:20AM	0.31	6.88	93.63	93.87

Data from the two Solinst Levelloggers, which were retrieved on August 8, 1998, are presented graphically in Figure 3.1. The logger installed below the water table showed values of 1200 to 1250 cm corresponding to a water table elevation (measured manually) of about 95.8 m. During October 1997, the readings dropped off by 250 cm and fluctuated within a fairly narrow range (maximum variation of 100 cm) until the end of the recording interval in August 1998. The reading on August 8, 1998 of 969 cm corresponds to a manually recorded water level of about 96 m. The drop in reading in October 1997 cannot be readily rationalized. It may represent a drift in the transducer.

Apart from the dramatic adjustment in pressure readings, the water level appears to vary by about 30 cm with the occasional spikes of 50 cm or more. However, the two prominent short-term increases in water levels occur in December 1997 and mid April 1998. No major external impact, such as spring recharge or high river stage would be expected to influence groundwater levels.

Barometric pressure fluctuations appear reasonable except for a broad rise of some 200 cm between mid-April and mid-June 1998. This may be due to drift in the instrument. No natural event would produce this type of response over a 60 day period.

It is important to continue the automatic water level monitoring to observe long-term trends, however it does not appear that there are significant seasonal changes to the groundwater table. This in turn implies that the flux of groundwater discharging to the Klehini River also does not vary in a significant way.

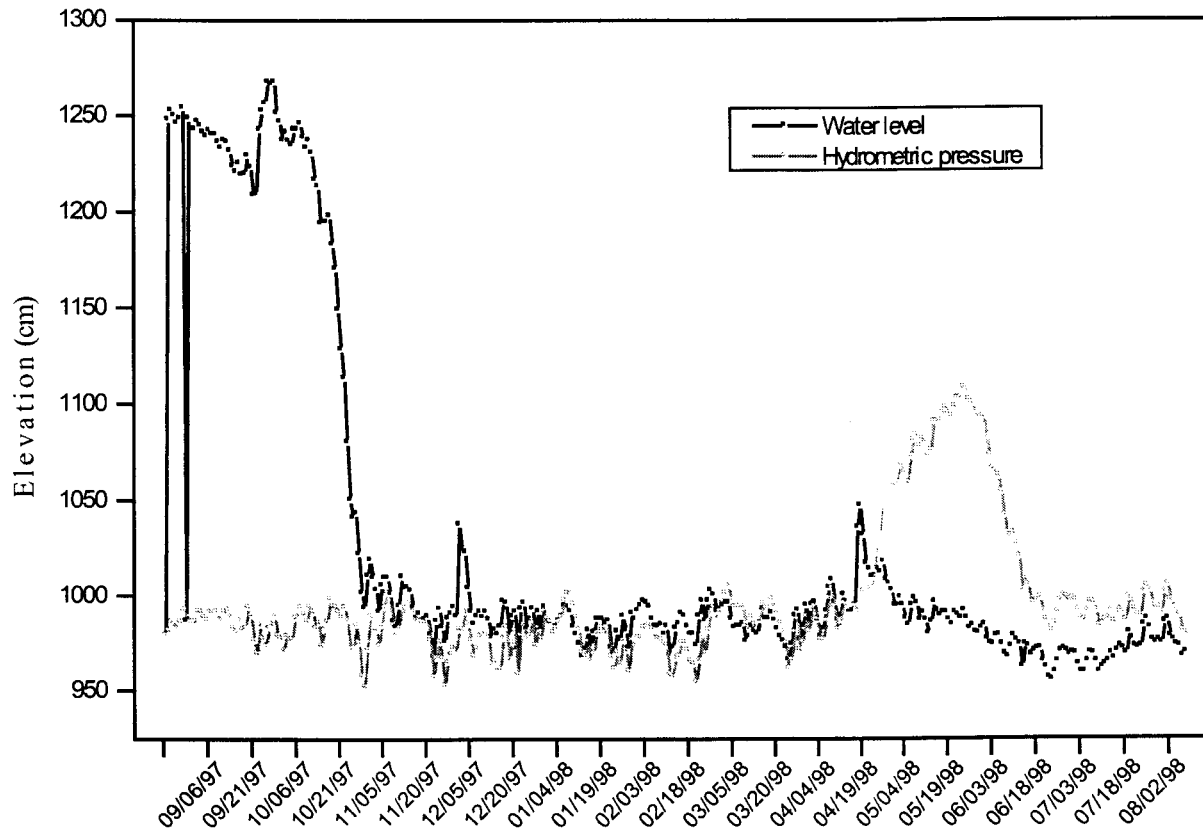


Figure 3.1: Groundwater Level and Hydrometric Pressure between August 1997 to August 1998 as Recorded by Automatic Solinst Levelloggers

3.4 DDTs in Groundwater

The concentrations of DDTs (sum of all DDT, DDD and DDE isomers analyzed) in the water samples collected in 1997 and 1998 are given in Tables 3.5 and 3.6 respectively. These results, along with data from the 1996 analyses are presented graphically in Figure 3.2, below.

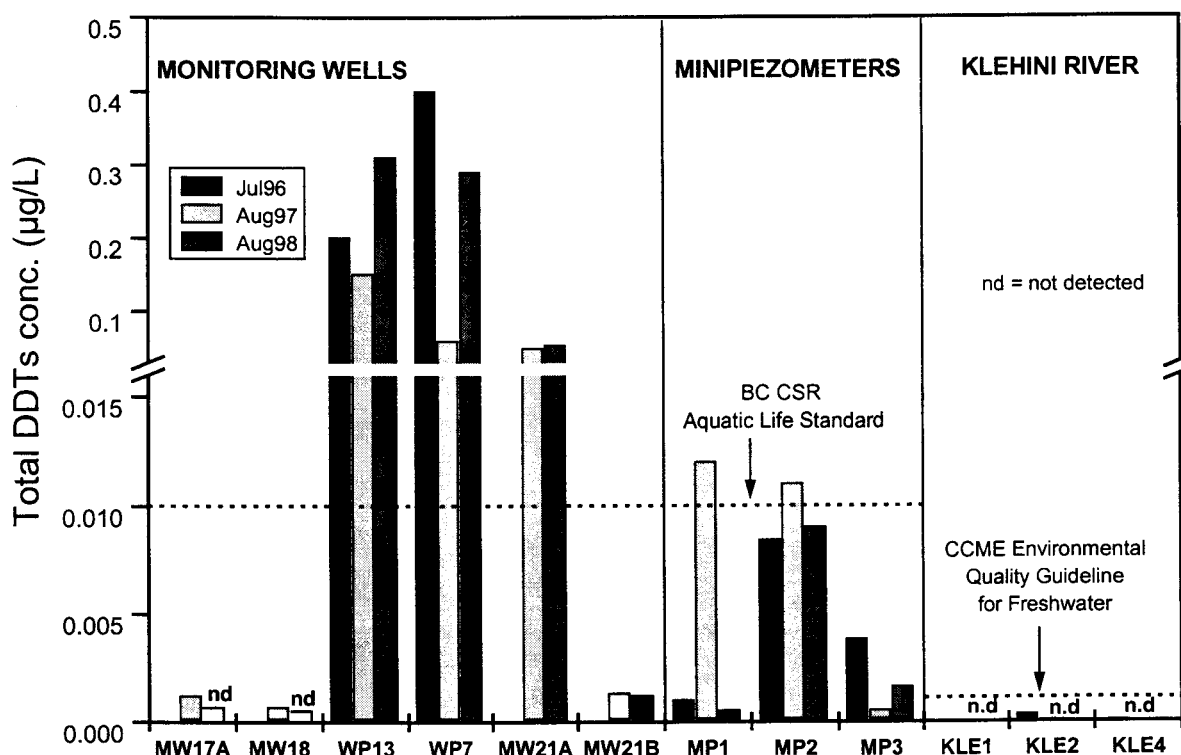


Figure 3.2: DDT Concentration in Groundwater and Surface Water Samples Collected at Rainy Hollow in July 1996, Aug 1997 and Aug 1998

3.4.1 DDTs in Monitoring Wells

The concentration of DDT in MW-17A, a shallow well, located up gradient of the Trench was 0.0012 µg/L in 1997 but below detection (<0.001) in 1998. Comparable results were also obtained for MW-18, which is located west of the Trench and is not directly influenced by contamination from either the Trench or the upper bench; DDT concentration was 0.00066 µg/L in 1997 and <0.001 µg/L in 1998.

The highest concentrations of DDT were found in groundwater samples obtained from the two wells located immediately down gradient from the Trench (WP-7 and WP-13). The levels in samples from WP-7 were 0.4 µg/L (1996), 0.059 µg/L (1997) and 0.29 µg/L

(1998) while the concentrations measured in groundwater at WP-13 were 0.2 µg/L (1996), 0.15 µg/L (1997) and 0.35 µg/L (1998). All these levels exceed the 1997 BC CSR aquatic life standard of 0.01 µg/L. The principal isomer in all the samples was p,p'-DDD, the initial degradation product of DDT by either hydrolysis or reductive dehalogenation.

The concentration of DDT was comparable in the two wells in 1998, however, as depicted in Figure 3.2, there were slight variations in DDT concentrations over the three-year period. There was no significant difference between the 1996 and 1997 levels at WP-13. The concentration at WP-7 was, however, lower in 1997. Results from the 1996 program were generated using dual column gas chromatography with electron capture detector (GC-ECD) at detection limits of <0.1 µg/L. Data were generated in the subsequent years using gas chromatography with mass spectrometric (GC-MS) detection which yielded a better detection limit of <0.001 µg/L. This difference in detection limits may account for variations between the 1996 and 1997 data.

Detectable concentrations of DDT were also found in the nested wells located along the groundwater migration pathway to the Klehini River. Comparable levels (0.049 and 0.053 µg/L), which exceeded the BC CSR AW standard, were found in the shallow well (MW-21A) in 1997 and 1998. The concentrations in the deeper well (MW-21B) were an order of magnitude lower (0.0013 and 0.0012 µg/L in 1997 and 1998, respectively). Quantitative data are not available from the 1996 program for comparison since as with WP-7 and WP-13, GC-ECD with a detection limit of <0.1 µg/L was employed for the analysis.

3.4.2 DDTs in Mini-Piezometers

Groundwater samples collected in 1996 – 1998 from the three mini-piezometers adjacent to the Klehini River also contained detectable levels of DDT, with MP-2 having concentrations which were in the same concentration range as the BC CSR AW standard (Figure 3.2). This mini-piezometer, MP-2, was directly along the groundwater migration pathway to the Klehini River. The concentrations are also comparable to that predicted by the groundwater model (0.007 µg/L). No significant difference in concentration was noted over the three-year period. This is in line with the groundwater model, which suggested that temporal changes in DDT flux at the interface are predicted to occur relatively slowly as such a drastic short-term increase in inputs to the river will not occur.

Apart from one anomalous data point of 0.012 ng/L obtained in 1997, the concentrations in samples from MP-1 (up gradient of MP-2) and MP-3 (down gradient of MP-2) were lower than the standard. An examination of the 1997 data indicated the principal contaminants as parent DDT isomers as opposed to DDD (the degradation product). No water samples could be withdrawn from the existing mini-piezometer at location MP-1 during the 1997 monitoring program as such, a new one was re-installed. Groundwater samples were then obtained the following day and it appears the new mini-piezometer was not fully developed prior to sampling. Hence the presence of elevated o,p'-DDT and p,p'-DDT contaminants. It should be noted that the results obtained during the 1998 monitoring program were comparable to the 1996 data.

3.4.3 DDTs in Klehini River

Most of the concentrations of DDT detected in the mini-peizometers exceeded the CCME criteria for the protection of aquatic life (0.001 ng/L). However, DDT concentrations in water samples obtained from the Klehini River (Kle-2), within 2 – 3 m of MP-2 for each of the three years, were either less than the detection limit or well below the criteria. DDT levels in samples collected upstream (Kle-1) and downstream (Kle-4) of the site were also below detection.

3.5 Hydrocarbons

The concentrations of hydrocarbons in groundwater samples were measured as BETX (Benzene, ethylbenzene, toluene and xylene) VPHs (volatile hydrocarbons, C6-10), EPH (extractable hydrocarbons), LEPHs (light extractable petroleum hydrocarbons), HEPHs (Heavy Extractable Petroleum Hydrocarbons) and PAHs (Polycyclic Aromatic hydrocarbons). Data obtained over the course of the 1997 and 1998 monitoring programs are given in Tables 3.7 to 3.9. Extractable petroleum hydrocarbon (EPH) results are presented graphically in Figure 3.3. Analytical results from the 1996 program are included for comparison; however, please refer to the Detailed Site Investigation and Risk Assessment Report (Royal Roads, 1997) for a complete presentation of the 1996 hydrocarbon results for groundwater.

No British Columbia or federal criteria or standards currently exist for hydrocarbons in surface water when measured as the group parameter such as VPHs, EPH, or LEPHs, except that the presence of free product is a trigger for further action. The Province of British Columbia is currently developing standards for VPH and LEPH (http://www.bc.environment-issues.com/bcei_scripts/updates.cgi/Petroleumhydro1.html, accessed November 16, 1998).

Detectable concentrations of VPH, EPH (C10 - C18) and LEPH (C10 - C18) were found in groundwater samples obtained from various monitoring wells and mini-piezometers (Table 3.6 and 3.7). Generally, the concentrations of EPH were lower in 1998 compared to 1997. This observation is illustrated in Figure 3.3 below.

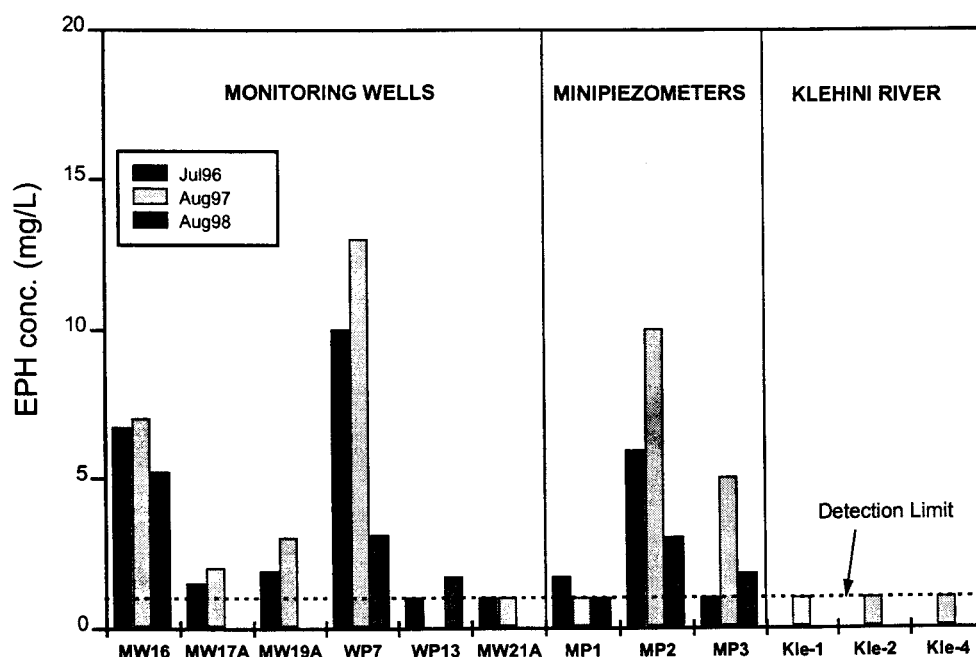


Figure 3.3: EPH (C10 – C18) Concentration in Groundwater and Surface Water Samples Collected at Rainy Hollow in July 1996, Aug 1997 and Aug 1998

The highest concentration detected at the lower site was at WP-7, located immediately down gradient of the Trench. There were also low levels of ethylbenzene, toluene, and xylene in groundwater samples obtained from this well. The concentrations obtained over the monitoring period were consistent and well below the BC CSR AW standard.

Mini-piezometer MP-2 contained EPH in the C10-C18 range at a concentration 2.8 to 10 mg/L while levels in MP-3 were between <1.0 and 6 mg/L. Ethylbenzene and xylenes were also detected at low concentrations in samples from MP-2 and MP-3. None of the concentrations exceeded the BC CSR AW standard or the CCME freshwater guidelines. Samples from MP-1 did not contain detectable levels in 1997 and 1998.

Surface water samples collected from the Klehini River in 1997 were analyzed for EPH. The concentrations of EPH in all three samples were below detection. No surface water samples were therefore analyzed for EPH during the 1998 monitoring program.

The detectable concentrations of all individual PAHs in the 1998 samples (Table 3.9) were below the BC CSR AW standard. Naphthalene, however, occurred at concentrations, which exceeded the CCME freshwater guidelines of 0.0011 mg/L. Even a minor dilution of the contaminated groundwater as it enters the river would decrease the naphthalene concentration below the criterion for the protection of aquatic life. Furthermore, it does not persist in the environment in surface water, sediment, or living organisms.

3.6 Metals

Total metal concentrations were determined for a number of samples during the 1998 monitoring program (Table 3.10). Aluminum, iron and manganese concentrations in most of the samples exceeded the BC CSR aquatic wildlife standard. The elevated concentrations in ground water might, in some small part, be attributable to mineralization in the surrounding bedrock and overburden. Due to the natural variability of these elements, the BC Ministry of the Environment is currently considering deleting these elements from Schedule 6 of the Contaminated Sites Regulation (http://www.bc-environment-issues.com/changes_to_csr.html, accessed January 21, 1999).

The elevated concentrations of aluminum and iron in the water samples were generally associated with particulate matter. This is illustrated in Figure 3.4 below which compares the concentrations of total and dissolved metal levels in the 1998 water samples.

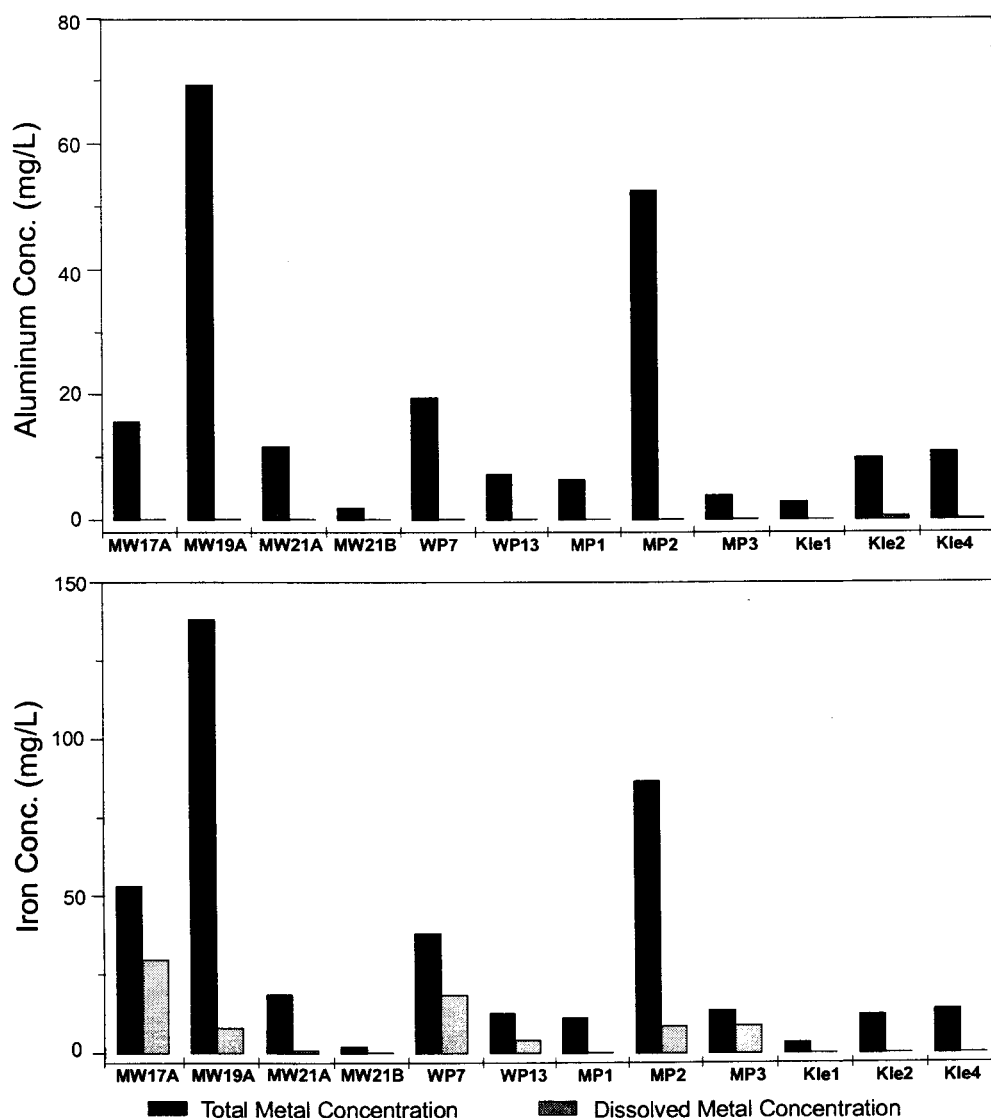


Figure 3.4: Concentration of Total and Dissolved Iron and Aluminum in Groundwater and Surface Water Samples Collected at Rainy Hollow in August 1998

The concentrations of most of the other dissolved metals in groundwater samples collected in 1997 (Table 3.11) and 1998 (Table 3.12) were either below detection or well below the BC CSR AW standard, with the exception of zinc. Samples from MP-2 and MP-3 contained zinc at levels that exceeded the standard (Figure 3.5). The elevated levels, however, were attributed to contamination by the galvanized up-riser of the mini-piezometer.

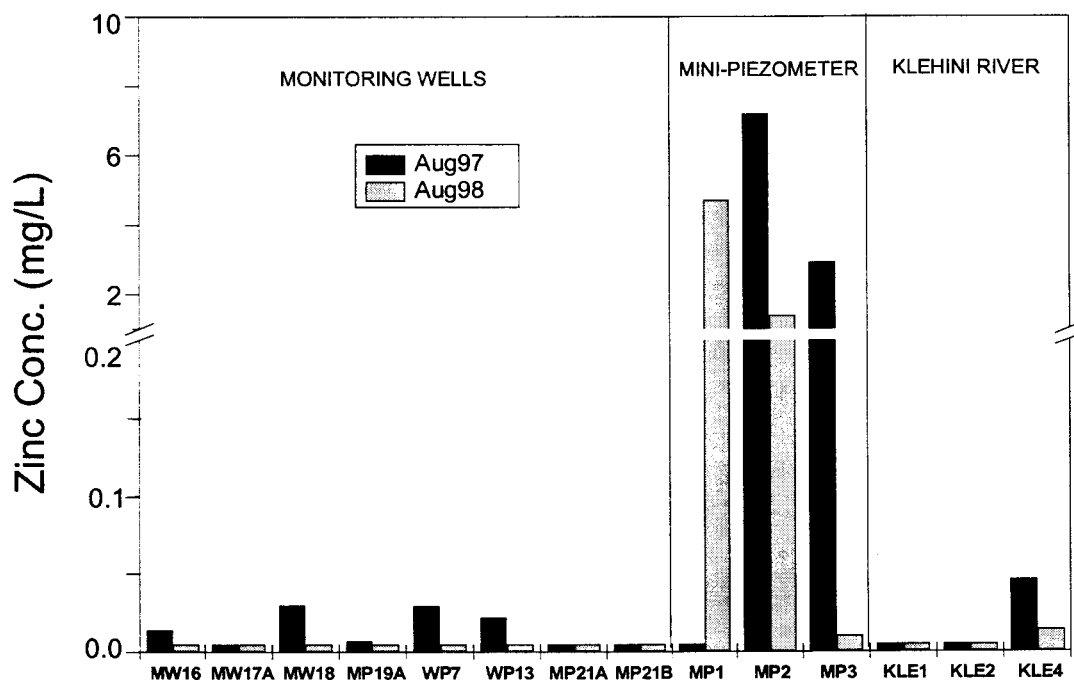


Figure 3.5: Zinc Concentration in Groundwater and Surface Water Samples Collected at Rainy Hollow in July 1997 and August 1998

4. Conclusions and Recommendations

4.1 The Larger Context Re-visited

Rainy Hollow/Border Station, in northern British Columbia, was remediated in the summer of 1997, based on a detailed site investigation and recommendations derived from an ecological and human health risk assessment. The remediation plan and conclusions regarding risks to biota in the aquatic environment, however, were based on several assumptions about the future fate of contaminants remaining in the subsurface environment of the upper and lower benches.

Some assumptions were derived from predictions about how concentrations of DDT isomers would change over time in groundwater en-route to and entering the Klehini River. In particular, field data gathered in the summer of 1996 documented DDT isomer (including all p,p'-DDT, o,p'-DDT, p,p'-DDD, o,p'-DDD, p,p'-DDE, and o,p'-DDE) and hydrocarbon concentrations in groundwater across the site, at the outflow face into the Klehini River, and in the river itself. The data provided evidence that, during the time of sampling, contaminant fluxes to the Klehini River did not constitute an elevated risk to aquatic life or piscivorous species. A groundwater model was developed by Woodbury (Royal Roads, 1997) to determine if DDT concentrations entering the river will increase over time, based on a model by Domenico and Swartz (1990).

A brief summary of the assumptions inherent in the risk management and remediation of Rainy Hollow is as follows:

- The residual mass of DDTs in subsurface soils and groundwater at Rainy Hollow was estimated at between 7 and 22 kg.
- Based on site data on DDT in groundwater samples from various wells, an estimated mean hydraulic conductivity of 2.5×10^{-4} cm/sec, a horizontal gradient between the former location of the trench and the river of 0.075 m/m, an estimated porosity of 0.27, a DDT solubility limit of 3,400 ng/L, and a DDT half-life of 15 years, the groundwater model provided the following predictions:
 - The total concentration of DDTs in groundwater 80 m from a concentrated source (the distance between the former burial trench and the bank of the Klehini River) was predicted twenty years after post-burial release to be 7 ng/L⁶. This was in excellent agreement with the 1996 groundwater data for mini-piezometer MP-2 (8.4 ng/L)
 - The concentration of DDTs is predicted to increase at the bank of the Klehini River (outflow face) for about 50 years after the time of release, or about 30 years from 1996, when it is expected to level off.
 - The concentration of DDTs is expected to rise over this time period to a maximum asymptotic concentration of around 37 ng/L.
 - Interactive effects of DDTs and hydrocarbons in groundwater and subsurface soils have not been accounted for, but were not expected to play a role away from the source of non-

⁶ The specific date of DDT release within the trench is not known. Although the DDT containing drums were thought to have been buried around 1970-71, there may or may not have been substantial releases from the drums initially. Based on re-excavation of the trench, it would appear that at least some of the DDT-containing drums were crushed by heavy equipment during burial, although other drums may have started to leak at a much later date.

aqueous phase hydrocarbons. As fresh water moves the DDTs away from the source, DDT fractions in excess of the solubility limit would most likely precipitate into solid form (Pankow and Cherry, 1996).

- For hydrocarbons (primarily diesel source) derived from spills or a possible injection well under the former Border Station pump house -
 - there was no evidence of an ongoing source of free-phase hydrocarbons to the groundwater except in monitoring well MW-8B (sometimes referred to as TH-8B in previous reports) located at the upper bench.
 - There is a 95% probability that the mass flux of hydrocarbons to the Klehini River lies within the range of approximately 4,800 to 490,000 g/yr (based on 1996 estimates)

No modeling was conducted in 1996 of future hydrocarbon concentrations adjacent to and in the Klehini River. The greater emphasis was placed on DDTs, given the closer proximity of the source of DDT contamination to the river environment, the much greater expected persistence of DDTs than the lighter hydrocarbons, and the interest in DDT as a substance that biomagnifies in aquatic food webs - including piscivorous bald eagles. In addition, diesel inputs into the Klehini River adjacent to Rainy Hollow were not deemed to pose unacceptable risks since few ecological receptors inhabit this portion of the river, and there are huge dilution factors as the hydrocarbon-contaminated groundwater becomes entrained in the main flow of the river.

There was consultation in early 1997 with major stakeholders regarding predictions of future DDT flux to the river, which subsequently lead to obtainment of an approval in principal of the site remediation plan. In particular, it was accepted that a maximum total DDT isomer concentration at some future date in groundwater entering the Klehini River of around 37 ng/L would not elevate actual DDT concentrations in river water except within a radius of a few metres of the outflow face to levels beyond the CCME criterion for the protection of aquatic life of 1 ng/L total DDT isomers.

The minimum expected dilution factors for DDT once the site groundwater enters the river can be estimated from the 1996 data: A groundwater concentration of 8.4 ng/L total DDT isomers in mini-piezometer MP-2 was associated with a river water concentration of 0.31 ng/L, at a point within 2 m of the mini-piezometer in a very low flow side channel, suggesting a minimum dilution factor of at least 25 fold. For the main flow of the river, the dilution factors would undoubtedly exceed several hundred fold.

The 1996 Rainy Hollow Detailed Site Investigation (RRU, 1997) recommended that future monitoring will be the key to determining whether concentrations will increase or decrease over time. Details of the recommended monitoring plan have been summarized in Section 2 of this report.

Overall, the Rainy Hollow monitoring program is generally intended to -

- confirm the original predictions of future DDT isomer fate and concentrations;
- allow, if necessary, refinements to the model, thus ensuring the long-term accuracy of contaminant fate predictions;

- allow further intervention at the site, including a possible re-evaluation of remedial/risk-management strategies, through comparison with pre-defined action triggers (please see section 4.3 below); and
- provide assurances that contaminants other than DDT isomers - including hydrocarbons and various metals - are not entering the river at potentially deleterious concentrations.

The adherence of the 1997 and 1998 monitoring data to the original model prediction is addressed in Section 4.2. The overall consistency of the groundwater data is also covered.

The desire to facilitate any necessary model refinements has direct implications for the frequency of the monitoring program, as well as change in frequency over time. The groundwater total DDT isomer concentration at the bank of the Klehini River is predicted to rise only slowly from 1995 through around 25 years to some asymptotic value. For example, the increase in total DDT isomer concentration and the year 2001 is presently predicted to be from around 7-8 ng/L to around 13 ng/L. Over the next five years (2001 to 2006) the rise is predicted to be from 13 ng/L to around 19 ng/L. The slow predicted rate of change suggests that the ability to validate the groundwater model predictions by assessing deviations between measured and predicted DDT concentrations will not be feasible for at least five years from 1996 (i.e. - the year 2001). **It has been recommended, therefore, that annual monitoring be undertaken for the first four years following the original (1996) site investigation, and that the frequency be substantially reduced thereafter (possibly at five or ten year intervals) provided that the modeling predictions are deemed valid, and no new contaminant issues arise.**

4.2 Overview of Monitoring Data to the Present Time

The 1997 and 1998 Rainy Hollow monitoring data in conjunction with the 1996 data from the detailed site investigation, provided in Section 3, show a remarkable overall consistency in the concentrations of DDTs and hydrocarbons in groundwater at various points under the Rainy Hollow/Border Station site over a three year period. Aside from a small number of anomalous results (discussed in more detail in Section 3), the data reaffirm the validity of the 1996 data and conclusions derived from them.

One of the biggest challenges in obtaining valid estimates of hydrophobic organic contaminant concentrations in groundwater is to avoid the inclusion of particulates in groundwater samples. This was especially problematic at Rainy Hollow due to limitations of well installation in 1994 as part of the emergency response program. Furthermore, thorough development of the wells in subsequent years did not result in any marked decrease in the silt load of water samples drawn from the majority of piezometers. The 1994 results for DDT in groundwater samples from the lower bench have generally not been included in the discussion in this report, since many of the concentrations far exceeded the theoretical solubility limits for DDT, and the results have not been reproduced samples collected from the same wells in recent years. The problem associated with quantifying DDT dissolved in groundwater is sometimes acute, since truly dissolved concentrations of DDT as low as 1 ng/L are deemed to have possible toxicological significance, and because of the strong tendency of DDT to sorb to particles. The inclusion of even minute quantities of DDT-containing particulates (soil or sediment) in an extracted water sample can create anomalously high analytical results. This probably accounts for the high DDT result (12

ng/L total DDTs) in a newly installed mini-piezometer MP-1 in 1997: The primary isomer detected was the parent compound p,p'-DDT, rather than p,p'-DDD, which is the predominant isomer in the groundwater at the site.

Based on previous investigations, it is estimated that mini-piezometer MP-2 is located in the approximate centre of the DDT-contaminated groundwater plume. The annual DDT monitoring results for 1996 through 1998 (based on total isomer concentrations) were as follows: 1996: 8.4 ng/L; 1997: 11 ng/L; 1998: 9.0 ng/L⁷. These concentrations are deemed to be the same, in light of an expected analytical variation of around 10% RSD.

Similarly, the total DDT isomer concentrations over the three year period in monitoring well MW-21A, between the former trench location and the river and approximately centre-plume, were - 1996: <100 ng/L⁸; 1997: 49 ng/L; 1998: 53 ng/L.

As shown in Figure 3.3, groundwater data for extractable petroleum hydrocarbons (C10-C18 fraction) have also been relatively consistent between years.

Overall, two major conclusions arise from the monitoring program to the present time:

1. The field sampling and analytical methods are appropriate for the monitoring objectives. All QA/QC data, as well as the lack of inter-annual variation attest to the overall validity of the data.
2. There has been no increase in the concentrations of the original contaminants of potential concern at the site since 1996 - in groundwater entering the Klehini River, or in river water collected adjacent to the site. This, along with the original risk assessment and subsequent risk management activities, leads us to conclude that there remain no unacceptable risks to wildlife or humans at or near the site.

4.3 Recommended Response Triggers

One of the final requirements for obtaining a Conditional Certificate of Compliance for the Rainy Hollow site under the British Columbia Contaminated Sites Regulation is the derivation of acceptable response triggers for the proposed monitoring program. These response triggers are intended to stimulate a specific course of action, should the monitored concentrations of specific substances increase over time beyond some acceptable level. Also, representatives of the Champagne-Aishihik First Nations at the stakeholder meeting convened at RRU in March of 1997 expressed a strong interest in receiving a more concrete indication of expected scenarios for further action based on results of the monitoring program.

Recommendations for specific response triggers and recommended courses of action include the following:

1. **DDT inputs to the Klehini River.** A response should be initiated if the concentration of total DDT isomers at the approximate centre of the contaminated groundwater plume at the bank

⁷ Based on the average of two field duplicates.

⁸ Detection limit for all individual isomers.

of the Klehini River (based on samples collected from mini-piezometer MP-2) increases at a rate that exceeds presently predicted concentrations for a given year by 50% and/or the truly dissolved total DDT isomer concentration in a sample from MP-2 exceeds 50 ng/L.

In the event of the above, the validity of the data should be re-evaluated by re-sampling/re-analysis. If the trigger is still deemed to have been exceeded, a limited re-evaluation of the risks to aquatic receptors in the Klehini River should be undertaken, through the re-evaluation of DDT isomer concentrations in river water, river sediment, and aquatic biota in the river adjacent to the site. The larger intent would be to examine whether biota have been or will be reasonably exposed to DDT concentrations in river water in excess of 1 ng/L. If there is evidence of unacceptable risks, a more aggressive remediation plan that curtails or reduces the lateral movement of contaminated groundwater into the river should be investigated and implemented if justified.

2. **Hydrocarbon inputs to the Klehini River.** A response should be initiated if the concentration of truly dissolved Light Extractable Petroleum Hydrocarbons in groundwater at the bank of the Klehini River (as measured in water samples from the mini-piezometers) exceeds 15 mg/L. This trigger value has been calculated using a draft criterion for LEPHs in surface water for the protection of aquatic life of 50 µg/L, (presently under consideration by B.C. Ministry of Environment) and including a 300-fold dilution factor based on the hydrodynamics of the Klehini River and lack of sensitive habitat or ecological receptors in the river immediately adjacent to the site. Use of a trigger based on LEPH data should account for presently unpredicted risks for other hydrocarbon fractions such as BTEX or PAHs.

In the event of the above, the validity of the data should be re-evaluated by re-sampling/re-analysis. If the trigger is still deemed to have been exceeded, a limited re-evaluation of the risks to aquatic receptors in the Klehini River should be undertaken, through the re-evaluation of LEPHs in river water at various distances away from the site.

3. **A shift in river channel, or strong stream bank erosion** event diminishes by 10 m or more the distance between the original DDT source and the river flow, and/or re-exposes previously capped soils with total DDT concentrations exceeding 1 µg/g but generally not exceeding 10 µg/g.

In the event of the above, the groundwater contaminant fate modeling exercise should be revisited to provide revised predictions based on the new set of circumstances. Risk management activities may need to be considered in light of the new predictions.

If changes in hydrology allow the direct erosion of DDT- and hydrocarbon-containing soils into the Klehini River, the soils with concentrations of DDTs exceeding 1 mg/kg or hydrocarbons exceeding 1000 µg/g LEPHs, in danger of erosion should be encapsulated with an impermeable layer between the soils and the river bank. The existing bank should then be armoured to further discourage lateral cutback. The surface cap should also be restored.

The necessity for considering these triggers will undoubtedly decline over several decades as

naturally-occurring *in situ* degradation processes decrease the overall remaining mass of either DDTs or hydrocarbons in subsurface soils and groundwater.

4.4 Recommendations for Future Monitoring Programs

1. Future monitoring programs should ensure a greater consistency in the substances analyzed in groundwater samples from MW-18, as well as other monitoring wells.
2. Measurement using an interface probe or other suitable technique of the depth of free-phase hydrocarbons (LNAPL) in well MW-8B be routinely included as part of the monitoring program.
3. Monitoring wells MW-19A/19B be dropped from future monitoring efforts for contaminants, to reduce annual monitoring costs, since this data point does not provide significant additional information [they were also not included in the original (RRU, 1997) monitoring program recommendations, except as points for monitoring water levels].
4. The metals monitoring data for 1998 suggest that these are not generally of concern in terms of riverine ecosystems risks. If the low concentrations (less than the relevant BC CSR Schedule 6 standards) with the exception of iron, manganese, aluminum, and zinc⁹ are confirmed in the 1999 monitoring program, metals should be dropped from the list of analytes monitored.
5. Woodbury (1997) suggested that a more sophisticated groundwater model be used to replace the analytical/conceptual model used originally, in order to incorporate new information from the monitoring program (in terms of long-term modeling) and make more precise predictions about future behaviour. Since the results obtained to date are within the concentrations predicted by the conceptual model it is anticipated that this exercise may not be necessary, as long as the analytical results are consistent with the model.
6. The original monitoring program suggested that water levels should be monitored at three locations (MW-18, MW-19A and MW-22) on a twice per month frequency from May to October. This was in anticipation of data requirements for a more detailed mathematical model. As suggested above a more sophisticated model is not required at the present time and hence this task is not deemed necessary. It is suggested however, that the continuous recording of water levels using the Solinst Levelloggers should be continued. The two loggers should be set in separate wells and checked at least twice in the season, including a manual measurement of water level to compare against the logger reading in an attempt to sort out the variability in water pressure over the year.

⁹ Zinc levels in samples from the mini-piezometers are believed to have originated from the galvanized mini-piezometer up-riser. Zinc concentrations were not elevated in any Rainy Hollow groundwater samples from PVC piezometers.

5. References

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Appendix A: Groundwater Sampling Sheets

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-16 Location: Border Station
 Date: Aug 7, 1998 Weather: Cloudy
 Time: 1:45 pm Temperature: 19°C
 Samples Collected by: Mona Palfeyman / Elizabeth Doering

MONITORING WELL INFORMATION

Depth to water from top of casing A 19.00 meters
 Depth to bottom of well from top of casing B 21.50 meters
 Diameter of standpipe C 2.50 meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 5.0 litres
 (B-A)*1.1 (for 1 inch i.d. well) litres

WELL PURGING

Start 1:45 pm Volume purged (well vol x 3) 36 litres
 Finish 2:30 pm Method Watering

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
2:10 pm	12 L	6.00	7.4	3.07 x 10 ²	
2:15 pm	6 L	6.10	6.6	3.01 x 10 ²	
2:20 pm	8 L	6.18	6.7	2.99 x 10 ²	
2:25 pm	6 L	6.00	6.4	2.98 x 10 ²	
2:30 pm	4 L	5.9	6.4	2.95 x 10 ²	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	2:30	Glass	40 mL	NO	Cu SO ₄	BTEX / VPH
2	2:30	Glass	40 mL	NO	Cu SO ₄	BTEX / VPH
3	2:35	Glass	500 mL	NO	NONE	LEPH / HEPH
4	2:35	Glass	500 mL	NO	NONE	LEPH / HEPH
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☒ Yes If yes Hydro Carbon
 Sheen ☐ No ☒ Yes If yes thin sheen observed
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / 097004126 Calibration pH 4, pH 7
 Cond. meter (model & serial #): Cole Palmer 1481/60 8807025 Calibration 1413 µS
 Water Level Meter: Solinst Interface meter m3 / 30 m
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet **Royal Roads University - Applied Research Division**

Well No: MW-17A Location: RAINY HOLLOW
 Date: AUG 7, 1998 Weather: SLIGHT SHOWERS
 Time: 3:15 PM Temperature: 15 °C
 Samples Collected by: Muna Paffreyman / m. Dood

MONITORING WELL INFORMATION

Depth to water from top of casing A 1.77 meters
 Depth to bottom of well from top of casing B 8.65 meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 14 L litres
 (B-A)*1.1(for 1 inch i.d. well) _____ litres

WELL PURGING

Start 3:20 PM Volume purged (well vol x 3) 55 L litres
 Finish 3:40 PM Method Water foot valve

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
3:20 pm	40 L	5.7	6.51	4.21 x 10 ²	
3:22 pm	45 L	6.0	6.49	4.16 x 10 ²	
3:25 pm	50 L	5.2	6.40	4.14 x 10 ²	
3:27 pm	55 L	5.4	6.35	4.13 x 10 ²	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	3:30 pm	Glass	1 L	NO	NO	DDT (AXYS)
2	3:31 pm	Glass	1 L	NO	NO	DDT (AXYS)
3	3:34 pm	Plastic	250 mL	NO	HNO ₃	TOTAL METALS (ATL)
4	3:37 pm	Plastic	250 mL	YES 45	HNO ₃	DISSOLVED METAL (MSL)
5	3:39 pm	Glass	40 mL	—	CuSO ₄	BTX/VPH
6	3:40 pm	Glass	40 mL	—	CuSO ₄	BTX/VPH
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes _____
 Sheen ☒ No ☐ Yes If yes _____
 Other: slightly turbid

EQUIPMENT LIST

pH Meter (model & serial #) Barret 30 / D97004126 Calibration pH 4 & pH 7
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413 µS
 Water Level Meter: Solinst Interface meter m3 / 30m
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-18 Location: RAINY HOLLOW
 Date: AUGUST 8, 1998 Weather: SHOWERS
 Time: 9:20 AM Temperature: 10°C
 Samples Collected by: Mark Dodd / Elizabeth Doering

MONITORING WELL INFORMATION

Depth to water from top of casing A 2.10 meters
 Depth to bottom of well from top of casing B 7.39 meters
 Diameter of standpipe C 5.29 meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 10.5 litres
 (B-A)*1.1 (for 1 inch i.d. well) _____ litres

WELL PURGING

Start 9:20 AM Volume purged (well vol x 3) 59 litres
 Finish _____ Method water

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
9:30 AM	3.6L	5.2	7.47	4.38 x 10 ²	Turbid
9:32 AM	5L	5.2	7.35	4.35 x 10 ²	
9:34 AM	5L	5.2	7.33	4.41 x 10 ²	
9:35 AM	8L	4.9	7.28	4.38 x 10 ²	
9:38 AM	5L	5.1		4.38 x 10 ²	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	9:38am	Glass	1L	NO	NO	DOT (A+YS)
2	9:39am	Glass	1L	NO	NO	DOT (A+YS)
3						
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes _____
 Sheen ☒ No ☐ Yes If yes _____
 Other: High turbidity

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / 097004126 Calibration pH 4 & pH 7
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413-115
 Water Level Meter: Solinst Interface meter M3/M30
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-19 Location: RAINY HOLLOW
 Date: AUG 7, 1998 Weather: LIGHT RAIN
 Time: 3:55 pm Temperature: 15°C
 Samples Collected by: MONA PALMERMAN / ELIZABETH DDERING

MONITORING WELL INFORMATION

Depth to water from top of casing A 2.26 meters
 Depth to bottom of well from top of casing B 4.47 meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 4.42 litres
 (B-A)*1.1(for 1 inch i.d. well) _____ litres

WELL PURGING

Start 3:57 pm Volume purged (well vol x 3) 32 L litres
 Finish 4:10 pm Method Watering

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
4:04 pm	20 L	6.5	6.43	1.79 x 10 ²	
4:05 pm	5 L	5.6	6.39	1.76 x 10 ²	
4:07 pm	7 L	5.9	6.30	1.76 x 10 ²	
4:08 pm	2 L			1.77 x 10 ²	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	4:09	Plastic	250 mL	NO	HNO ₃	Total metals
2	4:12	Plastic	250 mL	0.45	HNO ₃	Dissolved metal
3						
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes _____
 Sheen ☒ No ☐ Yes If yes _____
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / D97004126 Calibration pH 4 & pH 7
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413 µS
 Water Level Meter: Solinst interface meter m3 / m30
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet Royal Roads University - Applied Research Division

Well No: MW 21A Location: Quarry Hollow
 Date: Aug 8, 98 Weather: partially Sunny
 Time: 12:45 pm Temperature: 13°C
 Samples Collected by: MD/ED

MONITORING WELL INFORMATION

Depth to water from top of casing A 0.32 meters
 Depth to bottom of well from top of casing B 1.70 meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 2.8 litres
 (B-A)*1.1(for 1 inch i.d. well) _____ litres

WELL PURGING

Start 12:45 pm Volume purged (well vol x 3) 23 L litres
 Finish 1:15 pm Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
12:52	15 L	9.2	7.18	461	
12:55	2 L	8.0	7.25	463	
12:57	2 L	7.9	7.20	457	
12:59	2 L	7.2	7.19	464	
1:01	2 L	7.5	7.14	456	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	1:05 pm	Glass	40 ml x 2	NO	CuSO ₄	BTEX/VPI+
2	1:07 pm	Glass	1 L	NO	NO	DO (AXYS)
3	1:08 pm	Glass	1 L	NO	NO	DO (AXYS)
4	1:09 pm	plastic	250 mL	NO	HNO ₃	Total metals
5	1:11 pm	plastic	250 ml	0.45	HNO ₃	Dissolved metals
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes _____
 Sheen ☒ No ☐ Yes If yes _____
 Other: moderate turbidity

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / D97004126 Calibration pH 7 & 4
 Cond. meter (model & serial #): Cde Palmer 1481-60 / 8807029 Calibration 1413 µS
 Water Level Meter: Solinst Inter-face meter m3 / 30 m
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW 21B Location: Rainy Hollow
 Date: Aug 8, 98 Weather: partially cloudy
 Time: 1:20 pm Temperature: 17°C
 Samples Collected by: _____

MONITORING WELL INFORMATION

Depth to water from top of casing A 0.31 meters
 Depth to bottom of well from top of casing B 6.88 meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 13 litres
 (B-A)*1.1(for 1 inch i.d. well) _____ litres

WELL PURGING

Start 1:20 pm Volume purged (well vol x 3) 48.55 litres
 Finish 2:00 pm Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
1:35 pm	40L	6.0	7.24	484	
1:38 pm	5L	5.2	7.20	486	
1:40 pm	5L	5.0	7.19	482	
1:42 pm	5L	5.1	7.16	480	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	1:45 pm	Glass	40 ml x 2	NO	CuSO ₄	BTEX / VPH
2	1:47 pm	Glass	1 L x 2	NO	NO	DDT (A x 45)
3	1:52 pm	Plastic	250 ml	NO	Nitric acid	Total metals
4	1:56 pm	Plastic	250 ml	0.45	Nitric acid	Dissolved metals
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes _____
 Sheen ☒ No ☐ Yes If yes _____
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30/D97004126 Calibration pH 7.44
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration _____
 Water Level Meter: Solinst Interface meter M3/30m
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: WP-7 Location: Rainy Hollow
 Date: August 8, 98 Weather: overcast
 Time: 2:55 Temperature: _____
 Samples Collected by: ED/MVP

MONITORING WELL INFORMATION

Depth to water from top of casing A 1.95 meters
 Depth to bottom of well from top of casing B 2.54 meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 1.18 litres
 (B-A)*1.1 (for 1 inch i.d. well) _____ litres

WELL PURGING

Start 2:55 pm Volume purged (well vol x 3) 16 litres
 Finish 3:35 pm Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
3:03	10L	9.6	6.93	456	
3:10	2L	9.5	6.82	450	
3:13	2L	9.0	6.82	445	
3:15	2L	8.8	6.88	438	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	3:20	Glass	40 ml x 2	NO	CuSO ₄	3TEX
2	3:22	Glass	500 ml x 2	NO	NONE	HEPH/LEPH (AXYS)
3	3:24	Glass	1L x 2	NO	NONE	DDT (AXYS)
4	3:29	Plastic	250 mL	NO	HNO ₃	Total metals
5	3:35	Plastic	250 mL	0.45	HNO ₃	Dissolved metals
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☒ Yes If yes hydrocarbon
 Sheen ☐ No ☒ Yes If yes hydrocarbon (light sheen)
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / D97004126 Calibration pH 4.47
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413 µS
 Water Level Meter: Solinst Interface meter 1113 / 30m
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet Royal Roads University - Applied Research Division

Well No: WP-13 Location: Quincy Hollow
 Date: Aug 8, '98 Weather: overcast
 Time: 2:00 pm Temperature: _____
 Samples Collected by: ED/MP

MONITORING WELL INFORMATION

Depth to water from top of casing A 2.60 meters
 Depth to bottom of well from top of casing B 3.89 meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) 2.6 litres
 (B-A)*1.1 (for 1 inch i.d. well) _____ litres

WELL PURGING

Start 2:00 pm Volume purged (well vol x 3) 14 litres
 Finish 2:40 pm Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
2:10 pm	8L	7.9	7.16	459	
2:12 pm	2L	6.7	7.14	459	
2:14 pm	2L	6.8	7.16	460	
2:16 pm	2L	7.2	7.16	457	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	2:24	Glass	40 ml x 2	NO	CuSO ₄	BTEX / VPH
2	2:27	Glass	500 ml x 2	NO	NONE	LEAD / HEDH (ASL)
3	2:28	Glass	1L x 2	NO	NONE	DDT (A x YS)
4	2:29	Plastic	250 ml	NO	HNO ₃	Total metals
5	2:36	Plastic	250 ml	0.45	HNO ₃	Dissolved metals
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☐ Yes If yes _____
 Sheen ☐ No ☐ Yes If yes _____
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / 097004126 Calibration pH 4 47
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413 mS
 Water Level Meter: Solinst Interface meter M3 / 30 m
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MP-1 Location: Rainy Hollow
 Date: August 8, '98 Weather: Overcast
 Time: 10:05 Temperature: _____
 Samples Collected by: MD

MONITORING WELL INFORMATION

Depth to water from top of casing A _____ meters
 Depth to bottom of well from top of casing B _____ meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) _____ litres
 (B-A)*1.1(for 1 inch i.d. well) _____ litres

WELL PURGING

Start 10:05 Volume purged (well vol x 3) 8 L litres
 Finish 10:40 Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
10:10 am	4L	7.7	7.12	367	slightly turbid
10:14 am	2L	7.3	7.21	370	✓
10:15 am	1L	7.4	7.29	370	✓
10:22 am	1L	7.5	7.33	370	✓

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	10:25am	Glass	40ml x 2	NO	CuSO ₄	BTEX / VPAH
2	10:28	Glass	500ml x 2	NO	NONE	LEAD / MERCURY
3	10:30	Plastic	250 ml	NO	HNO ₃	Total metal
4	10:34	Plastic	250 ml	Yes.45	HNO ₃	Dissolved metal
5	10:40	Glass	1L x 2	NO	NONE	DDT (A x 45)
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes _____
 Sheen ☒ No ☐ Yes If yes _____
 Other: slightly turbid

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / D97004126 Calibration pH 4 & 7
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413.45
 Water Level Meter: _____
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MP 2 Location: Rainy Hollow
 Date: August 2, 98 Weather: overcast
 Time: 11:15 am Temperature: 13°C
 Samples Collected by: MD

MONITORING WELL INFORMATION

Depth to water from top of casing A _____ meters
 Depth to bottom of well from top of casing B _____ meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) _____ litres
 (B-A)*1.1 (for 1 inch i.d. well) _____ litres

WELL PURGING

Start 11:15 am Volume purged (well vol x 3) 10 L litres
 Finish 12:00 pm Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
11:20	4 L	8.0	7.34	439	
11:23	4 L	7.9	7.34	427	
11:25	1 L	8.0	7.31	426	
11:27	1 L	8.0	7.31	425	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	11:30	Glass	40 mL x 2	NO	CaSO ₄	BTEX/VPH
2	11:31	Glass	40 mL x 2	NO	CaSO ₄	BTEX/VPH Field Duplicate MP2B
3	11:40	Glass	500 mL x 2	NO	None	H ₂ O ₂ /LEPH (Duplicate)
4	11:45	Glass	1 L x 2	NO	None	DDT (A x Ys)
5	11:50	Glass	1 L x 2	NO	None	DDT Field Duplicate (MP2B)
6	11:53	Plastic	250 mL	NO	Nitric acid	Total metals
7	11:55	Plastic	250 mL	NO	Nitric acid	Total metals Field duplicate
8	11:58	Plastic	250 mL	0.45	Nitric acid	Dissolved metals
9	12:00	Plastic	250 mL	0.45	Nitric acid	Dissolved metal duplicate
10						

OBSERVATIONS

Odour ☐ No ☒ Yes If yes Hydrocarbon
 Sheen ☐ No ☐ Yes If yes _____
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barett 30 / D97004126 Calibration pH 7 & 4
 Cond. meter (model & serial #): Cole Palmer 1481-60 / 8807029 Calibration 1413 µS
 Water Level Meter: _____
 Pump: _____
 Other: _____

Groundwater Sampling Data Sheet **Royal Roads University - Applied Research Division**

Well No: MP 3 Location: Rainy Hollow
 Date: August 8, 90 Weather: Sunny
 Time: 3:45 pm Temperature: 20°C
 Samples Collected by: MD/ED

MONITORING WELL INFORMATION

Depth to water from top of casing A _____ meters
 Depth to bottom of well from top of casing B _____ meters
 Diameter of standpipe C _____ meters
 One well volume (B-A)*2 (for 2 inch i.d. well) _____ litres
 (B-A)*1.1 (for 1 inch i.d. well) _____ litres

WELL PURGING

Start 3:40 Volume purged (well vol x 3) _____ litres
 Finish 4:05 Method _____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
3:45 pm	8L	12.5	7.10	445	
3:48	2L	8.8	7.22	428	
3:49	1L	8.7	7.25	423	
3:50	1L	8.7	7.20	420	
3:51	1L	8.6	7.19	419	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	3:53 pm	Glass	40ml x2	NO	CUSV ₄	BTEX / VPH
2	3:55	Glass	500ml x2	NO	NO	HEPT / LOPH
3	4:00	Glass	1L x2	NO	NO	DDT (A x YS)
4	4:01	Plastic	250ml	NO	Nitric acid	Total metals
5	4:03	Plastic	250ml	Yes 0.45	Nitric acid	Dissolved metals
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☐ Yes If yes _____
 Sheen ☐ No ☐ Yes If yes _____
 Other: _____

EQUIPMENT LIST

pH Meter (model & serial #) Barnet 30 / D97004126 Calibration pH 7 & 4
 Cond. meter (model & serial #): Cole Palmer 1481-6 / 8807029 Calibration 1413 µS
 Water Level Meter: _____
 Pump: _____
 Other: _____

Appendix B: Chain of Custody Forms

PAGE 1 OF 3

1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
FAX: (604) 253-6700
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

July 1950 0000

ROYAL BONDS 11/11/10

ADDRESS: 2005 Sooke RD

Vici217, BC VGB 572

TELEPHONE: (250) 341-2583 FAX: (250) 341-2522

PROJECT NAME/NO.:

QUOTATION NO.:

QUOTATION NO.: _____

DATE _____

DATE SUBMITTED: Aug 24, 1992

ASI CONTACT: Brent Markelki

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ANALYSIS REQUESTED

EPH
METALS
GEX/VPT

LAB USE ONLY

SAMPLE IDENTIFICATION

72

1 / KLÉ 97 - 01

10-453771

KL 57 - 02

7-45317-000

720-4531X

5/ KLE 97 - 07

97-mp2	
--------	--

97-1112

97-1412

71 / 0497-174

21197-17A

✓	11/11/00	11/11/00
---	----------	----------

	✓	0.897 = 17%	31191 = 17%
--	---	-------------	-------------

✓ 6497 = 171

TURN AROUND REQUIRED.

☐ ROUTINE (7 - 10 WORKING DAYS)☐ RUSH (SPECIFY BELOW)

SPECIAL INSTRUCTIONS:

ANALYZE MEALS TO

FRESH WITH A GOOD LIFE

5. 11/10/2025

*** For organic analyses only.**

Please refer to the back of this form for further instructions.

NOTE: Failure to properly complete all portions of this form may delay analysis.

Abstract

PAGE 2 OF 3

1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
FAX: (604) 253-6700
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

**Specialists in
Environmental Chemistry**

**analytical service
laboratories ltd.**

ANALYSIS REQUESTED

[illegible]

DISTRIBUTION: White - ASL Copy Yellow - Report Copy Pink - Client Copy

TURN AROUND REQUIRED:

- ☐
- ROUTINE (7 - 10 WORKING DAYS)
-
- ☐
- RUSH (SPECIFY BELOW)

SPECIAL INSTRUCTIONS:

**SAMPLE CONDITION
UPON RECEIPT:**

- ☐ FROZEN
- ☐ COLD
- ☐ AMBIENT

RELINQUISHED BY:

DATE Aug 24 '97

DATE _____
TIME _____

RELINQUISHED BY:

DATE _____

DATE _____

*** For organic analyses only.**

Please refer to the back of this form for further instructions.

NOTE: Failure to properly complete all portions of this form may delay analysis.

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

PAGE 3 OF 3

CLIENT: ROYAL ROADS UNIV
 ADDRESS: 2005 SODKE RD
VICTORIA, BC, V9B 5Y2
 TELEPHONE: (250) 391-2583 FAX: (250) 391-2522
 PROJECT NAME/NO.: _____
 QUOTATION NO.: _____ PO. NUMBER (if applicable) _____
 DATE SUBMITTED: Aug 24, 97
 ANALYST CONTACT: Brent McKeeth

1988 Triumph Street
 Vancouver, BC
 Canada V5L 1K5
 FAX: (604) 253-6700
 TEL: (604) 253-4188
 TOLL FREE: (800) 665-0243

Specialists in
 Environmental Chemistry



analytical service
 laboratories Ltd.

ANALYSIS REQUESTED

FRH
 METALS
 BTEX / VPH
 * DECONT (O) TOTAL (M)
 OR OTHER (O)

LAB USE ONLY	SAMPLE IDENTIFICATION		DATE / TIME COLLECTED		MATRIX	ANALYSIS REQUESTED										NOTES
	Y	M	D	AM		1	2	3	4	5	6	7	8	9	10	
WP97-21B	97	08	21	5:15 PM	Water	X										
WP97-21B				5:15 PM												
WP97-21B				5:15 PM												
WP97-19A	97	08	21	5:30 PM		X										
WP97-19A				5:30 PM												
WP97-19A				5:30 PM												
97-MP1	97	08	22	4:10 PM		X										
97-MP1				4:10 PM												
97-MP3				8:30 AM		X										
97-MP3-1				2:30 PM												
97-MP3-2				2:35 PM		X										
97-MP3				2:30 PM		X										
Travel Blank																

TURN AROUND REQUIRED:
☐ ROUTINE (7 - 10 WORKING DAYS)
☐ RUSH (SPECIFY BELOW) DATE DUE: _____

SPECIAL INSTRUCTIONS:

RELINQUISHED BY: MPD DATE: Aug 24, 97 TIME: 10:00
 RECEIVED BY: _____ DATE: _____ TIME: _____

RELINQUISHED BY: _____ DATE: _____ TIME: _____
 RECEIVED BY: _____ DATE: _____ TIME: _____

* For organic analyses only.
 Please refer to the back of this form for further instructions.
 NOTE: Failure to properly complete all portions of this form may delay analysis.

1988 Triumph Street
 Vancouver, BC
 Canada V5L 1K5
 FAX: (604) 253-6700
 TEL: (604) 253-4188
 TOLL FREE: (800) 665-0243



AXYS | Ays Analytical Services Ltd

POST OFFICE BOX 2219, 2045 MILLS ROAD
SIDNEY, BRITISH COLUMBIA, CANADA V8L 3S8

TEL: (604) 656-0881
FAX: (604) 656-4511

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

Date Submitted: Aug 10 Date Required: _____

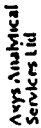
4. 1 of 2

ANALYSIS REQUESTED					Sample Received (Y or N)	Lab Sample No.
Sample ID	Date/Time Sample	Sample Type	Preservative Added (Y or N)			
98-BH17A	98/8/7 3:30pm	WATER	N	✓		
98-BH18	98/8/8 9:40 am	✓	N	✓		
98-BH21A	98/8/8 1:05 pm	✓	N	✓		
98-BH21B	98/8/8 1:45 pm	✓	N	✓		
98-WPT	98/8/8 3:25 pm	✓	N	✓		
98-WP13	98/8/8 2:30 pm	✓	N	✓		
98-MP1	98/8/8 10:40 am	✓	N	✓		
98-MP2A	98/8/8 11:45 am	✓	N	✓		

Client: ROYAL ROADS	No. Samples Submitted:	No. Coolers/Boxes: 3	Instruction to lab: (include quote #, if applicable)
Contact: MATT DODD			DECANT BEFORE ANALYSIS
Address: 2005 SPOKE RD VICTORIA BC			
Postal code: V9B 5Y2			
FAX No.: (250) 391-2560			
Tel No.: (250) 391-2583			
P.O. No.: _____			

Relinquished by: MATT DODD	Date: Aug 9 98	Received by:	Date:
	Time: 2:00		Time:
Relinquished by:	Date:	Received by:	Date:
	Time:		Time:

Sample Condition upon Receipt:	
Frozen: _____	Cold: _____
Ambient: _____	
Other (Breakage, Leakage, etc.): _____	



AXYS-1

TEL: (604) 656-0881
FAX: (604) 656-4511

POST OFFICE BOX 2219, 2045 MILLS ROAD
SIDNEY, BRITISH COLUMBIA, CANADA V8L 3S8

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

Date Submitted: AUG 10 Date Required: _____

Date Required: _____

Sample ID	Date/Time Sample	Sample Type
98-MP2B	98/8/8 11:50am	WATER
98-MP3	98/8/8 4:00pm	✓
98-KLE1	98/8/8 5:00pm	✓
98-KLE2	98/8/8 1:45pm	✓
98-KLE4	98/8/8 5:30pm	✓

Client: ROYAL ROADS UNIV	No. Samples Submitted: 26 JAAS
Contact: MATT DODD	No. Coolers/Boxes: 3
Address: 2005 SPOKE RD VICTORIA, BC	Instruction to lab: (include quote #, if applicable)
Postal code: V9B 5Y2	DECANT BEFORE ANALYSIS
FAX No.: (250) 391-2560	
Tel No.: (250) 391-2583	
P.O. No.: _____	Job No: _____

[illegible]

Sample Control /05 Rev. 2. November 25/94

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
FAX: (604) 253-6700
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243

Specialists in
Environmental Chemistry



analytical service
laboratories Ltd.

CLIENT: ROYAL ROADS UNIV
ADDRESS: 2005 SOOKE RD
CONTACT: MATT DODD
TELEPHONE: (250) 391-0583 FAX: (250) 391-2560
PROJECT NAME/NO.: RAINY HOLLOW
QUOTE / PO. NO.:
DATE SUBMITTED: ASL CONTACT: BRENT MAXTELKI

ANALYSIS REQUESTED

PAGE OF

LEAD / HEDH	
3TEX / VPH	
DISSOLVED METALS	
TOTAL METALS	

LAB USE ONLY	Y	M	D	DATE / TIME COLLECTED	MATRIX	NOTES
27584	98	08	07	2:30 PM	water	
1	98	08	07	3:30 PM	water	
2	98	08	07	4:10 PM	water	
3	98	08	07	1:00 PM	water	
4	98	08	08	1:35 PM	water	
5	98	08	08	2:30 PM	water	
6	98	08	08	2:25 PM	water	
7	98	08	08	10:25 PM	✓	
8	98	08	08	11:30 PM	✓	
9	98	08	08	11:40 PM	✓	
10	98	08	08	4:00 PM	✓	
11	98	08	08	5:00 PM	✓	
12	98	08	08	1:35 PM	✓	
13	98	08	08	5:30 PM	✓	
14						

TURN AROUND REQUIRED:
☒ ROUTINE (7 - 10 WORKING DAYS)
☐ RUSH (SPECIFY DATE):

SPECIAL INSTRUCTIONS:
Freshwater aquatic life
for metals

RELINQUISHED BY: Edella DATE: Aug 9 98 TIME: 1:30 pm
RECEIVED BY: [Signature] DATE: Aug 12 1998 TIME: 8:30

SAMPLE CONDITION UPON RECEIPT:
☐ FROZEN
☐ COLD
☐ AMBIENT

FOR LAB USE ONLY

Appendix C-1:
1997 Axys Data Reports for DDTs

ANALYSIS OF PCBs (AROCLORS) AND CHLORINATED PESTICIDES IN WATER SAMPLES

All samples were spiked with an aliquot of surrogate standard solution containing ^{13}C -labelled surrogates (see Table 1) for the analysis of Aroclors and pesticides by mass spectrometry and d4-endosulphan I for analysis of F3 pesticides by GC/ECD. Water samples were liquid/liquid extracted. The raw extract was fractionated and cleaned up into two fractions (F1 + F2 and F3) on a Florisil column. The first fraction (F1 + F2) was analyzed by high resolution gas chromatography with low resolution mass spectrometric detection (HRGC/HRMS) for PCBs as Aroclors non-polar to moderately polar chlorinated pesticides. The F3 fraction was analyzed for the most polar chlorinated pesticides by high resolution gas chromatography with electron capture detection (GC/ECD).

1. Extraction

The entire water sample (approximately 2 L) was placed in a separatory funnel, spiked with an aliquot of the surrogate standard solution and extracted by shaking with 100 mL of dichloromethane. The dichloromethane layer was set aside and the extraction repeated twice more. The extracts were combined, dried over anhydrous sodium sulphate and solvent exchanged to hexane while being reduced in volume.

2. Column Chromatography For Pesticides and PCB Congeners

The extract was applied to a Florisil column for which cutpoints had been previously determined. The column was eluted with hexane followed by 15:85 dichloromethane:hexane and these eluates were collected together (F1 + F2). The column was then eluted with 1:1 dichloromethane:hexane (F3). Each fraction was concentrated to a small volume and soil/sediment and water extracts were again treated with activated copper. All extracts were spiked with an aliquot of recovery standard solution (^{13}C -labelled PCB 153) prior to instrumental analysis.

After initial instrumental analysis some samples required additional cleanup on Biobeads (SX-3) and reanalysis by HRGC/LRMS.

3. HRGC/LRMS Analysis Of PCB Congeners and Pesticides

The F1 + F2 fraction was analyzed for PCBs as Aroclors and non-polar to moderately polar chlorinated pesticides using either a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 GC, a CTC autosampler and a DG 10 data system running Incos 50 (Rev 9) software. The MS was operated at unit mass resolution in the MID mode acquiring two characteristic ions for each target analyte and surrogate standard. Chromatographic separation of PCBs and pesticides was achieved with a 60 metre DB-5 chromatography column (0.25 mm i.d., 0.10 μm film thickness). Reported concentrations were corrected for the recovery of the surrogate standards added prior to workup.

4. GC/ECD Analysis for Polar Pesticides

Polar chlorinated pesticides in F3 were analyzed (by GC/ECD) using a Hewlett Packard 5890 gas chromatograph, equipped with a 60 m x 0.25 mm, 0.10 μm film DB5 Durabond Fused Silica capillary column and a ^{63}Ni electron capture detector.

REFERENCE: CL-W-04/Ver.2, AXYS Method Doc. CL/01 Rev 3 May 12, 1997.

TABLE 1.

SURROGATE AND INTERNAL (RECOVERY) STANDARD
USED FOR PCB AND PESTICIDE ORGANIC ANALYSES

SURROGATE STANDARD(Axys ID CL024A-SUR)

$^{13}\text{C}_6$ -chlorobenzene
 $^{13}\text{C}_6$ -1,4-dichlorobenzene
 $^{13}\text{C}_6$ -1,2,3-trichlorobenzene
 $^{13}\text{C}_6$ -1,2,3,4-tetrachlorobenzene
 $^{13}\text{C}_6$ -pentachlorobenzene
 $^{13}\text{C}_6$ -hexachlorobenzene
 $^{13}\text{C}_6$ - γ BHC
 $^{13}\text{C}_8$ -Mirex
 $^{13}\text{C}_{12}$ -p,p'-DDE
 $^{13}\text{C}_{12}$ -p,p'-DDT
 $^{13}\text{C}_{12}$ -PCB 101
 $^{13}\text{C}_{12}$ -PCB 105
 $^{13}\text{C}_{12}$ -PCB 118
 $^{13}\text{C}_{12}$ -PCB 180
 $^{13}\text{C}_{12}$ -PCB 209
 d_4 -alpha Endosulphan

INTERNAL STANDARD(Axys ID CL004A-REC)

 $^{13}\text{C}_{12}$ -PCB 153



BATCH SUMMARY

Batch ID: CL-1137		Date: 16 October 1997
Analysis Type: PCB/Aroclor, Pesticide/DDT		Matrix Type: Water
BATCH MAKEUP		
Samples: 9718 -14 i -15 i -16 i -17 Li -18 Li -19 i -20 i	Blank: CL-W-BLK 1137 i	
	Reference or Spike: CL-W-SPM 815 i	
	Duplicate:	
Comments 1. Detection limits are higher for samples 9718-17, -18 due to the extra cleanup required for these samples.		

Copyright Axys Analytical Services Ltd.
February 1993

BATCH SUMMARY

Batch ID: CL-1138	Date: 21 October 1997
Analysis Type: PCB/Aroclor, Pesticide/DDT	Matrix Type: Water
BATCH MAKEUP	
Samples: 9718 -21 i -22 i -23 i -24 i -25 i -26 i -27 i	Blank: CL-W-BLK 1138 i
	Reference or Spike: CL-W-SPM 816 i
	Duplicate:
Comments 1. Detection limits for Aroclor 1242 are higher in some cases due to interferences.	

Copyright Axys Analytical Services Ltd.
February 1993

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: Spiked Matrix

AXYS ID: CL-W-SPM 816 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

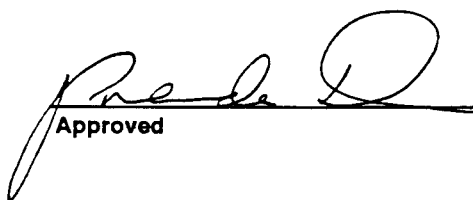
SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS
RUNFILE ID: CL762541.D
CONCENTRATION IN: ng/L

Compounds	Determined	Expected	% Recovery
o,p'-DDE	35	30	117
p,p'-DDE	35	29	121
o,p'-DDD	31	27	115
p,p'-DDD	39	36	108
o,p'-DDT	41	32	128
p,p'-DDT	37	32	116
Aroclor 1242	310	260	119
Aroclor 1254	280	240	117
Aroclor 1260	260	240	108

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	68
13C-p,p'-DDE	81
13C-p,p'-DDT	87
13C-PCB 101	80
13C-PCB 180	100

1. Concentrations are recovery corrected


Approved



PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: Spiked Matrix

AXYS ID: CL-W-SPM 815 I

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.0 L

INSTRUMENT: GC-MS

RUNFILE ID: CL791906.D

CONCENTRATION IN: ng/L

Compounds	Determined	Expected	% Recovery
o,p'-DDE	28	30	93
p,p'-DDE	27	29	93
o,p'-DDD	28	27	102
p,p'-DDD	35	36	97
o,p'-DDT	32	33	97
p,p'-DDT	33	32	103
Aroclor 1242	215	260	83
Aroclor 1254	235	240	98
Aroclor 1260	230	245	94

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	45
13C-p,p'-DDE	98
13C-p,p'-DDT	99
13C-PCB 101	93
13C-PCB 180	98

1. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: Procedural Blank

AXYS ID: CL-W-BLK 1137 I

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Blank

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL791898.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.05
p,p'-DDE	NDR 0.08	0.06
o,p'-DDD	ND	0.04
p,p'-DDD	ND	0.03
o,p'-DDT	ND	0.06
p,p'-DDT	ND	0.05
Aroclor 1242	ND	1.2
Aroclor 1254	ND	1.3
Aroclor 1260	ND	0.9

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	44
13C-p,p'-DDE	86
13C-p,p'-DDT	96
13C-PCB 101	86
13C-PCB 180	100

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: Procedural Blank

AXYS ID: CL-W-BLK 1138 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Blank

METHOD NO.: CL-W-04/Ver.2

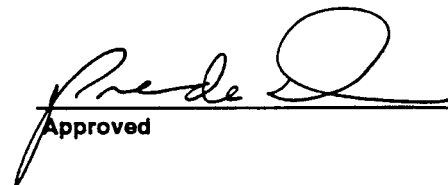
SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS
RUNFILE ID: CL762531.D
CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.08
p,p'-DDE	0.16	0.09
o,p'-DDD	ND	0.06
p,p'-DDD	ND	0.05
o,p'-DDT	ND	0.12
p,p'-DDT	ND	0.11
Aroclor 1242	ND	3.7
Aroclor 1254	NDR 4.6	3.9
Aroclor 1260	ND	1.2

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	65
13C-p,p'-DDE	88
13C-p,p'-DDT	100
13C-PCB 101	86
13C-PCB 180	94

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: WP97-7 Aug 22/97

AXYS ID: 9718-15 I

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL791900.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	0.26	0.14
p,p'-DDE	1.9	0.26
o,p'-DDD	11	0.08
p,p'-DDD	44	0.15
o,p'-DDT	ND	0.87
p,p'-DDT	2.2	0.14
Aroclor 1242	ND	14
Aroclor 1254	ND	2.5
Aroclor 1260	ND	2.0

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	52
13C-p,p'-DDE	90
13C-p,p'-DDT	89
13C-PCB 101	97
13C-PCB 180	94

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: WP97-13

AXYS ID: 9718-161

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL791901.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	0.3	0.22
p,p'-DDE	1.5	0.13
o,p'-DDD	35	0.08
p,p'-DDD	110	0.12
o,p'-DDT	ND	0.14
p,p'-DDT	1.5	0.17
Aroclor 1242	ND	9.0
Aroclor 1254	ND	4.0
Aroclor 1260	ND	3.0

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	56
13C-p,p'-DDE	93
13C-p,p'-DDT	85
13C-PCB 101	98
13C-PCB 180	96

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: BH97-17A Aug21/97

AXYS ID: 9718-23 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL762536.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.12
p,p'-DDE	NDR 0.24	0.13
o,p'-DDD	0.29	0.13
p,p'-DDD	0.67	0.59
o,p'-DDT	ND	0.1
p,p'-DDT	ND	0.16
Aroclor 1242	ND	2.7
Aroclor 1254	ND	3.9
Aroclor 1260	ND	2.5

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	60
13C-p,p'-DDE	86
13C-p,p'-DDT	100
13C-PCB 101	88
13C-PCB 180	100

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: 97MP-1

AXYS ID: 9718-17 LI

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL782532.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.32
p,p'-DDE	ND	1.3
o,p'-DDD	0.72	0.53
p,p'-DDD	0.98	0.66
o,p'-DDT	3.2	1.4
p,p'-DDT	7.6	1.7
Aroclor 1242	ND	23
Aroclor 1254	ND	22
Aroclor 1260	ND	14

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	66
13C-p,p'-DDE	89
13C-p,p'-DDT	100
13C-PCB 101	91
13C-PCB 180	93

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: WP97-17B

AXYS ID: 9718-24 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL762537.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.08
p,p'-DDE	NDR 0.12	0.09
o,p'-DDD	ND	0.04
p,p'-DDD	ND	0.07
o,p'-DDT	ND	0.07
p,p'-DDT	ND	0.15
Aroclor 1242	ND	1.6
Aroclor 1254	ND	2.2
Aroclor 1260	ND	1.8

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	78
13C-p,p'-DDE	100
13C-p,p'-DDT	92
13C-PCB 101	110
13C-PCB 180	100

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: BH97-18 Aug 22/97

AXYS ID: 9718-14 I

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL791899.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.05
p,p'-DDE	0.15	0.06
o,p'-DDD	ND	0.03
p,p'-DDD	ND	0.13
o,p'-DDT	ND	0.12
p,p'-DDT	0.51	0.05
Aroclor 1242	ND	0.64
Aroclor 1254	ND	1.8
Aroclor 1260	ND	0.48

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	52
13C-p,p'-DDE	82
13C-p,p'-DDT	83
13C-PCB 101	86
13C-PCB 180	91

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: BH97-21A

AXYS ID: 9718-25 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL762538.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.17
p,p'-DDE	ND	0.27
o,p'-DDD	10	0.13
p,p'-DDD	39	0.17
o,p'-DDT	ND	0.16
p,p'-DDT	0.3	0.2
Aroclor 1242	ND	7.0
Aroclor 1254	ND	2.9
Aroclor 1260	ND	1.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	59
13C-p,p'-DDE	82
13C-p,p'-DDT	75
13C-PCB 101	85
13C-PCB 180	91

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: BH97-21B

AXYS ID: 9718-26 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS
RUNFILE ID: CL762539.D
CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.1
p,p'-DDE	NDR 0.14	0.08
o,p'-DDD	0.67	0.12
p,p'-DDD	0.5	0.38
o,p'-DDT	ND	0.15
p,p'-DDT	ND	0.08
Aroclor 1242	ND	2.0
Aroclor 1254	ND	3.0
Aroclor 1260	ND	1.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	71
13C-p,p'-DDE	90
13C-p,p'-DDT	90
13C-PCB 101	96
13C-PCB 180	100

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected

Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: 97MP-2 Aug21/97

AXYS ID: 9718-221

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL762535.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	NDR 0.48	0.2
p,p'-DDE	NDR 0.61	0.11
o,p'-DDD	2.0	0.28
p,p'-DDD	7.6	0.05
o,p'-DDT	NDR 0.35	0.32
p,p'-DDT	ND	0.43
Aroclor 1242	ND	36
Aroclor 1254	ND	3.5
Aroclor 1260	ND	4.7

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	67
13C-p,p'-DDE	94
13C-p,p'-DDT	99
13C-PCB 101	100
13C-PCB 180	90

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: 97MP3-1

AXYS ID: 9718-18 LI

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL762533.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.79
p,p'-DDE	ND	1.1
o,p'-DDD	NDR 1.3	0.57
p,p'-DDD	3.3	0.55
o,p'-DDT	NDR 1.2	1.0
p,p'-DDT	ND	1.2
Aroclor 1242	ND	28
Aroclor 1254	ND	26
Aroclor 1260	ND	15

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	78
13C-p,p'-DDE	87
13C-p,p'-DDT	85
13C-PCB 101	92
13C-PCB 180	83

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected

Approved



PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: 97MP3-2 *

AXYS ID: 9718-27 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL762540.D

CONCENTRATION IN: ng/L

* Field Duplicate of 97MP3-1

Compounds	Concentration	(SDL)
o,p'-DDE	NDR 0.74	0.28
p,p'-DDE	ND	0.29
o,p'-DDD	NDR 0.85	0.29
p,p'-DDD	2.0	0.13
o,p'-DDT	ND	1.3
p,p'-DDT	0.88	0.11
Aroclor 1242	NDR 19	16
Aroclor 1254	ND	2.8
Aroclor 1260	NDR 1.2	0.92

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	58
13C-p,p'-DDE	71
13C-p,p'-DDT	57
13C-PCB 101	78
13C-PCB 180	78

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: KLE97-01 Aug 21/97

AXYS ID: 9718-191

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS
RUNFILE ID: CL791904.D
CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.06
p,p'-DDE	ND	0.12
o,p'-DDD	ND	0.04
p,p'-DDD	ND	0.04
o,p'-DDT	ND	0.05
p,p'-DDT	ND	0.11
Aroclor 1242	ND	0.69
Aroclor 1254	ND	1.4
Aroclor 1260	ND	1.8

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	44
13C-p,p'-DDE	75
13C-p,p'-DDT	76
13C-PCB 101	79
13C-PCB 180	74

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved



PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D: KLE97-02 Aug 21/97

AXYS ID: 9718-201

CLIENT: Royal Roads University

DATE: 16/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL791905.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.03
p,p'-DDE	NDR 0.12	0.05
o,p'-DDD	ND	0.03
p,p'-DDD	ND	0.03
o,p'-DDT	ND	0.04
p,p'-DDT	ND	0.04
Aroclor 1242	ND	1.1
Aroclor 1254	ND	1.4
Aroclor 1260	ND	1.6

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	43
13C-p,p'-DDE	84
13C-p,p'-DDT	75
13C-PCB 101	85
13C-PCB 180	70

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected

Approved

PCB/PESTICIDE ANALYSIS REPORT

CLIENT SAMPLE I.D.: KLE97-04 Aug21/97

AXYS ID: 9718-21 I

CLIENT: Royal Roads University

DATE: 21/Oct/97

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 2.00 L

INSTRUMENT: GC-MS

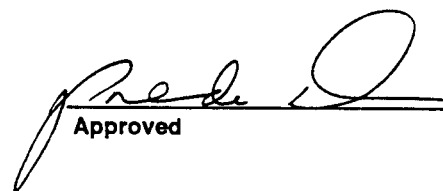
RUNFILE ID: CL762534.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.19
p,p'-DDE	ND	0.11
o,p'-DDD	ND	0.05
p,p'-DDD	ND	0.1
o,p'-DDT	ND	0.15
p,p'-DDT	ND	0.13
Aroclor 1242	ND	4.7
Aroclor 1254	ND	3.7
Aroclor 1260	ND	1.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	61
13C-p,p'-DDE	83
13C-p,p'-DDT	91
13C-PCB 101	85
13C-PCB 180	94

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

Appendix C-2:
1998 Axys Data Reports for DDTs

BATCH SUMMARY

Batch ID: CL-1412	Date: 15 September 1998
Analysis Type: PCB/Pesticide	Matrix Type: Water
BATCH MAKEUP	
Samples: 9809 -14 -15 -16 -17 A -18 -19 -20	Blank: CL-W-BLK 1412
	Reference or Spike: CL-W-SPM 1050
	Duplicate: 9809-17 B
Comments 1. Please note that sample results have not been corrected for concentrations detected in laboratory procedural blanks.	

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PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: Procedural Blank

AXYS ID: CL-W-BLK 1412

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Blank

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

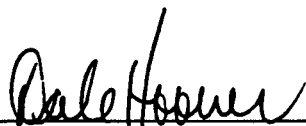
RUNFILE ID: CL893003.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.3
p,p'-DDE	ND	0.4
o,p'-DDD	ND	0.2
p,p'-DDD	ND	0.2
o,p'-DDT	ND	0.3
p,p'-DDT	ND	0.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	32
13C-p,p'-DDE	51
13C-p,p'-DDT	83
13C-PCB 101	52

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected


Approved



PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: Spiked Matrix

AXYS ID: CL-W-SPM 1050

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

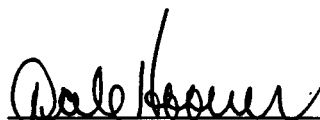
RUNFILE ID: CL893004.D

CONCENTRATION IN: ng/L

Compounds	Determined	Expected	% Recovery
o,p'-DDE	65	60	108
p,p'-DDE	71	56	127
o,p'-DDD	59	56	105
p,p'-DDD	83	72	115
o,p'-DDT	63	64	98
p,p'-DDT	76	64	119

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	40
13C-p,p'-DDE	65
13C-p,p'-DDT	98
13C-PCB 101	70

1. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-BH17A

AXYS ID: 9809-14

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS


RUNFILE ID: CL893005.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.2
p,p'-DDE	ND	0.3
o,p'-DDD	ND	0.2
p,p'-DDD	ND	0.2
o,p'-DDT	ND	0.3
p,p'-DDT	ND	0.5

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	41
13C-p,p'-DDE	55
13C-p,p'-DDT	68
13C-PCB 101	63

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-BH18

AXYS ID: 9809-15

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

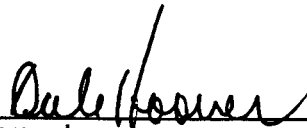
RUNFILE ID: CL893006.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.3
p,p'-DDE	ND	0.4
o,p'-DDD	ND	0.3
p,p'-DDD	ND	0.4
o,p'-DDT	ND	0.2
p,p'-DDT	ND	0.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	37
13C-p,p'-DDE	56
13C-p,p'-DDT	100
13C-PCB 101	56

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-BH21A

AXYS ID: 9809-16

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893007.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.1
p,p'-DDE	0.41	0.2
o,p'-DDD	11	0.2
p,p'-DDD	41	0.5
o,p'-DDT	0.33	0.3
p,p'-DDT	0.65	0.3

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	35
13C-p,p'-DDE	60
13C-p,p'-DDT	87
13C-PCB 101	62

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-BH21B

AXYS ID: 9809-17 A

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

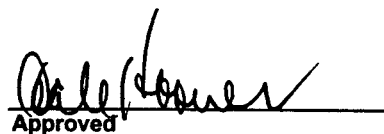
RUNFILE ID: CL893008.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.2
p,p'-DDE	ND	0.2
o,p'-DDD	0.54	0.2
p,p'-DDD	0.66	0.2
o,p'-DDT	ND	0.2
p,p'-DDT	ND	0.5

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	37
13C-p,p'-DDE	61
13C-p,p'-DDT	97
13C-PCB 101	63

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-BH21B

AXYS ID: 9809-17 B

CLIENT: Royal Roads University

Duplicate

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 0.93 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893009.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.3
p,p'-DDE	ND	0.3
o,p'-DDD	0.52	0.2
p,p'-DDD	0.68	0.4
o,p'-DDT	ND	0.2
p,p'-DDT	ND	0.3

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	36
13C-p,p'-DDE	60
13C-p,p'-DDT	92
13C-PCB 101	63

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-WP7

AXYS ID: 9809-18

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS


RUNFILE ID: CL893010.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	NDR 1.5	0.4
p,p'-DDE	11	1.6
o,p'-DDD	54	0.8
p,p'-DDD	220	1.5
o,p'-DDT	ND	1.0
p,p'-DDT	4.2	1.5

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	42
13C-p,p'-DDE	65
13C-p,p'-DDT	84
13C-PCB 101	67

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-WP13

AXYS ID: 9809-19

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

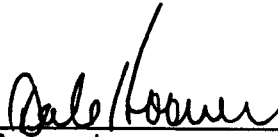
RUNFILE ID: CL893011.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	0.46	0.2
p,p'-DDE	2.9	0.2
o,p'-DDD	62	0.2
p,p'-DDD	240	0.3
o,p'-DDT	ND	0.6
p,p'-DDT	7.5	0.6

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	43
13C-p,p'-DDE	70
13C-p,p'-DDT	87
13C-PCB 101	73

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-MP1

AXYS ID: 9809-20

CLIENT: Royal Roads University

DATE: 15/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893012.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.3
p,p'-DDE	0.5	0.3
o,p'-DDD	ND	0.4
p,p'-DDD	ND	0.9
o,p'-DDT	ND	0.6
p,p'-DDT	ND	1.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	37
13C-p,p'-DDE	69
13C-p,p'-DDT	93
13C-PCB 101	72

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

BATCH SUMMARY

Batch ID: CL-1413	Date: 18 September 1998
Analysis Type: PCB/Pesticide	Matrix Type: Water
BATCH MAKEUP	
Samples: 9809 -21 A -22 -23 -24 -25 -26	Blank: CL-W-BLK 1413
	Reference or Spike: CL-W-SPM 1051
	Duplicate: 9809-21 B
Comments 1. Please note that sample results have not been corrected for concentrations detected in laboratory procedural blanks.	

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PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: Procedural Blank

AXYS ID: CL-W-BLK 1413

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Blank

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

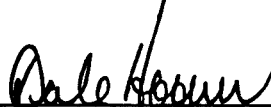
RUNFILE ID: CL893069.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.6
p,p'-DDE	ND	0.3
o,p'-DDD	ND	0.3
p,p'-DDD	ND	0.4
o,p'-DDT	ND	0.3
p,p'-DDT	ND	0.4

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	45
13C-p,p'-DDE	65
13C-p,p'-DDT	98
13C-PCB 101	62

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: Spiked Matrix

AXYS ID: CL-W-SPM 1051

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893070.D

CONCENTRATION IN: ng/L

Compounds	Determined	Expected	% Recovery
o,p'-DDE	60	60	100
p,p'-DDE	65	56	116
o,p'-DDD	63	56	113
p,p'-DDD	86	72	119
o,p'-DDT	63	64	98
p,p'-DDT	71	64	111

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	46
13C-p,p'-DDE	68
13C-p,p'-DDT	94
13C-PCB 101	70

1. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-MP2A

AXYS ID: 9809-21 A

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893071.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	1.1
p,p'-DDE	ND	1.6
o,p'-DDD	2.1	1.3
p,p'-DDD	8.3	1.7
o,p'-DDT	ND	1.8
p,p'-DDT	ND	1.3

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	58
13C-p,p'-DDE	72
13C-p,p'-DDT	83
13C-PCB 101	73

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-MP2A

AXYS ID: 9809-21 B
Duplicate

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 0.990 L

INSTRUMENT: GC-MS

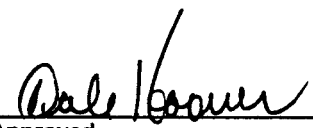
RUNFILE ID: CL893072.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.5
p,p'-DDE	ND	1.1
o,p'-DDD	1.7	0.4
p,p'-DDD	5.3	0.8
o,p'-DDT	ND	1.1
p,p'-DDT	ND	1.0

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	59
13C-p,p'-DDE	78
13C-p,p'-DDT	90
13C-PCB 101	79

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-MP2B

AXYS ID: 9809-22

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 0.960 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893073.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	1.1
p,p'-DDE	ND	1.6
o,p'-DDD	2.3	0.9
p,p'-DDD	6.9	1.1
o,p'-DDT	ND	0.4
p,p'-DDT	ND	1.1

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	48
13C-p,p'-DDE	63
13C-p,p'-DDT	70
13C-PCB 101	67

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-MP3

AXYS ID: 9809-23

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893074.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.7
p,p'-DDE	ND	0.9
o,p'-DDD	ND	1.0
p,p'-DDD	1.6	1.2
o,p'-DDT	ND	1.1
p,p'-DDT	ND	1.7

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	50
13C-p,p'-DDE	63
13C-p,p'-DDT	78
13C-PCB 101	65

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved



PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D.: 98-KLE1

AXYS ID: 9809-24

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS


RUNFILE ID: CL893075.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.6
p,p'-DDE	ND	0.8
o,p'-DDD	ND	0.4
p,p'-DDD	ND	0.8
o,p'-DDT	ND	0.7
p,p'-DDT	ND	1.3

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	38
13C-p,p'-DDE	58
13C-p,p'-DDT	84
13C-PCB 101	57

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved

PCB/PESTICIDE ANALYSIS REPORT

CL002

CLIENT SAMPLE I.D: 98-KLE2

AXYS ID: 9809-25

CLIENT: Royal Roads University

DATE: 18/Sep/98

SAMPLE TYPE: Water

METHOD NO.: CL-W-04/Ver.2

SAMPLE SIZE: 1.00 L

INSTRUMENT: GC-MS

RUNFILE ID: CL893076.D

CONCENTRATION IN: ng/L

Compounds	Concentration	(SDL)
o,p'-DDE	ND	0.6
p,p'-DDE	ND	0.6
o,p'-DDD	ND	0.5
p,p'-DDD	ND	1.0
o,p'-DDT	ND	0.4
p,p'-DDT	ND	0.6

Surrogate Standards	% Recovery
13C-Hexachlorobenzene	49
13C-p,p'-DDE	62
13C-p,p'-DDT	100
13C-PCB 101	60

1. SDL = Sample Detection Limit
2. ND = Not Detected
3. NDR = Peak detected but did not meet quantification criteria
4. Data have not been blank corrected
5. Concentrations are recovery corrected


Approved



Appendix C-3:
1997 ASL Chemical Analysis Report for Metals and
Hydrocarbons

service

laboratories

ltd.



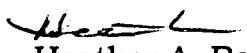
CHEMICAL ANALYSIS REPORT

Date: September 12, 1997
ASL File No. H6527
Report On: Water Analysis
Report To: **Royal Roads University**
Applied Research Division
2005 Sooke Road
Victoria, BC
V9B 5Y2
Attention: **Dr. Matthew Dodd**, Professor
Received: August 25, 1997

ASL ANALYTICAL SERVICE LABORATORIES LTD.

per:


Brent A. Makelki, B.Sc.
Project Chemist


Heather A. Ross, B.Sc.
Project Chemist





RESULTS OF ANALYSIS - Water

File No. H6527

		KLE 97-01	KLE 97-02	KLE 97-04	97-MP2	BH97-17A
		97 08 21 12:30	97 08 21 04:00	97 08 21	97 08 21 04:15	97 08 21 07:00
<hr/>						
Physical Tests						
Hardness	CaCO3	33.3	43.1	59.2	264	241
Dissolved Metals						
Aluminum	D-Al	0.12	0.06	2.02	<0.05	0.05
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	<0.01	0.01	0.02	0.09	0.13
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	D-Cd	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	D-Ca	11.4	15.0	19.0	96.4	89.6
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	0.12	<0.03	2.63	<0.03	31.3
Lead	D-Pb	<0.01	<0.01	<0.01	<0.01	<0.01
Magnesium	D-Mg	1.17	1.39	2.86	5.66	4.30
Manganese	D-Mn	0.011	0.015	0.081	1.72	2.37
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.02	<0.02	0.02	<0.02	<0.02
Selenium	D-Se	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	D-Ag	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	D-Tl	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	D-U	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	D-Zn	<0.005	<0.005	0.046	7.19	0.005
Non-halogenated Volatiles						
Benzene		-	-	-	<0.0005	0.0007
Ethylbenzene		-	-	-	0.0025	0.0320
Toluene		-	-	-	<0.0005	0.0022
meta- & para-Xylene		-	-	-	0.0033	0.0311
ortho-Xylene		-	-	-	0.0012	0.0038
Light Hydrocarbons (C5-9)		-	-	-	0.3	3.6
VPH ¹		-	-	-	0.1	1.6
Extractables²						
EPH (C10-18)		<1	<1	<1	10	2
EPH (C19-31)		<1	<1	<1	<1	<1

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹VPH = Volatile Petroleum Hydrocarbons.

²EPH = Extractable Petroleum Hydrocarbons.

**RESULTS OF ANALYSIS - Water**

File No. H6527

		BH97-17B	BH97-18	BH97-16	BH97-8B	WP97-7
		97 08 21 07:15	97 08 22 10:00	97 08 22 12:45	97 08 22 01:00	97 08 22 11:15
<hr/>						
Physical Tests						
Hardness	CaCO ₃	-	232	172	-	222
Dissolved Metals						
Aluminum	D-Al	-	0.15	<0.05	-	0.14
Antimony	D-Sb	-	<0.2	<0.2	-	<0.2
Arsenic	D-As	-	<0.2	<0.2	-	<0.2
Barium	D-Ba	-	0.04	0.12	-	0.09
Beryllium	D-Be	-	<0.005	<0.005	-	<0.005
Cadmium	D-Cd	-	<0.002	<0.002	-	<0.002
Calcium	D-Ca	-	81.8	61.4	-	80.8
Chromium	D-Cr	-	<0.01	<0.01	-	<0.01
Cobalt	D-Co	-	<0.01	<0.01	-	<0.01
Copper	D-Cu	-	<0.01	<0.01	-	<0.01
Iron	D-Fe	-	0.21	32.2	-	25.7
Lead	D-Pb	-	<0.01	<0.01	-	<0.01
Magnesium	D-Mg	-	6.80	4.41	-	4.83
Manganese	D-Mn	-	0.007	4.07	-	2.41
Mercury	D-Hg	-	<0.00005	<0.00005	-	<0.00005
Molybdenum	D-Mo	-	<0.03	<0.03	-	<0.03
Nickel	D-Ni	-	<0.02	<0.02	-	<0.02
Selenium	D-Se	-	<0.01	<0.01	-	<0.01
Silver	D-Ag	-	<0.001	<0.001	-	<0.001
Thallium	D-Tl	-	<0.001	<0.001	-	<0.001
Uranium	D-U	-	0.002	<0.001	-	<0.001
Zinc	D-Zn	-	0.030	0.014	-	0.029
Non-halogenated Volatiles						
Benzene		0.0007	<0.0005	<0.0005	-	0.0009
Ethylbenzene		0.0236	<0.0005	0.0010	-	0.0232
Toluene		0.0017	<0.0005	<0.0005	-	0.0015
meta- & para-Xylene		0.0262	<0.0005	0.0015	-	0.0500
ortho-Xylene		0.0035	<0.0005	0.0007	-	0.0135
Light Hydrocarbons (C5-9)		2.8	<0.1	0.6	-	1.8
VPH ¹		1.3	<0.1	0.3	-	0.8
Extractables²						
EPH (C10-18)		2	<1	7	6640	13
EPH (C19-31)		<1	<1	<1	67	1

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹VPH = Volatile Petroleum Hydrocarbons.²EPH = Extractable Petroleum Hydrocarbons.



RESULTS OF ANALYSIS - Water

File No. H6527

		WP97-13	WP97-21A	WP97-21B	WP97-19A	97-MP1
		97 08 22 10:45	97 08 21 05:00	97 08 21 05:15	97 08 22 05:30	97 08 22 04:10
Physical Tests						
Hardness	CaCO ₃	293	263	282	109	188
Dissolved Metals						
Aluminum	D-Al	0.49	<0.05	<0.05	0.06	<0.05
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	0.09	0.07	0.07	0.05	0.04
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Cadmium	D-Cd	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	D-Ca	103	94.2	100	38.2	67.4
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	2.62	0.39	0.03	7.74	<0.03
Lead	D-Pb	<0.01	<0.01	<0.01	<0.01	<0.01
Magnesium	D-Mg	8.70	6.80	7.75	3.30	4.80
Manganese	D-Mn	1.04	1.61	2.21	0.691	0.012
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.02	<0.02	<0.02	<0.02	<0.02
Selenium	D-Se	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	D-Ag	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	D-Tl	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	D-U	0.002	0.002	0.002	<0.001	0.001
Zinc	D-Zn	0.022	<0.005	<0.005	0.007	0.021
Non-halogenated Volatiles						
Benzene		-	<0.0005	<0.0005	-	<0.0005
Ethylbenzene		-	<0.0005	<0.0005	-	<0.0005
Toluene		-	<0.0005	<0.0005	-	<0.0005
meta- & para-Xylene		-	<0.0005	<0.0005	-	<0.0005
ortho-Xylene		-	<0.0005	<0.0005	-	<0.0005
Light Hydrocarbons (C5-9)		-	0.2	<0.1	-	<0.1
VPH ¹		-	<0.1	<0.1	-	<0.1
Extractables²						
EPH (C10-18)		-	1	<1	3	<1
EPH (C19-31)		-	<1	<1	<1	<1

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹VPH = Volatile Petroleum Hydrocarbons.

²EPH = Extractable Petroleum Hydrocarbons.



RESULTS OF ANALYSIS - Water

File No. H6527

		97-MP3	97-MP3-1	97-MP3-2	Travel Blank
		97 08 22 02:30	97 08 22 02:30	97 08 22 02:35	97 08 22
<hr/>					
Physical Tests					
Hardness	CaCO3	279	-	-	-
Dissolved Metals					
Aluminum	D-Al	<0.05	-	-	-
Antimony	D-Sb	<0.2	-	-	-
Arsenic	D-As	<0.2	-	-	-
Barium	D-Ba	0.07	-	-	-
Beryllium	D-Be	<0.005	-	-	-
Cadmium	D-Cd	<0.002	-	-	-
Calcium	D-Ca	104	-	-	-
Chromium	D-Cr	<0.01	-	-	-
Cobalt	D-Co	<0.01	-	-	-
Copper	D-Cu	<0.01	-	-	-
Iron	D-Fe	<0.03	-	-	-
Lead	D-Pb	<0.01	-	-	-
Magnesium	D-Mg	5.10	-	-	-
Manganese	D-Mn	1.75	-	-	-
Mercury	D-Hg	<0.00005	-	-	-
Molybdenum	D-Mo	<0.03	-	-	-
Nickel	D-Ni	<0.02	-	-	-
Selenium	D-Se	<0.01	-	-	-
Silver	D-Ag	<0.001	-	-	-
Thallium	D-Tl	<0.001	-	-	-
Uranium	D-U	<0.001	-	-	-
Zinc	D-Zn	2.91	-	-	-
Non-halogenated Volatiles					
Benzene		<0.0005	-	-	<0.0005
Ethylbenzene		0.0008	-	-	<0.0005
Toluene		0.0007	-	-	<0.0005
meta- & para-Xylene		0.0012	-	-	<0.0005
ortho-Xylene		<0.0005	-	-	<0.0005
Light Hydrocarbons (C5-9)		0.3	-	-	<0.1
VPH ¹		0.2	-	-	<0.1
Extractables²					
EPH (C10-18)		-	4	6	-
EPH (C19-31)		-	<1	<1	-

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹VPH = Volatile Petroleum Hydrocarbons.

²EPH = Extractable Petroleum Hydrocarbons.

**Appendix 1 - QUALITY CONTROL - Replicates**

File No. H6527

Water

BH97-18 BH97-1897 08 22 QC #
10:00 99770**Physical Tests**

Hardness

CaCO₃

232

232

Dissolved MetalsAluminum D-Al
Antimony D-Sb
Arsenic D-As
Barium D-Ba
Beryllium D-Be0.15 0.19
<0.2 <0.2
<0.2 <0.2
0.04 0.04
<0.005 <0.005Cadmium D-Cd
Calcium D-Ca
Chromium D-Cr
Cobalt D-Co
Copper D-Cu<0.002 <0.002
81.8 81.6
<0.01 <0.01
<0.01 <0.01
<0.01 <0.01Iron D-Fe
Lead D-Pb
Magnesium D-Mg
Manganese D-Mn
Molybdenum D-Mo0.21 0.21
<0.01 <0.01
6.80 6.77
0.007 0.007
<0.03 <0.03Nickel D-Ni
Selenium D-Se
Silver D-Ag
Thallium D-Tl
Uranium D-U<0.02 <0.02
<0.01 <0.01
<0.001 <0.001
<0.001 <0.001
0.002 0.002

Zinc D-Zn

0.030 0.030

Non-halogenated VolatilesBenzene
Ethylbenzene
Toluene
meta- & para-Xylene
ortho-Xylene<0.0005 <0.0005
<0.0005 <0.0005
<0.0005 <0.0005
<0.0005 <0.0005
<0.0005 <0.0005Light Hydrocarbons (C5-9)
VPH<0.1 <0.1
<0.1 <0.1Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.



Appendix 1 - QUALITY CONTROL - Replicates

File No. H6527

Water

BH97-18 BH97-18

97 08 22
10:00

QC #
99770

Extractables

EPH (C10-18)
EPH (C19-31)

<1
<1

<1
<1

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.



Appendix 1 - QUALITY CONTROL - Replicates

File No. H6527

Water

97-MP3-2 97-MP3-2

97 08 22 QC #
02:35 99868

Extractables

EPH (C10-18)
EPH (C19-31)

6 8
<1 <1

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.



Appendix 2 - METHODOLOGY

File No. H6527

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005), followed by instrumental analysis by atomic absorption spectrophotometry (EPA Method 7000), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association. A cold-oxidation procedure involving bromine monochloride is used, followed by instrumental analysis by cold-vapour atomic absorption spectrophotometry (CVAAS).

Volatile Organic Compounds in Water - Headspace Method

This analysis is based on U.S. EPA Methods 3810, 8015, 8020 and 8240 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method "Volatile Petroleum Hydrocarbons in Water". The procedure involves the use of a headspace technique in which the volatile compounds partition into the headspace of a sealed vial. A portion of this gaseous headspace is then analysed by capillary column gas chromatography with mass spectrometric / flame-ionization detection or photo-ionization / flame-ionization



detection.

Extractable Hydrocarbons in Water

This analysis is carried out using procedures adapted from U.S. EPA Methods 3510/8015 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Water by GC/FID" (January 1996). The procedure involves a methylene chloride solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

End of Report

HYDROCARBON DISTRIBUTION REPORT

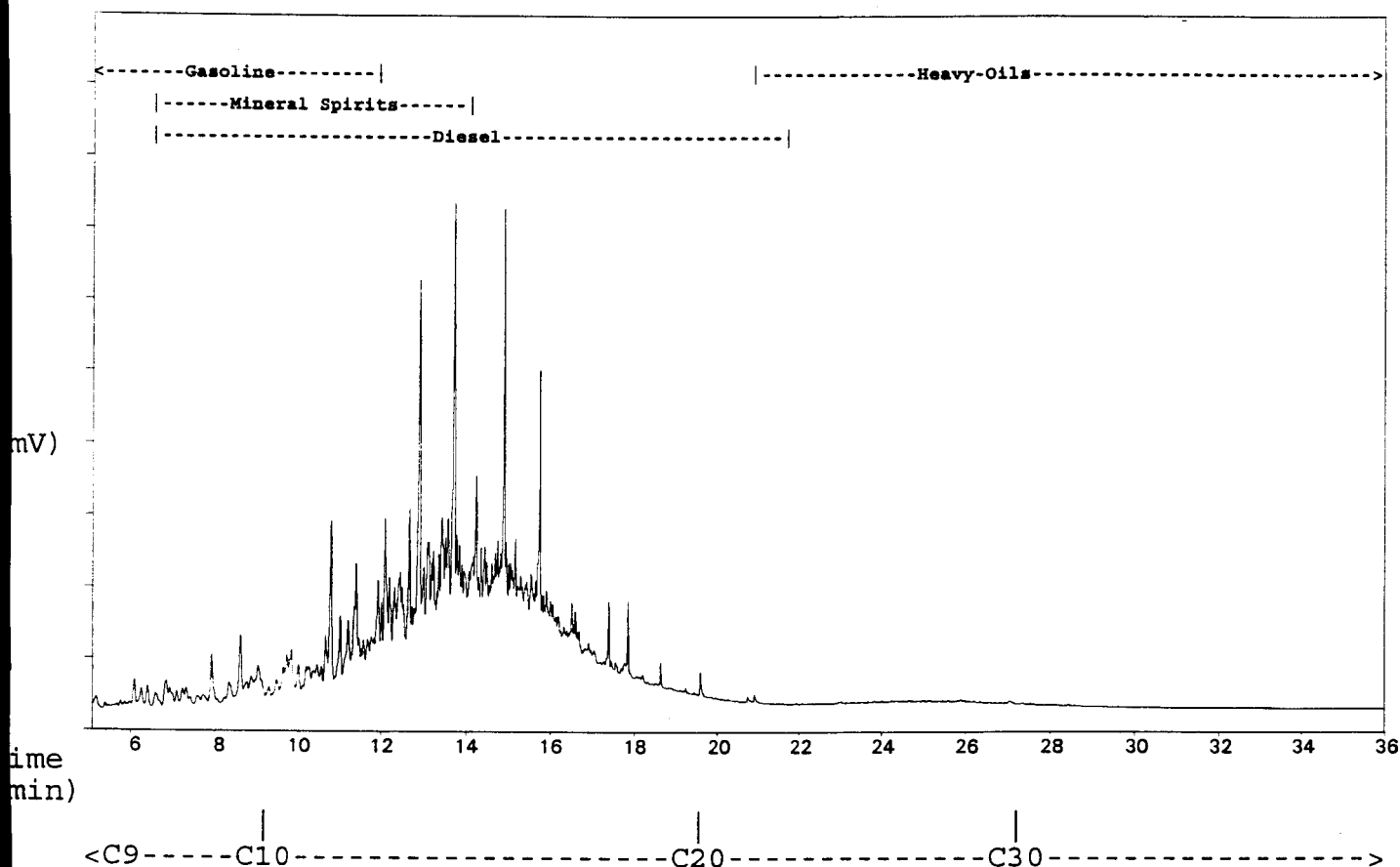
SAMPLE NAME:

97-MP2

Sample acquired: AUG 30, 1997 17:12:03

File Name: C:\TEH\AUG29\TEHAUG29.68R , Sample Name: H6527 4

Sequence file: TEHAUG29



ASL Sample ID: H6527 4* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	3.5
C10-C19 (beg-nC10 to beg-nC20)	91.2
C20-C30 (beg-nC20 to beg-nC31)	3.9
C31-C40 (beg-nC31 to beg-nC41)	1.3

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

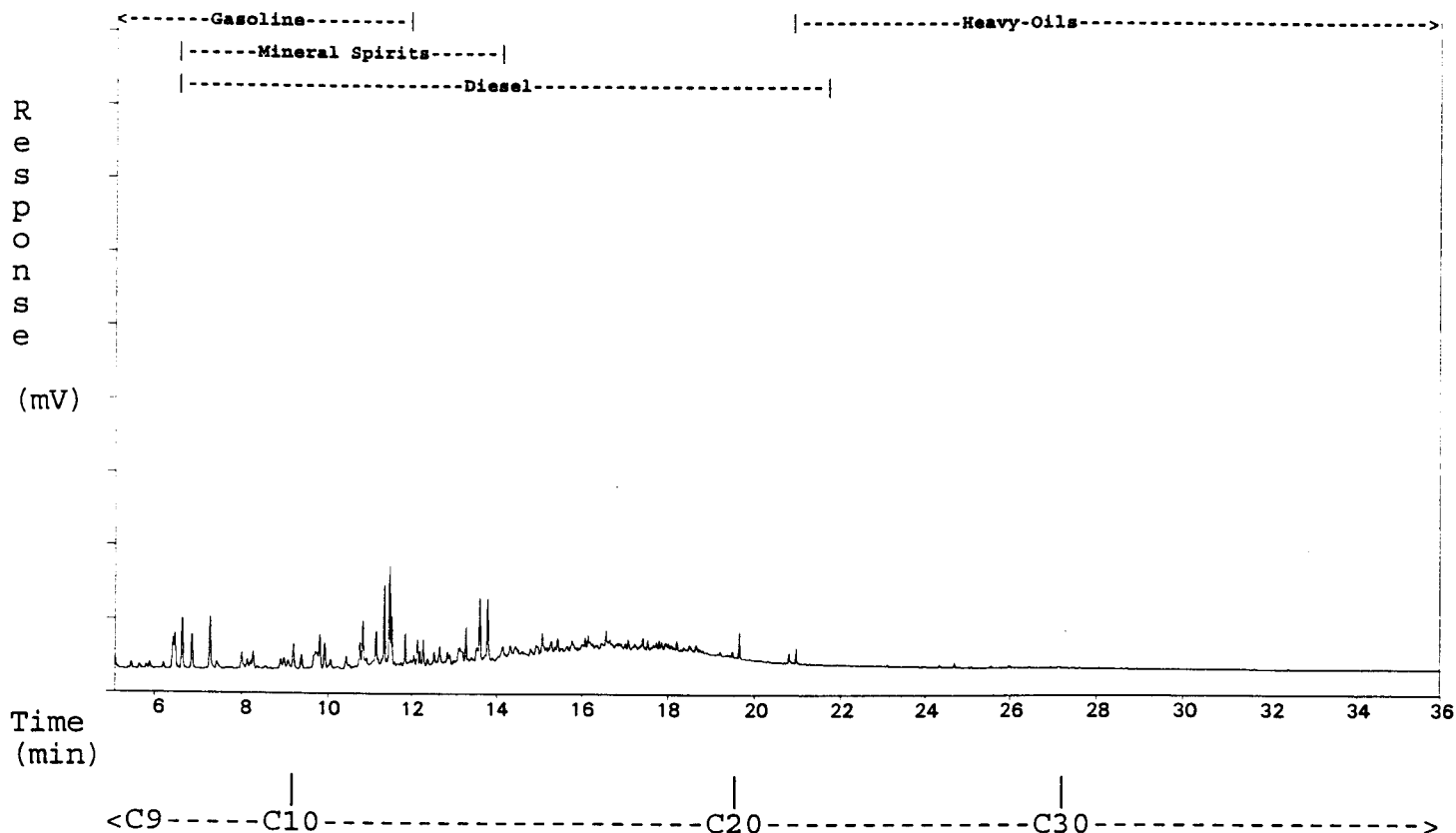
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: BH97-17A

Sample acquired: AUG 30, 1997 18:03:30

File Name: C:\TEH\AUG29\TEHAUG29.69R , Sample Name: H6527 5

Sequence file: TEHAUG29



ASL Sample ID: H6527 5* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	5.8
C10-C19 (beg-nC10 to beg-nC20)	80.2
C20-C30 (beg-nC20 to beg-nC31)	10.8
C31-C40 (beg-nC31 to beg-nC41)	3.2

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

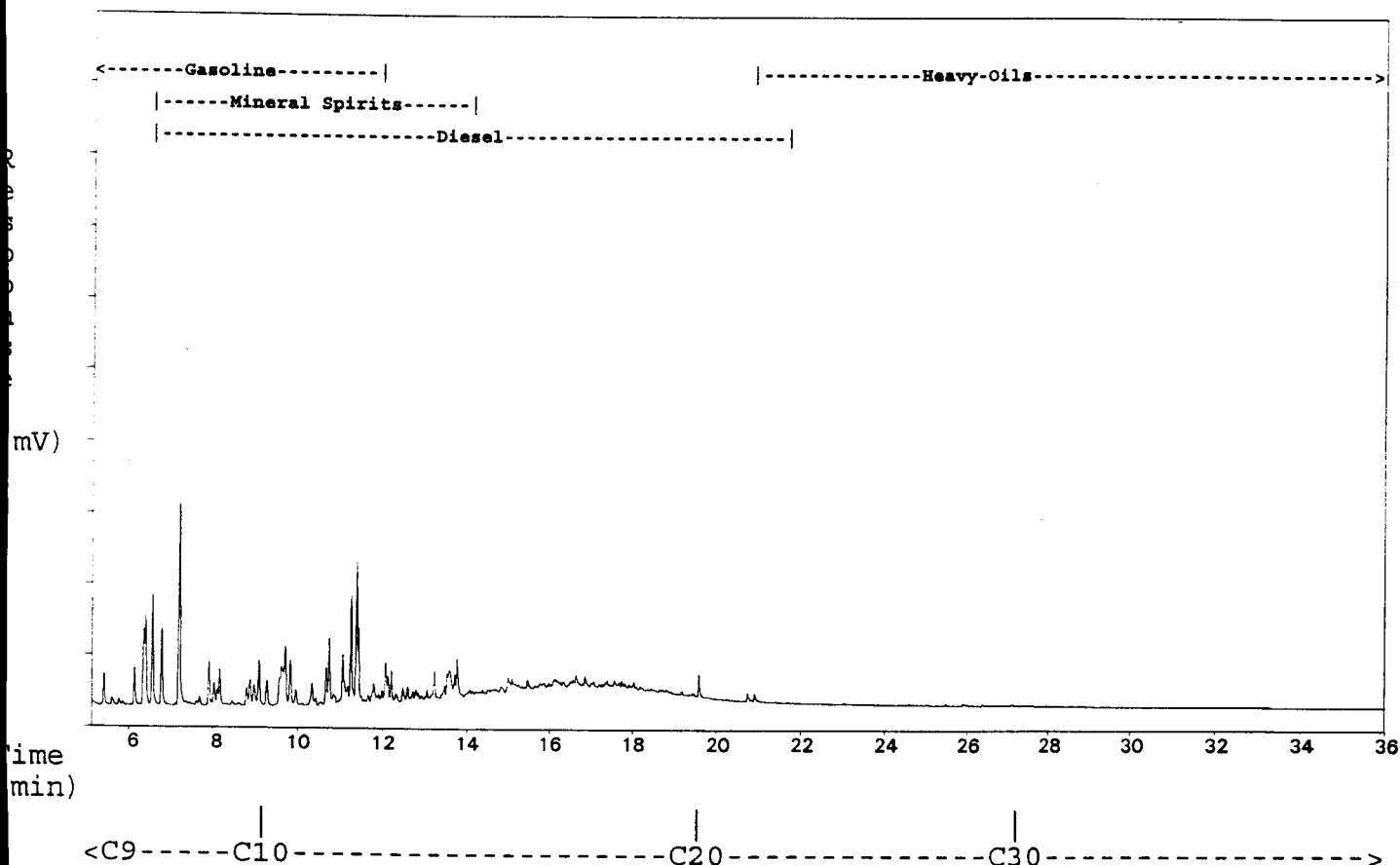
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: BH97-17B

Sample acquired: AUG 30, 1997 18:03:30

File Name: C:\TEH\AUG29\TEHAUG29.70R , Sample Name: H6527 6

Sequence file: TEHAUG29



ASL Sample ID: H6527 6* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	13.7
C10-C19 (beg-nC10 to beg-nC20)	77.5
C20-C30 (beg-nC20 to beg-nC31)	7.2
C31-C40 (beg-nC31 to beg-nC41)	1.6

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

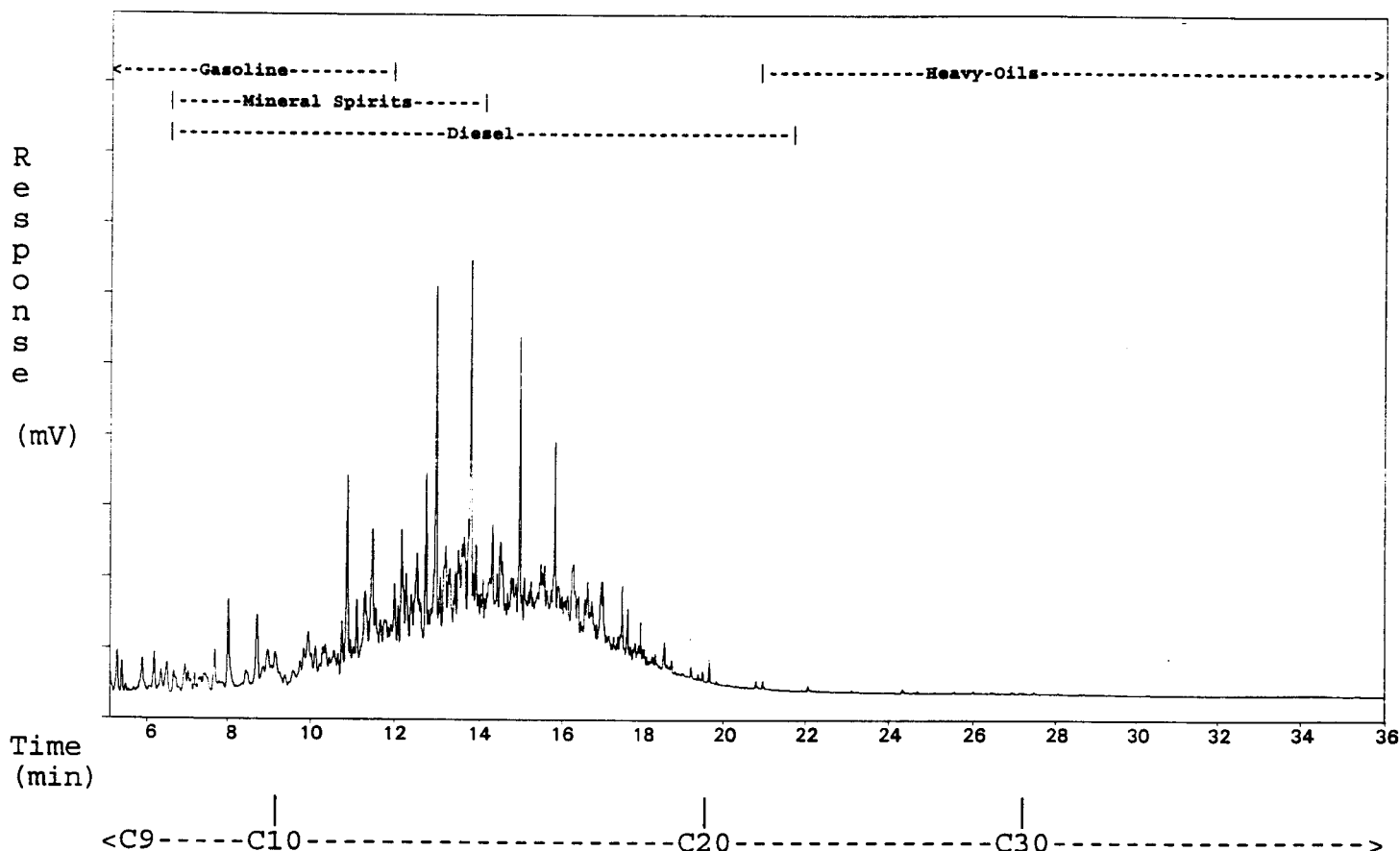
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: BH97-16

Sample acquired: AUG 30, 1997 19:45:33

File Name: C:\TEH\AUG29\TEHAUG29.73R , Sample Name: H6527 8

Sequence file: TEHAUG29



ASL Sample ID: H6527 8* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	4.8
C10-C19 (beg-nC10 to beg-nC20)	91.5
C20-C30 (beg-nC20 to beg-nC31)	2.9
C31-C40 (beg-nC31 to beg-nC41)	0.8

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

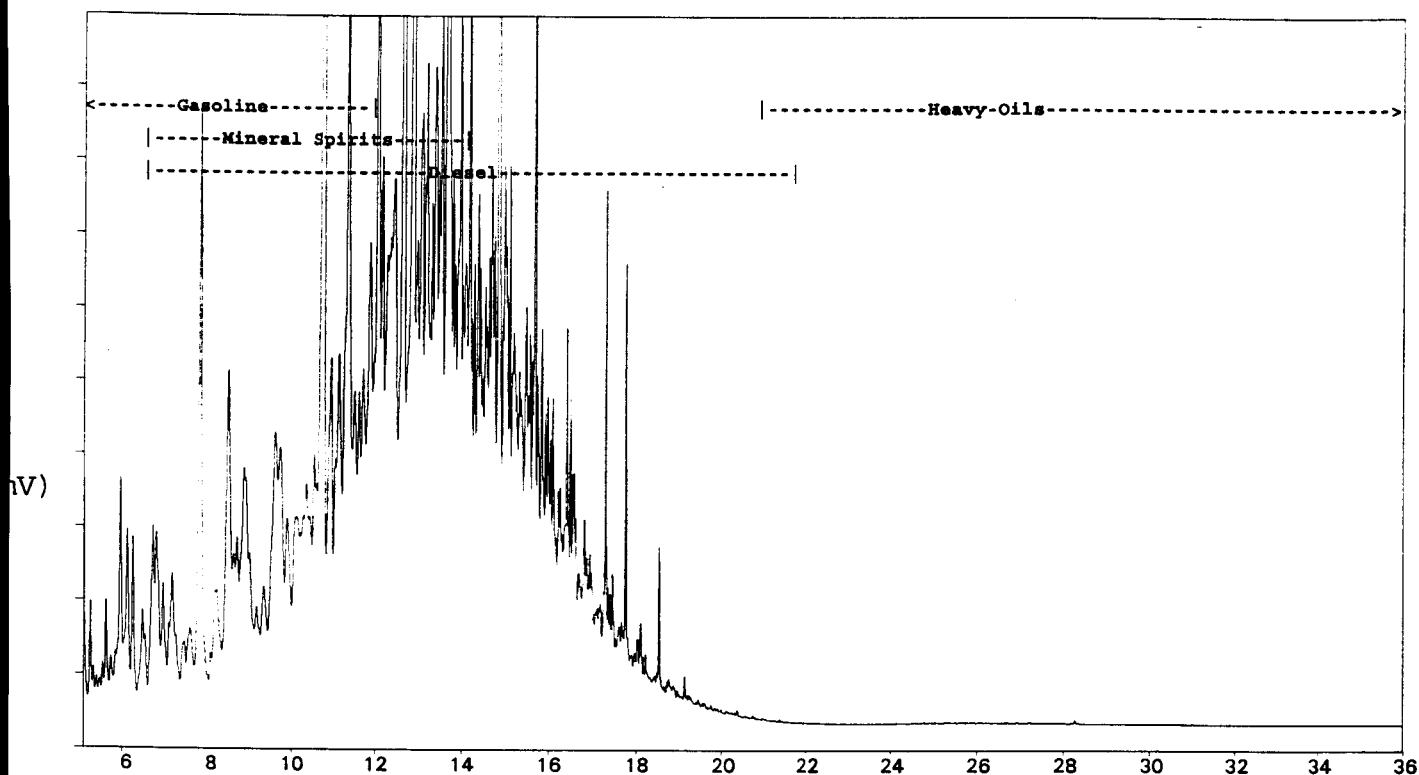
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: H6527 9#RX25

Sample acquired: SEP 2, 1997 17:34:59

File Name: C:\TEH2\SEP02\TEH02SEP.14R , Sample Name: H6527 9#RX25

Sequence file: TEH02SEP



<C9-----C10-----C20-----C30----->
ASL Sample ID: H6527 9#RX25* 150.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	8.8
C10-C19 (beg-nC10 to beg-nC20)	90.8
C20-C30 (beg-nC20 to beg-nC31)	0.3
C31-C40 (beg-nC31 to beg-nC41)	0.1

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

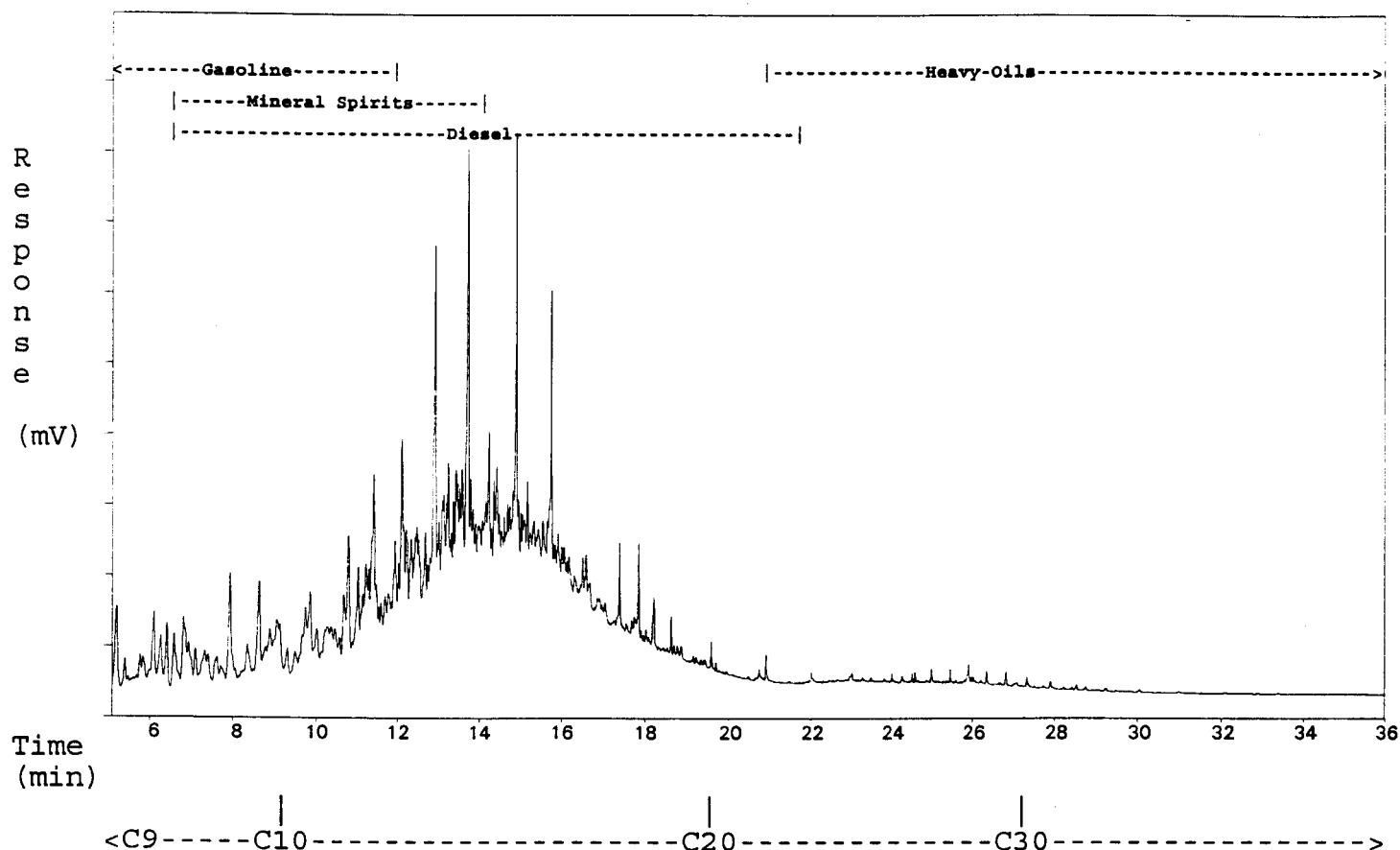
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **WP97-7**

Sample acquired: AUG 30, 1997 19:45:33

File Name: C:\TEH\AUG29\TEHAUG29.74R , Sample Name: H6527 10

Sequence file: TEHAUG29



ASL Sample ID: H6527 10* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	6.3
C10-C19 (beg-nC10 to beg-nC20)	85.2
C20-C30 (beg-nC20 to beg-nC31)	5.9
C31-C40 (beg-nC31 to beg-nC41)	2.5

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

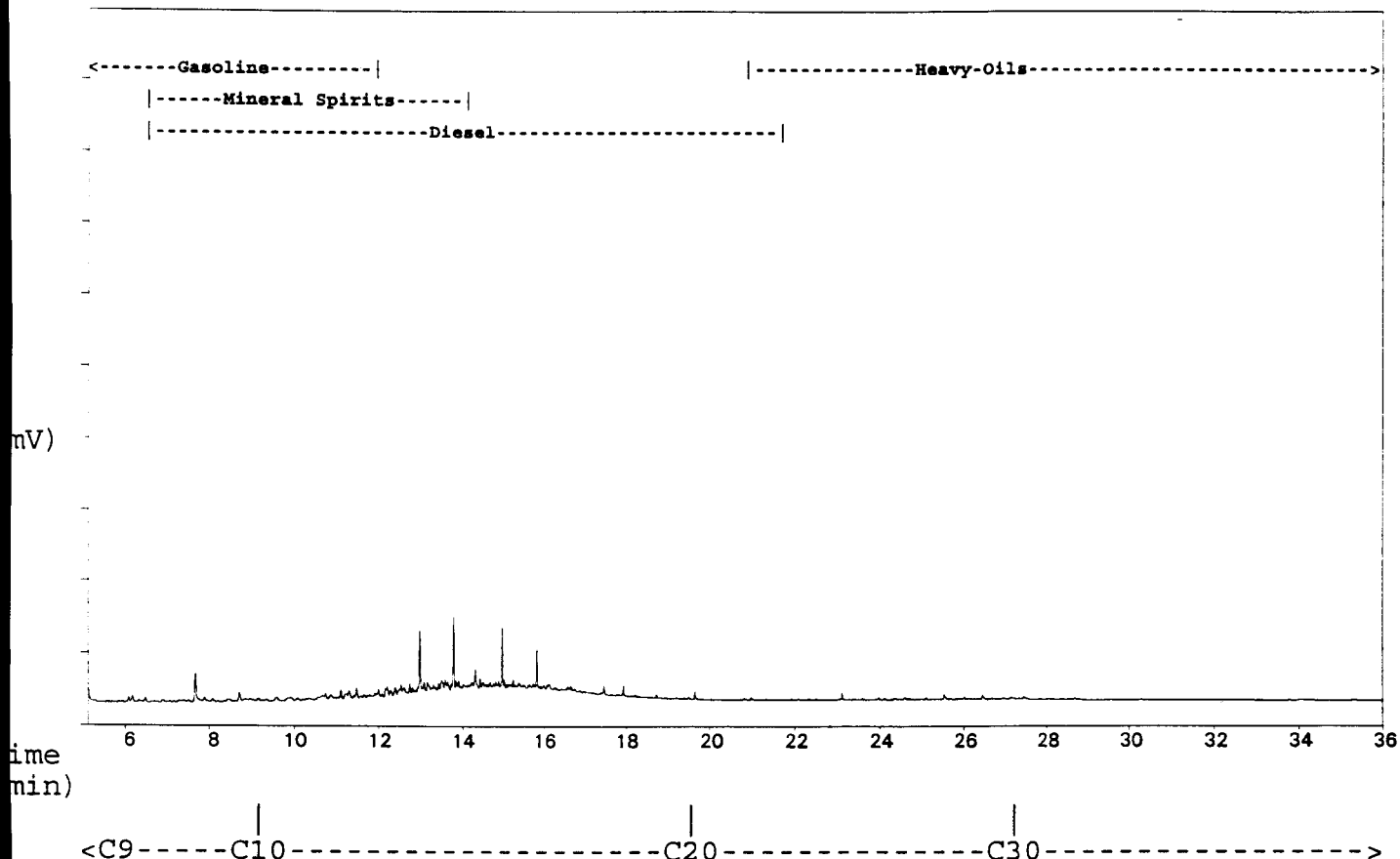
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: WP97-21A

Sample acquired: AUG 30, 1997 20:36:55

File Name: C:\TEH\AUG29\TEHAUG29.75R , Sample Name: H6527 12

Sequence file: TEHAUG29



ASL Sample ID: H6527 12* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	3.4
C10-C19 (beg-nC10 to beg-nC20)	80.5
C20-C30 (beg-nC20 to beg-nC31)	9.4
C31-C40 (beg-nC31 to beg-nC41)	6.6

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

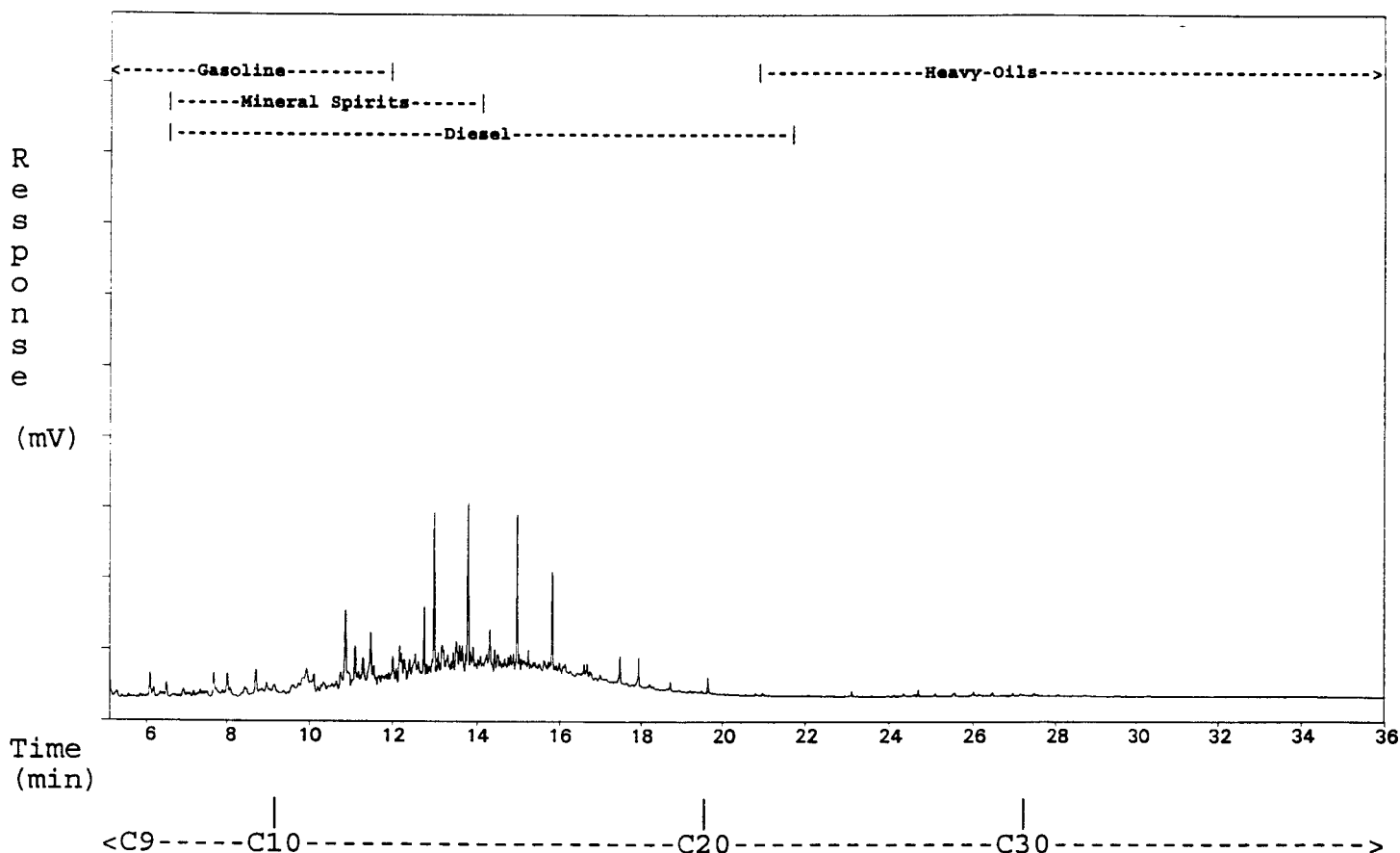
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: WP97-19A

Sample acquired: AUG 30, 1997 21:28:18

File Name: C:\TEH\AUG29\TEHAUG29.77R , Sample Name: H6527 14

Sequence file: TEHAUG29



ASL Sample ID: H6527 14* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	4.4
C10-C19 (beg-nC10 to beg-nC20)	89.7
C20-C30 (beg-nC20 to beg-nC31)	3.4
C31-C40 (beg-nC31 to beg-nC41)	2.5

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

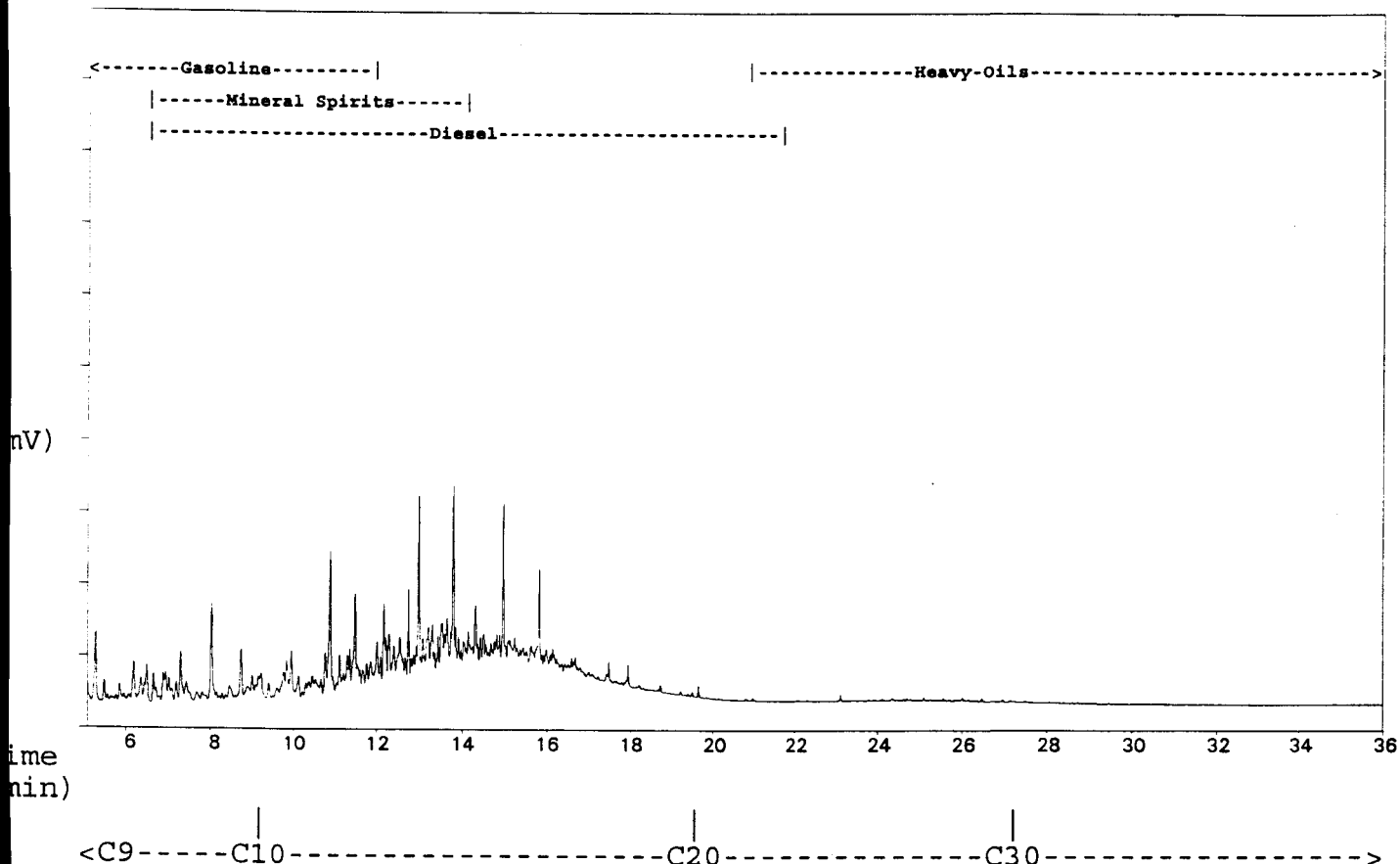
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: 97-MP3-1

Sample acquired: AUG 30, 1997 22:19:20

File Name: C:\TEH\AUG29\TEHAUG29.79R , Sample Name: H6527 17

Sequence file: TEHAUG29



ASL Sample ID: H6527 17* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	7.2
C10-C19 (beg-nC10 to beg-nC20)	86.1
C20-C30 (beg-nC20 to beg-nC31)	5.1
C31-C40 (beg-nC31 to beg-nC41)	1.6

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

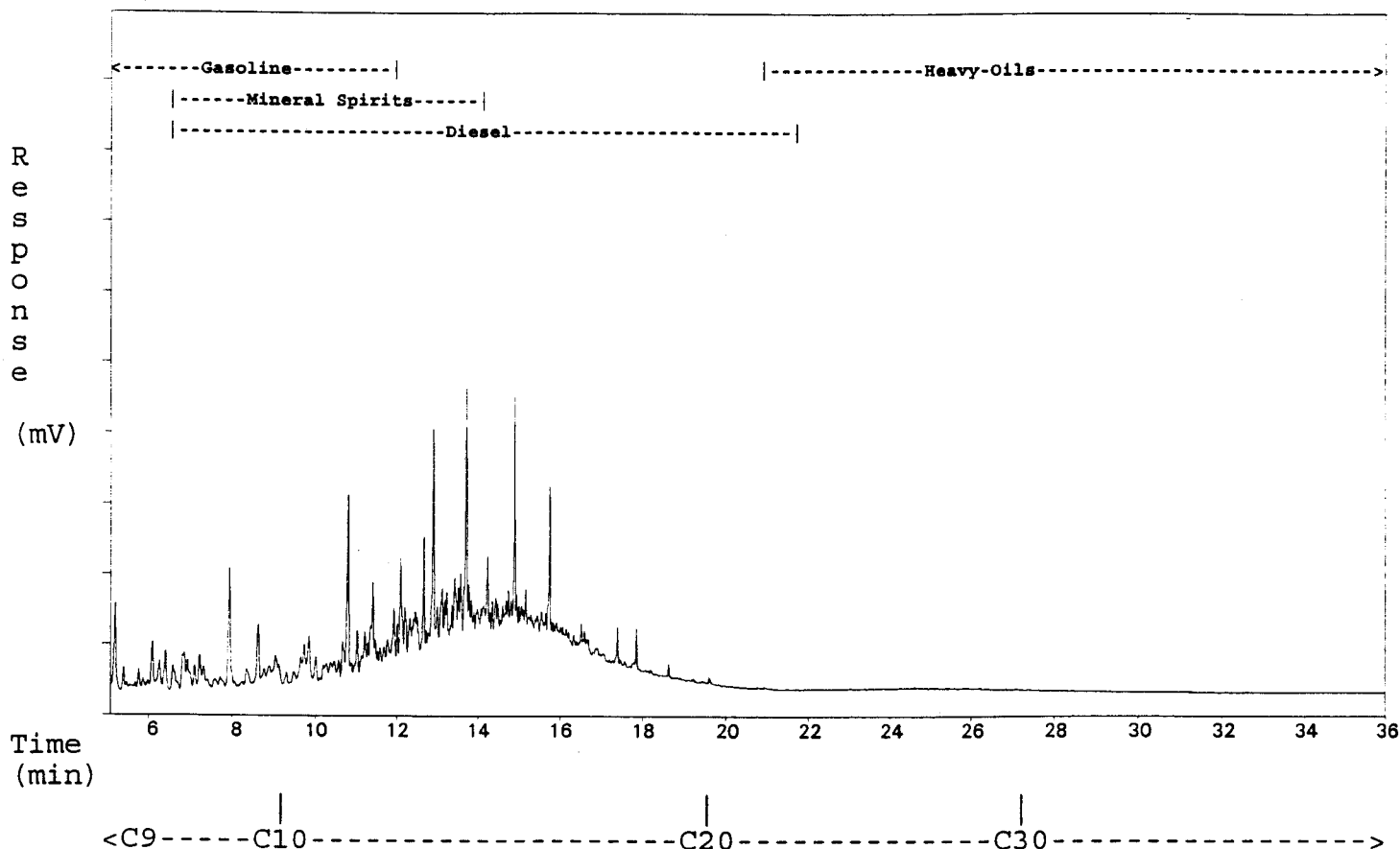
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: 97-MP3-2

Sample acquired: AUG 30, 1997 22:19:20

File Name: C:\TEH\AUG29\TEHAUG29.80R , Sample Name: H6527 18

Sequence file: TEHAUG29



ASL Sample ID: H6527 18* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	7.3
C10-C19 (beg-nC10 to beg-nC20)	87.6
C20-C30 (beg-nC20 to beg-nC31)	4.0
C31-C40 (beg-nC31 to beg-nC41)	1.1

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

Appendix C-4:
1998 ASL Chemical Analysis Report for Metals and
Hydrocarbons



CHEMICAL ANALYSIS REPORT

Date: August 28, 1998
ASL File No. J7584
Report On: Rainy Hallow Water Analysis
Report To: **Royal Roads University**
Applied Research Division
2005 Sooke Road
Victoria, BC
V9B 5Y2
Attention: **Dr. Matthew Dodd**, Professor
Received: August 10, 1998

ASL ANALYTICAL SERVICE LABORATORIES LTD.

per:

A handwritten signature in black ink, appearing to read 'Brent A. Makelki'.

Brent A. Makelki, B.Sc. - Supervisor, Client Services
Frederick Chen, B.Sc. - Manager, Special Projects



**RESULTS OF ANALYSIS - Water**

File No. J7584

		98-BH17A	98-BH19A	98-BH21A	98-BH21B	98-WP7
		98 08 07 15:30	98 08 07 16:10	98 08 08 13:00	98 08 08 13:35	98 08 08 15:30
Physical Tests						
Hardness	CaCO3	229	96.1	286	298	238
Total Metals						
Aluminum	T-Al	15.6	69.3	11.7	1.88	19.4
Antimony	T-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	T-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	T-Ba	0.34	0.90	0.15	0.08	0.21
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.002	0.020	<0.002	0.003	<0.002
Calcium	T-Ca	91.0	65.5	108	106	93.6
Chromium	T-Cr	0.03	0.21	0.03	<0.01	0.04
Cobalt	T-Co	0.02	0.08	0.02	<0.01	0.01
Copper	T-Cu	0.12	0.59	0.06	0.02	0.07
Iron	T-Fe	53.2	138	18.5	2.16	38.0
Lead	T-Pb	0.04	0.10	0.01	<0.01	0.02
Magnesium	T-Mg	12.0	53.7	12.9	8.0	12.5
Manganese	T-Mn	2.66	2.18	1.55	2.47	2.11
Mercury	T-Hg	<0.00005	0.00015	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.05	0.19	<0.05	<0.05	<0.05
Selenium	T-Se	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	T-Ag	<0.001	0.002	<0.001	<0.001	<0.001
Thallium	T-Tl	<0.001	0.003	<0.001	<0.001	<0.001
Uranium	T-U	0.0007	0.0038	0.0020	0.0020	0.0017
Zinc	T-Zn	0.171	0.653	0.096	0.013	0.129

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.

**RESULTS OF ANALYSIS - Water**

File No. J7584

		98-WP13	98-MP1	98-MP2A	98-MP2B	98-MP3
		98 08 08 14:25	98 08 08 10:25	98 08 08 11:30	98 08 08 11:40	98 08 08 16:00
Physical Tests						
Hardness	CaCO3	285	221	260	256	265
Total Metals						
Aluminum	T-Al	7.30	6.38	46.5	58.6	3.92
Antimony	T-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	T-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	T-Ba	0.13	0.10	0.38	0.42	0.09
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	T-B	0.1	0.1	<0.1	<0.1	0.1
Cadmium	T-Cd	<0.002	<0.002	0.006	0.006	<0.002
Calcium	T-Ca	102	87.1	181	186	106
Chromium	T-Cr	0.02	0.12	0.18	0.25	<0.01
Cobalt	T-Co	<0.01	<0.01	0.04	0.05	<0.01
Copper	T-Cu	0.04	0.03	0.27	0.29	0.02
Iron	T-Fe	12.5	11.0	86.7	97.5	13.4
Lead	T-Pb	0.01	<0.01	0.72	0.59	0.03
Magnesium	T-Mg	11.3	9.1	41.8	46.9	6.9
Manganese	T-Mn	1.06	0.223	3.56	3.67	1.81
Mercury	T-Hg	<0.00005	<0.00005	0.00009	0.00012	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.05	0.09	0.10	0.13	<0.05
Selenium	T-Se	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	T-Ag	<0.001	<0.001	0.001	0.001	<0.001
Thallium	T-Tl	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	T-U	0.0018	0.0017	0.0044	0.0040	0.0004
Zinc	T-Zn	0.055	0.036	53.1	40.2	5.59

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.

**RESULTS OF ANALYSIS - Water**

File No. J7584

		98-KLE1	98-KLE2	98-KLE4
		98 08 08 17:00	98 08 08 13:35	98 08 08
Physical Tests				
Hardness	CaCO3	24.4	38.4	36.9
Total Metals				
Aluminum	T-Al	2.87	9.89	10.8
Antimony	T-Sb	<0.2	<0.2	<0.2
Arsenic	T-As	<0.2	<0.2	<0.2
Barium	T-Ba	0.02	0.06	0.07
Beryllium	T-Be	<0.005	<0.005	<0.005
Boron	T-B	<0.1	<0.1	0.1
Cadmium	T-Cd	<0.002	<0.002	<0.002
Calcium	T-Ca	11.8	23.9	22.4
Chromium	T-Cr	<0.01	0.02	0.03
Cobalt	T-Co	<0.01	<0.01	<0.01
Copper	T-Cu	<0.01	0.02	0.02
Iron	T-Fe	3.38	12.0	13.7
Lead	T-Pb	<0.01	<0.01	<0.01
Magnesium	T-Mg	2.1	6.7	7.5
Manganese	T-Mn	0.072	0.245	0.264
Mercury	T-Hg	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.05	<0.05	<0.05
Selenium	T-Se	<0.01	<0.01	<0.01
Silver	T-Ag	<0.001	<0.001	<0.001
Thallium	T-Tl	<0.001	<0.001	<0.001
Uranium	T-U	0.0009	0.0010	0.0009
Zinc	T-Zn	0.015	0.036	0.042

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.

**RESULTS OF ANALYSIS - Water**

File No. J7584

		98-BH16	98-BH17A	98-BH19A	98-BH21A	98-BH21B
		98 08 07 14:30	98 08 07 15:30	98 08 07 16:10	98 08 08 13:00	98 08 08 13:35
<hr/>						
<u>Dissolved Metals</u>						
Aluminum	D-Al	-	<0.05	0.17	0.06	<0.05
Antimony	D-Sb	-	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	-	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	-	0.12	0.04	0.06	0.07
Beryllium	D-Be	-	<0.005	<0.005	<0.005	<0.005
Boron	D-B	-	<0.1	<0.1	<0.1	<0.1
Cadmium	D-Cd	-	<0.002	<0.002	<0.002	<0.002
Calcium	D-Ca	-	85.1	33.6	103	107
Chromium	D-Cr	-	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	-	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	-	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	-	29.7	7.79	0.83	0.06
Lead	D-Pb	-	<0.01	<0.01	<0.01	<0.01
Magnesium	D-Mg	-	4.1	3.0	6.8	7.4
Manganese	D-Mn	-	2.40	0.575	1.76	2.53
Mercury	D-Hg	-	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	-	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	-	<0.05	<0.05	<0.05	<0.05
Selenium	D-Se	-	<0.01	<0.01	<0.01	<0.01
Silver	D-Ag	-	<0.001	<0.001	<0.001	<0.001
Thallium	D-Tl	-	<0.001	<0.001	<0.001	<0.001
Uranium	D-U	-	0.0002	0.0001	0.0013	0.0019
Zinc	D-Zn	-	<0.005	<0.005	<0.005	<0.005
<u>Non-halogenated Volatiles</u>						
Benzene		<0.0005	<0.0005	-	<0.0005	<0.0005
Ethylbenzene		0.0016	0.0190	-	<0.0005	<0.0005
Toluene		<0.0005	0.0012	-	<0.0005	<0.0005
meta- & para-Xylene		0.0020	0.0202	-	<0.0005	<0.0005
ortho-Xylene		0.0007	0.0027	-	<0.0005	<0.0005
Volatile Hydrocarbons (VH) C6-10		0.8	1.2	-	0.3	0.1
VPH C6-10 (calculated) ¹		0.8	1.2	-	0.3	0.1

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹VPH = Volatile Petroleum Hydrocarbons.



RESULTS OF ANALYSIS - Water

File No. J7584

		98-WP7	98-WP13	98-MP1	98-MP2A	98-MP2B
		98 08 08 15:30	98 08 08 14:25	98 08 08 10:25	98 08 08 11:30	98 08 08 11:40
<u>Dissolved Metals</u>						
Aluminum	D-Al	0.06	<0.05	<0.05	0.11	0.07
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	0.08	0.07	0.05	0.09	0.09
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	D-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	D-Cd	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	D-Ca	88.0	101	80.0	95.9	94.6
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	0.01	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	18.3	4.09	0.09	8.64	8.40
Lead	D-Pb	<0.01	<0.01	<0.01	<0.01	<0.01
Magnesium	D-Mg	4.6	7.7	5.2	4.9	4.8
Manganese	D-Mn	1.90	0.977	0.010	2.28	2.25
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	D-Se	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	D-Ag	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium	D-Tl	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	D-U	0.0002	0.0012	0.0013	0.0001	<0.0001
Zinc	D-Zn	0.005	<0.005	<0.005	3.59	5.82
<u>Non-halogenated Volatiles</u>						
Benzene		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Ethylbenzene		0.0256	<0.0005	<0.0005	0.0045	0.0045
Toluene		0.0012	<0.0005	<0.0005	<0.0005	<0.0005
meta- & para-Xylene		0.0649	<0.0005	<0.0005	0.0074	0.0075
ortho-Xylene		0.0149	<0.0005	<0.0005	0.0022	0.0023
Volatile Hydrocarbons (VH) C6-10		1.4	0.3	<0.1	0.7	0.9
VPH C6-10 (calculated) ¹		1.3	0.3	<0.1	0.7	0.8

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹VPH = Volatile Petroleum Hydrocarbons.



RESULTS OF ANALYSIS - Water

File No. J7584

		98-MP3	98-KLE1	98-KLE2	98-KLE4	Travel Blank
		98 08 08 16:00	98 08 08 17:00	98 08 08 13:35	98 08 08	
<hr/>						
<u>Dissolved Metals</u>						
Aluminum	D-Al	<0.05	0.12	0.52	0.22	-
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	-
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	-
Barium	D-Ba	0.07	<0.01	<0.01	<0.01	-
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	-
Boron	D-B	<0.1	<0.1	<0.1	<0.1	-
Cadmium	D-Cd	<0.002	<0.002	<0.002	<0.002	-
Calcium	D-Ca	98.7	8.57	13.2	12.7	-
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	-
Cobalt	D-Co	<0.01	<0.01	<0.01	<0.01	-
Copper	D-Cu	0.05	<0.01	<0.01	<0.01	-
Iron	D-Fe	8.70	0.11	0.36	0.21	-
Lead	D-Pb	<0.01	<0.01	<0.01	<0.01	-
Magnesium	D-Mg	4.5	0.7	1.4	1.2	-
Manganese	D-Mn	1.80	0.009	0.021	0.014	-
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	-
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	-
Nickel	D-Ni	<0.05	<0.05	<0.05	<0.05	-
Selenium	D-Se	<0.01	<0.01	<0.01	<0.01	-
Silver	D-Ag	<0.001	<0.001	<0.001	<0.001	-
Thallium	D-Tl	<0.001	<0.001	<0.001	<0.001	-
Uranium	D-U	<0.0001	0.0006	0.0004	0.0004	-
Zinc	D-Zn	1.39	0.010	<0.005	<0.005	-
<hr/>						
<u>Non-halogenated Volatiles</u>						
Benzene		<0.0005	-	-	-	<0.0005
Ethylbenzene		0.0030	-	-	-	<0.0005
Toluene		<0.0005	-	-	-	<0.0005
meta- & para-Xylene		0.0043	-	-	-	<0.0005
ortho-Xylene		0.0014	-	-	-	<0.0005
Volatile Hydrocarbons (VH) C6-10		1.2	-	-	-	<0.1
VPH C6-10 (calculated) ¹		1.2	-	-	-	<0.1

Results are expressed as milligrams per litre.
 < = Less than the detection limit indicated.
¹VPH = Volatile Petroleum Hydrocarbons.

**RESULTS OF ANALYSIS - Water**

File No. J7584

	98-BH16	98-WP7	98-WP13	98-MP1	98-MP2A
	98 08 07 14:30	98 08 08 15:30	98 08 08 14:25	98 08 08 10:25	98 08 08 11:30
<hr/>					
<u>Polycyclic Aromatic Hydrocarbons</u>					
Acenaphthene	0.0022	<0.0005	<0.0005	<0.0005	<0.0005
Acenaphthylene	0.0007	<0.0005	<0.0005	<0.0005	<0.0005
Acridine	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Anthracene	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Benz(a)anthracene	0.00001	0.00002	<0.00001	<0.00001	0.00001
Benzo(a)pyrene	<0.00001	0.00001	<0.00001	<0.00001	0.00001
Benzo(b)fluoranthene	<0.00001	0.00001	<0.00001	<0.00001	<0.00001
Benzo(g,h,i)perylene	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Benzo(k)fluoranthene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Chrysene	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Dibenz(a,h)anthracene	0.00001	<0.00001	<0.00001	<0.00001	0.00002
Fluoranthene	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluorene	0.0024	0.0007	<0.0001	<0.0001	0.0003
Indeno(1,2,3-c,d)pyrene	0.00001	0.00001	<0.00001	<0.00001	0.00001
Naphthalene	0.0100	0.0075	0.0004	<0.0002	0.0025
Phenanthrene	0.0010	<0.0002	<0.0002	<0.0002	<0.0002
Pyrene	0.00004	0.00003	<0.00002	<0.00002	0.00002
<u>Extractables¹</u>					
EPH (C10-18)	5.2	3.1	1.7	<0.5	2.8
EPH (C19-31)	<1.0	<1.0	<1.0	<1.0	<1.0
LEPH ²	5.2	3.1	1.7	<0.5	2.8
HEPH	<1	<1	<1	<1	<1

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹EPH = Extractable Petroleum Hydrocarbons.²LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

**RESULTS OF ANALYSIS - Water**

File No. J7584

98-MP2B

98-MP3

98 08 08
11:4098 08 08
16:00**Polycyclic Aromatic Hydrocarbons**

Acenaphthene	<0.0005	<0.0005
Acenaphthylene	<0.0005	<0.0005
Acridine	<0.00005	<0.00005
Anthracene	<0.0001	<0.0001
Benz(a)anthracene	0.00001	0.00001
Benzo(a)pyrene	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00001	<0.00001
Benzo(g,h,i)perylene	<0.0001	<0.0001
Benzo(k)fluoranthene	<0.00001	<0.00001
Chrysene	<0.0001	<0.0001
Dibenz(a,h)anthracene	<0.00001	0.00001
Fluoranthene	<0.0001	<0.0001
Fluorene	0.0003	0.0003
Indeno(1,2,3-c,d)pyrene	<0.00001	<0.00001
Naphthalene	0.0042	0.0031
Phenanthrene	<0.0002	<0.0002
Pyrene	<0.00002	<0.00002

Extractables¹

EPH (C10-18)	3.5	1.8
EPH (C19-31)	<1.0	<1.0
LEPH ²	3.5	1.8
HEPH	<1	<1

Results are expressed as milligrams per litre.

< = Less than the detection limit indicated.

¹EPH = Extractable Petroleum Hydrocarbons.²LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

**Appendix 1 - QUALITY CONTROL - Replicates**

File No. J7584

Water

98-WP13 98-WP1398 08 08 QC #
14:25 128622**Physical Tests**

Hardness

CaCO3

285

285

Total Metals

Aluminum	T-Al
Antimony	T-Sb
Arsenic	T-As
Barium	T-Ba
Beryllium	T-Be
Boron	T-B
Cadmium	T-Cd
Calcium	T-Ca
Chromium	T-Cr
Cobalt	T-Co
Copper	T-Cu
Iron	T-Fe
Lead	T-Pb
Magnesium	T-Mg
Manganese	T-Mn
Mercury	T-Hg
Molybdenum	T-Mo
Nickel	T-Ni
Selenium	T-Se
Silver	T-Ag
Thallium	T-Tl
Uranium	T-U
Zinc	T-Zn

7.30	7.46
<0.2	<0.2
<0.2	<0.2
0.13	0.13
<0.005	<0.005
0.1	0.1
<0.002	<0.002
102	101
0.02	0.02
<0.01	<0.01
0.04	0.04
12.5	12.5
0.01	0.01
11.3	11.2
1.06	1.05
<0.00005	<0.00005
<0.03	<0.03
<0.05	<0.05
<0.01	<0.01
<0.001	<0.001
<0.001	<0.001
0.0018	0.0018
0.055	0.056

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.

**Appendix 1 - QUALITY CONTROL - Replicates**

File No. J7584

Water

98-WP13

98-WP13

98 08 08
14:25QC #
128622**Dissolved Metals**

Aluminum	D-Al	<0.05	<0.05
Antimony	D-Sb	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2
Barium	D-Ba	0.07	0.07
Beryllium	D-Be	<0.005	<0.005
Boron	D-B	<0.1	<0.1
Cadmium	D-Cd	<0.002	<0.002
Calcium	D-Ca	101	101
Chromium	D-Cr	<0.01	<0.01
Cobalt	D-Co	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01
Iron	D-Fe	4.09	4.09
Lead	D-Pb	<0.01	<0.01
Magnesium	D-Mg	7.7	7.7
Manganese	D-Mn	0.977	0.977
Mercury	D-Hg	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05
Selenium	D-Se	<0.01	<0.01
Silver	D-Ag	<0.001	<0.001
Thallium	D-Tl	<0.001	<0.001
Uranium	D-U	0.0012	0.0012
Zinc	D-Zn	<0.005	<0.005

Non-halogenated Volatiles

Benzene	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005
Toluene	<0.0005	<0.0005
meta- & para-Xylene	<0.0005	<0.0005
ortho-Xylene	<0.0005	<0.0005
Volatile Hydrocarbons (VH) C6-10	0.3	0.2
VPH C6-10 (calculated)	0.3	0.2

Results are expressed as milligrams per litre.
< = Less than the detection limit indicated.



Appendix 2 - METHODOLOGY

File No. J7584

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000A), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association. A cold-oxidation procedure involving bromine monochloride is used, followed by instrumental analysis by cold-vapour atomic absorption spectrophotometry (CVAAS).

Volatile Organic Compounds in Water

This analysis is based on United States Environmental Protection Agency Methods 624/524 and 5030/8260. These procedures involve purge and trap extraction of the sample and subsequent analysis of the volatile components by capillary column gas chromatography with mass spectrometric detection.



Volatile Petroleum Hydrocarbons (VPH) in Water

Volatile Petroleum Hydrocarbons (VPH) is a calculation defined by British Columbia Ministry of Environment, Lands and Parks (BCMELP) Draft Method "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water", June 1998. The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10). Analysis of Volatile Hydrocarbons adheres to all prescribed elements of BCMELP method "Volatile Hydrocarbons in Water", June 1998.

Polycyclic Aromatic Hydrocarbons in Water

This analysis is carried out using a procedure adapted by ASL from U.S. EPA Methods 3510, 3630 and 8270 (publ. #SW-846, 3rd Ed., Washington, DC 20460). The procedure involves the extraction of the sample with methylene chloride followed by silica column chromatography cleanup. This cleanup procedure has been found to effectively remove aliphatic and heterocyclic hydrocarbons which could potentially interfere with the analysis. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection.

Extractable Hydrocarbons in Water

This analysis is carried out using procedures adapted from U.S. EPA Methods 3510/8015 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Water by GC/FID" (January 1996). The procedure involves a methylene chloride solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Light and Heavy Extractable Petroleum Hydrocarbons in Water

This analysis is carried out as outlined in the method descriptions for Extractable Petroleum Hydrocarbons and Polycyclic Aromatic Hydrocarbons. The concentrations of acenaphthene, fluorene and naphthalene are subtracted from EPH (C10-18) to obtain the LEPH result. Concentrations of acridine, anthracene, benzo[a]anthracene, fluoranthene, phenanthrene, pyrene and benzo[a]pyrene are subtracted from EPH (C19-31) to obtain the



Appendix 2 - METHODOLOGY (cont'd)

File No. J7584

HEPH result.

End of Report



APPENDIX

**HYDROCARBON
DISTRIBUTION
REPORTS**

HYDROCARBON DISTRIBUTION REPORT

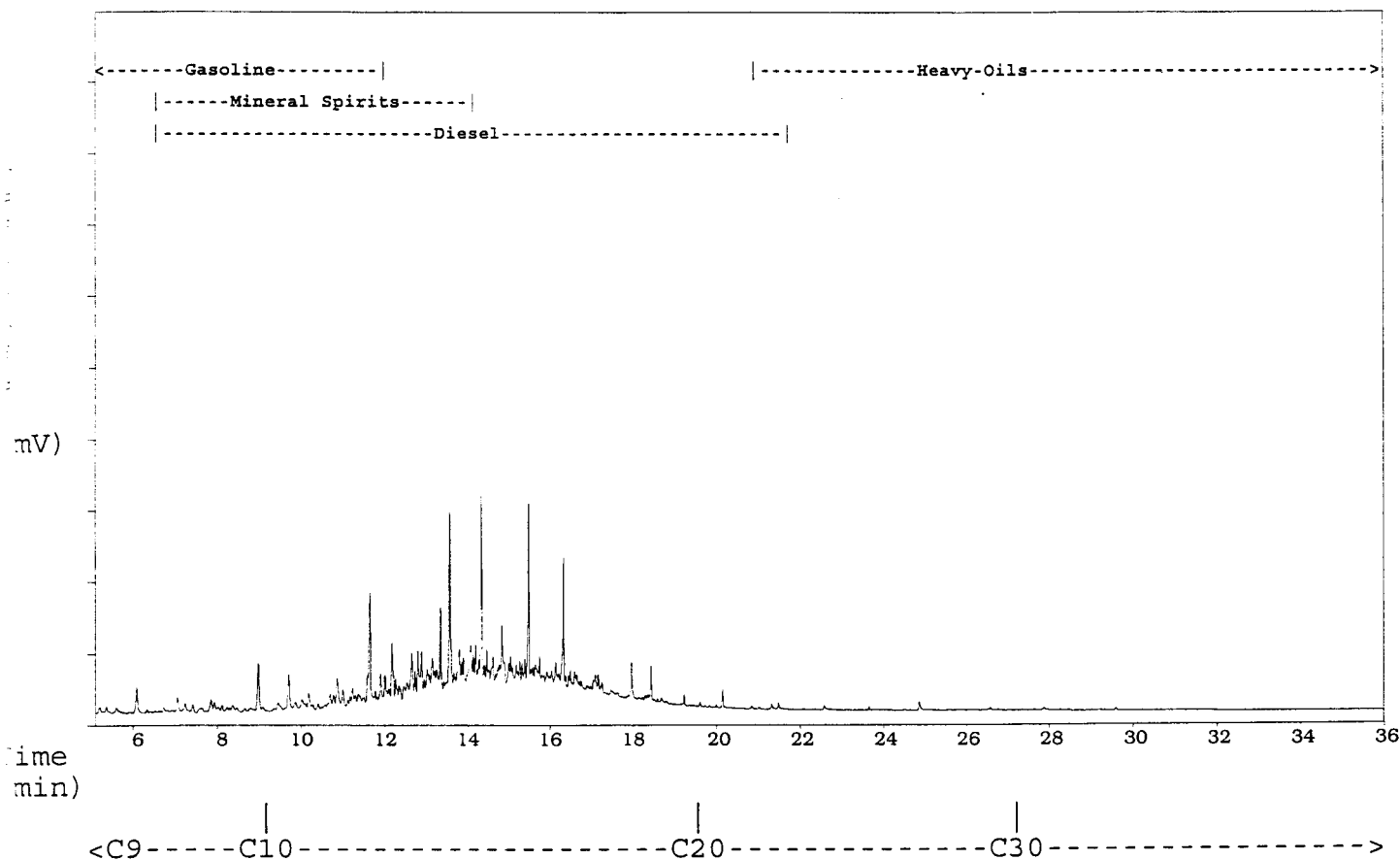
SAMPLE NAME: 98-BH16

Sample acquired: AUG 14, 1998 03:14:44

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13\TEHAUG13.33R , Sample Name: J7584-T--1

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--1* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	3.2
C10-C19 (beg-nC10 to beg-nC20)	89.6
C20-C30 (beg-nC20 to beg-nC31)	5.1
C31-C40 (beg-nC31 to beg-nC41)	2.1

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

HYDROCARBON DISTRIBUTION REPORT

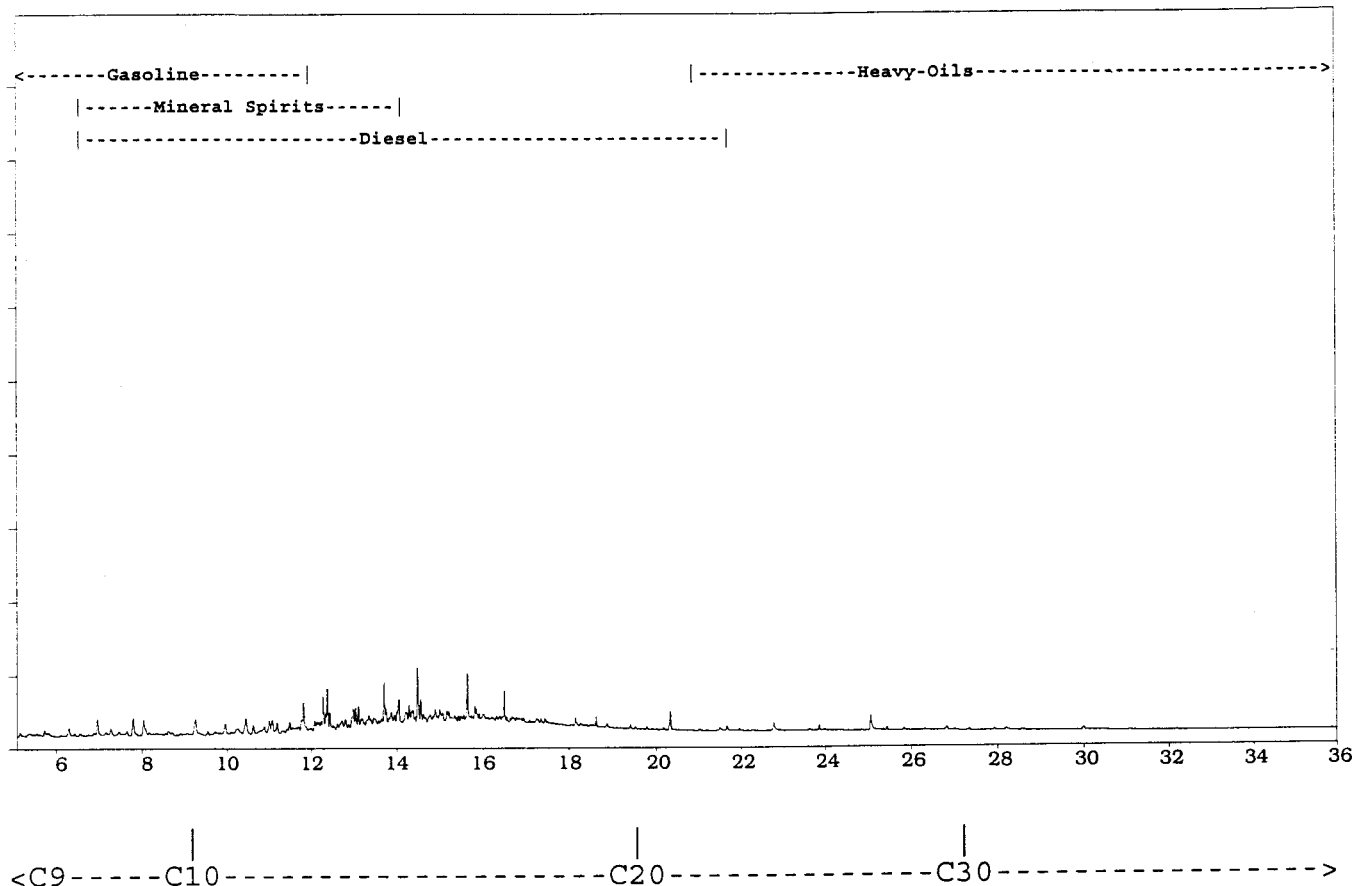
SAMPLE NAME: 98-WP7

Sample acquired: AUG 14, 1998 04:07:51

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13\TEHAUG13.39R , Sample Name: J7584-T--6

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--6* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	4.4
C10-C19 (beg-nC10 to beg-nC20)	77.9
C20-C30 (beg-nC20 to beg-nC31)	12.2
C31-C40 (beg-nC31 to beg-nC41)	5.6

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

HYDROCARBON DISTRIBUTION REPORT

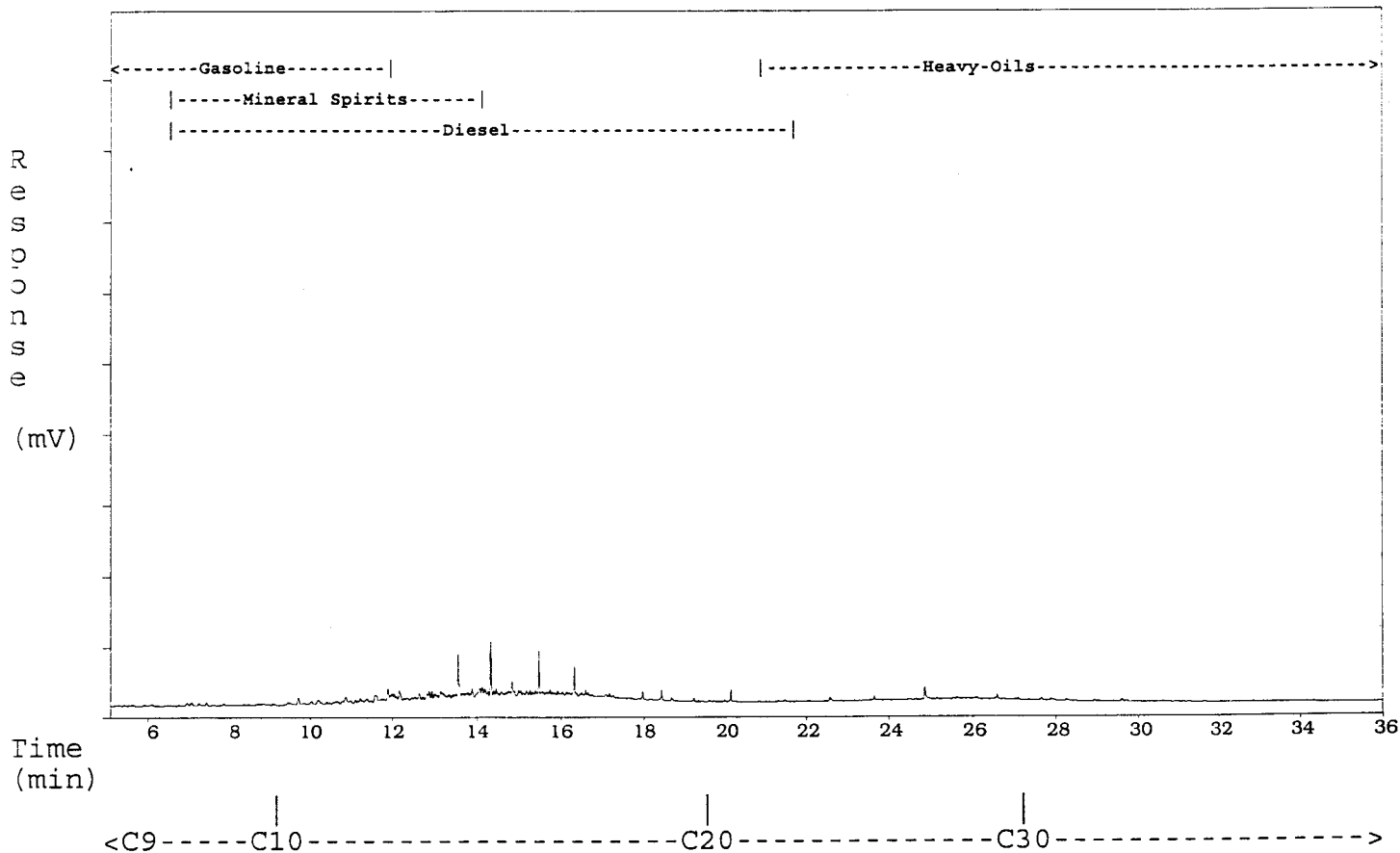
SAMPLE NAME: 98-WP13

Sample acquired: AUG 14, 1998 04:07:51

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13\TEHAUG13.40R , Sample Name: J7584-T--7

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--7* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	1.7
C10-C19 (beg-nC10 to beg-nC20)	68.4
C20-C30 (beg-nC20 to beg-nC31)	16.7
C31-C40 (beg-nC31 to beg-nC41)	13.2

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

HYDROCARBON DISTRIBUTION REPORT

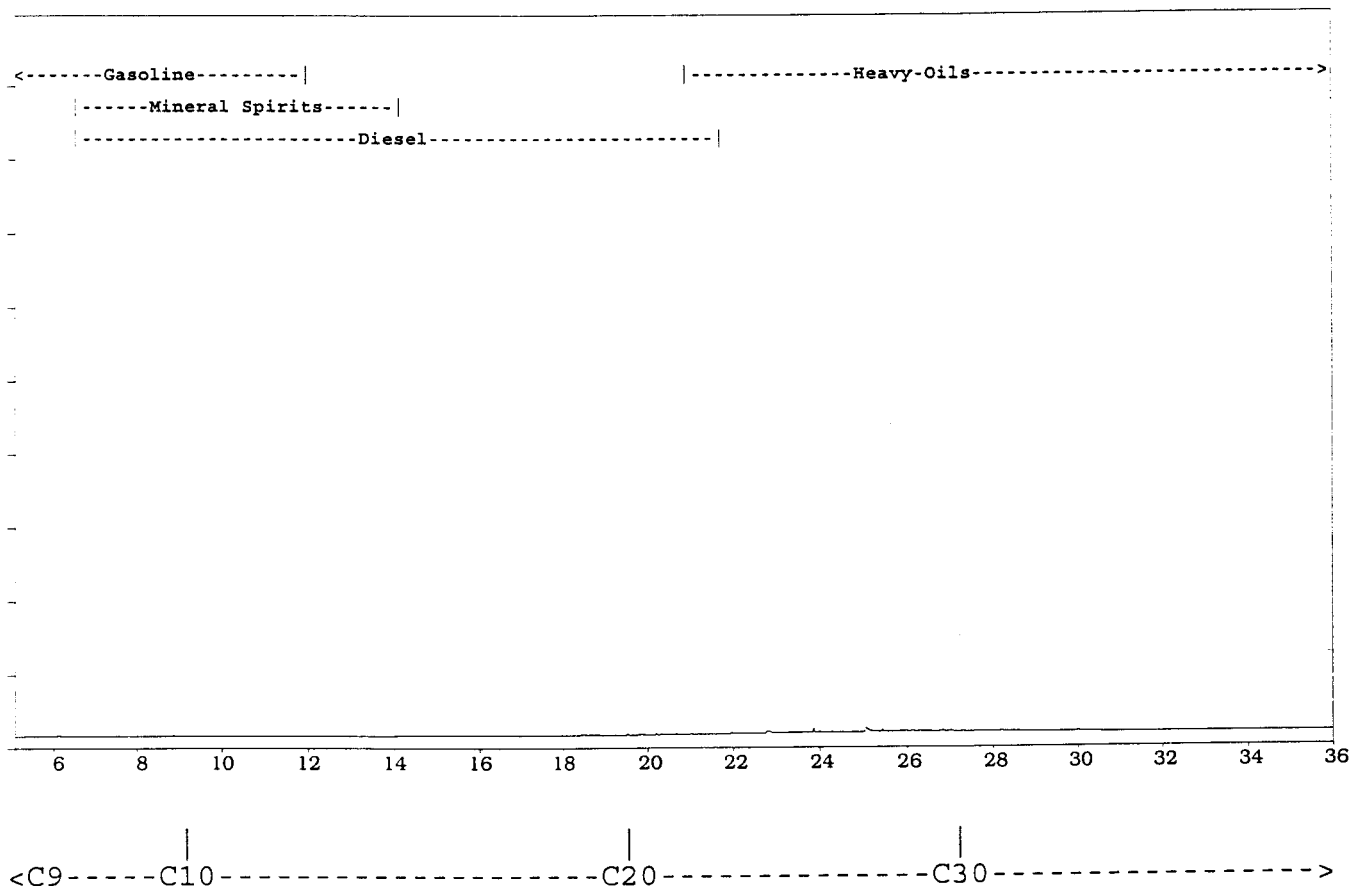
SAMPLE NAME: 98-MP1

Sample acquired: AUG 14, 1998 05:00:57

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13\TEHAUG13.41R , Sample Name: J7584-T--8

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--8*

1.0Dilution

HYDROCARBON RANGE (by Carbon#)

RELATIVE AMOUNT (%)

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	0.7
C10-C19 (beg-nC10 to beg-nC20)	4.5
C20-C30 (beg-nC20 to beg-nC31)	49.9
C31-C40 (beg-nC31 to beg-nC41)	44.8

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

HYDROCARBON DISTRIBUTION REPORT

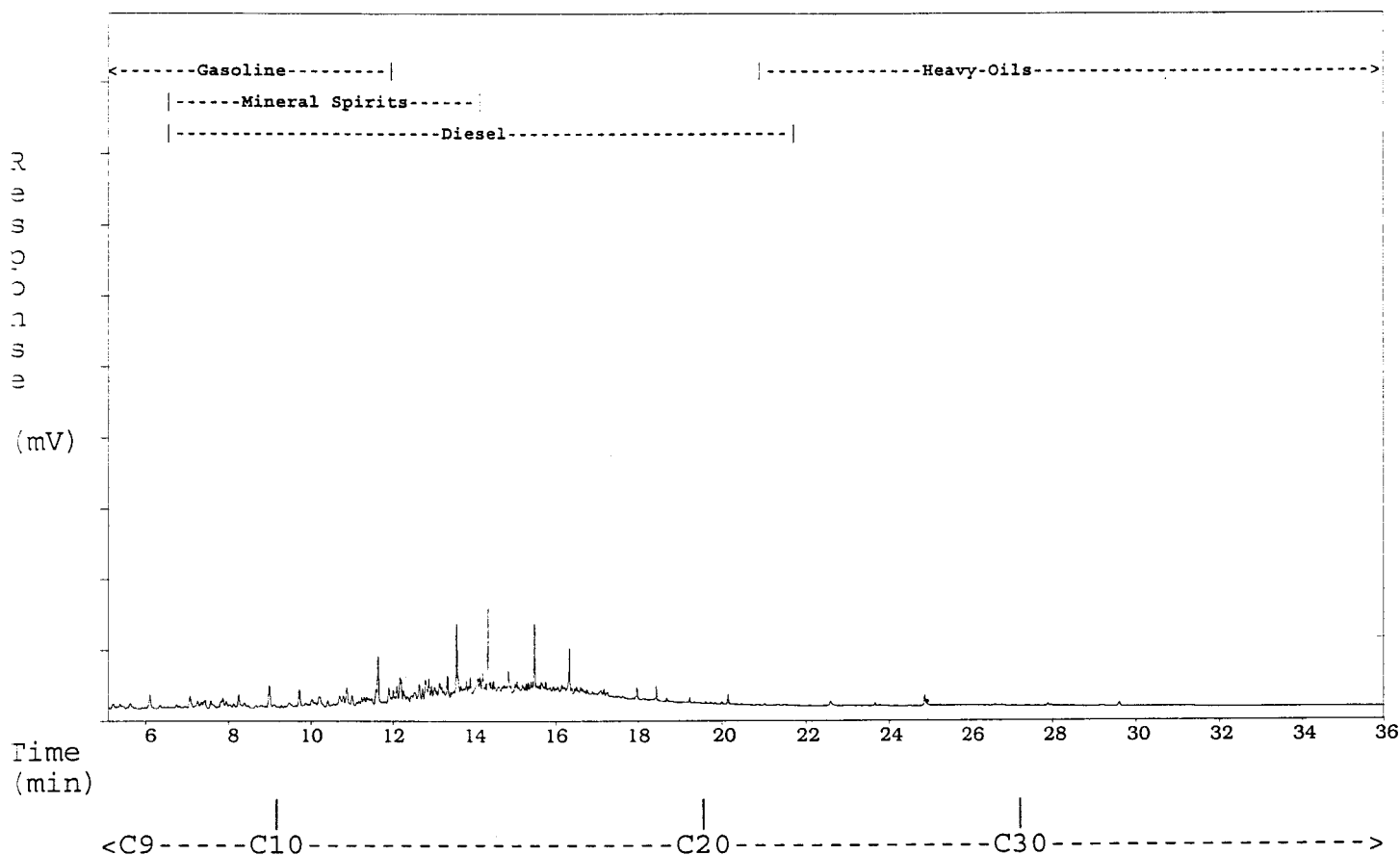
SAMPLE NAME: 98-MP2A

Sample acquired: AUG 14, 1998 05:00:57

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13\TEHAUG13.42R , Sample Name: J7584-T--9

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--9* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	5.0
C10-C19 (beg-nC10 to beg-nC20)	83.6
C20-C30 (beg-nC20 to beg-nC31)	8.1
C31-C40 (beg-nC31 to beg-nC41)	3.3

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

HYDROCARBON DISTRIBUTION REPORT

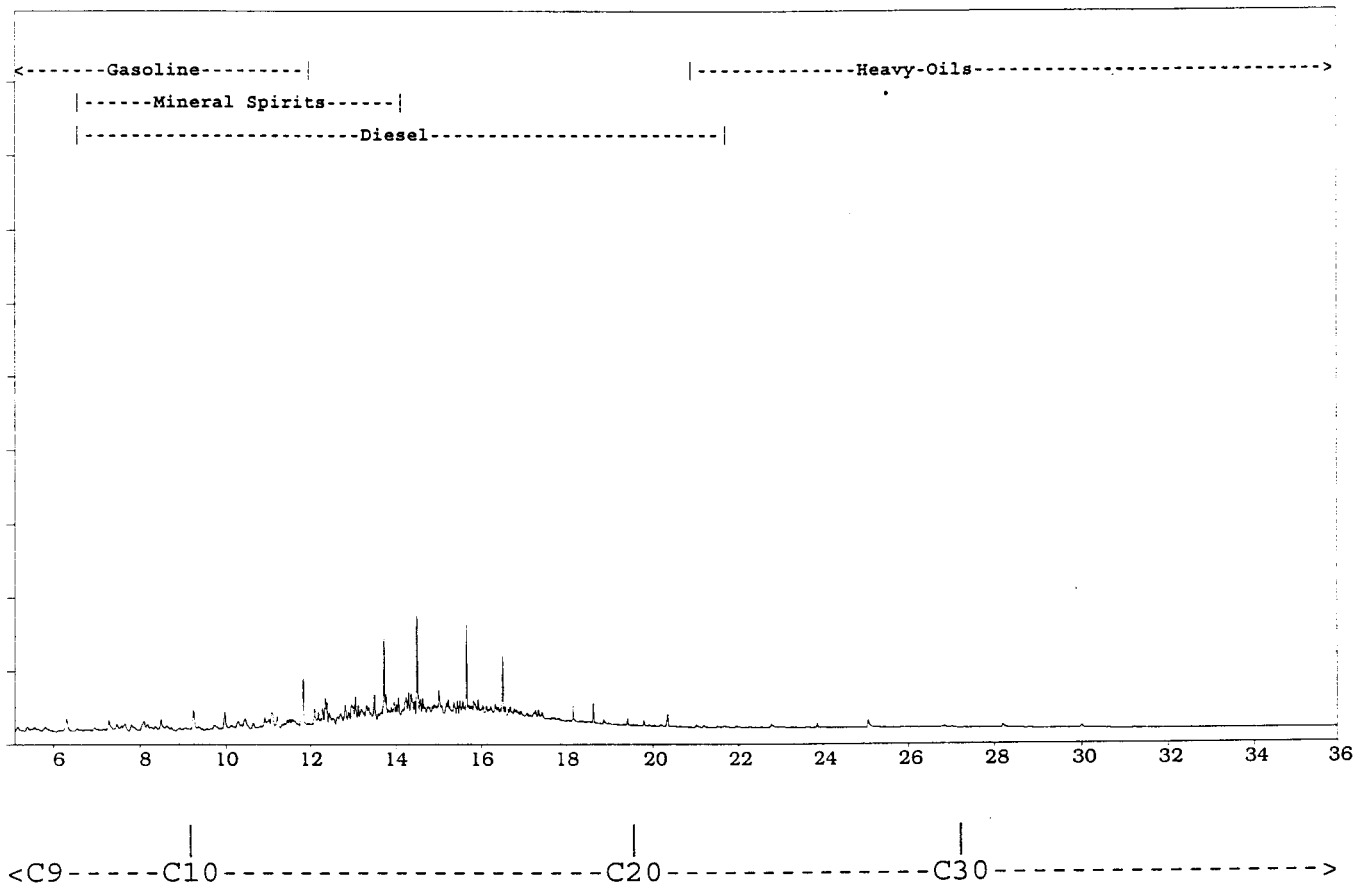
SAMPLE NAME: 98-MP2B

Sample acquired: AUG 14, 1998 05:53:54

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13 TEHAUG13.43R , Sample Name: J7584-T--10

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--10* 1.0Dilution

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	4.3
C10-C19 (beg-nC10 to beg-nC20)	83.4
C20-C30 (beg-nC20 to beg-nC31)	9.0
C31-C40 (beg-nC31 to beg-nC41)	3.3

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.

HYDROCARBON DISTRIBUTION REPORT

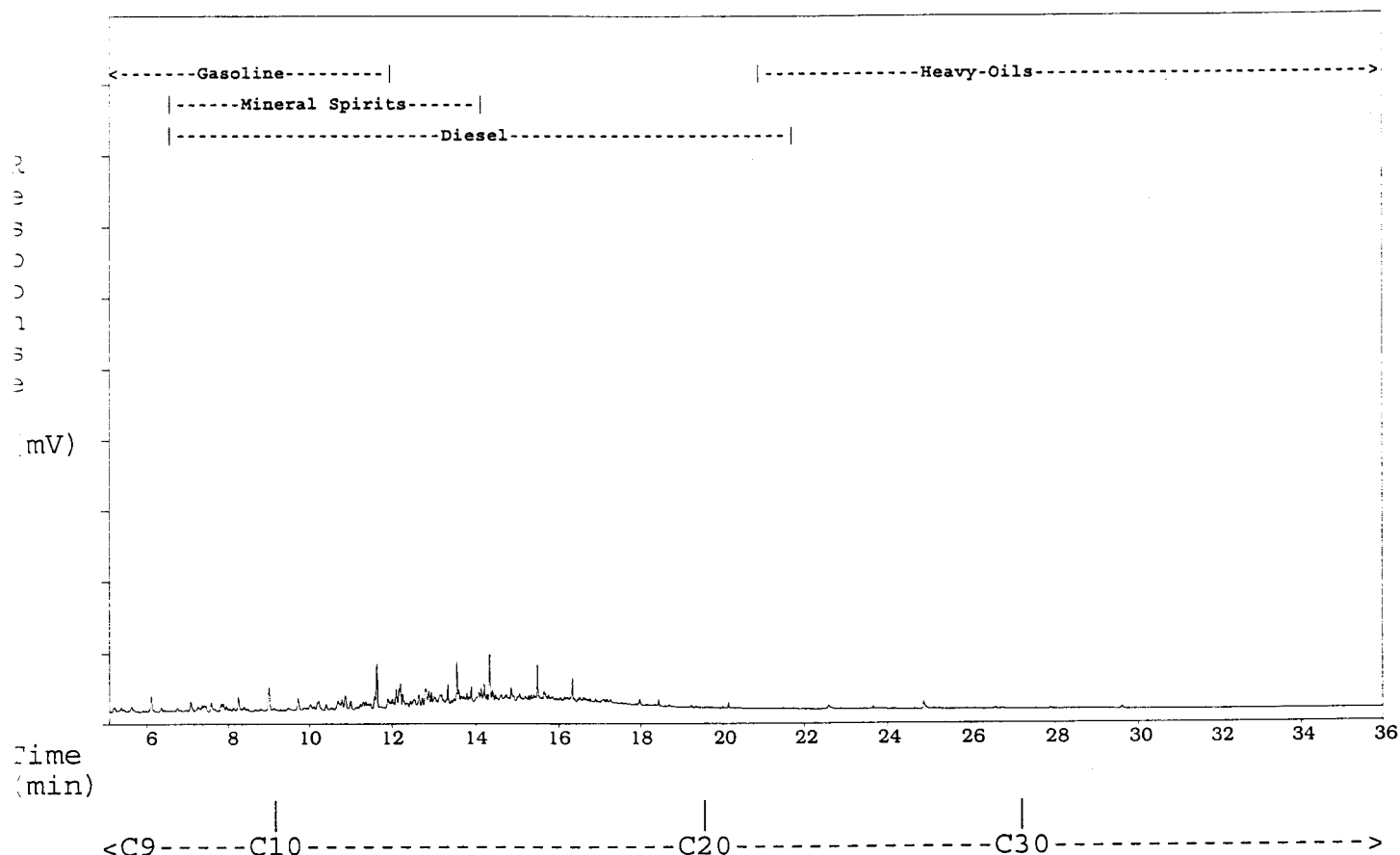
SAMPLE NAME: 98-MP3

Sample acquired: AUG 14, 1998 05:53:54

Sequence File: TEHAUG13

File Name: C:\TEH\AUG13\TEHAUG13.44R , Sample Name: J7584-T--11

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: J7584-T--11*

1.0Dilution

HYDROCARBON RANGE (by Carbon#)

RELATIVE AMOUNT (%)

HYDROCARBON RANGE (by Carbon#)	RELATIVE AMOUNT (%)
C9 (beg-nC9 to beg-nC10)	6.5
C10-C19 (beg-nC10 to beg-nC20)	85.4
C20-C30 (beg-nC20 to beg-nC31)	6.2
C31-C40 (beg-nC31 to beg-nC41)	1.9

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample. The second part of the report is a table that expresses the relative amounts of hydrocarbon product present in the ranges specified. Percent values are relative to the sum of all chromatographic peaks between the retention times of the alkanes n-C9 and n-C40, and are based solely on the areas of those peaks.