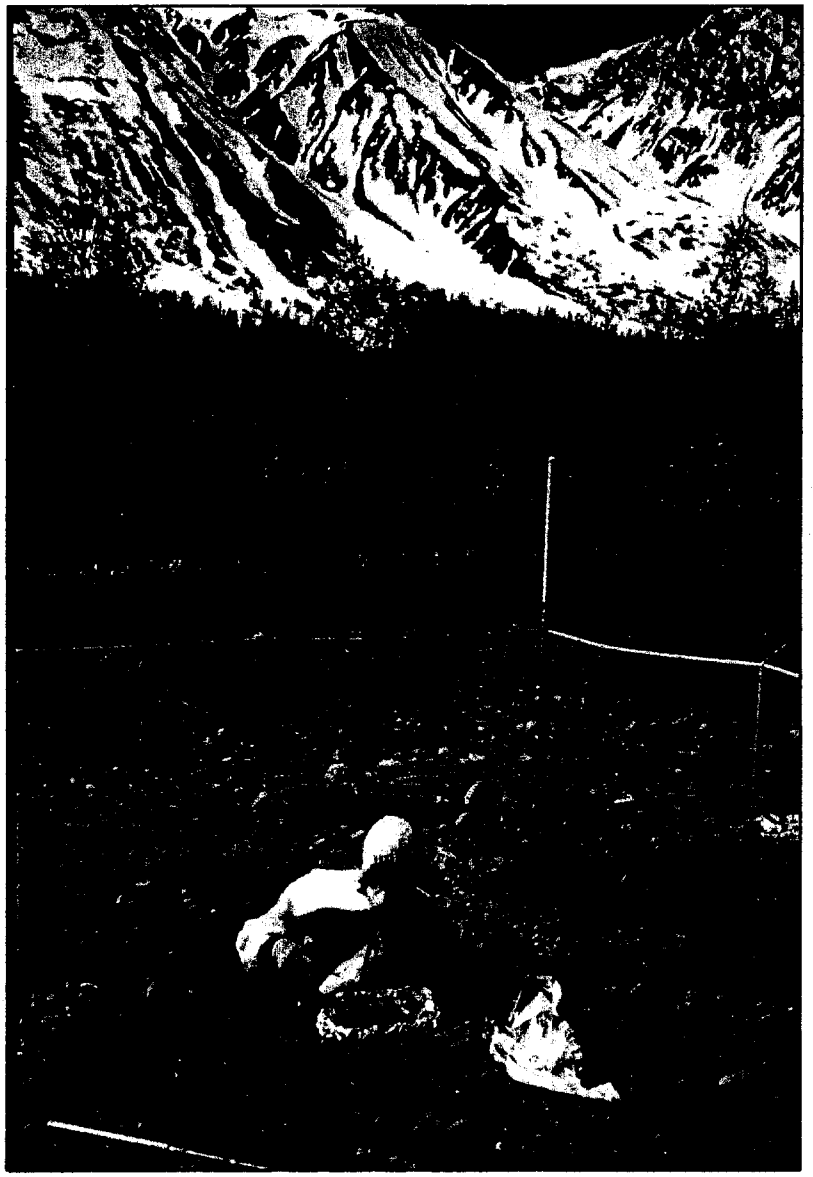
CHARACTERIZATION OF SOILS AT THE TEMPORARY STORAGE FACILITY, BORDER PUMP STATION



Prepared for
INDIAN AND NORTHERN AFFAIRS
ARCTIC ENVIRONMENTAL STRATEGY

Prepared by:

ROYAL ROADS UNIVERSITY
APPLIED RESEARCH DIVISION

October 1996

ROYAL ROADS UNIVERSITY

2005 Sooke Road Victoria, British Columbia, Canada V9B 5Y2
Tel (250) 391-2511 Fax (250) 391-2500
http://www.royalroads.ca

Mr. Brett Hartshorne
Manager
Action on Waste - Yukon
Indian and Northern Affairs Canada
#345, 300 Main St.
Whitehorse, Yukon
Y1A 2B5

2 December, 1996

Dear Brett:

We are very pleased to submit 12 additional copies of our report, *Characterization of Soils at the Temporary Storage Facility, Border Pump Station.*

The report addresses investigations into the DDT and hydrocarbon concentrations, soil contaminant leachability (B.C. SWEP), bioassays (static acute trout), and physical characteristics of the soil pile. A brief overview of the characteristics of DDT and its metabolites (DDE and DDD) including environmental fates is also provided. The above information provided guidance into the remedial solutions for the contaminated soil as well as some insights into the environmental partitioning of DDT.

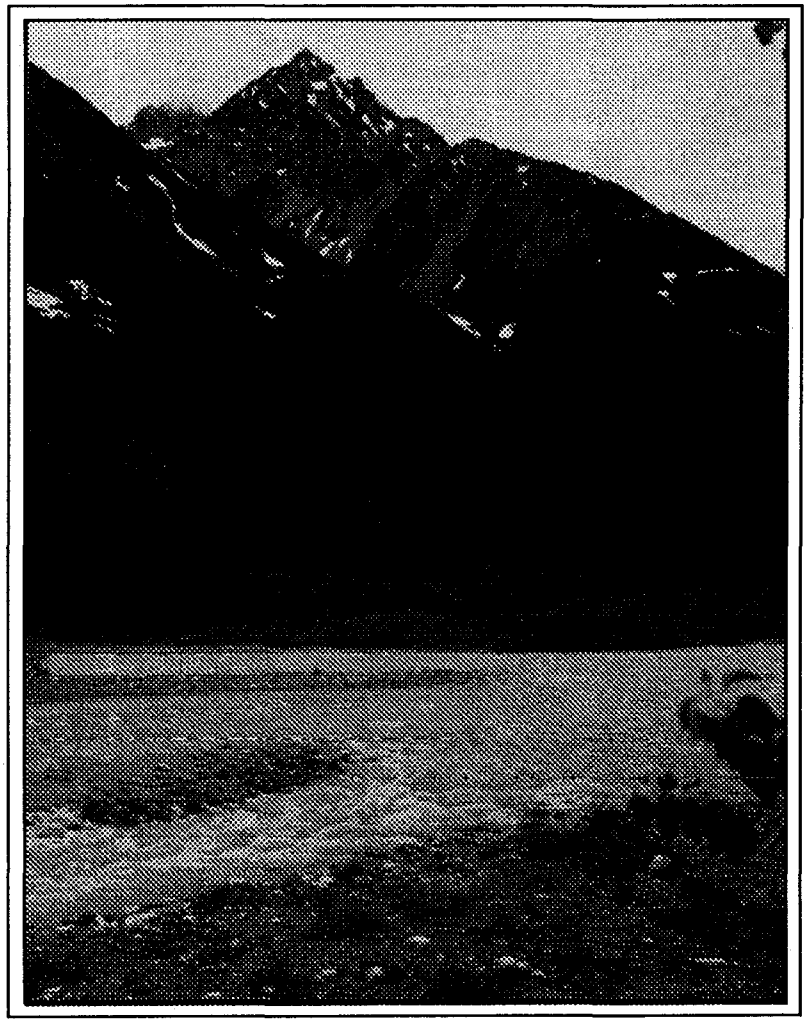
The total volume of the soil pile was estimated to be less than 330 m^3 with DDT and its metabolites in collected soil samples ranging in concentration between 3.58 to 571 mg/kg (ppm). Elevated concentrations (2.34 to 4.71 mg/kg) were also detected in the retaining berm. Hydrocarbon in the soils was mostly diesel in origin with measureable quantities of heavy oils (lubricants and grease). Leachability results for DDT (and metabolites) in the soils was far below the criterium set for B.C. (3.0 mg/L); these results were also highly correlated with total DDT concentrations. The two soil samples submitted for the 96 h trout bioassay exhibited extremely low mortality (≤ 3%) at the three different dilutions tested and were not considered to be dangerous or extremely hazardous in accordance with Washington State Dept. of Ecology Guidelines.

We trust this report meets your satisfaction. If you have any questions or comments, please let us know. We look forward to doing additional environmental work with you in the near future.

Sincerely,

Matt Dodd
Applied Research Division

CHARACTERIZATION OF SOILS AT THE TEMPORARY STORAGE FACILITY, BORDER PUMP STATION



Prepared for
INDIAN AND NORTHERN AFFAIRS
ARCTIC ENVIRONMENTAL STRATEGY

Prepared by:

ROYAL ROADS UNIVERSITY
APPLIED RESEARCH DIVISION

October 1996

TABLE OF CONTENTS

LIST OF TABLES, FIGURES AND PHOTOGRAPHS

1. INTRODUCTION

2. METHODS

3. RESULTS AND DISCUSSIONS

1. INTRODUCTION

1.1 Scope and Objectives

Some of the research interests of the Applied Research Division include the environmental partitioning, cycling, and persistence of chlorinated organic contaminants - especially DDT isomers. The high concentrations of DDT detected in the soils at Border Station and Rainy Hollow (Golder, 1995) afforded an opportunity to investigate the effects of soil and groundwater properties on the environmental fate of DDT and related residues. In May 1996, the Applied Research Division submitted a proposal for funding consideration under the Yukon Arctic Environmental Strategy, Action on Waste Program. The proposal was approved and funded under a Contribution Agreement between the Arctic Environmental Strategy - Action on Waste and Royal Roads University - Applied Research Division which was signed on the 24th day of May, 1996.

The objectives outlined in the RRU proposal included:

- The determination of the concentrations and relative composition of DDT and it's breakdown products, and of hydrocarbons in soils within the Temporary Storage Facility at Border Station;

- The collection of data and other relevant information as required for the evaluation of remedial solutions and for the examination of influences on the environmental partitioning of DDT. This included Special Waste Extraction Protocols (SWEP) and bioassays tests; and

- The measurement of the physical parameters of the soil samples and the Temporary Storage Facility.

In order to achieve these objectives, soil samples were collected from the Temporary Storage Facility on May 31st and June 1st, 1996. Sampling was carried out using the BC Ministry of Environment Confirmation Testing Guidelines (1993) for the characterization of *ex situ* soils at contaminated sites. The samples were analyzed for total extractable

hydrocarbons (TEH) and organochlorine pesticides. A selected number of samples were also subjected to static acute trout bioassay and the BC Special Waste Extraction Protocol (SWEP). This report presents the overall results and describes the sampling and analytical methods employed in this study. Analytical laboratory reports also provided.

1.2 Background

1.2.1 Site Location and History

Border Pump Station (59^{O} 31' N, 136^{O} 28' W) is located near the Klehini River at an elevation of 396 m above sea level, just inside the British Columbia border, and 8 km north of the Canada Customs Post at Pleasant Camp. The site is within the Tatsheshini-Alsek Wilderness Park and World Heritage Site and upstream of the Chilkat Eagle Preserve. Border Pump Station, which was one of the largest stations along the Haines-Fairbanks Pipeline, was constructed at Mile 47 on the old Haines Highway in the mid 1950's. The station consisted of several facilities (main pump buildings and accommodations) along the upper bench of the old Haines Highway and an airstrip and water pumping station situated along an old flood plain to the south on the shore of the Klehini River. The lower bench is referred to as "Rainy Hollow". A general layout of the site is given in Figure 1-1.

The Haines-Fairbanks pipeline was decommissioned in 1972. Following its closure, the 13 ha of land used by the station was reclaimed by the BC Land Management Branch in 1977; the Border Station facilities were used as a base camp for the Haines Road re-alignment in 1978 and 1979, and for mineral exploration from 1983 to 1987. The station was finally closed in 1987 at which time a cleanup was conducted by BC Ministry of Forests. All of the buildings and facilities were subsequently demolished by the Department of Public Works under contract to DIAND in 1992-3, and buried on site (Royal Roads University, 1995).

1.2.2 1994 Remedial Response Action

Following receipt of a verbal report (June 1993) that canisters containing DDT pesticides were buried in a dump along the airstrip at Rainy Hollow, an investigation was conducted by BC Environment on September 6, 1994 (Golder, 1995). This initial site investigation confirmed the presence of two canisters containing DDT in a hydrocarbon carrier at the identified location. An environmental emergency was declared and CEDA Reactor Ltd. of Edmonton, Alberta was contracted by Environment Canada to assist in the excavation and removal of all additional DDT canisters. Golder Associates Ltd. provided technical assistance for this remediation work (Golder 1995).

The excavation uncovered 38 additional canisters in the Trench with estimated total DDT concentrations in the range of 378 to 2177 mg/kg. The canisters, along with other materials which were suspected to be contaminated such as wastewater, empty barrels, transformer oil, and unknown solids were placed in overpack barrels and shipped off-site for treatment at a facility in the USA. Soils and associated debris were placed in four stockpiles adjacent to the Trench. The concentration of total DDT in five samples collected from these piles ranged from 15 mg/kg to 59 mg/kg. After completion of the excavation, an Arctic grade polyethylene line was placed in the bottom of the excavation and the Trench was backfilled with surface material. A reinforced polyethylene liner was placed over the backfilled material to prevent water infiltration and the area was fenced off.

1.2.3 Temporary Storage Facility

A temporary storage facility was constructed on the upper bench at Border Station for the DDT contaminated soils removed during the excavation of the buried canisters. After grading the selected area with a D-4 dozer, a polyethylene line of 30 mil thickness, which was the only piece available at the time, was placed at the northern end. An Arctic 30 liner, delivered to the site at a later date, was used to underlay the southern section. After manual removal of associated debris, the contaminated soil was hauled by truck from the trench area and placed onto the liner. Six composite samples were collected from the soil

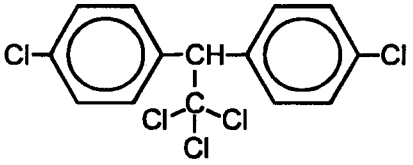
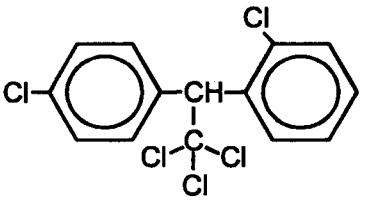
stockpiled on the liner. The concentrations of total DDT (parent DDT and its degradation products) ranged from 4.8 to 35.8 mg/kg (ppm). After placing all the contaminated soil on the liner, a dozer was used to spread and compact the material. Two reinforced polyethylene tarps (24' x 80', 15 mil thickness) were placed on top of the pile so that the edges were covered leaving a two-foot gap along the centre line of the pile. A third tarp (40' x 80') was placed over the top to provide a double layer over the majority of the material. The facility was secured within a chain-link fence.

1.3 DDT, DDE and DDD: BRIEF OVERVIEW

1.3.1 What are DDT, DDE and DDD?

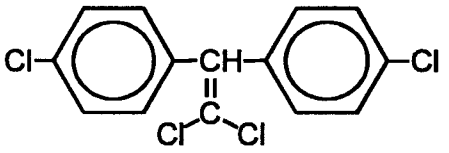
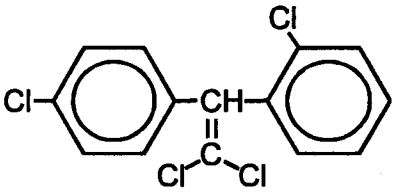
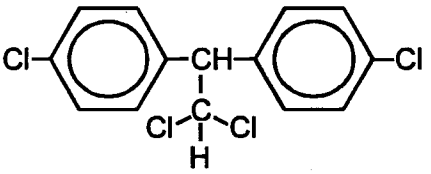
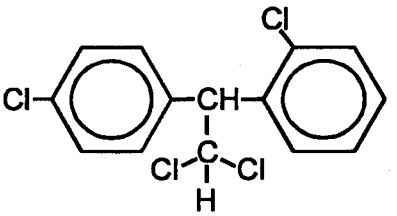
The name DDT is derived from Dichloro-Diphenyl-Trichloroethane and is the generic name for 1,1,1-trichloro-2,2-*bis*-(p-chlorophenyl) ethane. Pure DDT is a white, crystalline, tasteless, odourless solid. It is not very volatile (vapour pressure at 20 C = $1.5x10^{-7}$ mm Hg) and has a very low water solubility but high solubility in organic solvents. Technical grade DDT is a white amorphous powder containing several similar compounds. The two principal isomers of DDT are given in Table 1.1 below. The o, o'-DDT or 2,2'-DDT isomer 1,1,1-trichloro-2,2-*bis*-(o-chlorophenyl) ethane also occurs in smaller quantities.

Table 1.1: Chemical names and structures of DDT isomers

Common Name	Chemical Name	Composition in Technical Mixture	Structure
p, p'-DDT or 4,4'-DDT	1,1,1-trichloro-2,2-*bis*-(p-chlorophenyl) ethane	70-80%	
o, p'-DDT or 2,4'-DDT	1,1,1-trichloro-2- (o-chlorophenyl)-2-(p-chlorophenyl) ethane	up to 30%	

DDE (dichloro-diphenyl-ethylene) and DDD (dichloro-diphenyl-dichloroethane) occur in small quantities as impurities in technical DDT mixtures: chemical names and structural formulae for DDE and DDD isomers are given in Table 1.2. DDE and DDD are also produced either metabolically or photochemically in the environment from the dechlorination of DDT.

Table 1.2: Chemical names and structures of DDE (dichloro-diphenyl-ethylene) isomers

Common Name	Chemical Name	Structure
p, p'-DDE or 4,4'-DDE	1,1-dichloro-2,2-*bis* (p-chlorophenyl) ethylene	
o, p'-DDE or 2,4'-DDE	1,1-dichloro-2- (o-chlorophenyl)-2-(p-chlorophenyl) ethylene	
p, p'-DDD or 4,4'-DDD	1,1-dichloro-2,2-*bis* (p-chlorophenyl) ethane	
o, p'-DDD or 2,4'-DDD	1,1-dichloro-2-(o-chlorophenyl)-2-(p-chlorophenyl) ethane	

1.3.2 Environmental Fate

DDT was discovered to have insecticidal properties during the second world war and its use significantly reduced the incidence of insect borne diseases such as malaria and typhus. The low cost of DDT, its high activity against insects, ease of application and persistence encouraged its use by civilians after the war. It was used extensively to control a wide ranges of insect pests on agricultural lands. Swamps, forests as well as residential areas were sprayed with DDT to control insect pests.

Early investigations indicated that excessive use of DDT could kill fish, birds and other wildlife. Residues of DDT were found in plant and animal tissue and cows milk, but these were accepted as unavoidable hazards and of little concern. During the 1950's and 1960's, residues of DDT and other organochlorine insecticides were detected in soils and small amounts in water and sediments[5]. Dead birds and fish were found around areas sprayed with DDT. Thinning of bird egg shells and birth deformities in birds were also linked to DDT and other organochlorine compounds. Humans were exposed to DDT through ingesting food containing DDT residues and there were indications that DDT and other organochlorine insecticides were concentrated into the upper trophic levels of the food chain (biomagnification). For example, high levels of DDT were detected in mother's milk. Other pathways for human exposure to DDT include ingestion of contaminated soil particles, inhalation of contaminated air and adsorption through the skin. Short term exposure to DDT affects the primarily the nervous system; highly exposed soldiers in the second world war had suffered aching joints, tremors and depression. Long term exposure to low doses results in some reversible changes in the level of liver enzymes. Because of these observed effects and the potential harm to human beings (such as carcinogenesis and endocrine disruption), the use of DDT was banned in many developed countries including Canada and the USA in the early 1970's. It is still, however, in use in some countries including Mexico.

The presence of DDT in the Canadian environment is generally a result of contamination due to past use or incorrect disposal practices, as is the case in Rainy Hollow. DDT degrades rapidly in air with a half life of less than two days. It is not readily soluble in water, but adheres strongly to soil particles wherein it is persistent (half life of up to 15 years). Metabolites (degradation products) in the soil are usually DDE and DDD. No numerical soil guidelines exist in Canada.

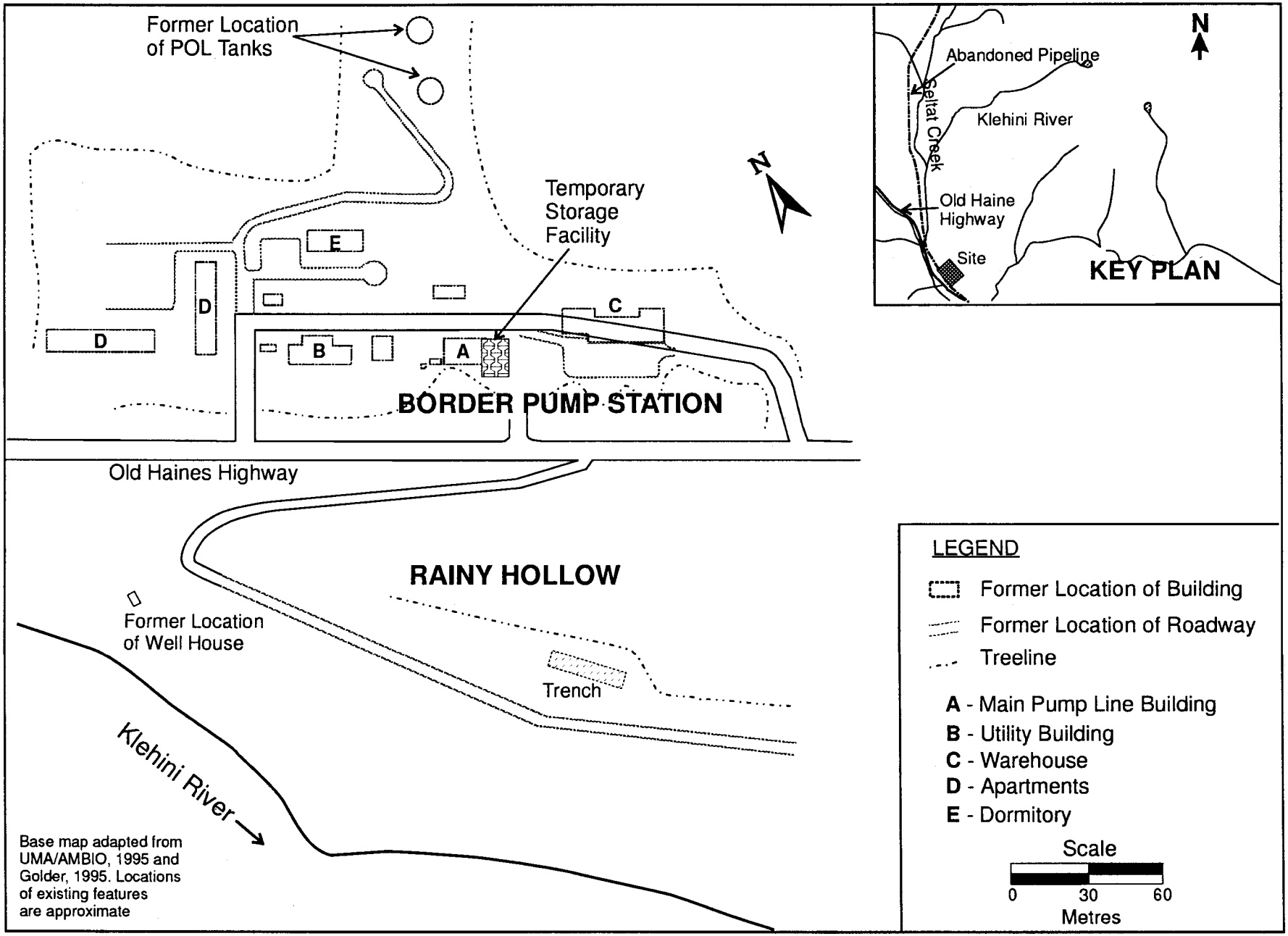


Figure 1.1: General Layout of Border Pump Station and Rainy Hollow

2. METHODS

2.1 Field Program

2.1.1 General

A field team comprised of Matt Dodd and Bill Dushenko from Royal Roads University and Werner Liebau from the Northern Research Institute, Yukon College (AES, Action on Waste summer student trainee) conducted the field program at the Temporary Storage Facility on May 31st and June 1st, 1996. The field team was accompanied by Alex Grant (British Columbia Ministry of the Environment Lands and Parks, Smithers) and Nikki Krocker (a DIAND summer trainee) during the site reconnaissance survey on the morning of May 31st.

Sampling was carried out using the "Confirmation Testing Guidelines for the Characterization of *ex situ* Soils at Contaminated Sites" (BC Ministry of Environment, 1993). In order to protect the team members from exposure to DDT contaminated soil through ingestion, dermal adsorption or inhalation, disposable gloves, coveralls, and dust masks were used throughout the sampling program.

2.1.2 Physical Characterization

After removing the three reinforced polyethylene tarpaulin coverings (Photographs 2.1 and 2.2), the length and width of the pile of contaminated soil were measured using survey tapes. The pile measured 20 m x 12 m and was divided into 15 quadrats comprising a 4 m by 4 m grid system. These quadrats were assigned a letter designation from "A" to "O". A general layout of the Temporary Storage Facility and the grid system is shown in Figure 2.1. The height of contaminated soil relative to the surrounding terrain was estimated from each corner of the grid by means of survey tape. The data obtained are presented in a three-dimensional plot in Figure 2.2. The physical characteristics of the substrate in the pile was also noted; this comprised sand, gravel, rocks, wood and metallic debris and pieces of tarpaulin (Photographs 2.3 and 2.4).

2.1.3 Sampling Program

Twenty soil samples were collected from the Temporary Storage Area. These included composite samples taken from each of the 15 quadrats, field duplicate samples obtained from three of the quadrats (to satisfy quality assurance/quality control requirements) and two samples collected from the northeast and the southwest berms. The composite sample from each quadrat was obtained as follows. Five samples were collected from varying depths at different locations using a shovel and a 2.5 cm diameter x 25 cm stainless steel auger equipped with a one-meter handle (Photograph 2.5). The sampling locations and depths are given in Figure 2.3. The samples from each quadrat were placed in an aluminum foil lined-bowl and carefully homogenized using a stainless steel scoop (Photograph 2.6). A subset of the homogenized sample was then placed into a labeled 125 mL glass jar and capped with a Teflon lined lid. In order to avoid cross contamination, a fresh aluminum foil lining and stainless steel scoop was used for each quadrant. The jars were kept in a cooler and shipped to the laboratory via guaranteed air freight.

2.2 Analytical Program

All of the samples were analyzed for organochlorine pesticides (OCP) and extractable hydrocarbons at Analytical Services Laboratories Ltd. (ASL), Vancouver, BC. Five samples were subjected to the BC MOE Special Waste Extraction Procedure (SWEP) and the extracts were analyzed for OCP. In addition, a rainbow trout bioassay was carried out on two of the samples.

2.2.1 Organochlorine Pesticides (OCP)

Organochlorine pesticides in soils were determined with methodology adapted from US EPA Methods. A summary of the method is provided in the ASL Chemical Analysis Report attached in Annex A. The analytes included the following pesticides: Aldrin, alpha-BHC (Benzene HexaChloride or hexachlorocyclohexane), beta-BHC, delta-BHC, cis-Chlordane, trans-Chlordane, 2,4'-DDD (Dichloro Diphenyl Dichloroethane), 4,4'-DDD, 2,4' DDE (Dichloro Diphenyl Ethylene) 4,4'-DDE, 2,4'-DDT (Dichloro Diphenyl

Trichloroethane), 4,4'-DDT, Dieldrin, Endosulfan, Endrin, Heptachlor, Heptachlor epoxide, Lindane, Metoxychlor, Mirex, cis-Nonachlor, trans-Nonaclor, Oxychlordane and Toxaphene.

2.2.2 Extractable Hydrocarbons

Two different procedures were used for the determination of extractable hydrocarbons in the soil samples. The methods are summarized in the ASL Chemical Analysis Report attached in Annex A. The first method is equivalent to the BC Ministry of Environment Land and Parks Method for "Extractable Petroleum Hydrocarbons (EPH) in Soils" involving hexane/acetone extraction and analysis using GC/FID. EPH results are presented for components in the C10 to C18 and C19 to C31 ranges. The second methodology which is referred to as Total Extractable Hydrocarbons (TEH) is based upon US EPA Method 3500/8015. Data is reported for the C9 - C40 and C10 - C30 hydrocarbon ranges.

2.2.3 Leachable Organic Components

The organic components in five soil samples were tested for leachability according to the BC Ministry of Environment Land and Parks (Waste Management Act - Special Waste Regulation) extraction procedure. A summary of the method is given in the ASL Chemical Analysis Report attached in Annex B. The procedure simulates the aqueous mobility of organic contaminants in the soil and hence the potential for migration into the environment. The extract obtained was analyzed for organochlorine pesticides as outline above.

2.2.4 Bioassay

Two soil samples were subjected to a 96-hour static acute bioassay using rainbow trout in accordance with the Washington State Department of Ecology Guidelines (Method 80-12). This is a required test for the classification of hazardous waste in Washington State. The analysis was carried out by Parametrix Inc., Kirkland, WA, USA. A laboratory report, which includes the methods, is given in Annex C.

Photograph 2.1: Temporary Storage Facility showing fence and DDT contaminated soil with tarpaulin covering

Photograph 2.2: Removing tarpaulin coverings from the DDT contaminated soil at the Temporary Storage Facility

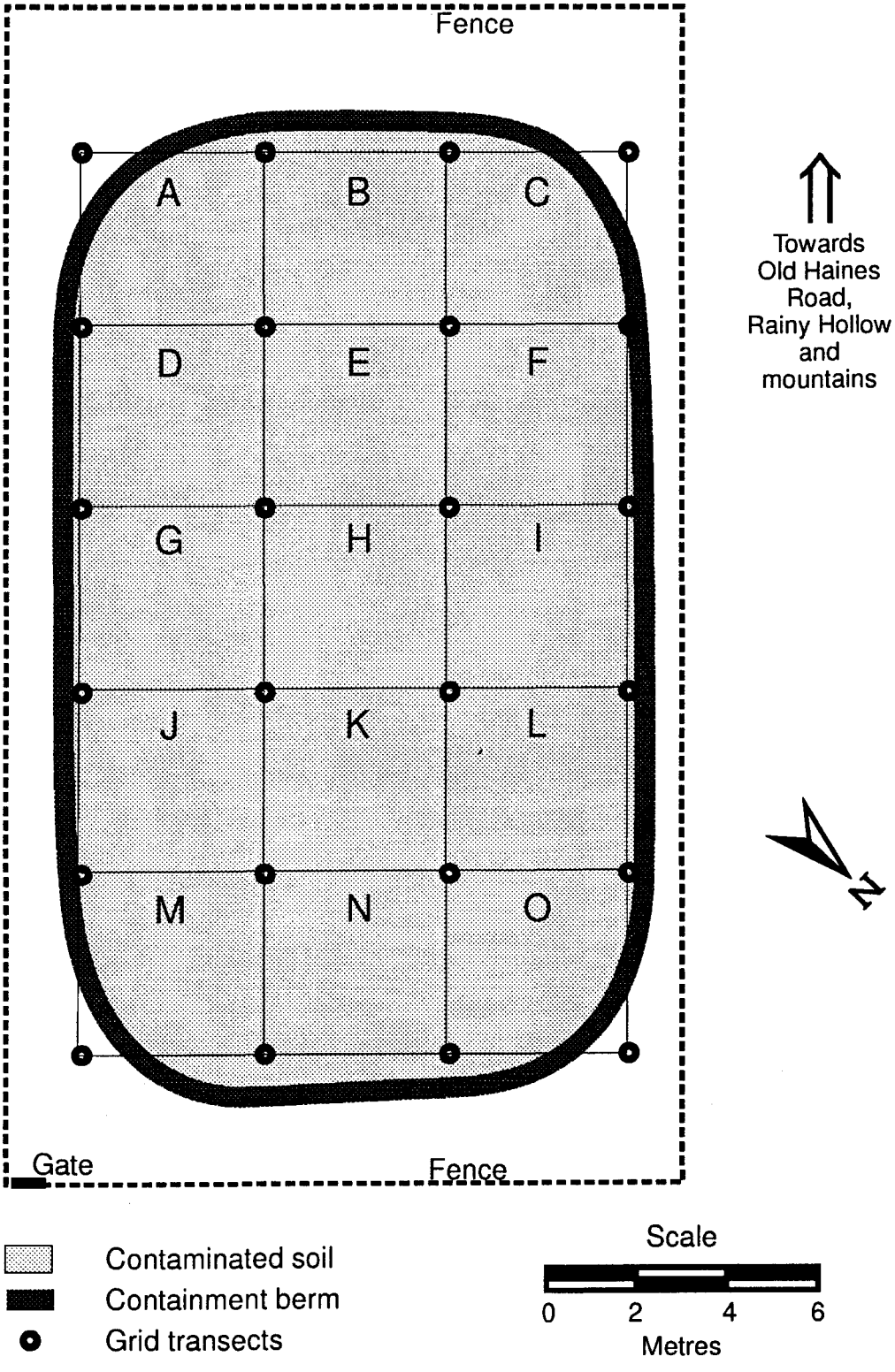
Photograph 2.3: Surface of contaminated soil at the Temporary Storage Facility showing rocks, tarpaulin, wood and metallic debris

Photograph 2.4: Examples of debris excavated from a test pit at the Temporary Storage Facility

Photograph 2.5: Collecting a soil sample from a test pit at the Temporary Storage Facility

Photograph 2.6: Aluminum foil-lined bowl containing a homogenized sample and a stainless steel scoop

Figure 2.1: General Layout and Sampling Grid System Used at the Temporary Storage Facility, Border Station



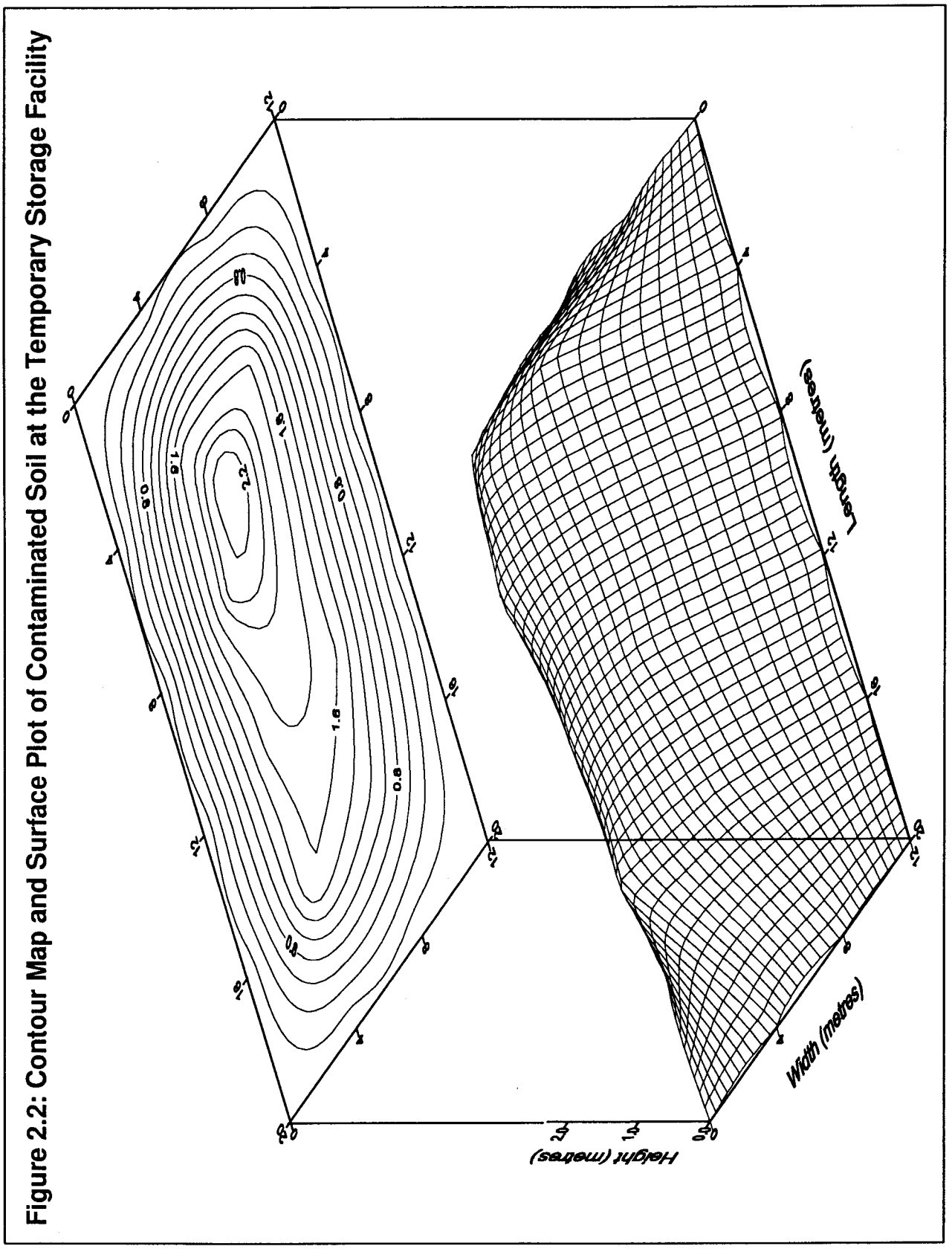
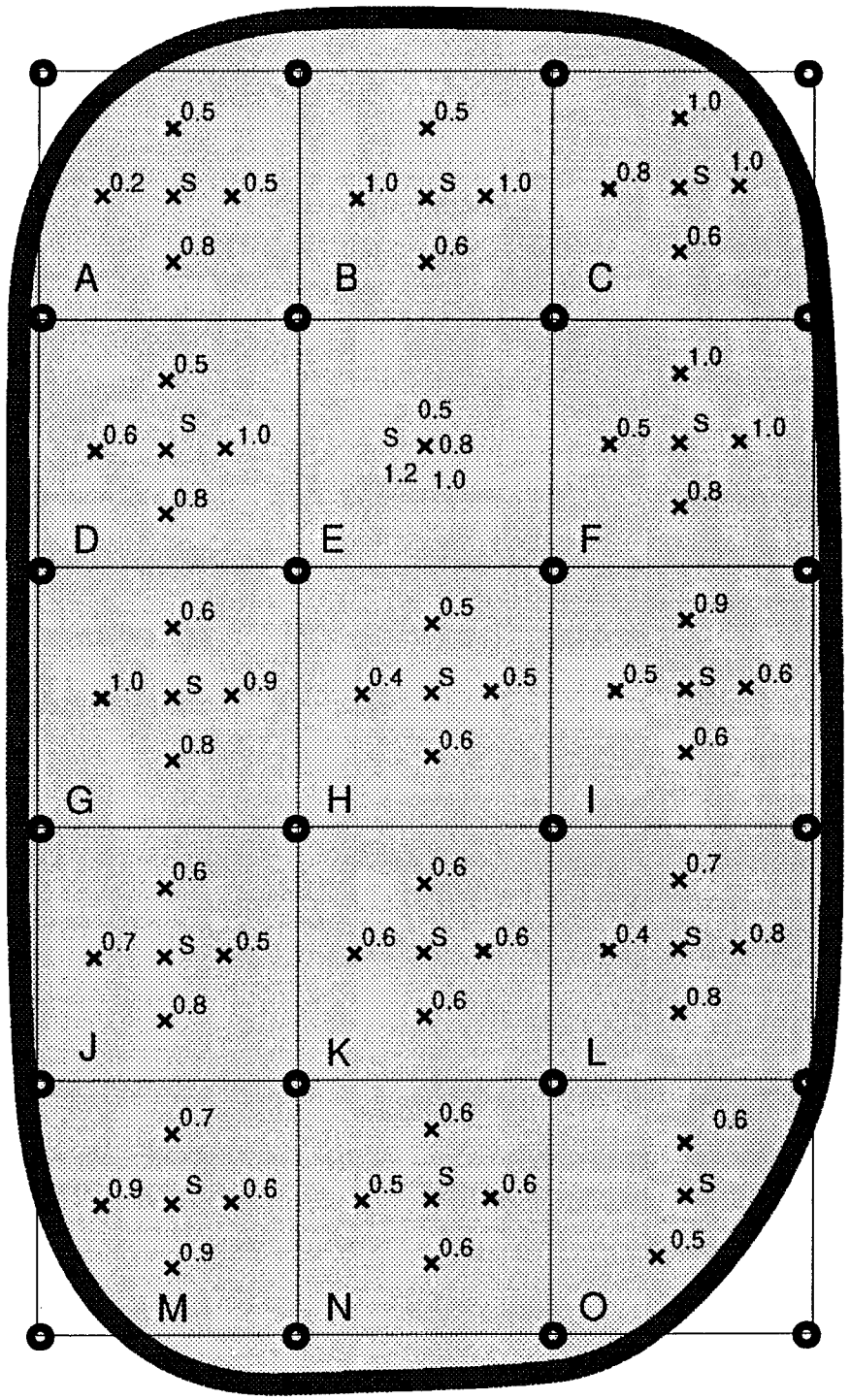


Figure 2.2: Contour Map and Surface Plot of Contaminated Soil at the Temporary Storage Facility

Figure 2.3: Sampling Locations and Depths



S Surface sample

0.5 Sub-surface samples with depth (m)

Samples from each quadrant were pooled into one composite

Scale

0 2 4 6

Metres

3. RESULTS AND DISCUSSIONS

3.1 Physical Characterization

The volume of contaminated substrate in the Temporary Storage Facility, which included sand, gravel, rocks, wood, metallic debris and pieces of tarpaulin, was estimated by trapezoidal rule using Surfer® software. On the basis of a length of 20 m, width of 12 m and height of up to 2.3 m relative to the surrounding terrain, the volume was calculated to be 275 m^3. Allowing for a 20% margin of error, the estimated total volume is less than 330 m^3.

3.2 Analytical Results

3.2.1 Organochlorine Pesticides

The concentrations of organochlorine pesticides in samples collected from the Temporary Storage Facility are given in the Laboratory Chemical Analysis Report located in Annex A. The data obtained were consistent with the disposal of DDT containing canisters in the Trench. The predominant analytes detected were DDT and its breakdown products (DDD and DDE); most of the other organochlorine pesticides were below detection.

A summary of the DDT, DDD and DDE data is given in Table 3.1. The total concentrations of DDT and metabolites in samples collected from the contaminated substrate (A1 - O17) ranged from 3.58 to 57.1 mg/kg (ppm). These concentrations were in roughly the same order of magnitude as those found in composite samples collected during the emergency response, which had total DDT that varied from 4.8 to 35.8 mg/kg (Golder, 1995). The average total concentration (18.4 mg/kg) was virtually identical to the average value measured for the samples obtained the emergency response (18.8 mg/kg).

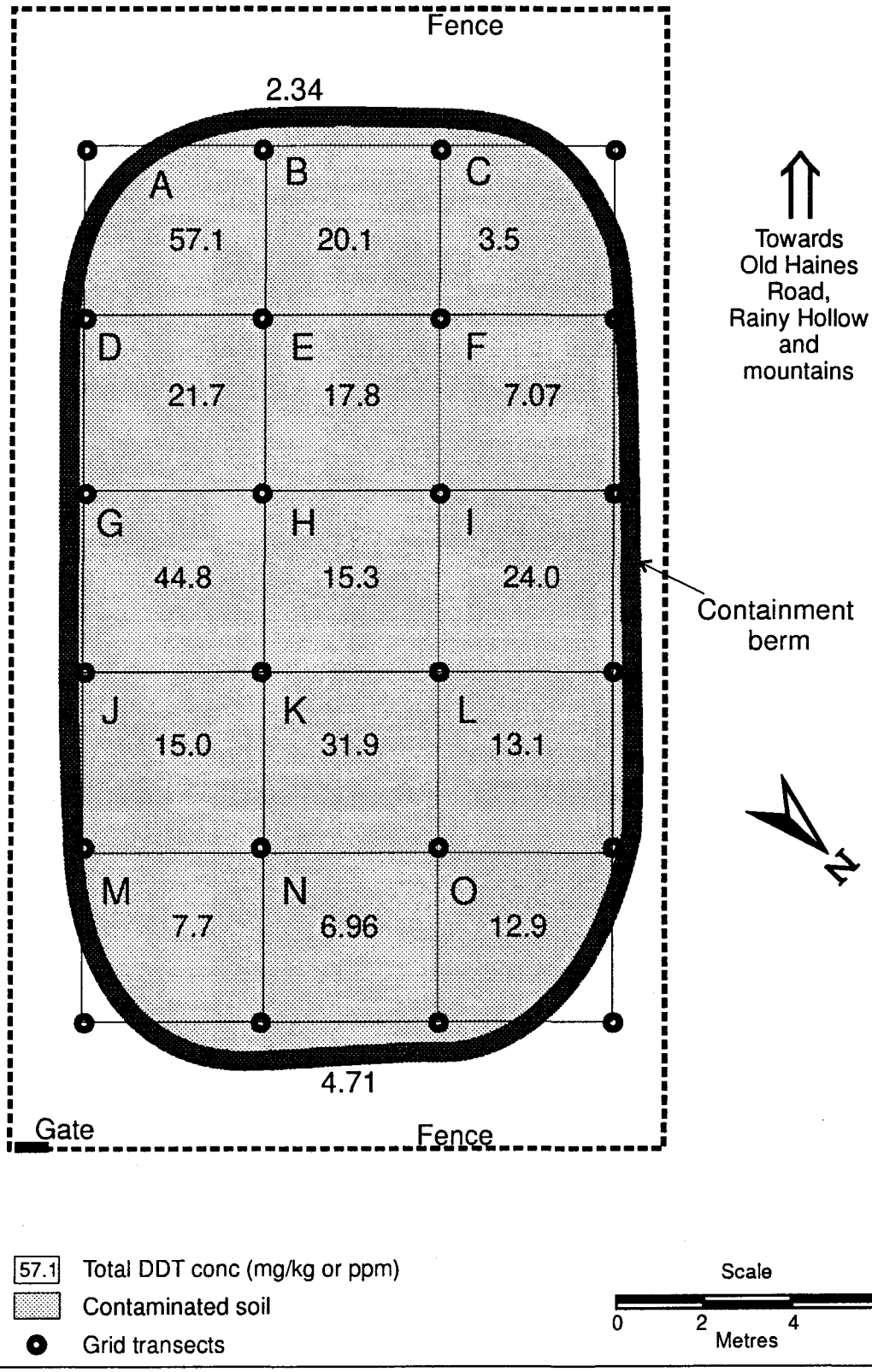
Samples collected from the retaining berm (NEB 18 and SWB19) were also found to contain DDT and metabolites. The total concentrations were 2.34 and 4.71 mg/kg, respectively. A general layout of the Temporary Storage Area with the concentrations of total DDT, DDD and DDE isomers is given in Figure 3.1.

Table 3.1: Concentrations (mg/kg or ppm) of DDD, DDE and DDT in soils samples collected from the Temporary Storage Facility at Border Station

Sample	2,4'-DDD	4,4'-DDD	2,4'-DDE	4,4'-DDE	2,4'-DDT	4,4'-DDT	Total DDD, DDE and DDT Isomers	Location
A1	4.72	22.3	0.070	0.26	8.83	20.9	**57.1**	Grid A
B2	1.78	7.79	0.035	0.11	2.81	7.57	**20.1**	Grid B
C3	0.38	2.09	0.015	0.053	N/A	1.04	**3.58**	Grid C
D4	2.16	11.9	0.032	0.109	N/A	7.49	**21.7**	Grid D
E5	1.67	12.1	0.27	0.73	N/A	2.72	**17.9**	Grid E
E6	1.89	12.8	0.032	0.083	N/A	2.78	**17.6**	Grid E, duplicate
F7	0.33	2.27	0.008	0.039	1.18	3.24	**7.07**	Grid F
G8	2.13	14.8	0.26	0.174	7.78	19.7	**44.8**	Grid G
H9	1.34	9.11	0.021	0.062	N/A	4.77	**15.3**	Grid H
I10	0.96	6.37	0.026	0.093	4.98	11.6	**24.0**	Grid I
J11	1.01	6.08	0.013	0.056	2.25	5.56	**15.0**	Grid J
J20	1.05	6.03	0.012	0.032	N/A	1.13	**8.25**	Grid J, bottom
K12	2.29	14.0	0.038	0.114	4.58	10.9	**31.9**	Grid K
L13	1.03	5.68	0.026	0.069	1.96	4.34	**13.1**	Grid L
M14	0.551	4.85	0.006	0.033	N/A	2.26	**7.70**	Grid M
N15	0.523	4.36	0.007	0.033	N/A	1.52	**6.44**	Grid N
N16	0.467	3.53	<0.002	0.027	N/A	3.46	**7.48**	Grid N duplicate
O17	1.06	8.36	0.012	0.056	N/A	3.46	**12.9**	Grid O
NEB18	0.092	0.508	0.005	0.124	0.361	1.25	**2.34**	Northwest berm
SWB19	0.105	1.27	0.009	0.376	N/A	2.95	**4.71**	Southwest berm

N/A = The compounds 2,4'-DDT and 4,4'-DDD eluted together and could not be quantified separately. The 2,4'-DDT and 4,4'-DDD results were calculated as the sum of the two compounds and the data is noted and reported for 4,4'-DDD.

Figure 3.1: General Layout and Concentrations of Total DDT at the Temporary Storage Area, Border Station

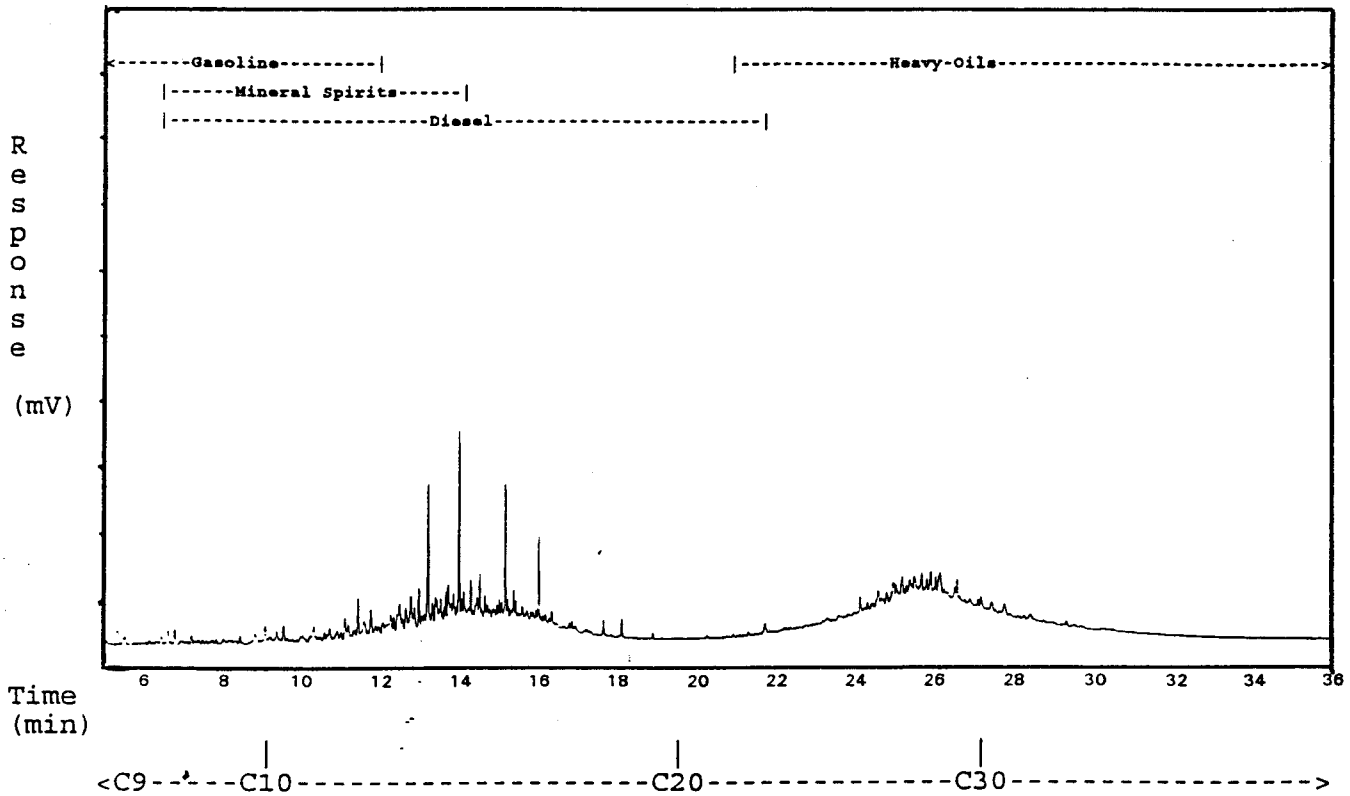


3.2.2 Extractable Hydrocarbons

The complete data for extractable petroleum hydrocarbons (EPH) and total extractable hydrocarbons (TEH) in soil samples collected from the Temporary Storage Area are provided in the ASL Chemical Analysis Report attached in Annex A. Extractable petroleum hydrocarbon components in the C10 to C18 range varied from <250 mg/kg to a maximum of 2940 mg/kg while concentrations for the C19 to C31 components were up to 2200 mg/kg. Concentrations for the entire range of total extractable hydrocarbons (C9 - C40) varied from 609 to 4130 mg/kg.

In order to characterize the type of hydrocarbon products present in the Temporary Storage Facility, the gas chromatographs obtained from the analysis were examined. Chromatographic traces of all the samples are attached to Annex A; the trace shown in Figure 3.2 below was typical of the hydrocarbon signature. An examination of this trace indicated the hydrocarbons consisted mostly of diesel along with measurable quantities of heavy oils. These observations are consistent with the use and disposal of diesel and heavy oils, such as lubricating oils and grease, at the site.

Figure 3.2: Gas chromatographic trace and hydrocarbon distribution report of composite sample collected from Grid N16 at the Temporary Storage Facility, Border Station



ASL Sample ID: G1666 3* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	2.3
Carbon 10 to Carbon 20	(C10-C20)	45.0
Carbon 20 to Carbon 30	(C20-C30)	31.8
Greater than Carbon 30	(>C30)	20.9

3.2.3 Leachable Organochlorine Pesticides

The organic components in five soil samples (A1, C3, G8, J20 and SWB19) were tested for leachability according to the BC Ministry of Environment Land and Parks, Special Waste Regulation, Leachate Extraction Procedure. The procedure simulates the aqueous mobility of organic contaminants in the soil and hence the potential for migration of contaminants into the environment under normal weather conditions. Samples were extracted with dilute acetic acid solution and resulting leachates were analyzed for organochlorine pesticides.

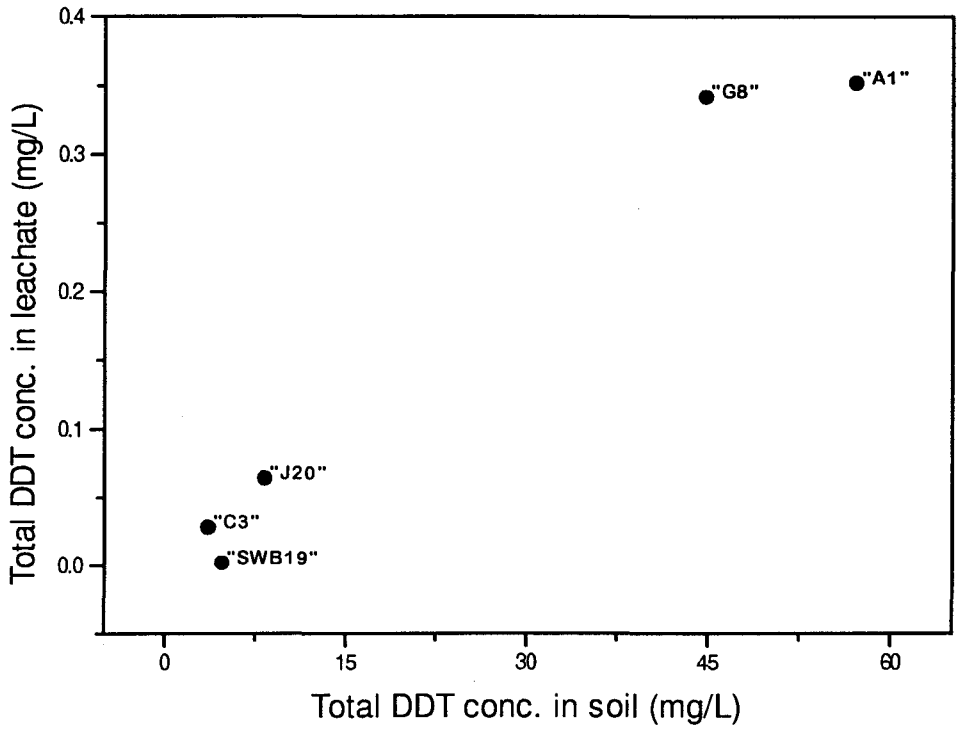
Detailed leachable organochlorine pesticide concentrations are given in Annex B. A summary of the DDD, DDE and DDT data is provided in Table 3.2. The maximum concentration of total DDT and metabolites detected in the extracts was 0.352 mg/L which is well below the Leachate Quality Criteria for DDT (3.0 mg/L) (Special Waste Regulations, BC Reg. 63/88).

Table 3.2: Concentrations (mg/L) of DDD, DDE and DDT in SWEP extracts

Sample	2,4'-DDD	4,4'-DDD	2,4'-DDE	4,4'-DDE	2,4'-DDT	4,4'-DDT	Total DDD, DDE and DDT Isomers	Location
A1	0.028	0.109	<0.001	0.001	0.065	0.149	0.352	Grid A
C3	0.003	0.012	<0.001	<0.001	0.003	0.01	0.028	Grid c
G8	0.02	0.079	<0.001	0.001	0.071	0.171	0.342	Grid G
SWB19	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	Southwest berm
J20	0.012	0.046	<0.001	<0.001	<0.005	0.006	0.064	Grid J

There was a significant positive correlation between the total DDT concentration in the SWEP extracts and total DDT levels in the soil samples (r^2 = 0.98, p <0.001). The relationship is depicted in Figure 3.3.

Figure 3.3: Relationship between soil and leachate DDT concentrations



3.2.4 Bioassay

Two soil samples (D4 and E5) were subjected to a 96-hour static acute bioassay using rainbow trout (*Oncorhynchus mykiss*). The bioassay was conducted at the 10 mg/L and 100 mg/L concentrations. Sample D4 exhibited 0% mortality at the 10 mg/L concentration and 3% mortality at the 100 mg/L concentration while E5 showed 3% mortality at both concentrations. The samples are therefore not considered dangerous or extremely hazardous in accordance with the Washington State Department of Ecology Guidelines. A detail laboratory report which contains the analytical results are given in Annex C.

3.3 Quality Assurance/Quality Control (QA/QC)

A quality assurance/quality control program was implemented to allow monitoring of data quality. The program included analysis of two field duplicates and two analytical or

procedural duplicates. Agreement between duplicates can be measured either by direct comparison or by calculating the relative standard deviation (RSD), which is simply the standard deviation of the duplicates divided by the mean (expressed as a percentage). Values of RSD less than 30% indicate reasonable to good precision, while those exceeding this value are fair to poor.

3.3.1 Organochlorine Pesticide in Soil

For organochlorine pesticide and extractable hydrocarbon analysis, two field duplicate samples (E5, E6 and N15, N16) were submitted to the laboratory to monitor precision externally. The concentrations of all the organochlorine pesticides in these samples except oxychlordane and DDTs were below detection. The average relative standard deviations for DDD, DDE and DDT concentrations in the two sets of replicate samples were between 8.4 and 12% which indicated good precision (Table 3.3).

Table 3.3: Concentrations (mg/L) of DDD, DDE and DDT in field duplicate samples

	2,4'-DDD	4,4'-DDD	2,4'-DDE	4,4'-DDE	4,4'-DDT
E5	1.67	12.1	0.027	0.073	2.72
E6	1.89	12.8	0.032	0.083	2.78
Mean	1.78	12.5	0.03	0.078	2.75
Standard Deviation	0.16	0.50	0.004	0.007	0.042
Relative Standard Deviation (%)	8.7	4.0	12	9.1	1.5
N15	0.523	4.36	0.007	0.033	1.52
N16	0.467	3.53	<0.002	0.027	1.09
Mean	0.495	3.94	-	0.03	1.305
Standard Deviation	0.040	0.050	-	0.004	0.30
Relative Standard Deviation (%)	8	14	-	14	23
Average Relative Standard Deviation (%)	**8.4**	**9.4**	**12**	**11**	**12**

Precision was also monitored internally by ASL through the analysis of two sets of analytical duplicates. The average relative standard deviations for DDD, DDE and DDT concentrations in the two sets of replicate samples (between 2 and 16%) were comparable to those obtained for the field duplicate samples. A summary of the data is given in Table 3.4 below.

Table 3.4: Concentrations (mg/L) of DDD, DDE and DDT in laboratory analytical duplicate samples

	2,4'-DDD	4,4'-DDD	2,4'-DDE	4,4'-DDE	4,4'-DDT
J20	1.05	6.03	0.012	0.032	1.13
J20	1.08	6.84	0.013	0.035	1.33
Mean	1.1	6.4	0.013	0.034	1.2
Standard Deviation	0.02	0.57	0.001	0.002	0.14
Relative Standard Deviation	2.0	8.9	5.7	6.3	11.5
O17	1.06	8.36	0.012	0.056	3.46
O17	1.1	9.42	0.014	0.082	4.52
Mean	1.1	8.9	0.013	0.069	4.0
Standard Deviation	0.028	0.75	0.001	0.018	0.75
Relative Standard deviation	2.6	8.4	11	27	19
Average Relative Standard Deviation	**2.3**	**8.7**	**8.3**	**16**	**15**

3.3.2 Extractable Hydrocarbons

Precision for extractable hydrocarbons (EPH) and total extractable petroleum hydrocarbons (TPH) analysis was performed externally by RRU using two sets of field duplicate samples (E5, E6 and N15, N16). Good analytical precision was indicated for

both samples on the basis of the average relative standard deviations which were between 14 and 22% (Table 3.5).

Table 3.5: Concentrations (mg/L) of extractable petroleum hydrocarbons (EPH) and total extractable hydrocarbons (TEH) in Field duplicate samples

	EPH (C10-18)	EPH (C19-31)	TEH (C9-40)	TEH (C10-30)
E5	2940	570	4130	3630
E6	2260	504	3210	2730
Mean	2600	537	3670	3180
Standard Deviation	480	46	650	636
Relative Standard Deviation (%)	18	8.7	18	20
N15	555	428	1120	850
N16	637	557	1450	1180
Mean	596	492	1285	1015
Standard Deviation	57	91	233	233
Relative Standard Deviation (%)	9.7	18	18	23
Average Relative Standard Deviation (%)	**14**	**14**	**18**	**22**

Two pairs of samples were analyzed by ASL as internal monitors for analytical precision. Average relative standard deviations for the analytes were between 3.8% and 9.0% which indicated good precision.

Table 3.6: Concentrations (mg/L) of extractable petroleum hydrocarbons (EPH) and total extractable hydrocarbons (TEH) in laboratory analytical duplicate samples

	EPH (C10-18)	EPH (C19-31)	TEH (C9-40)	TEH (C10-30)
J20	1630	337	2340	1950
J20	1610	323	2160	1890
Mean	14	10	127	42
Standard Deviation	1620	330	2250	1920
Relative Standard Deviation (%)	0.9	3.0	5.7	2.2
O17	403	<250	531	488
O17	456	<250	637	540
Mean	37		75	37
Standard Deviation	430		584	514
Relative Standard Deviation (%)	8.7		13	7.2
Average Relative Standard Deviation (%)	**4.8**	**3.0**	**9.2**	**4.7**

3.3.3 Leachable Organochlorine Pesticides

One pair of soil samples was analyzed to monitor analytical precision for leachable organochlorine pesticide analysis. Concentrations of all the organochlorine pesticides, except DDD and DDT were below detection (Annex B). Good precision were found for the analytes detected 2,4'-DDD (0.012 and 0.011 mg/L), 4,4'-DDD (0.046 and 0.045 mg/L) and 4,4'-DDT (0.006 and 0.006 mg/L).

References

British Columbia Ministry of Environment (1993) Confirmation Testing Guidelines for the Characterization of *ex situ* Soils at Contaminated Sites.

C. A. Edwards, 1970. Persistent Chemicals in the Environment, CRC Press Ohio.

Golder Associates, 1995. Site Assessment & Remedial Response Program Border Pump Station Rainy Hollow, BC. Report submitted to Environment Canada in March, 1995.

Royal Roads University - Applied Research Division, 1996. Haines-Fairbanks Pipeline: Environmental Issues at Border Pump Station and Rainy Hollow Sites. Report prepared for Indian and Northern Affairs (DIAND) AES in March, 1996.

Special Waste Regulation, Waste Management Act, B.C. Reg. 63/88. Deposited February 18, 1988. O.C. 268/88 effective April 1, 1988 (includes amendments up to B.C. Reg. 52/95)

ANNEX A

Laboratory Chemical Analysis Report: Organochlorine Pesticides and Extractable Hydrocarbons

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: June 28, 1996

ASL File No. G1666

Report On: Soil Analysis

Report To: **Royal Roads University**
Applied Research Division
2005 Sooke Road
Victoria, BC
V9B 5Y2

Attention: **Mr. Matt Dodd**

Received: June 3, 1996

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent A. Makelki, B.Sc.
Project Chemist

Katherine Thomas, B.Sc.
Project Chemist

REMARKS File No. G1666

The Organochlorine Pesticides (OCP) results for the sediment samples are included in the data section of this report in addition to the extactable hydrocarbon analyses. The OCP compounds "2,4'-DDT" and "4,4'-DDD" eluted very close together and in some samples they could not be quantified separately. In these instances the 2,4'-DDT and 4,4'-DDD results were calculated as the sum of the two compounds and the data is noted and reported for 4,4'-DDD. For the remaining samples it was possible to calculate these OCP's due to the specific levels of 2,4'-DDT and 4,4'-DDD detected and the data is reported for the individual compounds.

The replicate results for the selected samples are included in Appendix 1 of this report. Please note that the replicate OCP data for 4,4'-DDD are summations of the 2,4'-DDT and 4,4'-DDD results as noted above.

The Hydrocarbon Distribution Reports for the extractable hydrocarbon analyses are included in Appendix 3 of this report to assist you in determining the type of contamination.

RESULTS OF ANALYSIS - Sediment/Soil File No. G1666

	M14	N15	N16	O17	SWB19
	96 06 01 09:10	96 06 01 09:45	96 06 01 09:45	96 06 01 10:00	96 06 01 10:20
Physical Tests					
Moisture %	13.1	11.5	14.3	12.6	10.9
Organochloride Pesticides					
Aldrin	<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC	<0.002	<0.002	<0.002	<0.002	<0.002
delta-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	<0.001	<0.001	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.001	<0.001	<0.001	<0.001
2,4'-DDD	0.551	0.523	0.467	1.06	0.105
4,4'-DDD	4.85	4.36	3.53	8.36	1.27
2,4'-DDE	0.006	0.007	<0.002	0.012	0.009
4,4'-DDE	0.033	0.033	0.027	0.056	0.376
2,4'-DDT	N/A	N/A	N/A	N/A	N/A
4,4'-DDT	2.26	1.52	1.09	3.46	2.95
Dieldrin	<0.010	<0.010	<0.010	<0.010	<0.010
Endosulfan I	<0.007	<0.007	<0.007	<0.007	<0.007
Endosulfan II	<0.001	<0.001	<0.001	<0.001	<0.001
Endrin	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	<0.007	<0.007	<0.007	<0.007	<0.007
Heptachlor Epoxide	<0.003	<0.003	<0.003	<0.003	<0.003
Lindane (gamma - BHC)	<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.005	<0.005	<0.005	<0.005	<0.005
Mirex	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
trans-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
Oxychlordane	0.014	0.012	0.010	0.020	0.011
Toxaphene	<0.030	<0.030	<0.030	<0.030	<0.030
Extractables					
EPH (C10-18)	484	555	637	395	<250
EPH (C19-31)	325	428	557	525	<250
Total Extr Hydrocarbons (C9-40)	949	1120	1450	1100	64
Total Extr Hydrocarbons (C10-30)	814	850	1180	734	<40

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

RESULTS OF ANALYSIS - Sediment/Soil File No. G1666

	NEB18	A1	B2	C3	D4
	96 06 01 10:10	96 05 31 10:45	96 05 31 11:30	96 05 31 12:00	96 05 31 12:30
Physical Tests					
Moisture %	10.5	9.3	11.2	17.0	11.4
Organochloride Pesticides					
Aldrin	<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC	<0.002	<0.002	<0.002	<0.002	<0.002
delta-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	0.001	0.001	<0.001	0.001
trans-Chlordane (gamma)	<0.001	0.001	0.001	<0.001	0.001
2,4'-DDD	0.092	4.72	1.78	0.381	2.16
4,4'-DDD	0.508	22.3	7.79	2.09	11.9
2,4'-DDE	0.005	0.070	0.035	0.015	0.032
4,4'-DDE	0.124	0.261	0.112	0.053	0.109
2,4'-DDT	0.361	8.83	2.81	N/A	N/A
4,4'-DDT	1.25	20.9	7.57	1.04	7.49
Dieldrin	<0.010	<0.010	<0.010	<0.010	<0.010
Endosulfan I	<0.007	0.020	0.022	<0.007	0.008
Endosulfan II	<0.001	<0.001	<0.001	<0.001	<0.001
Endrin	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	<0.007	<0.007	<0.007	<0.007	<0.007
Heptachlor Epoxide	<0.003	<0.003	<0.003	<0.003	<0.003
Lindane (gamma - BHC)	<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.005	<0.005	<0.005	<0.005	<0.005
Mirex	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
trans-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
Oxychlordane	0.006	0.058	0.025	0.011	0.026
Toxaphene	<0.030	<0.030	<0.030	<0.030	<0.030
Extractables					
EPH (C10-18)	<250	424	<250	846	403
EPH (C19-31)	<250	<250	327	581	<250
Total Extr Hydrocarbons (C9-40)	67	609	611	1670	531
Total Extr Hydrocarbons (C10-30)	<40	513	467	1250	488

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

RESULTS OF ANALYSIS - Sediment/Soil File No. G1666

	E5	E6	F7	G8	H9
	96 05 31 13:15	96 05 31 14:00	96 05 31 14:00	96 05 31 14:15	96 05 31 14:30
Physical Tests					
Moisture %	8.5	7.9	11.9	16.5	9.1
Organochloride Pesticides					
Aldrin	<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC	<0.002	<0.002	<0.002	<0.002	<0.002
delta-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	0.009	0.002	0.001	0.006
trans-Chlordane (gamma)	<0.001	<0.001	0.001	0.001	<0.001
2,4'-DDD	1.67	1.89	0.330	2.13	1.34
4,4'-DDD	12.1	12.8	2.27	14.8	9.11
2,4'-DDE	0.027	0.032	0.008	0.026	0.021
4,4'-DDE	0.073	0.083	0.039	0.174	0.062
2,4'-DDT	N/A	N/A	1.18	7.87	N/A
4,4'-DDT	2.72	2.78	3.24	19.7	4.77
Dieldrin	<0.010	<0.010	<0.010	<0.010	<0.010
Endosulfan I	<0.007	<0.007	<0.007	0.012	<0.007
Endosulfan II	<0.001	<0.001	<0.001	<0.001	<0.001
Endrin	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	<0.007	<0.007	<0.007	<0.007	<0.007
Heptachlor Epoxide	<0.003	<0.003	<0.003	<0.003	<0.003
Lindane (gamma - BHC)	<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.005	<0.005	<0.005	<0.005	<0.005
Mirex	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
trans-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
Oxychlordane	0.035	0.004	0.011	0.032	0.021
Toxaphene	<0.030	<0.030	<0.030	<0.030	<0.030
Extractables					
EPH (C10-18)	2940	2260	355	660	1040
EPH (C19-31)	570	504	418	957	2200
Total Extr Hydrocarbons (C9-40)	4130	3210	961	1880	4030
Total Extr Hydrocarbons (C10-30)	3630	2730	747	1270	2910

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

RESULTS OF ANALYSIS - Sediment/Soil File No. G1666

	I10	J11	K12	L13	J20
	96 05 31 15:00	96 05 31 15:30	96 05 31 16:10	96 05 31 16:30	96 05 31 15:30
Physical Tests					
Moisture %	10.1	11.8	10.0	13.0	22.0
Organochloride Pesticides					
Aldrin	<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC	<0.002	<0.002	<0.002	<0.002	<0.002
delta-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Chlordane (alpha)	0.002	<0.001	0.001	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.001	0.001	<0.001	<0.001
2,4'-DDD	0.959	1.01	2.29	1.03	1.05
4,4'-DDD	6.37	6.08	14.0	5.68	6.03
2,4'-DDE	0.026	0.013	0.038	0.026	0.012
4,4'-DDE	0.093	0.056	0.114	0.069	0.032
2,4'-DDT	4.98	2.25	4.58	1.96	N/A
4,4'-DDT	11.6	5.56	10.9	4.34	1.13
Dieldrin	<0.010	<0.010	<0.010	<0.010	<0.010
Endosulfan I	<0.007	<0.007	<0.007	<0.007	<0.007
Endosulfan II	<0.001	<0.001	<0.001	<0.001	<0.001
Endrin	<0.005	<0.005	<0.005	<0.005	<0.005
Heptachlor	<0.007	<0.007	<0.007	<0.007	<0.007
Heptachlor Epoxide	<0.003	<0.003	<0.003	<0.003	<0.003
Lindane (gamma - BHC)	<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.005	<0.005	<0.005	<0.005	<0.005
Mirex	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
trans-Nonachlor	<0.050	<0.050	<0.050	<0.050	<0.050
Oxychlordane	<0.001	0.016	0.035	0.023	0.007
Toxaphene	<0.030	<0.030	<0.030	<0.030	<0.030
Extractables					
EPH (C10-18)	<250	701	760	629	1630
EPH (C19-31)	356	473	884	329	337
Total Extr Hydrocarbons (C9-40)	509	1360	1920	1110	2340
Total Extr Hydrocarbons (C10-30)	326	1120	1360	960	1950

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

Appendix 1 - QUALITY CONTROL - Replicates

File No. G1666

Sediment/Soil	O17	O17
	96 06 01 10:00	QC # 63761
Physical Tests		
Moisture %	12.6	10.9
Organochloride Pesticides		
Aldrin	<0.001	<0.001
alpha-BHC	<0.001	<0.001
beta-BHC	<0.002	<0.002
delta-BHC	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.001
2,4'-DDD	1.06	1.10
4,4'-DDD	8.36	9.42
2,4'-DDE	0.012	0.014
4,4'-DDE	0.056	0.082
4,4'-DDT	3.46	4.52
Dieldrin	<0.010	<0.010
Endosulfan I	<0.007	<0.007
Endosulfan II	<0.001	<0.001
Endrin	<0.005	<0.005
Heptachlor	<0.007	<0.007
Heptachlor Epoxide	<0.003	<0.003
Lindane (gamma - BHC)	<0.001	<0.001
Methoxychlor	<0.005	<0.005
Mirex	<0.001	<0.001
cis-Nonachlor	<0.050	<0.050
trans-Nonachlor	<0.050	<0.050
Oxychlordane	0.020	0.024
Toxaphene	<0.030	<0.030
Extractables		
Total Extr Hydrocarbons (C9-40)	1100	1500
Total Extr Hydrocarbons (C10-30)	734	1140

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

Appendix 1 - QUALITY CONTROL - Replicates

File No. G1666

Sediment/Soil	**D4**	**D4**
	96 05 31 12:30	QC # 63905
Physical Tests		
Moisture %	11.4	9.4
Extractables		
EPH (C10-18)	403	456
EPH (C19-31)	<250	<250
Total Extr Hydrocarbons (C9-40)	531	637
Total Extr Hydrocarbons (C10-30)	488	540

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

Appendix 1 - QUALITY CONTROL - Replicates

File No. G1666

Sediment/Soil	J20	J20
	96 05 31 15:30	QC # 63908
Physical Tests		
Moisture %	22.0	15.8
Organochloride Pesticides		
Aldrin	<0.001	<0.001
alpha-BHC	<0.001	<0.001
beta-BHC	<0.002	<0.002
delta-BHC	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.001
2,4'-DDD	1.05	1.08
4,4'-DDD	6.03	6.84
2,4'-DDE	0.012	0.013
4,4'-DDE	0.032	0.035
4,4'-DDT	1.13	1.33
Dieldrin	<0.010	<0.010
Endosulfan I	<0.007	<0.007
Endosulfan II	<0.001	<0.001
Endrin	<0.005	<0.005
Heptachlor	<0.007	<0.007
Heptachlor Epoxide	<0.003	<0.003
Lindane (gamma - BHC)	<0.001	<0.001
Methoxychlor	<0.005	<0.005
Mirex	<0.001	<0.001
cis-Nonachlor	<0.050	<0.050
trans-Nonachlor	<0.050	<0.050
Oxychlordane	0.007	0.008
Toxaphene	<0.030	<0.030
Extractables		
EPH (C10-18)	1630	1610
EPH (C19-31)	337	323
Total Extr Hydrocarbons (C9-40)	2340	2160
Total Extr Hydrocarbons (C10-30)	1950	1890

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons

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

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Organochloride Pesticides in Sediment/Soil

This analysis is carried out using procedures adapted from U.S. EPA Methods 3540, 3610 and 8081 (Publ. # SW-846 3rd ed., Washington, DC 20460. Updated January 1995). The procedure involves a soxlet extraction with dichloromethane. The extract is then solvent exchanged to hexane followed by an alumina column clean-up. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

Extractable Petroleum Hydrocarbons in Sediment/Soil

This analysis is equivalent to British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID", January 1996 but does not provide correction for Polycyclic Aromatic Hydrocarbons (PAHs). The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection.

Total Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460). This procedure involves hexane/acetone extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection.

End of Report

APPENDIX 3

HYDROCARBON DISTRIBUTION REPORTS

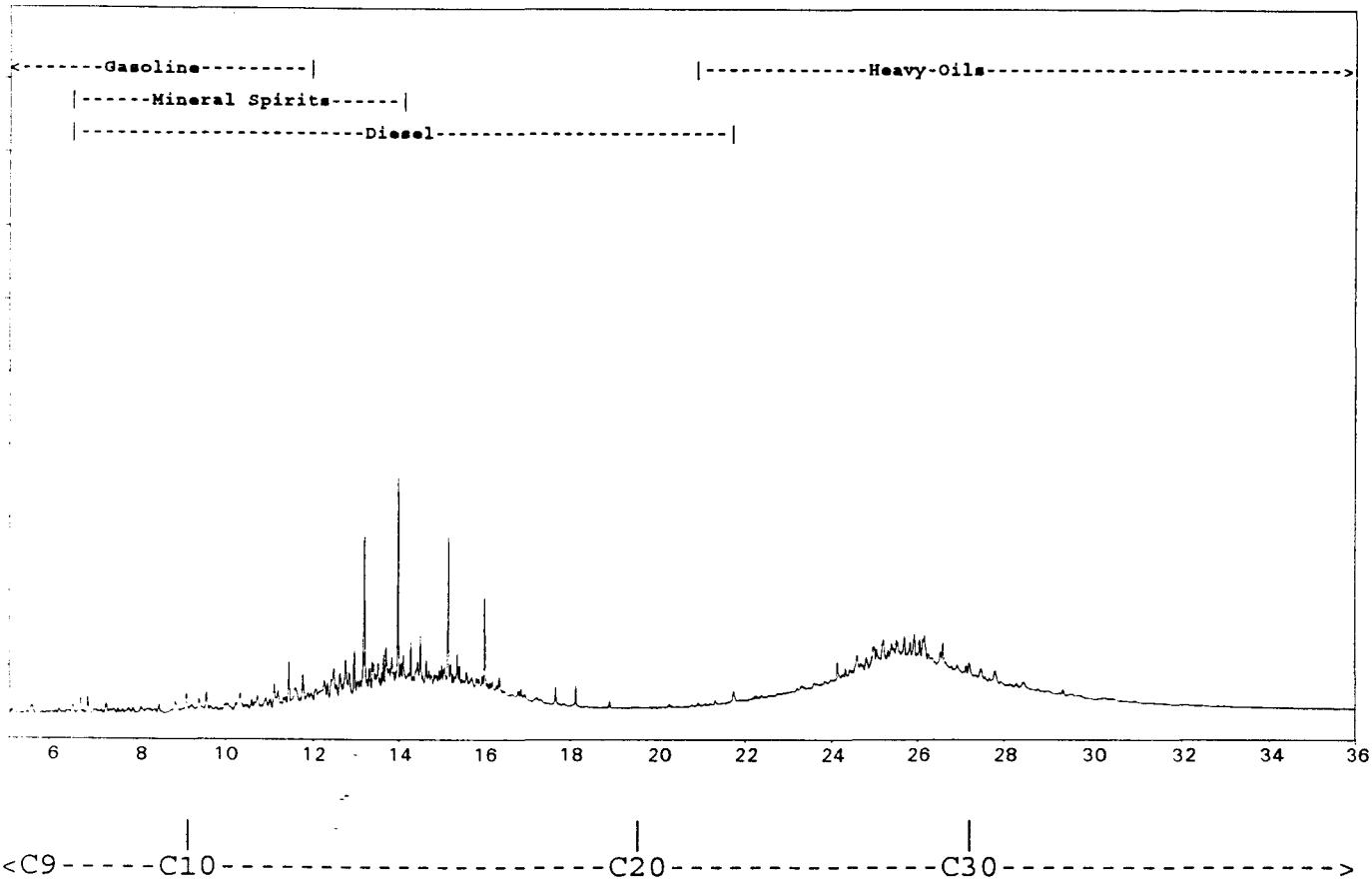
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **N16**

Sample acquired: JUN 9, 1996 14:48:26

File Name: c:\TEH\TEHJUN08.60R , Sample Name: G1666 3

Sequence file: TEHJUN08



ASL Sample ID: G1666 3* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	2.3
Carbon 10 to Carbon 20	(C10-C20)	45.0
Carbon 20 to Carbon 30	(C20-C30)	31.8
Greater than Carbon 30	(>C30)	20.9

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 amount of hydrocarbon product present in the ranges specified.

HYDROCARBON DISTRIBUTION REPORT

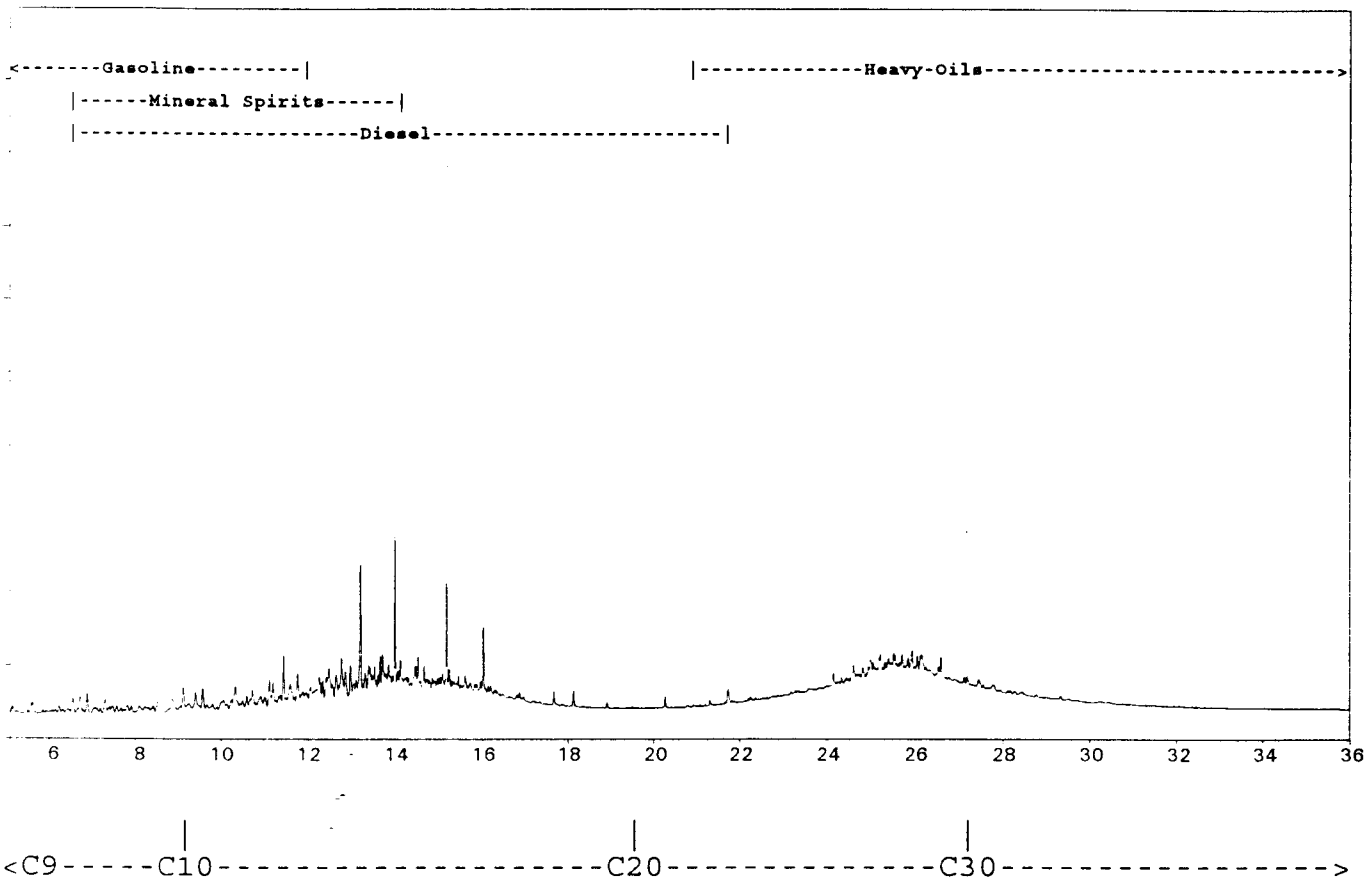
SAMPLE NAME: G1666 1

M14

Sample acquired: JUN 9, 1996 14:00:06

File Name: c:\TEH\TEHJUN08.58R , Sample Name: G1666 1

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	3.9
Carbon 10 to Carbon 20	(C10-C20)	49.5
Carbon 20 to Carbon 30	(C20-C30)	29.9
Greater than Carbon 30	(>C30)	16.7

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 amount of hydrocarbon product present in the ranges specified.

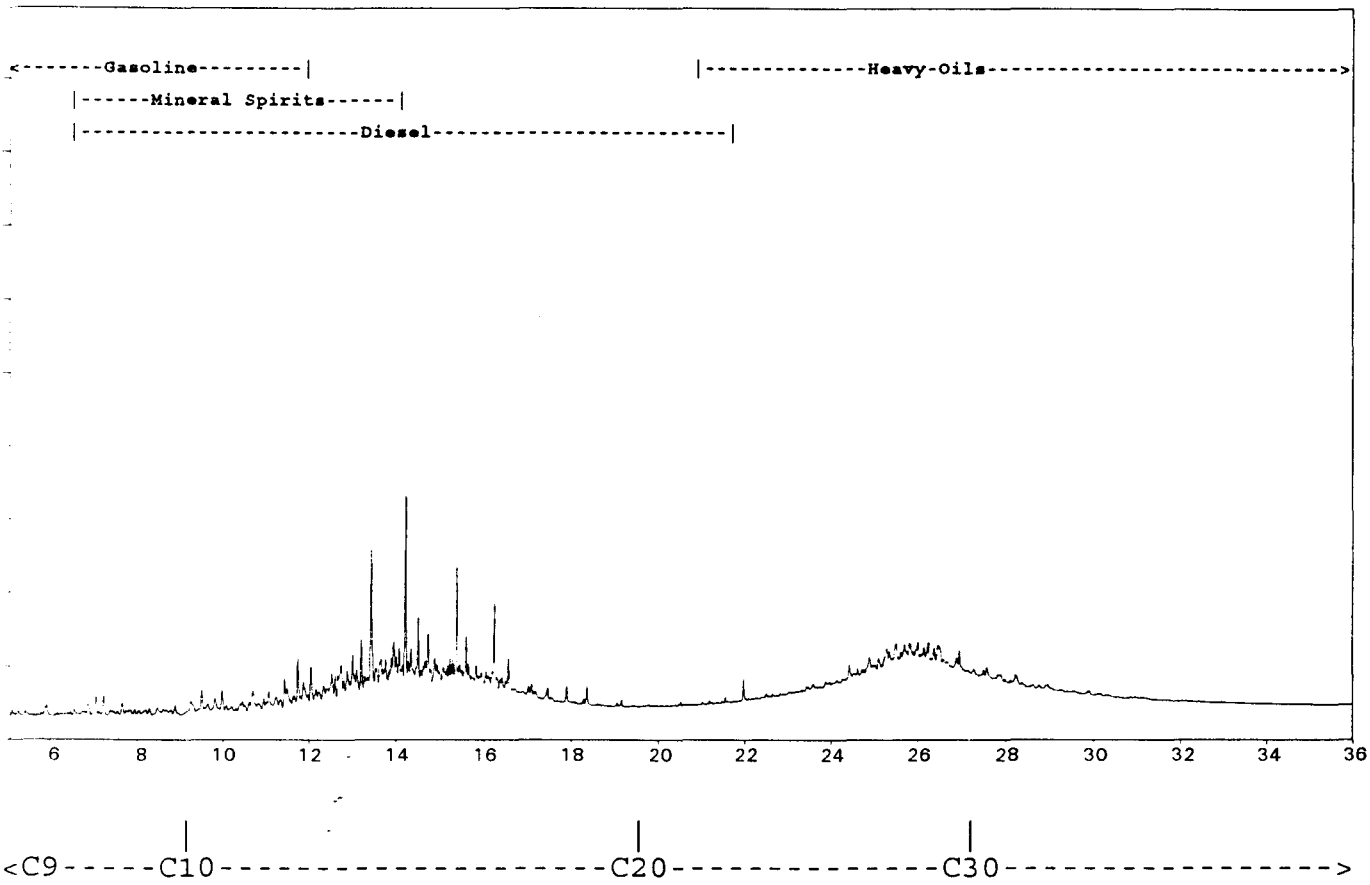
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: N15

Sample acquired: JUN 9, 1996 14:48:26

File Name: c:\TEH\TEHJUN08.59R , Sample Name: G1666 2

Sequence file: TEHJUN08



ASL Sample ID: G1666 2* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	2.5
Carbon 10 to Carbon 20	(C10-C20)	49.4
Carbon 20 to Carbon 30	(C20-C30)	25.9
Greater than Carbon 30	(>C30)	22.3

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 amount of hydrocarbon product present in the ranges specified.

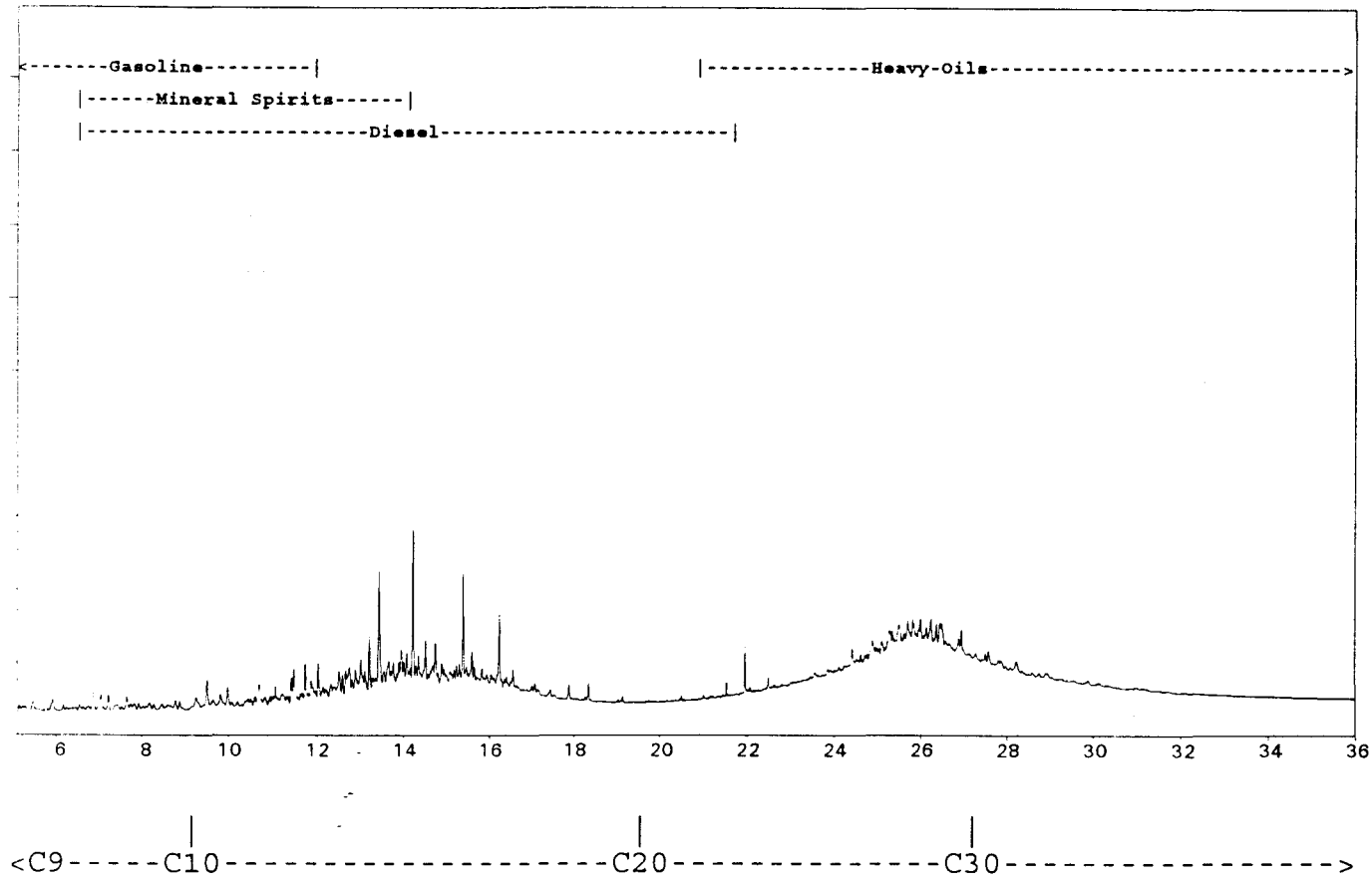
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: O17

Sample acquired: JUN 9, 1996 15:37:26

File Name: c:\TEH\TEHJUN08.61R , Sample Name: G1666 4

Sequence file: TEHJUN08



ASL Sample ID: G1666 4* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	3.0
Carbon 10 to Carbon 20	(C10-C20)	39.2
Carbon 20 to Carbon 30	(C20-C30)	31.0
Greater than Carbon 30	(>C30)	26.8

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 amount of hydrocarbon product present in the ranges specified.

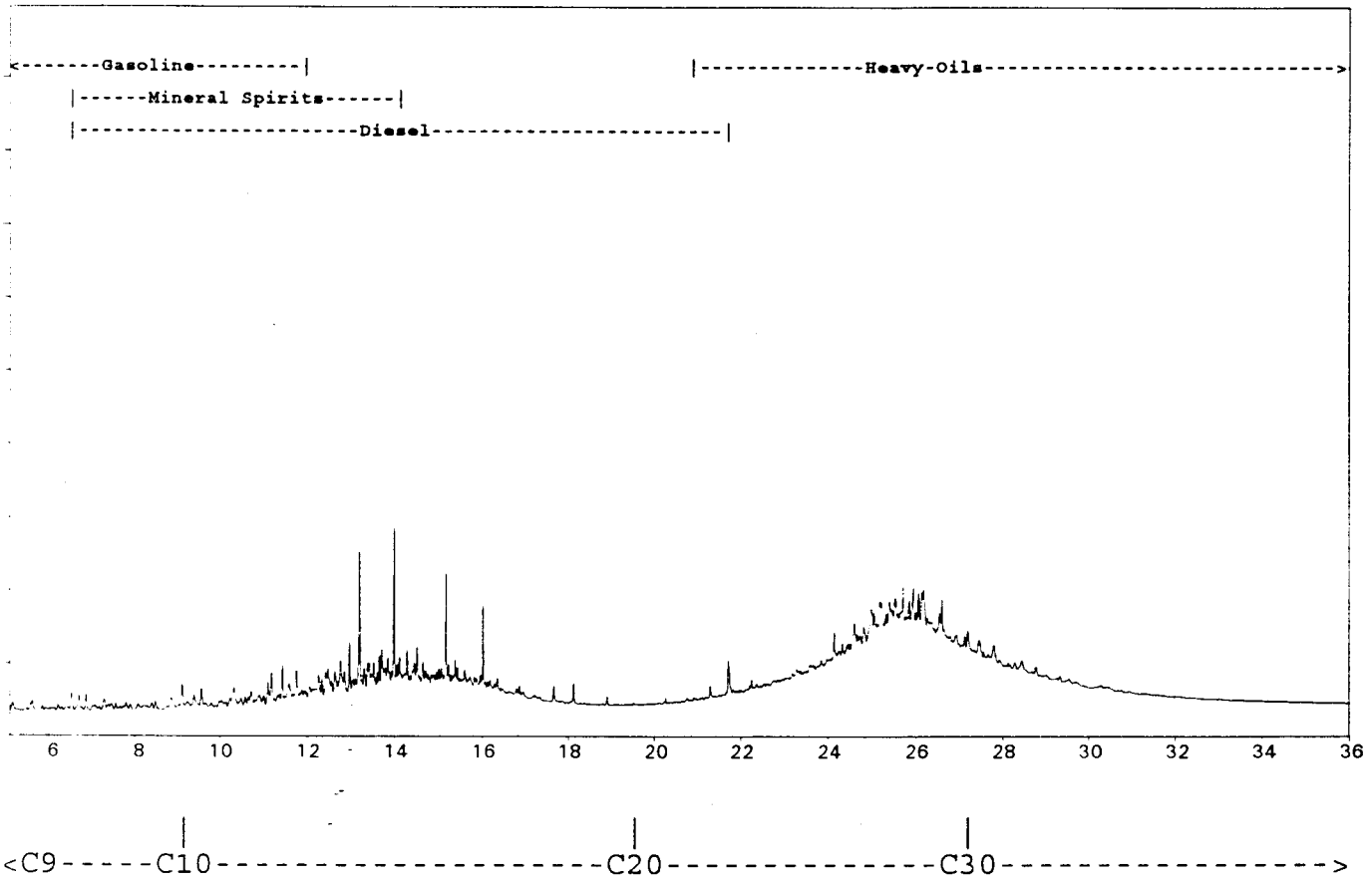
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: QC 63761#G1666 4'

Sample acquired: JUN 9, 1996 15:37:26

File Name: c:\TEH\TEHJUN08.62R , Sample Name: QC 63761#G1666 4'

Sequence file: TEHJUN08



ASL Sample ID: QC 63761#G1666 4'* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	2.2
Carbon 10 to Carbon 20	(C10-C20)	31.8
Carbon 20 to Carbon 30	(C20-C30)	38.5
Greater than Carbon 30	(>C30)	27.5

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 amount of hydrocarbon product present in the ranges specified.

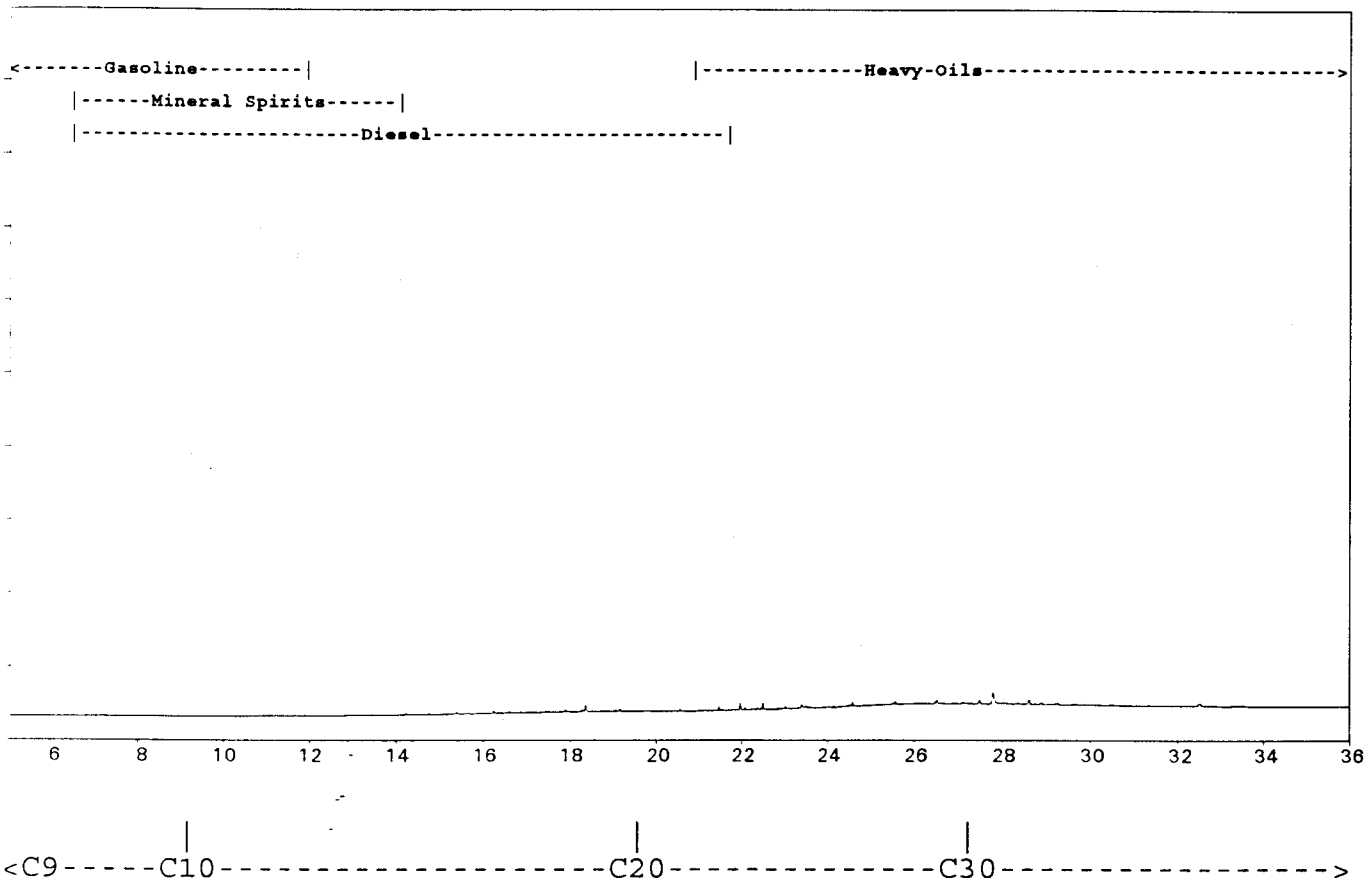
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **SWB 19**

Sample acquired: JUN 9, 1996 16:26:01

File Name: c:\TEH\TEHJUN08.63R , Sample Name: G1666 5

Sequence file: TEHJUN08



ASL Sample ID: G1666 5* 8.0Dilution

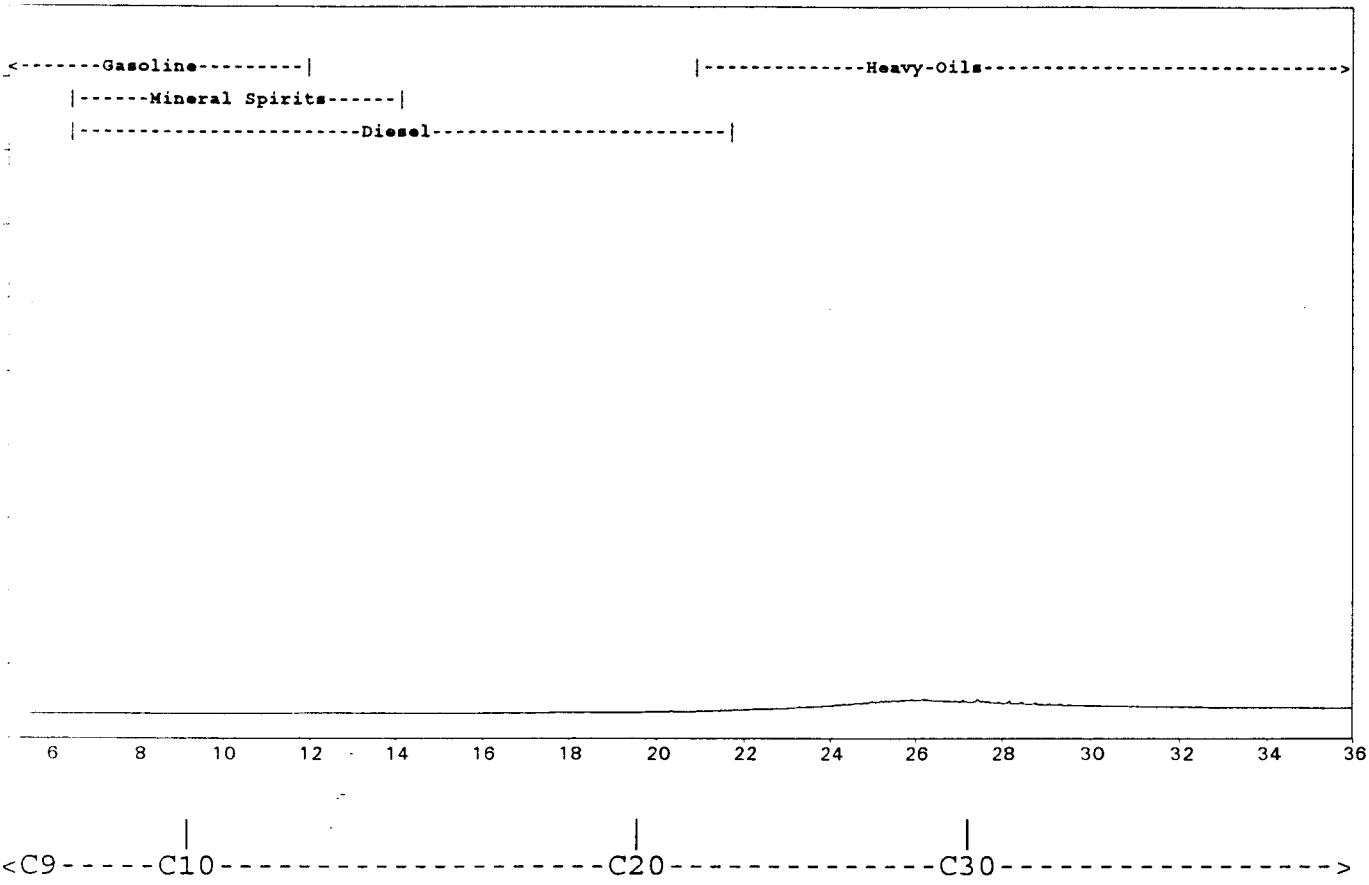
HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	0.0
Carbon 10 to Carbon 20	(C10-C20)	12.7
Carbon 20 to Carbon 30	(C20-C30)	36.6
Greater than Carbon 30	(>C30)	51.0

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 amount of hydrocarbon product present in the ranges specified.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: NEB 18

Sample acquired: JUN 9, 1996 16:26:01
File Name: c:\TEH\TEHJUN08.64R , Sample Name: G1666 6
Sequence file: TEHJUN08



ASL Sample ID: G1666 6* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	0.1
Carbon 10 to Carbon 20	(C10-C20)	0.2
Carbon 20 to Carbon 30	(C20-C30)	59.3
Greater than Carbon 30	(>C30)	40.5

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 amount of hydrocarbon product present in the ranges specified.

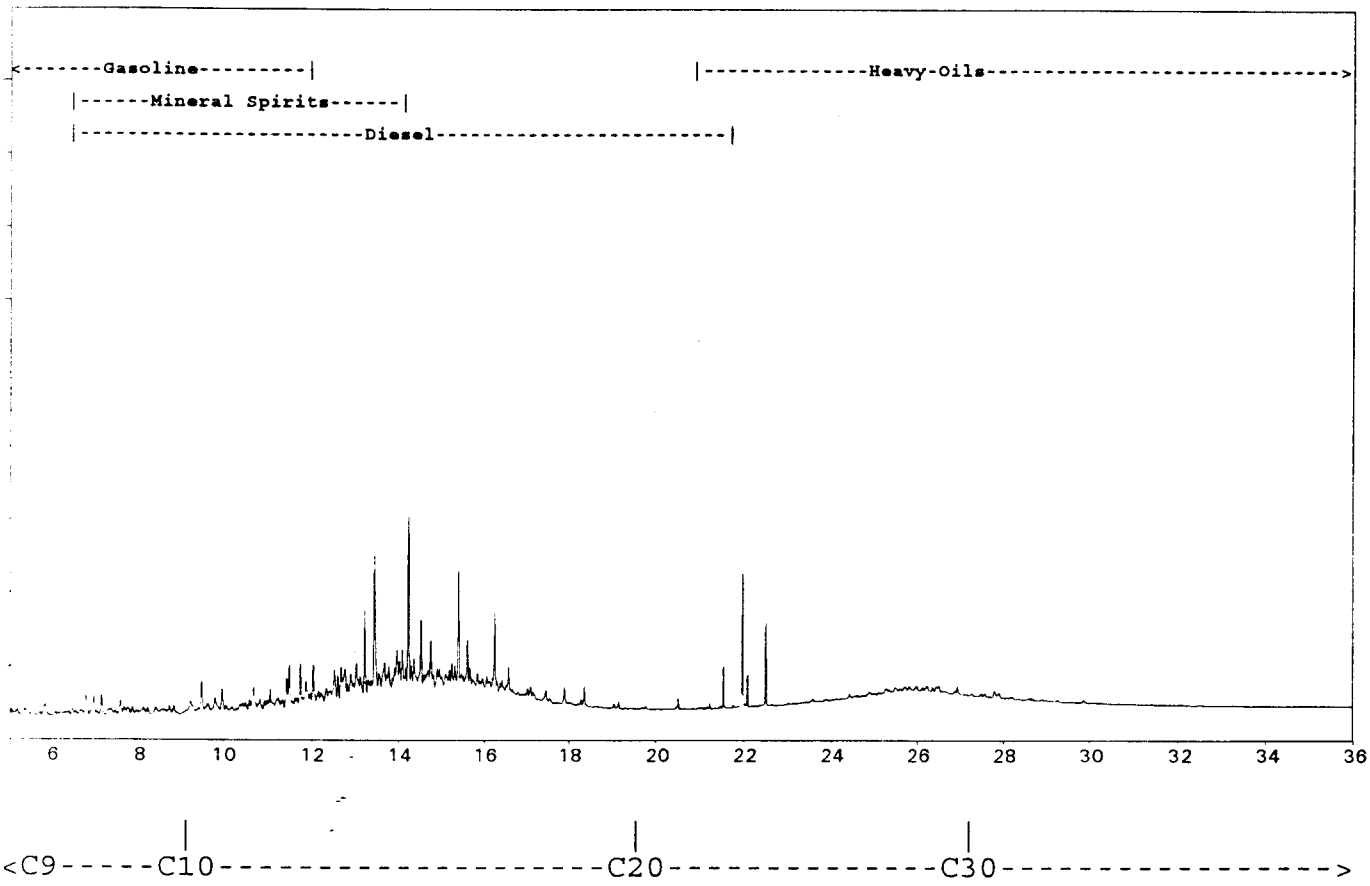
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **A1**

Sample acquired: JUN 9, 1996 17:14:27

File Name: c:\TEH\TEHJUN08.65R , Sample Name: G1666 7

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	5.0
Carbon 10 to Carbon 20	(C10-C20)	66.8
Carbon 20 to Carbon 30	(C20-C30)	16.1
Greater than Carbon 30	(>C30)	12.1

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 amount of hydrocarbon product present in the ranges specified.

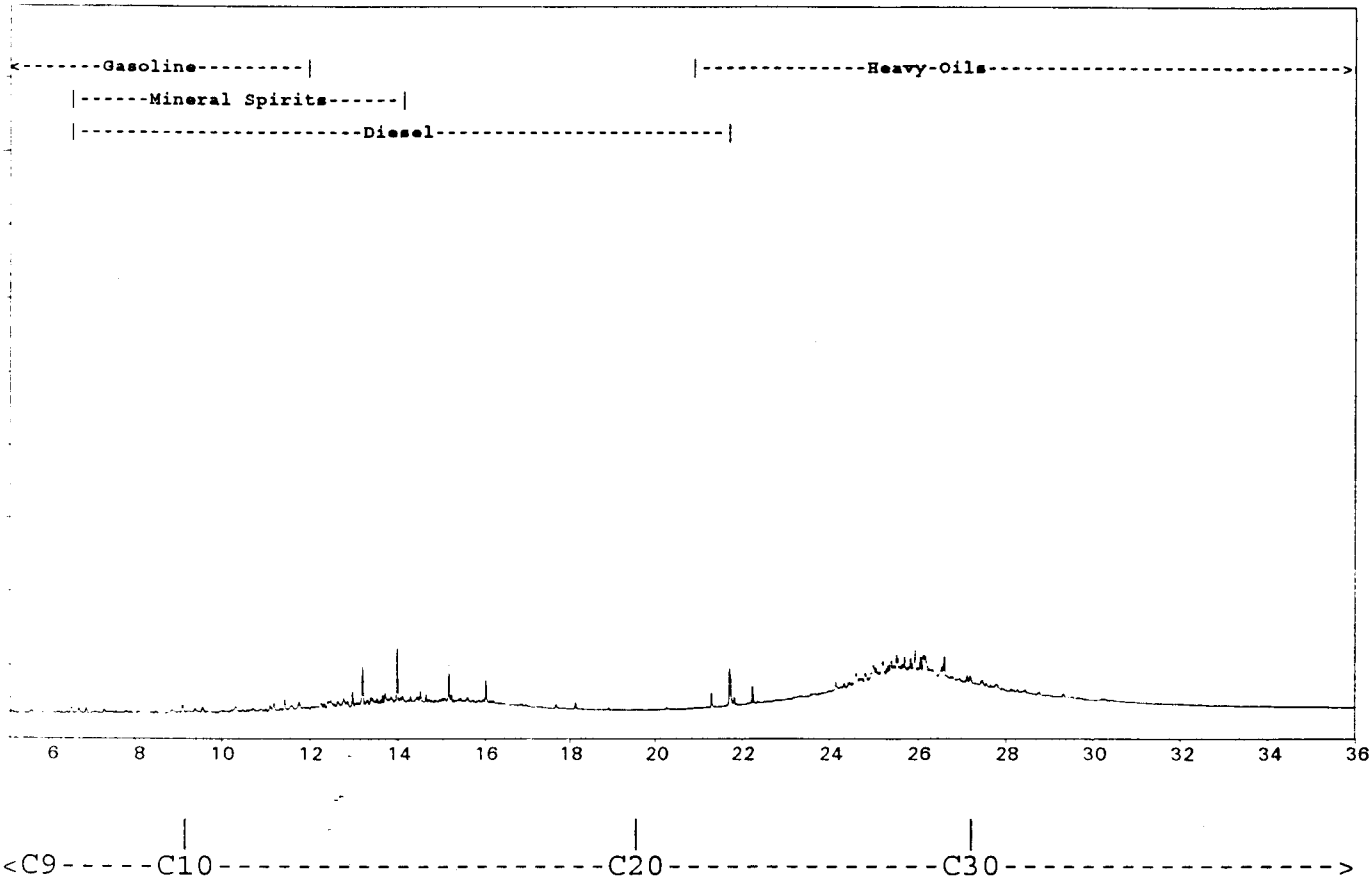
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **B2**

Sample acquired: JUN 9, 1996 17:14:27

File Name: c:\TEH\TEHJUN08.66R , Sample Name: G1666 8

Sequence file: TEHJUN08



ASL Sample ID: G1666 8* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	1.7
Carbon 10 to Carbon 20	(C10-C20)	28.1
Carbon 20 to Carbon 30	(C20-C30)	42.3
Greater than Carbon 30	(>C30)	27.9

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 amount of hydrocarbon product present in the ranges specified.

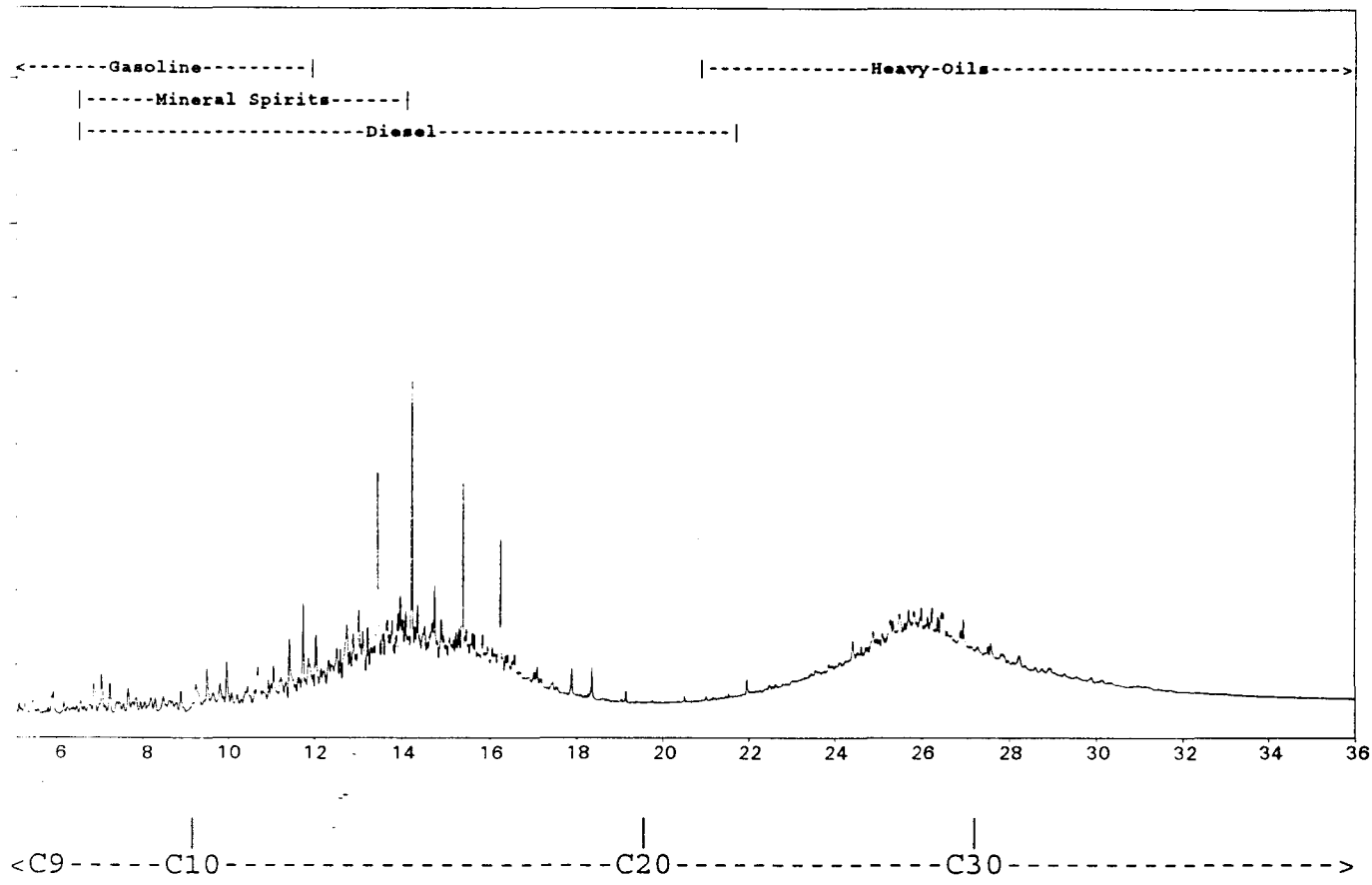
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: C3

Sample acquired: JUN 9, 1996 18:02:47

File Name: c:\TEH\TEHJUN08.67R , Sample Name: G1666 9

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	3.7
Carbon 10 to Carbon 20	(C10-C20)	50.6
Carbon 20 to Carbon 30	(C20-C30)	23.2
Greater than Carbon 30	(>C30)	22.5

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 amount of hydrocarbon product present in the ranges specified.

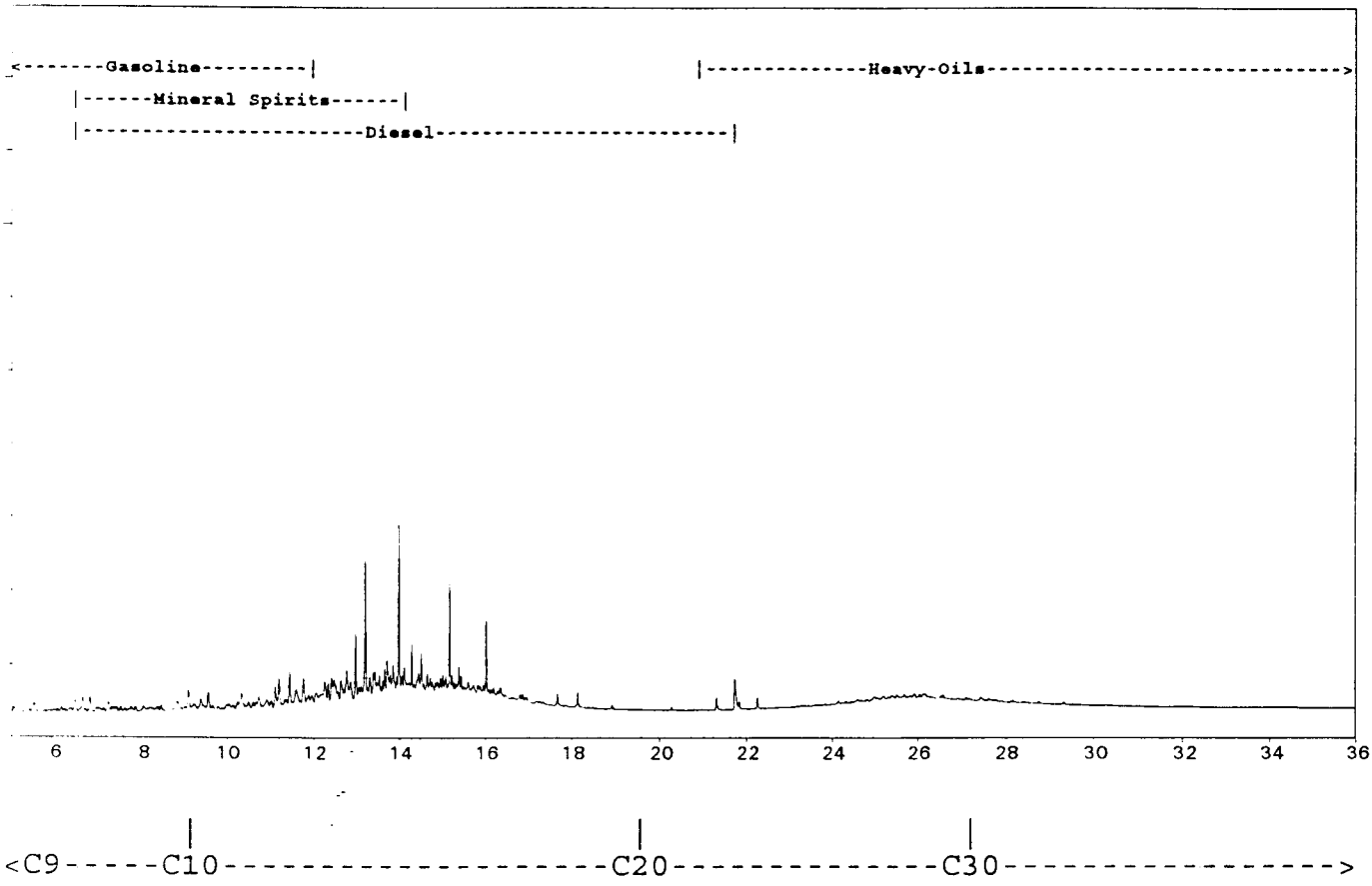
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **D4**

Sample acquired: JUN 9, 1996 18:02:47

File Name: c:\TEH\TEHJUN08.68R , Sample Name: G1666 10

Sequence file: TEHJUN08



ASL Sample ID: G1666 10* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	5.3
Carbon 10 to Carbon 20	(C10-C20)	74.1
Carbon 20 to Carbon 30	(C20-C30)	12.2
Greater than Carbon 30	(>C30)	8.4

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 amount of hydrocarbon product present in the ranges specified.

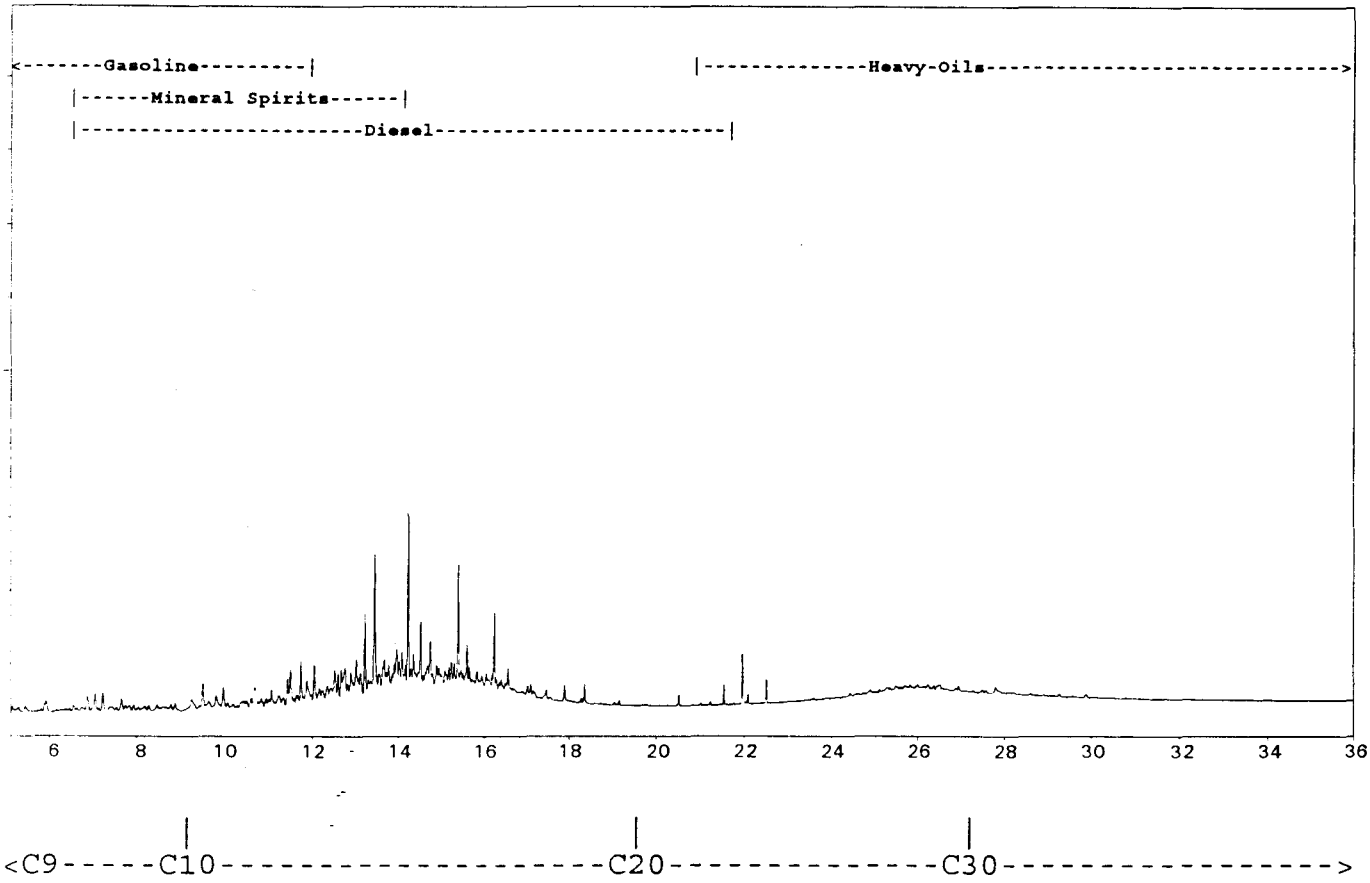
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: QC 63905#G1666 10'

Sample acquired: JUN 9, 1996 18:51:05

File Name: c:\TEH\TEHJUN08.69R , Sample Name: QC 63905#G1666 10'

Sequence file: TEHJUN08



ASL Sample ID: QC 63905#G1666 10'* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	4.7
Carbon 10 to Carbon 20	(C10-C20)	70.8
Carbon 20 to Carbon 30	(C20-C30)	12.1
Greater than Carbon 30	(>C30)	12.4

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 amount of hydrocarbon product present in the ranges specified.

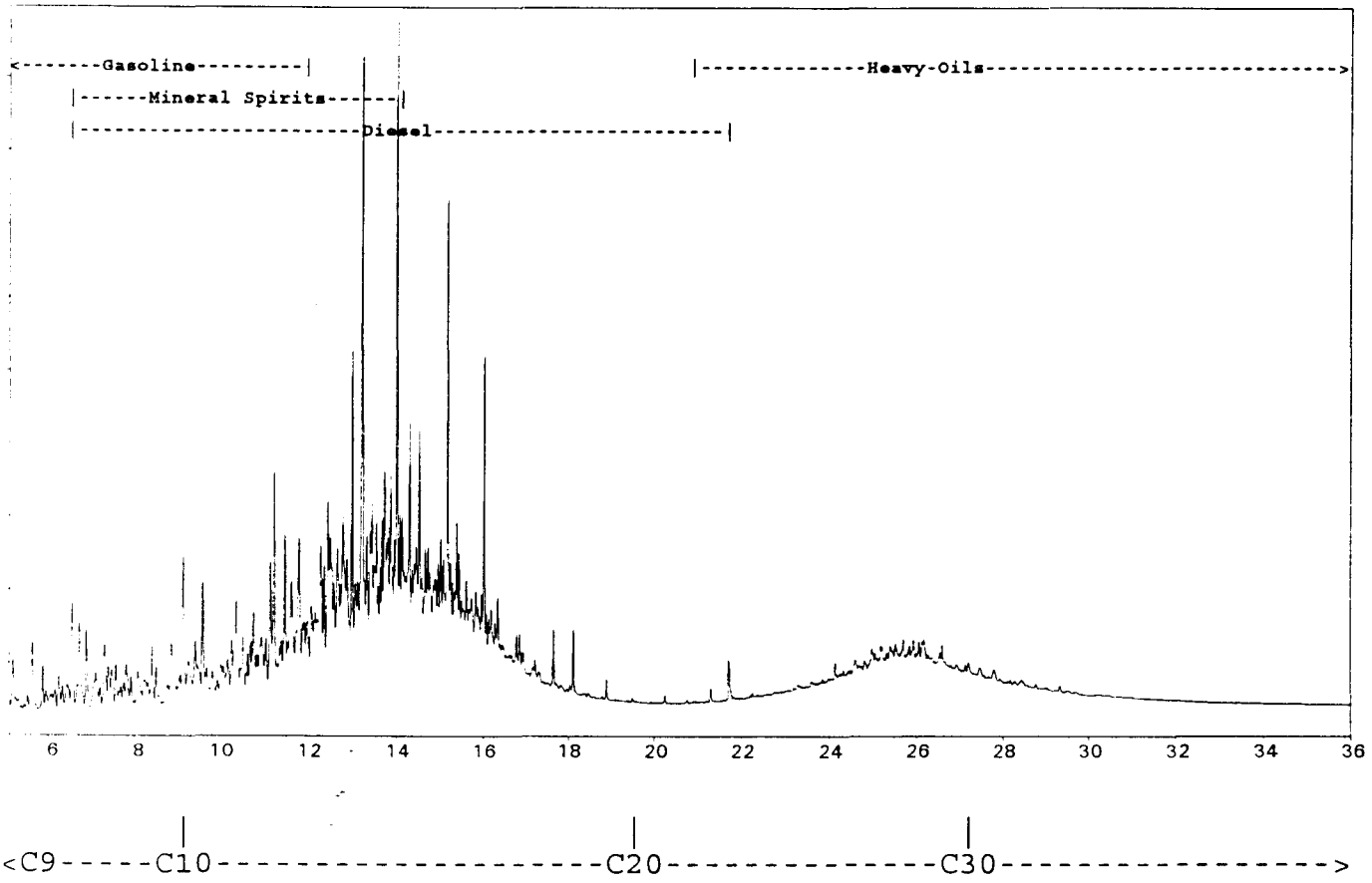
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **E5**

Sample acquired: JUN 9, 1996 18:51:05

File Name: c:\TEH\TEHJUN08.70R , Sample Name: G1666 11

Sequence file: TEHJUN08



ASL Sample ID: G1666 11* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	7.9
Carbon 10 to Carbon 20	(C10-C20)	71.2
Carbon 20 to Carbon 30	(C20-C30)	12.4
Greater than Carbon 30	(>C30)	8.5

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 amount of hydrocarbon product present in the ranges specified.

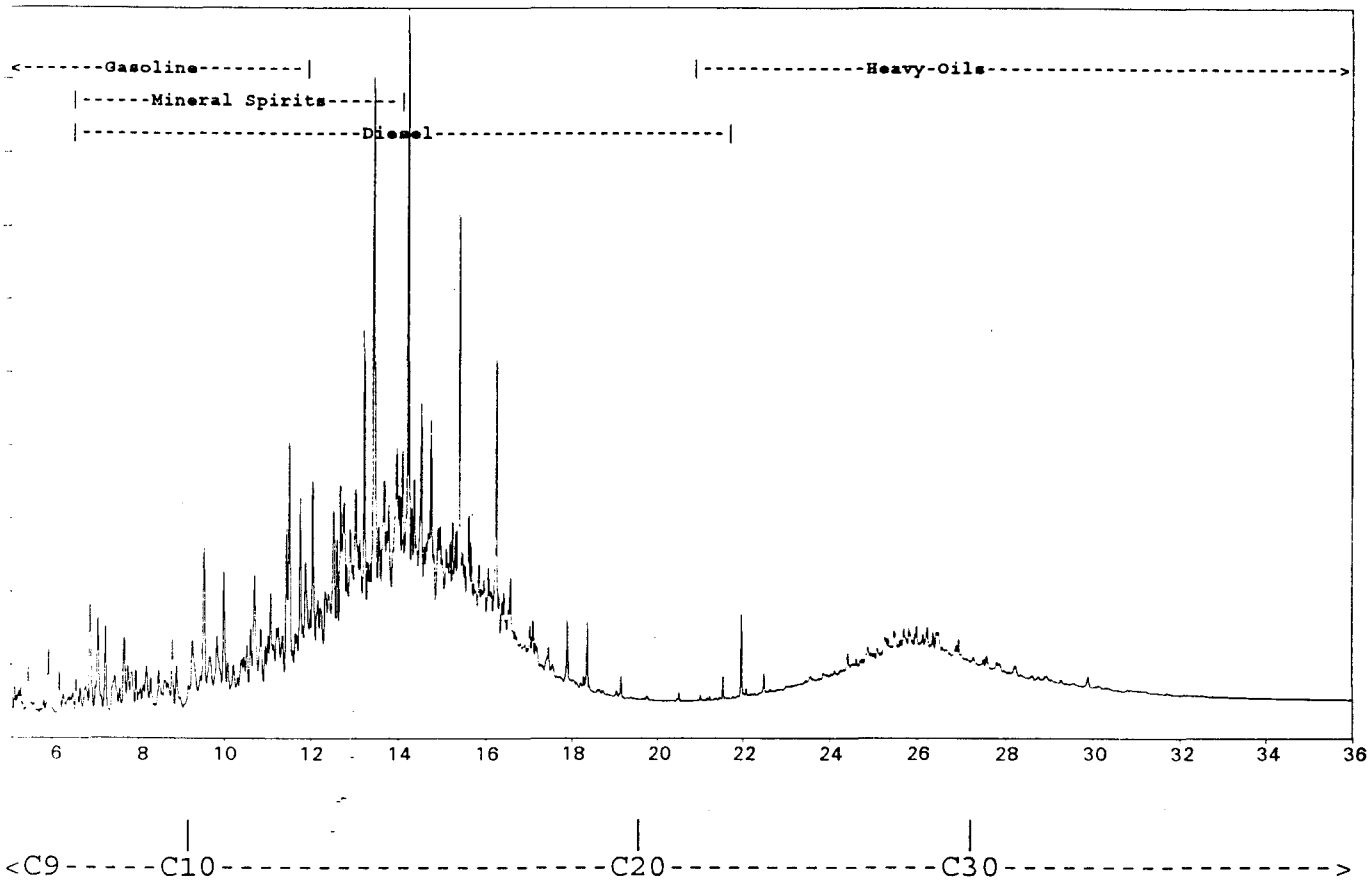
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: E6

Sample acquired: JUN 9, 1996 19:39:48

File Name: c:\TEH\TEHJUN08.71R , Sample Name: G1666 12

Sequence file: TEHJUN08



ASL Sample ID: G1666 12* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	6.4
Carbon 10 to Carbon 20	(C10-C20)	71.9
Carbon 20 to Carbon 30	(C20-C30)	11.2
Greater than Carbon 30	(>C30)	10.6

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 amount of hydrocarbon product present in the ranges specified.

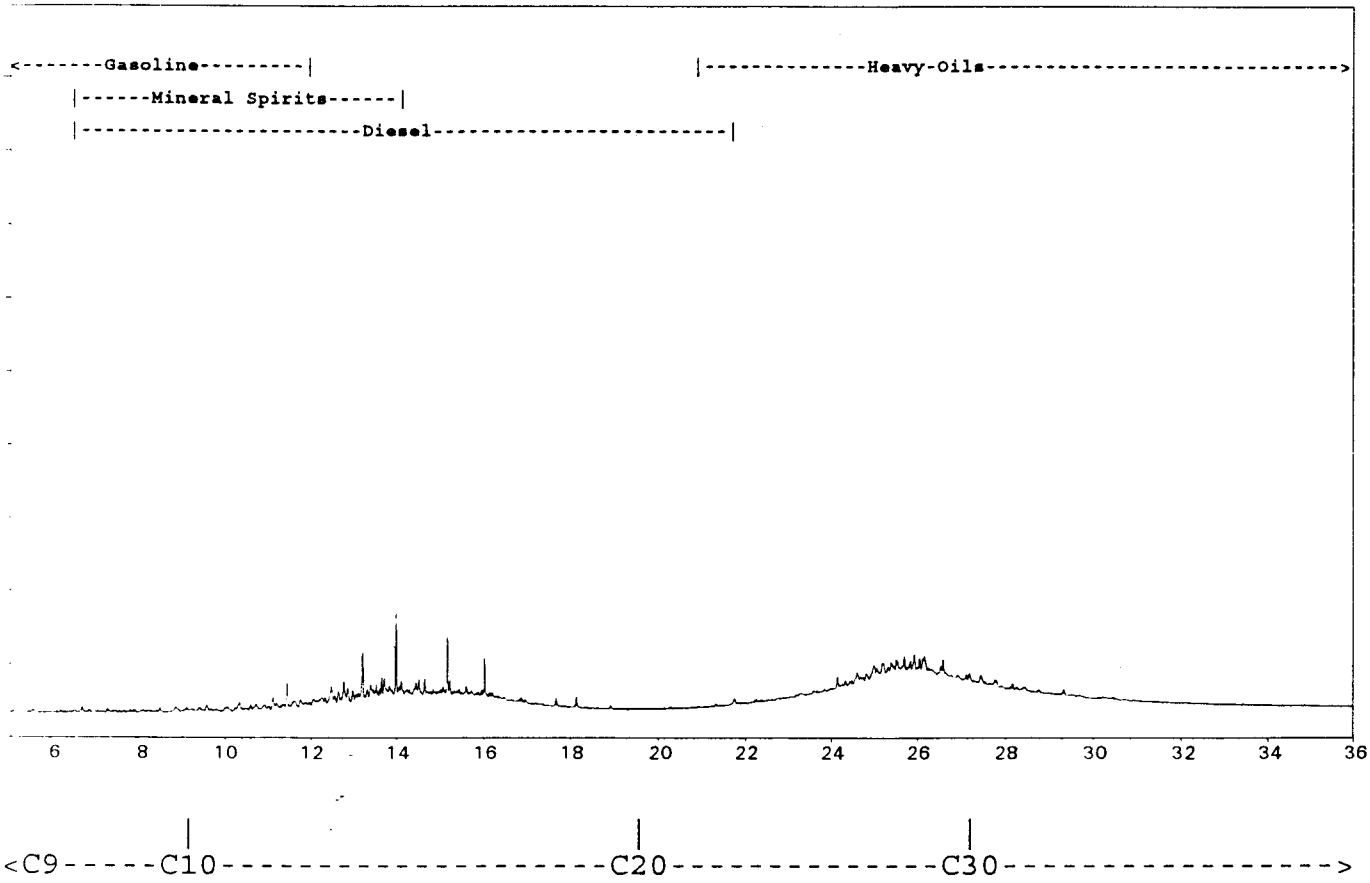
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: F7

Sample acquired: JUN 9, 1996 19:39:48

File Name: c:\TEH\TEHJUN08.72R , Sample Name: G1666 13

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	1.2
Carbon 10 to Carbon 20	(C10-C20)	36.1
Carbon 20 to Carbon 30	(C20-C30)	34.8
Greater than Carbon 30	(>C30)	27.9

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 amount of hydrocarbon product present in the ranges specified.

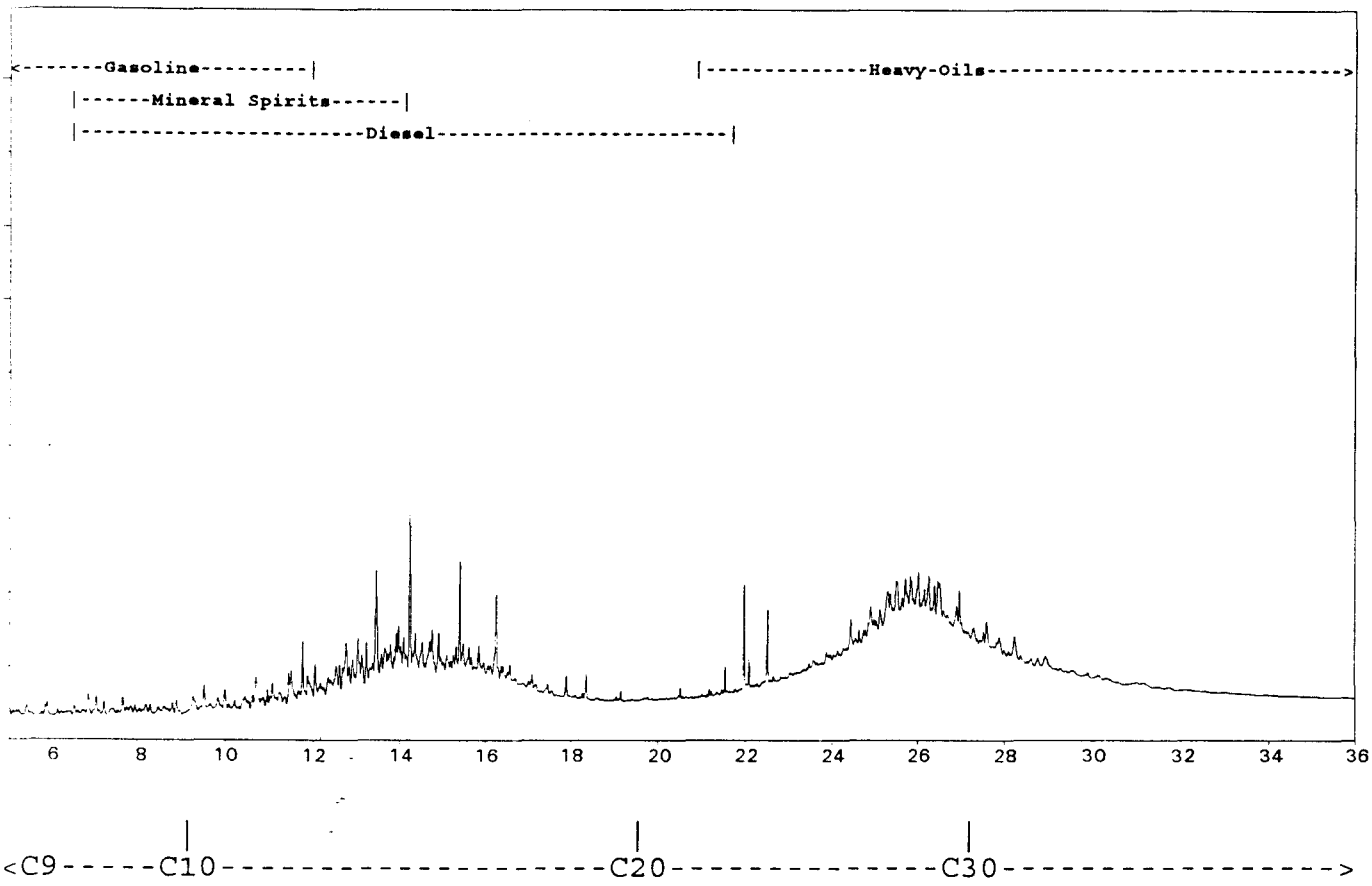
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **G8**

Sample acquired: JUN 9, 1996 20:27:41

File Name: c:\TEH\TEHJUN08.73R , Sample Name: G1666 14

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	2.1
Carbon 10 to Carbon 20	(C10-C20)	37.5
Carbon 20 to Carbon 30	(C20-C30)	31.5
Greater than Carbon 30	(>C30)	28.9

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 amount of hydrocarbon product present in the ranges specified.

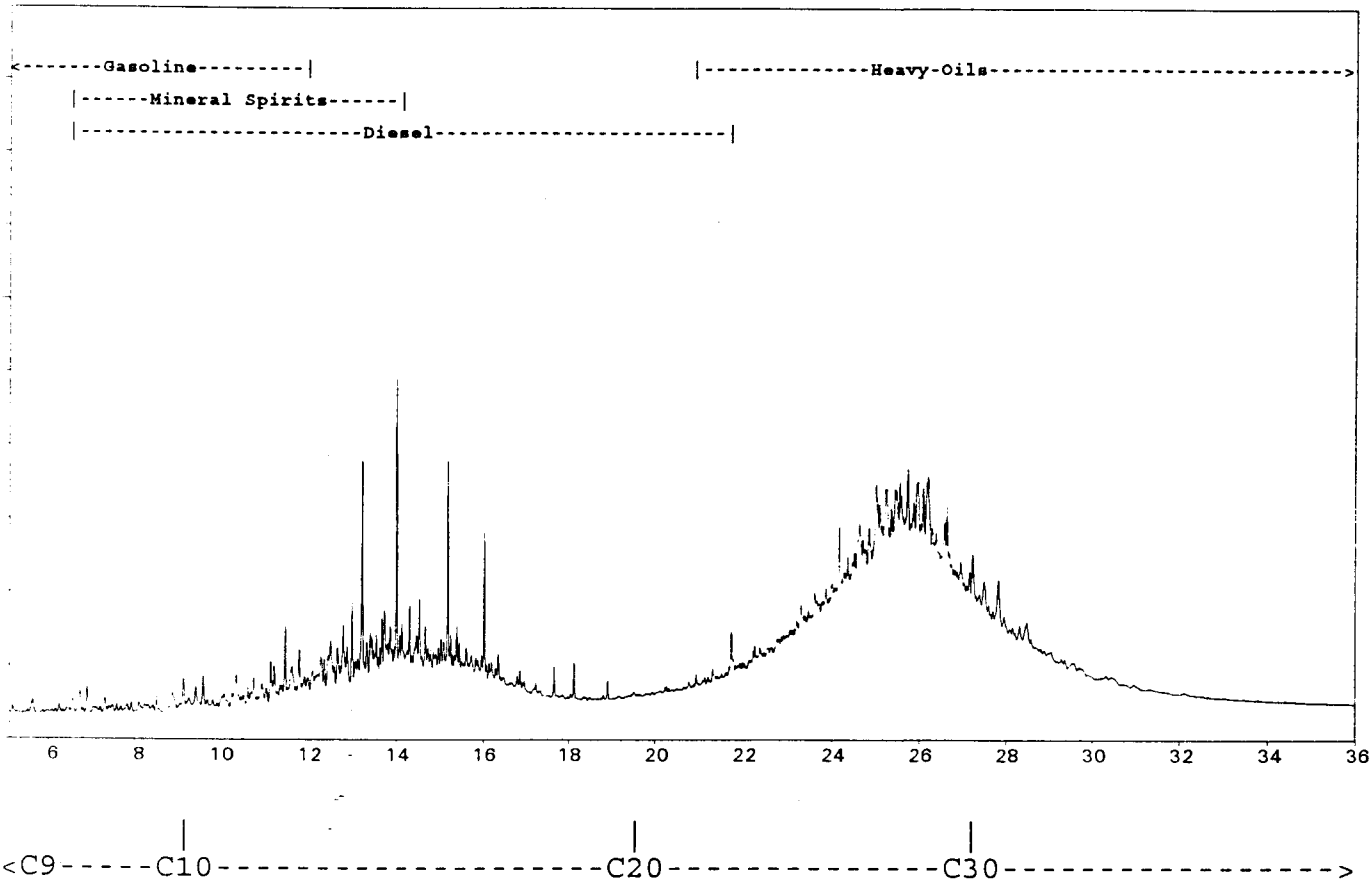
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **H9**

Sample acquired: JUN 9, 1996 20:27:41

File Name: c:\TEH\TEHJUN08.74R , Sample Name: G1666 15

Sequence file: TEHJUN08



ASL Sample ID: G1666 15* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	1.3
Carbon 10 to Carbon 20	(C10-C20)	27.9
Carbon 20 to Carbon 30	(C20-C30)	41.4
Greater than Carbon 30	(>C30)	29.4

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 amount of hydrocarbon product present in the ranges specified.

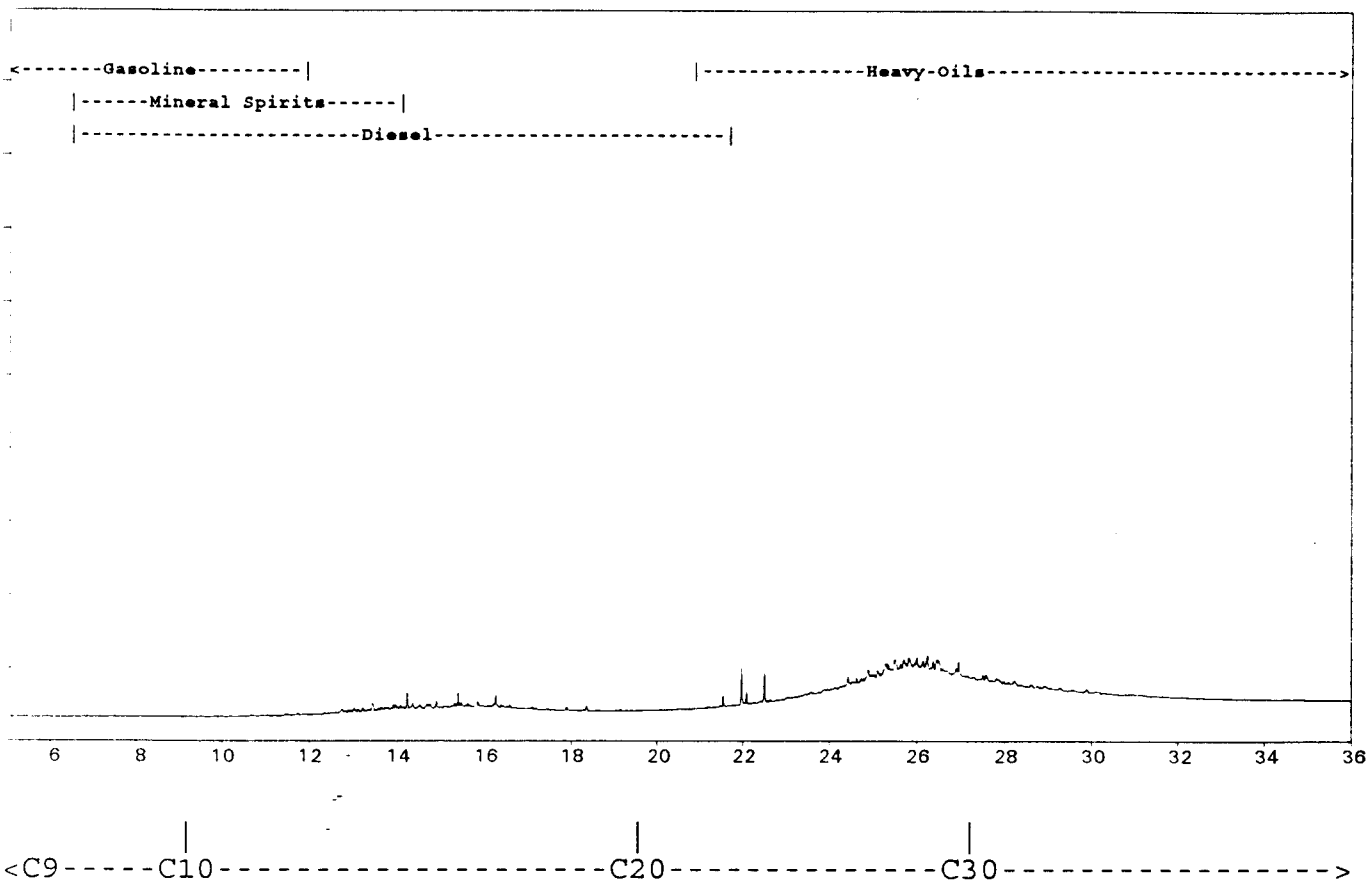
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: I 10

Sample acquired: JUN 9, 1996 21:15:33

File Name: c:\TEH\TEHJUN08.75R , Sample Name: G1666 16

Sequence file: TEHJUN08



ASL Sample ID: G1666 16* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	0.1
Carbon 10 to Carbon 20	(C10-C20)	15.4
Carbon 20 to Carbon 30	(C20-C30)	43.9
Greater than Carbon 30	(>C30)	40.8

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 amount of hydrocarbon product present in the ranges specified.

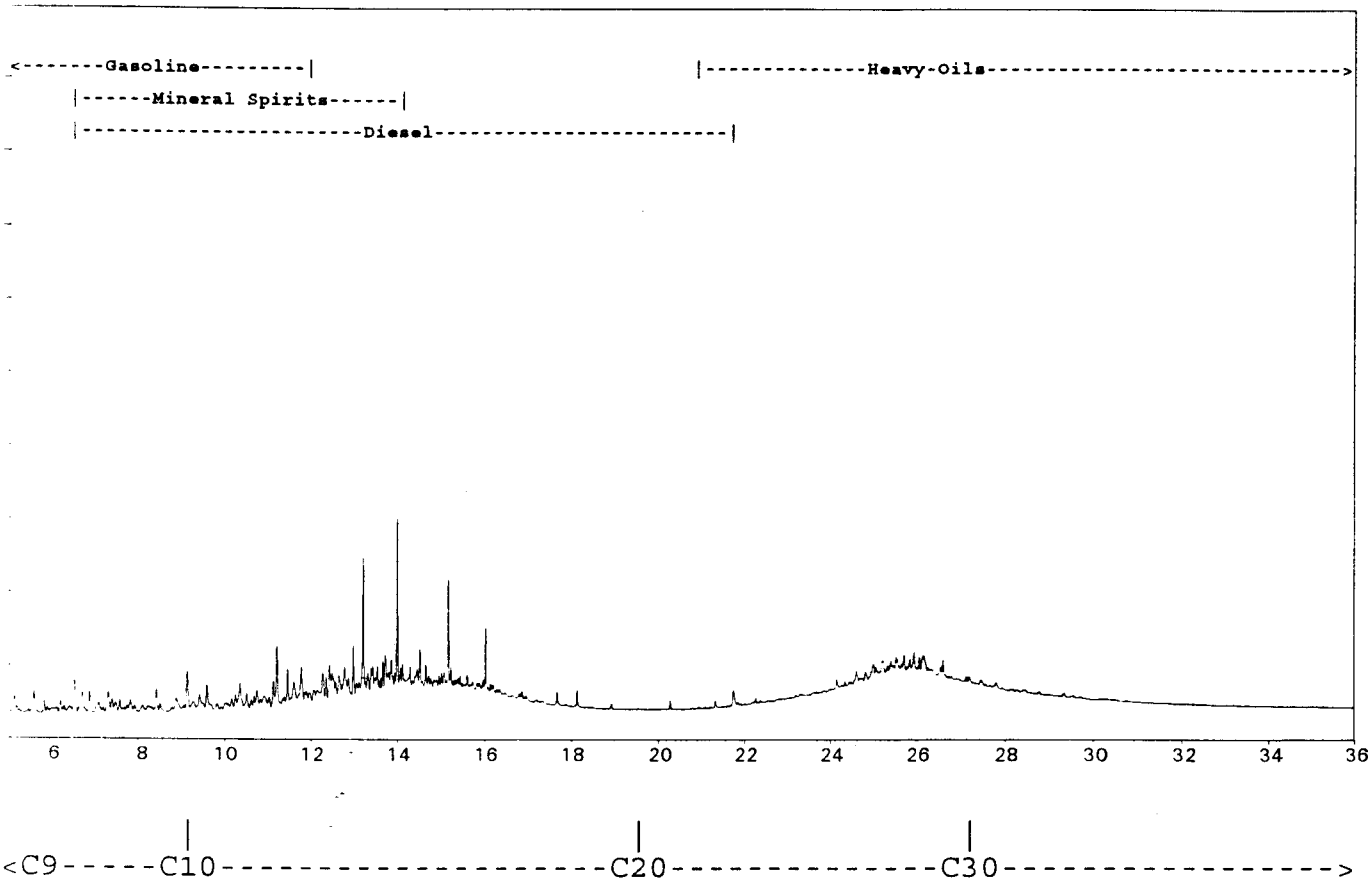
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: J11

Sample acquired: JUN 9, 1996 21:15:33

File Name: c:\TEH\TEHJUN08.76R , Sample Name: G1666 17

Sequence file: TEHJUN08



ASL Sample ID: G1666 17* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	6.6
Carbon 10 to Carbon 20	(C10-C20)	49.6
Carbon 20 to Carbon 30	(C20-C30)	26.4
Greater than Carbon 30	(>C30)	17.4

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 amount of hydrocarbon product present in the ranges specified.

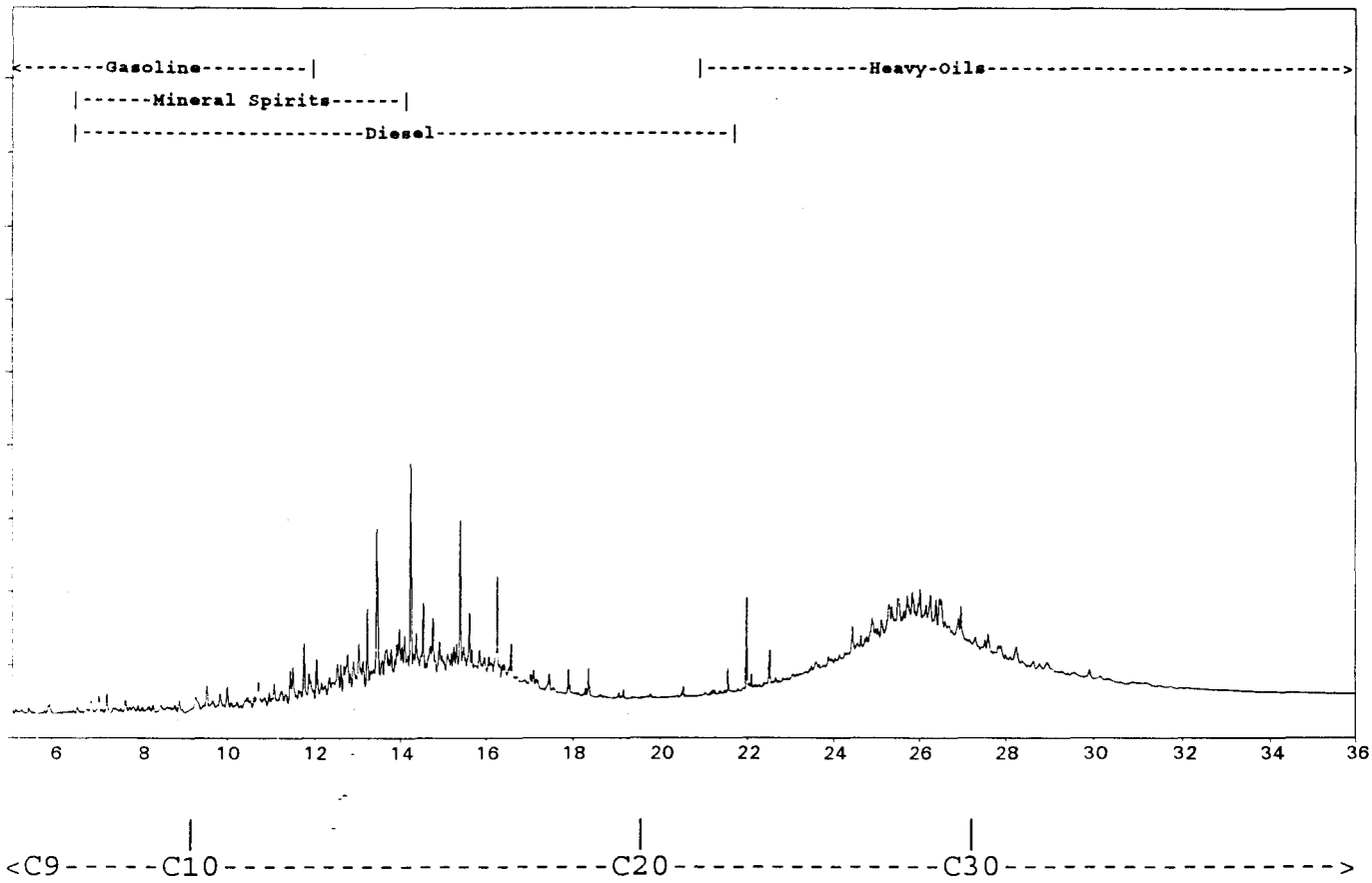
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K12**

Sample acquired: JUN 9, 1996 22:03:15

File Name: c:\TEH\TEHJUN08.77R , Sample Name: G1666 18

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	1.6
Carbon 10 to Carbon 20	(C10-C20)	41.2
Carbon 20 to Carbon 30	(C20-C30)	30.4
Greater than Carbon 30	(>C30)	26.9

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 amount of hydrocarbon product present in the ranges specified.

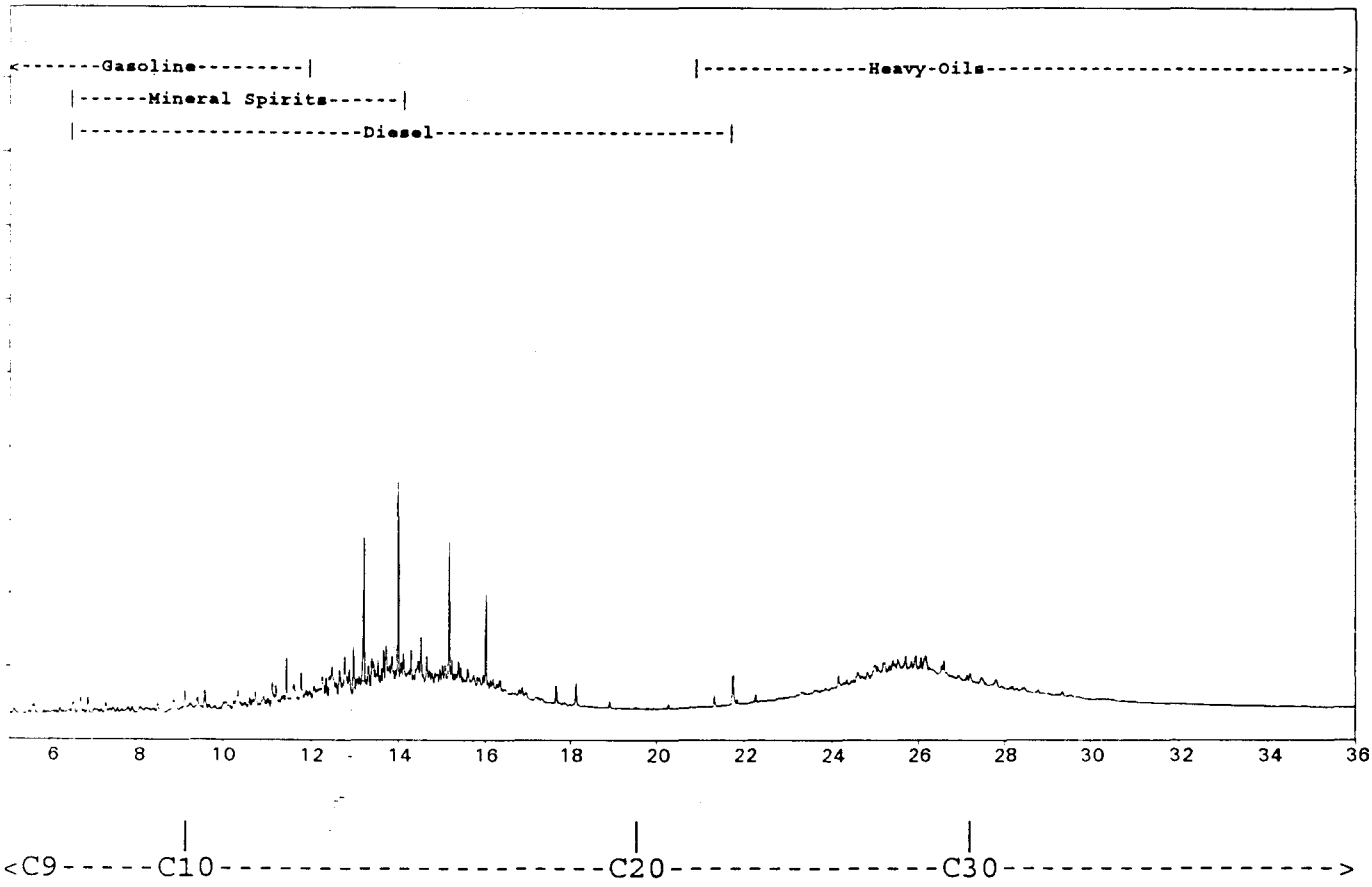
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **L13**

Sample acquired: JUN 9, 1996 22:03:15

File Name: c:\TEH\TEHJUN08.78R , Sample Name: G1666 19

Sequence file: TEHJUN08



ASL Sample ID: G1666 19* 8.0Dilution

HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	3.0
Carbon 10 to Carbon 20	(C10-C20)	52.6
Carbon 20 to Carbon 30	(C20-C30)	26.2
Greater than Carbon 30	(>C30)	18.2

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 amount of hydrocarbon product present in the ranges specified.

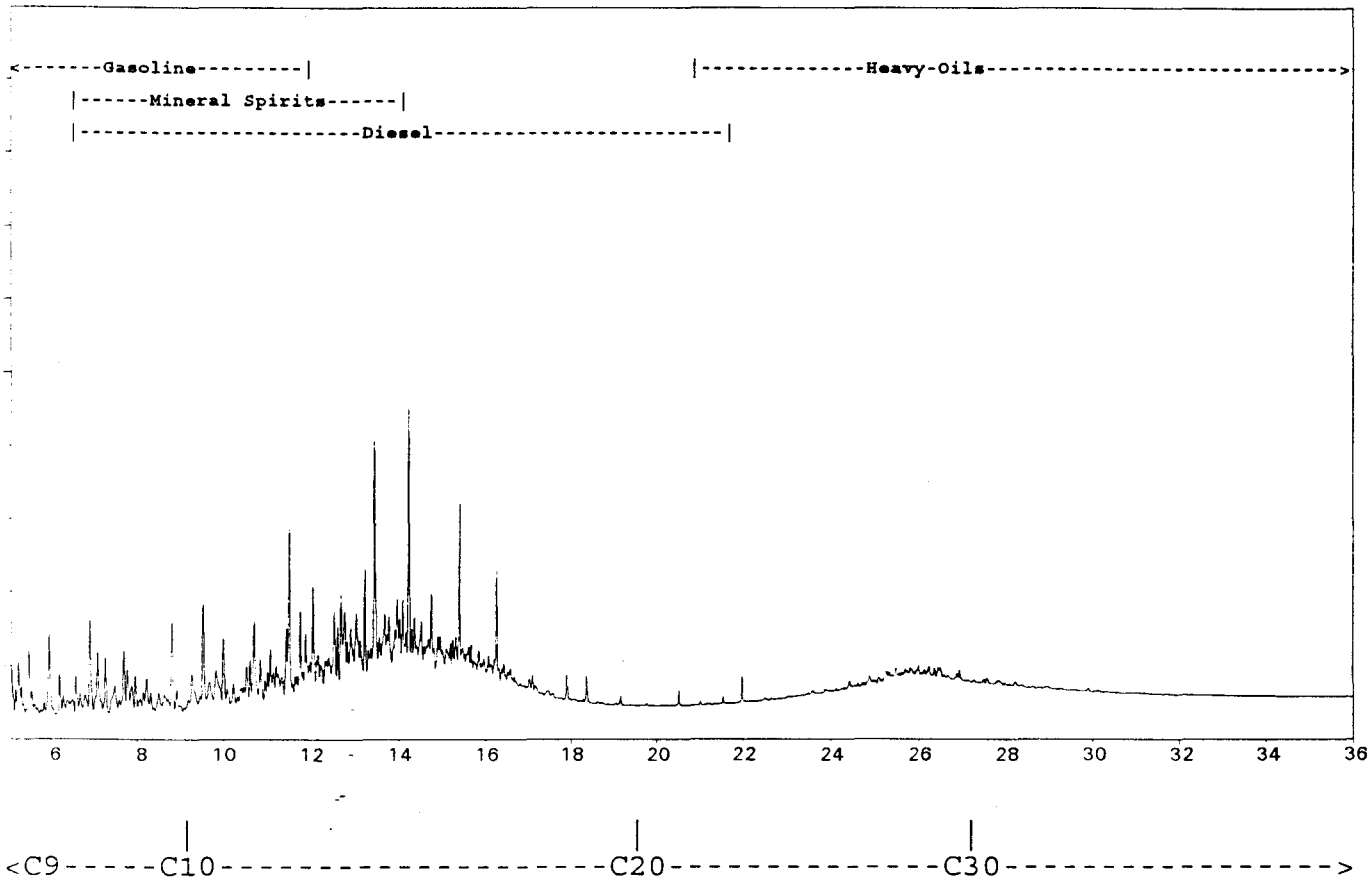
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: J20

Sample acquired: JUN 9, 1996 22:50:56

File Name: c:\TEH\TEHJUN08.79R , Sample Name: G1666 20

Sequence file: TEHJUN08



HYDROCARBON RANGE (C#)		RELATIVE AMOUNT (%)
Less than Carbon 10	(<C10)	13.3
Carbon 10 to Carbon 20	(C10-C20)	67.9
Carbon 20 to Carbon 30	(C20-C30)	9.6
Greater than Carbon 30	(>C30)	9.2

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 amount of hydrocarbon product present in the ranges specified.

ANNEX B

Laboratory Chemical Analysis Report: Special Waste Extraction Procedure (SWEP) for Leachable Organochlorine Pesticides

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: July 31, 1996

ASL File No. G2515

Report On: Soil Analysis

Report To: **Royal Roads University**
Applied Research Division
2005 Sooke Road
Victoria, BC
V9B 5Y2

Attention: **Mr. Matt Dodd**

Received: June 3, 1996

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent A. Makelki, B.Sc.
Project Chemist

Katherine Thomas, B.Sc.
Project Chemist

RESULTS OF ANALYSIS - Sediment/Soil File No. G2515

	A1	C3	G8	SWB19	J20
	96 05 31 10:45	96 05 31 12:00	96 05 31 14:15	96 05 31 10:20	96 05 31 15:30
Physical Tests					
Moisture %	12.6	17.7	13.2	9.9	17.5
Organochloride Pesticides					
Aldrin	<0.001	<0.001	<0.001	<0.001	<0.001
alpha-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
beta-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
delta-BHC	<0.001	<0.001	<0.001	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	<0.001	<0.001	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.001	<0.001	<0.001	<0.001
2,4'-DDD	0.028	0.003	0.020	<0.001	0.012
4,4'-DDD	0.109	0.012	0.079	<0.001	0.046
2,4'-DDE	<0.001	<0.001	<0.001	<0.001	<0.001
4,4'-DDE	0.001	<0.001	0.001	<0.001	<0.001
2,4'-DDT	0.065	0.003	0.071	<0.001	<0.005
4,4'-DDT	0.149	0.010	0.171	0.002	0.006
Dieldrin	<0.001	<0.001	<0.001	<0.001	<0.001
Endosulfan I	<0.002	<0.002	<0.002	<0.002	<0.002
Endosulfan II	0.0012	<0.0005	<0.0005	<0.0005	<0.0005
Endosulfan Sulfate	<0.010	<0.010	<0.010	<0.010	<0.010
Endrin	<0.001	<0.001	<0.001	<0.001	<0.001
Heptachlor	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Heptachlor Epoxide	<0.010	<0.010	<0.010	<0.010	<0.010
Lindane (gamma - BHC)	<0.001	<0.001	<0.001	<0.001	<0.001
Methoxychlor	<0.010	<0.010	<0.010	<0.010	<0.010
Mirex	<0.010	<0.010	<0.010	<0.010	<0.010
cis-Nonachlor	<0.010	<0.010	<0.010	<0.010	<0.010
trans-Nonachlor	<0.010	<0.010	<0.010	<0.010	<0.010
Oxychlordane	<0.010	<0.010	<0.010	<0.010	<0.010
Toxaphene	<0.030	<0.030	<0.030	<0.030	<0.030

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. G2515

Sediment/Soil	**J20** 96 05 31 15:30	**J20** QC # 66078
Organochloride Pesticides		
Aldrin	<0.001	<0.001
alpha-BHC	<0.001	<0.001
beta-BHC	<0.001	<0.001
delta-BHC	<0.001	<0.001
cis-Chlordane (alpha)	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.001
2,4'-DDD	0.012	0.011
4,4'-DDD	0.046	0.045
2,4'-DDE	<0.001	<0.001
4,4'-DDE	<0.001	<0.001
2,4'-DDT	<0.005	<0.005
4,4'-DDT	0.006	0.006
Dieldrin	<0.001	<0.001
Endosulfan I	<0.002	<0.002
Endosulfan II	<0.0005	<0.0005
Endosulfan Sulfate	<0.010	<0.010
Endrin	<0.001	<0.001
Heptachlor	<0.0005	<0.0005
Heptachlor Epoxide	<0.010	<0.010
Lindane (gamma - BHC)	<0.001	<0.001
Methoxychlor	<0.010	<0.010
Mirex	<0.010	<0.010
cis-Nonachlor	<0.010	<0.010
trans-Nonachlor	<0.010	<0.010
Oxychlordane	<0.010	<0.010
Toxaphene	<0.030	<0.030

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

Appendix 2 - METHODOLOGY File No. G2515

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

Leachable Organic Components

This analysis is carried out using the extraction procedure outlined by the B.C. Ministry of Environment and Parks (Waste Management Act - Special Waste Regulation, February 18, 1988. B.C. Reg. 63/88 OC 268/88). In summary, 50 grams of solid (dry weight) is mixed with about 800 mL of water and the pH adjusted to 5.0 with acetic acid (0.5N). The pH is maintained at 5.0 for 24 hours after which the volume is adjusted to 1000 mL and the liquid separated by filtration. The filtered extract is then analysed using the appropriate organic water procedure.

Organochloride Pesticides in Water

This analysis is carried out in accordance with U.S. EPA Method 3510, 3610 and 8080 (Publ. #SW-846 3rd ed., Washington, DC 20460). The procedure involves a solvent extraction using dichloromethane. The extract is then solvent exchanged to hexane followed by an alumina column clean-up. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

End of Report

ANNEX C

Laboratory Chemical Analysis Report:
Static Acute Rainbow Trout Bioassay

Parametrix, Inc. *Consultants in Engineering and Environmental Scienc*

5808 Lake Washington Blvd. N.E. Kirkland, WA 98033-7350
206-822-8880 • Fax: 206-889-8808

SENT VIA FACSIMILE (604) 391-2522

Mr. Matt Dodd
Royal Roads University
2005 Sooke Road
Victoria, British Columbia CANADA V9B5Y2

August 20, 1996
55-3150-01

SUBJECT: RESULTS OF STATIC ACUTE TROUT BIOASSAY

Dear Mr. Dodd:

Please find enclosed results of the 96-hour static acute bioassay using rainbow trout, *Oncorhynchus mykiss* conducted on samples #1 and #2 provided by Royal Roads University on 14 August 1996. Testing was initiated on 15 August 1996 and conducted in accordance with Washington State Department of Ecology Guidelines (Methods 80-12). The bioassay was conducted at the 10 mg/L and 100 mg/L concentrations in order to determine how the sample should be classified.

In summary, sample #1 exhibited 0% mortality at the 10 mg/L concentration and 3% mortality at the 100 mg/L concentration. Sample #2 exhibited 3% mortality at both the 10 mg/L and 100 mg/L concentrations. Neither sample should be classified as dangerous or extremely hazardous waste. Testing was conducted concurrently with negative and positive control groups which met all acceptable test criteria. Copies of the raw data, reference toxicant results and chain-of-custody forms are also enclosed in this data package.

If you have any questions regarding the results of this test, or are in need of further assistance, please contact either myself or Ms. Dayle Ormerod at (206) 822-8880. Thank you.

Sincerely,

PARAMETRIX, INC.

Paul Stenhouse
Project Manager, Toxicology Laboratory

cc: D. Ormerod
file

Summary of test conditions for static acute *O. mykiss* bioassay.

Job Name: Royal Road University — Test Date: 15-19 August 1996

Test Protocol:	WDOE, 1994. WAC 173-303-110 (3) (Amended ordinance 92-33), Washington State Department of Ecology, Olympia, Washington June 1991.
Test Material:	Samples #1 and #2
Test Organisms/Age:	*O. mykiss* (rainbow trout); 36 days from swim up at test initiation
Source:	Mt. Lassen Trout Farm; Red Bluff, California
Loading Limit:	0.8 g (wet weight) per liter of test solution
Number/Container:	10
Volume/Container:	6 liters
Test Chambers:	20 L High-density linear polyethylene containers
Replicates:	Three
Test Concentrations:	10 mg/L and 100 mg/L
Reference Toxicant:	Potassium chloride
Test Duration:	96 hours
Control:	Natural spring water from Gold Creek Trout Farm, Woodinville, Washington
Lighting:	Fluorescent bulbs (50-100 foot candles)
Photoperiod:	16 hours light; 8 hours dark
Aeration:	None
Renewal:	None
Temperature:	12 ± 1° C
Chemical Data:	Dissolved oxygen, temperature and pH measured at initiation of test and every 24 hours; hardness, alkalinity and specific conductivity determined at each concentration
Effect Measured:	Mortality
Test Acceptability:	Control mortality ≤ 10%

Summary of Results:

	Percent Mortality			
Sample	Control - Unspun	Control - Spun	10 mg/L	100 mg/L
#1	3%	7%	0%	3%
#2	3%	7%	3%	3%
Reference Toxicant LC50 =	1.6 ppt KCl			

Characterization criteria: >36.7% mortality at 100 mg/L = Dangerous waste
>33.3% mortality at 10 mg/L = Extremely hazardous waste

Parametrix, Inc.
Environmental Toxicology Laboratory

Oncorhynchus mykiss

Test Type: Static Acute Trout Hazardous Waste (80-12) Sample Number: BIOASSAY #1 & #2

Test Initiation Date: 8/15/96 Time: 1545 Source of Organisms: MT LASSEN TROUT FARMS

Client: ROYAL ROADS UNIV. Age of Organisms: 36 DAYS FROM SWIMUP

Conc.	Rep.	Number of Survivors				
		0 hours	24 hours	48 hours	72 hours	96 hours
Control (unspun)	A	10	10	10	10	10
	B	10	10	10	10	JK ~~10~~ 9-1
	C	10	10	10	10	10
Control (spun)	A	10	10	10	10	~~10~~ 9-1
	B	10	10	10	10	9-1
	C	10	10	10	10	10
10 mg/L #1	A	10	10	10	10	10
	B	10	10	10	10	10
	C	10	10	10	10	10
100 mg/L #1	A	10	10	10	10	9-1
	B	10	10	10	10	10
	C	10	10	10	10	10
10 mg/L #2	A	10	10	10	10	9-1
	B	10	10	10	10	10
	C	10	10	10	10	10
100 mg/L #2	A	10	10	10	10	9-1
	B	10	10	10	10	10
	C	10	10	10	10	10
	Initals	PS	MP	AE	MD/PS	JK
	Date	8/15	8/16	8/17	8/15	8/19

Test Volume: 6 L

Mean Control Fish Weight: 470.0 mg

Fish Length Range: MAXIMUM: 4.0 cm MINIMUM: 3.5 cm

Control Fish Lengths (cm): 1. 4.0 2. 3.6 3. 3.6

4. 3.7 5. 3.5 6. 3.9 7. 3.6

8. 3.5 9. 3.6 10. 3.5 - Mean: 3.65 cm

Concentration	Alkalinity	Hardness
Cont. (unspun)	56	84
Cont. (spun)	58	80
10 mg/L #1	58	78
100 mg/L #1	56	100
10 mg/L #2	60	88
100 mg/L #2	58	88

Comments:

Parametrix, Inc.
Environmental Toxicology Laboratory

Oncorhynchus mykiss

Test Type: Static Acute Trout Hazardous Waste (80-12) Client: ROYAL ROADS UNIV.

Test Initiation Date: 8/15/96 Sample Number: BIOASSAY #1 + #2

Temperature (°C) 0 hr 11 24 hrs 11 48 hrs 11 72 hrs 11 96 hrs 11

		pH (°C)					Dissolved Oxygen (mg/l)					Conductivity (µMHOS)	
		Time in Hours					Time in Hours					Time in Hours	
Concentration	Rep.	0	24	48	72	96	0	24	48	72	96	0	96
Control (unspun)	A	7.4	7.1	7.81	7.0	7.2	10.3	10.4	9.8	9.5	9.4	135	145
	B	7.4	~~7.1~~ 7.2	7.82	7.1	7.3	10.4	10.4	9.8	9.5	9.4	135	140
	C	7.2	7.3	7.2	7.1	7.3	10.4	10.6	9.8	9.6	9.5	135	140
Control (spun)	A	7.3	7.3	7.2	7.1	7.3	10.6	10.4	9.9	9.7	9.5	135	140
	B	7.3	7.4	7.3	7.2	7.3	10.6	10.6	9.8	9.7	9.5	135	140
	C	7.3	7.3	7.2	7.2	7.3	10.5	10.4	9.8	9.8	9.6	135	140
10 mg/L #1	A	7.1	7.1	7.3	7.2	7.3	10.3	10.5	9.7	9.6	9.6	135	140
	B	7.1	7.1	7.3	7.2	7.3	10.4	10.5	9.7	9.6	9.7	135	140
	C	7.0	7.1	7.2	7.2	7.3	10.4	10.5	9.7	9.6	9.7	135	140
100 mg/L #1	A	7.0	7.2	7.2	7.2	7.3	10.5	10.6	9.7	9.6	9.7	135	140
	B	7.0	7.2	7.2	7.2	7.3	10.4	10.6	9.8	9.8	9.7	135	140
	C	7.0	7.2	7.2	7.2	7.3	10.5	10.6	9.8	9.8	9.7	135	140
10 mg/L #2	A	7.0	7.3	7.1	7.2	7.4	10.3	10.6	9.9	9.6	9.6	135	140
	B	7.0	7.3	7.1	7.2	7.3	10.3	10.5	9.9	9.6	9.6	135	140
	C	7.0	7.3	7.1	7.2	7.4	10.4	10.6	9.8	9.7	9.6	135	140
100 mg/L #2	A	7.0	7.3	7.1	7.2	7.3	10.4	10.6	9.8	9.7	9.6	135	140
	B	7.0	7.3	7.1	7.2	7.3	10.4	10.6	9.9	9.8	9.6	135	140
	C	7.0	7.2	7.1	7.1	7.3	10.4	10.6	9.8	9.7	9.6	135	140
	Initals	PS	MD	AE	MD/PS	JK	JK	MD	AE	MD/PS	JK	JK	JK
	Date	8/15	8/16	8/17	8/18	8/19	8/15	8/16	8/17	8/18	8/19	8/15	8/19

PARAMETRIX, INC.
5808 Lake Washington Blvd. NE
Kirkland, Washington 98033

STATIC ACUTE TROUT TOXICITY TEST

Sample: KCl REF TOX — Test Dates: 8/14/96 – — Time: 1616
Source: IN HOUSE — Lot No.: N/A
Source of Organisms: MT LASSEN TROUT FARM — Age of Organisms: 35 DAYS FROM SWIMUP

Temp (°C): Day 0 11 — Day 1 11 — Day 2 11 — Day 3 11 — Day 4 11

Conc.	Rep.	Num. Org. Cont	No. of Survivors 24	48	72	96	pH 0	24	48	72	96	Dissolved Oxygen (mg/L) 0	24	48	72	96	Specific Conductivity (µS) 0	96
Control	A	10	10	10	10	10	7.6	7.2	7.3	7.[illegible]	7.1	10.6	9.7	10.2	10.0	9.4	135	140
	B	10	10	10	10	10												
.26 G/L	A	10	9-1	9	8-1	8	7.7	7.3	7.5	7.3	7.3	10.6	9.7	10.4	10.0	9.7	1700	1700
	B	10	10	10	8-2	8												
.715 G/L	A	10	9-1	6-3	3-3	3	7.7	7.3	7.16	7.4	7.4	10.6	9.8	10.7	10.5	10.4	2300	2300
	B	10	9-1	8-1	6-2	5-1												
2.45 G/L	A	10	1-9	1	1	1	7.7	7.3	7.6	7.5	7.5	10.6	9.9	10.7 ~~10.0~~	10.4	10.4	3000	3100
	B	10	1-9	0-1	0	0												
3.5 G/L	A	10	0-10	0	0	0	7.7	7.3	–	–	–	10.6	10.1	–	–	–	4800	4550*
	B	10	0-10	0	0	0												
5.0 G/L	A	10	0-10	0	0	0	7.7	7.4	–	–	–	10.6	10.2	–	–	–	6300	6000*
	B	10	0-10	0	0	0												
	A																	
	B																	
	A																	
	B																	
	A																	
	B																	
Initials		PS	PS	MD	AE	MD	PS	PS	MD	AE	MD	PS	JK	MD	AE	MD	PS	MD
Date		8/14	8/15	8/16	8/17	8/18	8/14	8/15	8/16	8/17	8/18	8/14	8/15	8/16	8/17	8/18	8/14	8/18

Comments: * 24 hrs

Parametrix Toxicology Laboratory

FISH TEST DATA

Test Number: REFTOX551 ( ) Chronic (x) Acute 96 hours
Test Date: 14-Aug-96
Source: REF Test Material: KCL (g/l)

Conc		Rep	Cont. No.	Start	Daily Survival 1	2	3	4	5	6	End	Prop Alive	Weight /Fish
0.00	D	1		10							10	1.00	
0.00	D	2		10							10	1.00	
1.20	D	1		10							8	.80	
1.20	D	2		10							8	.80	
1.72	D	1		10							3	.30	
1.72	D	2		10							5	.50	
2.45	D	1		10							1	.10	
2.45	D	2		10							0	0.00	
3.50	D	1		10							0	0.00	
3.50	D	2		10							0	0.00	
5.00	D	1		10							0	0.00	
5.00	D	2		10							0	0.00	

Parametrix Toxicology Laboratory

Test Date: 8/14/96
Sample Date: 8/13/96
Species: Oncorhynchus mykiss
Test Type: Acute - 96 hours

Test Number: REFTOX551
Test Material: Potassium chloride g/l
Source: REF
Reference Toxicant

SUMMARY

End Point	Day	Transformation		Conc		#Reps	Mean	StDev	% Surv
Proportion Alive	4	Arc sine sqrt w/ adj.							
			X	0.000	D	2	1.41	0.000	
			X	1.200	D	2	1.11	0.000	
			X	1.715	D	2	.68	.145	
			X	2.450	D	2	.24	.115	
				3.500	D	2	.16	0.000	
				5.000	D	2	.16	0.000	
Proportion Alive	4	No transformation							
				0.000	D	2	1.00	0.000	
				1.200	D	2	.80	0.000	
				1.715	D	2	.40	.141	
				2.450	D	2	.05	.071	
				3.500	D	2	0.00	0.000	
				5.000	D	2	0.00	0.000	

X = indicates concentrations used in calculations

- HYPOTHESIS TEST -

End Point	Day	Transformation/Analysis	NOEC	LOEC	TU	MSE	MSD
Proportion Alive	4	Arc sine sqrt w/ adj. Dunnett + t-test				.006	

- PROPORTION POINT ESTIMATE -

End Point	Day	Method	P	Conc	95% CI		TU
Proportion Alive	4	Probit	EC 50	1.556	1.37 -	1.74	

8/19/96–11:01 am TOXIS ANALYSIS SUMMARY

Fish Larvae

Lab	Species	Test Date	Test Material	Permit	Protocol	Test Number
WAPTL	OM	8/14/96	KCL (g/l)	REF	EPAA 91	REFTOX551

Statistics Parameters

PROPORTION

End Point:	PA Proportion Alive		
Analysis:	EPA Flowchart (Chronic and Acute)		1 control
Transform:	Arc sine square root w/ Bartlett adj.		
Tail:	One–tailed, decreasing		
Constant:	–.01	Variance:	.01
Root:	–1.00	Alpha Normality:	.01
		NOEC:	.05

EC/LC Method: F (P,S,G,L,N) Superdunnet: 4000

GROWTH

End Point:	GW Weight		
Analysis:	No Analysis		
Transform:			
Tail:			
Constant:	.01	Variance:	.01
Root:		Alpha Normality:	.01
		NOEC:	.05

Calculate IC? N (Y,N) IC resamples: 120

Errors/Warnings

Type	Number	
EC/LC	0	Analysis completed with no errors
PROP	44	Not enough replication for Steel test

Probit Analysis For EC/LC

Parametrix Toxicology Laboratory

Species: Oncorhynchus mykiss
Test Material: Potassium chloride (g/l)
Endpoint: Prop

Test Number: REFTOX551
Test Date: 8/14/96

Conc.	Number Exposed	Number Resp.	Observed Proportion Responding	Proportion Responding Adjusted for Controls	Predicted Proportion Responding
1.2000	20	4	0.2000	0.2000	0.1830
1.7150	20	12	0.6000	0.6000	0.6326
2.4500	20	19	0.9500	0.9500	0.9430
3.5000	20	20	1.0000	1.0000	0.9976
5.0000	20	20	1.0000	1.0000	1.0000

Chi-square for heterogeneity (calculated) = 0.197
Probability(Chi-square > 0.197) = 0.97807

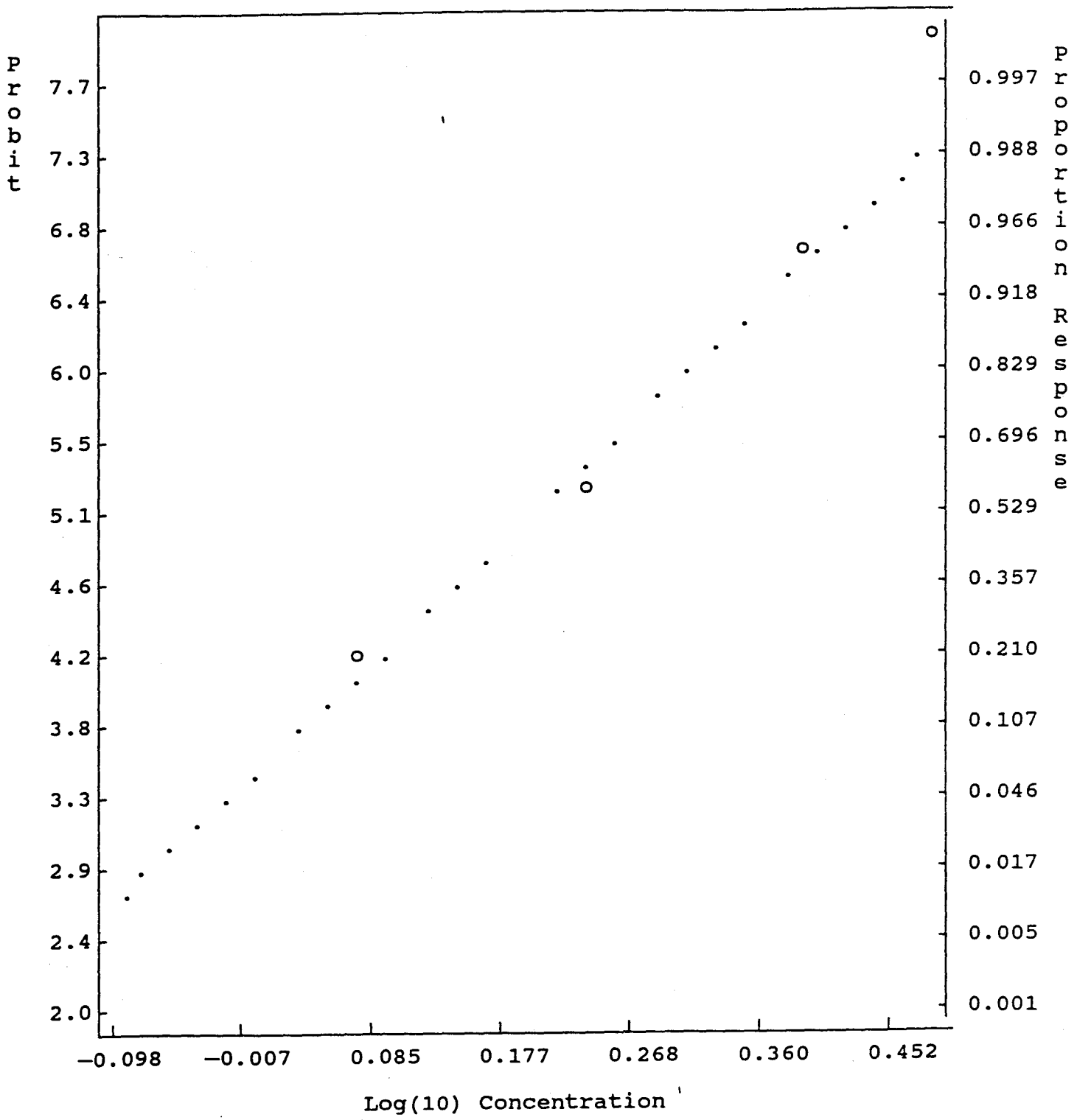
Parameter	Estimate	Std. Err.	95% Confidence Limits Lower	Upper
Intercept	3.461304	0.397239	2.682715	4.239893
Slope	8.013917	1.625862	4.827229	11.200606

Theoretical spontaneous response rate = 0.0000

Estimated LC/EC values

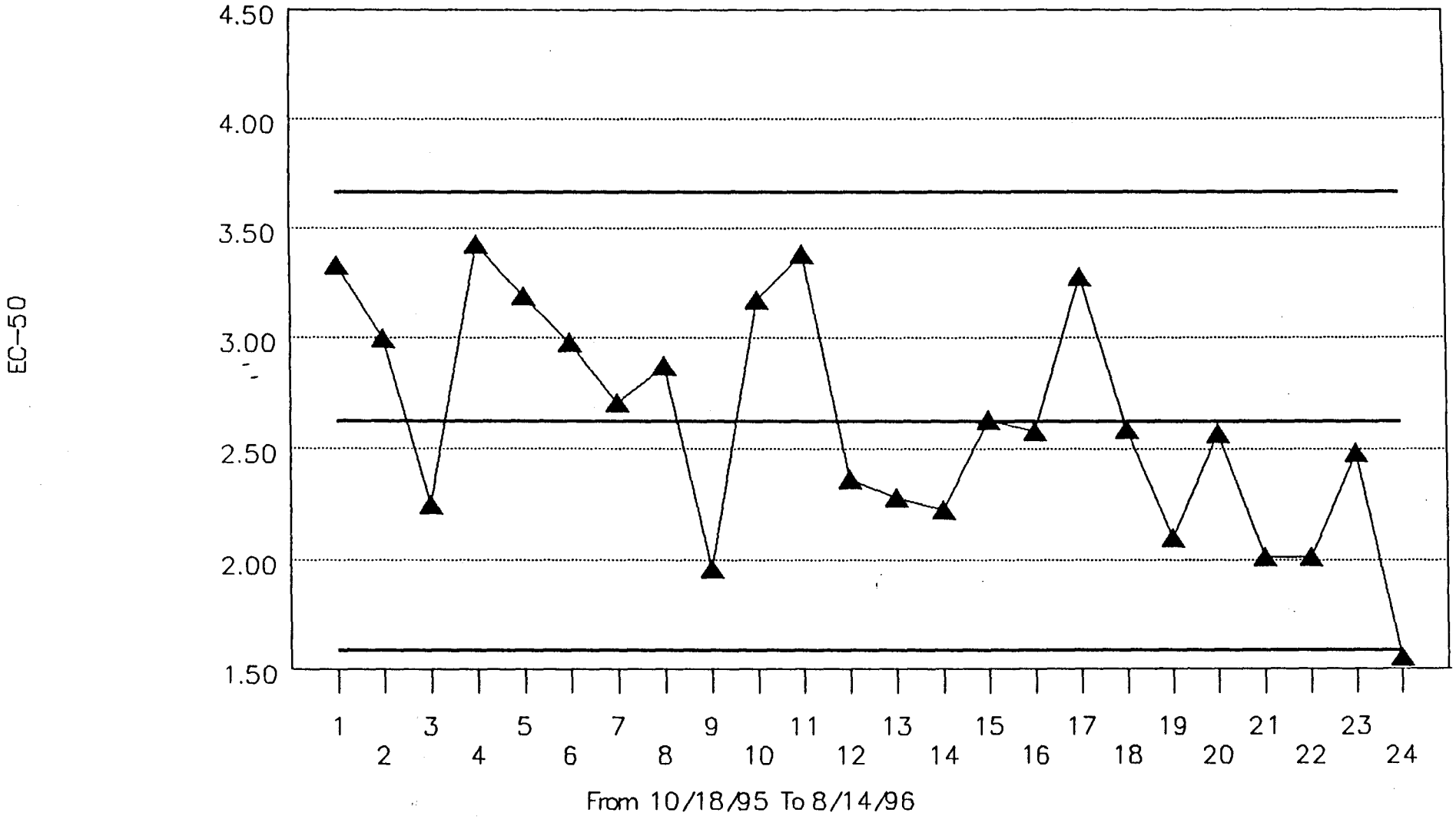
Point	Exposure Conc.	95% Confidence Limits Lower	Upper
50.00	1.556	1.366	1.739

Plot of adjusted probits and predicted regression line



CONTROL CHART

Acute O. mykiss/Potassium chloride



Field Sampling / Chain of Custody Record

Parametrix, Inc. · 5808 Lake Washington Blvd. · Kirkland, Washington 98033-7350 · 206-822-8880 · Fax 206-889-8808

Project Name: ROYAL ROADS UNIV.	Project Number: 55 3150 01	Client: ROYAL ROADS
Samplers:		Recorder:

Matrix				# of Containers and Preservatives							Sample Number	Date				Analysis Required
Water	Tissue	Sediment	Other	Unpreserved	HCl	H2S04	HNO3	NAOH	NAOH and Zinc Acetate	Other		Month	Day	Year	Time	
										1	BIOASSAY 01	8	14	96	1010	80-12 BIOASSAY
										1	BIOASSAY 02	8	14	96	1010	80-12 BIOASSAY
Total Containers:										2						

Chain of Custody Record (Please Print)

Relinquished By: (Name)	Date:	Time:	Received By: (Name)	Date:	Time:
			[signature]	14/NOV/96	1010

Shipping Information

Cooler#:

Airbill #:

____ of ____ Coolers on this Airbill

White C[illegible]abora[illegible] Yel[illegible]py R[illegible]o Pa[illegible]x Inc. [illegible] Pink C[illegible]