DETAILED SITE INVESTIGATIONS AND SITE RESTORATION OF BLANCHARD RIVER STATION, YUKON, CANADA

Prepared for:

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EXECUTIVE SUMMARY

The Blanchard River Pump Station was constructed along the Haines-Fairbanks Pipeline in 1962 to increase the throughput of fuel delivery from the deep-water port at Haines to military sites in Alaska. Facilities built at the original pump station consisted of one main building and six trailers. The main building housed the engine room, pumps, generators, maintenance shop and water supply, while the six trailers provided family accommodations. In 1971, the US Department of Defense decommissioned the Haines-Fairbanks Pipeline and title to the pipeline infrastructure was reverted to Canada. All the facilities, including those at Blanchard River, were transferred to Indian and Northern Affairs (DIAND) in 1982. The decommissioned pump station was converted to a Yukon Territorial Government (YTG) Highway Maintenance Camp in 1986. In the process, the main building was extended on the north end and converted to the Highways Maintenance Garage. The six trailers were also removed and an accommodation building was constructed on the original site of the trailers to house the highway workers. Demolition debris was buried to the north of the site.

A Preliminary Environmental Investigation was conducted at Blanchard Station in 1995 as part of studies along the Haines Fairbanks Pipeline. This investigation identified (i) a rust coloured drainage ditch on the north side of the site and (ii) subsurface soils at the southwest side of the maintenance building as the main areas of contamination. Extractable hydrocarbons, mono-aromatic hydrocarbons and metals were the main contaminants of concern at both locations. There was no evidence for elevated levels of PCBs, halogenated volatile hydrocarbons, phenoxy herbicides, pesticides such as DDT or polycyclic aromatic hydrocarbons.

A Detailed Site Investigation (DSI) was conducted by Royal Roads University – Applied Research Division (Royal Roads) and UMA Engineering Ltd. (UMA) in June 1999. This was followed by additional investigations and remedial activities in September 1999. Over 250 soil/sediment and 50 ground water/Blanchard River surface water samples were collected over the course of these site investigations. Using a combination of field and laboratory analytical techniques these samples were analyzed for one or more of the following parameters - metals/metalloids, petroleum hydrocarbon constituents (VPH, LEPH, HEPH, PAHs, BTEX), halogenated volatile organic compounds, chlorinated pesticides, herbicides, chlorobenzenes, and Polychlorinated Biphenyls (PCBs).

The major conclusions as well as, areas of concern identified, remedial activities conducted and recommendations include:

- Volatile Organic Compounds (VOCs), Polychlorinated Biphenyls (PCBs), chlorobenzenes and pesticides such as DDTs were not contaminants of concern at Blanchard River in that they were found to be either less than the appropriately low method detection limit, or well below the relevant environmental quality benchmarks;

- Potable water samples collected from the camp water well did not contain metals/metalloids and hydrocarbons at levels exceeding the Yukon CSR drinking water standards.

- Apart from one area of the site (Rust-Coloured Drainage Ditch), the concentrations of most metals/metalloids were not of concern (i.e., did not exceed the relevant Yukon CSR standard). There were naturally elevated levels of chromium in the Blanchard River site soils, and ten soil samples contained chromium in excess of the Yukon CSR standard.

- North of Maintenance Building (Burn Pit) – Subsurface soils and groundwater in this area where a burn pit was operated historically (prior to conversion of the pump station to a highway maintenance camp) were contaminated with hydrocarbons. Petroleum hydrocarbon contaminated soils (approximately 700 m^3 or 1,400 tonnes) were excavated from the burn pit area and placed in a containment cell for temporary storage pending construction of the proposed land farm treatment facility. Land farming was identified as the most cost effective remedial option, based on the availability of sufficient land area along the former highway right-of-way, immediately adjacent to the site. It is recommended that a monitoring program be initiated to verify the expected decrease in hydrocarbon concentrations in the groundwater plume following removal of contaminated substrate from the burn pit.

- Rust-Coloured Drainage Ditch North of Site – Hydrocarbons and metal-contamination were present in soil and surface water along a rust-coloured stained drainage ditch at the north end of the site, and leading down to the Blanchard River. The contaminated substrate was excavated and placed into polyethylene-lined, woven polypropylene bags. The bags containing approximately 10 m^3 (15 tonnes) of material were placed in a temporary storage area pending removal for off-site disposal. The DSI showed that a culvert, which was previously identified in 1995 using an EM survey, was serving as a conduit for the diversion of hydrocarbon-contaminated groundwater from the burn pit to the rust-coloured draw. The culvert was removed and the excavation backfilled with native soils.

- Southwest of Maintenance Building – Contaminants including extractable petroleum hydrocarbons, BTEX components, and PAHs were present in either subsurface soils or groundwater. There was some evidence of the introduction of low levels of hydrocarbons into Blanchard River. The available data however suggested that, based on current site conditions, the risks to aquatic life were not elevated. In the absence of any other risk management activities, it is recommended that changes in concentration of hydrocarbons over time in this location of the site should be monitored.

- Above Ground Storage Tanks South of Maintenance Building – A small amount of hydrocarbon-contaminated soil was found near the abandoned tank. There was no evidence that this limited soil mass was creating appreciable groundwater contamination, or the movement of hydrocarbons to adjacent surface areas where humans or ecological receptors might be exposed. This area, therefore, was excluded as an area of potential concern.

- Floor Drains, Rock Pit and Soak Away Pit – Hydrocarbons and other materials have been introduced on an ongoing basis to the floor drains and then to either a rock-filled soak away pit west of the maintenance building or perforated barrels, via an oil/water separator, southwest of the building. There were hydrocarbon-contaminated soils and rock within the perforated culvert from which the rock pit was constructed, as well as in the immediate vicinity of the barrels. A replacement of the rock pit and soak away pit with an up-to-date system has been recommended. It is anticipated that the current system would be decommissioned and replaced with more up-to-date oil/water separation technology, with offsite disposal of recovered oily waste for recycling. This would curtail the chronic discharge of hydrocarbon-contaminated water into the subsurface environment. The localized hydrocarbon-contaminated materials within and around the pits do not appear to have resulted in a more widespread lateral or down-gradient contamination of the subsurface environment. Removal or isolation of the decommissioned rock pit, therefore, is not deemed to be necessary based on the expected limited risks to the environment.

- East of Maintenance Building - It was evident that free product in at least some portions of the six-inch line was not removed prior to decommissioning of the old Haines-Fairbanks pipeline. There was no evidence that limited free product releases from remaining buried pipeline have adversely impacted the site, except through the contamination of very small subsurface soil masses. It is recommended therefore that the presence of free product be documented. Should an opportunity present itself, it might be prudent to recover the remaining free product through use of a vacuum truck or similar method.

- Rafters Camp and Storage Area - Surficial hydrocarbon contamination was noted in the parking area near the Rafter's Camp, and to the south of the maintenance camp. It was evident from the analytical results that the staining was recent, and limited to shallow soils, with a decline at depths of 2 to 3 m or less. The presence of localized hydrocarbon-contaminated soils in this area of the site suggested recent release, probably associated with draining of and the inappropriate discarding of used crankcase oils from motor vehicles. It is recommended that measures be taken to control the unauthorized disposal of used oil in the future.

- Underground Storage Tanks – The underground storage system, consisting of two single-walled steel tanks (11,360 L gasoline and 30,280 L diesel) and concrete pump island located on the northwest of the maintenance building was decommissioned in July 1999. The decommissioned tanks, associated pumps and hydrocarbon-contaminated soils surrounding the tanks were removed in September 1999. The contaminated soils were placed in the temporary containment cell pending landfarming.

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1. INTRODUCTION

1.1 Background

During the period 1950-1952, the United States (US) government commissioned the Fluor Corporation, Los Angeles, California to construct an eight-inch multi-fuel line to supply fuels from the deep-water port at Haines to military sites in Alaska. In response, the Haines-Fairbanks Pipeline was constructed in 1954-1955. Five pump stations and associated facilities were constructed along the pipeline. Six additional pump stations, including Blanchard River were built along the line in 1962 to increase the throughput. The Blanchard River Station is located at Mile 87 of the pipeline and is just on the Yukon side of the border with British Columbia (Drawing 1.1).

In 1971, the US Department of Defense decommissioned the Haines-Fairbanks Pipeline and title to the pipeline infrastructure was reverted to Canada. All the facilities, including those at Blanchard River, were transferred to Indian and Northern Affairs (DIAND) in 1982. Facilities at the original Blanchard Pump Station consisted of one main building and six trailers. The main building housed the engine room, pumps, generators, maintenance shop and water supply, while the six trailers provided family accommodations.

The decommissioned pump station was converted to a Yukon Territorial Government (YTG) Highway Maintenance Camp in 1986. In the process, the main building was extended on the north end and converted to the Highways Maintenance Garage. The six trailers were also removed and an accommodation building was constructed on the original site of the trailers to house the highway workers. Demolition debris was buried to the north of the site. Other old disposal areas that were associated with the original pump station are present at the site. A brief historical overview of the site is given in Chapter 2 of this report. Detailed historical information of the site has been compiled in a report by Bisset and Associates (1995).

A preliminary environmental investigation was conducted at Blanchard Station in 1995 by UMA Engineering Ltd. and Ambio Research Associates as part of studies along the Haines Fairbanks Pipeline (UMA 1995). This investigation identified (i) a rust coloured drainage ditch on the north side of the site and (ii) subsurface soils at the southwest side of the maintenance building as the main areas of contamination. Extractable hydrocarbons, mono-aromatic hydrocarbons and metals were the main contaminants of concern at both locations. There was no evidence for elevated levels of PCBs, halogenated volatile hydrocarbons, phenoxy herbicides, pesticides such as DDTs or polycyclic aromatic hydrocarbons (PAHs).

Elevated levels of inorganic elements (arsenic, barium, cobalt, selenium and zinc) and extractable hydrocarbons were found in soil/sediment samples collected from the above-mentioned drainage ditch. It appeared this drainage ditch received contaminated groundwater from source(s) within the vicinity of the maintenance complex. The results of an electromagnetic survey (EM) survey indicated that a buried pipe originating between the shop and residence terminated at the leachate plume. It was suspected that this pipe might be the conduit for the contaminants found in the samples collected in the leachate. The origin of this pipe was not ascertained during the preliminary investigation. Hydrocarbon contamination was also found in groundwater and subsurface soils obtained from the southwest side of the site. In addition, a spatially limited oily sheen was occasionally observed on the surface of water in the Blanchard River near the south end of the site, and near the sampling locations.

The origin and extent of the two-contaminant plumes summarized above could not be determined from the limited investigation. There was evidence, however, that these plumes were introducing hydrocarbons and inorganic elements into the Blanchard River – an important river for salmon spawning. The report recommended a detailed site investigation to characterize the source, composition and extent of contamination at the site.

1.2 Scope and Objectives

1.2.1 Detailed Site Investigation

The recommendations provided above formed the basis for a detailed site investigation undertaken by Royal Roads University – Applied Research Division (Royal Roads) and UMA Engineering Ltd. (UMA) in 1999.

The main objectives were to –

- Conduct a detailed investigation to determine the source, composition and aerial extent of soil and groundwater contamination at Blanchard River Station;
- Evaluate the current operation of the site and its contribution, if any to contaminant loading;
- Carry out an environmental assessment of the data obtained; and,
- Define cleanup/remedial options, if required.

To achieve these objectives, a field program was conducted in June 1999. The field team included representatives from Royal Roads, UMA and DIAND Waste Management. Prior to the field investigations, a review of previous site investigation reports (UMA, 1995 and RRU, 1996), aerial photographs, maps and drawings was conducted. Information gathered was incorporated into a Detailed Work Plan that was submitted to DIAND, YTG and the Champaign and Aishihik First Nations. Comments received were incorporated into the Work Plan.

Components of the field program included –

- Information exchange with local stakeholders, including YTG;
- Borehole drilling and monitoring well installation;
- Sampling of surface and subsurface soil and water;
- Acquisition of field data for calculation of hydraulic conductivity, groundwater flow and contaminant migration rates;
- Use of field test methods for analysis of contaminants in soil and water;
- A quality assurance/quality control program;
- Surveying of boreholes, monitoring wells and all features relevant to the derivation and carrying out of clean up plans; and,
- Complete documentation of site conditions and sampling program.

The field program was followed by laboratory analysis for metals, hydrocarbons, pesticides and PCBs. The results were evaluated by using the Yukon Contaminated Sites Regulations (Yukon CSR). The major conclusions as well as areas of concern identified based on the review and interpretations of the data are presented in this report (see especially Chapters 4 and 5).

1.2.2 Site Restoration and Additional Investigations

Preliminary results and recommendations from the detailed site investigations formed the basis of remedial activities and additional site investigations that were undertaken by Royal Roads, UMA, and Champaign and Aishihik First Nations in September 1999. The main objective of the September program included –

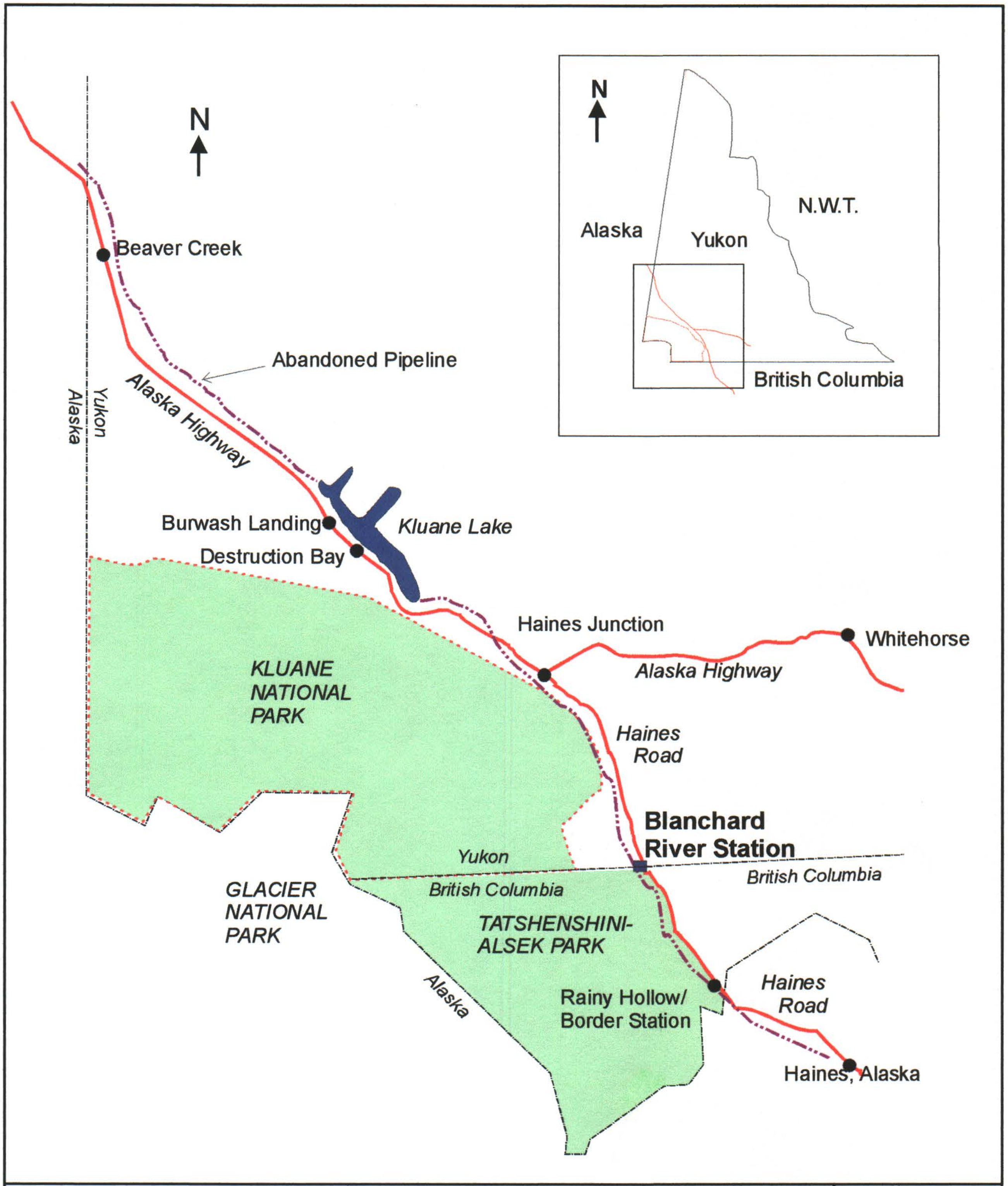
- Additional investigations to verify the source, composition and aerial extent of hydrocarbon contamination in soil and groundwater at localized areas of the site;
- Remediation of hydrocarbon contamination at the former burn pit;
- Curtailment of the discharge of hydrocarbon and metal contaminated water and sediments along the rust-coloured drainage ditch;
- An evaluation of the current floor drains and replacement with more up-to-date technology, if necessary;
- An environmental assessment of the data obtained; and
- Derivation of cleanup/remedial options, if required.

Specific work tasks conducted to achieve the objectives for this phase of the project comprised –

- Excavation of petroleum hydrocarbon contaminated soils in the vicinity of the former burn pit;
- Establishment of a temporary holding facility for the excavated contaminated soil;
- Curtailment of contaminated groundwater discharge from culvert at top of rust-coloured drainage ditch at the northern end of the site;
- Removal and packaging of metal and hydrocarbon contaminated sediments in the rust-coloured stain at the northern end of site for off-site disposal;
- Excavation of six inch fuel line at the eastern side of maintenance shop;
- Inspection of floor drains in the maintenance building along with the oil/water separator and soak away pit and recommendation for replacement options with more up-to-date technology;
- Completion of a detailed site investigation of the petroleum hydrocarbon plume on south end of site;
- Confirmatory testing of excavated areas; and,
- Additional sampling and analysis at the rafters' camp, and other areas of the site.

1.2.3 Scope of this Report

This report presents the results and interpretations of both the detailed site investigation and the site remediation program.



INDIAN AFFAIRS AND NORTHERN DEVELOPMENT BLANCHARD RIVER STATION: SITE INVESTIGATION	DWG. No: 1-1
TITLE: GENERAL LOCATION OF BLANCHARD RIVER STATION	

2. ECOLOGICAL SITE DESCRIPTION AND HISTORICAL OVERVIEW

2.1 Site Description

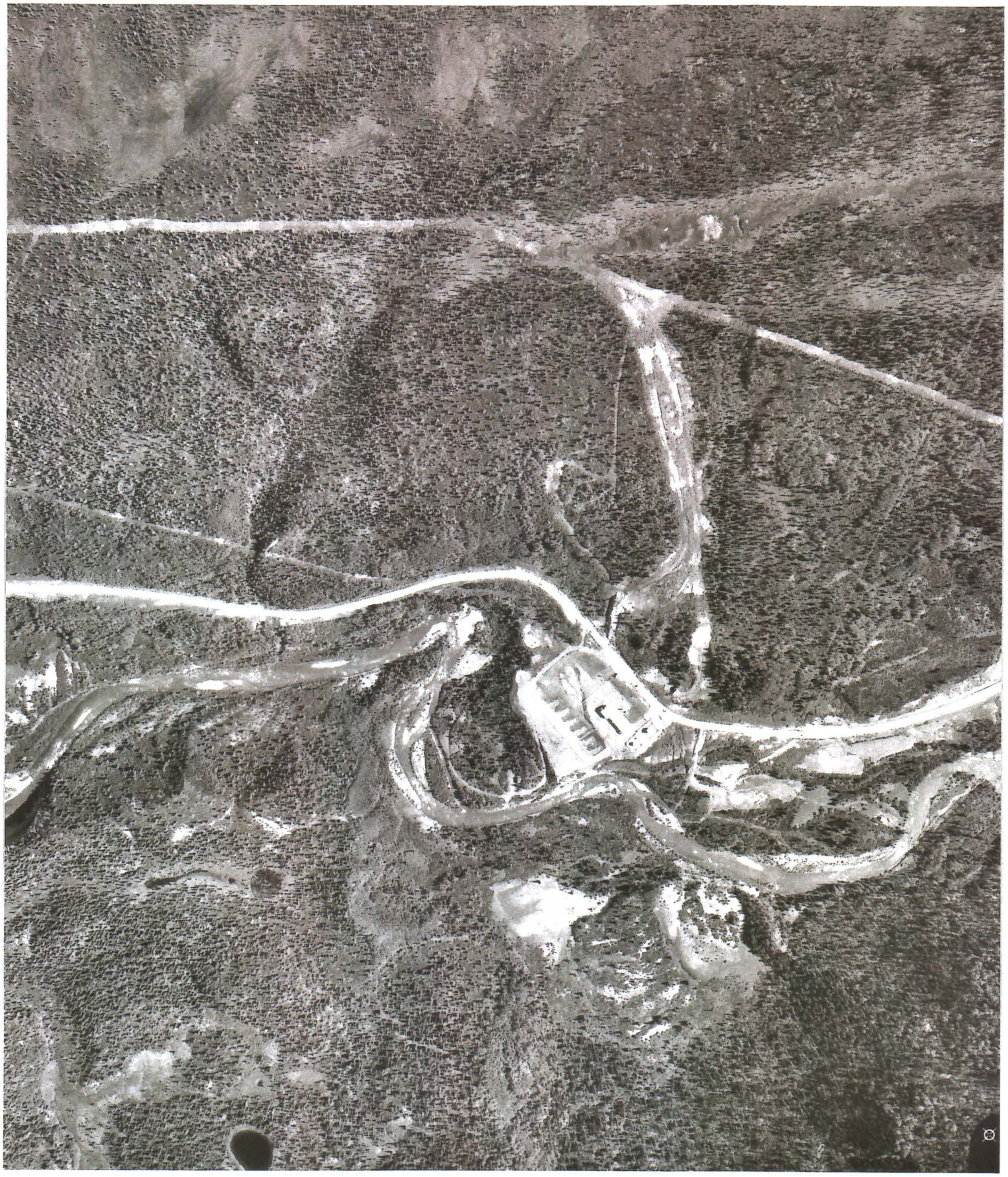
Blanchard River Pump Station is located in the Yukon Territory at Milepost 95.8 on the Haines Highway and is just on the Yukon side of the border with British Columbia (60° 31' N, 136° 28' W). It was constructed at Mile 87 of the old pipeline, at an elevation of 829 m above sea level. The original station, occupying an area of 5 ha, is situated on a foothill terrace with the Blanchard River ravine flanking the north, west and south sides (Photograph 2-1).

The site is currently owned by the Yukon Territorial Government and is used as a Highway Maintenance Camp. Facilities existing at the site include a maintenance garage, an accommodation building and fuel storage tanks (Photograph 2-2). Additional private and public facilities also exist just outside the current boundaries of the maintenance camp. A series of old worked areas to the south of the station border fence are presently occupied by a whitewater rafting company. These areas serve as storage and camping space for the company's operations. A spring-fed pipe in this area also provides a water supply for the camp. An old service road curves from the western end of the site in a northern direction to the river shore and to an old log cabin below. From this point, the road follows the riverbank to the north side of the site. Camping areas and an outhouse have been set up for anglers at the end of this road (Photograph 2-3).

Surface soils at the station are variable and consist of mixtures of silt-sand-gravel (mainly fill) in disturbed and worked areas at the station, organic-sandy soils in wooded regions, and sand with varying amounts of silt along drainage and waterways. Based on test pits and borehole logs, soils in the station area overlay a base, gray silty clay layer occurring at depths ranging from 2.4 to 10 m. Permafrost was not detected in the test pits.

Vegetation in the region, outside of disturbed areas is primarily late successional to mature spruce (*Picea* sp.) forest with the occasional balsam poplar (*Populus* sp.), and understory plants such as willow (*Salix* sp.) and horsetail (*Equisetum* sp.). Natural riverbank areas are dominated by willow, balsam poplar, horsetail, and grasses [e.g., squirrel-tail grass (*Hordeum* sp.)]. Forbs such as willow-herb (*Epilobium* sp.) are common. Grizzly bears are reported to frequent the region, and the waters are well-known for salmon sport fishing.

The valley sediments constitute a subsurface reservoir for groundwater storage and transport with the Blanchard River being the discharge boundary for the upper groundwater flow system. Groundwater levels in the area are influenced by seasonal and annual variations in precipitation. From the water level data collected, it can be inferred that groundwater flow across the south end of the site is in a southwest direction, and groundwater flow on the north side of the site is to the north direction. Both flow regimes are directed towards the Blanchard River that meanders around the south, west and north sides of the site. The base of the upper flow system was determined to be the upper surface of the clay stratigraphy.



Photograph 2-1: Aerial photograph of Blanchard River Pump Station (1960's) showing the maintenance building, above ground storage tanks, trailers and the Blanchard River.

Photograph 2-2: Blanchard Maintenance Camp looking west from the Haines Highway.

Photograph 2-3: Blanchard Maintenance Camp with Blanchard River to the right.

2.2 Operational History of Blanchard River Pump Station

2.2.1 Haines-Fairbanks Pipeline

The Haines-Fairbanks pipeline was conceived in response to the need for fuel in Alaska for defence purposes during the Korean War of 1953. Construction began in 1954 and the pipeline became operational in 1956 (US Department of the Army, 1982). The 626-mile long eight-inch pipeline paralleled the Haines and Alaska Highways and provided a conduit for fuel transmission from the deep-water port of Haines, Alaska to northern military installations at Fairbanks, Alaska. A portion of the pipeline alignment (approximately 251 miles) crossed the Yukon Territory. The pipeline was placed on the surface, along a 50-foot right of way, except in a few places where conditions required it to be buried. It was a multi-product line, which transported diesel fuel, aircraft turbine and jet engine fuel (JP-4), aviation gasoline and automotive combat gasoline. Initially, five pump stations were constructed along the pipeline to deliver 16,500 barrels of product per day.

2.2.2 Construction of Blanchard Station (1962)

In 1962 Blanchard River Pump Station and five other pump stations were built in response to the requirement for an increase in throughput to 27,500 barrels per day. Facilities constructed at Blanchard River included a combination building and family housing complex. The single story combination building housed an engine room, pump room, generator room, office and maintenance shop. The pump unit consisted of three diesel driven multistage centrifugal pumps. Two low pressure oil fired steam boilers and two 60 KW Caterpillar diesel generators were located in the generator room. A burn pit was established adjacent to the combination building. Two POL storage tanks were located at the south end of the site. The family housing complex consisted of six 10’ by 50’ trailers. (Photograph 2-1)

The pipeline right-of-way was periodically treated with herbicides, including 2,4,-D, 2,4,5-T (Esteron), 3-phenyl-1,1-dimethylurea (Fenuron), and 4-amino-3,5,6-trichloropicolinic acid (Tordon 101). Permission was granted to the US Army to store herbicides at Blanchard River Pump Station (K. Bisset & Associates, 1995). A DFO memo from 1968 directs the US Army to dispose excess spray materials by burying them in plastic containers or by another manner approved by the contracting officer (K. Bisset & Associates, 1995).

2.2.3 Decommissioning and Subsequent Use/Activity (1971 – 1991)

In 1971, the US Department of Defense decommissioned the Haines-Fairbanks Pipeline. Fuel was emptied from the pipeline and the pipeline was purged with water and dried with methanol and compressed air. In 1982 the Haines-Fairbanks Pipeline was transferred to the Canadian Department of Indian Affairs and Northern Development. In 1985-86, the Yukon Territorial Government converted the Blanchard River Pump Station to a highways maintenance camp. The combination building was extended and converted to a garage. The family housing complex was removed and a new accommodation unit was constructed on site. The demolition debris from the original housing complex was buried to the north of the site. The pipeline was dismantled in 1991 and hauled south.

Site drawings of the original pump station site layout, as well as of the 1985-86 conversion to a highways maintenance camp are available at the site. These were consulted to provide clues on subsurface utilities, historical operations and disposal infrastructure, and other site features of relevance to the detailed site investigation.

2.3 Previous Environmental Assessments

2.3.1 Pipeline Spill Investigation (1971)

The US Army undertook an investigation of 20 operational spills and fuel releases during decommissioning. Eleven of the 20 spills were in the Yukon Territory. There were no reported investigations of releases at Blanchard River Pump Station; the closest spill was at Pipeline milepost 119.1 (Garfield, *et. al.* 1971).

2.3.2 Aerial Survey (1972)

Representatives from DIAND, YTG and Environment Canada carried out an aerial survey of the pipeline within the Yukon Territory to consider possible salvage and removal options. The pipeline reportedly appeared to be in "good condition". Indications that defoliants had been used to clear the pipeline right-of-way were noted. The buildings and compounds at Blanchard River were reported to be "well maintained" and "generally tidy and clean". It was recommended that "detailed inspection and certification" be used to verify these observations prior to any salvage activities (DIAND, 1972).

2.3.3 Herbicide Assessment (1994)

In 1994, a report on historical herbicide application and consequent contamination was carried out for the Champagne and Aishihik First Nations. The report states that the pipeline right-of-way was annually sprayed with herbicides from the "mid in 1950's until about 1970". The herbicides used included 2,4-D and 2,4,5-T. An analysis of soil samples collected from the Klukshu village site in 1993 revealed a dioxin and furan homologue profile consistent with the application of 2,4,5-T. (Gray, 1994 and Axys Analytical Services Ltd., 1993).

2.3.4 Preliminary Environmental Assessment (1995)

A preliminary environmental assessment was carried out at Blanchard River in July 1995 to identify areas of waste disposal and surface and subsurface soil and water contamination (UMA, 1995). The program included an electromagnetic survey to identify buried debris, the excavation of six test pits and drilling of five bore holes, followed by the installation of monitoring wells in each hole. Subsurface soils were collected from the bore holes and test pits, in addition to surface soils and water samples from a brown rust-coloured drainage ditch observed north of the site. Groundwater samples were obtained from the monitoring wells as well as two mini-piezometers, which were established near the groundwater-surface water interface at a stained area near Blanchard River. A combination of field and laboratory analytical techniques was used to analyze the soil and water samples. A summary of the analytical program is given in Table 2.1 below.

Table 2.1: Summary of 1995 Analytical Program

Parameter	**Field Analysis**		**Laboratory Analysis**	
	Soil	**Water**	**Soil**	**Water**
Volatile Organic Compounds (VOC)	37	1	4	8
Benzene, Toluene, Ethylbenzene, xylene (BTEX)	2	8	5	9
Total Extractable Hydrocarbons (TEH)	14	-	5	7
PCBs	20	-	4	5
Polycyclic Aromatic Hydrocarbons (PAHs)	19	-	-	1
Pesticides	-	-	1	3
Herbicides	-	-	-	3
Metals	-	-	12	9
Conductivity, pH	-	4	-	-

The results of the laboratory analysis indicated that the rust coloured drainage ditch on the northern side of the site and subsurface soils at the southwest side of the maintenance building were the main areas of contamination. Extractable hydrocarbons (TEH), BTEX and metals were the main contaminants of concern. High levels of inorganic elements (arsenic, barium, cobalt, selenium and zinc) and extractable hydrocarbons were found in soil/sediment samples collected from the drainage ditch. It appeared this ditch originated from the maintenance complex. The results of an EM survey indicated that a buried pipe originating between the shop and residence terminated at the ditch plume. This pipe may be the conduit for the contaminants found in the samples collected in the leachate. The origin of this pipe was not ascertained during the preliminary investigation.

Hydrocarbon contamination was also found in groundwater and subsurface soils obtained from the southwest side of the site. In addition, a small amount of free product was observed on the surface of water in the Blanchard River, near the sampling locations. The origin and extent of the two-contaminant plumes summarized above could not be determined from the limited investigation. There was, however, evidence that these plumes were introducing hydrocarbons and inorganic elements into the Blanchard River. The investigation found no evidence of contamination from PCBs, chlorinated pesticides, PAHs, phenoxy acid herbicides or volatile organohalogens. The investigation recommended that a full site investigation and risk assessment be completed at Blanchard River (UMA, 1995).

2.3.5 Preliminary Environmental Assessment (1996)

A follow-up to the 1995 preliminary environmental assessment was conducted in 1996 (Royal Roads, 1996b). Five archived soil samples were analyzed for PCBs, chlorobenzenes, organochlorine pesticides (OCPs) including DDTs, and metals to characterize further the nature of contamination identified. The original findings and recommendations were confirmed by the re-assessment; hydrocarbons and metals in the drainage ditch and groundwater were the main contaminants of concern. PCBs, chlorobenzenes, and OCPs were either below detection or very low. The report recommended that a full site assessment be carried out at Blanchard River to delineate the extent of subsurface hydrocarbon contamination followed by an analysis of remedial options.

A few samples were subjected to detailed characterization of petroleum hydrocarbon constituents (Royal Roads, 1996a), including alkyl-PAH, alkane and hopane profiles. These marker compounds can be used to indicate degree of weathering or biodegradation of samples. Overall, the results indicated that there was evidence on only limited weathering of petroleum hydrocarbon subsurface contamination at the south end of the site.

2.3.6 Potable Water Sampling Program (1996 – 1997)

2.3.6.1 Metals and PCBs

A potable water sampling program was initiated in the summer of 1996 at the request of the camp supervisor to ensure that water obtained from the camp well for domestic purposes continues to meet drinking water standards. Accordingly, a water sample was collected from a sink in the washroom located within the garage/maintenance complex on July 22nd, 1996. This sample was analyzed at Analytical Services Laboratory (ASL) Vancouver for dissolved metals, PCBs, and extractable hydrocarbons. The concentrations of all the parameters analyzed, except selenium, were extremely low and well below any benchmark indicative of compromised water quality. Quality assurance data indicated that the drinking water results were reliable, with the exception of the value for selenium (1,700 μg/L), which exceeded the 1991 CCME Drinking water criteria (10 μg/L). The laboratory was therefore asked to re-evaluate this result. After re-evaluation, the laboratory reported that the original value of 1,700 μg/L was erroneous due to a transcription error. The correct value was 1.7 μg/L, which was well below the CCME drinking water benchmark. The 1996 results are compared to data obtained during the 1995 Preliminary site investigation (UMA 1995) and the current Yukon Contaminated Sites Regulation (CSR) standards for drinking water in Table 2.2. Metal concentrations in another sample collected on June 4, 1997 were comparable to the 1996 data.

Table 2.2: Concentration (µg/L) of Metals and PCBs in a Drinking Water Sample Collected from Blanchard River Camp in 1995 - 1997

Sample #	**BL1GW001**	**BLA96-01**	**Sample**	**Yukon CSR Drinking Water Standard**
Location	**Shop Washroom**	**Pressure Tank #2**	**Pressure Tank #3**	
Date Collected	**Jun-95**	**21-Jul-96**	**4-Jun-97**	
Metals				
Aluminum	<150	<5	<200	200
Antimony	<150	-	<200	-
Arsenic	<1	0.6	0.7	25
Barium	66	60	70	1,000
Beryllium	<3	<5	<5	-
Boron	30	<100	<100	5,000
Cadmium	<0.2	<0.2	<0.2	5
Calcium	29,200	28,900	30,700	-
Chromium	<1	<1	<1	50
Cobalt	<1	<20	<10	-
Copper	110	117	40	1,000
Iron	<30	<30	70	300
Lead	3	2	7	10
Magnesium	5,570	5,740	6,450	-
Manganese	<3	<5	<5	-
Mercury	<50	<0.05	<0.05	1
Molybdenum	3	<30	<30	250
Nickel	3	<20	<20	-
Selenium	<40	1.7	3	10
Silver	3	<1	<1	-
Sodium	2,400	<2,000	<2,000	200,000
Thallium	-	-	<30	-
Tin	<1	-	<30	-
Uranium	-	-	0.7	100
Vanadium	<10	<30	<30	-
Zinc	37	53	80	5,000
PCBs	<1	-		-

2.3.6.2 Volatile Hydrocarbons and BTEX

In September 1996, at the request of the camp supervisor, a sample was collected from the washroom sink located in the garage/maintenance complex for volatile hydrocarbon analysis (including BTEX compounds). All the analytes were below detection except for toluene. The concentration of toluene (138 µg/L) was greater than the 1991 CCME drinking water criterion of ≤ 24 µg/L. The elevated toluene concentration apparently corroborated some earlier data (Sam Dion, personal communication); however, toluene was not detected in the sample collected in summer of 1995 (UMA, 1995). This suggested the need for follow-up. Indian and Northern Affairs personnel subsequently collected four water samples in October 1996. BTEX concentrations in the samples were below detection. The data, along with the 1995 results and the current YTG Drinking Water Standards are given in Table 2.3.

Table 2.3: Concentration (µg/L) of Volatile Hydrocarbons in Drinking Water Samples Collected at Blanchard River Camp from June 1995 to October 1996

Date Collected	**01-Jun-95**	**17-Sep-96**	**22-Oct-96**				**Yukon CSR Drinking Water Standard**
Location	**Shop Washroom**	**Shop Washroom Sink**	**Shop Washroom Sink**	**Kitchen Tap**	**First Tap After Well**	**Room 5 Sink**	
Benzene	<0.08	<0.5	<0.5	<0.5	<0.5	<0.5	0.005
Ethylbenzene	<0.02	<0.5	<0.5	<0.5	<0.5	<0.5	0.0024
Toluene	<0.88	**138**	<0.5	<0.5	<0.5	<0.5	0.024
meta- & para-Xylene	<0.02	<0.5	<0.5	<0.5	<0.5	<0.5	0.3 (total xylenes)
ortho-Xylene	<0.02	<0.5	<0.5	<0.5	<0.5	<0.5	
VH C6-10	-	200	<100	<100	<100	<100	
VPH C6-10	-	<100	<100	<100	<100	<100	100

The sampling and analysis of potable water for BTEX was continued until the installation of a water purification system in 1997.

The concentrations of BTEX components in samples collected from the shop washroom sink over the monitoring period were all below detection (Table 2.4). Volatile petroleum hydrocarbons (VPH) and light hydrocarbons were also below detection (< 100 µg/L).

Table 2.4: Concentration (µg/L) Volatile Hydrocarbons in Potable Water Samples Collected from a Sink in the Shop Washroom at Blanchard River Camp from November 1996 to June 1997

Date Collected	28-Nov-96	13-Jan-97	25-Feb-97	10-Apr-97	30-Apr-97	4-Jun-97	26-Jun-97
Benzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
meta- & para-Xylene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
ortho-Xylene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
VH C6-10	<100	<100	<100	<100	<100	<100	<100
VPH C6-10	<100	<100	<100	<100	<100	<100	<100

The concentrations of BTEX in samples collected from Pressure Tank #1, which is the first storage tank for water pumped from the well, are given in Table 2.5. BTEX components were below the detection limit of <0.5 µg/L except for toluene (0.6 µg/L) in the sample collected on 10th April 1997. This value is of no major concern since it is very close to the analytical detection limit of 0.5 µg/L and far less than the CCME Drinking Water Criteria or the Yukon CSR drinking water standard of 300 µg/L for xylenes. Volatile petroleum hydrocarbons (VPH) and light hydrocarbons were all below detection (< 100 µg/L).

Table 2.5: Concentration (µg/L) of Benzene, Ethylbenzene, Toluene, Xylene and Volatile Hydrocarbons in Water Samples Collected from Pressure Tank #1 located in the Shop Washroom at Blanchard River Camp from November 1996 to June 1997

Date Collected	28-Nov-96	13-Jan-97	25-Feb-97	10-Apr-97	30-Apr-97	4-Jun-97	26-Jun-97
Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
meta- & para-Xylene	<0.0005	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
ortho-Xylene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
VH C6-10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
VPH C6-10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

2.3.6.3 Water Purification System

The potable water monitoring program was discontinued following the installation of the water purification system in July 1997. One water sample was collected shortly after the installation on July 17, 1997. BTEX and volatile hydrocarbons results are not available due to the fact that the sample was received in the laboratory after the sample hold time of seven days. Metal results were generally below detection (Table 2.6).

Table 2.6: Concentration (µg/L) of Metals in a Drinking Water Sample Collected from Blanchard River Camp in July 1997

Sampling Location	**Pressure Tank #3**	**YTG CSR Drinking Water Standard**
Date Collected	**17-Jul-97**	
Metals		
Aluminum	<200	200
Arsenic	<100	25
Barium	<10	1,000
Boron	<0.1	5,000
Cadmium	<0.2	5
Calcium	750	-
Chromium	<10	50
Copper	20	1,000
Iron	<30	300
Lead	6	10
Magnesium	21	-
Manganese	<5	50
Mercury	<0.05	1
Selenium	<0.0005	0.01
Sodium	<2,000	200,000
Zinc	37	5,000

2.4 Historical Timeline of Blanchard River Camp

A summary of information presented in this chapter is provide in a historical timeline below:

→ 1954	Construction of Haines Fairbanks Pipeline and main pump stations
→ 1956	Pipeline becomes operational
→ 1962	Construction of additional pump stations including Blanchard River
→ 1971	Pipeline decommissioned
→ 1982	Pipeline transferred to DIAND
→ 1986	Blanchard Pump Station converted to Yukon Territorial Government Highway Maintenance Camp
→ 1991	Pipeline dismantled and hauled south
→ 1995	Preliminary Environmental Assessment by UMA Engineering and Ambio Research Associates
→ 1999	Detailed Site Investigation

3. METHODS

The field program was conducted in two phases: a Detailed Site Investigation in June followed by Additional Investigations and Site Remediation in September 1999. A Detailed Work Plan for the June investigation program was developed and submitted to DIAND Waste Management Program for review prior to the initiation of field investigation activities. Copies of this Work Plan were circulated by DIAND to YTG and Champaign and Aishihik First Nations for review. Comments received were incorporated into the work plan. The results and recommendations of the Detailed Site Investigation were presented at a stakeholders meeting in Whitehorse on August 5 1999. Participants included representatives from DIAND, Champaign and Aishihik First Nations, Yukon Territorial Government and Environment Canada. Following this, a Detailed Work Plan for Additional Investigation and Site Restoration Activities was prepared and submitted to DIAND for review. The revised work plan was used for the September investigation. This chapter presents field and laboratory methodologies, as well as field observations for both the Detailed and Additional Site Investigations. Remedial activities are presented in Chapter 6.

3.1 Sampling Protocols

All samples were collected, transported, and stored under conditions that maintained sample integrity using the general protocols presented in Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites (CCME, 1993). Pre-cleaned sampling jars and preservatives were provided by Analytical Services Laboratory (ASL), Vancouver, BC.

3.1.1 Groundwater

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

Samples designated for organic analyses (extractable hydrocarbons and polycyclic aromatic hydrocarbons) were placed into 1 L amber glass jars. For volatile organic compounds analyses, aliquots of groundwater were placed into two 40 mL vials containing sulphuric preservative and sealed with Teflon–lined septum lids. Samples earmarked for dissolved metals analyses were field filtered using disposable in-line 700 cm^2 x 0.45 μm membrane filter (Gelman Sciences). The filtered sample was placed directly into a 250 mL plastic container and preserved with nitric acid. The sample for total metals analyses was placed directly into a 250 mL plastic container without filtration and preserved with nitric acid. Disposable gloves were worn during sampling to reduce the chance of cross-contamination.

The static water levels, volumes of purge water, pH, temperature, conductivity and samples collected were recorded on Groundwater Sampling Data Sheets that are provided in Appendix D.

3.1.2 Surface Water

Grab surface water samples were collected directly into the appropriate sampling containers as per groundwater samples. The container was held at the base and the neck plunged below the surface (25 - 40 cm). It was tilted such that the neck pointed to the water flow during filling. For dissolved metal analysis, a Waterra™ foot valve was attached to a piece of HPDE tube and used to obtain the sample which was passed through a disposable in-line filter and placed into the container. Disposable gloves were worn during sampling to reduce the chance of cross-contamination.

3.1.3 Potable Water

Potable water samples were collected from faucets attached to the pressure tanks directly into the appropriate containers. Each faucet was flushed for three minutes following which the flow was reduced to a thin stream before filling the container.

3.1.4 Subsurface Soils

Subsurface soil samples were obtained from test pits and boreholes. Soil samples from shallower strata of test pits were sampled directly from the bottoms of the pits, into pre-cleaned glass jars, using stainless steel scoops. Samples from strata greater than 0.5 m were retrieved from the backhoe bucket, taking care to avoid inclusion of soils that had been in direct contact with the bucket. The scoops were pre-cleaned by washing with laboratory detergent (Sparkleen™), rinsing with distilled-deionized water and methanol. They were then baked at 400°C for three hours, cooled and wrapped in baked aluminum foil to preclude contaminants. Samples designated for field analyses were placed into 125 mL amber glass jar with aluminum foil lined-lid while those earmarked for laboratory analyses (metals, hydrocarbons pesticides and PCBs) were placed into 500 mL glass jars with Teflon lined lids. For volatile organic compounds analyses, the samples were placed into 125 ml glass jars and sealed with Teflon-lined lids. Disposable gloves were worn during sampling to reduce the chance of cross-contamination and changed after each sample.

Drill cuttings were placed into bags (in two-foot sections) from which sub-samples were collected using stainless steel scoops for analysis. Sample containers were similar to those used for the testpits.

3.1.5 Surface Soil/Sediments

The top 10 cm of surface soil or sediment was removed with a pre-cleaned and dedicated stainless steel scoop and placed into appropriate glass containers as used for sub-surface soils.

3.1.6 Sample Handling

All the labeled sample containers were placed into coolers and shipped to the Analytical Laboratory via Canadian Airlines guaranteed cargo. Chain of custody forms accompanied the shipment.

3.2 Analytical Methods

The analytical program consisted of:

- analysis of soil and water samples for contaminant concentrations and other soil properties relevant to hydrogeology and remedial options;
- contaminant screening of soil and water samples using field test methods (PID, PetroFLAG™, immunoassay-based field test kits for TPH, PAHs, chlorinated pesticides, PCBs), with at least 20% of these also subjected to laboratory analysis as per US EPA protocols for field test kits;
- confirmatory sampling and analysis for hydrocarbons in soils using PetroFLAG™ test kits;
- laboratory analyses at Analytical Services Laboratory (ASL), Vancouver; and,
- collection and submission of field duplicates for at least 10% of all samples.

3.2.1 Potential Contaminants of Concern

Based on the previous site investigations and other contaminants of concern in the region as a whole, the following contaminants were considered to be of concern with respect to human health or ecological risk at or around Blanchard River:

- *Hydrocarbons:* The preliminary site investigations (UMA, 1995 and Royal Roads, 1996) identified hydrocarbons (volatile, light and heavy extractable petroleum hydrocarbons monocyclic aromatics such as benzene, toluene, ethylbenzene and xylene) as contaminants of concern in some locations. Some activities at the sites could have contributed a complex suite of these hydrocarbons, including polycyclic aromatic hydrocarbons, to other locations. This may include discharge into the burn pit, leakage in pipelines, shut-off valves or storage tanks, general spillage, the discarding of used oil, and disposal via the soak away pits or other methods as part of historical operation and maintenance procedures at the former pump station and current activities of the highway maintenance camp.

- *Metals and metalloids:* Some metals/metalloids were detected at elevated levels in samples collected from the drainage ditch north of the site. The presence of uncharacterized, subsurface refuse disposal areas requires a further examination of soil and water samples for these metals/metalloids, which could have been contributed from a large number of sources such as car battery disposal, leaded gasoline and metallic debris.
- *Organochlorine compounds including PCBs, DDTs, toxaphene, and chlordane pesticides:* The preliminary site investigations (UMA, 1995 and Royal Roads, 1996) indicated these were not present at elevated concentrations and were therefore of minor concern. These substances, however, were screened in a subset of samples obtained from refuse burial locations not investigated in previous studies to confirm that they are not potential contaminants of concern at Blanchard River.
- *Volatile Organic Compounds (VOCs)*: These are generally used in solvents, degreasers and paint thinners and include monocyclic aromatic hydrocarbons, halogenated compounds and light hydrocarbons (C5 – C9). These compounds are often not found in historic spills since they do not persist in soil. They evaporate rapidly from surface water or soils but may enter groundwater where they persist.

3.2.2 Field Analysis

An iterative approach was used to maximize the analytical data relative to analytical costs during both investigations. Field test methods, including a volatile organic compounds (VOC) detector (Photoionization Detector – PID) and immunoassay-based test kits were used on a large number of surface and subsurface samples as a preliminary screening tool for hydrocarbons, chlorinated pesticides, PAHs and PCBs. For the delineation of the spatial extent of hydrocarbon contamination and confirmatory sampling during site restoration activities in September, PetroFLAG™ test kits were employed.

3.2.2.1 Jar Headspace Analysis for Volatile Organic Compounds

The Jar Headspace Procedure is a quick and simple field screening procedure used to determine the presence of volatile organic compounds in soil. The procedure involves collecting a soil or water sample, placing it in an airtight container and then analyzing the headspace vapor using a portable analytical instrument such as a photoionization detector (PID). The "headspace" is the area between the sample and the top of the container. This procedure has been incorporated into US EPA and Environment Canada protocols. (Driscoll, 1993; Environment Canada, 1997)

A PE Photovac Photoionization Detector (Model PE 2020) was used in this program. This detector measured the concentrations of VOCs in the 1-2000 parts per million range and was calibrated using 100 ppm isobutylene in accordance with the manufacturer's specification.

The soil sample was collected into a 125 mL glass jar that was half filled with soil. The jar was sealed with an aluminum lined screw-on lid and shaken thoroughly for 30 seconds. The headspace was subsequently allowed to equilibrate for 10 min. Each lid was then carefully removed leaving the aluminum foil lining in place. The foil was pierced using the vapour probe and care was taken to sample only the headspace. The maximum reading on the PID was recorded. The sample was retained and later analyzed by immunoassay or PetroFLAG™ test kits.

3.2.2.2 Immunoassay Field Test Kits

Based on unusual physical characteristics such as odour and staining, selected samples were screened in the field for one or more of the following: EPH, PAHs, and DDTs using Diagnostics Inc. Test Kit. The kits utilize the enzyme linked immuno-sorbent assay, which is based on antibodies that are specifically designed to bind to target analyte molecules. These have been accepted for US EPA SW-846 Methods (US EPA, 2000a).

The immunoassay was carried out on site according to the manufacturer's instructions. A 5 g portion of soil was weighed and extracted with 5 mL methanol. The soil-methanol mixture was filtered and an aliquot of the extract used for subsequent analysis. At least 20% of the samples were also subjected to laboratory analysis as per US EPA protocols for field test kits.

3.2.2.3 PetroFLAG™ Hydrocarbon Analyzer

The PetroFLAG™ hydrocarbon analysis system (Dexsil Corporation, One Hamden Park Drive, Hamden, CT 06517) is a turbidimetric method designed to quickly analyze soil samples for any type of hydrocarbon. It responds to all types of hydrocarbons regardless of the source or state of degradation. The response factor however, is dependent on the type of hydrocarbon. A table containing the response factor for a number of hydrocarbon contaminants is supplied with the kit (e.g., diesel fuel has a response factor of 5 while weathered gasoline has a response factor of 2). The specially designed analyzer is easily calibrated with a blank and a single calibration standard. When a prepared sample is placed in the analyzer, it uses the calibration data to convert the optical reading into a preliminary concentration. Following this, the selected response factor is used to calculate the correct concentration. The method has been incorporated into Draft Update IVA of US EPA SW-846 Method 9074 (US EPA, 2000b).

The PetroFLAG™ test kits were used to screen soil samples, delineate the spatial extent of hydrocarbon contamination and for confirmatory sampling during the September investigations. The samples were analyzed on site using the manufacturers instructions (Dexsil, 1998). A portion of the soil sample (between 2 to 10 g) was extracted with a solvent mixture composed primarily of methanol. The resulting mixture was allowed to settle and the free liquid is decanted into the barrel of a filter-syringe assembly. The liquid was filtered through a 0.2-µm filter into a vial containing an aqueous emulsifier development solution. The solution was allowed to develop for 10 minutes. During the development, any hydrocarbons present precipitated out and become suspended in solution. The developed sample was placed in a turbidimeter that had been calibrated using a blank and a single calibration standard. A beam of yellow light at 585 nm was passed through the sample and the scattering of light through the suspension at 90° was measured. The analyzer then reported the concentration of total extractable petroleum hydrocarbons present in the sample.

3.2.3 Laboratory Analysis

Samples from both the June and September field programs were submitted to ASL, Vancouver, for laboratory analyses. ASL has been evaluated and accredited by the Canadian Association for Environmental Laboratories (CAEL). Prior to and throughout the field program, communication with the laboratory was maintained to ensure that all QA/QC objectives, such as detection limits, proper sample containers, sample delivery, etc., were being met. Samples were submitted to the laboratories via a rigorous chain-of-custody. Selected samples based on field screening tests were targeted for immediate analysis on the chain-of-custody forms; additional samples for metal analysis were archived and frozen for later analysis as warranted, based on the initial round of analyses. Summaries of the analytical methods are given in the following subsections.

3.2.3.1 Conventional Parameters in Water

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

3.2.3.2 Moisture Content in Soil/Sediment

The percentage content of moisture in the soil samples was determined gravimetrically by drying the sample at 103 °C for a minimum of six hours.

3.2.3.3 pH in Soil/Sediment

This analysis was carried out in accordance with procedures described in "Soil Sampling and Methods of Analysis" (CSSS). The procedure involved mixing the air-dried sample with deionized-distilled water. The pH of the solution is then measured using a standard probe. A 1:2 ratio of sediment and water is used for mineral soils and a 1:10 ratio is used for highly organic soils.

3.2.3.4 Metals in Soil/Sediment

This analysis was carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050 or Method 3051, published by the US EPA. The procedure involved a digestion using a 1:1 ratio of nitric acid and hydrochloric acid, along with hot plate or microwave heating. Instrumental analysis was by atomic absorption spectrophotometry (EPA Method 7000) and/or inductively coupled plasma -

optical emission spectrophotometry. A limitation of this method is that the stated acid digestion will provide excellent results for total recoverable metals; however, it is only partially effective on mineralized or non-environmentally available metals. The metals analyzed included: antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), chromium (Cr), cobalt (Co), copper (Cu), lead (Pb), molybdenum (Mo), nickel (Ni), selenium (Se), silver (Ag), tin (Sn), vanadium (V) and zinc (Zn).

3.2.3.5 Metals in Water

This analysis was carried out using procedures described in "Standard Methods for the Examination of Waste Water", 20th Edition, 1998, published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050 or Method 3051, published by the US EPA. The procedure may involve a preliminary sample treatment by acid digestion or filtration (EPA Method 3005A) followed by instrumental analysis by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma (EPA Method 6010B) and/or inductively coupled - mass spectrometry (EPA Method 6020).

Elements analyzed included: aluminum (Al), antimony (Sb), arsenic (As), barium (Ba), beryllium (Be), bismuth (Bi), boron (B), cadmium (Cd), calcium (Ca), chromium (Cr), cobalt (Co), copper (Cu), iron (Fe), lead (Pb), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), nickel (Ni), phosphorus (P), potassium (K), selenium (Se), silicon (Si), silver (Ag), sodium (Na), strontium (Sr), Thallium (Th), tin (Sn), Titanium (Ti), vanadium (V) and zinc (Zn)

3.2.3.6 Mercury in Water

This analysis was carried out using procedures described in "Standard Methods for the Examination of Water and Wastewater", 20th Edition, 1998, published by the American Public Health Association and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the US EPA. A cold oxidation procedure involving bromine monochloride was used, followed by cold-vapour atomic absorption spectrophotometry (CVAAS). EPA Method 7470A/7471A.

3.2.3.7 Volatile Organic Compounds in Water

This analysis was based on US EPA Methods 624/524 and 5030/8260. These procedures involved a purge and trap extraction of the sample and subsequent analysis of the volatile component by gas chromatography with mass spectrometric detection. The analytes included halogenated volatiles such as bromodichloromethane, bromoform, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, chloromethane, dibromochloromethane,1,2-dichlorobenzene 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, 1,1-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropylene, trans-1,3-dichloropropylene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichlorofluoromethane and vinyl chloride. The non-halogenated volatiles benzene, ethylbenzene, toluene and meta- & para-xylene were also part of this suite.

3.2.3.8 Volatile Organic Compounds in Soil/Sediment

This analysis was based on US EPA Methods 5030, 5035 and 8260. The procedure involved a purge and trap extraction of the sample and subsequent analysis of the volatile component by gas chromatography with mass spectrometric detection. The analytes included halogenated volatiles such as bromodichloromethane, bromoform, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, chloromethane, dibromochloromethane,1,2-dichlorobenzene 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, 1,1-dichloroethylene, dichloromethane, 1,2-dichloropropane, cis-1,3-dichloropropylene, trans-1,3-dichloropropylene, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, tetrachloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, trichloroethylene, trichlorofluoromethane and vinyl chloride. The non-halogenated volatiles benzene, ethylbenzene, toluene, meta- & para-xylene and ortho-xylene were also part of this suite.

3.2.3.9 Volatile Hydrocarbons in Soils/Sediment

This analysis was carried out in accordance with US EPA Methods 5035, 8260/8021 and British Columbia Ministry of the Environment Lands and Parks Method "Volatile Hydrocarbons in Soil by GC/FID". The procedure involves a 1:2 extraction of the sample with methanol. An aliquot of this methanol extract is added to a sealed vial containing a constant volume of water. This vial is sealed and heated, causing the volatile compounds to partition into the gaseous headspace above the sample. A portion of this headspace is then analyzed by gas chromatography with mass spectrometric detection (GC-MS) or photo ionization (GC-PID)/flame ionization (GC-FID) detection.

3.2.3.10 Volatile Petroleum Hydrocarbons (VPH) in Soil/Sediment

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

3.2.3.11 Volatile Petroleum Hydrocarbons in Water

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

3.2.3.12 Extractable Hydrocarbons in Soil/Sediment

The method used was carried out using procedures adapted from the US EPA Methods 3540, 3610 and 8081 (Publ. No. SW-846, 3rd Ed., Washington DC 20460) and lent to the BC Ministry of Environment Land and Parks Method for "Extractable Petroleum Hydrocarbons (EPH) in Soils by GC/FID (January 1996) but does not provide correction for Polycyclic Aromatic Hydrocarbons (PAH). The procedure involved hexane/acetone extraction and analysis using GC/FID. EPH results are presented for components in the C10 to C19 and C19 to C32 ranges.

3.2.3.13 Extractable Hydrocarbons in Water

The method used was carried out using procedures adapted from the US EPA Methods 3540, 3610 and 8081 (Publ. No. SW-846, 3rd Ed., Washington DC 20460) and lent to the BC Ministry of Environment Land and Parks Method for "Extractable Petroleum Hydrocarbons (EPH) in Soils by GC/FID (January 1996). Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAH). The procedure involved methylene chloride solvent extraction followed by analysis of the extract using GC/FID. EPH results are presented for components in the C10 to C18 and C19 to C31 ranges.

3.2.3.14 Polycyclic Aromatic Hydrocarbons (PAHs) in Soil/Sediment

This analysis was carried out in accordance with US EPA methods 3545(SW-846 Laboratory Manual – Update III, Federal register, Vol. 60, No. 142/Tuesday July 25, 1995, pg. 37974-37980,). An automated system was used to extract the sample with 1:1 mixture of hexane and acetone. A portion of the extract was exchanged to toluene, cleaned and analyzed by capillary column GC with mass spectrometric detection. The analytes included acenaphthene, acenaphthylene, acridine, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene and pyrene.

3.2.3.15 Polycyclic Aromatic Hydrocarbons (PAHs) in Water

This analysis was carried out using a procedure adapted by ASL from US EPA methods 3510, 3630 and 8270 (Publ. No. SW-846, 3rd Ed., Washington DC 20460). The procedure involved extraction of the sample with methylene chloride followed by a cleanup on a silica gel column. This cleanup effectively removed aliphatic and heterocyclic hydrocarbons, which could potentially interfere with the analysis. The final extract was analyzed by capillary column GC with mass spectrometric detection. The analytes included acenaphthene, acenaphthylene, acridine, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, naphthalene, phenanthrene and pyrene.

3.2.3.16 Light and Heavy Extractable Petroleum Hydrocarbons in Soil/Sediment

This method was carried out as outlined in the method descriptions for Extractable Petroleum hydrocarbons and Polycyclic Aromatic Hydrocarbons. The concentrations for light extractable hydrocarbons (LEPH) were derived by the subtraction of naphthalene and phenanthrene from the EPH (C10 to C18) values. Similarly, heavy extractable hydrocarbons (HEPH) were calculated by subtracting the concentrations of benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a) pyrene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene and pyrene from the EPH (C19 to C31) data.

3.2.3.17 Light and Heavy Extractable Petroleum Hydrocarbons in Water – ASL

This method was carried out as outlined in the method descriptions for Extractable Petroleum hydrocarbons and Polycyclic Aromatic Hydrocarbons. As per BC MELP Contaminated Sites Regulations, the concentrations for light extractable hydrocarbons (LEPH) were derived by the subtraction of acenaphthene, acridine, anthracene, fluorene, naphthalene and phenanthrene concentrations from the EPH (C10 to C18) values. Similarly, heavy extractable hydrocarbons (HEPH) were calculated by subtracting the concentrations of benz(a)anthracene, fluoranthene, pyrene and benzo(a)pyrene from the EPH (C19 to C31) data.

3.2.3.18 Organochlorine Pesticides (OCPs) in Soil/Sediment

Organochlorine pesticides in soils were determined with methodology adapted from US EPA Methods 3540, 3610 and 8081 (Publ. No. SW-846, 3rd Ed., Washington DC 20460). The procedure involved a soxlet extraction with dichloromethane. The extract was then solvent exchanged to hexane followed by an alumina column clean up. The final extract was analyzed by dual capillary column gas chromatography with electron capture detector.

The analytes included the following pesticides: Aldrin, alpha-BHC (Benzene HexaChloride or hexachlorocyclohexane), beta-BHC, delta-BHC, cis-Chlordane, trans-Chlordane, o,p'-DDD (Dichloro Diphenyl Dichloroethane), p,p'-DDD, o,p' DDE (Dichloro Diphenyl Ethylene) p,p'-DDE, o,p'-DDT (Dichloro Diphenyl Trichloroethane), p,p'-DDT, Dieldrin, Endosulfan, Endrin, Heptachlor, Heptachlor epoxide, Lindane, Metoxychlor, Mirex, cis-Nonachlor, trans-Nonaclor, Oxychlordane and Toxaphene.

3.2.3.19 Polychlorinated Biphenyls (PCBs) in Soil/Sediment

This analysis was carried out using a procedure adapted from EPA Method 8082 (Publ. No. SW-846, 3rd Ed., Washington DC 20460). The procedure involves a solid-liquid extraction of the sample with hexane/acetone and back extraction with water. The hexane extract was cleaned and analyzed by capillary column gas chromatography with electron capture detection. The results were reported as total polychlorinated biphenyls.

3.3 Detailed Site Investigation (June 1999)

The field program was conducted from June 14 to 19, 1999 by a field team which included representatives from:

- Royal Roads (M. Dodd and D. Bright);
- UMA Engineering (T. Wingrove and N. Plato);
- DIAND Waste Management (S. Aichele and K. Svec);
- Midnight Sun Drilling Services (Boreholes and monitoring well installation);
- Yukon Engineering Services (Survey); and,
- Darling Maintenance Services (Test pit excavation).

Specific task addressed during the field investigations included:

- Borehole drilling and piezometer installation to identify and delineate sources of subsurface contamination found during the Preliminary Site Investigation;
- Excavation of testpits to characterize the nature and extent of subsurface contamination;
- Collection of subsurface soil samples from testpits and boreholes;
- Sampling of groundwater from monitoring wells and acquisition of field data for the calculation of hydraulic conductivity, groundwater flow direction and gradient, and contaminant migration rates;
- Collection of surface water and soil samples from the rust coloured drainage ditch and other locations around the site;
- Obtaining sediment and water samples from Blanchard River;
- Use of field test methods for the screening analysis of contaminants in soil and water;
- A field quality assurance/quality control program;
- Surveying of boreholes, monitoring wells, testpits and relevant features;
- Information exchange with local stakeholders, including YTG; and,
- Complete documentation of site conditions and sampling program.

3.3.1 Test Pits

Thirty test pits were excavated to augment six pits that were previously completed in 1995. The locations of both the previously established test pits (TP95-1 to TP95-6) and newly excavated test pits (TP99-7 to TP99-36) are provided on Drawing 1. All test pits were excavated using a backhoe to a depth of up to 2.7 m. The depth of each test pit, description of subsurface soils and debris found, as well as a list of samples collected are provided in Table 3.1. The majority of these pits were excavated to characterize and delineate areas of hydrocarbon contamination.

Interpretation of old aerial photographs suggested a burn pit was situated north of the maintenance building during the operation of Blanchard River as a pump station, prior to 1985. The location of the burn pit and extent of hydrocarbon contamination was determined through the excavation of ten test pits (TP99-7 to TP99-13, TP99-26 to TP99-28) north of the maintenance building.

Another set of test pits was established along the drain lines and to the soak away pit at the southwestern end of the maintenance building. The soak away pit receives discharge from the oil/water separator from the floor drains in the shop's welding bay. This soak away pit, which was installed during the construction of the pump station in 1962 is still in use today. The pit and drain lines were tested in 1985, when the building was converted for use by YTG transport. The feed line, a four-inch pipe wrapped in Styrofoam, was encountered in the first pit (TP99-14) dug 3 m from the building. A trench was excavated along the line from the first test pit to a point where the pipe was supported on barrels (Photograph 3.1). The diameter of the pipe changed from four inches to six inches near the barrels. A close examination of the pipe revealed openings cuts at the bottom that allowed wastewater discharged through the pipe to flow into the barrels. The barrels were also perforated (Photograph 3.2) as such any liquid introduced would infiltrate into the surrounding substrate, which comprised sandy gravel with cobbles. Three additional samples (TP99-15 to TP99-17) were subsequently collected along the trench excavation. No obvious odour and stains were noted along most sections of the trench except for a strong hydrocarbon odour near TP99-15 and this was probably due to localized releases.

Test pits were also established on the northwestern side of the maintenance building in order to establish the location of the 1985 vintage rock pit, which receives floor drainage from the main shop area. The pipe was encountered in the first pit excavated within 3 to 4 m of the shop wall (TP99-22). Further excavation along the pipe uncovered the top part of the rock pit, which pit consisted of a 3 m diameter culvert filled with boulders and surrounded by native fill comprising sandy gravel with cobbles. No hydrocarbon odour was detected in the area.

Investigations were undertaken near the abandoned large above ground storage tank (AST) located south of the maintenance building (Photograph 3.3). Petroleum hydrocarbon contaminated soil was encountered at a depth of 20 cm and beyond in TP99-19 which was excavated at the northern end of the tank, right under the fill valve. Other pits established near the tanks (TP99-20, TP99-35 and TP99-36) did not contain any discernable staining or odour, however, a copper tank electrode was found in TP99-20.

Historical photographs indicated a small above ground storage tank was previously located to the east of the maintenance building, near the current to the generator room. A strong odour of hydrocarbons was detected from samples collected in a test pit (TP99-33) that was excavated to a depth of 2.3 m at this location (Photograph 3.4). A second test pit (TP99-34) established 6 m to the east of TP99-33 did not have any odour.

Test pits were also used to investigate areas containing visible debris and areas suspected to contain buried debris based on electromagnetic (EM) geophysical surveys conducted during the preliminary investigations in 1995. To this end, three pits were dug in a push out dump near the gravel stockpile northeast of the residence. Surficial debris encountered in the area included diesel manifold, electrical cable and metal shutters (Photograph 3.5). No visible debris other than a piece of 4" x 4" wood was encountered in three test pits excavated in the dump (TP99-23 to TP99-25) suggesting that metal debris was limited to surface of ground only.

Anomalies from the 1995 EM survey suggested buried debris near the rafters' camp, situated south of the site. Three test pits (TP99-31 to TP99-32) were advanced in the area to ground truth the EM anomalies. Apart from a few metal braces and cans and an old plastic tarpaulin near the surface of one of the holes, no debris was found in the test pits. A hydrocarbon odour was detected in a pit excavated for a new outhouse constructed in this area in July 1999 for the rafters use. To ascertain the nature and extent of contamination in the area, six additional test pits (TP0799-1 to TP0799-6) were excavated (Table 3.2). The pits were hand-dug to a maximum depth of 1 m. Visible staining and hydrocarbon odour were noted in the top few centimetres of some of the soils (Photograph 3-6).

Table 3.1: Blanchard River June 1999 Test Pit Excavation Program

Test Pit	Sample Designation	Sample Depth	PID Reading	Location and Observations
TP99-7	no sample taken			Outside of gate and just inside road; obviously beyond original extent of burn pit.
TP99-8	no sample taken	120 cm	0.0	Middle of access road to camp, at Y in road. (1.2 m depth: some wood debris; 1.9 m depth: bottom of test pit; clay at ~ 1.8 m. depth). No unnatural odor.
TP99-9	TP9-1 TP9-2	40 to 50 cm 100 cm		About 8 m to E. of TP-8. Edge of camp access road. One layer of blacker soil at around 20-35 cm depth. No obvious odor. No staining below this depth.
TP99-10	no sample taken			Around 8 m. to N. of TP-8. Off camp access road in a shallow depression. (1.6 m total depth; > 1 m: mixed clay and silt; continuous clay-silt at bottom of pit; sandy soils with more loam and cobbles near surface)
TP99-11	TP11-1	60 cm		Just inside fence at corner; across from light standard. Encountered old metal cladding and other metal debris, probably originating from 1985 shop renovation. Encountered PHC contaminated cobble-silt-clay soils at 0.6 m depth. Top of former burn pit presumed to be around 65 cm below present grade. Organic horizon below this.
TP99-12	TP12-1 TP12-2	115 cm 220 cm	12.2 >1000	Corner of compound just before berm/slope. 12.5 m E. of TP-11. Sand and gravel, cobbles to around 2 m depth; no evidence of PHC odors. At 2.0 to 2.2 m, encountered strong PHC odor and slate to dark grey coloured sands. Water infiltration through bottom of pit at around 2.1 m. Hydrocarbon sheen on water surface.
TP99-13	TP13-1 TP13-2	115 cm 230 cm	256 >1000	15 m to S. of TP-12 and in line with long side of shop building. Middle of driving surface. Visually clean sand, gravel, cobble down to and beyond 1 m. At 85 cm, encountered 2" diameter (50 phi) oil line that ran to burn pit. Soil around it was clean.
TP99-14	TP14-1	Bottom of Pit (around 1 m)		Near southern welding bay of shop near origin of line to original soak away pit. Encountered feed line from oily water separator, installed in 1985, to soak away pit. Wrapped in styrofoam (4" line).
TP99-15	TP15-1	Bottom of Pit (around 1 m)		Pit along feed line at point neat edge of present berm for small AST. Odor of PHCs encountered at 45 cm depth in pit, probably due to localized releases 4" feed pipe to soak away pit covered here in sheet styrofoam.

cont'd

Table 3.1: Continued

Test Pit	Sample Designation	Sample Depth	PID Reading	Location and Observations
TP99-16	TP16-1	Bottom of Pit (around 1.6 m)		Along feed line. Pipe is wrapped in pink fibreglass insulation along this section. No hydrocarbon odour. Sand and gravel.
TP99-17	TP17-1	Bottom of Pit and below pipe. 250 cm depth	2.7	Along path and pipe to soak away pit. At point where pipe is 6" diameter, not 4". Sandy gravel with cobbles; no obvious odor.
TP99-19	TP19-1 TP19-2 TP19-3	30 cm 123 cm 190 cm	119 182 157	At N. end of abandoned large AST, right under infill valve. Encountered obviously PHC contaminated soil at a depth of 20 cm and beyond.
TP99-20	TP20-1 TP20-2	100 cm 190 cm	0.6 0.6	S. side of large empty AST. Excavated copper tank electrode.
TP99-21	TP21-1	215 cm		Near presumed site of 1985 vintage rock pit from main shop area. Sandy-gravel throughout with cobbles. No clay layers. No groundwater encountered.
TP99-22	No sample collected			Along line to rock pit within 3 to 4 m of shop wall. Broke 4" cast iron line with backhoe bucket. Excavated further along and uncovered top of constructed rock pit. 3 m diameter culvert with boulder fill and surrounded by native fill. Drainage is obviously impeded due to inappropriate construction.
TP99-23	TP23-1	50 cm		Push out dump near gravel stockpile. 3 to 5 m from edge of pad, west of gravel pile. 1 m deep. No visible debris. Appears that metal debris is limited to surface of ground only.
TP99-24	TP24-1 TP24-2	50 cm 120 m		Around 20 m W. of TP-23 in possible push-out dump. Surficial debris encountered only, including diesel manifold, electrical cable, shutters. Excavated to 1.2 m. 5 m. from edge of gravel pad.
TP99-25	No sample collected			No visible debris to 1.2 m. 13 m W. of TP24. 5 m from edge of gravel pad. No visible subsurface debris other than a piece of 4"x4" wood.
TP99-26	No sample collected			Burn pit area. Coarse fill to 150 cm depth. Silt at 195 cm. No odor throughout.
TP99-27	No sample collected			Burn pit area. Petroleum hydrocarbon odor encountered at 110 cm depth. No odor in soils above this. 2" feed line encountered at 70 cm depth. Clay layer encountered at 1.1 m depth to bottom of hole at 1.9 m. Strong odor at bottom of pit.

cont'd

Table 3.1: Continued

Test Pit	Sample Designation	Sample Depth	PID Reading	Location and Observations
TP99-28	TP28-2/3 (field duplicates)	260 cm		Near original burn pit location. (0 to 1 m: sand and gravel; 1 to 1.5 m: gray silt-clay; 1.5 to 2.3 m: brown sand and gravel; bottom of pit completed at 2.6 m.). Minimal PHC odors above 2.3 m depth. Strong hydrocarbon smell from 2.3 to 2.6 m.
TP99-30	TP30-1	50 cm		Possible dump by rafters camp. Clean sandy loam soils with cobbles. One metal brace, old plastic tarp at surface. No debris found below 0.5 m depth.
TP99-31	No samples collected			Possible dump by rafters camp. Clean sandy loam soils with cobbles. No debris found below soil surface.
TP99-32	TP32-1	100 cm		Clean test pit in sand/loam/cobble. Metal debris on surface nearby, but none in pit.
TP99-33	TP33-1	40 cm	117	To E. of building in front of Gen. Set. Screens. where small storage tank, identified on aerial oblique historical photo, was located.
	TP33-2	90 cm	132	
	TP33-3	150 cm	130	
	TP33-4	230 cm	58.2	
TP99-34	TP34-1	90 cm	0.3	Around 6 m. to E. of TP-33. Coarse sand and cobbles.
	TP34-2	130 cm	0.0	
	TP34-3	230 cm	0.0	
TP99-35	TP35-1	40 cm	273	Around empty, large AST. (0-35 cm: sand; 35-40 cm: mixed sand and clay; 120 cm more sandy)
	TP35-2	120 cm	16	
	TP35-3	250 cm	73	
TP99-36	TP36-1	170 cm	2.6	Around AST. Brown coarse sand and gravel through depth of hole to 1.7 m. Very large boulders at 1.7 m. No unnatural odors detected.

Table 3.2: Test Pits Excavated at the Rafters Camp in July 1999

Test Pit	Sample Designation	Sample Depth	Location and Observations
TP0799-1	TP0799-1	Composite	Old outhouse site. Hole was filled with dirt excavated from new outhouse location. Sample is a composite from this soil. Visible staining and strong hydrocarbon odour.
TP0799-2	TP0799-2	25 cm	Stained surface near new outhouse. Odour observed in top 25 cm only.
TP0799-3	No sample collected		11 m north of new outhouse. No hydrocarbon stain or odour detected in test pit.
TP0799-4	TP0799-4	Top 30 cm	14 m north of new outhouse. Hydrocarbon stain and strong odour in an area which extends for at least 3 m^2 and to a depth beyond 30 cm. Could not dig beyond 30 cm.
TP0799-5	TP0799-5	Side wall	Excavation for new outhouse. Stained soil and hydrocarbon odour to bottom of pit at 80 cm, except on thin surface layer. Sample taken from sidewall.
TP0799-6	TP0799-6		Area of limited re-vegetation along road parallel to outhouse area closer to the river. Located on west side of road. Growth on site is limited but vegetation does not look stressed.

←←

Photograph 3.1: Trench excavated on the southern end of maintenance building showing feed line to the soak away pit

Photograph 3.2: Soak away pit at the southwestern end of maintenance building showing the feed line that discharges into perforated barrels

↓↓

Photograph 3.3: Excavating a test pit near the empty large above ground storage tank (AST) located south of the maintenance building

Photograph 3.4: Test pit excavation on the eastern side of the maintenance building at a location where a small above ground storage tank was previously situated

Photograph 3.5: Debris including diesel manifold, electrical cables and metal scattered at a push out dump near the gravel stock pile north of the residence

Photograph 3.6: A shallow test pit excavated near the new outhouse at the rafters camp

3.3.2 Boreholes and Monitoring Wells

The major portion of fieldwork revolved around the delineation of subsurface hydrocarbon contamination detected during the initial site investigation. Five boreholes were drilled and monitoring wells (TH95-1 to TH95-5) were installed in the holes during the preliminary site investigation in 1995 (UMA, 1995). The 1995 monitoring wells were still intact during the 1999 field program. As such, they were used to augment the current investigation. Field work undertaken in June 1999 included: drilling of boreholes to obtain vertical subsurface profiles of contaminants in soils and determine subsurface stratigraphy; installation of groundwater monitoring wells in most of the boreholes, for subsequent sampling of groundwater; determining water levels; and, completing response tests to estimate the hydraulic conductivity.

The site plan (Drawing 1) illustrates the previously established boreholes and monitoring wells (TH95-1 to TH95-5) along with an additional 12 boreholes that were completed in June 1999 (TH99-6 to TH99-17). An air-rotary drill equipped with an ODEX system, supplied by Midnight Sun Drilling, Whitehorse, was used (Photograph 3.7). This drilling method cuts the hole and advances the casing simultaneously. Cuttings are delivered to the surface between the drill rods and casing using compressed air. The drill cuttings are collected in bags (one for each two feet of hole drilled) that are attached to the end of a cyclone (Photograph 3.8). Following observation and recording of physical characteristics including particle size, odour, moisture content, sub-samples were collected for field and laboratory analysis. Field analysis conducted included a Jar Headspace Procedure that employed a photoionization detector (PID) to determine the presence of volatile organic compounds in soil (see Section 3.3 for methodology). A piezometer was then installed in the borehole. Two inch threaded and coupled PVC casing and well screen was used for all monitoring wells. Silica sand was placed in the annular space opposite the well screen and bentonite pieces placed opposite the solid casing. Steel protective casings were placed over the well to guard against damage. A list of boreholes completed, samples collected and PID results is given in Table 3.3. The details of borehole depth and piezometer construction for all boreholes are provided in the borehole logs, (Appendix A).

Following installation of the wells, Waterra™ dedicated sampling systems were placed in each well, for retrieval of groundwater. All wells were developed by intermittently pumping large volumes of water (over five well volumes) to remove suspended particles.

The first set of boreholes (TH99-6 to TH99-8) was established north of the maintenance building to delineate the extent of hydrocarbon-contaminated groundwater found in TH99-1 and TH99-2 during the 1995 investigation. Two of these boreholes (TH99-6 and TH99-8) were developed as monitoring wells.

Five new boreholes were established southwest of the maintenance building to delineate and characterize hydrocarbon contamination encountered at this end of the site. Two of these (TH99-13 and TH99-14), which were converted into monitoring wells, were placed on the upper terrace. The remaining three boreholes (TH99-9 to TH99-11) were located on the lower terrace, near the river. Monitoring wells were placed in all of these except TH99-11.

One borehole/monitoring well each, was established at the former location of the burn pit (TH99-12) and near the rock pit west of the maintenance building (TH99-15). Finally, two boreholes were advanced on the eastern side of the maintenance building near the former location of the small above ground storage tanks (TH99-16 and TH99-17). A piezometer was installed in TH99-17.

3.3.3 Hydraulic Conductivity

Field data were collected in order to calculate the hydraulic conductivity of the soils surrounding the monitoring wells. Rising head tests were carried out on the wells by lowering water levels to the maximum extent possible with the dedicated sampling systems. The high hydraulic conductivity of the coarse, granular material around some piezometers did not allow for drawing the water levels down more that 10 to 30 cm; other wells took more than two to three hours to fully recovery. For those wells that responded, very rapidly falling head tests were conducted. Water was rapidly pored into the well to surcharge the natural head in the formation and the decline in water level measured.

Table 3.3: Boreholes Completed, Samples Collected and Soil Organic Vapour Results

Sample Designation	Sample Depth	PID[1] (ppm)	Lab Sample Collected	Sample Designation	Sample Depth	PID[1] (ppm)	Lab Sample Collected
Borehole 6				***Borehole 10***			
TH99-6-1	0 to 2'	5.3		TH99-10-1	0 to 2'	No recovery	
TH99-6-2	2 to 4'	No recovery		TH99-10-2	2 to 4'	0	Org/Metals
TH99-6-3	4 to 6'	13.2		TH99-10-3	4 to 6'	0.3	
TH99-6-4	6 to 8'	6.2	Org[2]/Metals	TH99-10-4	6 to 8'	1	
TH99-6-5	8 to 10'	8.4		TH99-10-5	8 to 10'	1.1	
TH99-6-6	10 to 12'	5.7		TH99-10-6	10 to 12'	0.4	
TH99-6-7	12 to 14'	2.9	Org/Metals	TH99-10-7	12 to 14'	0.3	
				TH99-10-8	14 to 16'	1.7	
Borehole 7				***Borehole 11***			
TH99-7-1	0 to 2'	2.9		TH99-11-1	0 to 2'	0	
TH99-7-2	2 to 4'	3.2		TH99-11-2	2 to 4'	0	Organic
TH99-7-3	4 to 6'	3.6	Org/Metals	TH99-11-3	4 to 6'	0	
TH99-7-4	6 to 8'	2		TH99-11-4	6 to 8'	0	
TH99-7-5	8 to 10'	2.8		TH99-11-5	8 to 10'	5.8	
TH99-7-6	10 to 12'	2.8		TH99-11-6	10 to 12'	0	
TH99-7-7	12 to 14'			TH99-11-7	12 to 14'	0	Org/Metals
Borehole 8				***Borehole 12***			
TH99-8-1	0 to 2'	No recovery		TH99-12-1	0 to 2'	No recovery	
TH99-8-2	2 to 4'	0		TH99-12-2	2 to 4'	2.1	
TH99-8-3	4 to 6'	1.3		TH99-12-3	4 to 6'	809	
TH99-8-4	6 to 8'	2.3	Org/Metals	TH99-12-4	6 to 8'	706	
TH99-8-5	8 to 10'	1.9		TH99-12-5	8 to 10'	716	Org/Metals
TH99-8-6	10 to 12'	1.8		TH99-12-6	10 to 12'	486	
TH99-8-7	12 to 14'	0		TH99-12-7	12 to 14'	452	
TH99-8-8	14 to 16'	0	Org	TH99-12-8	14 to 16'	240	
Borehole 9				TH99-12-9	16 to 18'	150	
TH99-9-1	0 to 2'	No recovery		TH99-12-10	18 to 20'	193	Org/Metals
TH99-9-2	2 to 4'	No recovery		TH99-12-11	20 to 22'	222	
TH99-9-3	4 to 6'	0		TH99-12-12	22 to 24'	193	
TH99-9-4	6 to 8'	1.1	Org/Metals	TH99-12-13	24 to 26'	146	
TH99-9-5	8 to 10'	0.3		TH99-12-14	26 to 28"	35	
TH99-9-6	10 to 12'	0.4		TH99-12-15	28 to 30'	23	Org
TH99-9-7	12 to 14'	0.7	Organic	TH99-12-16	Field duplicate of TH99-12-5p		
TH99-9-8	14 to 16'	1.2					

cont'd

Notes:

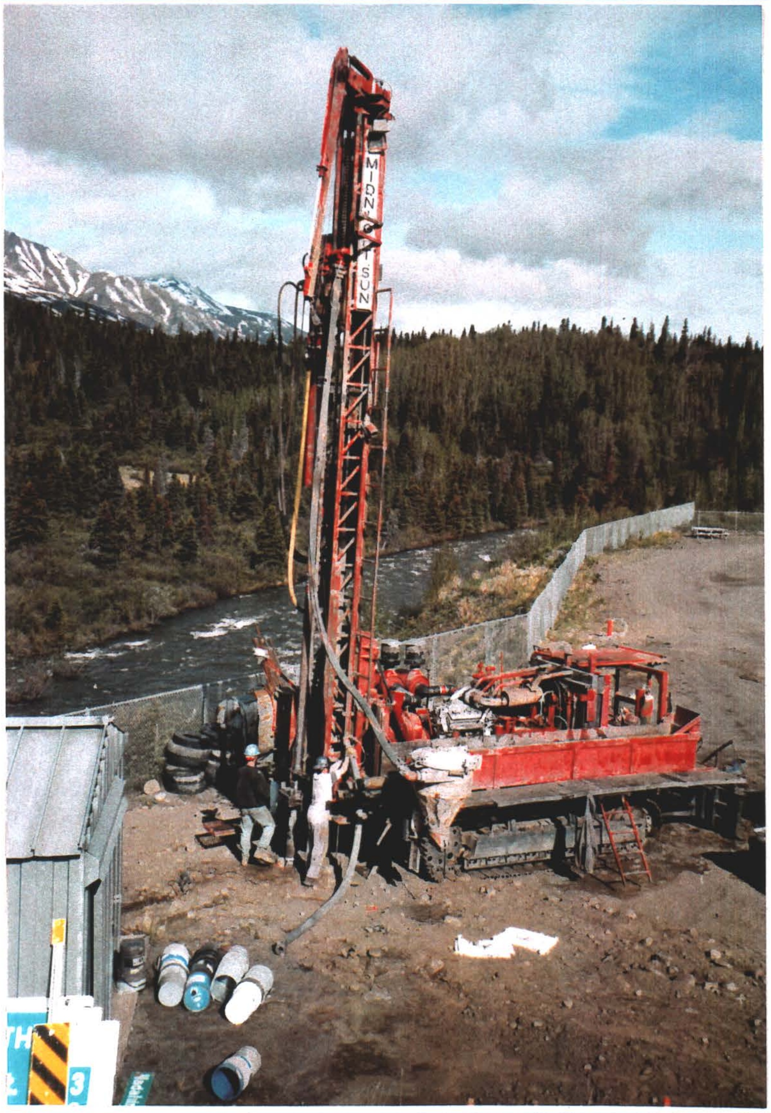
1. PID = Volatile Organic Compounds in soil vapour as determined by headspace analysis using a portable photoionization detector.
2. Org = Laboratory analysis for organic contaminants including one or more of the following: extractable hydrocarbons, polycyclic aromatic hydrocarbons, volatile organic compounds, polychlorinated biphenyls, and chlorinated pesticides

Table 3.3: Continued

Sample Designation	Sample Depth	PID[1] (ppm)	Lab Sample Collected
Borehole 13			
TH99-13-1	0 to 2'	No recovery	
TH99-13-2	2 to 4'	11	
TH99-13-3	4 to 6'	2.8	
TH99-13-4	6 to 8'	13.9	
TH99-13-5	8 to 10'	6.8	
TH99-13-6	10 to 12'	8.2	
TH99-13-7	12 to 14'	6.6	
TH99-13-8	14 to 16'	7	
TH99-13-9	16 to 18'	3.5	
TH99-13-10	18 to 20'	3.6	
TH99-13-11	20 to 22'	3.3	
TH99-13-12	22 to 24'	7.2	
TH99-13-13	24 to 26'	2.5	
TH99-13-14	26 to 28"	3.2	
TH99-13-15	28 to 30'	4.2	
TH99-13-16	30 to 32"	141	Org/Metals
TH99-13-17	32 to 34"	133	
TH99-13-18	34 to 36"	31	
TH99-13-19	36 to 38"	3.6	
TH99-13-20	38 to 40"	5.6	Organic
Borehole 14			
TH99-14-1	0 to 2'	No recovery	
TH99-14-2	2 to 4'	No recovery	
TH99-14-3	4 to 6'	No recovery	
TH99-14-4	6 to 8'		Org/Metals
TH99-14-5	8 to 10'		
TH99-14-6	10 to 12'		
TH99-14-7	12 to 14'		
TH99-14-8	14 to 16'		
TH99-14-9	16 to 18'		
TH99-14-10	18 to 20'		
TH99-14-11	20 to 22'		
TH99-14-12	22 to 24'		
TH99-14-13	24 to 26'		
TH99-14-14	26 to 28"		Org/Metals.
TH99-14-15	28 to 30'		
TH99-14-16	30 to 32"		
TH99-14-17	32 to 34"		Org/Metals
Borehole 15			
TH99-15-1	0 to 2'	No recovery	
TH99-15-2	2 to 4'		
TH99-15-3	4 to 6'		
TH99-15-4	6 to 8'		
TH99-15-5	8 to 10'		
TH99-15-6	10 to 12'		
TH99-15-7	12 to 14'		Org/Metals
TH99-15-8	14 to 16'		
TH99-15-9	16 to 18'		
TH99-15-10	18 to 20'		Org
Borehole 16			
TH99-16-1	0 to 2'		
TH99-16-2	2 to 4'		
TH99-16-3	4 to 6'		
TH99-16-4	6 to 8'		Org
TH99-16-5	8 to 10'		
TH99-16-6	10 to 12'		Org
TH99-16-7	12 to 14'		
TH99-16-8	14 to 16'		
TH99-16-9	16 to 18'		
TH99-16-10	18 to 20'		
TH99-16-11	20 to 22'		
Borehole 17			
TH99-17-1	0 to 2'	No recovery	
TH99-17-2	2 to 4'	No recovery	
TH99-17-3	4 to 6'	No recovery	
TH99-17-4	6 to 8'		Org/Metals
TH99-17-5	8 to 10'		
TH99-17-6	10 to 12'		
TH99-17-7	12 to 14'		
TH99-17-8	14 to 16'		
TH99-17-9	16 to 18'		
TH99-17-10	18 to 20'		Org/Metals
TH99-17-11	20 to 22'		

Notes:

1. PID = Volatile Organic Compounds in soil vapour as determined by headspace analysis using a portable photoionization detector.
2. Org = Laboratory analysis for organic contaminants including one or more of the following: extractable hydrocarbons, polycyclic aromatic hydrocarbons, volatile organic compounds, polychlorinated biphenyls, and chlorinated pesticides



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Photograph 3.7: Air rotary drilling at the upper terrace southeast of the maintenance building south and near the storage shed (TH99-14) with Blanchard River below the lower terrace

Photograph 3.8: Drilling above rust coloured leachate plume (TH99-6). Note white sampling bag attached to the end of the cyclone.

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3.3.4 Surface Investigations at Rust Coloured Drainage Ditch

The 1995 preliminary environmental investigation identified a drainage ditch containing a rust-coloured substrate on the northern side of the site. High levels of inorganic elements (arsenic, barium, cobalt, selenium and zinc) and extractable hydrocarbons were found in soil/sediment samples collected from the rust-coloured leachate. The results of an EM survey indicated that a buried pipe originating between the shop and residence terminated at the drainage ditch, might be the conduit for the contaminants found in the samples collected in the leachate. The origin of this pipe was not ascertained during the preliminary investigation. The rust-coloured leachate water was still visible during the 1999 investigations (Photograph 3.9). A shallow test pit was excavated near the source of the rust coloured leachate water. This unearthed a galvanized zinc culvert (Photograph 3.10), which confirmed the results of the 1995 EM survey that had indicated that a metal culvert was the conduit for the leachate.

Surface water and soil samples were collected along the drainage channel to characterize the composition and extent of contamination at this area of the site (Table 3.3).

Table 3.4: Sample Locations and Description for Surface Soil and Water Samples Collected along the Rust Coloured Drainage Channel

Sample Designation	Samples Collected	Location	Observations
BLW-2	Water	At the punctured culvert where the contaminated water emerges, 6 m along the drainage channel from TH-6	Oily sheen visible on water surface.
BLS-16	Soil	10 m along drainage channel from top (origin) of stain, near a 0.5 m diameter rock. Channel is 11 m wide.	Mostly brown iron oxides with slight hydrocarbon odour. PID reading: 144 ppm
BLS-17	Soil	"Reference" sample collected from a small ravine about 10 m west of stained drainage channel.	Brown-black soil with plant detritus and humus. Numerous soil invertebrates including earthworms. No odours/stains.
BLW-3	Water and Soil	40 m along drainage channel	Very thin rust film, 1- 2 mm, over gravel. Water has no odour or visible sheen.
BLW-4	Water and soil	In slow moving water in a wetland amid horsetail, willow and carex	Organic detritus

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Photograph 3.9: Rust-coloured stained soil and water with hydrocarbon sheen in drainage ditch north of the site.

Photograph 3.10: Galvanized zinc culvert unearthed at the source of rust-coloured leachate.

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3.3.5 Blanchard River

3.3.5.1 Sediment and Water Samples

A targeted sampling program was designed to identify potential contaminant introduction into the aquatic environment of the Blanchard River. Table 3.5 lists the samples of water and sediment collected from the river. One water and sediment sample each was obtained at the location where flow from the rust coloured drainage channel enters the river (BLW-5) and at the edge of Blanchard River where subsurface contaminant inputs from the southern side of the site would be most pronounced (BLW-6). Hydrocarbon sheen was noted on the surface of the river when the sediment was disturbed at the latter location (i.e., BLW-6). Water was present at this location during the high flow season only. An upstream location approximately 300 m from the station, halfway between the station and the bridge on Haines Highway was chosen to serve as the reference site. Attempts to obtain a downstream reference sample proved unsuccessful since the river was inaccessible by land beyond the station.

Table 3.5: Sample Locations and Description for Sediment Soil and Water Samples Collected from the Blanchard River

Sample Designation	Samples Collected	Location	Observations
BLW-5	Water and Sediment	At the edge of Blanchard River where flow from rust coloured drainage channel enters	Sand and gravel
BLW-6	Water and sediment	Edge of Blanchard River below terrace on southeast side of site and down gradient of BH99-9	Sand and gravel
BLW-7	Water and sediment	Upstream reference approximately 300 m from the station, halfway between the station and the bridge on Haines Highway	Sand and gravel

3.3.5.2 Mini-Piezometers

Two mini-piezometers were also established by hand along the bank of the Blanchard River. Their locations are indicated on Drawing 1. MP-3 was installed to intercept groundwater flow from the southwest side of site, just before it enters the river while MP-4 was placed about 100 m upstream to serve as a reference. The mini-piezometers consisted of a conical stainless-steel drive point threaded to four-foot sections of 19 mm stainless steel riser pipes. The point included water intake holes over which fine stainless steel screening was attached. The mini-piezometers were assembled and driven into the ground using a sledgehammer. An insert Waterra™ foot valve connected to LDPE tubing was installed as a dedicated sampling system.

3.3.6 Potable Water

Two potable water samples were obtained from the pressure tanks within the maintenance building camp to ascertain if the camp's water continues to meet drinking water standards. Sample BLDW-1 was collected from Tank-2, which is a storage tank for water pumped from the well and BLDW-2 was taken from Tank-3 used for storing treated water.

3.3.7 Summary of Sampling Program for Detailed Site Investigation

Table 3.6 provide a summary of the soil/sediment sampling program for the detailed site investigation.

Table 3.6: Summary of Soil/Sediment Sampling Program for Blanchard River Detailed Site Investigation

Sample Type	Method	Number Completed	Matrix	Number of Samples Collected
Boreholes	Track mounted air rotary drill	12	Subsurface soil	90
Test pits	Backhoe excavation	30	Subsurface soil	30
Shallow test pits	Hand shovel excavation	6	Subsurface soil	6
Surface soils	Hand collected	4	Surface soil	4
Blanchard River	Hand collected	3	Sediment	3

The water sampling program is summarized in Table 3.7 below.

Table 3.7: Summary of Soil/Sediment Sampling Program for Blanchard River Detailed Site Investigation

Type	Matrix	Number of Samples Collected
Monitoring wells	Groundwater	10
Mini-piezometers	Groundwater	2
Surface water	Surface water	5
Potable water	Drinking water	2

3.3.8 Summary of Analytical Program for Detailed Site Investigation

3.3.8.1 Soil/Sediment Samples

A summary of the analytical program for soil/sediment samples is given in Table 3.8 below. One hundred and thirty six samples were screened in the field for volatile organic compounds (VOCs) using a portable Photoionization Detector (PID). Immunoassay test kits were also employed on-site for EPH (34 samples), PAH (34 samples) and DDTs (14 samples). Laboratory analysis conducted at Analytical Services Laboratories (ASL) included VOCs (14), BTEX/VPH (25), EPH (34), LEPH/HEPH (24), PAH (24), OCPs (14) and PCBs (14). Detailed laboratory results are given in Appendix E and discussed in Chapter 4.

Table 3.8: Summary of June 1999 Field and Laboratory Analytical Program for Blanchard River Soil/Sediment Samples

Sample Type	**Field Analysis**				**Laboratory Analysis**							
	PID	**EPH**	**PAH**	**DDTs**	**VOC**	**BTEX /VPH**	**EPH**	**LEPH/ LEPH**	**PAHs**	**PCBs**	**OCP**	**Metals**
Boreholes	113	20	20	7	5	13	12	14	14	4	4	14
Test Pits	22	13	13	6	4	8	20	5	5	10	10	7
Surface Soils	1	1	1	1	2	2	2	2	2	-	-	4
Blanchard River	-	-	-	-	1	2	-	3	3	-	-	3
Total Analyzed	**136**	**34**	**34**	**14**	**12**	**25**	**34**	**24**	**24**	**14**	**14**	**28**

Notes:

1: VOC = Volatile Organic Contaminants
2: VPH = Volatile Petroleum Hydrocarbons.
3: BTEX = Benzene, Toluene, Ethylbenzene, Xylenes
4: EPH = Extractable Petroleum Hydrocarbons
5: LEPH/HEPH = Light/Heavy Extractable Petroleum Hydrocarbons
6: OCP = Organochlorine Pesticides.

3.3.8.2 Water Samples

All water samples were analyzed in the field for physical parameters including pH, temperature and conductivity. Table 3.9 presents a summary of both the field and laboratory analytical program.

Table 3.9: Summary of June 1999 Field and Laboratory Analytical Program for Blanchard River Water Samples

Sample Type	VOC	BTEX/ VPH	EPH	LEPH/ HEPH	PAH	Total Metals	Dissolved Metals	Physical Parameters
Monitoring Well	5	11	4	12	12	-	11	14
Mini-Piezometer	-	1	2	1	1	-	-	-
Surface Water	-	1	-	3	3	3	1	3
Blanchard River	-	2	-	0	0	1	3	3
Potable Water	-	2	-	2	2	2	-	2
Total Analyzed	**5**	**17**	**6**	**18**	**18**	**6**	**15**	**22**

See Table 3.8 for definitions of abbreviations.

3.3.9 Site Topographic Survey

Yukon Engineering Services completed a detailed survey to generate a site plan, locate all existing features, including test holes/monitoring wells, test pits and any other sampling locations. The survey also established site topography and elevations of monitoring wells to geodetic datum.

3.4 Additional Site Investigation (September 1999)

The results of the Detailed Site Investigation indicated soils and groundwater at the south end of the site were contaminated with petroleum hydrocarbon (discussed in Chapter 4). The original source, the mass of soil affected and the possible migration of the contaminants toward the river could not be identified with the information available. The detailed site investigation was therefore augmented with additional investigations to fully characterize the nature and extend of contamination in this and other areas of the site. Field activities were conducted between September 15 and 29, 1999 by a team comprising participants from:

- DIAND Waste Management (S. Aichele);
- Royal Roads (M. Dodd and D. Bright);
- UMA Engineering (A. Passalis and T. Starodub);
- Midnight Sun Drilling Services (Boreholes and monitoring well installation); and,
- Darling Maintenance Services (Test pit excavation).

Additional tasks undertaken to complete detailed site characterization included –

- Completion of new boreholes at the south end of the site and installation of monitoring wells;
- Excavation of test pits to characterize the nature and extent of subsurface contamination around the large abandoned above ground storage tank (AST), at the rafters camp, and other areas of the sites;
- Collection of subsurface soil samples from testpits and boreholes;
- Development and sampling of the new monitoring wells and re-sampling of wells TH-5, 9-11, 13 and 14;
- Completion of response tests for new wells;
- Survey in new wells, test pits and other relevant features; and,
- Laboratory analysis of test pit and borehole soil samples for VPHs, LEPHs, and HEPHs (including BTEX and PAHs).

3.4.1 Test Pits

Sixteen test pits were excavated during the September program. The locations of these (TP99-44 to TP99-59) and all other previously established test pits (TP95-1 to TP95-6), (TP99-7 to TP99-36) and TP0799-1 to TP0799-6 are provided on Drawing 1. The depth of each test pit, description of subsurface soils and debris found, as well as a list of samples collected at various depths are provided in Table 3.10. The majority of these pits were excavated to characterize and delineate areas of hydrocarbon contamination.

The results of an EM survey indicated that a buried pipe originating between the shop and residence terminated at the drainage ditch north of the site, may be the conduit for the contaminants found in the samples collected in the leachate. Excavations at the source of the leachate plume during the June 1999 investigation uncovered a galvanized culvert (see Sections 3.3.4, Photograph 3.10). As such, test pits were excavated along the EM anomaly in September to ascertain the origin of the culvert. The first test pit (TP99-45) was dug at the southernmost end of the EM grid (Photograph 3.11). A metal utilidor was encountered at approximately 2.0 m (Photograph 3.12). This contained various pipes and serviced the six accommodation trailers, which were removed during reconfiguration of the site to a maintenance camp in 1986. The utilidor was dry indicating it was not the conduit for contaminated water that was surfacing at the drainage ditch. A second test pit (TP99-46), excavated along the EM anomaly, 4 m north of the fence, intercepted a galvanized culvert which was similar to that uncovered at the drainage ditch in June 1999. Groundwater was encountered in this culvert and a faint hydrocarbon odour was detected. Excavation was therefore continued along this culvert to its outlet at the drainage ditch. The culvert was then removed and the area re-graded. Sections of the retrieved culvert are shown in Photograph 3.13. Soil samples were collected from three additional locations along the trench (TP99-47 and TP99-48) in addition to TP99-44 and TP99-45.

Two test pits (TP99-49 and TP99-50) were established near the former burn pit to further characterize hydrocarbon contamination and allow a comparison of the PetroFLAG™ field test kit results to laboratory data.

Test pits were also excavated (TP99-55 to TP99-59) to determine the nature and extent of hydrocarbon contamination at the rafters' camp, situated south of the site. This followed the discovery of hydrocarbons in soil samples collected from hand excavated test pits in the area in July 1996. No visible staining, hydrocarbon odours or debris was found in the test pits apart from domestic garbage including wood, plastic and glass, which were present in TP99-58 (Photograph 3.14).

The Blanchard River Site Supervisor discovered a buried six inch pipe line to the east of the maintenance shop during the installation of new above ground storage tanks in the area in July 1999. This line was not associated with any utility or supply in current use. A test pit (TP99-50) was therefore excavated in this area during the September program for further investigation. The pipe, which contained free product was encountered in this test pit (Photograph 3.15 and 3.16). A strong hydrocarbon odour was present in coarse sand surrounding the pipe.

Finally, one test pit each was excavated at three locations around the site to investigate possible hydrocarbon contamination. These included TP99-52 (south of fence on the bench below the ASTs), TP99-53 (northeast end of maintenance building) and TP99-54 (50 m north of the maintenance building).

Table 3.10: Blanchard River September 1999 Test Pit Excavation Program

Test Pit	Sample Designation	Sample Depth	PID Reading	Location and Observations
TP99-44	no sample taken			South edge of EM grid. Water at around 2.5 m depth. No hydrocarbon odour. No clay layers to bottom of trench around 2.75 m. Top of 2 foot diameter culvert encountered at approximately 2 m depth. lines up to old utilidor.
TP99-45	TP45-1	2.15 m	1.6 ppm	Along EM anomaly, about 4 m north of fence. 20 cm black loam above cobble/sand/silt. Groundwater at 2 m. Coarse sand and gravel, faint hydrocarbon odour.
TP99-46	TP46-1	2.2 m	1.5	Culvert excavation. Soil sample below depth of culvert. Very faint hydrocarbon odour.
TP99-47	TP47-1	2 m	49.2	Along culvert trench, within 3 m of road.
TP99-48	TP48-1	2 m	2.0	Other side of road, towards end of culvert and rust coloured stain.
TP99-49	TP49-1 TP49-2 TP49-3 TP49-4 TP49-5	0.5 m 1.0 m 1.5 m 2.4 m 2.8 m	0.6 0.6 0.5 243 134	Within 0.5 m of fence and 3 m from gate to north of burn pit. Excavated to locate lateral edge of contamination in burn pit. Reworked native till to 1.0 m. silt clay at 1.5 m just below woody debris layer. Slight hydrocarbon odour. Coarse sand at 2.2 m, stronger hydrocarbon odour.
TP99-50	TP50-1	1.9 m		Excavated at 6 inch pipeline southeast of maintenance building. Natural layered homogenous sand in pit. Note: this pipeline was excavated during the installation of the new fuel tanks. The pipe, which was filled with product, was cut with an oxyacetylene torch at the top.
TP51	TP51-1 TP51-2 TP51-3 TP51-4 TP51-5 TP51-6	2.2 m 2.3 m 2.8 m 2.9 m 3.1 m 3.2 m	1.2 5.5 250 247 268	Excavated at the burn pit, 1 m south of TP28 to collect samples from below 2.2 m to allow a comparison between PetroFLAG™ test kit results and laboratory data. Brown sand and cobbles to 1.5 m depth. 1.5 to 1.6 m clay layer. 1.6 to 2.2 m brown sand no odour. 2.2 m clay mixed with sand and silt. Brown gravelly sand beyond 2.3 m.
TP52	TP52-1		0	South of fence, on bench beneath ASTs south of maintenance building. No hydrocarbon odour or staining.

cont'd

Table 3.10: Continued

Test Pit	Sample Designation	Sample Depth	PID Reading	Location and Observations
TP53	No sample collected			20 m northeast of burn pit area. No visible debris or odours noted.
TP54	No sample collected			20 m west of the southern end of maintenance building. No debris, no visible staining or hydrocarbon odour.
TP55	No sample collected			4.5 m north of new outhouse, 5 m from edge of brush. Native fills to clay layer at 2.6 m. No visible staining or hydrocarbon odour. No debris.
TP56	TP56-1 TP56-2	1.5 m 3.3 m		17 m north of the outhouse. Black organic layer to 3 cm. Sand and gravel to 2.5 m. Coarse gravel beyond 2.5 m. Clay layer not reached at 3.3 m. Water infiltration at this point.
TP57	TP57-1			Sand, gravel and cobbles to 1.2 m. No debris, odour or stains noted.
TP58	TP58-1	40 cm		Organic layer to 30 cm. Domestic garbage including wood, plastic and glass from 30 cm to 1 m. Water table at 1.2 m.
TP59	No sample collected			Water table at 1.3 m. Sand, gravel and cobbles. No debris.

Photograph 3.11: Excavating a test pit (TP99-45) at the southernmost end of the EM anomaly, northeast of the residence.

Photograph 3.12: A metal utilidor encountered at a depth of 2 m in TP99-45 with a section of the cover removed.

Photograph 3.13: Sections of galvanized culvert removed from trench dug along the EM anomaly leading to the rust-coloured graining ditch.

Photograph 3.14: Test pit excavation at the rafters camp (TP99-58) showing debris including wood and plastic materials.

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Photograph 3.15: Excavation southeast of maintenance building showing vertical pipe (TP99-50). Note: this pipe was first encountered during the installation of the new fuel tanks by the station supervisor.

Photograph 3.16: Close-up view of pipe at TP99-50 showing free product.

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3.4.2 Boreholes and Monitoring Wells

Seven boreholes were advanced south of the maintenance building to further identify the source, characterize and delineate the extent of hydrocarbon contamination detected during previous investigations. Locations of these boreholes (TH99-18 to TH99-24) are also shown on Drawing 1.

Two boreholes (TH99-18 and TH99-19) were drilled on the lower terrace, near the river (Photograph 3.17) to delineate the lateral extent of hydrocarbon contamination detected in TH99-9. Monitoring wells were installed in both wells to complement the two that were installed during the June investigation (Photograph 3.18). Borehole TH99-20 was drilled 20 m east of the southern end of the maintenance building while TH99-21 and TH99-24 were located near the berm for the AST and up gradient of TH99-14. The remaining two boreholes (TH99-22 and TH99-23) were drilled near the empty above ground storage tanks (Photograph 3.19). Monitoring wells were placed in two of the wells drilled on the upper terrace (TH99-20 and TH99-24).

The drilling and sampling methods were similar to those used for the June investigation. Briefly, an air-rotary drill was used to advance the hole and deliver cuttings to the surface. The drill cuttings were placed into bags covering a two foot drilling zone. Following observation and recording of physical characteristics including particle size, odour, moisture content, sub-samples were collected for field and laboratory analysis. A split spoon sampler (Photograph 3.20) was used in selected boreholes to obtain a less disturbed vertical profile at specific depths.

Two inch threaded and coupled PVC casings and screens were used for all monitoring wells. Following installation of the wells, a Waterra™ dedicated sampling system was placed in each well, for retrieval of groundwater. All wells were developed by intermittently pumping large volumes of water (over five well volumes).

A list of the boreholes completed in September 1999, samples collected and field test kit results is given in Table 3.11. The details of borehole depth and piezometer construction for all boreholes are provided in the borehole logs (Appendix A).

Table 3.11: Boreholes Completed, Samples Collected and Soil Organic Vapour Results

Sample Designation	Sample Depth	PID[1] (ppm)	PetroFLAG™ Results (ppm)	Lab Sample Collected
Borehole 18				
TH99-18-1	0 to 2'	No recovery		
TH99-18-2	2 to 4'	ND		
TH99-18-3	4 to 6'	ND		
TH99-18-4	6 to 8'	ND	160	
TH99-18-5	8 to 10'	3.8	320	Hydrocarbons
TH99-18-6	10 to 11'	53	1500	
TH99-18-7	11 to 12'	7.8	320	
TH99-18-8	12 to 13'	5.0	283	
TH99-18-9	13 to 15'	1.3	248	
Borehole 19				
TH99-19-1	0 to 2'	No recovery		
TH99-19-2	2 to 4'	ND	153	
TH99-19-3	4 to 6'	ND		
TH99-19-4	6 to 8'	34.7	1105	
TH99-19-5	8 to 10'	21.4	150	
TH99-19-6/7	10 to 10'10	Field duplicates using split spoon		Hydrocarbons
TH99-19-8	11'20 to 11'60	Split spoon		Hydrocarbons
TH99-19-9	12 to 14'	8.5		
Borehole 20				
TH99-20-1	0 to 2'	1.5		
TH99-20-2	2 to 4'	1.4		
TH99-20-3	4 to 6'	1.4		
TH99-20-4	6 to 8'	0.9		Hydrocarbons
TH99-20-5	8 to 10'	0.9		
TH99-20-6	10 to 12'	3.6		
TH99-20-7	12 to 14'	-		
TH99-20-8	14 to 16'	2.6		Hydrocarbons
TH99-20-9	16 to 18'	5.0		
TH99-20-10	18 to 20'	1.0		
TH99-20-11	20 to 22'	9.5		
TH99-20-12	22 to 24'	6.0		
TH99-20-13	24to 26'	8.2		Hydrocarbons
Borehole 22				
TH99-22-1	0 to 2'	ND		
TH99-22-2	2 to 4'	ND		
TH99-22-3	4 to 6'	ND		
TH99-22-4	6 to 8'	ND		
TH99-22-5	8 to 10'	ND		
TH99-22-6	10 to 11'4"	ND		Hydrocarbons
TH99-22-7	12 to 14'	Split spoon		

cont'd

Notes:

1. PID = Volatile Organic Compounds in soil vapour as determined by headspace analysis using a portable photoionization detector.

Table 3.11 Continued

Sample Designation	Sample Depth	PID[1] (ppm)	PetroFLAG™ Results (ppm)	Lab Sample Collected
Borehole 21				
TH99-21-1	0 to 2'	55.8	1005	
TH99-21-2	2 to 4'	49.4	1250	
TH99-21-3	4 to 6'	18.7		
TH99-21-4	6 to 8'	19.6		
TH99-21-5	8 to 10'	15.3		
TH99-21-6	10 to 12'	10.5	128	
TH99-21-7	12 to 14'	4.0		
TH99-21-8	14 to 16'	3.8		
TH99-21-9	16 to 17.5'	2.4		
TH99-21-10	24.5 to 26'	ND		
TH99-21-11	26 to 28'	ND		
TH99-21-12	28 to 30'	ND		
Borehole 23				
TH99-23-1	0 to 2'	No recovery		
TH99-23-2	2 to 4'	ND		
TH99-23-3	4 to 6'	ND		
TH99-23-4	6 to 8'	ND		
TH99-23-5	8 to 10'	ND		
TH99-23-6	10 to 11'4"	ND		
TH99-23-7	12'8" to 13'	ND, Split spoon		Lab sample
Borehole 24				
TH99-24-1	0 to 2'	No recovery		
TH99-24-2	2 to 4'	ND		
TH99-24-3	4 to 6'	ND		
TH99-24-4	6 to 8'	ND		
TH99-24-5	8 to 10'	0.7		
TH99-24-6	10 to 12'	ND		
TH99-24-7	12 to 14'	0.8		
TH99-24-8	14 to 16'	0.7		
TH99-24-9	16 to 18'	0.7		
TH99-24-10	18 to 20'	0.9		
TH99-24-11	20 to 22'	8.0		
TH99-24-12	22 to 24'	10.9		Lab
TH99-24-13	24.5 to 26'	28.7		
TH99-24-14	26 to 28'			
TH99-24-20	Field Dup of 13			

Notes:

1. PID = Volatile Organic Compounds in soil vapour as determined by headspace analysis using a portable photoionization detector.

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Photograph 3.17: Installation of borehole TH99-18 on the lower terrace southwest of the station and near Blanchard River with monitoring well TH99-9 nearby.

Photograph 3.18 View of all four monitoring wells installed on the lower terrace southwest of the station.

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Photograph 3.19: Drilling near the empty above ground storage tank south of the maintenance building.

Photograph 3.20: Split spoon sampler with a core sample.

3.4.3 Summary of Sampling Program for Additional Site Investigation

Table 3.12 provides a summary of subsurface soils collected during additional site investigations in September 1999. Sampling methods have been described in Section 3.1.

Table 3.12: Summary of Soil Program for Blanchard River Additional Site Investigation

Sample Type	Method	Number Completed	Matrix	Number of Samples Collected
Boreholes	Track mounted air rotary drill	7	Subsurface soil	67
Test pits	Backhoe excavation	16	Subsurface soil	20

The water sampling program is summarized in Table 3.13 below.

Table 3.13: Summary of Water Sampling Program for Blanchard River Additional Site Investigation

Sample Type	Matrix	Number of Samples Collected
Monitoring Wells	Groundwater	8
Mini-piezometer	Groundwater	1
Blanchard River	Surface water	1

3.4.4 Summary of Analytical Program for Additional Site Investigation

3.4.4.1 Soil Samples

As per the detailed site investigations, samples were analyzed using a combination of field and laboratory methods, which are described in Section 3.2. A summary of the analytical program for soil/sediment samples is given in Table 3.13. Detailed laboratory results are given in Appendix E and discussed in Chapter 4.

Table 3.14: Summary of Field and Laboratory Analytical Program for Soil Samples Collected During Additional Site Investigations at Blanchard River

Type	Field Analysis		Laboratory Analysis				
	PID	PetroFLAG™	BTEX/ VPH	EPH	LEPH/ LEPH	PAHs	Metals
Boreholes	61	13	8	20	20	20	-
Test Pits	18	19	3	9	3	3	4
Total Analyzed	**79**	**32**	**11**	**29**	**23**	**23**	**4**

Notes:

1: PID = Headspace analysis using a portable Photoionization Detector
2: BTEX = Benzene, Toluene, Ethylbenzene, Xylenes
3: VPH = Volatile petroleum hydrocarbons
4: EPH = Extractable Petroleum Hydrocarbons
5: LEPH/HEPH = Light/Heavy Extractable Petroleum Hydrocarbons

3.4.4.2 Water Samples

All water samples were analyzed in the field for physical parameters including pH, temperature and conductivity. Table 3.15 presents a summary of both the field and laboratory analytical program.

Table 3.15: Summary of September 1999 Field and Laboratory Analytical Program for Blanchard River Water Samples

Sample Type	BTEX/ VPH	EPH	LEPH/ HEPH	PAH	Total Metals	Dissolved Metals	Physical Parameters
Monitoring Well	8	7	7	7	-	4	8
Mini-Piezometer	1	1	1	1	-	-	-
Surface Water	1	-	-	-	1	-	-
Total Analyzed	**10**	**8**	**8**	**8**	**1**	**4**	**8**

3.5 Quality Assurance and Quality Control Program

The project team utilized a field QA/QC program that incorporated measures to ensure the integrity of the soil and groundwater samples collected and met sampling program data quality objectives. The QA/QC program included –

- documentation (date, time, site identification, site conditions, sampling equipment, sample type, preservatives, etc.) of sampling;
- collection of field duplicates for at least 10% of all samples;
- traveling blank samples;
- collection of background (reference) samples; and,
- rigorous chain-of-custody.

The QA/QC results are discussed in Chapter 4.

3.6 Health and Safety Program

As part of the field investigation and restoration programs, a Health and Safety Program was designed to meet the requirements of applicable Canadian Occupational Health and Safety Regulations, the Workers Compensation Board (WCB), Workplace Hazardous Materials Information System (WHMIS) and territorial statutes. Equipment provided for the team included necessary personal protective coverall (Tyvek™ suit), protective mask, gloves and first aid kit. The specifications for the equipment met the National Institute for Occupational Health and Safety (NIOSH) guidelines. All members familiarized themselves with the Safety Program and actions to be taken in case of safety violations, accidents, personal injury and emergencies.

4. RESULTS

Soil and water samples collected at Blanchard River Maintenance Camp were analyzed for a variety of parameters including hydrocarbons, volatile organic compounds, organochlorine pesticides, polychlorinated biphenyls and metals. These parameters were selected on the basis of results from the preliminary site investigations and historical review of site usage. The results for soil and water samples collected during the June and September site investigations are presented and discussed in this chapter. In addition data from previous preliminary site investigations (UMA and Ambio, 1995; Royal Roads, 1996) have been incorporated to provide a comprehensive summary of analytical results to date. A summary of the environmental quality standards to assess the data is also provided in this chapter.

4.1 Assessment Criteria

In order to minimize or eliminate environmental impact, it is necessary to anticipate concentrations of contaminants, which could lead to a decrease in environmental quality and respond accordingly. An initial approach to this exercise is to compare the concentrations of the contaminants to appropriate benchmarks. Guidance on acceptable levels of analytes in soil and water samples for this study was obtained from the following sources:

- Yukon Renewable Resources, *Contaminated Sites Regulation,* 1996.
- BC Ministry of Environment, Lands and Parks (BC MELP, 1999). *Contaminated Sites Regulation First Stage Amendments (Order in Council 843).* Guidance on extractable hydrocarbon levels in water only.
- Canadian Council of Ministers of the Environment (CCME, 1999), *Canadian Environmental Quality Guidelines.*

4.1.1 Soil Standards

The Yukon CSR defines five land use categories for soil samples as follows:

i) Agricultural (AL) – the land is used for producing agricultural products;

ii) Park (PL) – the land is used for outdoor recreation;

iii) Residential (RL) – the land is used for the purpose of a residence by persons on a permanent, temporary or seasonal basis or the land is used for institutional facilities.

iv) Commercial (CL) – the land is used for the purpose of buying, selling or trading of merchandise or services and storage associated with these activities.

v) Industrial (IL) – the land is used for the purpose of operating a public waste disposal activity or conducting industrial manufacturing or assembly processes and their ancillary uses.

Schedules, which contain tabulated numerical standards for contaminants in soil, are given in the CSR. Schedule 1, Generic Numerical Soil Standards, comprises the concentration of various contaminants in soil specified for each of the land uses described above. Schedule 2 gives the Matrix Numerical Soil Standards for selected parameters. These Matrix Numerical Soil Standards consider site-specific factors along with land usage. The site specific factors deemed relevant to this study include intake of contaminated soil, groundwater used for drinking water, toxicity to soil invertebrates and plants, and groundwater flow to surface water used for aquatic life.

Under the Yukon CSR, a site is considered contaminated if the concentration of any contaminant at the site is greater than or equal to the generic numerical soil standards of the particular land use in Schedule 1, or the matrix numerical soil standard in Schedule 2 with respect to land use and site specific factors. This definition takes into account background concentrations as such the site is not contaminated if it does not contain any substance with a concentration greater than or equal to the local background concentration.

Three of the five land use categories, residential (RL), park (PL) and industrial (IL) land use standards are considered to be applicable to soil samples collected from different areas of Blanchard Maintenance Camp as follows:

- Industrial land use is appropriate to samples collected from locations close to the Maintenance Building, which is used for maintenance and storage of vehicles and snow removal equipment.
- Residential applies to soils within the vicinities of the Residence Building.
- Remaining areas around the site are classified as parkland since they are used for recreational activities such as camping, rafting and fishing.

4.1.1.1 Metals

Table 4.1 provides a summary of the standards for relevant metals analyzed in this study. Matrix numeric standards are available for arsenic, cadmium, chromium, copper, lead and zinc. For these elements, the values for the site-specific factors 'groundwater flow to surface water used for drinking', 'soil ingestion', 'toxicity to soil invertebrates and plants', and groundwater flow to surface water used by aquatic life are given for park (PL), residential (RL) and industrial (IL) land use. The Generic Numerical standards for PL, RL and IL land uses for the remaining metals are also provided in the table. Note that the standards for PL and RL are identical for each metal.

Table 4.1: Relevant Yukon Renewable Resources Contaminated Sites Regulation Soil Standards for Metals

Total Metals	**Schedule 1 Generic Numerical Soil Standards**		**Schedule 2 Matrix Numerical Standards**					
			Human Health Protection			**Environmental Health Protection**		
	PL/RL	*IL*	*Ground-water used for drinking*	*Soil ingestion (PL/RL)*	*Soil Ingestion (IL)*	*Toxicity to soil inverte-brates and plants (PL/RL)*	*Toxicity to soil inverte-brates and plants (IL)*	*Ground-water flow to surface water used by aquatic life*
Antimony (Sb)	20	40	-	-	-	-	-	-
Arsenic (As)			15	100	300	35	150	60
Barium (Ba)	500	2000	-	-	-	-	-	-
Beryllium (Be)	4	8	-	-	-	-	-	-
Cadmium (Cd)	-	-	1.5 to 1,000[3]	35	100	250	700	1.5 to 4000[3]
Chromium (Cr)	-	-	60	150	500	250	800	60
Cobalt (Co)	50	300	-	-	-	-	-	-
Copper (Cu)[3]	-	-	250 to 350000[3]	15000	50000	150	250	90 to 30000[3]
Lead (Pb)	-	-	100 to 4000[3]	500	1000	1000	2000	150 to 40000[3]
Mercury (Hg)	2	10	-	-	-	-	-	-
Molybdenum (Mo)	10	40	-	-	-	-	-	-
Nickel (Ni)	100	500	-	-	-	-	-	-
Selenium (Se)	3	10	-	-	-	-	-	-
Silver (Ag)	20	40	-	-	-	-	-	-
Tin (Sn)	50	300	-	-	-	-	-	-
Vanadium (V)	200	-	-	-	-	-	-	-
Zinc (Zn)	-	-	150 to 15000[3]	10000	30000	450	600	150 to 1000[3]

Notes:

1. All values are in µg/g or mg/kg
2. PL = Park Land use, RL = Residential and IL = Industrial land use.
3. Value is based on the pH of the soil at the site

4.1.1.2 Hydrocarbons

The Yukon CSR standards for hydrocarbons study are given in Table 4.2. These include the monocyclic aromatic hydrocarbons (benzene, toluene, ethylbenzene, xylenes and styrene - collectively referred to as BTEX), Volatile Petroleum Hydrocarbon (VPH), Polycyclic Aromatic Hydrocarbons (PAH), Extractable Hydrocarbons (EPH), Light Extractable Hydrocarbons (LEPH) and Heavy Extractable Hydrocarbons (HEPH). VPH is obtained by subtracting the concentrations of benzene, toluene, ethylbenzene and xylenes from that of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10). The concentrations for LEPHs are derived by the subtraction of naphthalene and phenanthrene from the EPH (C10-C19) values. Similarly, HEPHs are calculated by subtracting the concentrations of benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a) pyrene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene and pyrene from the EPH (C19-C31) data (See Section 3.2.3).

Table 4.2: Relevant Yukon Renewable Resources Contaminated Sites Regulation Soil Standards for Hydrocarbons

Hydrocarbons	**Schedule 1 Generic Numerical Soil Standards**		**Schedule 2 Matrix Numerical Standards**					
			Human Health Protection			**Environmental Health Protection**		
	PL/RL	*IL*	*Ground-water used for drinking*	*Soil ingestion (PL/RL)*	*Soil ingestion (IL)*	*Toxicity to soil inverte-brates and plants (PL/RL)*	*Toxicity to soil inverte-brates and plants (IL)*	*Ground-water flow to surface water used by aquatic life*
Volatiles								
Benzene	-	-	0.04	1000	4000	80	150	8
Ethylbenzene	-	-	7	3500	10000	5	50	1000
Styrene	5	50						
Toluene	-	-	2.5	6500	20000	3	30	300
Xylenes (totals)	-	-	20	65000	200000	5	50	NS
VPH C6-10	200	200	-	-	-	-	-	-
PAHs								
Acenaphthene	-	-	-	-	-	-	-	-
Acenaphthylene	-	-	-	-	-	-	-	-
Acridine	-	-	-	-	-	-	-	-
Anthracene	-	-	-	-	-	-	-	-
Benz(a)anthracene	1	10	-	-	-	-	-	-
Benzo(a)pyrene	-	-	NS	5	15	1	10	NS
Benzo(b)fluoranthene	1	10	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	1	10	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-
Fluoranthene	-	-	-	-	-	-	-	-
Fluorene	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	1	10	-	-	-	-	-	-
Naphthalene	5	50	-	-	-	-	-	-
Phenanthrene	5	50	-	-	-	-	-	-
Pyrene	10	100	-	-	-	-	-	
Extractables								
EPH (C10-18)	-	-	-	-	-	-	-	-
EPH (C19-31)	-	-	-	-	-	-	-	
LEPH	1000	2000	-	-	-	-	-	-
HEPH	1000	5000	-	-	-	-	-	-

Notes:

1. All values are in µg/g or mg/kg
2. PL = Park Land use, RL = Residential and IL = Industrial land use.
3. See text for definitions of VPH, EPH, LEPH and HEPH

4.1.1.3 Halogenated Volatile Organic Compounds (VOCs)

Standards for halogenated volatile organic compounds, which are generally found in solvents, degreasers and paint thinners are given in Table 4.3. Almost all the values are from the Generic Numerical Standards of the CSR except for tetrachloroethylene (PERC) and trichloroethylene (TCE) that are matrix numerical standards.

Table 4.3: Relevant Yukon Renewable Resources Contaminated Sites Regulation Soil Standards for Halogenated Volatile Organic Compounds

Volatile Organic Compounds	**Schedule 1 Generic Numerical Soil Standards**		**Schedule 2 Matrix Numerical Standards**					
			Human Health Protection			**Environmental Health Protection**		
	PL/RL	*IL*	*Ground-water used for drinking*	*Soil ingestion (PL/RL)*	*Soil ingestion (IL)*	*Toxicity to soil inverte-brates and plants (PL/RL)*	*Toxicity to soil inverte-brates and plants (IL)*	*Ground-water flow to surface water used by aquatic life*
Bromodichloromethane	5	50	-	-	-	-	-	-
Bromoform	-	-	-	-	-	-	-	-
Carbon Tetrachloride	5	50	-	-	-	-	-	-
Chlorobenzene	1	10	-	-	-	-	-	-
Chloroethane	5	50	-	-	-	-	-	-
Chloroform	5	50	-	-	-	-	-	-
Chloromethane	5	50	-	-	-	-	-	-
Dibromochloromethane	5	50	-	-	-	-	-	-
1,2-Dichlorobenzene	1	10	-	-	-	-	-	-
1,3-Dichlorobenzene	1	10	-	-	-	-	-	-
1,4-Dichlorobenzene	1	10	-	-	-	-	-	-
1,1-Dichloroethane	5	50	-	-	-	-	-	-
1,2-Dichloroethane	5	50	-	-	-	-	-	-
cis-1,2-Dichloroethylene	5	50	-	-	-	-	-	-
trans-1,2-Dichloroethylene	5	50	-	-	-	-	-	-
1,1-Dichloroethylene	5	50	-	-	-	-	-	-
Dichloromethane	5	50	-	-	-	-	-	-
1,2-Dichloropropane	5	50	-	-	-	-	-	-
cis-1,3-Dichloropropylene	5	50	-	-	-	-	-	-
trans-1,3-Dichloropropylene	5	50	-	-	-	-	-	-
1,1,1,2-Tetrachloroethane	5	50	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	5	50	-	-	-	-	-	-
Tetrachloroethylene	-	-	-	1000	-	5	50	5
1,1,1-Trichloroethane	5	50	-	-	-	-	-	-
1,1,2-Trichloroethane	5	50	-	-	-	-	-	-
Trichloroethylene	-	-	0.15	200	-	5	50	0.65
Trichlorofluoromethane	5	50	-	-	-	-	-	-
Vinyl Chloride	5	50	-	-	-	-	-	-

Notes:

1. All values are in µg/g or mg/kg
2. PL = Park Land use, RL = Residential and IL = Industrial land use.

4.1.1.4 Chlorinated Organic Compounds

Table 4.4 contains standards for persistent chlorinated organic compounds including polychlorinated biphenyls (PCBs) and pesticides. There are generally no standards for most of the chlorinated pesticides, including DDTs. Matrix numerical standards are, however available for PCBs.

Table 4.4: Relevant Yukon Renewable Resources Contaminated Sites Regulation Soil Standards for Chlorinated Organic Compounds

Chlorinated Organic Compounds	**Schedule 1 Generic Numerical Soil Standards**		**Schedule 2 Matrix Numerical Standards**					
			Human Health Protection			**Environmental Health Protection**		
	PL/RL	*IL*	*Ground-water used for drinking*	*Soil ingestion (PL/RL)*	*Soil ingestion (IL)*	*Toxicity to soil inverte-brates and plants (PL/RL)*	*Toxicity to soil inverte-brates and plants (IL)*	*Ground-water flow to surface water used by aquatic life*
Polychlorinated Biphenyls (PCBs)	-	-	-	5	15	5	50	-
Pesticides								
Aldrin	-	-	-	-	-	-	-	-
alpha-BHC	2	10	-	-	-	-	-	-
beta-BHC	2	10	-	-	-	-	-	-
delta-BHC	2	10	-	-	-	-	-	-
cis-Chlordane (alpha)	-	-	-	-	-	-	-	-
trans-Chlordane (gamma)	-	-	-	-	-	-	-	-
2,4'-DDD	-	-	-	-	-	-	-	-
4,4'-DDD	-	-	-	-	-	-	-	-
2,4'-DDE	-	-	-	-	-	-	-	-
4,4'-DDE	-	-	-	-	-	-	-	-
2,4'-DDT	-	-	-	-	-	-	-	-
4,4'-DDT	-	-	-	-	-	-	-	-
Dieldrin	-	-	-	-	-	-	-	-
Endosulfan I	-	-	-	-	-	-	-	-
Endosulfan II	-	-	-	-	-	-	-	-
Endosulfan Sulfate	-	-	-	-	-	-	-	-
Endrin	-	-	-	-	-	-	-	-
Endrin Aldehyde	-	-	-	-	-	-	-	-
Heptachlor	-	-	-	-	-	-	-	-
Heptachlor Epoxide	-	-	-	-	-	-	-	-
Lindane (gamma - BHC)	2	10	-	-	-	-	-	-
Methoxychlor	-	-	-	-	-	-	-	-
Mirex	-	-	-	-	-	-	-	-
cis-Nonachlor	-	-	-	-	-	-	-	-
trans-Nonachlor	-	-	-	-	-	-	-	-

Notes:

1. All values are in µg/g or mg/kg
2. PL = Park Land use, RL = Residential and IL = Industrial land use.
3. Total Polychlorinated Biphenyls (PCBs) include Arochlor mixtures 1242, 1248, 1254 and 1260

4.1.2 Water Standards

The Yukon CSR standards for water are divided into four use categories:

- Aquatic life water use (AW) – means the use of water as a habitat for any component of the freshwater or marine ecosystem;
- Irrigation water use (IW) – means the use of water for producing agricultural products;
- livestock water use (LW) – means the use of the water for the purpose of consumption by livestock; and,
- Drinking water use (DW) – means the use of water for consumption by humans.

For groundwater and surface water samples collected at Blanchard Maintenance Camp, Aquatic Life (AW) life are relevant, as are drinking water standards since the station currently draws water from a groundwater well for drinking. Numerical Standards for various analytes in water are given in Schedule 3 of the Yukon CSR. Under the CSR, a site is contaminated if the surface water or groundwater located at the site, or flows from the site is used or has a reasonable probability of being used for aquatic life, irrigation, livestock or drinking, and the concentration of contaminants in the surface water or groundwater is greater than or equal to the concentration of that specified for that use in Schedule 3.

4.1.2.1 Metals

Standards for relevant metals and metalloids are given in Table 4.5 below. The aquatic life water use (AW) standard for aluminum is dependent on pH while that for cadmium, copper, lead or nickel varies with water hardness. For surface water samples obtained from the actual aquatic receiving environment of the Blanchard River, a ten-fold dilution was taken into account.

Table 4.5: Yukon Renewable Resources Contaminated Sites Regulation Water Standards for Metals and Metalloids (µg/L)

Total Metals and Metalloids	**Schedule 3: Generic Numeric Water Standards**		
	Aquatic Life (AW)[1]	**Drinking Water (DW)**	**Blanchard River Water[2]**
Aluminum (Al)	50 to 500[3]	200	5 to 50[3]
Antimony (Sb)	300	-	30
Arsenic (As)	500	25	50
Barium (Ba)	10,000	100	1000
Beryllium (Be)	53	-	5.3
Boron (B)		5000	
Cadmium (Cd)	2 to 18[4]	5	0.2 to 1.8[4]
Calcium (Ca)	-	-	-
Chromium (Cr)	20	50	2
Cobalt (Co)	500		50
Copper (Cu)	20 to 90[4]	1000	2 to 9[4]
Iron (Fe)	3000	300	300
Lead (Pb)	40 to 160[4]	10	4 to 16[4]
Magnesium (Mg)	-	-	-
Manganese (Mn)	1000	50	100
Mercury (Hg)	1	1	0.1
Molybdenum (Mo)	10,000	250	1000
Nickel (Ni)	250 to 1500[4]	-	25 to 150[4]
Selenium (Se)	10	10	1
Silver (Ag)	1	-	0.1
Sodium (Na)	3	-	200,000
Thallium (Tl)	3	-	0.3
Uranium (U)	3000	100	300
Zinc (Zn)	300	5000	30

Notes:

1. Aquatic life assumes minimum 1:10 dilution is available.
2. Ten fold dilution applied to AW Standard for receiving environment
3. Value depends on pH of the water sample
4. Value depends on hardness (H) of the water sample.

4.1.2.2 Hydrocarbons

Aquatic life and drinking water standards for BTEX, PAHs and extractable hydrocarbons are given in Table 4.6. There are currently no standards in the Yukon CSR for extractable hydrocarbons in water as such values for these parameters were adapted from the BC CSR (BC MELP, 1999).

Table 4.6: Yukon Renewable Resources Contaminated Sites Regulation Water Standards for Hydrocarbons (µg/L)

Total Metals and Metalloids	**Schedule 3: Generic Numeric Water Standards**		
	Aquatic Life (AW)[1]	**Drinking Water (DW)**	**Blanchard River Water[2]**
Benzene	3,000	5	300
Ethylbenzene	7,000	2.4	700
Styrene	-	-	-
Toluene	3,000	24	300
meta-, ortho-& para-Xylene	-	300	
Volatile Hydrocarbons (VH) C6-10	15,000[3]	-	1,500
VPH C6-10 (calculated)	1,500[3]	-	150
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	60	-	6
Acenaphthylene	-	-	-
Acridine	0.5	-	0.05
Anthracene	1	-	0.1
Benz(a)anthracene	1	-	0.1
Benzo(a)pyrene	0.1	-	0.01
Benzo(b)fluoranthene	-	-	-
Benzo(g,h,i)perylene	-	-	-
Benzo(k)fluoranthene	-	-	-
Chrysene	-	-	-
Dibenz(a,h)anthracene	-	-	-
Fluoranthene	2	-	0.2
Fluorene	120	-	12
Indeno(1,2,3-c,d)pyrene	-	-	-
Naphthalene	10	-	1
Phenanthrene	3	-	0.3
Pyrene	0.2	-	0.02
Extractables			
EPH (C10-18)	5,000[3]	-	500
EPH (C19-31)	-	-	-
LEPH	500[3]	-	50
HEPH	-	-	-

Notes:

1. Aquatic life assumes minimum 1:10 dilution is available.
2. Ten fold dilution applied to Blanchard River water.
3. Values taken from BC CSR (BC MELP, 1999).

4.1.2.3 Volatile Organic Compounds

Generic numeric standards for VOCs are given in Table 4 below.

Table 4.7: Yukon Renewable Resources Contaminated Sites Regulation Water Standards for Volatile Organic Compounds

Volatile Organic Compounds	Schedule 3: Generic Numeric Water Standards		
	Aquatic Life (AW)[1]	Drinking Water (DW)	Blanchard River Water[2]
Bromodichloromethane	-	-	-
Bromoform	-	-	-
Carbon Tetrachloride	130	5	13
Chlorobenzene	150	30	15
Chloroethane	-	-	-
Chloroform	-	-	-
Chloromethane	-	-	-
Dibromochloromethane	-	-	-
1,2-Dichlorobenzene	25	3	2.5
1,3-Dichlorobenzene	25	-	2.5
1,4-Dichlorobenzene	4	1	0.4
1,1-Dichloroethane	-	-	-
1,2-Dichloroethane	500	5	50
cis-1,2-Dichloroethylene	-	-	-
trans-1,2-Dichloroethylene	-	-	-
1,1-Dichloroethylene	-	-	-
Dichloromethane	-	50	-
1,2-Dichloropropane	-	-	-
cis-1,3-Dichloropropylene	-	-	-
trans-1,3-Dichloropropylene	-	-	-
1,1,1,2-Tetrachloroethane	-	-	-
1,1,2,2-Tetrachloroethane	-	-	-
Tetrachloroethylene	1,100	-	110
1,1,1-Trichloroethane	-	-	-
1,1,2-Trichloroethane	-	-	-
Trichloroethylene	200	50	20
Trichlorofluoromethane	-	-	-
Vinyl Chloride	-	2	-

Notes:

1. Aquatic life assumes minimum 1:10 dilution is available.
2. Ten fold dilution applied to Blanchard River water.

4.1.3 Sediment Standards

At present no standards exist in the Yukon CSR for contaminants in sediment. The results were therefore assessed using the CCME Canadian Environmental Quality Guidelines for Freshwater Sediments (CCME, 1999). Table 4.8 present the Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL) values for the analytes examined in sediment samples collected from Blanchard River.

Table 4.8: Canadian Environmental Quality Guidelines for Metals in Freshwater Sediment (μg/kg)

Parameter	ISQG	PEL	Parameter	ISQG	PEL
Metals			***Extractables***		
Antimony	-	-	EPH (C10-19)	-	-
Arsenic	5900	17 000	EPH (C19-31)	-	-
Barium	-	-	LEPH	-	-
Beryllium	-	-	HEPH	-	-
Cadmium	600	3500			
Chromium	37,300	90,000			
Cobalt	-	-	PCBs	34.1	277
Copper	35,700	197,000			
Lead	35,000	91,300	***Pesticides***		
Mercury	170	486	Aldrin	-	-
Molybdenum	-	-	alpha-BHC		
Nickel	-	-	beta-BHC		
Selenium	-	-	delta-BHC		
Silver	-	-	cis-Chlordane (alpha)	4.5	8.87
Tin	-	-	trans-Chlordane (gamma)	4.5	8.87
Vanadium	-	-	2,4'-DDD	3.54	8.51
Zinc	123,000	315,000	4,4'-DDD	3.54	8.51
Volatiles			2,4'-DDE	1.42	6.75
Benzene	-	-	4,4'-DDE	1.42	6.75
Ethylbenzene	-	-	2,4'-DDT	1.19	4.77
Styrene	-	-	4,4'-DDT	1.19	4.77
Toluene	-	-	Dieldrin	-	-
Xylenes (totals)	-	-	Endosulfan I	-	-
VPH C6-10	-	-	Endosulfan II	-	-
PAHs			Endosulfan Sulfate	-	-
Acenaphthene	6.71	88.9	Endrin	2.67	62.4
Acenaphthylene	5.87	128	Endrin Aldehyde	-	-
Acridine	-	-	Heptachlor	0.6	2.74
Anthracene	46.9	245	Heptachlor Epoxide	0.6	2.74
Benz(a)anthracene	31.7	385	Lindane (gamma - BHC)	0.94	1.38
Benzo(a)pyrene	31.9	782	Methoxychlor	-	-
Benzo(b)fluoranthene	-	-	Mirex	-	-
Benzo(g,h,i)perylene	-	-	cis-Nonachlor	-	-
Benzo(k)fluoranthene	-	-	trans-Nonachlor	-	-
Chrysene	57.1	862			
Dibenz(a,h)anthracene	6.22	135			
Fluoranthene	111	2355			
Fluorene	21.2	144			
Indeno(1,2,3-c,d)pyrene	-	-			
Naphthalene	34.6	391			
Phenanthrene	41.9	515			
Pyrene	53.0	875			

4.2 Surficial Geology

The Blanchard River site is typical of glaciofluvial channels in that area of the Yukon. The surficial materials consist of sand and gravel deposits overlying clay and silt. The origin of the granular deposits is likely outwash deposits associated with the end of the last glacial event coupled with more recent fluvial and alluvial deposition by modern flows in the Blanchard River. The uppermost sediments consist of intermixed sands and gravels that contain appreciable amounts of finer grained soils. Granular materials are poorly to well graded with sands varying from medium- to coarse-grained and gravels varying from fine to medium grained. Both sand and gravel materials contain between 5 to 15 percent silt and clay. The underlying fine-grained soils were encountered between 2.4 m to 10.7 m below ground surface (823.8 m to 817.0 m elevation), with the greatest depths observed on the southwest area of the site closest to the Blanchard River. The underlying material consists of an intermediate to low plastic clay that includes a significant silt fraction (40-45%) and less than 10 percent sand sized particles. The clay is typically very stiff, dry to moist and of low hydraulic conductivity. As a result, the clay surface becomes a permeability boundary causing groundwater to preferentially flow along the clay surface to the river. This flow pattern is best observed along the clay interface on the south side of the site. Bedrock was not encountered in any of the test holes drilled. Logs of the test holes competed in the 1995 and 1999 investigations are appended (Appendix A), along with gradation analyses completed on selected soil samples (Appendix B).

4.3 Groundwater Conditions

The valley sediments constitute a subsurface reservoir for groundwater storage and transport with the Blanchard River being the discharge boundary for the upper groundwater flow system. Perennial glaciers feed the system and are supplemented by abundant precipitation, both by rainfall and snowmelt within the catchment area of the valley. Groundwater levels in the area are influenced by seasonal and annual variations in precipitation. The position of the water table may vary, and with it the magnitude of the horizontal gradient. However, the direction of groundwater flow is unlikely to change.

Only one aquifer unit was identified during the investigation, and consists of intermixed sands and gravels encountered in the uppermost section of all test holes. Water levels recorded in September 1999, beneath the site ranged between 1.6 m to 3.2 m below ground surface. The depth to groundwater increases to between 7.5 m to 8.8 m along the south boundary of the maintenance yard, closest to the Blanchard River. The water level in TH99-15 is about 2.9 m below surface (elev. 825.93 m) and appears to be slightly elevated, possibly due to mounding effects from the nearby rock pit that receives discharge from the maintenance garage. Subsequently, water level data from TH99-15 was discounted from piezometric calculations.

The slope of the piezometric surface forms the basis for estimating the direction and magnitude of the local groundwater flow through the subsurface, and toward the Blanchard River. The direction of shallow groundwater flow across the site can be inferred from the local topography, surface drainage patterns and groundwater monitoring levels. Regionally, groundwater flows westerly from the steep west-facing slope of the Boundary Ranges to the valley sediments below, with groundwater discharging to the river. As the river valley is a significant topographic feature, it is unlikely that groundwater flows beneath the river to another discharge location. One complete set of water level table measurements was recorded on September 27, 1999 following the Additional Investigation phase of work. The measured water table elevations are summarized on Table 4.9 and illustrated on Drawing 4.1.

From the water level data collected, it can be inferred that groundwater flow across the south end of the site is in a southwest direction, and groundwater flow on the north side of the site is to the north direction. Both flow regimes are directed towards the Blanchard River that meanders around the south, west and north sides of the site. The base of the flow system was determined to be the upper surface of the clay stratigraphy.

Table 4.9: Summary of Water Level Data (Sept 27, 1999)

Well No.	TOC Elev. (m)	Ground Elevation (m)	Depth to Water (m)	Groundwater Elevation (m)
TH95-1	828.141	827.481	3.028	825.113
TH95-2	828.071	828.271	2.592	825.479
TH95-3	827.704	827.1 (est.)	2.722	824.982
TH95-4	827.357	826.682	2.801	824.556
TH95-5	829.434	828.784	9.009	820.425
TH99-6	825.969	825.419	1.831	824.138
TH99-8	827.615	827.125	2.170	825.445
TH99-9	823.076	822.506	3.799	819.277
TH99-10	823.818	823.278	3.486	820.332
TH99-13	829.095	828.695	9.216	819.879
TH99-14	829.061	829.281	7.571	821.490
TH99-15	828.88	829.100	2.950	825.930
TH99-17	829.522	829.542	2.903	826.619
TH99-18	822.277	821.769	3.361	818.916
TH99-19	822.764	822.213	3.130	819.634
TH99-20	829.636	829.893	7.238	822.398
TH99-24	829.895	830.091	dry	-
MP3	820.229	819.05 (est.)	1.179	819.050
MP4	819.208	818.35 (est.)	1.149	818.059

Drawing 4-1 represents the piezometric surface in the sand and gravel unit. Horizontal hydraulic gradients in the order of 0.09 m/m and 0.017 m/m were measured in the south and north ends of the site, respectively. Hydraulic gradients are steepest along the southwest boundary of the site closest to the river. The depth to clay along the south end of the site is consistent with water levels observed in the Blanchard River.

The hydraulic conductivity (K) of the groundwater flow system was evaluated through single-well response (falling head) tests in selected wells and by the assessment of grain size. Response test data was evaluated using the Bower-Rice method and is presented in Appendix C. As the dominant material type is sand and gravel, the hydraulic conductivity is relatively high. The calculated hydraulic conductivities (K) are tabulated in Table 4.10. K varies from 1.2×10^{-3} cm/sec (TH95-2) to 7.1×10^{-5} cm/sec (TH99-14). Based on these results, average K values of 8.4×10^{-4} cm/sec and 1.2×10^{-3} cm/sec were calculated for the south and north ends of the site, respectively. Estimates of hydraulic conductivity were also made based on grain size using Hazen's equation. All values fall within the published ranges for silty sand and gravel (Freeze and Cherry, 1979). Table 10 and summarize the hydraulic conductivity calculated from field response tests and grain size, respectively.

Table 4.10: Summary of Field Hydraulic Conductivity Results (Sept 2, 1999)

Well No.	Effective Screen Length (m)	Sat. Thickness of Aquifer (m)	Material Type	Hydraulic Conductivity (cm/s)	Hazen's relationship (cm/s)
TH95-1	1.2	1.065	Sand	1.46E-3	-
TH95-2	1.5	1.655	Gravel & Sand	1.18E-3	-
TH95-4	1.2	1.4	Sand	2.66E-3	-
TH95-5	1.5	1.295	Gravel & Sand	1.33E-3	-
TH99-6	0.9	1.038	Gravel	1.32E-4	-
TH99-8	3.05	0.78	Gravel & Sand	3.18E-4	-
TH99-9	1.5	0.405	Sand	9.73E-4	-
TH99-10	1.5	0.935	Sand	1.56E-3	-
TH99-12	3.05	2.775	Sand & Gravel	1.43E-3	1.9E-3
TH99-13	3.05	1.125	Sand	2.44E-4	-
TH99-14	3.05	1.08	Gravel	7.14E-5	4.0E-4
TH99-15	2.1	1.29	Sand & Gravel	8.39E-4	1.2E-4
TH99-17	3.05	3.148	Gravel	4.83E-4	1.3E-3

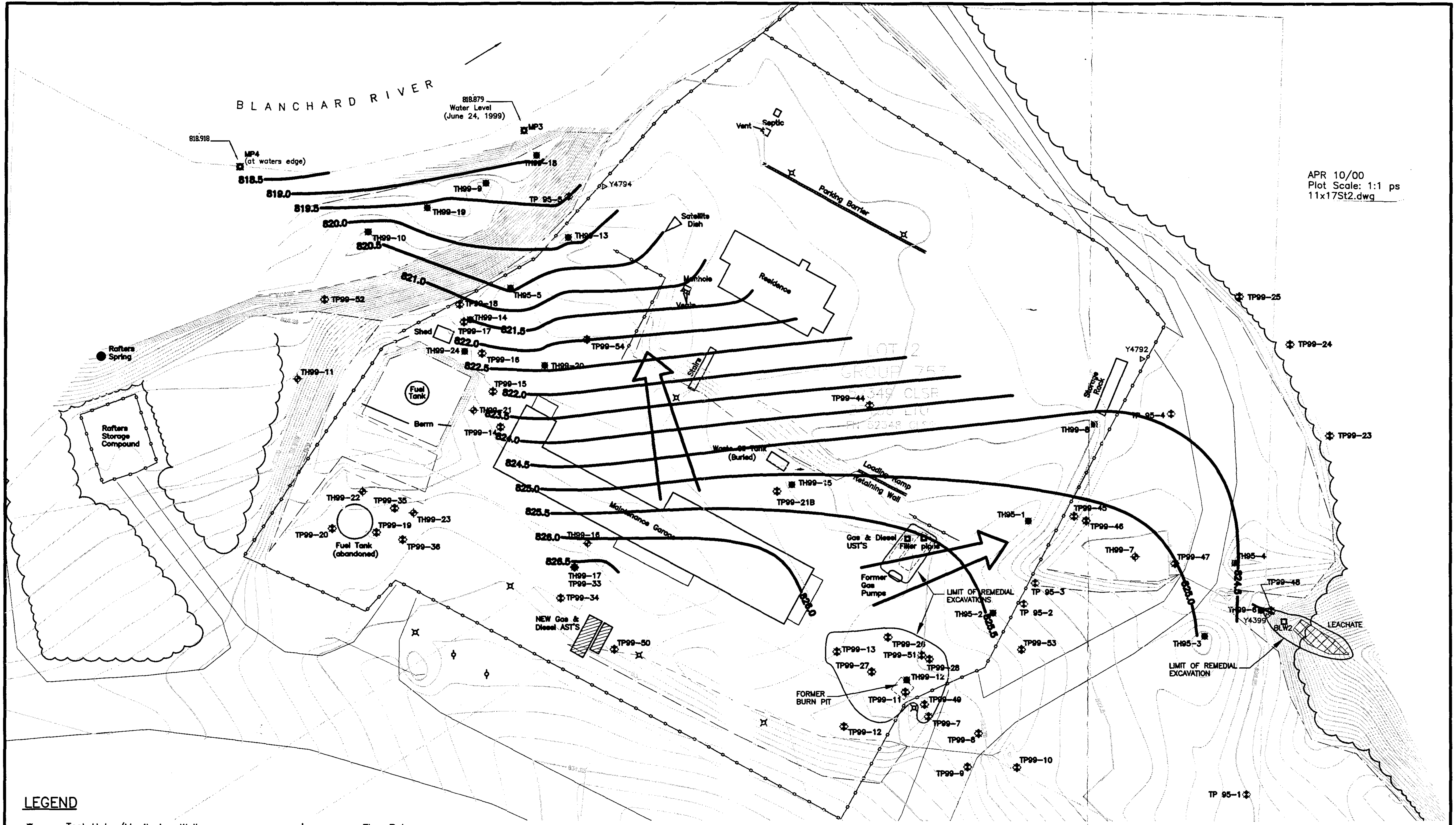
An order-of-magnitude estimate of the linear groundwater flow velocity across the site can be obtained using Darcy's equation for steady-state flow:

$$v^* = K * i / n$$

where

v^* = linear groundwater flow velocity (cm/s)
K = hydraulic conductivity; 8.4×10^{-4} cm/s (south) to 1.2×10^{-3} cm/s (north)
i = hydraulic gradient; 0.09 (south) to 0.017 (north)
n = soil porosity; assume 0.3

Solving the above equation for the linear groundwater velocity (v^*) yields values ranging from 0.22 m/day in the south end of the site to 0.06 m/day in the north side of the site. The rate of movement of petroleum hydrocarbons and other dissolved contaminants is typically slower than the linear groundwater velocity due to effects of dispersion and diffusion.



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LEGEND

■ – Test Holes/Monitoring Wells
⌖ – Test Holes
⊕ – Test Pits
▣ – Mini Piezometer
¤ – Yard Light Standards
⇒ – Inferred Groundwater Flow Direction
ϕ – Flag Poles
– Lot Boundary
– Culvert
– Top of Slopes
– Toe of Slopes
826.5 – Piezometric Elevation (09/99)

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INDIAN AFFAIRS and NORTHERN DEVELOPMENT
BLANCHARD RIVER STATION: SITE INVESTIGATION

TITLE: PIEZOMETRIC SURFACE
JOB No. C799-044-01-01
DATE: April, 2000
SCALE: 1:750
DWG. No. 4-1
CHECKED: AP

4.4 North of Maintenance Building (Burn Pit)

Petroleum hydrocarbon contamination was identified in soils and groundwater collected from boreholes (TH95-1 and TH95-2) established north of the maintenance building during the preliminary site investigation in 1995. High levels of inorganic elements (arsenic, barium, cobalt, selenium and zinc) and extractable hydrocarbons were also found in soil/sediment samples collected from a rust-coloured leachate plume north of the building, down gradient of TH95-1 and TH95-2. The results of an EM survey conducted in 1995 indicated that a buried culvert passed through the contaminated area suggesting that this culvert served as a conduit for the contaminants north of the maintenance building. To ascertain the source of this contamination a literature review including aerial photographic interpretation was conducted. Interpretation of the old aerial photographs suggested a burn pit was situated north of the maintenance building during the operation of Blanchard River as a pump station, prior to 1985. It was strongly suspected that this burn pit was the source of the contaminants found in the boreholes and the rust-coloured leachate plume.

The location of the burn pit and extent of hydrocarbon contamination was determined through the excavation of ten test pits (TP99-7 to TP99-13, TP99-26 to TP99-28) north of the maintenance building during the detailed site investigation in June. Two additional test pits (TP99-49 and TP99-51) were excavated in the area during the September investigation.

4.4.1 Hydrocarbons

The concentrations of hydrocarbons including BTEX, PAHs and extractables in samples collected from test pits are given in Table 4.11. Benzene, ethylbenzene, xylenes, VPH, LEPH and HEPH at concentrations exceeding the Yukon CSR Standards were found in samples collected from TP99-11, which was excavated at the approximate location of the burn pit. Hydrocarbon contaminated cobble-silt-clay soils were encountered at 0.6 m depth and the top of the former burn pit was assumed to be 0.6 m below present grade. The maximum observed concentration of petroleum hydrocarbons at TP99-11 was 19,000 μg/g HEPHs and 2,500 μg/g LEPHs at the depth of 0.6 m. These concentrations exceed both the Yukon CSR industrial and residential/parkland standards for extractable petroleum hydrocarbons. EPHs at concentrations exceeding the residential/parkland criteria were also found in two of the testpits (TP99-13 and TP99-28). Contamination in these pits was encountered beyond a depth of 1.1 m. BTEX, PAHs, LEPH and HEPH concentrations in samples from the remaining test pits were all below the standard. The lateral extent of hydrocarbon contamination in soils is indicated on Figure 4.2

Table 4.11: Concentrations of Hydrocarbons (µg/g) in Soil Samples Collected from Testpits Excavated in the Vicinity of the Burn Pit

Sample #	**TP99 9-1**	**TP99 9-2**	**TP99 11-1**	**TP99 11-2**	**TP99 12-1**	**TP99 12-2**	**Yukon Standard**
Volatiles							
Benzene	-	-	<0.04	**0.71**	<0.04	<0.04	0.04^2
Ethylbenzene	-	-	<0.05	**7.06**	<0.05	<0.05	7^2
Styrene	-	-	<0.05	<0.05	<0.05	<0.05	5
Toluene	-	-	<0.05	2.35	<0.05	<0.05	2.5^2
meta- & para-Xylene	-	-	<0.05	**29.8**	<0.05	<0.05	20^2
ortho-Xylene	-	-	<0.05	**49.8**	<0.05	<0.05	20^2
VH C6-10	-	-	<100	**2680**	<100	168	-
VPH C6-10	-	-	<100	**2590**	<100	168	200
PAHs							
Acenaphthene	-	-	<0.5	0.9	-	<0.02	-
Acenaphthylene	-	-	<0.5	0.4	-	<0.01	-
Anthracene	-	-	<0.5	0.1	-	<0.01	-
Benz(a)anthracene	-	-	<0.5	<0.5	-	<0.01	1
Benzo(a)pyrene	-	-	<0.5	<0.5	-	<0.01	1
Benzo(b)fluoranthene	-	-	<0.5	<0.5	-	<0.01	1
Benzo(g,h,i)perylene	-	-	<0.5	<0.5	-	<0.01	-
Benzo(k)fluoranthene	-	-	<0.5	<0.5	-	<0.01	1
Chrysene	-	-	<0.5	<0.5	-	<0.01	-
Dibenz(a,h)anthracene	-	-	<0.5	<0.5	-	<0.01	-
Fluoranthene	-	-	<0.5	0.2	-	<0.01	-
Fluorene	-	-	<0.5	1.4	-	<0.02	-
Indeno(1,2,3-c,d)pyrene	-	-	<0.5	<0.5	-	<0.01	1
Naphthalene	-	-	<0.5	**10.8**	-	<0.03	5
Phenanthrene	-	-	<0.5	1.1	-	<0.02	5
Pyrene	-	-	<0.5	0.5	-	<0.02	10
Extractables							
EPH (C10-18)	<200	<200	**2520**	<200	<200	<200	1000
EPH (C19-31)	508	<200	**19,300**	<200	<200	<200	1000
LEPH	-	-	**2520**	<200	-	<200	1000
HEPH	-	-	**19,300**	<200	-	<200	1000

cont'd

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Table 4.11: Continued

Sample #	**TP99 13-1**	**TP99 13-2**	**TP99 28-1**	**TP99 28-2**	**TP99 28-3**	**TP99 49-3**	**TP99 49-4**	**Yukon Standard**
Volatiles								
Benzene	-	-	-	-	<0.04	<0.04	<0.04	0.04^2
Ethylbenzene	-	-	-	-	0.97	<0.05	<0.05	7^2
Styrene	-	-	-	-	<0.05	<0.05	<0.05	5
Toluene	-	-	-	-	0.72	<0.05	<0.05	2.5^2
meta- & para-Xylene	-	-	-	-	4.86	<0.05	<0.05	20^2
ortho-Xylene	-	-	-	-	1.15	<0.05	<0.05	20^2
VH C6-10	-	-	-	-	441	<100	168	-
VPH C6-10	-	-	-	-	433	<100	168	200
PAHs								
Acenaphthene	-	-	-	-	<0.2	<0.01	<0.04	-
Acenaphthylene	-	-	-	-	<0.05	<0.01	<0.02	-
Anthracene	-	-	-	-	<0.01	<0.01	<0.01	-
Benz(a)anthracene	-	-	-	-	<0.01	<0.01	<0.01	1
Benzo(a)pyrene	-	-	-	-	<0.01	<0.01	<0.01	1
Benzo(b)fluoranthene	-	-	-	-	<0.01	<0.01	<0.01	1
Benzo(g,h,i)perylene	-	-	-	-	<0.01	<0.01	<0.01	
Benzo(k)fluoranthene	-	-	-	-	<0.01	<0.01	<0.01	1
Chrysene	-	-	-	-	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	-	-	-	-	<0.01	<0.01	<0.01	-
Fluoranthene	-	-	-	-	<0.01	<0.01	<0.01	-
Fluorene	-	-	-	-	0.14	<0.01	0.06	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	<0.01	<0.01	<0.01	1
Naphthalene	-	-	-	-	0.52	0.52	<0.03	5
Phenanthrene	-	-	-	-	0.06	0.06	0.02	5
Pyrene	-	-	-	-	<0.01	<0.01	<0.01	10
Extractables								
EPH (C10-18)	**1260**	**470**	<200	**1710**	764	<200	455	1000
EPH (C19-31)	<200	<200	<200	<200	<200	281	<200	1000
LEPH	-	-	-	-	763	<200	455	1000
HEPH	-	-	-	-	<200	281	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

The concentrations of hydrocarbons in boreholes establish down gradient of the burn pit in 1995 (TH95-1 to TH95-4) are given in Table 4.12 while Table 4.14 presents results for boreholes installed in 1999. These include TH99-12, which was established at the approximate location of the former burn pit, and TH99-6 to TH99-8 that were drilled down gradient of the pit. Drawing 4-2 illustrates the interpreted areal extent of hydrocarbon impacted subsurface soils in the area.

The maximum LEPH concentration observed in borehole TH99-12 was 1,300 µg/g in sample TH99-10-12, at a depth of 5.5 to 6 meters. This value exceeded the Yukon CSR standard for residential/parkland use; other petroleum hydrocarbons constituents were all below the standard.

Based on discussions with major stakeholders during and subsequent to the August 5th, 1999 meeting in Whitehorse, it was deemed appropriate to apply industrial soil remediation standards to the portion of the site used almost exclusively for non-residential activities associated with the highways maintenance camp. A residential or parkland soil standard is more appropriate in areas within the vicinity of the residence, near areas used recreationally, and on or adjacent to wild lands such as the riparian zone of the Blanchard River. The former location of the burn pit could reasonably be considered as being of industrial land use under the present conditions. Wildlife use of this area is expected to be rare and transient. In addition, exposure of human beings would occur over shorter duration on a daily basis (generally less than eight hours per day) and there is little potential for more sensitive sub-populations such as young children to be exposed. If the industrial standard is applied, none of the soil samples collected below 3 m, the presumed bottom of the burn pit, had concentrations of LEPHs or HEPHs in excess of the standards which are, 2000 µg/g and 5000 µg/g, respectively.

The hydrocarbon signature in soils collected from the burn pit indicated the contamination is influenced by both gasoline release and combustion, resulting in a dominance of heavy hydrocarbon fractions. Gas chromatograms showing the hydrocarbon signatures are given in Appendix F.

There is a zone of impacted soil associated with the former burn pit arising from the residual contamination from materials introduced into the bit. This contamination may have migrated from the source towards TH95-1 as suggested by the results presented in Tables 4.12 and 4.13. Total extractable hydrocarbon concentrations were in the range of 20 to 430 µg/g. The distribution of hydrocarbons in boreholes TH99-12, TH95-1 and TH95-2 is also depicted the borehole logs (Appendix A) that contain concentration of volatile organic compounds as determined by headspace analysis with a PID.

Light extractable petroleum hydrocarbons (C10-C18) levels in TH99-8 (205 µg/g), established down gradient of TH95-1 were slightly above detection whiles concentrations in TH99-6 and TH99-7 were all below the limit of 200 µg/g. Thus, these boreholes demarcated the periphery of hydrocarbon contamination.

Table 4.12: Concentration of Hydrocarbons in Soil Samples Collected from Boreholes North of the Maintenance Building in 1995

Sample #	TH95-1 8-10’	TH95-1 10–12’	TH95-2 8-10’	TH95-2 10-12’	TH95-2 12-14’	TH95-3 8-10’	TH95-4 8-10’	Yukon Standard
Volatiles								
Benzene	-	<0.0015	<0.0015	-	-	-	-	0.04^2
Ethylbenzene	-	<0.0002	<0.0002	-	-	-	-	7^2
Toluene	-	<0.008	<0.008	-	-	-	-	2.5^2
meta- & para-Xylene	-	<0.0002	<0.0002	-	-	-	-	20^2
ortho-Xylene	-	<0.0001	<0.0001	-	-	-	-	20^2
VH C6-10	-		-	-	-	-	-	-
VPH C6-10	-		-	-	-	-	-	200
PAHs								
Acenaphthene	-	0.0029	-	0.0022	-	-	-	-
Acenaphthylene	-	0.013	-	<0.00005	-	-	-	-
Anthracene	-	0.00047	-	<0.00007	-	-	-	
Benz(a)anthracene	-	0.00023	-	<0.00011	-	-	-	1
Benzo(a)pyrene	-	<0.00018	-	<0.00015	-	-	-	1
Benzo(b)fluoranthene	-	-	-	-	-	-	-	1
Benzo(g,h,i)perylene	-	0.00028	-	<0.00013	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	1
Chrysene	-	0.0012	-	0.00029	-	-	-	-
Dibenz(a,h)anthracene	-	<0.00019	-	<0.00017	-	-	-	-
Fluoranthene	-	0.002	-	0.00026	-	-	-	-
Fluorene	-	0.013	-	0.0025	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	<0.00017	-	<0.00016	-	-	-	1
Naphthalene	-	0.11	-	0.051	-	-	-	5
Phenanthrene	-	0.0052	-	0.0017	-	-	-	5
Pyrene	-	0.0028	-	0.00053	-	-	-	10
Extractables								
EPH (C10-18)	-	-	-	-	-	-	-	1000
EPH (C19-31)	-	-	-	-	-	-	-	1000
LEPH	-	-	-	-	-	-	-	1000
HEPH	-	-	-	-	-	-	-	1000
TEH	130	430	43	48	<20	<20	<20	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Table 4.13: Concentrations of Hydrocarbons (µg/g) in Soil Samples Collected from Boreholes Established North of the Maintenance Building in 1999

Sample #	TH99-6- 4	TH99-6- 7	TH99-7- 3	TH99-8- 4	TH99-8- 8	TH99-12-5	TH99-12-10	TH99-12-16	TH99-12-15	Yukon Standard
Volatiles										
Benzene	-	-	-	<0.04	-	<0.04	<0.04	<0.04	<0.04	0.04[2]
Ethylbenzene	-	-	-	<0.05	-	0.49	0.06	0.61	<0.05	7[2]
Styrene	-	-	-	<0.05	-	<0.05	<0.05	<0.05	<0.05	5
Toluene	-	-	-	<0.05	-	0.89	0.18	1.11	<0.05	2.5[2]
Meta- & para-Xylene	-	-	-	<0.05	-	2.74	0.38	3.42	0.05	20[2]
Ortho-Xylene	-	-	-	<0.05	-	1.55	0.2	1.92	<0.05	20[2]
VH C6-10	-	-	-	<100	-	117	<100	130	<100	-
VPH C6-10 (calculated)	-	-	-	<100	-	111	<100	123	<100	200
PAHs										
Acenaphthene	-	-	<0.01	<0.01	-	0.12	0.08	0.13	<0.01	-
Acenaphthylene	-	-	<0.01	<0.01	-	0.03	0.03	0.04	<0.01	-
Anthracene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-
Benz(a)anthracene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	1
Benzo(a)pyrene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	1
Benzo(b)fluoranthene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	1
Benzo(g,h,i)perylene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	1
Chrysene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-
Fluoranthene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	-
Fluorene	-	-	<0.01	<0.01	-	0.17	0.1	0.16	<0.01	-
Indeno(1,2,3-c,d)pyrene	-	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	1
Naphthalene	-	-	<0.01	<0.01	-	1.33	0.59	1.51	0.06	5
Phenanthrene	-	-	<0.02	<0.02	-	0.06	0.04	0.05	0.01	5
Pyrene	-	-	<0.02	<0.01	-	<0.01	<0.01	<0.01	<0.01	10
Extractables										
EPH (C10-18)	<200	<200	<200	<200	<200	912	**1260**	962	<200	1000
EPH (C19-31)	<200	<200	<200	205	<200	<200	<200	<200	302	1000
LEPH	-	-	<200	<200	-	911	**1250**	960	<200	1000
HEPH	-	-	<200	205	-	<200	<200	<200	302	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

4.4.1.1 Groundwater

The interpreted areal extent of hydrocarbons contaminated in groundwater is included in Drawing 4.3 while Drawing 4.4 illustrates sections along the boreholes/monitoring wells established on the north end of the maintenance building.

There was an area of impacted groundwater that originated from the former location of the burn and extended northwest through TH95-2 to TH95-1. The LEPH concentration was 38,300 µg/L in a groundwater sample collected from TH99-12 (burn pit location). This value exceeded the aquatic life (AW) standard of 500 µg/L. A number of PAHs and VPH in this sample also exceeded the aquatic life standard (see Table 4.14) while concentrations of benzene, ethylbenzene, toluene, and xylenes were greater than the drinking water standard but did not exceed the aquatic life standard.

A water sample from TH95-2, the first well located down gradient of the burn pit contained 5,800 µg/L of LEPHs whiles that from TH95-1, further down gradient was 1,100 µg/L. Both of these values exceeded the aquatic life standard. Naphthalene concentrations in these two samples (34.7 µg/L and 16.5 µg/L, respectively) also exceeded the aquatic life standard. As with the soil samples, no hydrocarbons were detected in wells located down gradient of TH95-1 (i.e., TH95-3, TH95-4 and TH99-8).

Table 4.14: Concentrations of Hydrocarbons (µg/L) in Water Samples Collected from Boreholes North of the Maintenance Building in 1999

Sample No.	**MW-1**	**MW-2**	**MW-3**	**MW-4**	**MW-6**	**MW-8**	**MW-12**	**MW-12**	**Yukon CSR Standard**	
Volatiles								**Dup.**	**AW**	**DW**
Benzene	19.8	42.7	-	-	-	<0.5	-	**34.4**	3,000	5
Ethylbenzene	76.9	160	-	-	-	<0.5	-	**62.2**	7,000	2.4
Toluene	0.8	11.5	-	-	-	<0.5	-	**457**	3,000	24
meta- & para-Xylene	54.6	**319**	-	-	-	<0.5	-	**376**	-	300
ortho-Xylene	2.2	195	-	-	-	<0.5	-	137	-	-
VH C6-10	1,000	2,100	-	-	-	<100	-	4300	15,000[3]	-
VPH C6-10	800	1,400	-	-	-	<100	-	**3300**	1000[3]	-
PAHs										
Acenaphthene	0.18	<0.4	-	-	-	<0.05	1.06	21	60	-
Acenaphthylene	<0.05	<0.05	-	-	-	<0.05	0.26	3	-	-
Acridine	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.02	0.5	-
Anthracene	<0.05	<0.05	-	-	-	<0.05	<0.05	**4.8**	1	-
Benz(a)anthracene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	0.1	-
Benzo(a)pyrene	<0.01	<0.01	-	-	-	<0.01	<0.01	0.02	-	-
Benzo(b)fluoranthene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	-	-
Benzo(g,h,i)perylene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	-	-
Benzo(k)fluoranthene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	-	-
Chrysene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	-	-
Dibenz(a,h)anthracene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	-	-
Fluoranthene	<0.05	<0.05	-	-	-	<0.05	<0.05	0.53	2	-
Fluorene	0.11	0.19	-	-	-	<0.05	0.97	29.5	120	-
Indeno(1,2,3-c,d)pyrene	<0.05	<0.05	-	-	-	<0.05	<0.05	<0.05	-	-
Naphthalene	**16.5**	**34.7**	-	-	-	<0.05	**63.8**	**65.8**	10	-
Phenanthrene	<0.05	<0.06	-	-	-	<0.05	0.14	**51.1**	3	-
Pyrene	<0.05	<0.05	-	-	-	<0.05	<0.05	**3.6**	0.2	-
Extractables										
EPH (C10-18)	1100	**5800**	<300	<300	<300	<300	3,500	**38,500**	5000[3]	-
EPH (C19-31)	<1000	<1000	<1000	<1000	<1000	<1000	<1000	12,000	-	-
LEPH	**1,100**	**5800**	-	-	-	<300	**3400**	**38,300**	500[3]	-
HEPH	<1000	<1000	-	-	-	<1000	<1000	12,000	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999).

4.4.2 Metals

Tables 4.15 to 4.17 present results obtained for metals in soil and water samples collected near and down gradient of the burn pit. Data for 1995 and the relevant Yukon CSR standards used are included for comparison. The generic numerical standard for residential/park land use was employed to evaluate the data except for arsenic, cadmium, chromium, copper, lead and zinc. The more stringent of the matrix numerical standard for either groundwater flow to surface water used for drinking or groundwater flow to surface water used for aquatic life was used these elements (see footnote in Table 4.15).

Apart from the concentration of chromium in samples collected from TP99-11-1 (78 µg/g) and TH99-6-7 (90 µg/g), metal levels were all below the standards. There are naturally elevated levels of chromium in the Blanchard River site soils as suggested by data from other locations of the site; the mean chromium concentration in soil samples was 51.4 µg/g.

Concentrations of most of the metals in water samples were either below detection or well below the CSR AW standard except for aluminum, iron and manganese. The elevated concentrations in the samples might, in some small part, be attributable to mineralization in the surrounding bedrock and overburden. Due to the natural variability of these elements, the BC Ministry of the Environment for example has deleted these elements from Generic Numerical Water Standards under the BC Contaminated Sites Regulation (BCMELP, 1999).

Table 4.15: Concentrations of Metals (µg/g) in Soil Samples Collected from Boreholes Established North of the Maintenance Building

Year	1995		1999					Yukon Standard
Sample #	**TH95-1**	**TH95-2**	**TH99-6-4**	**TH99-6-7**	**TH99-7-3**	**TH99-8-4**	**TH99-12-5**	
Physical Tests								
Moisture %	5.38	4.73	3.7	15.9	4.5	5.3	4.2	-
pH	-	-	8.46	8.29	8.46	8.35	7.66	-
Total Metals								
Antimony	<10	<10	<20	<20	<20	<20	<20	20
Arsenic	2.2	1.4	4	1.2	0.7	0.42	3	15[2]
Barium	78	162	106	307	298	193	139	500
Beryllium	<1	<1	<0.5	<0.5	<0.5	<0.5	<0.5	4
Cadmium	<0.25	<0.25	0.2	0.4	0.1	<0.1	0.1	15[3]
Chromium	25	41	41	**90**	57	31	57	60[4]
Cobalt	8	10	11	21	12	10	11	50
Copper	31	31	36	70	39	38	29	30,000[5]
Lead	<1	<1	<50	<50	<50	<50	<50	4,000[6]
Mercury	0.029	0.018	0.051	0.165	0.067	0.015	0.044	2
Molybdenum	<4	<4	<4	<4	<4	<4	<4	10
Nickel	22	29	30	58	33	20	30	100
Selenium	<0.5	<0.5	0.1	0.3	<0.1	<0.1	<0.1	3
Silver	<2	<2	<2	<2	<2	<2	<2	20
Tin	<5	<5	<10	<10	<10	<10	<10	50
Vanadium	39	44	64	127	69	64	72	200
Zinc	37	48	79	97	61	59	62	1000[7]

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater flow to surface water used for drinking.
3. Matrix numerical standard for groundwater flow to surface water used for drinking (pH > 7.5).
4. Matrix numerical standard for groundwater flow to surface water used for aquatic life.
5. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
6. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
7. Matrix numerical standard for groundwater flow to surface water used by aquatic life (pH > 7).

Table 4.16: Concentrations of Metals (µg/g) in Soil Samples Collected from Testpits Excavated North of the Maintenance Building in 1999

Sample #	**TP99-11-1**	**TP99-12-1**	**TP99-17-1**	**TP99-19-1**	**TP99-28-3**	**Yukon Standard**
Physical Tests						
Moisture %	6.2	5.6	7.6	6.9	4.5	-
pH	8.14	7.21	7.23	7.92	7.06	-
Total Metals						
Antimony	<20	<20	<20	<20	<20	20
Arsenic	1.8	4.3	4.5	1.5	4	15[2]
Barium	477	98	148	113	117	500
Beryllium	<0.5	<0.5	<0.5	<0.5	<0.5	4
Cadmium	0.5	0.2	0.2	0.1	0.1	15[3]
Chromium	**78**	29	42	38	32	60[4]
Cobalt	17	9	11	9	9	50
Copper	49	35	42	31	27	30,000[5]
Lead	<50	<50	<50	<50	<50	4,000[6]
Mercury	0.049	0.042	0.033	0.02	0.022	2
Molybdenum	<4	<4	<4	<4	<4	10
Nickel	48	20	28	23	24	100
Selenium	0.3	<0.1	<0.1	<0.1	<0.1	3
Silver	<2	<2	<2	<2	<2	20
Tin	<10	<10	<10	<10	<10	50
Vanadium	95	53	65	53	52	200
Zinc	269	48	61	55	51	1000[7]

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater flow to surface water used for drinking.
3. Matrix numerical standard for groundwater flow to surface water used for drinking (pH > 7.5).
4. Matrix numerical standard for groundwater flow to surface water used for aquatic life.
5. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
6. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
7. Matrix numerical standard for groundwater flow to surface water used by aquatic life (pH > 7).

Table 4.17: Concentrations of Metals (µg/L) in Water Samples Collected from Boreholes North of the Maintenance Building in 1999

Sample #	MW-1	MW-2	MW-3	MW-4	MW-12	MW-D2	Yukon CSR	Standard
Physical Tests							**AW**	**DW**
Hardness as CaCO3	135	109	393	332	58.4	59.5		
pH	6.41	5.77	6.58	6.4	5.90	5.90		
Dissolved Metals								
Aluminum	69	50	40	210	100	107	110 - 500[3]	200
Antimony	<200	<200	<200	<200	<200	<200	300	-
Arsenic	<200	<200	<200	<200	<200	<200	500	250
Barium	190	280	490	350	140	150	10,000	1,000
Beryllium	<5	<5	<5	<5	<5	<5	53	-
Boron	<100	<100	<100	<100	<100	<100	-	500
Cadmium	<0.2	<0.2	<1	<1	<0.2	<0.2	2 - 180[4]	5
Calcium	44,400	35,000	123,000	103,000	18,500	18,900	-	-
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	20	50
Cobalt	<10	20	<10	<10	<10	<10	500	-
Copper	<10	<10	<10	<10	<10	<10	30 - 90	1,000
Iron	**20,800**	**45,900**	50	260	**16,100**	**16,400**	3000	300
Lead	<1	<1	<5	<5	<1	<1	50 - 160	10
Magnesium	6,000	5,300	20,600	18,100	3,000	3,000	-	-
Manganese	**4450**	**8790**	<5	7	**2500**	**2540**	1000	50
Mercury	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1	1
Molybdenum	<30	<30	<30	<30	<30	<30	10,000	250
Nickel	<50	<50	<50	<50	<50	<50	250 - 1500	
Selenium	<1	<1	<5	<5	<1	<1	10	10
Silver	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	1	-
Sodium	4,000	2,000	160,000	127,000	3,000	3,000	-	200,000
Thallium	<0.1	<0.1	<0.5	<0.5	<0.1	<0.1	3	-
Uranium	0.17	0.15	0.17	0.1	0.22	0.22	3000	100
Zinc	<5	<5	<5	6	6	6	300	5,000

Notes:

1. All values are in µg/L.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Standard depends on pH of the water samples (pH > 6.5).
4. Standard depends on hardness (H) of the water sample (H = 86 to 202).
5. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Aquatic life (AW) or Drinking Water (DW).

4.4.3 Chlorinated Organic Compounds

The concentrations of PCBs and organochlorine pesticides in soil samples collected from boreholes and test pits were either below detection or well below the standard (Table 4.18). No groundwater samples were analyzed for these parameters due to their low concentrations in the soil samples.

Table 4.18: Concentration (µg/g) of Polychlorinated Biphenyls (PCBs) and Chlorinated Pesticides in Soil Samples Collected North of the Maintenance Building

Sample #	1995			1999				Yukon Standard[1]
	TH-1	TH-1	TH-2	TH12-5	TH12-16	TP11-1	TP11-2	
Polychlorinated Biphenyls								
Total PCBs	<0.01	0.00024	<0.0018	<0.05	<0.05	<0.05	<0.05	5[2]
Organochloride Pesticides								
Aldrin	-	-	-	<0.001	<0.001	<0.001	<0.001	-
alpha-BHC	-	-	-	<0.001	<0.001	<0.001	<0.001	2
beta-BHC	-	-	-	<0.002	<0.002	<0.002	<0.002	2
delta-BHC	-	-	-	<0.001	<0.001	<0.001	<0.001	2
cis-Chlordane (alpha)	-	-	-	<0.001	<0.001	<0.001	<0.001	-
trans-Chlordane (gamma)	-	-	-	<0.001	<0.001	<0.001	<0.001	-
2,4'-DDD	-	-	-	<0.001	<0.001	<0.001	<0.001	-
4,4'-DDD	-	-	-	<0.001	<0.001	<0.001	<0.001	-
2,4'-DDE	-	-	-	<0.002	<0.002	<0.002	<0.002	-
4,4'-DDE	-	-	-	<0.001	<0.001	<0.001	<0.001	-
2,4'-DDT	-	-	-	<0.001	<0.001	<0.001	<0.001	-
4,4'-DDT	-	-	-	<0.002	<0.002	<0.002	<0.002	-
Dieldrin	-	-	-	<0.001	<0.001	<0.001	<0.001	--
Endosulfan I	-	-	-	<0.001	<0.001	<0.001	<0.001	-
Endosulfan II	-	-	-	<0.001	<0.001	<0.001	<0.001	-
Endosulfan Sulfate	-	-	-	<0.001	<0.001	<0.001	<0.001	-
Endrin	-	-	-	<0.005	<0.005	<0.005	<0.005	-
Endrin Aldehyde	-	-	-	<0.001	<0.001	<0.001	<0.001	-
Heptachlor	-	-	-	<0.002	<0.002	<0.002	<0.002	-
Heptachlor Epoxide	-	-	-	<0.001	<0.001	<0.001	<0.001	-
Lindane (gamma - BHC)	-	-	-	<0.001	<0.001	<0.001	0.002	2
Methoxychlor	-	-	-	<0.005	<0.005	<0.005	<0.005	-
Mirex	-	-	-	<0.001	<0.001	<0.001	<0.001	-
cis-Nonachlor	-	-	-	<0.001	<0.001	<0.001	<0.001	-
trans-Nonachlor	-	-	-	<0.001	<0.001	<0.001	<0.001	-

Notes:

1 Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.

2 Matrix numerical standard for ingestion of contaminated soils.

4.4.4 Halogenated Volatile Organic Compounds

As with chlorinated pesticides, the concentrations of all these compounds were below detection (Table 4.19).

Table 4.19: Concentrations (μg/g) of Halogenated Volatile Organic Compounds in Soil Samples Collected North of the Maintenance Building

Year	**1995**	**1999**		**Yukon CSR Standard[1]**
Sample #	**TH-1 (10-12')**	**TP11-1**	**TP11-2**	
Bromodichloromethane	<0.00008	<0.01	<0.01	5
Bromoform	<0.00017	<0.01	<0.01	
Carbon Tetrachloride	-	<0.01	<0.01	5
Chlorobenzene	-	<0.01	<0.01	1
Chloroethane	-	<0.01	<0.01	5
Chloroform	<0.00008	<0.01	<0.01	5
Chloromethane	-	<0.01	<0.01	5
Dibromochloromethane	-	<0.01	<0.01	5
1,2-Dichlorobenzene	-	<0.01	<0.01	1
1,3-Dichlorobenzene	-	<0.01	<0.01	1
1,4-Dichlorobenzene	-	<0.01	<0.01	1
1,1-Dichloroethane	<0.00005	<0.01	<0.01	5
1,2-Dichloroethane	<0.00006	<0.01	<0.01	5
cis-1,2-Dichloroethylene	<0.00008	<0.01	<0.01	5
trans-1,2-Dichloroethylene	-	<0.01	<0.01	5
1,1-Dichloroethylene	-	<0.01	<0.01	5
Dichloromethane	-	<0.4	<0.1	5
1,2-Dichloropropane	<0.00005	<0.01	<0.01	5
cis-1,3-Dichloropropylene	-	<0.01	<0.01	5
trans-1,3-Dichloropropylene	<0.00012	<0.01	<0.01	5
1,1,1,2-Tetrachloroethane	-	<0.01	<0.01	5
1,1,2,2-Tetrachloroethane	-	<0.01	<0.01	5
Tetrachloroethylene	<0.0003	<0.01	<0.01	5[2]
1,1,1-Trichloroethane	<0.00004	<0.01	<0.01	5
1,1,2-Trichloroethane	<0.00012	<0.01	<0.01	5
Trichloroethylene	<0.00006	<0.01	<0.01	0.15[3]
Trichlorofluoromethane	-	<0.01	<0.01	5
Vinyl Chloride	-	<0.01	<0.01	5

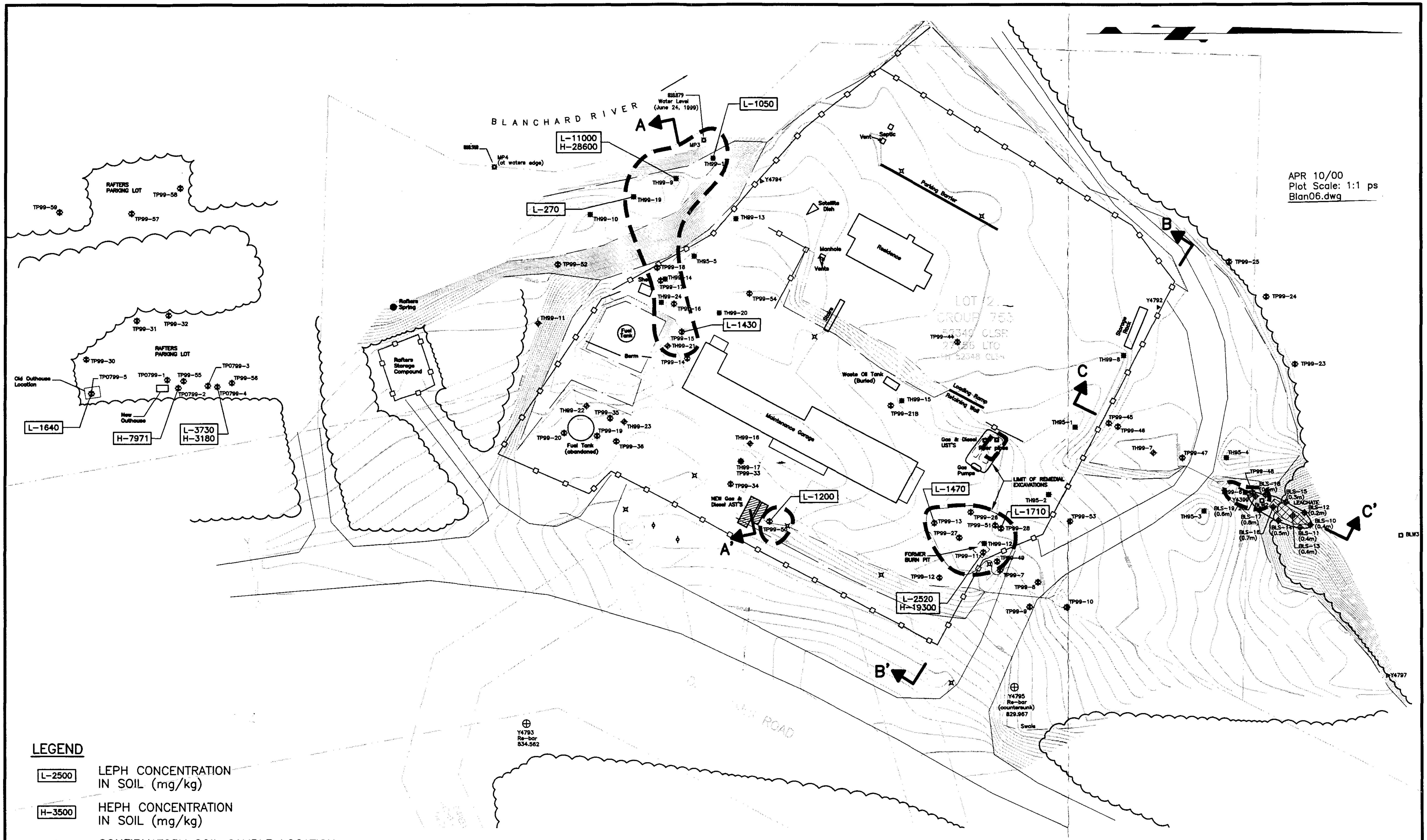
Notes:

1 Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.

2 Matrix numerical standard for toxicity to soil invertebrates.

3 Matrix numerical standard for groundwater used for drinking.

4 NDR = Peak detected but did not meet quantification criteria.



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LEGEND

L-2500	LEPH CONCENTRATION IN SOIL (mg/kg)
H-3500	HEPH CONCENTRATION IN SOIL (mg/kg)
BLS-14 (0.5m)	CONFIRMATORY SOIL SAMPLE LOCATION 0.5m = DEPTH IN METERS BELOW ORIGINAL GROUND SURFACE (m.bgs).
— — —	AREAL EXTENT OF SOILS IMPACTED BY HYDROCARBONS (EXTRACTABLE, VOLATILE AND/OR NON-HALDGENATED COMPONENTS)

ROYAL ROADS UNIVERSITY

UMA Engineering Ltd.
Engineers and Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

INDIAN AFFAIRS and NORTHERN DEVELOPMENT
BLANCHARD RIVER STATION: SITE INVESTIGATION

TITLE: AREAL EXTENT OF SOILS IMPACTED WITH HYDROCABONS

JOB No.	C799-044-01-01	DATE:	April, 2000
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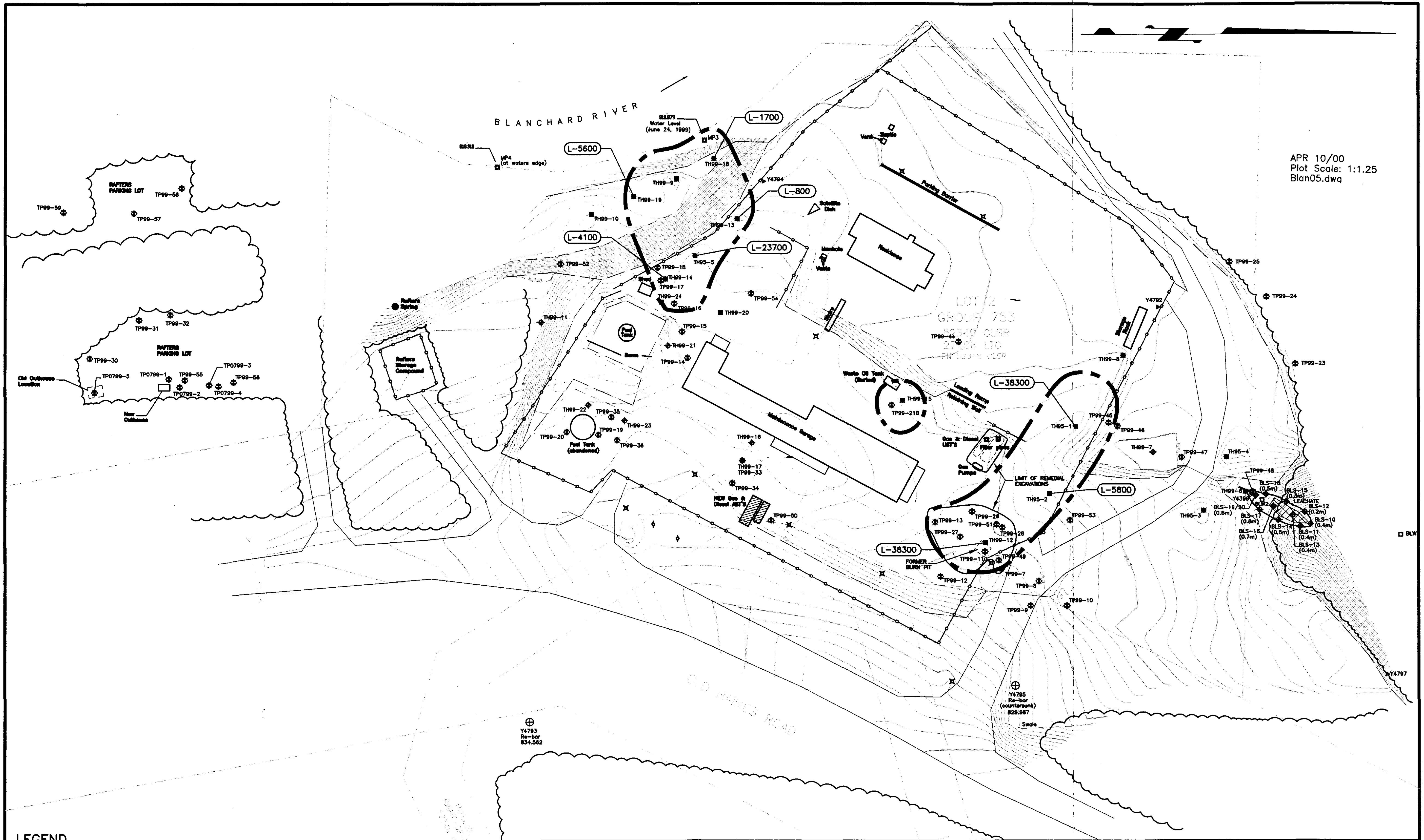
CHECKED:	AP		



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LEGEND

—·—·—	AREAL EXTENT OF HYDROCARBONS (EXTRACTABLE, VOLATILE AND/OR NON-HALDGENATED COMPONENTS) EXCEEDING METHOD DETECTION LIMITS IN GROUNDWATER	(L-4100)	LEPH CONCENTRATION IN GROUNDWATER (ug/L)

ROYAL ROADS UNIVERSITY

UMA Engineering Ltd.
Engineers and Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

INDIAN AFFAIRS and NORTHERN DEVELOPMENT
BLANCHARD RIVER STATION: SITE INVESTIGATION

TITLE: AREAL EXTENT OF GROUNDWATER IMPACTED WITH HYDROCARBONS			
JOB No.	C799-044-01-01	DATE:	April, 2000
SCALE:	1:1,000	DWG. No.	4-3
CHECKED:	AP		

APR 10/00 ljv
Plot Scale: 1:0.4
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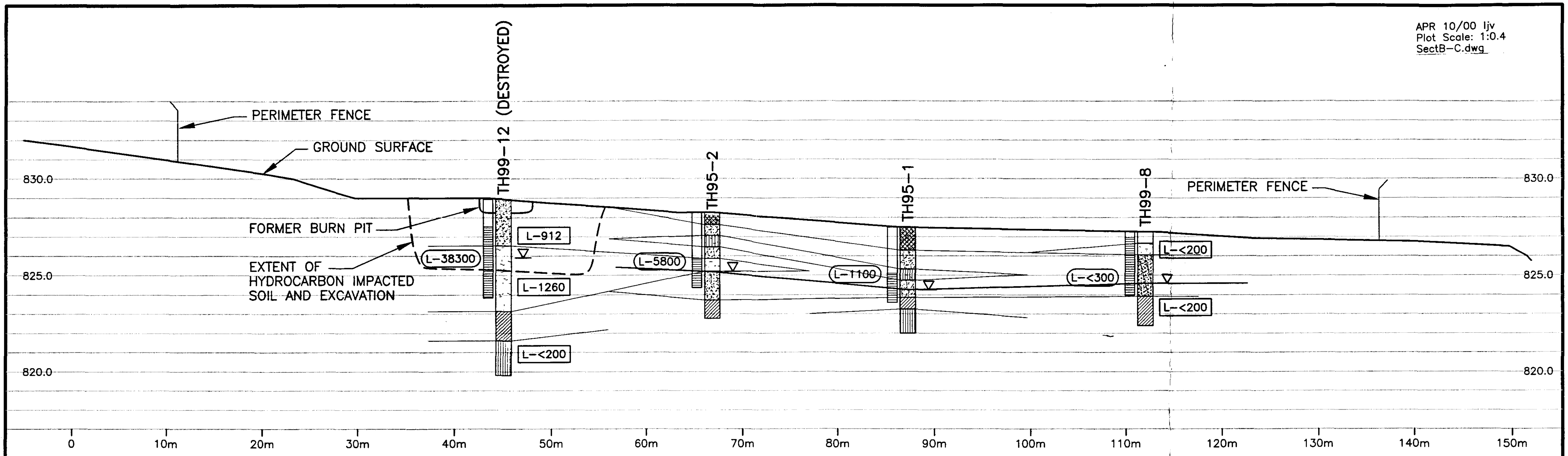
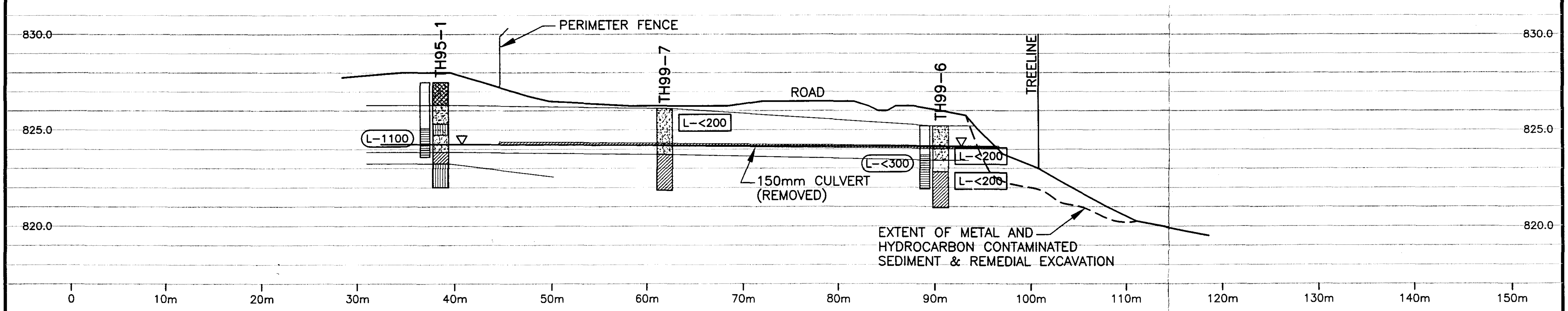


SECTION B



SECTION C

HORIZONTAL SCALE 1:400
VERTICAL SCALE 1:200

LEGEND

▨ CLAY
▨ SAND
▨ GRAVEL
▥ SILT
▽ WATER LEVEL (AS OF SEPT 27/99)
▤ INTAKE SCREEN
L–2500 LEPH CONCENTRATION IN GROUNDWATER (ug/L)
(L–1260) LEPH CONCENTRATION IN SOIL (mg/kg)

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NDIAN AFFAIRS and NORTHERN DEVELOPMENT
BLANCHARD RIVER STATION: SITE INVESTIGATION

TITLE:	SECTION B & C		
JOB No.	C799–004–01–01	DATE:	April, 2000
SCALE:	AS NOTED	DWG. No.	4–4
CHECKED:	AP		

4.5 Southwest of Maintenance Building

4.5.1 Hydrocarbons

Boreholes and testpits were established southwest of the maintenance building to delineate the extent of hydrocarbon contamination found in groundwater and subsurface soils collected from the borehole (TH95-5) drilled in this area during the 1995 investigation.

The 1999 investigation was initiated with the excavation of test pits along the drain lines leading to the soak away pit at the southwestern end of the maintenance building. This soak away pit, which was installed during the construction of the pump station in 1955, is still used to receive discharge from the oily water separator from the floor drains in the shop's welding bay. A trench was excavated along the line to a point where the pipe was supported on barrels (Photograph 3.1). A close examination of the pipe revealed cuts at the bottom that allowed wastewater discharged through the pipe to flow into the barrels that were also perforated (Photograph 3.2). Thus any liquid introduced into the barrel would infiltrate into the surrounding substrate that comprised sandy gravel with cobbles. Four samples (TP99-14 to TP99-17) were collected from test pits along the trench. No obvious odour and stains were noted along most sections of the trench except for a strong hydrocarbon odour near TP99-15 and this was probably due to localized releases. The concentrations of extractable hydrocarbons (EPH) in these samples are given in Table 4.20. EPH (C10 –18) concentrations were below detection (<200 μg/g) except for that at TP-15, which exceeded the standard for residential/parkland use (1000 μg/g). The value was however, less than the industrial standard of 2000 μg/g.

Table 4.20: Concentration of Hydrocarbons in Soil Samples (μg/g) Collected from Test Pits Excavated Along Drain Lines to Soak Away Pit Southwest of the Maintenance Building

Sample #	TP14-1	TP15-1	TP16-1	TP17-1	Yukon CSR Standard
EPH (C10-18)	<200	1430	<200	<200	1000
EPH (C19-31)	<200	264	<200	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.

Five new boreholes were drilled in June 1999 to delineate and characterize hydrocarbon contamination encountered at this end of the site. Two of these (TH99-13 and TH99-14), were placed on the upper terrace while the remaining three boreholes (TH99-9 to TH99-11) were located on the lower terrace, near the river. The concentrations of hydrocarbons in soil samples collected from the boreholes in June 1999 are given in Table 4.21 along with the 1995 data.

The concentrations of PAHs, BTEX and volatile hydrocarbons in these samples were generally below detection. Extractable hydrocarbons (both LEPHs and HEPHs) were however, detected in soil samples obtained from TH99-14 drilled near the soak away pit, albeit at levels below the standard. These parameters were also detected in samples from TH99-13 established 15 m down gradient of TH95-5. The highest concentrations of LEPH (11,000 µg/g) and HEPH (28,600 µg/g) were found at a depth of 4 m below the surface at TH-9. This contamination of soils just above the clay layer in TH99-9, located on the lower terrace, along the flood plain of the river, was dominated by a heavier hydrocarbon component compared to other boreholes or test pits soil samples from the site. The HEPH concentration in sample TH99-9-7 possibly indicated the presence of a dense non-aqueous phase liquid (DNAPL) plume migrating toward the river, in addition to the lighter hydrocarbon fraction noted in other boreholes/monitoring wells which is probably moving laterally in concert with, but slower than, groundwater flows. It appears the lateral extent of HEPH contamination was beyond TH99-10 as evidenced by the concentration of 499 µg/g detected at a depth of 1.0 m. No extractable hydrocarbons were detected in TH99-11 established up gradient of TH99-10, thus indicating the spatial limit of the contamination in that direction.

Hydrocarbon contamination was also noted in groundwater obtained from the monitoring wells established in the boreholes discussed above (Table 4.22). Both MW-5 and MW-14, situated on the upper bench down gradient of the soak away pit, contained LEPHs (13, 000 and 12,000 µg/L, respectively) that exceeded the proposed BC CSR standard of 500 µg/L. Elevated levels of HEPHs (2000 µg/L) were also detected in both samples. A number of PAHs including naphthalene, phenanthrene, and pyrene in these two samples also exceeded the Yukon CSR standard for aquatic life. With respect to volatile hydrocarbons, only ethylbenzene in these two samples (MW-5 and MW-14) exceeded the Yukon standard for drinking water use.

Groundwater contamination with LEPH (2100 µg/L), exceeding the standard was found in MW-13 down gradient and northwest of MW-14. Concentration of LEPH (700 µg/L) in excess of the standard was also present in MW-9 located on the lower bench near the river. The latter two results indicated contamination extended beyond these two wells, an observation which collaborated with the soil data. No extractable hydrocarbons were detected in the groundwater sample collected from MW-10.

Table 4.21: Concentration of Hydrocarbons in Soil Samples Collected from Boreholes Southwest of the Maintenance Building in 1995 and June 1999

Year	**1995**					**June 1999**			**Yukon CSR Standard**
Sample #	**TH95-5 24 -26**	**TH95-5 26 –28'**	**TH95-5 28-30'**	**TH95-5 30 - 32**	**TH95-5 32-34**	**TH99-9-4**	**TH99-9-7**	**TH99-10-2**	
Volatiles									
Benzene	-	-	-	-	-	<0.04	-	-	0.04^2
Ethylbenzene	-	-	-	-	-	<0.05	-	-	7^2
Styrene	-	-	-	-	-	<0.05	-	-	5
Toluene	-	-	-	-	-	<0.05	-	-	2.5^2
meta- & para-Xylene	-	-	-	-	-	<0.05	-	-	20^2
ortho-Xylene	-	-	-	-	-	<0.05	-	-	20^2
VH C6-10	-	-	-	-	-	<100	-	-	-
VPH C6-10	-	-	-	-	-	<100	-	-	200
PAHs									
Acenaphthene	-	-	-	0.068	-	-	<0.01	-	-
Acenaphthylene	-	-	-	<0.00033	-	-	<0.01	-	-
Anthracene	-	-	-	<0.00049	-	-	<0.01	-	
Benz(a)anthracene	-	-	-	<0.0011	-	-	<0.01	-	1
Benzo(a)pyrene	-	-	-	<0.0002	-	-	<0.01	-	1
Benzo(b)fluoranthene	-	-	-	-	-	-	<0.01	-	1
Benzo(g,h,i)perylene	-	-	-	0.00038	-	-	<0.01	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	<0.01	-	1
Chrysene	-	-	-	0.00069	-	-	<0.01	-	-
Dibenz(a,h)anthracene	-	-	-	<0.00022	-	-	<0.01	-	-
Fluoranthene	-	-	-	0.007	-	-	<0.02	-	-
Fluorene	-	-	-	0.2	-	-	<0.01	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	<0.00021	-	-	<0.01	-	1
Naphthalene	-	-	-	0.15	-	-	<0.01	-	5
Phenanthrene	-	-	-	0.45	-	-	<0.03	-	5
Pyrene	-	-	-	0.055	-	-	<0.02	-	10
Extractables									
EPH (C10-18)	-	-	-	-	-	<200	**11,000**	<200	1000
EPH (C19-31)	-	-	-	-	-	<200	**28,600**	499	1000
LEPH	-	-	-	-	-	-	**11,000**	-	1000
HEPH	-	-	-	-	-	-	**28,600**	-	1000
TEH	120	2500	1900	370	510	-	-	-	-

cont'd

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Table 4.21: Continued

Year	**June 1999**								**Yukon CSR Standard**
Sample #	**TH99-11-5**	**TH99-11-7**	**TH99-13-16**	**TH99-13-20**	**TH99-13-21**	**TH99-14-4**	**TH99-14-14**	**TH99-14-17**	
Volatiles									
Benzene	-	-	<0.04	-	<0.04	<0.04	-	-	0.04[2]
Ethylbenzene	-	-	<0.05	-	<0.05	<0.05	-	-	7[2]
Styrene	-	-	<0.05	-	<0.05	<0.05	-	-	5
Toluene	-	-	<0.05	-	<0.05	<0.05	-	-	2.5[2]
meta- & para-Xylene	-	-	<0.05	-	<0.05	<0.05	-	-	20[2]
ortho-Xylene	-	-	<0.05	-	<0.05	<0.05	-	-	20[2]
VH C6-10	-	-	<100	-	<100	<100	-	-	-
VPH C6-10	-	-	<100	-	<100	<100	-	-	200
PAHs									
Acenaphthene	-	-	<0.02	<0.01	<0.02	<0.02	<0.03	-	-
Acenaphthylene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Anthracene	-	-	0.01	<0.01	<0.02	<0.01	<0.02	-	
Benz(a)anthracene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	1
Benzo(a)pyrene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	1
Benzo(b)fluoranthene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	1
Benzo(g,h,i)perylene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Benzo(k)fluoranthene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	1
Chrysene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Dibenz(a,h)anthracene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Fluoranthene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Fluorene	-	-	0.02	<0.01	<0.03	<0.03	<0.05	-	-
Indeno(1,2,3-c,d)pyrene	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	-	1
Naphthalene	-	-	0.05	<0.02	0.06	<0.03	<0.05	-	5
Phenanthrene	-	-	0.04	<0.04	<0.05	<0.08	<0.1	-	5
Pyrene	-	-	0.04	<0.02	<0.04	<0.03	<0.03	-	10
Extractables									
EPH (C10-18)	<200	<200	<200	<200	246	<200	261	<200	1000
EPH (C19-31)	<200	<200	<200	<200	<200	461	<200	240	1000
LEPH	-	-	<200	<200	246	<200	261	-	1000
HEPH	-	-	<200	<200	<200	461	<200	-	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Table 4.22: Concentrations of Hydrocarbons (µg/L) in Water Samples Collected from Boreholes Southwest of the Maintenance Building in June 1999

Sample No.	MW-5	MW-5 Duplicate	MW-9	MW-10	MW-13	MW-14	Yukon Standard	
							AW	DW
Volatiles								
Benzene	1	1	<0.5	-	<0.5	<0.5	3,000	5
Ethylbenzene	26.1	27.5	<0.5	-	<0.5	4.8	7,000	2.4
Styrene	1.1	1.1	-	-	-	<0.5		
Toluene	1.9	1.4	<0.5	-	<0.5	1.5	3,000	24
meta- & para-Xylene	62.3	68	<0.5	-	0.5	12.1	-	300
ortho-Xylene	45.2	43.2	<0.5	-	10.3	39.4	-	-
VH C6-10	1,000	1,000	<100	-	100	500	15,000[3]	-
VPH C6-10	900	800	<100	-	100	400	1,500[3]	-
PAHs								
Acenaphthene	1.84	3	<0.05	-	1.22	1.8	60	-
Acenaphthylene	0.41	<1	<0.05	-	0.19	<0.5	-	-
Acridine	<0.1	<1	<0.05	-	<0.1	<0.1	0.5	-
Anthracene	0.14	<1	<0.05	-	0.13	<0.5	1	-
Benz(a)anthracene	<0.05	<0.05	<0.05	-	<0.05	<0.05	0.1	-
Benzo(a)pyrene	<0.01	<0.01	<0.01	-	<0.01	<0.01	-	-
Benzo(b)fluoranthene	<0.05	<0.05	<0.05	-	<0.05	<0.05	-	-
Benzo(g,h,i)perylene	<0.05	<0.05	<0.05	-	<0.05	<0.05	-	-
Benzo(k)fluoranthene	<0.05	<0.05	<0.05	-	<0.05	<0.05	-	-
Chrysene	<0.05	<0.05	<0.05	-	<0.05	<0.05	-	-
Dibenz(a,h)anthracene	<0.05	<0.05	<0.05	-	<0.05	<0.05	-	-
Fluoranthene	0.11	0.08	<0.05	-	<0.05	<0.05	2	-
Fluorene	1.8	4	<0.05	-	1.73	2.3	120	-
Indeno(1,2,3-c,d)pyrene	<0.05	<0.05	<0.05	-	<0.05	<0.05	-	-
Naphthalene	197	175	<0.2	-	9.48	35.5	10	-
Phenanthrene	2.3	5	<0.05	-	0.92	2.3	3	-
Pyrene	0.49	0.47	<0.05	-	0.17	0.19	0.2	-
Extractables								
EPH (C10-18)	13,600	13,300	700	<300	2,100	12,400	5,000[3]	-
EPH (C19-31)	2,000	2,000	<1000	<1000	<1,000	2,000	-	-
LEPH	13,400	13,100	700	-	2,100	12,300	500[3]	-
HEPH	2,000	2,000	<1,000	-	<1,000	2,000	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999).

As presented in the preceding paragraphs, the lateral and vertical extent of hydrocarbon contamination could not be ascertained on the basis of the information obtained during the June investigation. Five additional boreholes were therefore, drilled at the southwest end of the site in September 1999. The concentrations of hydrocarbons in soil samples collected from these boreholes are given in Table 4.23.

Table 4.23: Concentration of Hydrocarbons in Soil Samples Collected from Boreholes Drilled Southwest of the Maintenance Building in September 1999

Year	**September 1999**									**Yukon CSR Standard**
Sample #	**TH99-18-5**	**TH99-18-6**	**TH99-18-7**	**TH99-18-8**	**TH99-18-9**	**TH99-19-4**	**TH99-19-5**	**TH99-19-6**	**TH99-19-7**	
Volatiles										
Benzene	-	-	-	-	-	-	-	-	-	0.04[2]
Ethylbenzene	-	-	-	-	-	-	-	-	-	7[2]
Styrene	-	-	-	-	-	-	-	-	-	5
Toluene	-	-	-	-	-	-	-	-	-	2.5[2]
meta- & para-Xylene	-	-	-	-	-	-	-	-	-	20[2]
ortho-Xylene	-	-	-	-	-	-	-	-	-	20[2]
VH 6-10	-	-	-	-	-	-	-	-	-	-
VPH	-	-	-	-	-	-	-	-	-	200
PAHs										
Acenaphthene	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Acenaphthylene	<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Anthracene	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Fluorene	<0.01	0.17	<0.01	0.02	<0.01	<0.01	<0.01	0.01	<0.01	-
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Naphthalene	0.02	<0.2	0.04	0.04	<0.01	<0.03	0.17	0.23	0.28	5
Phenanthrene	<0.01	0.26	<0.01	0.05	0.01	<0.01	<0.01	<0.01	<0.01	5
Pyrene	<0.01	0.07	<0.01	0.02	<0.01	0.03	0.03	0.03	<0.01	10
Extractables										
EPH10-19	<200	**1050**	<200	<200	<200	270	<200	<200	<200	1000
EPH19-32	<200	<200	<200	<200	<200	<200	<200	<200	<200	1000
LEPH	<200	**1050**	<200	<200	<200	270	<200	<200	<200	1000
HEPH	<200	<200	<200	<200	<200	<200	<200	<200	<200	1000

cont'd

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Table 4.23: Continued

Year	**September 1999**									**Yukon CSR Standard**
Sample #	**TH19 -8**	**TH20 -13**	**TH21 -2**	**TH21 -6**	**TH21 -9**	**TH24 -12**	**TH24 -13**	**TH24 -14**	**TH24 -20**	
Volatiles										
Benzene	-	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.04[2]
Ethylbenzene	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	7[2]
Styrene	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	5
Toluene	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2.5[2]
meta- & para-Xylene	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	20[2]
ortho-Xylene	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	20[2]
VH 6-10	-	<100	<100	<100	<100	<100	<100	<100	<100	-
VPH	-	<100	<100	<100	<100	<100	<100	<100	<100	200
PAHs										
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.03	-
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	-
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	1
Naphthalene	0.14	<0.01	0.04	<0.01	<0.01	0.02	<0.01	<0.01	<0.1	5
Phenanthrene	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	5
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	10
Extractables										
EPH10-19	<200	<200	**1030**	<200	<200	<200	<200	<200	256	1000
EPH19-32	<200	<200	<200	<200	<200	<200	<200	<200	<200	1000
LEPH	<200	<200	**1030**	<200	<200	<200	<200	<200	256	1000
HEPH	<200	<200	<200	<200	<200	<200	<200	<200	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Volatile hydrocarbons (including BTEX) levels in the soil samples were all below detection. PAHs including fluorene, pyrene, naphthalene, and pyrene were detected in a few of the samples at very low concentrations, far below the Yukon CSR standard for residential/park land use. In addition, no heavy extractable petroleum hydrocarbons (HEPH) were found in any of the samples analyzed. This suggested the HEPH contamination (28,600 µg/g) detected at a depth of 4 m below the surface at TH99-9 was localized.

LEPH at concentrations exceeding the residential/park land standard were found in two of the boreholes (TH99-21 and TH99-18). Borehole TH-21 was drilled on the upper terrace in the vicinity of the berm for above ground storage tank. This tank is currently used for storing diesel fuel. The LEPH contamination (1030 µg/g) was encountered in the top 1.0 m of borehole. This concentration was comparable to that obtained for TP99-15 excavated nearby during the June investigation; the soil sample collected at a depth of 1.0 m from TP99-15 contained 1430 µg/g of EPH (C10-19). Since no other samples in the area had detectable levels of hydrocarbons, this contamination was attributed to local release, either from the fill valve or the feed line to the soakage pit. It should be noted that these concentrations are below the Yukon CSR industrial land use standard of 2000 µg/g.

Boreholes TH99-18 and TH99-19 were drilled approximately 15 m to the north and south, respectively of TH99-9 to define the limits of hydrocarbon contamination at the lower terrace. As indicated in the previous paragraph, one sample from TH99-18 contained LEPH (1050 µg/g) that exceeded the standard for residential/park land use. The contaminated sample was collected at a depth of 3.0 m below grade; LEPH concentrations the remaining samples, which were collected at different depths, were below detection. Due to the steep slope, and the closeness of the river, additional drilling could not be conducted beyond TH99-18. A sediment samples was collected from the river in a location where groundwater flow from TH99-18 would enter the river. In addition, a mini-piezometer was installed down gradient of TH99-19 to intercept groundwater flow just before it enters the river. Results are discussed under Blanchard River in Section 4.6. Only one of the samples from TH99-19 contained detectable levels of LEPH. This sample was collected from the 2.0 m depth and the concentration (270 µg/g) was slightly above the detection limit of 200 µg/g. Thus TH99-19 was considered as the southern limit of hydrocarbon contamination at the lower terrace.

The northern limits of hydrocarbon contamination on the upper terrace was defined using data from TH99-20 and TP99-54 in that no detectable odours or staining were noted in samples from these two locations. In addition all hydrocarbon concentrations were below detection.

As with the June 1999 groundwater results, hydrocarbon contamination was found in MW-5, MW-13 and MW-14, situated on the upper bench and down gradient of the soakage pit. These wells contained LEPH (23,300 µg/L, 800 µg/L and 4,100 µg/L respectively) that exceeded the proposed BC CSR standard of 500 µg/L. Elevated levels of HEPH were also detected in MW-5 and MW-14 (Table 4.24). A number of PAHs including naphthalene, phenanthrene, and pyrene in MW-5 also exceeded the Yukon CSR standard for aquatic life. In addition, volatile hydrocarbons results were comparable to the June data in that only ethylbenzene in MW-5 exceeded the Yukon standard for drinking water use.

Concentrations of LEPH (1700 µg/L and 5,600 µg/L) in excess of the proposed BC standard for aquatic life use were found in MW-18 and MW-19 both located on the lower terrace near the river. No extractable hydrocarbons were detected in the groundwater sample collected from MW-10.

The data for subsurface soils and groundwater presented in the preceding paragraphs indicated hydrocarbon contamination possibly originating from the soak away pit. The aerial extent of subsurface contamination at the south end of the site is illustrated in Drawings 4.2, 4.3 and 4.5. This contamination had on occasion been observed to result in the presence of hydrocarbon sheen along a limited portion of the Blanchard River shoreline. Results for samples obtained from the river are discussed in Section 4.6.

Table 4.24: Concentrations of Hydrocarbons (µg/L) in Water Samples Collected from Boreholes Southwest of the Maintenance Building in September 1999

Sample #	TH-5	TH5 Dup	TH-9	TH-10	TH-13	TH-14	TH-18	TH-19	Yukon CSR Standard	
Volatiles									**AW**	**DW**
Benzene	0.7	0.9	<0.5	<0.5	<0.5	-	<0.5	5.8	3,000	5
Ethylbenzene	**41.4**	33.2	<0.5	<0.5	<0.5	-	<0.5	44.4	7,000	2.4
Toluene	0.6	1.7	<0.5	<0.5	<0.5	-	<0.5	4.2	3,000	24
meta- & para-Xylene	60.5	51	<0.5	<0.5	<0.5	-	<0.5	38.4	-	300
ortho-Xylene	37	59.5	<0.5	<0.5	13.6	-	<0.5	2.5	-	-
VH (C6-10)	900	1,100	<100	<100	0.1	-	<100	300	15,000[2]	-
VPH	700	1,000	<100	<100	<0.1	-	<100	200	1,000[2]	-
PAHs										
Acenaphthene	8.6	-	<0.05	<0.05	0.28	<0.05	<0.05	1.5	60	-
Acenaphthylene	2.4	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Acridine	<0.5	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	-
Anthracene	**1.6**	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	1	-
Benz(a)anthracene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	-
Benzo(a)pyrene	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Benzo(b)fluoranthene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Benzo(g,h,i)perylene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Benzo(k)fluoranthene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Chrysene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Dibenz(a,h)anthracene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Fluoranthene	<0.2	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	2	-
Fluorene	13.2	-	<0.05	<0.05	0.22	<0.05	<0.05	1.2	120	-
Indeno(1,2,3-c,d)pyrene	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Naphthalene	**342**	-	<0.05	<0.05	<2	<0.03	<0.05	53.7	10	-
Phenanthrene	**21**	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	3	-
Pyrene	**0.98**	-	<0.05	<0.05	0.06	0.13	0.12	<0.05	0.2	-
Extractables										
EPH10-19	**23,700**	-	300	<100	800	4,100	1,700	**5600**	5000*	-
EPH19-32	3,600	-	400	<100	200	2,000	400	800	-	-
LEPH	**23,300**	-	<300	<300	**800**	**4100**	**1,700**	**5600**	500*	-
HEPH	4,000	-	<1,000	<1,000	<1,000	2,000	<1,000	<1,000	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999).

4.5.2 Metals

Metal concentrations in soil samples (Table 4.25) were generally below the relevant Yukon CSR standard except for the concentration of chromium in one sample (TH99-14-7, 113 µg/g). Chromium levels are naturally elevated at the site with an average concentration of 51.4 µg/g and therefore, of no major concern.

Table 4.25: Concentrations of Metals (µg/g) in Soil Samples Collected from Boreholes Established Southwest of the Maintenance Building

Date	1995	June 1999							Yukon CSR Standard
Sample #	TH5	TH9-4	TH10-2	TH11-5	TH13-16	TH14-4	TH14-14	TH14-17	
Depth	30 – 32'								
Physical Tests									
Moisture %	7.15	3.6	5	4.5	4.3	6.4	4.6	18.4	
pH	-	8.56	8.05	8.15	8.51	8.1	8.46	8.12	
Total Metals									
Antimony	<10	<20	<20	<20	<20	<20	<20	<20	20
Arsenic	1.8	3.6	1.8	5	4.2	1.1	3.4	1.5	15[2]
Barium	140	118	190	167	149	274	186	402	500
Beryllium	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	4
Cadmium	<0.25	0.2	0.2	0.2	0.2	0.2	0.2	0.5	15[3]
Chromium	28	39	49	44	40	55	43	**113**	60[4]
Cobalt	10	11	12	14	11	14	12	26	50
Copper	30	37	33	36	41	48	43	79	30,000[5]
Lead	<1	<50	<50	<50	<50	<50	<50	<50	4,000[6]
Mercury	0.032	0.046	0.024	0.048	0.054	0.037	0.041	0.069	2
Molybdenum	<4	<4	<4	<4	<4	<4	<4	<4	10
Nickel	25	32	31	32	29	36	31	69	100
Selenium	<0.5	<0.1	<0.1	<0.1	0.2	0.1	0.3	0.3	3
Silver	<2	<2	<2	<2	<2	<2	<2	<2	20
Tin	<5	<10	<10	<10	<10	<10	<10	<10	50
Vanadium	34	62	77	77	64	85	68	136	200
Zinc	42	58	67	70	63	76	60	127	1000[7]

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater flow to surface water used for drinking.
3. Matrix numerical standard for groundwater flow to surface water used for drinking (pH > 7.5).
4. Matrix numerical standard for groundwater flow to surface water used for aquatic life.
5. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
6. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
7. Matrix numerical standard for groundwater flow to surface water used by aquatic life (pH > 7).

Concentrations of most of the metals in water samples were either below detection or well below the Yukon standard for aquatic life use except for iron and manganese (Table 4.26). These elements are usually contributed from minerals in the surrounding bedrock and overburden and vary naturally in the environment. The BC Ministry of the

Environment has deleted these elements from Generic Numerical Water Standards under the BC Contaminated Sites Regulation (BCMELP, 1999). Their occurrences in these water samples are of no major concern.

Table 4.26: Concentrations of Metals (µg/L) in Water Samples Collected from Monitoring Wells Southwest of the Maintenance Building

Date	1995		June 1999		September 1999				Yukon Standard	
Sample #	MW-5	MW-5 Dup.	MW-5	MW-5 Dup.	MW-9	MW-10	MW-18	MW-19	AW	DW
Hardness as $CaCO_3$			456	477						
pH										
Aluminum	<150	<150	<30	<10	10	37	92	20	110 - 500[3]	200
Antimony	<150	<150	<200	<200	<200	<200	<200	<200	300	-
Arsenic	200	200	<200	<200	<200	<200	<200	<200	500	250
Barium	520	530	490	480	270	120	160	660	10,000	1,000
Beryllium	<3	<3	<5	<5	<5	<5	<5	<5	53	-
Boron	270	280	300	400	100	<100	<100	300	-	500
Cadmium	<0.2	<0.2	<1	<0.4	<0.4	<0.2	<0.2	1.5	2 - 180[4]	5
Calcium	149,000	145,000	151,000	158,000	128,000	78,000	66,500	137,000	-	-
Chromium	<1	<1	<10	<10	<10	<10	<10	<10	20	50
Cobalt	21	25	<10	<10	<10	<10	<10	10	500	-
Copper	3	2	<10	<10	<10	<10	<10	<10	30 - 90	1,000
Iron	100	40	**19,000**	**18,500**	<30	60	160	**2240**	3,000	300
Lead	<1	1	<5	<2	<2	<1	<1	<2	50 - 160	10
Magnesium	17500	17200	19200	19700	18800	12300	9000	17500	-	-
Manganese	**1970**	**2010**	**1930**	**2090**	23	<5	57	**4280**	1000	50
Mercury	<50	<50	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	1	1
Molybdenum	5	5	<30	<30	<30	<30	<30	<30	10,000	250
Nickel	50	50	<50	<50	<50	<50	<50	<50	250 - 1500	
Selenium	<1	<1	<5	<2	<2	<1	2	<2	10	10
Silver	<1	<1	<0.5	<0.2	<0.2	<0.1	<0.1	<0.2	1	
Sodium	13500	12600	14000	15000	34000	2000	10000	10000	-	200,000
Thallium	-	-	<0.5	<0.2	<0.2	<0.1	<0.1	<0.2	3	-
Uranium	-	-	0.34	0.37	1.7	0.78	0.42	0.35	3,000	100
Zinc	<10	<10	<5	<5	14	<5	<5	8	300	5,000

Notes:

1. All values are in µg/L.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Standard depends on pH of the water samples (pH > 6.5).
4. Standard depends on hardness (H) of the water sample (H = 86 to 202).
5. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Aquatic life (AW) or Drinking Water (DW).

4.5.3 Chlorinated Organic Compounds

The concentrations of the analytes in this suite, which includes persistent chlorinated organic compounds such as PCBs and DDTs were all below detection (Table 4.27). PCBs,

Table 4.27: Concentration (µg/g) of Polychlorinated Biphenyls (PCBs) and Chlorinated Pesticides in Soil Samples Collected Southwest of the Maintenance Building

Date	**1995**	**June 1999**		**Yukon CSR Standard**
Sample #	**TH95-5 (24-26')**	**TH99-14-4**	**TP99-31-1**	
Polychlorinated Biphenyls				
Total PCBs	<0.00055	<0.05	<0.05	5[2]
Organochlorine Pesticides				
Aldrin		<0.001	<0.001	-
alpha-BHC	<0.000006	<0.001	<0.001	2
beta-BHC	-	<0.002	<0.002	2
delta-BHC	-	<0.001	<0.001	2
cis-Chlordane (alpha)	-	<0.001	<0.001	-
trans-Chlordane (gamma)	-	<0.001	<0.001	-
2,4'-DDD	-	<0.001	<0.001	-
4,4'-DDD	-	<0.001	<0.001	-
2,4'-DDE	-	<0.002	<0.002	-
4,4'-DDE	-	<0.001	<0.001	-
2,4'-DDT	-	<0.001	<0.001	-
4,4'-DDT	-	<0.002	<0.002	-
Dieldrin	-	<0.001	<0.001	-
Endosulfan I	-	<0.001	<0.001	-
Endosulfan II	-	<0.001	<0.001	-
Endosulfan Sulfate	-	<0.001	<0.001	-
Endrin	-	<0.005	<0.005	-
Endrin Aldehyde	-	<0.001	<0.001	-
Heptachlor	-	<0.002	<0.002	-
Heptachlor Epoxide	-	<0.001	<0.001	-
Lindane (gamma - BHC)	-	<0.001	0.002	2
Methoxychlor	-	<0.005	<0.005	-
Mirex	-	<0.001	<0.001	-
cis-Nonachlor	-	<0.001	<0.001	-
trans-Nonachlor	-	<0.001	<0.001	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for ingestion of contaminated soils.

4.5.4 Halogenated Volatile Organic Compounds

As with chlorinated pesticides the concentrations these compounds in all the soil samples (Table 4.28) and water samples (Table 4.29) were below detection.

Table 4.28: Concentrations (µg/g) of Halogenated Volatile Organic Compounds in Soil Samples Collected Southwest of the Maintenance Building

Year	**1995**	**1999**			**Yukon CSR Standard[1]**
Sample #	**TH95-5 (10-12')**	**TH99-13-16**	**TH99-13-21**	**TH99-14-4**	
Bromodichloromethane	<0.00008	<0.01	<0.01	<0.01	5
Bromoform	<0.00017	<0.01	<0.01	<0.01	-
Carbon Tetrachloride	-	<0.01	<0.01	<0.01	5
Chlorobenzene	-	<0.01	<0.01	<0.01	1
Chloroethane	-	<0.01	<0.01	<0.01	5
Chloroform	<0.00008	<0.01	<0.01	<0.01	5
Chloromethane	-	<0.01	<0.01	<0.01	5
Dibromochloromethane	-	<0.01	<0.01	<0.01	5
1,2-Dichlorobenzene	-	<0.01	<0.01	<0.01	1
1,3-Dichlorobenzene	-	<0.01	<0.01	<0.01	1
1,4-Dichlorobenzene	-	<0.01	<0.01	<0.01	1
1,1-Dichloroethane	<0.00005	<0.01	<0.01	<0.01	5
1,2-Dichloroethane	<0.00006	<0.01	<0.01	<0.01	5
cis-1,2-Dichloroethylene	<0.00008	<0.01	<0.01	<0.01	5
trans-1,2-Dichloroethylene	-	<0.01	<0.01	<0.01	5
1,1-Dichloroethylene	-	<0.01	<0.01	<0.01	5
Dichloromethane	-	<0.4	<0.4	<0.1	5
1,2-Dichloropropane	<0.00005	<0.01	<0.01	<0.01	5
cis-1,3-Dichloropropylene	-	<0.01	<0.01	<0.01	5
trans-1,3-Dichloropropylene	<0.00012	<0.01	<0.01	<0.01	5
1,1,1,2-Tetrachloroethane	-	<0.01	<0.01	<0.01	5
1,1,2,2-Tetrachloroethane	-	<0.01	<0.01	<0.01	5
Tetrachloroethylene	<0.0003	<0.01	<0.01	<0.01	5[2]
1,1,1-Trichloroethane	<0.00004	<0.01	<0.01	<0.01	5
1,1,2-Trichloroethane	<0.00012	<0.01	<0.01	<0.01	5
Trichloroethylene	<0.00006	<0.01	<0.01	<0.01	0.15[3]
Trichlorofluoromethane	-	<0.01	<0.01	<0.01	5
Vinyl Chloride	-	<0.01	<0.01	<0.01	5

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for toxicity to soil invertebrates.
3. Matrix numerical standard for groundwater used for drinking.

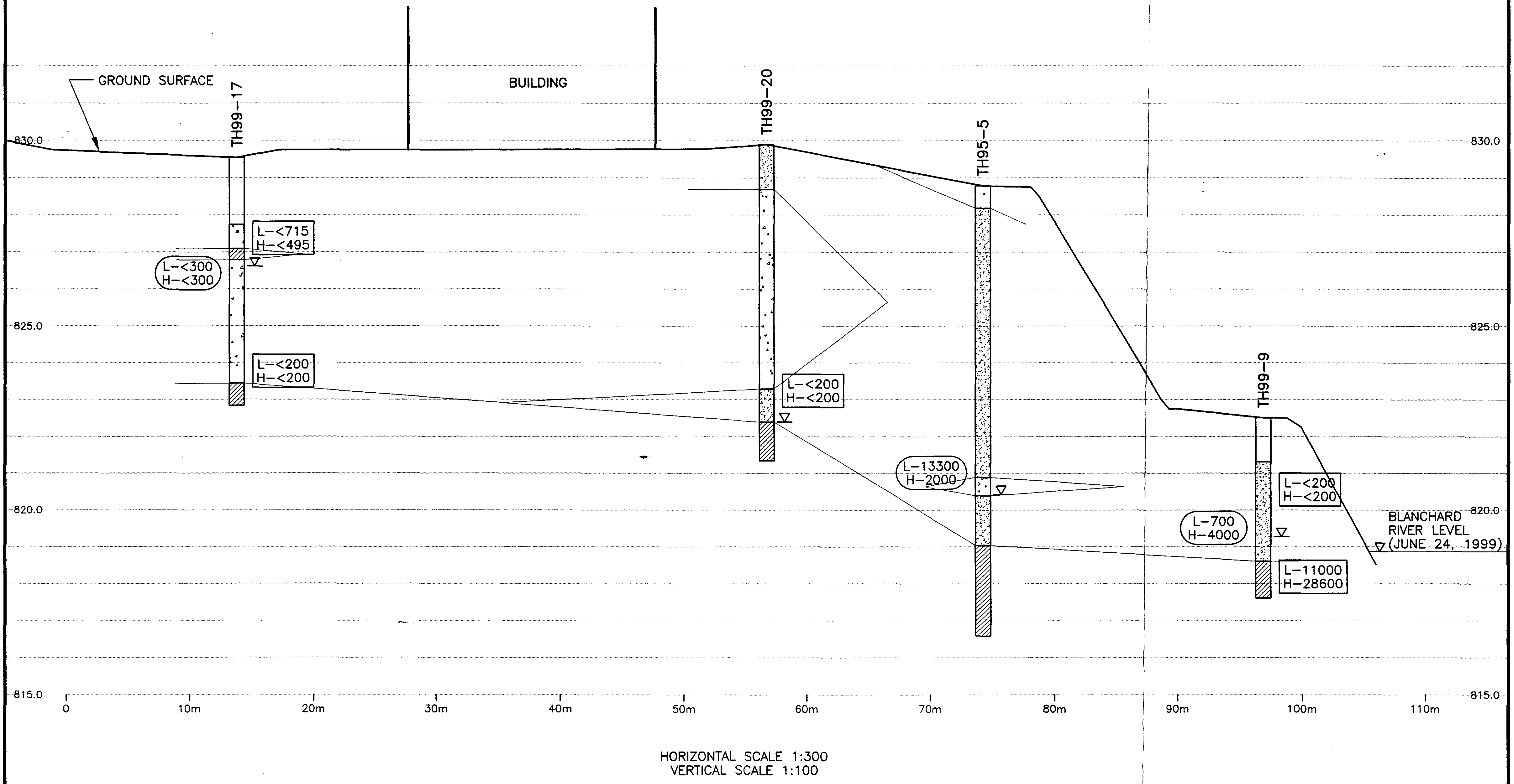
Table 4.29: Concentrations (µg/L) of Halogenated Volatile Organic Compounds in Water Samples Collected from Monitoring Wells Southwest of the Maintenance Building

Sample #	MW-5	MW-5 Dup.	MW-14	Yukon CSR Standard	
				Aquatic Life (AW)[1]	Drinking Water (DW)
Bromodichloromethane	<1	<1	<1	-	-
Bromoform	<1	<1	<1	-	-
Carbon Tetrachloride	<1	<1	<1	130	5
Chlorobenzene	<1	<1	<1	150	30
Chloroethane	<1	<1	<1	-	-
Chloroform	<1	<1	<1	-	-
Chloromethane	<2	<2	<2	-	-
Dibromochloromethane	<1	<1	<1	-	-
1,2-Dichlorobenzene	<1	<1	<1	25	3
1,3-Dichlorobenzene	<1	<1	<1	25	-
1,4-Dichlorobenzene	<1	<1	<1	4	1
1,1-Dichloroethane	<1	<1	<1	-	-
1,2-Dichloroethane	<1	<1	<1	500	5
cis-1,2-Dichloroethylene	<1	<1	<1	-	-
trans-1,2-Dichloroethylene	<1	<1	<1	-	-
1,1-Dichloroethylene	<1	<1	<1	-	-
Dichloromethane	<20	<5	<20	-	50
1,2-Dichloropropane	<1	<1	<1	-	-
cis-1,3-Dichloropropylene	<1	<1	<1	-	-
trans-1,3-Dichloropropylene	<1	<1	<1	-	-
1,1,1,2-Tetrachloroethane	<1	<1	<1	-	-
1,1,2,2-Tetrachloroethane	<1	<1	<1	-	-
Tetrachloroethylene	<1	<1	<1	1,100	-
1,1,1-Trichloroethane	<1	<1	<1	-	-
1,1,2-Trichloroethane	<1	<1	<1	-	-
Trichloroethylene	<1	<1	<1	200	50
Trichlorofluoromethane	<1	<1	<1	-	-
Vinyl Chloride	<1	<1	<1	-	2

Notes:

1. All values are in µg/L.
2. Aquatic life assumes minimum 1:10 dilution is available.

APR 7/00
Plot Scale: 1:0.3
SectionA.dwg



LEGEND

▨	CLAY
⬚	SAND
⊡	GRAVEL
▽	WATER LEVEL (AS OF SEPT 27/99)

L-<200 H-<200	LEPH HEPH	CONCENTRATIONS IN SOIL (mg/kg)
(L-<300 H-<300)	LEPH HEPH	CONCENTRATIONS IN GROUNDWATER (ug/L)

UMA Engineering Ltd.
Engineers and Planners
1479 Buffalo Place, Winnipeg, Manitoba, Canada R3T 1L7

NDIAN AFFAIRS and NORTHERN DEVELOPMENT
BLANCHARD RIVER STATION: SITE INVESTIGATION

TITLE:	SECTION A		
JOB No.	C799-004-01-01	DATE:	April, 2000
SCALE:	AS NOTED	DWG. No.	4-5
CHECKED:	AP		

4.6 Blanchard River

The data for subsurface soils and groundwater presented in preceding Sections indicated contamination of subsurface soils and groundwater with hydrocarbon. This contamination had on occasion been observed to result in the presence of hydrocarbon sheen along a limited portion of the Blanchard River shoreline. Hydrocarbon sheen was noted on the surface of the river when the sediment was disturbed during the June site investigation. A possible source of the contamination is the soak away pit that receives discharge from the oily water separator from the floor drains in the shop's welding bay.

As part of the site investigations, one sample each of river water and sediment was collected from an upstream reference location (BLW-7) and immediately adjacent to the south side of the site (BLW-6). Water was present at this location during the high flow season only. Attempts to obtain a downstream reference sample proved unsuccessful since the river was inaccessible by land beyond the station. In addition, two mini-piezometers were installed on the bank of the Blanchard River, within 1 m of the active flow. Mini-piezometer MP-3 was installed to intercept groundwater flow from the southwest side of site, just before it enters the river while MP-4 was placed about 100 m upstream to serve as a reference.

4.6.1 Hydrocarbons

Hydrocarbons concentrations in sediment samples, along with the CCME Canadian Environmental Quality Guidelines for Freshwater Sediments (CCME, 1999), are given in Table 4.30. Most of the parameters in both samples were below detection, however, LEPH (258 µg/g), HEPH (266 µg/g), o-xylene (0.06 µg/g) and naphthalene (0.01 µg/g) were found in BLW-6. The concentrations were, however, not very significant since they were all close to their respective detection limits and less than the Interim Sediment Quality Guidelines (ISQG) and Probable Effect Level (PEL) values.

Groundwater sample collected in June 1999 from MP-3 contained detectable hydrocarbons including LEPH (1,800 µg/L), acenaphthene (0.09 µg/L) and pyrene (0.14 µg/L) whereas the concentrations of all hydrocarbons in the sample from the reference mini-piezometers (MP-4) were below detection (Table 4.31). The LEPH value exceeded the BC CSR standard for aquatic life (500 µg/L). Hydrocarbon constituents were higher in a sample taken from MP-3 in September 1999. These included LEPH (19,200 µg/L), phenanthrene (3.46 µg/L) and pyrene (0.86 µg/L) all of which exceeded the AW standard. Anthracene (0.58 µg/L), o-xylene (1.8 µg/L) and HEPH (3,000 µg/L) were also found in this sample. The water level in the Blanchard River was substantially higher during the June investigation and the lower concentrations obtained may be attributed to dilution effects. The dilution effects would be more pronounced as the contaminated groundwater enters the river, which would in turn decrease the LEPH concentration below the standard for the protection of aquatic life. This is illustrated by water samples collected from the river; hydrocarbon concentrations in samples collected from the river adjacent to MP-3 (BLW-6) and upstream of the site (BLW-7) were all below detection.

Table 4.30: Concentrations (µg/g) of Hydrocarbons in Sediment Samples Collected from the Blanchard River

Sample #	**BLW-7**	**BLW-6**	**CCME Sediment Guidelines**	
			ISQG[1]	**PEL[2]**
Non-halogenated Volatiles				
Benzene	<0.04	<0.04	-	-
Ethylbenzene	<0.05	<0.05	-	-
Styrene	<0.05	<0.05	-	-
Toluene	<0.05	<0.05	-	-
meta- & para-Xylene	<0.05	<0.05	-	-
ortho-Xylene	<0.05	0.06	-	-
VH C6-10	<100	<100	-	-
VPH C6-10 (calculated)	<100	<100	-	-
PAHs				
Acenaphthene	<0.01	<0.01	0.00671	0.0889
Acenaphthylene	<0.01	<0.01	0.00587	0.128
Anthracene	<0.01	<0.01	0.0469	0.245
Benz(a)anthracene	<0.01	<0.01	0.0317	0.385
Benzo(a)pyrene	<0.01	<0.01	0.0319	0.782
Benzo(b)fluoranthene	<0.01	<0.01	-	-
Benzo(g,h,i)perylene	<0.01	<0.01	-	-
Benzo(k)fluoranthene	<0.01	<0.01	-	-
Chrysene	<0.01	<0.01	0.0571	0.862
Dibenz(a,h)anthracene	<0.01	<0.01	0.00622	0.135
Fluoranthene	<0.01	<0.01	0.111	2.355
Fluorene	<0.01	<0.01	0.0212	0.144
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	-	-
Naphthalene	<0.01	0.01	0.0346	0.391
Phenanthrene	<0.01	<0.01	0.0419	0.515
Pyrene	<0.01	<0.01	0.053	0.875
Extractables				
EPH (C10-18)	<200	258	-	-
EPH (C19-31)	<200	266	-	-
LEPH	<200	258	-	-
HEPH	<200	266	-	-

Notes:

1. ISQG = Interim Sediment Quality Guidelines
2. PEL = Probable Effect Level

Table 4.31: Concentrations (µg/L) of Hydrocarbons in Water Samples Collected from Mini-Piezometers and the Blanchard River.

Date	**June 1999**		**Sept. 1999**	**June 1999**		**Yukon CSR Standard**	
Sample #	**MP-4**	**MP-3**	**MP-3**	**BLW-7**	**BLW-6**	**AW**	**DW**
Volatiles							
Benzene	<0.5	<0.5	<0.5	-	<0.5	3000	5
Ethylbenzene	<0.5	<0.5	<0.5	-	<0.5	7000	2.4
Toluene	<0.5	<0.5	<0.5	-	<0.5	3000	24
meta- & para-Xylene	<0.5	<0.5	<0.5	-	<0.5	-	300
ortho-Xylene	<0.5	<0.5	1.8	-	<0.5	-	-
VH (C6-10)	<100	<100	100	-	<100	15,000^{3}	-
VPH	<100	<100	100	-	<100	1000^{3}	-
PAHs							
Acenaphthene	<0.05	0.09	<3	<0.05	<0.05	60	-
Acenaphthylene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Acridine	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	-
Anthracene	<0.05	<0.05	0.58	<0.05	<0.05	1	-
Benz(a)anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	-
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Benzo(b)fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Benzo(g,h,i)perylene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Benzo(k)fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Chrysene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Dibenz(a,h)anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	2	-
Fluorene	<0.05	<0.05	2.46	<0.05	<0.05	120	-
Indeno(1,2,3-c,d)pyrene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Naphthalene	<0.05	<0.7	<0.5	<0.05	<0.05	10	-
Phenanthrene	<0.05	<0.05	**3.46**	<0.05	<0.05	3	-
Pyrene	<0.05	0.14	**0.86**	<0.05	<0.05	0.2	-
Extractables							
EPH10-19	<300	1,800	**19,200**	<300	<300	5,000^{3}	-
EPH19-32	<1000	<1000	3,000	<1000	<1000	-	-
LEPH	<300	**1800**	**19,200**	<300	<300	500^{3}	-
HEPH	<1000	<1000	3,000	<100	<100	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999).

4.6.2 Metals

Metal concentrations in the sediment collected from the upstream location (BLW-7) were generally comparable to those for the sample taken adjacent to contaminated area (BLW-6) except for arsenic and barium. Arsenic was elevated in BLW-5. The concentration exceeded the Interim Sediment Quality Guideline (ISQG) but was below the Probable Effects Level (PEL) of the CCME sediment guidelines (Table 4.32). Dissolved metal concentrations in water samples collected from the two locations were comparable (Table 4.33) to each other. Thus, metals are not parameters of concern.

Table 4.32: Concentrations (µg/g) of Metals in Sediment Samples Collected from the Blanchard River

Sample #	BLW-7	BLW-6	CCME Sediment Guidelines	
			ISQG[1]	PEL[2]
Physical Tests				
Moisture %	12.6	31.7	-	-
pH	7.35	7.8	-	-
Total Metals				
Antimony	<20	<20	-	0.020
Arsenic	2.2	11.8	5.9	17
Barium	154	256	-	-
Beryllium	<0.5	<0.5	-	-
Cadmium	0.1	0.2	0.6	3.500
Chromium	45	46	37.3	90
Cobalt	11	12	-	-
Copper	25	30	35.7	197
Lead	<50	<50	35	91.3
Mercury	0.031	0.033	0.170	0.486
Molybdenum	<4	<4	-	-
Nickel	27	31	-	-
Selenium	<0.1	0.4	-	-
Silver	<2	<2	-	-
Tin	<10	<10	-	-
Vanadium	64	70	-	-
Zinc	60	79	123	315

Notes:

1. ISQG = Interim Sediment Quality Guidelines
2. PEL = Probable Effect Level
3. Shaded areas indicate parameters that are equal to or exceed the CCME guidelines.

Table 4.33: Concentrations (µg/L) of Metals in Water Samples Collected from Blanchard River.

Sample #	BLW-7	BLW-6	Yukon CSR Standard AW[1]
Physical Tests			
Hardness as $CaCO_3$ (mg/L)	6.57	6.91	
Dissolved Metals			
Aluminum D-Al	66	72	5 to 50[3]
Antimony D-Sb	<200	<200	30
Arsenic D-As	<200	<200	50
Barium D-Ba	<10	<10	1000
Beryllium D-Be	<5	<5	5.3
Boron D-B	<100	<100	-
Cadmium D-Cd	<0.2	<0.2	0.2 to 1.8[4]
Calcium D-Ca	2,050	2,160	-
Chromium D-Cr	<10	<10	2
Cobalt D-Co	<10	<10	50
Copper D-Cu	<10	<10	2 to 9[4]
Iron D-Fe	70	80	300
Lead D-Pb	<1	<1	4 to 16[4]
Magnesium D-Mg	400	400	-
Manganese D-Mn	10	9	100
Mercury D-Hg	<0.05	<0.05	0.1
Molybdenum D-Mo	<30	<30	1000
Nickel D-Ni	<50	<50	25 to 150[4]
Selenium D-Se	<1	<1	1
Silver D-Ag	<0.1	<0.1	0.1
Sodium D-Na	<2000	<2000	200,000
Thallium D-Tl	<0.1	<0.1	0.3
Uranium D-U	0.09	0.1	300
Zinc D-Zn	9	<5	30

Notes:

1. Ten fold dilution applied to standard for ambient Blanchard River water.
2. Values taken from BC CSR (BC MELP, 1999).

4.6.3 Halogenated Volatile Organic Compounds

As with the other areas of the site, the concentrations of these parameters in one sample analyzed (BLW-6) were all below detection.

4.7 Above Ground Storage Tank South of Maintenance Building

Investigations undertaken near the empty large above ground storage tank (AST) located south of the maintenance building consisted of the excavation of four test pits and two boreholes. A strong hydrocarbon odour was detected at a depth of 0.3 m and beyond in TP99-19 excavated at the northern side of the tank, right under the fill valve. The concentration of volatile hydrocarbons (VPH) in a sample collected from this test pit was elevated (162 µg/g) but below the residential/park land use standard (Table 4.34). Headspace analysis using the PID of samples collected from other test pits established near the tanks (TP99-20, TP99-35 and TP99-36) did not reveal the presence of elevated levels of volatile hydrocarbons. Laboratory analysis of one of the sample (TP99-35-3) collaborated the field data in that the concentrations of VPH, LEPH and HEPH were all below detection. Comparable results were also obtained for soil samples collected from the two boreholes (TH99-22 and TH99-23); no volatile organic hydrocarbons were detected with the PID and the concentrations of PAHs, LEPH and HEPH were all below detection.

There was no evidence of hydrocarbon contamination on the lower terrace down gradient of the AST in that extractable hydrocarbon concentrations in samples obtained from a borehole (TH99-11) and a test pit (TP99-52) established in the area were below detection. Thus hydrocarbon contamination near the AST is limited a small area below the fill valve. This may have resulted from accidental spills from the valve during fueling.

One sample each was analyzed for metals and halogenated volatile organic compounds (Table 4.35). Metal concentrations were all below the standard for residential/park land use while all the volatile organic compounds were below detection.

Table 4.34: Concentrations of Hydrocarbons (µg/g) in Soil Samples Collected near the Above Ground Storage Tank South of the Maintenance Building

Sample #	TP99-19-1	TP99-35-3	TP99-52	TH99-11-5	TH99-22-6	TH99-23-7	Yukon Standard
Volatiles							
Benzene	<0.04	<0.04	-	-	-	-	0.04^2
Ethylbenzene	<0.05	<0.05	-	-	-	-	7^2
Styrene	<0.05	<0.05	-	-	-	-	5
Toluene	<0.05	<0.05	-	-	-	-	2.5^2
meta- & para-Xylene	<0.05	<0.05	-	-	-	-	20^2
ortho-Xylene	<0.05	<0.05	-	-	-	-	20^2
VH 6-10	162	<100	-	-	-	-	-
VPH	162	<100	-	-	-	-	200
PAHs							
Acenaphthene	-	-	-	-	<0.01	<0.01	-
Acenaphthylene	-	-	-	-	<0.01	<0.01	-
Anthracene	-	-	-	-	<0.01	<0.01	-
Benz(a)anthracene	-	-	-	-	<0.01	<0.01	1
Benzo(a)pyrene	-	-	-	-	<0.01	<0.01	1
Benzo(b)fluoranthene	-	-	-	-	<0.01	<0.01	1
Benzo(g,h,i)perylene	-	-	-	-	<0.01	<0.01	-
Benzo(k)fluoranthene	-	-	-	-	<0.01	<0.01	1
Chrysene	-	-	-	-	<0.01	<0.01	-
Dibenz(a,h)anthracene	-	-	-	-	<0.01	<0.01	-
Fluoranthene	-	-	-	-	<0.01	<0.01	-
Fluorene	-	-	-	-	<0.01	<0.01	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	<0.01	<0.01	1
Naphthalene	-	-	-	-	<0.01	<0.01	5
Phenanthrene	-	-	-	-	<0.01	<0.01	5
Pyrene	-	-	-	-	<0.01	<0.01	10
Extractables							
EPH10-19	-	<200	<200	<200	<200	<200	1000
EPH19-32	-	<200	<200	<200	<200	<200	1000
LEPH	-	-	-	-	<200	<200	1000
HEPH	-	-	-	-	<200	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.

Table 4.35: Concentrations of Metals and Volatile Organic Compounds (µg/g) in Soil Samples Collected near the Above Ground Storage Tank South of the Maintenance Building

Metals			**Volatiles Organic Compound**		
Sample #	**TP19-1**	**Yukon CSR Standard**	**Sample #**	**TP35-3**	**Yukon CSR Standard**
Physical Tests			***Halogenated Volatiles***		
Moisture %	6.9	-	Bromodichloromethane	<0.01	5
pH	7.92	-	Bromoform	<0.01	-
			Carbon Tetrachloride	<0.01	5
Total Metals			Chlorobenzene	<0.01	1
Antimony	<20	20	Chloroethane	<0.01	5
Arsenic	1.5	15^{2}	Chloroform	<0.01	5
Barium	113	500	Chloromethane	<0.01	5
Beryllium	<0.5	4	Dibromochloromethane	<0.01	5
Cadmium	0.1	15^{3}	1,2-Dichlorobenzene	<0.01	1
Chromium	38	60^{4}	1,3-Dichlorobenzene	<0.01	1
Cobalt	9	50	1,4-Dichlorobenzene	<0.01	1
Copper	31	$30{,}000^{5}$	1,1-Dichloroethane	<0.01	5
Lead	<50	$4{,}000^{5}$	1,2-Dichloroethane	<0.01	5
Mercury	0.02	2	cis-1,2-Dichloroethylene	<0.01	5
Molybdenum	<4	10	trans-1,2-Dichloroethylene	<0.01	5
Nickel	23	100	1,1-Dichloroethylene	<0.01	5
Selenium	<0.1	3	Dichloromethane	<0.1	5
Silver	<2	20	1,2-Dichloropropane	<0.01	5
Tin	<10	50	cis-1,3-Dichloropropylene	<0.01	5
Vanadium	53	200	trans-1,3-Dichloropropylene	<0.01	5
Zinc	55	1000^{7}	1,1,1,2-Tetrachloroethane	<0.01	5
			1,1,2,2-Tetrachloroethane	<0.01	5
			Tetrachloroethylene	<0.01	5^{2}
			1,1,1-Trichloroethane	<0.01	5
			1,1,2-Trichloroethane	<0.01	5
			Trichloroethylene	<0.01	0.15^{3}
			Trichlorofluoromethane	<0.01	5
			Vinyl Chloride	<0.01	5

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.
3. Matrix numerical standard for groundwater water used for drinking (pH > 7.5).
4. Matrix numerical standard for groundwater flow to surface water used for aquatic life.
5. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
6. Matrix numerical standard for groundwater flow to surface water used by aquatic life (pH > 7).

4.8 Soak Away Pit West of Maintenance Building

Floor drainage from the main area of the maintenance building is conveyed through a pipe to a rock pit established on the northwestern side of the building in 1985. The pipe was encountered through the excavation a test pit within 3 to 4 m of shop wall. Further excavation along the pipe uncovered the top part of the rock pit, pit consisted of a 3 m diameter culvert filled with boulders and surrounded by native fill comprising sandy gravel with cobbles. No hydrocarbon odour was detected soil samples collected from either the test pits or a borehole drilled near the rock pit. Hydrocarbon concentrations were below detection (Table 4.36). The concentrations of metals in a sample collected from the borehole were all below the residential/park land use standards.

Table 4.36: Concentrations (µg/g) of Hydrocarbons and Metals in Soil Samples Collected near the Above Ground Storage Tank South of the Maintenance Building

Hydrocarbons				Metals		
Sample #	**TH99-15-7**	**TH99-15-9**	**Yukon CSR Standard**	**Sample #**	**TH99-15-7**	**Yukon CSR Standard**
Volatiles				***Physical Tests***		
Benzene	<0.04	-	0.04^{2}	Moisture %	4	-
Ethylbenzene	<0.05	-	7^{2}	pH	8.6	-
Styrene	<0.05	-	5			
Toluene	<0.05	-	2.5^{2}	***Total Metals***		-
meta- & para-Xylene	<0.05	-	20^{2}	Antimony	<20	20
ortho-Xylene	<0.05	-	20^{2}	Arsenic	2.6	15^{2}
VH C6-10	<100	-	-	Barium	118	500
VPH (C6-10)	<100	-	200	Beryllium	<0.5	4
				Cadmium	0.2	1000^{3}
Extractables				Chromium	52	60^{2}
EPH (C10-18)	<200	<200	1000	Cobalt	13	50
EPH (C19-31)	<200	<200	1000	Copper	48	$350{,}000^{4}$
				Lead	<50	$4{,}000^{4}$
				Mercury	0.043	2
				Molybdenum	<4	10
				Nickel	35	100
				Selenium	<0.1	3
				Silver	<2	20
				Tin	<10	50
				Vanadium	85	200
				Zinc	69	$15{,}000^{5}$

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.
3. Matrix numerical standard for groundwater water used for drinking (pH > 8).
4. Matrix numerical standard for groundwater used for drinking (pH > 6.5).
5. Matrix numerical standard for groundwater used for drinking (pH > 7).

A groundwater sample collected from TH99-15 (MW-15) was also analyzed for hydrocarbons. Detectable parameters were far less the standard for aquatic life or drinking water use (Table 4.37).

Table 4.37: Concentrations of Hydrocarbons (μg/L) in Water Samples Collected from Boreholes Southwest of the Maintenance Building in September 1999

Sample #	MW-15	Yukon CSR Standard	
Volatiles		**AW**	**DW**
Benzene	<0.5	3000	5
Ethylbenzene	<0.5	7000	2.4
Toluene	<0.5	3000	24
meta- & para-Xylene	<0.5	-	300
ortho-Xylene	0.8	-	-
VH (C6-10)	100	15,000[2]	-
VPH	100	1,000[2]	-
PAHs			
Acenaphthene	<0.05	60	-
Acenaphthylene	<0.05	-	-
Acridine	<0.05	0.5	-
Anthracene	<0.05	1	-
Benz(a)anthracene	<0.05	0.1	-
Benzo(a)pyrene	<0.01	-	-
Benzo(b)fluoranthene	<0.05	-	-
Benzo(g,h,i)perylene	<0.05	-	-
Benzo(k)fluoranthene	<0.05	-	-
Chrysene	<0.05	-	-
Dibenz(a,h)anthracene	<0.05	-	-
Fluoranthene	<0.05	2	-
Fluorene	<0.05	120	-
Indeno(1,2,3-c,d)pyrene	<0.05	-	-
Naphthalene	0.19	10	-
Phenanthrene	<0.05	3	-
Pyrene	<0.05	0.2	-
Extractables		-	-
EPH10-19	<100	5000[3]	-
EPH19-32	<100	-	-
LEPH	<300	500[3]	-
HEPH	<1,000	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999).

4.9 East of Maintenance Building

Historical photographs indicated a small above ground storage tank was previously located to the east of the maintenance building, near the current ventilation screens for the generators. A test pit (TP99-33) was established at the approximate location of the tank (Photograph 3.4) during the June investigation. Strong hydrocarbons odours were detected in samples collected from this test pit to a depth of 2.3 m. Results obtained for the headspace analysis of these samples with the PID ranged from 58 to 132 ppm. To delineate the lateral and vertical extent of contamination boreholes and additional test pits were excavated in the vicinity of TP99-33.

The first borehole (TH99-16) was advanced west of TP99-33, closer to the building. No hydrocarbon odour or staining was noted in this borehole to the clay layer, which was encountered at the 6 m depth approximately. The second borehole (TH99-17) was drilled near TP99-33. A faint hydrocarbon odour was detected in a sample obtained between the 2.0 to 2.5 m depths which collaborated with that observed in the test pit. A narrow clay layer, with trace hydrocarbon odour was present below this horizon (see borehole logs in Appendix A and no odour was detected beyond this layer indicating that contamination was restricted to the top 2.5 m. A monitoring well was established in TH99-17. Finally a test pit (TP99-34) was excavated 6 m east of TP-33 to determine the lateral extent of contamination in that direction. No hydrocarbon odours were detected and headspace analysis confirmed the absence of volatile hydrocarbons.

The concentrations of hydrocarbons in soil samples collected from the test pits and boreholes in this area are provided in Table 4.38. The laboratory results confirmed the olfactory observations and PID results. Extractable hydrocarbons and a few PAHs were detected in samples TP99-33-4 and TH99-17-4. The concentrations, however, did not exceed the CSR standards for residential or park land use; concentrations in TH99-16 were below detection.

Samples from TP99-33 and TH99-17 were also analyzed for halogenated volatile organic compounds to ascertain if the tank had been used for the storage of halogenated solvents commonly used as degreasers, cleaners and paint thinners. These compounds were all below detection (Table 4.39). Metals and metalloid levels in TH99-17 were either below detection or far less than CSR standard (Table 4.39).

A buried six-inch pipeline was discovered northeast of TP99-34 during the installation of a new above ground storage tanks in the area in July 1999. This line is not associated with any utility or supply in current use. A test pit (TP99-50) was therefore excavated in this area during the September program for further investigation. The pipe, which contained free product, was encountered in this test pit (see Photograph 3.15 and 3.16). A strong hydrocarbon odour was present in coarse sand surrounding the pipe and the concentration of LEPH in a sample collected from this sand (TP99-50-1) exceeded the exceeded the residential or park land use; BTEX and PAHs were all below detection.

Table 4.38: Concentration (μg/g) of Hydrocarbons in Soil Samples Collected East of the Maintenance Building

Sample #	TP33-4	TH16-4	TH16-6	TH17-4	TH17-10	TP50-1	Yukon CSR Standard
Volatiles							
Benzene	<0.04	<0.04	-	<0.04	<0.04	<0.04	8
Ethylbenzene	<0.05	<0.05	-	<0.05	<0.05	<0.05	1000
Styrene	<0.05	<0.05	-	<0.05	<0.05	<0.05	5
Toluene	<0.05	<0.05	-	<0.05	<0.05	<0.05	300
meta- & para-Xylene	<0.05	<0.05	-	<0.05	<0.05	<0.05	5
ortho-Xylene	<0.05	<0.05	-	<0.05	<0.05	<0.05	5
VH C6-10	<100	<100	-	<100	<100	<100	-
VPH C6-10 (calculated)	<100	<100	-	<100	<100	<100	200
PAHs							
Acenaphthene	<0.05	-	-	<0.1	<0.01	<0.01	-
Acenaphthylene	<0.05	-	-	<0.05	<0.01	<0.02	-
Anthracene	0.04	-	-	0.05	<0.01	<0.01	-
Benz(a)anthracene	<0.01	-	-	<0.01	<0.01	<0.01	1
Benzo(a)pyrene	<0.01	-	-	<0.01	<0.01	<0.01	1
Benzo(b)fluoranthene	<0.01	-	-	<0.01	<0.01	<0.01	1
Benzo(g,h,i)perylene	<0.01	-	-	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	<0.01	-	-	<0.01	<0.01	<0.01	1
Chrysene	<0.01	-	-	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	<0.01	-	-	<0.01	<0.01	<0.01	-
Fluoranthene	<0.01	-	-	<0.01	<0.01	<0.01	-
Fluorene	<0.02	-	-	<0.05	<0.01	<0.01	-
Indeno(1,2,3-c,d)pyrene	<0.01	-	-	<0.01	<0.01	<0.01	1
Naphthalene	0.04	-	-	<0.02	<0.01	<0.05	5
Phenanthrene	0.92	-	-	1.2	<0.01	<0.01	5
Pyrene	0.02	-	-	<0.02	<0.01	<0.01	10
Extractables							
EPH (C10-18)	598	<200	<200	715	<200	**1200**	1000
EPH (C19-31)	<200	<200	<200	495	<200	<200	1000
LEPH	597	-	-	714	<200	**1200**	1000
HEPH	<200	-	-	495	<200	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Residential/Park Land use.

Table 4.39: Concentration (µg/g) of Halogenated Organic Compounds and Metals in Subsurface Soil Samples Collected East of the Maintenance Building

Non Halogenated Volatile Organic Compounds					Metals and Physical Parameters		
Sample #	**TH99-17-4**	**TH99-17-10**	**TP99-33-4**	**Yukon Standard**	**Sample #**	**TH99-17-4**	**Yukon Standard**
Bromodichloromethane	<0.01	<0.01	<0.01	5	Moisture (%)	7.6	
Bromoform	<0.01	<0.01	<0.01		pH	8.31	
Carbon Tetrachloride	<0.01	<0.01	<0.01	5			
Chlorobenzene	<0.01	<0.01	<0.01	1	***Total Metals***		
Chloroethane	<0.01	<0.01	<0.01	5	Antimony	<20	20
Chloroform	<0.01	<0.01	<0.01	5	Arsenic	2.1	15[2]
Chloromethane	<0.01	<0.01	<0.01	5	Barium	170	500
Dibromochloromethane	<0.01	<0.01	<0.01	5	Beryllium	<0.5	4
1,2-Dichlorobenzene	<0.01	<0.01	<0.01	1	Cadmium	0.2	15[3]
1,3-Dichlorobenzene	<0.01	<0.01	<0.01	1	Chromium	46	60[2]
1,4-Dichlorobenzene	<0.01	<0.01	<0.01	1	Cobalt	12	50
1,1-Dichloroethane	<0.01	<0.01	<0.01	5	Copper	44	350,000[3]
1,2-Dichloroethane	<0.01	<0.01	<0.01	5	Lead	<50	4000[3]
cis-1,2-Dichloroethylene	<0.01	<0.01	<0.01	5	Mercury	0.044	2
trans-1,2-Dichloroethylene	<0.01	<0.01	<0.01	5	Molybdenum	<4	10
1,1-Dichloroethylene	<0.01	<0.01	<0.01	5	Nickel	32	100
Dichloromethane	<0.2	<0.2	<0.1	5	Selenium	0.1	3
1,2-Dichloropropane	<0.01	<0.01	<0.01	5	Silver	<2	20
cis-1,3-Dichloropropylene	<0.01	<0.01	<0.01	5	Tin	<10	50
trans-1,3-Dichloropropylene	<0.01	<0.01	<0.01	5	Vanadium	72	200
1,1,1,2-Tetrachloroethane	<0.01	<0.01	<0.01	5	Zinc	67	1500[3]
1,1,2,2-Tetrachloroethane	<0.01	<0.01	<0.01	5			
Tetrachloroethylene	<0.01	<0.01	<0.01	5[2]			
1,1,1-Trichloroethane	<0.01	<0.01	<0.01	5			
1,1,2-Trichloroethane	<0.01	<0.01	<0.01	5			
Trichloroethylene	<0.01	<0.01	<0.01	0.15[2]			
Trichlorofluoromethane	<0.01	<0.01	<0.01	5			
Vinyl Chloride	<0.01	<0.01	<0.01	5			

Notes:

1. Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.
3. Matrix numerical standard for groundwater used for drinking (pH > 7).

Groundwater collected from BH99-17 (MW-17) did not contain detectable levels of hydrocarbons and volatile organic compounds (Table 4.40) while metal concentrations were all below the AW and DW standards (Table 4.41).

Table 4.40: Concentration (µg/L) of Hydrocarbons and Volatile Organic Compounds in a Water Sample Collected from MW-17

Non-halogenated Volatiles	Concentration	*Halogenated Volatiles*	Concentration
Benzene	<0.5	Bromodichloromethane	<1
Ethylbenzene	<0.5	Bromoform	<1
Styrene	<0.5	Carbon Tetrachloride	<1
Toluene	<0.5	Chlorobenzene	<1
meta- & para-Xylene	<0.5	Chloroethane	<1
ortho-Xylene	<0.5	Chloroform	<1
VH C6-10	<100	Chloromethane	<1
VPH C6-10	<100	Dibromochloromethane	<1
PAHs		1,2-Dichlorobenzene	<1
Acenaphthene	<0.05	1,3-Dichlorobenzene	<1
Acenaphthylene	<0.05	1,4-Dichlorobenzene	<1
Acridine	<0.05	1,1-Dichloroethane	<1
Anthracene	<0.05	1,2-Dichloroethane	<1
Benz(a)anthracene	<0.05	cis-1,2-Dichloroethylene	<1
Benzo(a)pyrene	<0.01	trans-1,2-Dichloroethylene	<1
Benzo(b)fluoranthene	<0.05	1,1-Dichloroethylene	<1
Benzo(g,h,i)perylene	<0.05	Dichloromethane	<5
Benzo(k)fluoranthene	<0.05	1,2-Dichloropropane	<1
Chrysene	<0.05	cis-1,3-Dichloropropylene	<1
Dibenz(a,h)anthracene	<0.05	trans-1,3-Dichloropropylene	<1
Fluoranthene	<0.05	1,1,1,2-Tetrachloroethane	<1
Fluorene	<0.05	1,1,2,2-Tetrachloroethane	<1
Indeno(1,2,3-c,d)pyrene	<0.05	Tetrachloroethylene	<1
Naphthalene	<0.05	1,1,1-Trichloroethane	<1
Phenanthrene	<0.05	1,1,2-Trichloroethane	<1
Pyrene	<0.05	Trichloroethylene	<1
Extractables		Trichlorofluoromethane	<1
EPH (C10-18)	<300	Vinyl Chloride	<1
EPH (C19-31)	<1000		
LEPH	<300		
HEPH	<1000		

Table 4.41: Concentrations of Metals (µg/L) in Water Samples Collected from Monitoring Well MW-17

Parameter	Concentration	Yukon Standard	
		AW	DW
Hardness as $CaCO_3$	191		
pH	7.02		
Dissolved Metals			
Aluminum	**235**	500^3	200
Antimony	<200	300	-
Arsenic	<200	500	250
Barium	100	10,000	1,000
Beryllium	<5	53	-
Boron	<10	-	500
Cadmium	<0.2	180^4	5
Calcium	60,300	-	-
Chromium	<10	20	50
Cobalt	<10	500	-
Copper	<10	80	1000
Iron	**420**	3,000	300
Lead	<1	60	10
Magnesium	9,800	-	-
Manganese	28	1,000	50
Mercury	<0.05	1	1
Molybdenum	<30	10,000	250
Nickel	<50	1,500	-
Selenium	<1	10	10
Silver	<0.1	1	-
Sodium	3,000	-	200,000
Thallium	<0.1	3	-
Uranium	0.35	3,000	100
Zinc	<5	300	5000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Aquatic life (AW) or Drinking Water (DW).
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Standard depends on pH of the water samples (pH > 6.5).
4. Standard depends on hardness (H) of the water sample.

4.10 Rust-Coloured Drainage Ditch

Surface soil and water samples collected from locations along the rust-coloured drainage ditch north of the site were analyzed for metals, hydrocarbons and volatile organic compounds. No samples were analyzed for PCBs and pesticides in 1999 since the concentrations of these parameters in samples collected in 1995 were either below detection or very low (maximum of 0.0027 µg/g).

4.10.1 Hydrocarbons

Volatile hydrocarbons, BTEX and PAHs concentrations in soil samples were all below detection. Extractable hydrocarbons exceeding the standards was however, detected in the samples obtained close to the outlet (Table 4.42). A water sample taken from the spring where the contaminated water emerges contained detectable levels of benzene, ethylbenzene, xylene, EPH (C10 - C18), LEPH, and a few PAHs (Table 4.43). The concentration of ethylbenzene in a sample collected from the same location in 1999 (BLW-2) exceeded the drinking water standard.

Hydrocarbons concentrations in samples obtained further down the drainage channel (BLW-3 to BLW-5) were all below detection.

Table 4.42: Concentrations (µg/g) of Hydrocarbons in Soil Samples Collected from Rust-Coloured Drainage Channel

Date	1995	July 1999					YTG CSR Standard
Sample #	BLS 012	BLS-16	BLS-17	BLW-3	BLW-4	BLW-5	
Volatiles							
Benzene	-	<0.04	<0.04	-	-	-	8
Ethylbenzene	-	<0.05	<0.05	-	-	-	1000
Styrene	-	<0.05	<0.05	-	-	-	5
Toluene	-	<0.05	<0.05	-	-	-	300
meta- & para-Xylene	-	<0.05	<0.05	-	-	-	5
ortho-Xylene	-	<0.05	<0.05	-	-	-	5
VH C6-10	-	<500	<100	-	-	-	
VPH C6-10	-	<500	<100	-	-	-	200
PAHs							
Acenaphthene	-	<0.05	<0.01	-	-	<0.01	-
Acenaphthylene	-	<0.05	<0.01	-	-	<0.01	-
Anthracene	-	<0.05	<0.01	-	-	<0.01	-
Benz(a)anthracene	-	<0.05	<0.01	-	-	<0.01	1
Benzo(a)pyrene	-	<0.05	<0.01	-	-	<0.01	1
Benzo(b)fluoranthene	-	<0.02	<0.01	-	-	<0.01	1
Benzo(g,h,i)perylene	-	<0.05	<0.01	-	-	<0.01	-
Benzo(k)fluoranthene	-	<0.05	<0.01	-	-	<0.01	1
Chrysene	-	<0.05	<0.01	-	-	<0.01	-
Dibenz(a,h)anthracene	-	<0.05	<0.01	-	-	<0.01	-
Fluoranthene	-	<0.05	<0.01	-	-	<0.01	-
Fluorene	-	<0.05	<0.01	-	-	<0.01	-
Indeno(1,2,3-c,d)pyrene	-	<0.05	<0.01	-	-	<0.01	1
Naphthalene	-	<0.1	<0.01	-	-	<0.01	5
Phenanthrene	-	<0.05	<0.01	-	-	<0.01	5
Pyrene	-	<0.05	<0.01	-	-	<0.01	10
Extractables							
EPH (C10-18)	-	745	<200	<200	<200	<200	1000
EPH (C19-31)	-	**3760**	<200	<200	<200	<200	1000
LEPH	-	745	<200	-	-	<200	1000
HEPH	-	**3760**	<200	-	-	<200	1000
TEH (C10 – 30)	6800	-	-	-	-	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Residential/Park Land use.

Table 4.43: Concentrations (µg/L) of Hydrocarbons in Water Samples Collected from Rust-Coloured Drainage Channel

Year	1995	1999				Yukon CSR Standard	
Sample No.	BLGW004	BLW-2	BLW-3	BLW-4	BLW-5		
Volatiles						AW	DW
Benzene	0.52	1.4	-	-	<0.5	3,000	5
Ethylbenzene	1.7	**6.5**	-	-	<0.5	7,000	2.4
Toluene	<1.2	<0.5	-	-	<0.5	3,000	24
meta- & para-Xylene	1	2.8	-	-	<0.5		300
ortho-Xylene	0.15	<0.5	-	-	<0.5		
VH C6-10	-	200	-	-	<100	15,000[2]	-
VPH C6-10 (calculated)	-	200	-	-	<100	1,000[2]	-
PAHs							
Acenaphthene	39	0.08	-	-	<0.05	60	-
Acenaphthylene	0.004	<0.05	-	-	<0.05	-	-
Acridine	-	<0.05	-	-	<0.05	0.5	-
Anthracene	-	<0.05	-	-	<0.05	1	-
Benz(a)anthracene	<0.75	<0.05	-	-	<0.05	0.1	-
Benzo(a)pyrene	<0.43	<0.01	-	-	<0.01	-	-
Benzo(b)fluoranthene	-	<0.05	-	-	<0.05	-	-
Benzo(g,h,i)perylene	1.1	<0.05	-	-	<0.05	-	-
Benzo(k)fluoranthene	-	<0.05	-	-	<0.05	-	-
Chrysene	<0.73	<0.05	-	-	<0.05	-	-
Dibenz(a,h)anthracene	3.2	<0.05	-	-	<0.05	-	-
Fluoranthene	<2	<0.05	-	-	<0.05	2	-
Fluorene	3	0.06	-	-	<0.05	120	-
Indeno(1,2,3-c,d)pyrene	<3.2	<0.05	-	-	<0.05	-	-
Naphthalene	290	1.77	-	-	<0.05	10	-
Phenanthrene	-	<0.05	-	-	<0.05	3	-
Pyrene	<1.7	<0.05	-	-	<0.05	0.2	-
Extractables							
EPH (C10-18)	-	400	<300	<300	<300	5,000[3]	-
EPH (C19-31)	-	<1000	<1000	<1000	<1000	-	-
LEPH	-	400	-	-	<300	500[3]	-
HEPH	-	<1000	-	-	<1000	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999).

4.10.2 Metals

Tables 4.44 and 4.45 present for metals and metalloids results for soil and water samples respectively. Data for 1995 and the relevant Yukon CSR standards used are included for comparison. The generic numerical standard for residential/park land use was employed to evaluate the data except for arsenic, cadmium, chromium, copper, lead and zinc. The more stringent of the matrix numerical standard for either groundwater flow to surface water used for drinking or groundwater flow to surface water used for aquatic life was used these elements (see footnote in Table 4.45).

High levels of arsenic, barium, cobalt, selenium and zinc that exceeded the standards were found in soil samples obtained near the origin of the channel both in 1995 and 1999 (BLS013, BLS010, BLS16). Metal concentrations in samples obtained from locations 40 m beyond the origin (BLW-3 and BLW-4) and the reference location (BLS-17: a small ravine about 10 m west of stained drainage channel) were below the standard.

Concentrations of most of the metals in water samples were either below detection or well below the Yukon CSR AW standard except for aluminum, iron and manganese. The elevated concentrations in the surface water might, in some small part, be attributable to mineralization in the surrounding bedrock and overburden. Due to the natural variability of these elements, the BC Ministry of the Environment for example has deleted these elements from Generic Numerical Water Standards under the BC Contaminated Sites Regulation (BCMELP, 1999).

Aliquots of water samples from BLW-2 and BLW-5 were filtered on site using 0.45 µm inline filters for dissolved metals analysis. Comparisons of the concentrations for total and dissolved metals in the two pairs of water samples are given in Table 4.46. The dissolved metal concentrations were comparable to total metal concentrations for all the individual analytes except for aluminum, iron and manganese. This indicated that the contaminants were associated with particulates. The contaminated sediments are easily identified visually by the strong rust colouration due to the precipitation of iron oxides, which further adsorb other metals (such as arsenic, barium, selenium and zinc) from the groundwater when it surfaces.

Table 4.44: Physical Parameters and Concentration (µg/g) of Metals in Soil Samples Collected from Rust-Coloured Drainage Ditch

Year	**1995**		**1999**					**Yukon CSR Standard**
Sample #	**BLS013**	**BLS 010**	**BLS-17**	**BLS-16**	**BLW-3**	**BLW-4**	**BLW-5**	
Physical Tests								
Moisture %	92.3	79.7	29	82.3	40.8	44.8	8.6	
pH	-	-	6.89	7.39	7.43	7.14	7.24	
Total Metals								
Antimony	<10	<10	<20	<100	<20	<20	<20	20[2]
Arsenic	**138**	**85**	4.2	**218**	4	9	5.2	15
Barium	**2369**	**4770**	177	**2960**	381	485	218	500
Beryllium	<1	<1	<0.5	<3	<0.5	<0.5	<0.5	4
Cadmium	<0.25	2.2	0.4	1.6	0.9	0.6	0.2	3[3]
Chromium	59	58	42	28	37	55	**64**	60[4]
Cobalt	55	90	10	58	14	16	12	50
Copper	40	55	31	33	29	32	34	30,000[5]
Lead	<1	<1	<50	<300	<50	<50	<50	4,000[6]
Mercury	0.26	0.19	0.025	0.179	0.033	0.052	0.032	2
Molybdenum	<4	<4	<4	<20	<4	<4	<4	10
Nickel	41	**138**	27	30	30	36	34	100
Selenium	**3.1**	2.2	0.3	1.8	0.3	0.5	0.2	3
Silver	<2	17	<2	<10	<2	<2	<2	20
Tin	<5	5	<10	<50	<10	<10	<10	50
Vanadium	113	85	71	<200	61	79	76	200
Zinc	**1490**	**3570**	72	**1790**	187	196	74	1000[7]

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater flow to surface water used for drinking.
3. Matrix numerical standard for groundwater flow to surface water used for drinking (pH 7 to 7.5).
4. Matrix numerical standard for groundwater flow to surface water used for aquatic life.
5. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
6. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.5).
7. Matrix numerical standard for groundwater flow to surface water used by aquatic life (pH > 7).

Table 4.45: Physical Parameters and Concentration (µg/L) of Total Metals in Water Samples Collected from Rust-Coloured Drainage Ditch

Year	**1995**	**1999**				**Yukon CSR Standard**	
Sample #	**BL1GW004**	**BLW-2**	**BLW-3**	**BLW-4**	**BLW-5**	**AW**	**DW**
Physical Tests							
Hardness as $CaCO_3$		147	386	86.2	202		
Total Metals							
Aluminum	<150	**1740**	<30	96	147	500^3	200
Antimony	<150	<200	<200	<200	<200	300	
Arsenic	0.002	<200	<200	<200	<200	500	250
Barium	110	160	620	80	190	10,000	1000
Beryllium	<3	<5	<5	<5	<5	53	
Boron	60	<100	<100	<100	<100		500
Cadmium	<2	<0.2	<1	<0.2	<0.2	180^4	5
Calcium	46,500	46,800	124,000	27,700	57,700		
Chromium	<1	<10	<10	<10	<10	20	50
Cobalt	1	<10	<10	<10	<10	500	
Copper	2	<10	<10	<10	<10	80	1000
Iron	**2270**	**5730**	230	180	460	3,000	300
Lead	1	1	<5	<1	<1	60	10
Magnesium	5,570	7,100	18,600	4,200	8,900		
Manganese	**1640**	**2160**	**303**	**551**	**706**	1000	50
Mercury	<50	<0.05	<0.05	<0.05	<0.05	1	1
Molybdenum	<1	<30	<30	<30	<30	10,000	250
Nickel	3	<50	<50	<50	<50	1500	
Selenium	1	<1	<5	<1	<1	10	10
Silver	<1	<0.1	<0.5	<0.1	<0.1	1	
Sodium	5100	12,000	150,000	17,000	49,000	-	200,000
Thallium	-	<0.1	<0.5	<0.1	<0.1	3	
Uranium	-	0.2	0.17	0.16	0.19	3000	100
Zinc	17	45	11	<5	9	300	5000

Notes:

1. All values are in µg/L.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Standard depends on pH of the water samples (pH > 6.5).
4. Standard depends on hardness (H) of the water sample (H = 86 to 202).
5. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Aquatic life or drinking water.

Table 4.46: Comparison of Concentrations (µg/L) of Total and Dissolved Metals in Water Samples Collected from Rust-Coloured Drainage Channel

Sample #	BLW-2		BLW-5	
	Total	**Dissolved**	**Total**	**Dissolved**
Aluminum	1,740	7	147	24
Antimony	<200	<200	<200	<200
Arsenic	<200	<200	<200	<200
Barium	160	130	190	200
Beryllium	<5	<5	<5	<5
Boron	<100	<100	<100	<100
Cadmium	<0.2	<0.2	<0.2	<0.2
Calcium	46,800	47,000	57,700	64,700
Chromium	<10	<10	<10	<10
Cobalt	<10	<10	<10	<10
Copper	<10	<10	<10	<10
Iron	5,730	3,710	460	100
Lead	1	<1	<1	<1
Magnesium	7,100	6,700	8,900	9,900
Manganese	2,160	2,150	706	493
Mercury	<0.05	<0.05	<0.05	<0.05
Molybdenum	<30	<30	<30	<30
Nickel	<50	<50	<50	<50
Selenium	<1	<1	<1	<1
Silver	<0.1	<0.1	<0.1	<0.1
Sodium	12,000	13,000	49,000	55,000
Thallium	<0.1	<0.1	<0.1	<0.1
Uranium	0.2	0.12	0.19	0.17
Zinc	45	42	9	<5

4.10.3 Halogenated Volatile Organic Compounds

As with the 1995 results, the concentrations of all the compounds in this suite were below detection (Table 4.47).

Table 4.47: Concentrations (µg/g) of Halogenated Volatile Organic Compounds in Soil Samples Collected from Rust-Coloured Drainage Channel

Year	**1995**	**1999**		**Yukon CSR Standard**[1]
Sample #	**BLS012**	**BLS-16**	**BLS-17**	
Bromodichloromethane	-	<0.01	<0.01	5
Bromoform	<0.00008	<0.01	<0.01	
Carbon Tetrachloride	-	<0.01	<0.01	5
Chlorobenzene	-	<0.01	<0.01	1
Chloroethane	-	<0.01	<0.01	5
Chloroform	<0.0002	<0.01	<0.01	5
Chloromethane	-	<0.01	<0.01	5
Dibromochloromethane	<0.00008	<0.01	<0.01	5
1,2-Dichlorobenzene	-	<0.01	<0.01	1
1,3-Dichlorobenzene	-	<0.01	<0.01	1
1,4-Dichlorobenzene	-	<0.01	<0.01	1
1,1-Dichloroethane	<0.0002	<0.01	<0.01	5
1,2-Dichloroethane	<0.00014	<0.01	<0.01	5
cis-1,2-Dichloroethylene	<0.00022	<0.01	<0.01	5
trans-1,2-Dichloroethylene	-	<0.01	<0.01	5
1,1-Dichloroethylene	-	<0.01	<0.01	5
Dichloromethane	-	<0.4	<0.1	5
1,2-Dichloropropane	<0.00013	<0.01	<0.01	5
cis-1,3-Dichloropropylene	-	<0.01	<0.01	5
trans-1,3-Dichloropropylene	<0.00044	<0.01	<0.01	5
1,1,1,2-Tetrachloroethane	-	<0.01	<0.01	5
1,1,2,2-Tetrachloroethane	-	<0.01	<0.01	5
Tetrachloroethylene	NDR	<0.01	<0.01	5[2]
1,1,1-Trichloroethane	<0.00016	<0.01	<0.01	5
1,1,2-Trichloroethane	<0.00007	<0.01	<0.01	5
Trichloroethylene	<0.0002	<0.01	<0.01	0.15[3]
Trichlorofluoromethane	-	<0.01	<0.01	5
Vinyl Chloride	-	<0.01	<0.01	5

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for toxicity to soil invertebrates.
3. Matrix numerical standard for groundwater used for drinking.
4. NDR = Peak detected but did not meet quantification criteria.

4.10.4 Contaminant Distribution at Rust Coloured Drainage Ditch

Drawing 1 shows an estimation of the extent of metal and hydrocarbon contamination along the drainage ditch. The contaminated substrate is easily demarcated by the brown-rust colour arising from the precipitation of iron oxides. Excavations along the channel indicated the maximum depth of the rust staining is 3 cm. The stained sediments have a maximum depth of up to 3 cm.

A metal culvert that terminated at the source of the drainage channel was uncovered during the site investigation. This collaborated results of the 1995 EM survey that indicated that a buried pipe originating between the shop and residence terminated at the drainage ditch. It is strongly suspected that the culvert serves as a conduit for contaminated water plume. The culvert, based on an EM survey conducted in 1995, passes through the contaminated area, with its source at the former location of the burn pit.

4.11 Assessment of Contamination at Localized Surface Stains and Buried Debris

The requirements for further investigations in a number of locations at Blanchard River Maintenance Camp arose directly out of the identification during preliminary environmental investigations of possible previous burial activity through non-intrusive electromagnetic (EM) surveys. As described in the methods section (Chapter 3), representative areas within these areas were examined using test pits that were excavated to a depth of between approximately one and three meters using a backhoe. In all cases, the final depth of excavation extended well below natural, undisturbed soil horizons. The areas investigated during the 1999 investigations included the rafters' camp and storage areas, a push out dump north of the residence and other general locations.

4.11.1 Rafters Camp and Storage Area

A whitewater rafting company currently uses the series of worked areas to the south of the station as storage, camping grounds and parking lots. A spring-fed pipe in this area also provides a water supply for the camp. The concentration of metals, VOCs and hydrocarbons in a sample collected from this spring in 1995 were either below detection or very low. Anomalies from the 1995 EM survey suggested buried metallic debris were present in the worked areas. A few surface stains were also noted around the parking lots.

Apart from a few metal braces and cans and an old plastic tarpaulin near the surface, no debris was found in three test pits (TP99-31 to TP99-32) initially established in the area to ground truth the EM anomalies. No hydrocarbon odours were detected in these pits and extractable hydrocarbon concentrations in one of the pits (TP99-30-1) were all below detection (Table 4.48).

Further investigations were carried out at the parking lot near these test pits in July 1999. This followed the observation of hydrocarbon staining and odours in a pit excavated for a new outhouse at the eastern edge of the pad. Six shallow test pits (TP0799-1 to TP0799-6) were excavated using hand shovels to maximum depth of 90 cm near the outhouse. Visible staining and hydrocarbon odours were noted in the top few centimetres of soils in the test pits. Samples collected from the stains (TP0799-2, TP0799-4 and TP0799-5) contained EPH at levels that exceeded the Yukon CSR standard for parkland use.

Additional investigations were conducted in September 1999 with the excavation of two test pits in the stained areas to a depth of 2.6 m and 3.3 m respectively. Soils near the surface had very strong odours, whereas samples from the bottom of the excavation had barely detectable odours. EPH concentrations in a sample that was taken at the 3.3 m depth (TP99-56-2) were below detection (Table 4.43).

Three test pits (TP99-57 to 60) were also excavated at the second parking lot to the western edge of the campground. Domestic garbage including wood, plastic and glass was found from a depth of 30 cm to 1 m in TP99-58. EPH levels in the sample from this pit were below detection. Visible debris, staining or odours were not detected in the other two pits.

Metals and metalloids concentrations in samples taken from the test pits from various areas of the rafters' camp were all below the Yukon CSR standard (Table 4.49). All chlorinated pesticides and PCBs were also below detection (Table 4.50).

The results presented above indicate that surface soils at the rafters' parking lot are contaminated with hydrocarbons. The contamination, however, is restricted to surface soils and may have resulted from minor spills from parked vehicles. The hydrocarbon distribution report (Appendix F) suggested a mixture of diesel, gasoline and heavy oils that is consistent with spillage from vehicles.

Table 4.48: Concentration (µg/g) of Extractable Hydrocarbons (EPH) in Soil Samples Collected from the Rafters Camp

Sample #	**TP99-30-1**	**TP0799-1**	**TP0799-2**	**TP0799-4**	**TP0799-5**	**TP99-56-2**	**TP99-58-1**	**Yukon CSR Standard**
EPH (C10-18)	<200	<200	306	**3730**	**1640**	<200	<200	1000
EPH (C19-31)	<200	613	**7970**	**3180**	600	<200	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land.

Table 4.49: Physical Parameters and Concentration (mg/L) of Metals in Soil Samples Collected from Rafters Camp

Sample #	**TP99-32-1**	**TP0799-6**	**TP99-56-2**	**TP99-58-1**	**Yukon CSR Standard**[1]
Physical Tests					
Moisture %	5	3.2	16.1	18.8	
pH	6.36	6.37	7.56	6.12	
Total Metals					
Antimony	<20	<20	<20	<20	20
Arsenic	5.1	<5.0	<5	<5	15[2]
Barium	121	114	123	180	500
Beryllium	<0.5	<0.5	<0.5	<0.5	4
Cadmium	0.1	<0.5	<0.5	<0.5	1.5[3]
Chromium	38	42	44	57	60[2]
Cobalt	10	12	13	12	50
Copper	34	30	50	31	1,500[4]
Lead	<50	<50	<50	<50	250[6]
Mercury	0.033	0.027	0.041	0.03	2
Molybdenum	<4	<4	<4	<4	10
Nickel	31	31	33	32	100
Selenium	0.2	0.1	<2	<2	3
Silver	<2	<2	<2	<2	20
Tin	<10	<10	<10	<10	50
Vanadium	61	77	81	80	200
Zinc	51	63	60	60	200[6]

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater used for drinking.
3. Matrix numerical standard for groundwater used for drinking (pH <6.5).
4. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH 6.0 - 6.5).
5. Matrix numerical standard for groundwater used for drinking (pH 6.0 - 6.5).
6. Matrix numerical standard for groundwater flow to surface water used by aquatic life (pH 6.0 - 6.5).

Table 4.50: Concentration (µg/g) of Polychlorinated Biphenyls (PCBs) and Chlorinated Pesticides in Soil Samples Collected from Rafters Camp

Sample #	TP99-31-1	TP0799-1	TP0799-2	TP0799-4	TP0799-5	Yukon CSR Standard[1]
Polychlorinated Biphenyls						
Total PCBs	<0.05	<0.05	<0.05	<0.05	<0.05	5[2]
Organochloride Pesticides						
Aldrin	<0.001	<0.001	<0.01	<0.003	<0.003	-
alpha-BHC	<0.001	<0.001	<0.01	<0.003	<0.003	2
beta-BHC	<0.002	<0.002	<0.02	<0.003	<0.003	2
delta-BHC	<0.001	<0.001	<0.01	<0.001	<0.001	2
cis-Chlordane (alpha)	<0.001	<0.001	<0.01	<0.001	<0.001	-
trans-Chlordane (gamma)	<0.001	<0.001	<0.01	<0.001	<0.001	-
2,4'-DDD	<0.001	<0.001	<0.01	<0.001	<0.001	-
4,4'-DDD	<0.001	<0.001	<0.01	<0.001	<0.001	-
2,4'-DDE	<0.002	<0.002	<0.02	<0.002	<0.002	-
4,4'-DDE	<0.001	<0.001	<0.01	<0.001	<0.001	-
2,4'-DDT	<0.001	<0.001	<0.01	<0.001	<0.001	-
4,4'-DDT	<0.002	<0.002	<0.02	<0.002	<0.002	-
Dieldrin	<0.001	<0.001	<0.01	<0.001	<0.001	-
Endosulfan I	<0.001	<0.001	<0.01	<0.001	<0.001	-
Endosulfan II	<0.001	<0.001	<0.01	<0.001	<0.001	-
Endosulfan Sulfate	<0.001	<0.001	<0.01	<0.001	<0.001	-
Endrin	<0.005	<0.005	<0.05	<0.005	<0.005	-
Endrin Aldehyde	<0.001	<0.001	<0.01	<0.001	<0.001	-
Heptachlor	<0.002	<0.002	<0.02	<0.002	<0.002	-
Heptachlor Epoxide	<0.001	<0.001	<0.01	<0.001	<0.001	-
Lindane (gamma - BHC)	<0.001	<0.001	<0.01	<0.003	<0.003	2
Methoxychlor	<0.005	<0.005	<0.05	<0.005	<0.005	-
Mirex	<0.001	<0.001	<0.01	<0.001	<0.001	-
cis-Nonachlor	<0.001	<0.001	<0.01	<0.001	<0.001	-
trans-Nonachlor	<0.001	<0.001	<0.01	<0.001	<0.001	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for ingestion of contaminated soils.

4.11.2 Dump North of Residence Building

Debris including a diesel manifold, electrical cable and metal shutters were noted in a small dump near the gravel stockpile north of the residence. Review of historical information suggested that debris from the demolition of the six original accommodation trailers were buried in this area of the site. As such, three test pits (TP-23 to TP-25) were excavated. No visible debris other than pieces of wood were encountered in the test pits excavated in the dump suggesting that debris was limited to surface of ground only. Excavations were not conducted west of TP99-25 since the area is currently used as the septic field.

Soil samples collected from the test pits (TP99-23-1, TP99-24-1 and TP99-24-2) were analyzed for hydrocarbons, PCBs and organochlorine pesticides. The concentrations of all these parameters were below detection (Table 4.51 and 4.52).

Table 4.51: Concentration (µg/g) of Hydrocarbons in Soil Samples Collected from Dump North of Residence Building

Sample #	TP99-23-1	TP99-24-1	TP99-24-2	Yukon CSR Standard
Physical Parameters				
Moisture %	10.5	20.9	21.4	
Extractables				
EPH (C10-18)	<200	<200	<200	1000
EPH (C19-31)	<200	<200	<200	1000

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land.

Table 4.52: Concentration (µg/g) of Polychlorinated Biphenyls (PCBs) and Chlorinated Pesticides in Soil Samples Collected from the Dump North of the Residence Building

Sample #	**TP99-23-1**	**TP99-24-1**	**TP99-24-2**	**Yukon CSR Standard**
Physical Parameters				
Moisture %	10.5	20.9	21.4	
Polychlorinated Biphenyls				
Total PCBs	<0.05	<0.05	<0.05	5^2
Organochloride Pesticides				
Aldrin	<0.001	<0.001	<0.001	-
alpha-BHC	<0.001	<0.001	<0.001	2
beta-BHC	<0.002	<0.002	<0.002	2
delta-BHC	<0.001	<0.001	<0.001	2
cis-Chlordane (alpha)	<0.001	<0.001	<0.001	-
trans-Chlordane (gamma)	<0.001	<0.001	<0.001	-
2,4'-DDD	<0.001	<0.001	<0.001	-
4,4'-DDD	<0.001	<0.001	<0.001	-
2,4'-DDE	<0.002	<0.002	<0.002	-
4,4'-DDE	<0.001	<0.001	<0.001	-
2,4'-DDT	<0.001	<0.001	<0.001	-
4,4'-DDT	0.009	<0.002	<0.002	-
Dieldrin	<0.001	<0.001	<0.001	-
Endosulfan I	<0.001	<0.001	<0.001	-
Endosulfan II	<0.001	<0.001	<0.001	-
Endosulfan Sulfate	<0.001	<0.001	<0.001	-
Endrin	<0.005	<0.005	<0.005	-
Endrin Aldehyde	<0.001	<0.001	<0.001	-
Heptachlor	<0.002	<0.002	<0.002	-
Heptachlor Epoxide	<0.001	<0.001	<0.001	-
Lindane (gamma - BHC)	<0.001	<0.001	<0.001	2
Methoxychlor	<0.005	<0.005	<0.005	-
Mirex	<0.001	<0.001	<0.001	-
cis-Nonachlor	<0.001	<0.001	<0.001	-
trans-Nonachlor	<0.001	<0.001	<0.001	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for ingestion of contaminated soils.

4.12 Potable Water

Hydrocarbon and metal concentrations in two potable water samples were obtained from the pressure tanks within the maintenance building were either less than the limit of detection or below the Yukon CSR drinking water standard. Thus the concentrations of these parameters in potable water continue to meet acceptable limits.

Table 4.53: Concentration (µg/L) of Hydrocarbons and Metals in Potable Water Samples

Sample #	BLDW-1	BLDW-2	Yukon CSR Drink Water Standard
Physical Tests			
Hardness as CaCO3	62.3	0.13	-
Non-halogenated Volatiles			-
Benzene	<0.5	<0.5	5
Ethylbenzene	<0.5	<0.5	2.4
Toluene	<0.5	<0.5	24
meta- & para-Xylene	<0.5	<0.5	300
ortho-Xylene	<0.5	<0.5	-
VH C6-10	<100	<100	-
VPH C6-10 (calculated)	<100	<100	-
Total Metals			
Aluminum T-Al	<5	<5	200
Antimony T-Sb	<200	<200	-
Arsenic T-As	<200	<200	250
Barium T-Ba	50	<10	1,000
Beryllium T-Be	<5	<5	-
Boron T-B	<100	<100	500
Cadmium T-Cd	<0.2	3.6	5
Calcium T-Ca	18,800	50	-
Chromium T-Cr	<10	<10	50
Cobalt T-Co	<10	<10	-
Copper T-Cu	<10	20	1,000
Iron T-Fe	<30	<30	300
Lead T-Pb	2	9	10
Magnesium T-Mg	3,700	<100	-
Manganese T-Mn	<5	<5	50
Mercury T-Hg	<0.05	<0.05	1
Molybdenum T-Mo	<30	<30	250
Nickel T-Ni	<50	<50	-
Selenium T-Se	6	<1	10
Silver T-Ag	<0.0	<0.1	-
Sodium T-Na	<2,000	<2,000	200,000
Thallium T-Tl	<0.1	<0.1	-
Uranium T-U	1.39	<0.01	100
Zinc T-Zn	64	9	5,000

4.13 Quality Assurance/Quality Control (QA/QC)

4.13.1 Field QA/QC

The field QA/QC program incorporated measures, which ensured the integrity of the soil, sediment and water samples. Aspects of the program are described in the following sections.

4.13.1.1 Sampling Protocols

In order to guarantee that all the samples collected maintained their integrity prior to analysis, the general protocols presented in Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites (CCME, 1993) were used. Briefly, each sample was collected using dedicated pre-cleaned equipment. All the samples were placed in appropriate pre-cleaned containers supplied by the analytical laboratories. The containers were labeled, placed in coolers and transported via Canadian Air Cargo to the laboratory for analysis. Sample information was recorded on the chain-of-custody forms, copies of which accompanied the shipment.

All events were documented in field notebooks. Records included: date, time, site identification, site conditions, sample type, preservatives, visual characteristics, odour, and chain of custody.

4.13.1.2 Field Quality Control Samples

In addition to samples collected to meet the objective of the overall program, field duplicate samples were taken to meet the QA/QC objective of monitoring precision/reproducibility of sampling activities (Table 4.54).

Table 4.54: Field Duplicate Samples Collected at Blanchard River

Sample Type	Designation of Field Duplicates	Number of Field Duplicates
Surface Soils	BLS-19 and BLS-20	1
Test Pits	TP24-1 & TP24-1, TP28-2 & TP28-3	2
Boreholes	TH12-5 & TH12-16 TH13-16 & TH13-21 TH15-5 & TH15-16 TH19-6 and TH19-7 TH24-13 & TH24-20	5
Groundwater	MW-5 & MW-D1 MW-12 and MW-D2 TH-5 and TH-30	3
	Total Number of Field Duplicates	**11**

Other field QA/QC samples included one surface soil background sample obtained from an un-impacted area west of the rust coloured drainage ditch, one sediment taken from the Blanchard River up stream of the site for reference, and two travelling blanks.

4.13.2 Laboratory QA/QC

Water and soil/sediment samples were analyzed at Analytical Services Laboratory (ASL), Vancouver, BC. ASL has been evaluated and accredited by the Canadian Association for Environmental Laboratories (CAEL).

Prior to and throughout the field program, the laboratory was contacted to ensure that all QA/QC objectives; such as detection limits, proper sample containers, and sample delivery; were being met.

The QA/QC program, set up to monitor data quality and reliability on an ongoing basis, included running all samples in batches of varying sizes with control samples, which accompanied the set through the entire analytical procedure. These control samples included the following:

- analytical or procedural duplicates to monitor precision or reproducibility of the results;
- procedural blanks to monitor interferences from potential laboratory contamination; and,
- internal spike standards
- standard reference materials

Laboratory results for replicate samples are discussed along with data for field duplicate samples in the next sections. Data for internal spike standards and reference materials have not been included in this report and are available upon request.

4.13.3 Evaluation of Quality Control Samples

Field duplicate samples were submitted to the laboratory for analysis as individual samples. The data obtained was evaluated by direct comparison or by using the relative percent difference (RPD) when only two samples are available. The RPD is expressed mathematically as:

$$\mathrm{RPD} = 100\left[\frac{(x_1 - x_2)}{\left\{\frac{(x_1 + x_2)}{2}\right\}}\right]$$

where x_1 and x_2 are the concentrations of the analytes above the detection limits

Where more than two measurements are available, the Relative Standard Deviation (RSD) or the Coefficient of Variation (CV) is used. Mathematically,

$$\mathrm{RSD} = \mathrm{CV} = 100 \times \frac{S}{x_i}$$

where x_i is the arithmetic mean and S is the standard deviation.

Values of RPD or RSD less than 30% indicate reasonable to good precision, while those exceeding this value are considered fair to poor.

4.13.4 Volatile Hydrocarbons

4.13.4.1 Field Duplicates for Soil Samples

Three pairs of field duplicate samples were analyzed for volatile hydrocarbons, which included BTEX, VH and VPHs. The relative percent difference for ethylbenzene, toluene, xylenes, VH and VPH, which were found in TH12-5/TH12/16, were between 10 and 22%. The concentrations of all the parameters in the remaining two pairs of samples (TH24-13/TH24-20 and TH13-16/TH13-21) were below detection (Table 4.55). These results indicated good reproducible for the determination of volatile hydrocarbons in soils.

Table 4.55: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Volatile Hydrocarbons in Field Duplicate Soil Samples

Parameter	Field Duplicate		Mean	RPD (%)	Field Duplicate		Field Duplicate	
	TH12-5	TH12-16			TH24-13	TH24-20	TH13-16	TH13-21
Benzene	<0.04	<0.04	-	-	<0.04	<0.04	<0.04	<0.04
Ethylbenzene	0.49	0.61	0.55	21	<0.05	<0.05	<0.05	<0.05
Styrene	<0.05	<0.05	-	-	<0.05	<0.05	<0.05	<0.05
Toluene	0.89	1.11	1	22	<0.05	<0.05	<0.05	<0.05
meta- & para-Xylene	2.74	3.42	3.08	22	<0.05	<0.05	<0.05	<0.05
ortho-Xylene	1.55	1.92	1.735	21	<0.05	<0.05	<0.05	<0.05
VH (C6-10)	117	130	124	10	<100	<100	<100	<100
VPH	111	123	117	10	<100	<100	<100	<100

4.13.4.2 Laboratory Duplicate for Soil Samples

The concentrations of almost all volatile hydrocarbons in four pairs of laboratory duplicates were below detection except for meta- and para- xylene in TH12-5 (Table 4.56). The relative percent different for this detectable analyte was 18.5%. Thus, good reproducibility was obtained for the laboratory duplicates for volatile hydrocarbon analysis.

Table 4.56: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Volatile Hydrocarbons in Laboratory Duplicate Soil Samples

Parameter	June 1999								Sept 1999	
	Lab Duplicate		Mean	RPD (%)	Lab Duplicate		Lab Duplicate		Lab Duplicate	
	TH12-5	TH12-5			TH16-4	TH16-4	TP35-3	TP35-3	TH29-9	TH29-9
Benzene	<0.04	<0.04	-	-	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Ethylbenzene	<0.05	<0.05	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Styrene	<0.05	<0.05	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	<0.05	<0.05	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
meta- & para-Xylene	0.05	0.06	0.055	18.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
ortho-Xylene	<0.05	<0.05	-	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
VH C6-10	<100	<100	-	-	<100	<100	<100	<100	<100	<100
VPH C6-10	<100	<100	-	-	<100	<100	<100	<100	<100	<100

4.13.4.3 Field Duplicates for Water Samples

Reproducibility for the analysis of non-halogenated volatile hydrocarbons in water was monitored with two pairs of field duplicate samples (Table 4.57). The relative percent difference for the analytes in the June samples were acceptable, however, RPD values for the September field duplicate samples were relatively high ranging from 17 to 95%. The water samples obtained from MW-5 were turbid and the difference in concentrations may be attributable to particulates.

Table 4.57: Concentrations (µg/L), Mean and Relative Percent Difference (RPD) of Volatile Hydrocarbons in Field Duplicate Water Samples

Parameter	June '99 Field Duplicate		Mean	RPD (%)	Sept '99 Field Duplicate		Mean	RPD (%)
	MW-5	MW-D1			TH5	TH5		
Benzene	0.1	0.1	0.1	0.0	0.07	0.09	0.08	25
Ethylbenzene	2.61	2.75	2.68	5.2	4.14	3.32	3.73	22
Styrene	0.11	0.11	0.11	0.0	-	-	-	-
Toluene	0.19	0.14	0.165	30	0.06	0.17	0.115	95
meta- & para-Xylene	6.23	6.8	6.515	8.7	6.05	5.1	5.58	17
ortho-Xylene	4.52	4.32	4.42	4.5	3.7	5.95	4.82	46
VH (C6-10)	100	100	100	0.0	90	110	100	20
VPH C6-10	90	80	85	11.8	70	100	85	35

4.13.4.4 Laboratory Duplicates for Water Samples

Good reproducibility was obtained for laboratory duplicate samples as indicated by the RPD of 0 to 15.5% obtained for the three pairs of duplicate samples analyzed (Table 4.58).

Table 4.58: Concentrations (µg/L), Mean and Relative Percent Difference (RPD) of Volatile Hydrocarbons in Laboratory Duplicate Water Samples

June 1999							September 1999			
Parameter	**Lab Duplicate**		**Mean**	**RPD (%)**	**Lab Duplicate**		**Lab Duplicate**		**Mean**	**RPD (%)**
	MW-14	**MW-14**			**MP-3**	**MP-3**	**TH5**	**TH5**		
Benzene	<0.5	<0.5	-	-	<0.5	<0.5	0.7	0.6	0.65	15.4
Ethylbenzene	0.48	0.46	0.47	4.3	<0.5	<0.5	41.4	37	39.2	11.2
Toluene	1.5	1.4	1.45	6.9	<0.5	<0.5	0.6	0.6	0.6	0.0
meta- & para-Xylene	12.1	11.8	11.95	2.5	<0.5	<0.5	60.5	51.8	56.2	15.5
ortho-Xylene	39.4	38.8	39.1	1.5	<0.5	<0.5	37	31.9	34.4	14.8
VH (C6-10)	500	500	500	0.0	<100	<100	900	800	850	11.8
VPH C6-10	400	400	400	0.0	<100	<100	700	700	700	0.0

4.13.5 Extractable Hydrocarbons

4.13.5.1 Field Duplicates for Soil Samples

Extractable hydrocarbons – EPH (C10 –19), EPH (C19 – 32), LEPH and HEPH – were analyzed in seven pairs of field duplicate samples (Table 4.59). The relative percent differences for detectable parameters were within acceptable limits (5 to 23%) with the exception of EPH (C10 – 19) data for TP28-2/3. The high RPD (76%) for this pair was due to sample heterogeneity in that the substrate comprised sand and gravel.

Table 4.59: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Extractable Hydrocarbons in Field Duplicate Soil Samples

June 1996												
Parameter	**Field Dup.**		**Mean**	**RPD (%)**	**Field Dup.**		**Field Dup.**		**Field Dup.**		**Mean**	**RPD (%)**
	TH12-5	**TH12-16**			**TH13-16**	**TH13-21**	**TP24-1**	**TP24-2**	**TP28-2**	**TP28-3**		
EPH10-19	912	962	937	5.3	<200	246	<200	<200	1710	764	1237	76
EPH19-32	<200	<200	-	-	<200	<200	<200	<200	<200	<200	-	-
LEPH	911	960	935.5	5.2	<200	246	-	-	-	-	-	-
HEPH	<200	<200	-	-	<200	<200	-	-	-	-	-	-
September 1996												
Parameter	**Field Dup.**		**Mean**	**RPD (%)**	**Field Dup.**		**Mean**	**RPD (%)**	**Field Dup.**		**Mean**	**RPD (%)**
	TH19-6	**TH19-7**			**TH24-13**	**TH24-20**			**BLS-19**	**BLS-20**		
EPH10-19	<200	<200	-	-	<200	256	-	-	365	289	327	23
EPH19-32	<200	<200	-	-	<200	<200	-	-	523	427	475	20
LEPH	<200	<200	-	-	<200	256	-	-	365	289	327	23
HEPH	<200	<200	-	-	<200	<200	-	-	523	427	475	20

4.13.5.2 Laboratory Duplicates for Soil Samples

As with the field duplicates, good reproducibility was obtained for all but one of 13 pairs of laboratory duplicate samples (Table 4.60). The RPD for BLS-10 was 59% indicted poor precision. This was due to the nature of the substrate that consisted of a mixture of sand, gravel and organic matter.

Table 4.60: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Volatile Hydrocarbons in Laboratory Duplicate Soil Samples

June 1996												
Parameter	Lab Dup.		Lab Dup.		Lab Dup.		Lab Dup.		Lab Dup.		Mean	RPD (%)
	TH6-7	TH6-7	TH11-5	TH11-5	TH16-4	TH16-4	TP35-3	TP35-3	TP15-1	TP15-1		
EPH10-19	<200	<200	<200	<200	<200	<200	<200	<200	1430	1360	1395	5.0
EPH19-32	<200	<200	<200	<200	<200	<200	<200	<200	264	238	251	10.4

September 1996												
Parameter	Lab Dup.		Lab Dup.		Lab Dup.		Mean	RPD (%)	Lab Dup.		Mean	RPD (%)
	TP46-1	TP46-1	TH18-8	TH18-8	CS-37	CS-37			CS-51	CS-51		
EPH10-19	<200	<200	<200	<200	1870	1640	1755	13.1	5000	5020	5010	0.4
EPH19-32	<200	<200	<200	<200	<200	<200	-	-	<200	<200	-	-
LEPH	-	-	<200	<200	-	-	-	-	-	-	-	-
HEPH	-	-	<200	<200	-	-	-	-	-	-	-	-

September 1996												
Parameter	Lab Dup.		Lab Dup.		Lab Dup.		Mean	RPD (%)	Lab Dup.		Mean	RPD (%)
	TH21-9	TH21-9	TH18-8	TH18-8	BLS-10	BLS-10			BLS-20	BLS-20		
EPH10-19	<200	<200	<200	<200	423	231	327	59	289	293	291	1.4
EPH19-32	<200	<200	<200	<200	<200	<200	-	-	427	323	375	28
LEPH	<200	<200	<200	<200	-	-	-	-	289	293	291	1.4
HEPH	<200	<200	<200	<200	-	-	-	-	427	323	375	28

4.13.5.3 Field Duplicates for Water Samples

Reproducibility was very poor for one of the two sets of duplicate samples analyzed (Table 4.61). This result was attributed to particulates in the water sample obtained from MW-14, which was turbid.

Table 4.61: Concentrations (µg/L), Mean and Relative Percent Difference (RPD) of Extractable Hydrocarbons in Field Duplicate Water Samples

Parameter	Field Duplicate		Mean	RPD (%)	Field Duplicate		Mean	RPD (%)
	MW-5	MW-5			MW-12	MW-12		
EPH (C10-18)	13600	13300	13450	2.2	3500	38500	21000	166
EPH (C19-31)	2000	2000	2000	0.0	<1000	12000	12000	-
LEPH	13400	13100	13250	2.3	3400	38300	20850	167
HEPH	2000	2000	2000	0.0	<1000	12000	12000	-

4.13.6 Polycyclic Aromatic Hydrocarbons (PAHs)

4.13.6.1 Field Duplicate for Soil Samples

Results for five pairs of field duplicate samples that were analyzed for PAHs are given in Table 4.62. The concentrations of most of the PAHs were below detection. The RPD for detectable parameters were between 0.0 and 40% indicating fair to good reproducibility.

Table 4.62: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Polycyclic Aromatic Hydrocarbons in Field Duplicate Soil Samples

Parameter	Field Duplicate		Mean	RPD (%)	Field Duplicate		Mean	RPD (%)	Field Duplicate	
	BLS-19	BLS-20			TH19- 6	TH19- 7			TH24-13	TH24-20
Acenaphthene	<0.04	<0.02	--	--	<0.01	<0.01	--	--	<0.01	<0.03
Acenaphthylene	<0.02	<0.02	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Chrysene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Fluorene	0.05	0.07	0.06	33	0.01	<0.01	--	--	<0.01	0.02
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Naphthalene	<0.07	<0.06	--	--	0.23	0.28	0.255	20	<0.01	<0.1
Phenanthrene	0.04	0.06	0.05	40	<0.01	<0.01	--	--	<0.01	0.06
Pyrene	0.01	0.01	0.01	0.0	0.03	<0.01	--	--	<0.01	<0.01

Parameter	Field Duplicate		Mean	RPD (%)	Field Duplicate		Mean	RPD (%)	Note: Mean and RPD values were not calculated for TH24-13 and TH24-20 since all parameters were below detection for TH24-13
	TH12-5	TH12-16			TH13-16	TH13-21			
Acenaphthene	0.12	0.13	0.125	8.0	<0.02	<0.02	--	--	
Acenaphthylene	0.03	0.04	0.035	28	<0.01	<0.01	--	--	
Anthracene	<0.01	<0.01	--	--	0.01	<0.02	--	--	
Benz(a)anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Benzo(a)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Benzo(b)fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Benzo(g,h,i)perylene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Benzo(k)fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Chrysene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Dibenz(a,h)anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Fluorene	0.17	0.16	0.165	6.1	0.02	<0.03	--	--	
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	
Naphthalene	1.33	1.51	1.42	13	0.05	0.06	0.055	18	
Phenanthrene	0.06	0.05	0.055	18	0.04	<0.05	--	--	
Pyrene	<0.01	<0.01	--	--	0.04	<0.04	--	--	

4.13.6.2 Laboratory Duplicate for Soil Samples

Reproducibility for the laboratory duplicates was good as indicated by RPD values of 0.0% for detectable analytes (Table 4.63).

Table 4.63: Concentrations (μg/g), Mean and Relative Percent Difference (RPD) of Polycyclic Aromatic Hydrocarbons in Laboratory Duplicate Soil Samples

Parameter	Lab Duplicate		Mean	RPD (%)	Lab Duplicate		Mean	RPD (%)	Lab Duplicate	
	TH12-5	TH12-5			TH18-8	TH19- 7			TH21-9	TH21-9
Acenaphthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Chrysene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Fluoranthene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Fluorene	<0.01	<0.01	--	--	0.02	0.02	0.2	0.0	<0.01	0.02
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--	<0.01	<0.01
Naphthalene	0.06	0.06	0.06	0.0	0.04	0.04	0.04	0.0	<0.01	<0.1
Phenanthrene	0.01	0.01	0.01	0.0	0.05	0.05	0.05	0.0	<0.01	<0.01
Pyrene	<.01	0.01	--	--	0.02	0.02	0.02	0.0	<0.01	<0.01

4.13.6.3 Field Duplicates for Water Samples

As with extractable hydrocarbons in water samples (Section 4.13.5.3) reproducibility was generally poor for PAHs in MW-12 due to the presence of particulates in the water sample (Table 4.64).

Table 4.64: Concentrations (µg/L), Mean and Relative Percent Difference (RPD) of Polycyclic Aromatic Hydrocarbons in Field Duplicate Water Samples

Parameter	Field Duplicate		Mean	RPD (%)	Field Duplicate		Mean	RPD (%)
	MW-5	MW-D1			MW-12	MW-D2		
Acenaphthene	1.84	3	2.42	48	1.06	21	11.03	180
Acenaphthylene	0.41	<1	--	--	0.26	3	1.63	168
Acridine	<0.1	<1	--	--	<0.05	<2	--	--
Anthracene	0.14	<1	--	--	<0.05	4.8	4.8	--
Benz(a)anthracene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Benzo(a)pyrene	<0.01	<0.01	--	--	<0.01	<0.01	--	--
Benzo(b)fluoranthene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Benzo(g,h,i)perylene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Benzo(k)fluoranthene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Chrysene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Dibenz(a,h)anthracene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Fluoranthene	0.11	0.08	0.095	31	<0.05	0.53	--	--
Fluorene	1.8	4	2.9	76	0.97	29.5	15.2	187
Indeno(1,2,3-c,d)pyrene	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Naphthalene	197	175	186	12	63.8	65.8	64.8	3.1
Phenanthrene	2.3	5	3.65	74	0.14	51.1	25.62	198
Pyrene	0.49	0.47	0.48	4.2	<0.05	3.6	--	--

4.13.7 Metals

4.13.7.1 Field Duplicates for Soil Samples

Metal in soil analysis was monitored with one pair of a field duplicate sample (Table 4.65). Good precision was obtained for all detectable analytes based on the RPD values (0.0 to 17%).

Table 4.65: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Metals in Field Duplicate Soil Samples

Parameter	Field Duplicates		Mean	Relative Percent Difference (%)
	BLS-19	BLS-20		
Physical Tests				
Moisture %	46.7	39	42.8	18
pH	6.1	6.17	6.15	1.1
Total Metals				
Antimony	<20	<20	--	--
Arsenic	5	5	5	0.0
Barium	293	269	281	8.5
Beryllium	<0.5	<0.5	--	--
Cadmium	0.7	0.6	0.65	15.4
Chromium	60	65	62	8.0
Cobalt	13	14	13.5	7.4
Copper	38	37	37.5	2.7
Lead	<50	<50	--	--
Mercury	0.046	0.041	0.044	11.5
Molybdenum	<4	<4	--	--
Nickel	35	35	35	0.0
Selenium	<2	<2	--	--
Silver	<2	<2	--	--
Tin	<10	<10	--	--
Vanadium	88	93	90.5	5.5
Zinc	509	428	468	17

4.13.7.2 Laboratory Duplicates for Soil Samples

Four sets of laboratory duplicates were analyzed to monitored laboratory reproducibility (Table 4.66). Good to fair precision was obtained for all detectable analytes based on the RPD values (0.0 to 37%).

Table 4.66: Concentrations (µg/g), Mean and Relative Percent Difference (RPD) of Metals in Laboratory Duplicate Soil Samples

Parameter	**Lab Duplicate**		**Mean**	**RPD (%)**	**Lab Duplicate**		**Mean**	**RPD (%)**
	TH6-7	**TH6-7**			**TH11-5**	**TH11-5**		
Moisture %	46.7	39	42.85	18	4.5	4.9	4.7	8.5
pH	6.1	6.17	6.135	1.1	8.15	8.04	8.095	1.4
Total Metals								
Antimony T-Sb	<20	<20	--	--	<20	<20	--	--
Arsenic T-As	1.2	0.9	1.05	29	5	4	4.5	22
Barium T-Ba	307	306	306.5	0.3	167	115	141	37
Beryllium T-Be	<0.5	<0.5	--	--	<0.5	<0.5	--	--
Cadmium T-Cd	0.4	0.3	0.35	29	0.2	0.2	0.2	0.0
Chromium T-Cr	90	90	90	0.0	44	49	46.5	10.8
Cobalt T-Co	21	20	20.5	4.9	14	14	14	0.0
Copper T-Cu	70	72	71	2.8	36	34	35	5.7
Lead T-Pb	<50	<50	--	--	<50	<50	--	--
Mercury T-Hg	0.165	0.149	0.157	10.2	0.048	0.038	0.043	23
Molybdenum T-Mo	<4	<4	--	--	<4	<4	--	--
Nickel T-Ni	0.3	0.3	0.3	0.0	32	32	32	0.0
Selenium T-Se	<2	<2	--	--	<2	<2	--	--
Silver T-Ag	<2	<2	--	--	<2	<2	--	--
Tin T-Sn	<10	<10	--	--	<10	<10	--	--
Vanadium T-V	127	124	125.5	2.4	77	78	77.5	1.3
Zinc T-Zn	97	98	97.5	1.0	70	65	67.5	7.4

cont'd

Table 4.66: Continued

Parameter	**Lab Duplicate**		**Mean**	**RPD (%)**	**Lab Duplicate**		**Mean**	**RPD (%)**
	BLS-10	**BLS-10**			**BLS-20**	**BLS-20**		
Moisture %	61.2	62.2	61.7	1.6	39	33.3	36.15	15.8
pH	7.4	7.37	7.385	0.4	6.17	6.1	6.135	1.1
Total Metals								
Antimony T-Sb	<40	<40	--	--	<20	<20	--	--
Arsenic T-As	15	11	13	31	5	<5	--	--
Barium T-Ba	774	648	711	17.7	269	237	253	12.6
Beryllium T-Be	<1	<1	--	--	<0.5	<0.5	--	--
Cadmium T-Cd	0.5	0.6	0.55	18	0.6	0.6	0.6	0.0
Chromium T-Cr	71	83	77	15.6	65	53	49	20
Cobalt T-Co	23	23	23	0.0	12	14	13	15.4
Copper T-Cu	51	53	52	3.8	37	34	35.5	8.5
Lead T-Pb	<100	<100	--	--	<50	<50	--	--
Mercury T-Hg	0.088	0.101	0.095	13.8	0.041	0.041	0.041	0.0
Molybdenum T-Mo	<8	<8	--	--	<4	<4	--	--
Nickel T-Ni	50	49	49.5	2.0	35	31	33	12.1
Selenium T-Se	<2	<2	--	--	<2	<2	--	--
Silver T-Ag	<4	<4	--	--	<2	<2	--	--
Tin T-Sn	<20	<20	--	--	<10	<10	--	--
Vanadium T-V	106	118	112	10.7	93	74	83.5	23
Zinc T-Zn	369	299	334	21	428	474	451	10.2

4.13.7.3 Field Duplicates for Water Samples

Two sets of field duplicate water samples were analyzed for metals (Table 4.47). The RPD for detectable parameters were between 0.0 and 6.9% indicating good reproducibility.

Table 4.67: Concentrations (µg/L), Mean and Relative Percent Difference (RPD) of Metals in Field Duplicate Water Samples

Parameter	Field Duplicate		Mean	RPD (%)	Field Duplicate		Mean	RPD (%)
	MW-5	MW-D1			MW-12	MW-D2		
Physical Tests								
Hardness CaCO3	456	477	466.5	4.5	58.4	59.5	58.95	1.9
Dissolved Metals								
Aluminum D-Al	<30	<10	--	--	100	107	103.5	6.8
Antimony D-Sb	<200	<200	--	--	<200	<200	--	--
Arsenic D-As	<200	<200	--	--	<200	<200	--	--
Barium D-Ba	490	480	485	2.1	140	150	145	6.9
Beryllium D-Be	<5	<5	--	--	<5	<5	--	--
Boron D-B	300	400	350	28.6	<100	<100	--	--
Cadmium D-Cd	<1	<0.4	--	--	<0.2	<0.2	--	--
Calcium D-Ca	151,000	158,000	154500	4.5	18,500	18,900	18700	2.1
Chromium D-Cr	<10	<10	--	--	<0.01	<0.01	--	--
Cobalt D-Co	<10	<10	--	--	<10	<10	--	--
Copper D-Cu	<10	<10	--	--	<10	<10	--	--
Iron D-Fe	19,000	18,500	18750	2.7	16,100	16,400	16250	1.8
Lead D-Pb	<5	<2	--	--	<1	<1	--	--
Magnesium D-Mg	19,200	19,700	19450	2.6	3,000	3,000	3000	0.0
Manganese D-Mn	1930	2090	2010	8.0	2500	2540	2520	1.6
Mercury D-Hg	<0.05	<0.05	--	--	<0.05	<0.05	--	--
Molybdenum D-Mo	<30	<30	--	--	<30	<30	--	--
Nickel D-Ni	<50	<50	--	--	<50	<50	--	--
Selenium D-Se	<5	<2	--	--	<1	<1	--	--
Silver D-Ag	<0.5	<0.2	--	--	<0.1	<0.1	--	--
Sodium D-Na	14,000	15,000	14500	6.9	3,000	3,000	3000	0.0
Thallium D-Tl	<0.5	<0.2	--	--	<0.1	<0.1	--	--
Uranium D-U	0.34	0.37	0.355	8.5	0.22	0.22	0.22	0.0
Zinc D-Zn	<5	<5	--	--	6	6	6	0.0

4.13.7.4 *Laboratory Duplicates for Water Samples*

In order to monitor reproducibility for metal in water analysis, one laboratory duplicate sample was analyzed (Table 4.68). Good to fair precision was indicated based on the RPD values of 0.0 to 40% obtained.

Table 4.68: Concentrations (µg/L), Mean and Relative Percent Difference (RPD) of Metals in Laboratory Duplicate Water Samples

Parameter	Laboratory Duplicate		Mean	RPD (%)
	MW-2	MW-2		
Physical Tests				
Hardness CaCO3	109	114	111.5	4.5
Dissolved Metals				
Aluminum D-Al	50	51	50.5	2.0
Antimony D-Sb	<200	<200	--	--
Arsenic D-As	<200	<200	--	--
Barium D-Ba	280	290	285	3.5
Beryllium D-Be	<5	<5	--	--
Boron D-B	<100	<100	--	--
Cadmium D-Cd	<0.2	<0.2	--	--
Calcium D-Ca	35,000	36,500	35750	4.2
Chromium D-Cr	<10	<10	--	--
Cobalt D-Co	20	30	25	40
Copper D-Cu	<10	<10	--	--
Iron D-Fe	45,900	47,800	46850	4.1
Lead D-Pb	<1	<1	--	--
Magnesium D-Mg	5,300	5,500	5400	3.7
Manganese D-Mn	8,790	9,150	8970	4.0
Mercury D-Hg	<0.05	<0.05	--	--
Molybdenum D-Mo	<30	<30	--	--
Nickel D-Ni	<50	<50	--	--
Selenium D-Se	<1	<1	--	--
Silver D-Ag	<0.1	<0.1	--	--
Sodium D-Na	2,000	2,000	2000	0.0
Thallium D-Tl	<0.1	<0.1	--	--
Uranium D-U	0.15	0.15	0.15	0.0
Zinc D-Zn	<5	<5	--	--

4.13.8 Chlorinated Hydrocarbons

The concentrations of all chlorinated hydrocarbons including volatile organic compounds (VOCs), PCBs, and pesticides such as DDTs in duplicate soil and water samples were below detection. Direct comparisons of the results indicate good reproducibility.

5. SCREENING-LEVEL RISK ASSESSMENT AND RISK MANAGEMENT OPTIONS

5.1 Introduction

A summary and discussion of issues at the site where the possibility of contaminant risks to humans or ecological receptors were provisionally identified is presented in this Chapter. The results of the detailed site investigation are provided in Chapter 4.

Risks to living organisms are plausible where there is simultaneously the presence of a contaminant of potential concern, an organism or group of receptor organisms present (receptors), and an exposure pathway between the contaminant source and the receptor - either presently or in the future. For the purpose of this report, a contaminant was deemed to be of potential concern if there was evidence that the concentration in soil, water, or sediment exceeded the relevant environmental quality benchmarks, as presented in Section 4.1. In some cases, possible risks may be identified regardless of the contaminant concentration in instances where –

- there is evidence of the introduction of contaminants into sensitive ecosystems or microhabitats;
- highly valued or endangered species are present; or,
- there is evidence of introduction of deleterious substances into fish-bearing waters, as defined within the Federal Fisheries Act.

If a contaminant of potential concern was identified from an area of the Blanchard River site, evidence for contaminant transport (exposure pathways) and the ecological attributes of receiving environment (ecological receptors) are described in more detail. Situations where there may be elevated risks to humans at the site, based on exceedances of environmental quality benchmarks are also discussed.

For areas of Blanchard River Station where exceedances of environmental quality or human health protective benchmarks were identified, options for curtailing the possible risks in these areas are discussed. In general, risks may be managed or eliminated by either removing the contaminant source and contaminated environmental media, or by rendering any exposure pathways inoperative to ensure that the contaminant(s) cannot come into contact with living organisms in the future. In limited cases, it may be appropriate to manage risks by limiting the possibility that a receptor organism can gain access to the contaminated area.

5.2 Contaminants and Areas of Potential Concern at the Site

Various soil, ground water, and Blanchard River water and sediment samples have been screened as part of the 1995 and 1999 studies for levels of metals/metalloids, petroleum hydrocarbon constituents (VPH, LEPH, HEPHs, PAHs, BTEX), halogenated volatile organics, chlorinated pesticides, and PCBs. **Of these, halogenated volatile organics, chlorinated pesticides, or PCBs were not detected in any sample at levels of concern.** All chlorinated analytes were found to be either less than the method detection limit, or well below the relevant environmental quality benchmarks, in all samples.

Petroleum hydrocarbon contamination of subsurface soils was identified, originating from a variety of historical or current activities. Metals/metalloid contamination was also observed in surface and subsurface soils. The metal contamination occurred in association with hydrocarbon-contaminated soils, however, as discussed in Section 5.2.1, below. **The contaminant issues at Blanchard River identified to the present time are all based on petroleum hydrocarbon releases of various sizes.** Individual releases were identified as follows:

1. **Historical operation of an unlined burn pit during the operation of the pumping station** (prior to conversion of the site to a highway maintenance camp) to the north of the pump house and present day maintenance garage (see also Section 4.4). Hydrocarbons and metal-contaminated groundwater emerging into and creating a rust-coloured stained drainage ditch at the north end of the site, and leading down to the Blanchard River (Section 4.10), were associated with historical petroleum hydrocarbon contamination from this burn pit. Given the size of the contaminated area and role of the contaminated soil in the mobilization of metals/metalloids to the draw leading down to the Blanchard River, this was identified as an area of concern at the site. Additional details are provided in Section 5.2.1.

2. **Hydrocarbons in the subsurface environment at depth to the south end of the maintenance building**. This area of the site leads to where hydrocarbon releases to the Blanchard River have been visually observed on occasion as a small, intermittent sheen. The hydrocarbons are deemed to have been introduced primarily through a soak away pit at the top part of the embankment. The soak away pit was constructed as part of the original pump station, to receive floor drainage from the maintenance building. The soak away pit, however, was not decommissioned as part of the conversion of the pump station to a highways maintenance camp. Rather, the system was 'tested' and reconnected to overflow from a simple oil/water separator constructed in the southwest corner of the building. This area of the maintenance building is presently used as a wash-down area and welding bay.

   Some of the introduction of hydrocarbons to the subsurface environment may have occurred via direct overflow of the oil/water separator through holes in the side of the pit and outside of the building foundation. These holes allowed the routing of two vents for the separator to the outside of the building; however, the foundation was not sealed around the vent pipes, and there was evidence of staining on the side of the oil/water separator at a height above the vent holes. **This area was identified as being of concern since the hydrocarbon contaminated groundwater plume directly interacts with the Blanchard River.** Additional details are provided in Section 5.2.2.

3. **Hydrocarbons and materials introduced in the past and on an ongoing basis to the floor drains of the northern portion of the maintenance building** and then to a **rock-filled soak away pit** within 10 m of the building foundation to the west (see Drawing 1). The detailed site investigation indicated that soils in the immediate vicinity of the rock pit exhibited strong visual and olfactory evidence of hydrocarbon contamination. Soil samples and groundwater collected from Borehole 15, immediately down gradient from the rock pit at a distance of approximately 5 m, however, did not contain any petroleum hydrocarbon constituents in excess of the relevant environmental quality benchmarks (see also Section 4.5). No hydrocarbon odours were detected using the photoionization detector. Extractable petroleum hydrocarbons and BTEX were less than the analytical detection limits in the samples collected at depths of 4 and 5.5 m.

   The rock soak away pit was not deemed to have contributed to extensive hydrocarbon contamination in the subsurface environment. There were hydrocarbon-contaminated soils and rock within the perforated culvert from which the rock pit was constructed, as well as in the immediate vicinity of the pit. Of perhaps greater concern is that the rock pit was still in active use at the time of the detailed site investigation. There was concern, therefore, that further loading of contaminants from the shop floor drains could result in future, more extensive contamination of the subsurface environment. It was felt that this might reduce the value of site restoration activities for the burn pit area, which is close by.

   It was also noted during the site visit and in consultation with the Maintenance Camp manager, that the rock pit functions poorly and that water backs up into the shop drains during times of heavy use. This is due to limited separation between the end of the discharge pipe and soak away pit. There is limited ability to surcharge the water table before hydraulic gradient is reversed towards the shop. **Recommendations for the decommissioning of the present disposal regime for the floor drain system have been provided to DIAND and YTG under separate cover** (UMA, 2000). **From the perspective of this site investigation, it is assumed that the rock pit will be replaced with more up-to-date oil/water separation technology, with offsite disposal of recovered oily waste for recycling.** The localized hydrocarbon-contaminated materials within and around the pit do not appear to have resulted in a more widespread lateral or down-gradient contamination of the subsurface environment. In addition, the pit is located at considerable distance from areas of the site where groundwater could emerge and thus interact with human or ecological receptors, provided that no artificial conduit for migration exits. **Removal or isolation of the decommissioned rock pit, therefore, is not deemed to be necessary based on the expected limited risks to the environment.**

4. **Historical release from the largest above ground storage tank** (still present, but empty) south of the maintenance building (contaminant data provided in Section 4.7). Test pit excavations in the vicinity of the larger of two existing above-ground storage tanks (ASTs), at the southeast corner of the maintenance yard, and the associated analysis of soils, provided evidence of detectable hydrocarbons in subsurface soils. The analytical data from all boreholes and test pits samples in the vicinity of the larger AST, however, demonstrated that the concentration of hydrocarbons did not exceed the Yukon CSR standards. In addition, there is no evidence that this minimally contaminated soil mass is creating appreciable groundwater contamination, or the movement of hydrocarbons to adjacent surface areas where humans or ecological receptors might be exposed. **This area, therefore, is excluded as an area of potential concern.**

5. **Historical release from a smaller above ground storage tank to the east of the present-day office** of the maintenance building, and upgradient of the drinking water well for the camp.

   The results of the detailed site investigation for this area are provided in Section 4.9. In spite of strong olfactory evidence of volatile organics (possibly gasoline) in the soil beneath the former tank location, soil samples and photoionization detector profiles indicated a rapid decline in concentration from shallow subsurface soils to background (and non-detectable) concentrations at a depth of 2.5 m - within the unsaturated zone (TH99-17). In addition, another borehole, TH99-16, advanced between TH99-17 and the location of the sites drinking water well did not reveal any evidence of contamination down to the maximum excavation depth of 6 m, where a clay aquitard was encountered.

   The detailed site investigation indicated that a historical release from this tank had occurred, but that soil or groundwater concentrations for various petroleum hydrocarbon constituents were lower than the applicable environmental quality benchmarks. The depth and lateral extent of contaminated soils was clearly delineated. A possibility that the historical release might be adversely affecting the drinking water supply for the camp was ruled out.

   Additional evidence for the integrity of the drinking water supply is based on the direct analysis of various drinking water samples for metals and BTEX, as described in Sections 2.3.6 and 4.12. **In light of the detailed site investigation, this portion of the site was not deemed to be of concern, and no mitigative actions are advocated at the present time.**

6. **Localized hydrocarbon contaminated soil in the subsurface environment just inside the maintenance yard fence line, and at the location where the original Haines-Fairbanks pipeline entered the pump station yard**. It is evident that free product in at least some portions of the line was not removed prior to decommissioning. Small portions of the six-inch line that led off the main eight-inch line remain in the ground, with free product occurring in low sections, between breaks in the line.

   There is no evidence that limited free product releases from remaining buried pipeline have adversely impacted the site, except through the contamination of very small subsurface soil masses. **It is recommended therefore that the presence of free product be carefully documented. Should an opportunity present itself, it might be prudent to recover the remaining free product through use of a vacuum truck or similar method.** No further mitigative action appears to be warranted.

7. **Surficial hydrocarbon contamination in the parking area near the Rafter's Camp, and to the south of the maintenance camp**. Section 4.11.1 describes the results from surficial and tests pit samples for visually stained areas near the rafter's camp. It was evident from the analytical results that the staining was recent, and limited to shallow soils, with a decline at depths of 2 to 3 m or less.

   The presence of localized hydrocarbon-contaminated soils in this area of the site suggests recent release, probably associated with draining of and the inappropriate discarding of used crankcase oils from motor vehicles.

   It is recommended that measures be taken to control the unauthorized disposal of used oil in the future. The present limited spatial extent and level of hydrocarbon contamination (< 200 to approximately 8,000 μg/g light or heavy extractable petroleum hydrocarbons) probably does not pose a significant risk to wildlife or humans, since the area affected relative to the overall site size is very limited, and the contaminated soil is primarily subsurface. **The concentration of hydrocarbons in the surficial, sandy unsaturated soils is expected to slowly decrease over time through natural attenuation (through volatilization, photolysis, and biodegradation).**

5.2.1 Issues Associated with Hydrocarbon-Contamination Historically Originating from the Burn Pit

Table 5.1 summarizes samples and analytes for which concentrations exceeded the relevant environmental quality guidelines for northern portion of the Blanchard River site.

Table 5.1: Cases Where Environmental Quality Guidelines Were Exceeded – Burn Pit Area (North of Maintenance Building)[1]

Sample Type	Sample Number	Analyte	Concentration (µg/g-soils; µg/L-water)	Standard or Guideline
Test pit - soil	TP99-11-1	LEPHs (C10-C18)	2520	1000
		HEPHs (C19-C31)	19300	1000
		chromium	78	60[2]
	TP99-11-2	benzene	0.71	0.04
		ethylbenzene	7.06	7
		xylenes (total)	80	20
		VPH (C6-C10)	2590	200
		naphthalene	10.8	5
	TP99-13-1	EPHs (C10-C18)	1260	1000[3]
	TP99-13-2	EPHs (C10-C18)	1470	1000
	TP99-28-2	EPHs (C10-C18)	1710	1000
Borehole – soil	TH99-12-10	LEPHs (C10-C18)	1250	1000
	TH95-6-7	chromium	90	60
Groundwater	MW99-1	Naphthalene	16.5	10
		LEPHs (>nC10-C18)	1100	500
	MW99-2	naphthalene	34.7	10
		LEPHs (>nC10-C18)	5800	500
	MW99-12 (duplicate only)	benzene	34.4	5
		ethylbenzene	62.2	2.4
		meta- & para-xylene	457	24
		ortho-xylene	376	300
		anthracene	4.8	1.0
		naphthalene	65.8	10
		phenanthrene	51.1	3
		pyrene	3.6	0.2
		LEPHs (>nC10-C18)	38500	500

Notes:

1. Iron and manganese in groundwater were excluded as contaminants of potential concern based on the dependence of their concentrations in the subsurface environment on redox related adsorption-dissolution phenomena.
2. Standard depends on hardness (H) of the water sample (H = 86 to 202).
3. Standard assumes that virtually all of EPH concentration is equivalent to LEPH fraction.

The overall pattern of contamination reinforces the hypothesis that the subsurface soils and groundwater at the north end of the site have been influenced by the historical release of a relatively light petroleum hydrocarbon mixture from the former burn pit. The hydrocarbon distribution suggests a slightly weathered gasoline-like mixture, possibly with contributions of a lighter diesel-like mixture. For the vast majority of samples, higher molecular weight fractions, including five- and six-ring PAHs, were not detected, and are not deemed be of concern at the north end of the site. Elevated concentrations of BTEX constituents, naphthalene and LEPHs in groundwater samples beneath or down gradient from the former burn pit indicate that the subsurface soils are acting as a source of petroleum hydrocarbon contamination to the groundwater.

The inferred spatial extent of the contaminated groundwater plume is discussed in Section 4.4. The concentrations of hydrocarbon constituents in water samples from monitoring wells MW99-3, 4, and 8 and in the soils from TH99-7 suggest that subsurface hydrocarbon contamination does not extend to areas where groundwater would surface, and hence potentially comprise a risk to terrestrial or aquatic organisms.

An obvious exception to this is the emergence of petroleum hydrocarbon and metal contaminated water from the end of a small diameter culvert at the top of the small drainage ditch, which contains rust-coloured soils. This draw leads down from the bench and into a wetland. Water emanating from this portion of the site runs more diffusely through several poorly defined channels in the wetland, prior to entering the Blanchard River.

Table 5.2 summarizes metal and hydrocarbon concentrations in soil and water samples taken along the contaminated discharge pathway that exceed the relevant environmental quality benchmarks.

Table 5.2: Cases Where Environmental Quality Guidelines Were Exceeded – Rust-Coloured Drainage Ditch at N. End of Site

Sample Type	Sample Number	Analyte	Concentration (µg/g – soils; µg/L - water)	Standard or Guideline
Surface soil/ sediment	BLS013 (1995)	arsenic	138	15
		barium	2370	500
		selenium	3.1	3
		zinc	1490	1000
	BLS 010 (1995)	arsenic	85	15
		barium	4770	500
		nickel	138	100
		zinc	3570	1000
	BLS-16	arsenic	218	15
		barium	2960	500
		zinc	1790	1000
		HEPHs (C19-C31)	3760	1000
	BLW-5	chromium	64	60
Surface water	BLGW004 (1995)	naphthalene	290	10
	BLW-2	ethylbenzene	6.5	2.4

Notes:

1. Aluminum, iron and manganese were excluded as contaminants of potential concern based on the dependence of their concentrations in the subsurface environment on redox related adsorption-dissolution phenomena.

Water sample BLW-2 and soil sample BLS-16, near the top of the draw, showed evidence of petroleum hydrocarbon contamination (ethylbenzene and HEPHs, respectively). Petroleum hydrocarbon odours were also noted in water emerging from the culvert, into the top end of the ravine. All of the tabulated soil samples were contaminated beyond the relevant Yukon CSR standards with arsenic, barium and zinc. The concentrations of these and other metals/metalloids decreased in concentration down the discharge path.

Overall, the sampling and analytical program confirmed that contaminants emerging from the subsurface environment at the top of the rust-coloured draw decreased in concentration along the drainage path to the Blanchard River. There was no evidence for elevated concentrations of either petroleum hydrocarbons or metals in water, sediment, or soils in or immediately up stream from the Blanchard River, at concentrations beyond which risks to aquatic or terrestrial organisms would be plausible.

Rust coloured surficial soils/sediments at the upper end of the channel, however, were obviously metal contaminated. The spatial extent of contamination could be inferred visually through the presence of rust-coloured deposits along the discharge path. The source of the metals/metalloids was likely due to the dissolution from naturally occurring minerals in the subsurface environment, within the hydrocarbon contaminated groundwater plume associated with the burn pit. Petroleum hydrocarbons tend to serve as a carbon source (food substance) for microbial consortia in the subsurface environment. The consumption of oxygen by aerobic heterotrophs results in a decrease in the groundwater redox potential. Iron- and manganese oxyhydroxides readily dissolve under reduced redox conditions, and elevated dissolved concentrations of iron and manganese are transported in the groundwater. The amorphous iron and manganese oxyhydroxides are also excellent substrates for the adsorption of other metals and metalloids (especially arsenic) under oxidizing conditions, and limit solubility. Under suboxic conditions, solubility is greatly enhanced.

Detailed investigations in 1999 showed that the culvert, which was previously identified in 1995 using an EM survey, was serving as a conduit for the diversion of petroleum- and metal-contaminated groundwater to the rust-coloured draw. This is discussed in greater detail in Section 6. Typically, the spatial distribution of metals/metalloids, which are mobilized into groundwater in association with petroleum hydrocarbon contamination, is highly limited once groundwater emerges into a surface environment and is re-oxidized. Under renewed oxic conditions, iron and manganese are rapidly removed from solution, and the resulting relatively insoluble hydroxides produced adsorb arsenic and various metal ions. The observed metal distribution along the discharge, as shown in Table 4.44, Section 4.10, is consistent with expectations based on the underlying theories on metal/metalloid speciation and fate.

5.2.2 Contaminant Concerns Associated with Hydrocarbon Releases at the Southwest End of the Maintenance Building

As mentioned above, small, intermittent oil sheen has been observed occasionally at the shoreline of the Blanchard River to the east of the site. A borehole installed in 1995 at the southern edge of maintenance yard (TH95-5) confirmed the presence of subsurface hydrocarbon contamination, both in soils and groundwater.

The 1999 detailed site investigation allowed a detailed delineation of the extent of the hydrocarbon contaminant plume based on elevated levels of extractable petroleum hydrocarbons, BTEX components, and/or PAHs in either subsurface soils or groundwater. The inferred spatial extent of the contaminated groundwater plume is discussed in Section 4.5.

The advancement of new boreholes at the south end of the site in 1999 allowed us to rule out the existing operating and decommissioned above ground storage tanks as the major source of the petroleum hydrocarbon plume. The samples from the southern portion of the site that exceeded Yukon CSR relevant soil and groundwater quality standards are shown in Table 5.3.

Table 5.3: Cases Where Environmental Quality Guidelines Were Exceeded – Southwest End of Maintenance Building[1]

Sample Type	Sample Number	Analyte	Concentration (µg/g-soils; µg/L-water)	Standard or Guideline
Test pit – soil	TP99-15-1	LEPHs (C10-C19)	1420	1000
Borehole – soil	TH99-9-7	LEPH (C10 – C19)	11000	1000
		HEPH (C19 – C32)	28600	1000
	TH99-14-7	chromium	113	60
	TH99-18-6	LEPH (C10-C19)	1050	1000
	TP99-21-2	LEPH (C10-C19)	1030	1000
Groundwater	MW-5 (July)	ethylbenzene	27.5	2.4
		naphthalene	175	10
		phenanthrene	5	3
		pyrene	0.47	0.2
		LEPH	13,100	500
	MW14 (July)	naphthalene	35.5	10
		LEPH	12,300	500
	MW-5 (Sept)	ethylbenzene	41.4	2.4
		anthracene	1.6	1
		naphthalene	342	10
		phenanthrene	21	3
		pyrene	0.98	0.2
		LEPH	23,300	500
	MW-13 (Sept)	LEPH	800	500
	MW-14 (Sept)	LEPH	4,100	500
	MW-18 (Sept)	LEPH	1,700	500
	MW-19 Sept)	LEPH	5,600	500
	MP-3 (June)	LEPH	1,800	500
	MP-3 (Sept)	LEPH	19,200	

Notes:

1. Iron and manganese in groundwater were excluded as contaminants of potential concern based on the dependence of their concentrations in the subsurface environment on redox related adsorption-dissolution phenomena.
2. Standard depends on hardness (H) of the water sample (H = 86 to 202).

Chapter 4 describes the site hydrogeology in this part of the site. The major source of hydrocarbons to the subsurface environment was the soak away pit, constructed as part of the original pumping station and continued in use after conversion of the site to a highways maintenance camp. The major source of petroleum hydrocarbon inputs in recent years (post-1985) was from the floor drains in the welding bay, at the southern most end of the maintenance complex, via the oil/water separator. As mentioned previously, there is also some possibility that additional input to the contaminant plume might have occurred via leakage from the oil/water separator through the building foundation and into soils at the outside edge of the foundation. Overall, it is believed that the hydrocarbon contamination is limited to the shallow upper aquifer, which is underlain by a dense, homogenous clay aquitard. No attempt was made to advance a borehole beyond the base of the upper aquifer, since – in the absence of the appropriate drilling techniques – this might have created a future conduit for the introduction of hydrocarbons to deeper layers. The clay layer, however, plays a major role in acting as a vertical barrier to contaminant movement.

The petroleum hydrocarbon plume does not daylight on the lower bench, between the site and the river. The width of the plume as of the time of the site investigation, and concentrations of various hydrocarbon constituents in either groundwater or subsurface soils, can be approximated by the data from four boreholes/monitoring wells established on the lower bench (TH99-9, 10, 18, 19) along a line which is approximately perpendicular to the inferred groundwater flow direction. The western most edge of the plume was not ascertained, since TH99-18 was deemed to be contaminated and the site topography prevented the placement of an addition borehole in a more westerly direction. The subsurface soils and groundwater obtained from borehole/monitoring well TH99-19/MW19 exhibited no evidence of contamination, beyond the relevant Yukon CSR values (less than detection), and the elevation of only naphthalene and pyrene in soils at detectable concentrations (range of 0.03 to 0.28 μg/g for both in five soil samples from various depths; Table 4.23). This locale, therefore, delineates the eastern flank of the contaminant plume.

Since there is no evidence that contaminated groundwater resurfaces on the lower bench, there are no pathways that would result in risks to terrestrial receptors in this area of the site. Soils within the top 1.5 m or more are not contaminated with LEPHs or other hydrocarbon constituents. Since the contaminant plume emerges along the bank of the Blanchard River, and potentially farther out in the river as well, the ecological receptors of concern include aquatic life, such as salmonids or stream invertebrates.

The best estimate of the concentrations of various hydrocarbon constituents in the groundwater plume immediately upgradient from the river is afforded by the groundwater data for samples from mini-piezometers MP-3 and -4, installed in the bank of the river at or below the seasonal high water mark. As can be seen from Table 5.3 and 5.4, the documented concentrations of LEPH in only MP-3 were observed to exceed Yukon water quality standards for the protection of aquatic life, after dividing by ten to remove any allowance for dilution between groundwater and the surface water body.

Table 5.4 shows the concentrations of petroleum hydrocarbon constituents in water samples collected from the eastern shore of the Blanchard River upstream (BLW-7), and at the point where the contaminant plume enters (BLW-6). It is clear that, following mixing of the groundwater with the river, the concentrations of all substances of concern are reduced to background river concentrations, and below levels of concern based on the

Yukon CSR standards. In addition, there was only limited evidence of elevated levels of petroleum hydrocarbons or other contaminants in sediment samples from the Blanchard River relative to the upstream reference sample, or in comparison with CCME sediment quality standards (see Chapter 4; Table 4.30). The LEPH and HEPH concentrations in the sediment sample from site BLW-6 were 258 and 266 μg/g, respectively, while they were both < 200 μg/g for BLW-7.

The available data suggest that, based on current site conditions, the risks to aquatic life are not elevated. From a risk management perspective, it is anticipated that the source of petroleum hydrocarbon input would be curtailed following the installation of an up to date oil/water separation technology (Chapter 6). The existing, partially historical contaminated subsurface soil mass at the south end of the site lies at a depth of around 11-13 m below the surface of the upper bench and approximately 6 m below the surface of the lower bench (i.e. at an absolute elevation which is only slightly higher than the river elevation). In addition, the maximum concentration of LEPHs and other petroleum hydrocarbon constituents is found immediately overlying the clay layer, within a saturated zone that is seasonally variable and very thin on average. This would suggest that the total *in situ* mass of hydrocarbons in the soil or groundwater is limited (see also Chapter 4).

Because there was no evidence of exceedances of aquatic life standards within the river itself, and because the input source for the contaminant plume would no longer be active following its replacement, it is worthwhile exploring the necessity of removing the remaining deep, subsurface soils within the contaminant plume. Should this potentially ongoing contaminant source be demonstrated to result in unacceptable risks to Blanchard River ecological receptors, there are at least three major risk management or risk reduction strategies which merit further investigation. These are (i) contaminated soil removal, (ii) in situ remediation, and (iii) construction of an active or passive barrier upgradient from the outflow face in order to eliminate contamination of the river.

Table 5.4: Concentrations (µg/L) of Hydrocarbons in Water Samples Collected from Mini-Piezometers and the Blanchard River.

Date	**June 1999**		**Sept. 1999**	**June 1999**		**Yukon CSR Standard**	
Sample #	**MP-4**	**MP-3**	**MP-3**	**BLW-7**	**BLW-6**	**AW**	**DW**
Volatiles							
Benzene	<0.5	<0.5	<0.5	-	<0.5	3,000	5
Ethylbenzene	<0.5	<0.5	<0.5	-	<0.5	7,000	2.4
Toluene	<0.5	<0.5	<0.5	-	<0.5	3,000	24
meta- & para-Xylene	<0.5	<0.5	<0.5	-	<0.5	-	300
ortho-Xylene	<0.5	<0.5	1.8	-	<0.5	-	-
VH (C6-10)	<100	<100	100	-	<100	15,000[3]	-
VPH	<100	<100	100	-	<100	1,000[3]	-
PAHs							
Acenaphthene	<0.05	0.09	<3	<0.05	<0.05	60	-
Acenaphthylene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Acridine	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	-
Anthracene	<0.05	<0.05	0.58	<0.05	<0.05	1	-
Benz(a)anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	-
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01	-	-
Benzo(b)fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Benzo(g,h,i)perylene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Benzo(k)fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Chrysene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Dibenz(a,h)anthracene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Fluoranthene	<0.05	<0.05	<0.05	<0.05	<0.05	2	-
Fluorene	<0.05	<0.05	2.46	<0.05	<0.05	120	-
Indeno(1,2,3-c,d)pyrene	<0.05	<0.05	<0.05	<0.05	<0.05	-	-
Naphthalene	<0.05	<0.7	<0.5	<0.05	<0.05	10	-
Phenanthrene	<0.05	<0.05	**3.46**	<0.05	<0.05	3	-
Pyrene	<0.05	0.14	**0.86**	<0.05	<0.05	0.2	-
Extractables							
EPH10-19	<300	1,800	**19,200**	<300	<300	5,000[3]	-
EPH19-32	<1000	<1000	3,000	<1000	<1000	-	-
LEPH	<300	**1,800**	**19,200**	<300	<300	500[3]	-
HEPH	<1000	<1000	3,000	<100	<100	-	-

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Standards for Aquatic Life (AW) and/or Drinking Water (DW) use.
2. Aquatic life assumes minimum 1:10 dilution is available.
3. Values taken from BC CSR (BC MELP, 1999)

The absence of contaminant concentrations in the river itself in excess of the relevant Yukon CSR standards suggests that there is no immediate need to undertake extensive risk management activities. In the absence of immediate intervention, the subsurface contaminated soils will continue to contribute low-level PHC inputs to the river via partitioning into groundwater. In addition, some diminution of petroleum hydrocarbon concentration is expected through biodegradation, especially since the contaminated soils at this area of the site do not appear to undergo extensive bouts of anoxia (the microbial degradation of various petroleum hydrocarbon constituents generally occurs more rapidly in oxic than anoxic conditions). The finite mass of petroleum hydrocarbons will diminish over time; however, no specific numerical estimates have been undertaken.

Finally, there is some possibility that the contaminant plume will migrate down gradient over time such that contaminant concentrations at the outflow face could increase initially (accounting for retardation) and then decrease after that. At present, the maximum groundwater concentration of LEPHs was encountered in MW-5 (Sept., 1999 data), on the upper bench. The detailed site investigation did not include any attempt to predict future groundwater hydrocarbon concentrations at the outflow face into the river, as opposed to characterization of present-day conditions. In the absence of any other risk management activities, therefore, changes in concentration over time in the location of the mini-piezometers should be monitored.

5.3 Critical Evaluation of Human Health Issues at the Site

5.3.1 Drinking Water Integrity

Various stakeholders have expressed concern about the quality of drinking water at the site. This concern is based in part on the presence of localized subsurface hydrocarbon contamination near the drinking water well, as well as previously unknown extent of hydrocarbon contamination at the site. In addition, details of the construction of the drinking water well, which predates the conversion of the pump station to a highways maintenance camp, or off the spring used by the rafters/outfitters for drinking water, are not available. For the well, the depth to the aquifer from which drinking water is drawn is not known.

As discussed above, the detailed site investigation included the advancement of two boreholes within the shallow unconfined layer immediately up gradient from the drinking water well, and in the vicinity of or immediately down gradient from hydrocarbon-contaminated soils associated with a small upright AST formerly located at the site. The boreholes were advanced only as far as a clay layer encountered at around 6 m depth. This was done to avoid the creation of a conduit for the downward migration of contaminants below the clay aquitard. It is likely that the drinking water well draws from a deeper aquifer, which is isolated from the shallow aquifer by this clay layer, encountered in the majority of all boreholes drilled in 1995 and 1999.

Borehole 17 was completed as a groundwater-monitoring well (BH99-17). Groundwater collected from this well (MW-17) did not contain detectable levels of hydrocarbons and volatile organic compounds (Table 4.40) while metal concentrations were all below the

AW and DW standards (Table 4.41). A possibility that the contamination from the historical release of hydrocarbons from the small AST might be adversely affecting the drinking water supply for the camp was therefore ruled out.

Additional evidence for the integrity of the drinking water supply is based on the direct analysis of various drinking water samples for metals and BTEX, as described in Sections 2.3.6 and 4.12. Hydrocarbon and metal concentrations in potable water samples were either less than the limit of detection or well below the Yukon CSR drinking water standard. **Thus, the concentrations of these parameters in potable water continue to meet acceptable limits.**

5.3.2 Dermal Absorption From and Intake of Contaminated Surface Soils

This exposure pathway can be discounted for humans living at, working at, or otherwise visiting Blanchard River. Contamination of soils or groundwater at levels in excess of the relevant human-health protective benchmarks at the site (for either a residential or commercial use) is limited to the subsurface environment. In addition, the concentrations of various petroleum hydrocarbon constituents in subsurface soil samples were relatively low, and below the relevant human-health protective benchmarks with a few exceptions.

Where workers are engaged in subsurface excavations in the most contaminated areas of the site, and likely to be in intimate contact with petroleum hydrocarbon contaminated soils, it would be prudent to wear protective clothing, and to ensure good hygiene in order to minimize the accidental ingestion of contaminated soils which might be picked up on hands and other exposed body surfaces.

5.3.3 Infiltration of Hydrocarbons Into Indoor Air

One of the major concerns at sites of subsurface hydrocarbon contamination is the possibility that volatile constituents might be subject to indoor air infiltration. Hydrocarbon constituents such as benzene or naphthalene are mobilized from shallow subsurface soil particles in the unsaturated zone and transferred via soil gases into enclosed building envelopes, often gaining entry through cracks in the foundation. The major exposure pathway for humans for some of the more volatile compounds, and associated risks, is often associated with inhalation of indoor air. The contamination of indoor air through soil-gas intrusion is enhanced in coarse-grained and unsaturated as opposed to finer textured and saturated soils.

The air concentrations of volatile hydrocarbon constituents are not usually of concern in an outdoor setting except in the presence of massive petroleum hydrocarbon sources that are in close proximity to the receptor (e.g., at refinery sites). In addition, the potential for contaminated indoor air infiltration and unacceptably high indoor air concentrations decreases rapidly with the distance from the building foundation to the mass of petroleum hydrocarbon contaminated soil.

Detailed measurements of indoor air quality were not taken as part of this study. Infiltration of volatile hydrocarbons such as BTEX components from the two major contaminated areas of the site were not felt to be of concern, since there was a substantial separation between the building foundation and the contaminated soil mass of 10 m or greater. It is likely that the indoor air concentrations within the maintenance building exhibit an elevated background concentration which is typical of a shop and heavy equipment maintenance area, and that the direct sources of volatile compounds to the air in the shop would be far greater than any contribution from soil gas infiltration.

The apartment complex at Blanchard River sufficiently far removed from the contaminated areas of the site to preclude any indoor air filtration by petroleum hydrocarbon constituents.

5.3 Issues Requiring Mitigation

Three areas of the site were identified as being contaminated based on the presence of soil and/or water with analyte concentrations in representative samples that exceeded the appropriate Yukon CSR standard. These were –

- a petroleum hydrocarbon contaminated soil mass underlying the former site of the pump station burn pit;
- metal and petroleum hydrocarbon contaminated soils associated with the channelized flow associated with an old culvert established cross-gradient to the contaminated groundwater flow direction in the contaminant plume created by the burn pit soils. This flow emerges in and is responsible for the rust-coloured draw which eventually drains toward a wetland enroute to the Blanchard River; and,
- a petroleum hydrocarbon contaminated, subsurface soil mass at the south end of the maintenance building, originating from the historical and recent use of a soak away pit located within the maintenance yard to the southwest of the welding bay, south and outside of the containment berm of the existing diesel fuel tank, and inside the fence line of the maintenance yard.

On these three issues, the presence of metals and hydrocarbon contaminated soil/sediment at the top of the rust-coloured stain suggests – at a screening risk assessment level – the possibility of contaminant exposure by terrestrial and wetland soil fauna, plants and other ecological receptors. The more highly contaminated soils in the vicinity of the burn pit serve as a source area for the downgradient plume. The mass of PAHs and light extractable petroleum hydrocarbons is unlikely to diminish within a period of less than decades without some type of intervention.

The petroleum hydrocarbon contaminated soil mass at the south end of the maintenance complex has resulted in the introduction of hydrocarbons to the Blanchard River at the south end of the site; however, the available evidence suggests that the magnitude of inputs relative to the large dilutions afforded by mixing of the groundwater with river water in not presently creating unacceptable risks for aquatic life. There are no other plausible exposure pathways between the point of original introduction and the groundwater discharge face at the river associated with the contaminant plume or contaminated soil mass since hydrocarbon contamination is limited to deeper subsurface soil.

5.4 Recommendations for Remediation and Risk Management

Based on the pattern of distribution of various hydrocarbon constituents in subsurface soils and groundwater, the sources of subsurface contamination were identified and appropriate mitigative strategies developed. The detailed site investigation identified several source areas of hydrocarbons to the subsurface environment (Section 5.1).

In light of conclusions derived from the preliminary and detailed site investigations, the consulting team identified several major issues. These are summarized in the following Table, in order of priority.

Table 5.5: Major Contaminant Issues at Blanchard River Station

Issue	Comments	Action
1. Petroleum hydrocarbon contamination (PHC) in vicinity of burn pit	Past inputs have resulted in PHC contamination of groundwater and adjacent down gradient soils. Also accounts for contaminated discharge from culvert at N. end of site.	Removal of contaminated soil mass at former burn pit location to eliminate major component of in place contaminant source.
1a. Culvert identified in EM-survey and confirmed as part of DSI acts as conduit for movement of relatively anoxic, petroleum hydrocarbon contaminated groundwater to a surface discharge area at N. end of site, and has lead to visually obvious surface soil contamination.	Culvert appears to connect up to end of utilidor that formerly served row of six trailers at the pump station, and was left in place following conversion of the site to a highways maintenance camp.	Remove culvert, since it no longer serves any useful purpose, and is the conduit to transport contaminants to possible receptors.
2. PHC contamination at south end of Blanchard River site	The DSI documented the spatial extent of the contaminant plume, and examined levels of contaminant concentrations in the river.	Monitor groundwater contaminant concentrations annually (possibly at higher frequency to capture seasonal variation in the first year) within the plume and the river to ensure that concentrations in the riverine environment do not pose risks to aquatic life. Removal or active remediation of contaminated soil mass, or introduction of a subsurface barrier, is not justified based on existing risks due to the depth of the contaminated soils.
3. Rock pit from floor drains in the main shop area.	Installed in 1985. No evidence that the rock pit is causing substantial subsurface contamination. Rock pit is partially plugged, however, and ongoing use could cause future site contamination from oily waste.	Decommission rock pit and replace with more up-to-date oily waste – water separation technology, with offsite disposal of recovered oily waste for recycling.
4. Existing oil/water separator (1985 vintage) and soak away pit (1955 vintage) from welding bay floor drains.	The historical, and possibly ongoing use of the soak away pit has likely contributed to Issue 2.	Decommission. Capture floor drains discharge and re-route to new treatment facility as per issue 3.

From a perspective of environmental risks, the hydrocarbon contaminant plume at the north end of the site presently offers no viable exposure pathway for humans or other organisms except in the case where the contaminated groundwater emerges from the culvert at the top of the rust-coloured stain. Elsewhere, the contamination is limited to the subsurface environment (generally greater than 2 m in depth), where no possibility of exposure by humans, soil invertebrates, plants, birds, mammals, or other ecological receptors occurs.

The petroleum hydrocarbon plume at the south end of the site exhibited groundwater with concentrations of BTEX components in excess of Yukon CSR drinking water standards. The actual samples of drinking water from the station, however, did not contain detectable BTEX concentrations. Elevated human health risks, therefore, would not be plausible at the present time, unless recreational or other users derived drinking water from some point along the southern hydrocarbon plume where these substances were elevated. Groundwater samples from wells installed in this southern hydrocarbon plume also exhibited a limited number of PAHs (naphthalene, phenanthrene, pyrene) at concentrations in excess of the Yukon CSR water standards for aquatic life. Analytical data for river water and sediment samples, however, do not provide any evidence for concentrations in the aquatic environment that would result in risks to aquatic life. It is recommended that a monitoring plan be developed in lieu of other mitigative action at the present time.

5.4.1 Relevant Remediation Standards and Land Use Categorization

The maximum observed concentration of petroleum hydrocarbons in shallow subsurface soils beneath the former burn pit area was 19,000 µg/g HEPHs and 2,500 µg/g LEPHs. This occurred in a test pit sample collected from near the centre of the former location of the burn pit, at a depth from the present-day surface of 0.6 m. These concentrations exceed both the Yukon industrial and residential/parkland standards for extractable petroleum hydrocarbons. The maximum LEPH concentration observed in borehole TH-12 was 1,300 µg/g in sample TH12-5, at a depth of 2.5 to 3 meters. Soil samples collected below the presumed bottom of the burn pit prior to burial did not exhibit concentrations of LEPHs, HEPHs or other petroleum hydrocarbon constituents at concentrations in excess of industrial standards. Soils that were contained within the former burn bit during the time when it was used undoubtedly represent a special case: The hydrocarbon signature in these soils is influenced by both fuel oil release and combustion, resulting in a dominance of heavy hydrocarbon fractions.

Based on discussions with major stakeholders during and subsequent to the August 5th, 1999 meeting in Whitehorse, it was deemed appropriate to apply industrial soil remediation standards to the portion of the site used almost exclusively for non-residential activities associated with the highways maintenance camp. A residential or parkland soil standard is more appropriate in areas within the vicinity of the residence, near areas used recreationally, and on or adjacent to wildlands such as the riparian zone of the Blanchard River. The area of the Blanchard River Station between the north entrance gate, along a divide created by the small drop off which parallels and runs between the maintenance garage and residence, and extending to the outer existing fence on the southern perimeter could reasonably be considered as being of industrial land use under the present conditions. Wildlife use of this area is expected to be rare and transient. In addition, exposure of human beings would occur over shorter duration on a daily basis (generally less than eight hours per day) and there is little potential for more sensitive subpopulations such as young children to be exposed.

As an added level of assurance, surface soils - those most likely to come in direct contact with humans or wildlife - could be remediated down to a residential/parkland soil standard on the industrial portion of the site. The very small possibility of future risks to humans based on excavating contaminated soils would be further limited if soils within the top 2 m from the surface are remediated using a residential//parkland standard. This would further serve to eliminate a major portion of the total mass of petroleum hydrocarbons in the larger source and plume area, thus reducing future mobilization into groundwater, and lateral migration.

5.4.2 Remediation of Rust Coloured Stain

The "Detailed Work Plan for Site Remediation Activities" (RRU and UMA, September 07, 1999) provided an estimate of the spatial extent of sediments affected by metal/metalloid dissolution followed by adsorption under oxidized conditions, below the end of the culvert. Portions of these soils at the top of the discharge are also contaminated with light and heavy extractable hydrocarbons. The contaminated sediments are easily identified visually by the strong rust colouration of precipitated iron oxides, which further serves to adsorb other metals from the newly surfaced groundwater.

This material should be excavated and removed offsite. The remediation effort should aim to achieve an 80% capture of in place stained sediments within the upper 12 m of the stained watercourse. Spot removal only of areas of sediment accumulation should be carried out beyond this, since the watercourse and stained area narrow considerably beyond this point, and since the iron oxides have lower levels of associated adsorbed co-contaminants beyond this point.

6. SITE REMEDIATION

6.1 Stakeholder Meeting and Work Plan For Site Remediation

The results of the preliminary site investigations and the June 1999 Detailed Site Investigation indicated that polychlorinated biphenyls, volatile organic compounds and chlorinated pesticides such as DDT were not contaminants of concern at Blanchard River. Hydrocarbons at concentrations exceeding the Yukon Contaminated Sites Regulations standards for residential/parkland and/or industrial standards were, however, identified in five or more source areas. At least three of these sources had resulted in hydrocarbon contamination above levels, which merited remediation; metal contamination was also identified in one area.

The first problem area was located at and down gradient from the site where a burn pit was operated from 1962 to 1971. The discharge of hydrocarbon waste products to the burn pit from the pump house resulted in petroleum hydrocarbon contamination in the vicinity of borehole TH99-12 (Drawing 1) as well as the down-gradient contamination of groundwater and subsurface soils in boreholes TH95-1 and TH95-2. Rust coloured stain found in a drainage channel north of the site contained hydrocarbons and metals which exceeded the standards. This stain arises from contaminated water emanating from a culvert, which based on an EM survey conducted in 1995, passed through the area contaminated with materials from the burn pit. It was strongly suspected that the culvert served as a conduit for contaminated water plume originating from the burn pit to enter the drainage channel.

The third area of petroleum hydrocarbon contamination occurred at the south end of the maintenance building. The subsurface contamination at the south end of the site has on occasion been observed to result in the presence of hydrocarbon sheen along a limited portion of the Blanchard River shoreline. The area of subsurface contamination included boreholes TH95-5, TH99-9, TH99-13 and TH99-17 as well as mini-piezometer MP-3. A possible source of this petroleum hydrocarbon contamination to the south side of the site was a soak away pit, which receives discharge from the oil/water separator from the floor drains in the shop's welding bay.

The above information, including a summary of both the results of the preliminary and detailed investigations, was communicated to stakeholders at a meeting held in Whitehorse on August 5th, 1999. Participants included representatives from the Department of Indian and Northern Affairs Waste Management and Lands, Yukon Territorial Government (YTG) Renewable Resources and YTG Transport, Heritage Canada, Environment Canada, and Champagne and Aishihik First Nations. Following this meeting and in light of the conclusions derived from the preliminary and detailed site investigations, several major issues were identified and actions were proposed. These are summarized in Table 6.1.

Table 6.1: Major Contaminant Issues and Recommended Actions at Blanchard River Maintenance Camp Following June 1999 Detail Site Investigation

Issue	Comments	Recommended Action
1. Petroleum hydrocarbon contamination (PHC) in vicinity of former burn pit	Past inputs have resulted in PHC contamination of groundwater and adjacent down gradient soils. Probably accounts for contaminated discharge from culvert at north end of site into rust coloured drainage channel.	Removal of contaminated soil mass at former burn pit location to eliminate major component of in place contaminant source.
2.2. PHC contamination at south end of Blanchard River site	The soil mass affected, possible presence of other contaminants migrating toward the river, and original source areas cannot be confidently identified yet.	Augment detailed site investigation through the installation of four to five new boreholes/monitoring wells. Additional backhoe test pitting in vicinity of welding bay and above ground storage tanks.
3.3. Contaminated flow from culvert, causing rust coloured stain at north of site	The source of water to the culvert is not known. The culvert may have been installed to channel a spring discharge away from the site working area. Suspected source of hydrocarbon contamination is where culvert passes through contaminated soil mass.	Excavate culvert, with adequate precautions to capture and treat contaminated flow; verify source of water and whether contaminated or not. If clean, re-route through uncontaminated area.
4.4. Rock pit from floor drains in the main shop area.	Installed in 1985. No evidence that the rock pit is causing substantial subsurface contamination. Ongoing use could cause future site contamination from oily waste.	Decommission rock pit and replace with more up-to-date oil/water separation technology, with offsite disposal of recovered oily waste for recycling.
5.5. Existing oil/water separator and soak away pit from welding bay floor drains.	The historical, and possibly ongoing use of the soak away pit contributes to hydrocarbon contamination on the south side of the site (Issue 2.)	Decommission. Capture floor drains discharge and re-route to new treatment facility as per issue 4.
6.6. Empty Above Ground Storage Tank at south end of maintenance building.	Related to Issue 2, above. Additional investigation and possibly soil removal required if deemed to be a major source to plume migrating toward Blanchard River.	Additional test pitting and field investigation required. No requirement to disassemble the AST over the short term.

A Detailed Work Plan for Additional Investigation and Site Restoration Activities designed to address the issues and recommendations in Table 6.1 was prepared and submitted to DIAND and other stakeholders including YTG for review. Comments received were incorporated and the revised work plan was used for Additional Site Investigations and Remedial Activities in September 1999. This chapter presents an account of Site Remedial Activities.

6.2 Remedial Activities

6.2.1 Overview

Participants from DIAND Waste Management, Royal Roads University (RRU) and UMA Engineering Ltd. (UMA) monitored the remedial program that was conducted from September 18-26, 1999. Champagne and Aishihik First Nation of Haines Junction, YT was contracted to complete the remedial excavation and Analytical Service Laboratories (ASL) were subcontracted for laboratory analysis.

The main activities conducted included:

- Excavation of petroleum hydrocarbon contaminated soils in the vicinity of the former burn pit;
- Establishment of a temporary holding facility for the excavated contaminated soil;
- Curtailment of contaminated groundwater discharge from the culvert at the top of the rust-coloured drainage ditch at the northern end of the site;
- Removal and packaging of metal and hydrocarbon contaminated sediments in the rust-coloured stain at the northern end of the site for off-site disposal; and
- Confirmatory testing of excavated areas.

Personnel from RRU, with the assistance of UMA and DIAND Waste Management representatives, laid out the proposed limits of the areas to be excavated based on the previous site investigation results. A control grid was established for each remedial zone to monitor excavation of contaminated soil and identify locations of confirmatory samples. The contaminated soils were then excavated using a track-excavator and dump trucks contracted from the Champagne and Aishihik First Nation, Haines Junction, YT.

Impacted soils excavated from the Drainage Ditch were packaged into Transportation of Dangerous Goods - certified bulk bags (Mega Bag™ supplied by Trimeg Holdings, Alberta) for off-site transportation and disposal. Material removed from the former Burn Pit was stockpiled in a containment cell pending construction of an on-site bioremediation treatment facility.

Confirmatory samples were collected following the excavation. These were analyzed on site using PetroFLAG™ test kits. For QA/QC purposes, a subset of the samples was submitted to ASL for laboratory analysis. Detailed sampling and analytical methods are given in Chapter 3.

Once confirmatory sampling and analysis of the soils had indicated that the established remediation levels were achieved, the excavations were backfilled with granular fill. Sources of backfill material were obtained from either the on-site stockpile of overlying clean soil excavated during the remediation or from an off-site borrow area. Off-site borrow materials were extracted from an existing YTG pit located at Mile 157 on the Haines Road.

Backfilling of the excavations followed common construction practices. The backfill material was transported to the excavation area; end dumped and compacted with the bucket of the excavator. Additional compaction was carried out with multiple passes of the excavator over each excavation area.

The culvert leading to the rust coloured drainage ditch on the northern end of the site was also excavated. This was completed with a rubber-tired backhoe contracted from Darling Maintenance Services, Pleasant Camp, BC.

6.2.2 Burn Pit

6.2.2.1 Excavation

Data obtained from samples collected during the 1995 and 1999 site investigations indicated soils in the vicinity of the former burn pit were contaminated with light and heavy extractable hydrocarbon concentrations above the applicable Yukon CSR Industrial Land use standards. The limits of the remedial excavation were first established based on point concentrations of contaminants recorded during the site investigation programs. Remedial excavations were delineated over a 400 m^2 area surrounding the former burn pit (Photograph 6-1), with an average depth of 3m below grade.

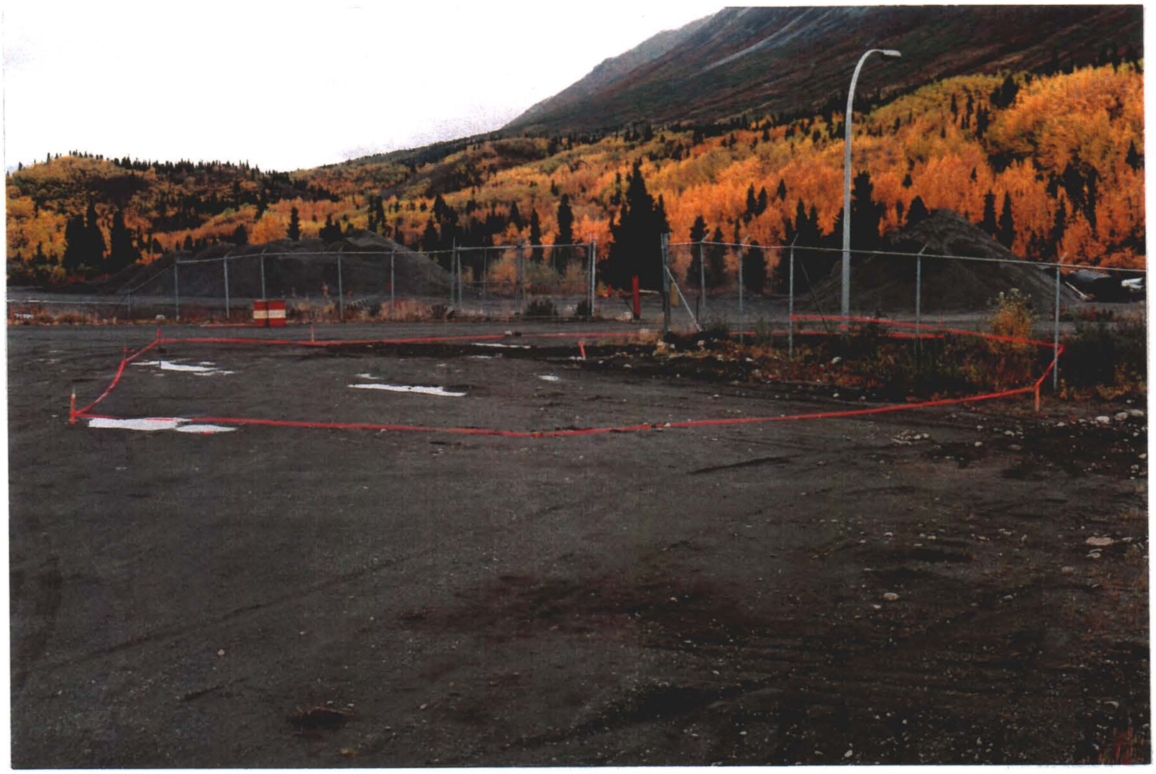
Prior to contaminated soil removal, uncontaminated overburden was removed from the demarcated area and stockpiled to the side of the excavation for future backfilling use (photograph 6.2). Debris such as concrete, wood or metal exposed during the excavation of the contaminated soil was segregated and temporarily stockpiled on-site in a designated area. Approximately 15 m^3 of demolition debris, including metal clad siding, wooden timbers, concrete, and 20 metres of associated piping were removed during the excavation of the burn pit. Debris not suitable for placement in the containment cell was later transported off-site to the YTG landfill. Debris found to be visually contaminated was cleaned prior to disposal.

Contaminated soils were excavated based on previous investigation results and field screening of samples collected during the remedial excavation. All soil samples were screened for petroleum hydrocarbons using PetroFLAG^{TM} test kits during the excavation. If hydrocarbon concentrations exceeded the benchmark of 2,000 μg/g, additional excavations were generally completed to remove the contaminated soil. Excavation and confirmatory sampling was continued until all the contaminated soil had been removed. Sampling locations are included on Drawing No. 6.1.

As part of the QA/QC process, a subset of the samples was submitted to ASL for laboratory analysis. The correlation between the field test kit data and laboratory result is discussed in Section 6.4.

Stratigraphy in the vicinity of the excavation was consistent with that observed during previous test pit and borehole investigations. The uppermost soils consisted of intermixed sands and gravels that contain appreciable amounts of finer grained soils to depths between 1.5 m to 2.0 m below grade. These soils were underlain by well-graded coarser sands and gravels that extended to the depth of the excavation. The lower permeability clay layer was not encountered during the excavation. Impacted soils excavated at depth typically exhibited a moderate to strong hydrocarbon odour and dark grey staining (Photographs 6.3 and 6-4).

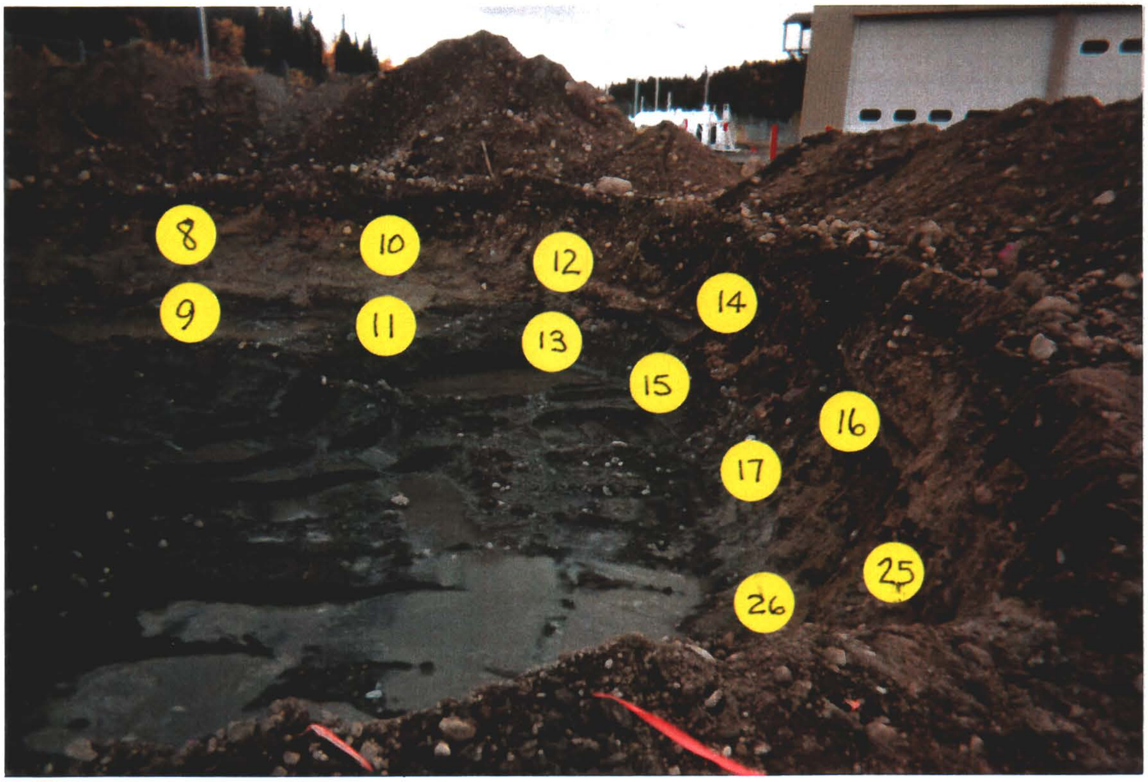
During the coarse of excavation, several groundwater seeps were observed along the perimeter walls of the excavation between 2.2 m and 3 m below grade. One groundwater sample (Seep1) was collected near the most southerly seep location and submitted for PAH and EPH determination. Observed seepage locations are denoted with an "S" on Drawing 6.1.



Photograph 6.1: Demarcated of the Burn Pit prior to excavation

Photograph 6.2: Uncontaminated overburden removed from burn pit stockpiled to the side of the excavation for future backfilling use

Photograph 6.3:Excavation of the burn pit and surrounding area. Note the heavily stained soils in the immediate vicinity of the former burn pit location (center of the photograph).



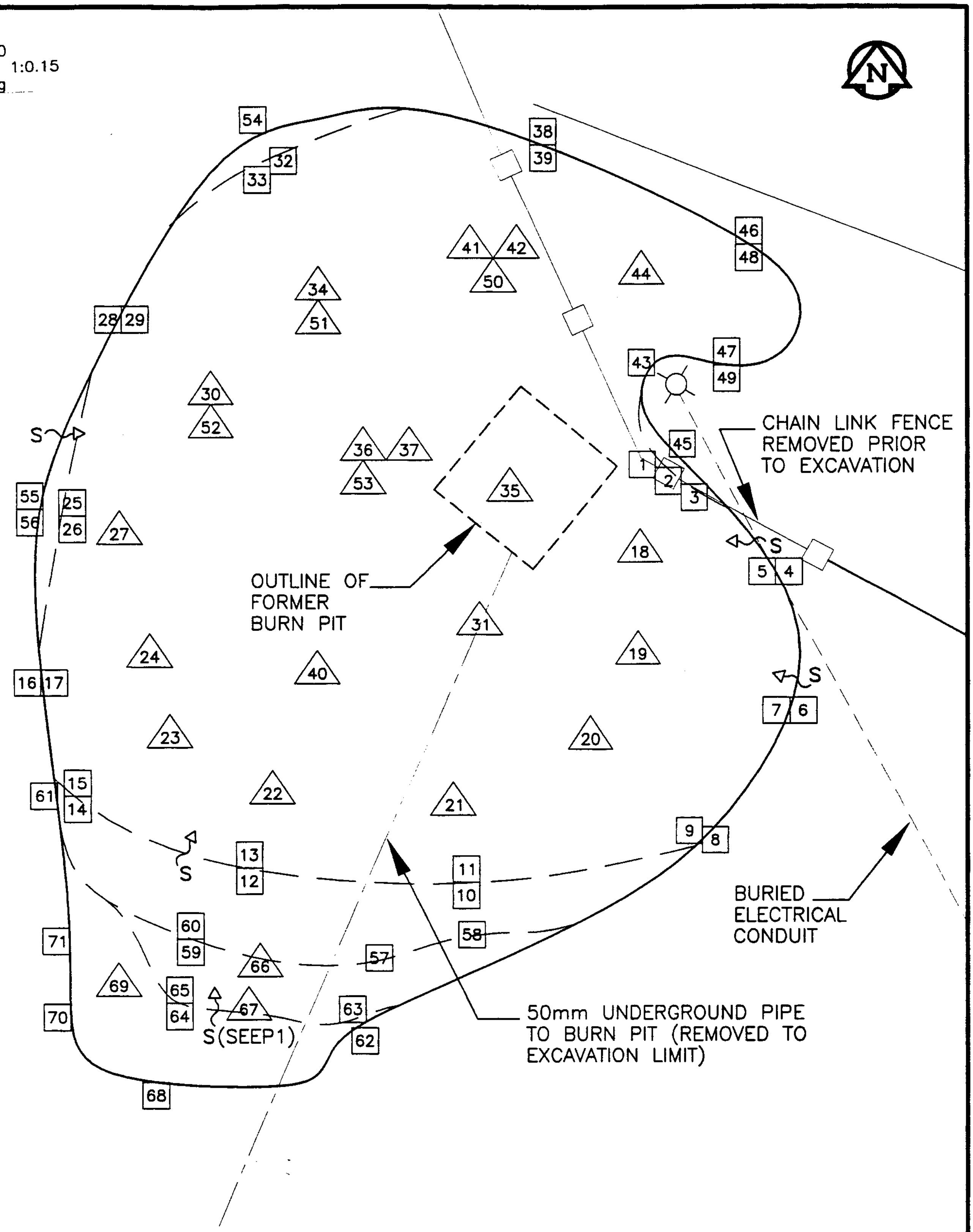
Photograph 6.4: Exposed wall along the south end of the burn pit excavation. Sample locations have been illustrated for reference.

6.2.2.2 Confirmatory Sampling and Analysis

The standards prescribed by the *Contaminated Sites Regulation (CSR)* were used to guide the remedial operations. The objectives of this remediation program were to reduce on-site contaminant concentrations in excess of current applicable Industrial Land use standards (2000 μg/g LEPH).

Confirmatory soil sampling employed during remediation was consistent with methodologies presented in Section 3.2.4 of this report. In most cases, soil samples were collected systematically on a 4-m grid spacing for the base and sidewalls of the excavation so that each sample point was approximately equidistant to all nearest neighbour sample points. The selection of the soil samples was also based on visual and olfactory observations made during the excavation. Visual and olfactory observations were made of the freshly excavated soil at closely spaced intervals as well as of the *in-situ* native material along the walls and base of the excavations. If hydrocarbon staining or odours were detected in the walls or base of the excavation, additional soil was removed before confirmatory soil samples were collected. Sampling locations and the limits of excavation are shown in Drawing 6-1.

MAR 13/00
Plot Scale: 1:0.15
BurnPit.dwg



LEGEND

CS- 6	CONFIRMATORY WALL SAMPLE
CS- △19	CONFIRMATORY FLOOR SAMPLE
⌖	LIGHT STANDARD
S⤳▷	GROUNDWATER SEEP
— —	INTERMEDIATE LIMITS OF EXCAVATION
——	FINAL LIMIT OF EXCAVATION

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INDIAN AFFAIRS and NORTHERN DEVELOPMENT
BLANCHARD RIVER STATION: SITE INVESTIGATION

TITLE: BURN PIT REMEDIAL EXCAVATION, SEPT 25–29, 1999

JOB No.	C799-004-01-01	DATE:	March, 2000
SCALE:	1:150	DWG. No.	6–1
CHECKED:	AP		

Preliminary excavations were completed on September 25 (see "Intermediate Limits of Excavation" on Drawing 6.1). Following this, 39 soil samples were collected from locations along the walls and bottom of the excavation. These were analyzed on site using the PetroFLAG analyzer; a subset was analyzed in the laboratory. Table 6.2 contains the results obtained.

Table 6.2: Concentrations of Hydrocarbons in Soil Samples Collected from the Burn Pit after Initial Excavation on September 25, 1999.

Sample ID	Depth	Field PetroFLAG Analysis				Laboratory Analysis	
		Weight Used (g)	Analyzer Reading	Dilution Factor	Actual Conc. (μg/g)	EPH 10-19 (μg/g)	EPH 19-32 (μg/g)
CS1	1.2	5	>>2000	2	>>4000	-	-
CS2	2.2	5	2682	2	5364	-	-
CS3	2.8	5	2296	2	4592	-	-
CS4	1.7	5	81	2	162	-	-
CS5	2.7	5	2152	2	4304	818	<200
CS6	1.5	5	16	2	32	-	-
CS7	2.7	5	188	2	376	-	-
CS8	2.0	5	610	2	1220	-	-
CS9	2.7	2.5	191	4	764	<200	<200
CS10	2.2	2.5	1476	4	5904	-	-
CS11	2.8	2.5	2132	4	8528	-	-
CS12	2.0	2.5	2035	4	8140	-	-
CS13	2.7	2.5	1353	4	5412	-	-
CS14	2.2	2.5	1514	4	6056	-	-
CS15	2.7	2.5	289	4	1156	2260	<200
CS16	2.2	2.5	0	4	<10	-	-
CS17	2.7	2.5	16	4	64	-	-
CS18	3.0	2.5	29	4	116	<200	<200
CS19	3.0	2.5	0	4	<10	-	-
CS20	3.0	2.5	3	4	12	<200	<200
CS21	3.0	2.5	250	4	1000	-	-
CS22	3.0	2.5	188	4	752	1730	<200
CS23	3.0	2.5	15	4	60	-	-
CS24	3.0	2.5	238	4	952	-	-
CS25	2.0	2.5	6	4	24	-	-
CS26	2.8	2.5	746	4	2984	2080	<200
CS27	3.0	2.5	22	4	88	<200	<200

Table 6.2: Continued

Sample ID	Depth	Field PetroFLAG Analysis				Laboratory Analysis	
		Weight Used (g)	Analyzer Reading	Dilution Factor	Actual Conc. (µg/g)	EPH 10-19 (µg/g)	EPH 19-32 (µg/g)
CS28	2.3	2.5	6	4	24	-	-
CS29	2.8	2.5	17	4	68	-	-
CS30	3.1	2.5	477	4	1908	-	-
CS31	3.0	2.5	41	4	164	<200	<200
CS32	2.1	2.5	22	4	88	-	-
CS33	2.9	2.5	1140	4	4560	-	-
CS34	3.2	2.5	>>2000	4	>>8000	-	-
CS35	3.0	2.5	16	4	64	-	-
CS36	3.1	2.5	1947	4	7788	2620	<200
CS37	3.1	2.5	2324	4	9296	1870	<200
CS38	2.3	2.5	157	4	628	-	-
CS39	3.0	3.5	50	4	200	-	-

The field test kit data indicated soils with concentrations exceeding 2000 µg/g EPH were still present at a number of locations (this was confirmed latter by laboratory analysis that indicated LEPH concentration of >2000 µg/g). These areas included the walls on northeastern side of the burn pit (CS1, CS2, CS3, and CS5), southern edge (CS10, CS-11, CS-12, CS13, CS14 and CS15), western side (CS26) and northern edge (CS33). Some of the samples collected from the floor of the pit also exceeded the standard (CS34, CS36 and CS37). Additional soils were therefore excavated from these areas on the following day (Table 6.3).

The second series of excavations was initiated with the removal of soils from the floor. Confirmatory sample CS40 was below the standard however, CS41 and CS42 still contained EPH at levels that exceeded the standard. Additional soils were therefore removed from the base of the excavation and CS50 to CS53 were taken. Samples CS51 and CS52 contained over 2000 µg/g EPH as determined by the PetroFLAG kits as such additional soils were removed from the base. The resultant base of the excavation was greater than 3.6 m below ground surface. Groundwater seep was encountered on the western side of the excavation. This flooded the pit and prevented further confirmatory sampling in the vicinity of CS51 and CS52. The impact of any residual contamination was considered to be minimal since it would be limited to a small area.

Table 6.3: Concentrations of Hydrocarbons in Soil Samples Collected from the Burn Pit after Additional Excavations on September 26, 1999.

Sample ID	Depth	Field PetroFLAG Analysis				Laboratory Analysis	
		Weight Used (g)	Analyzer Reading	Dilution Factor	Actual Conc. (µg/g)	EPH 10-19 (µg/g)	EPH 19-32 (µg/g)
CS40	3.1	2.5	<0	4	<0		
CS41	3.3	2.5	>2000	4	>8000	8180	<200
CS42	3.3	2.5	1624	4	6496	9130	<200
CS43	2.5	2.5	875	4	3500	2420	<200
CS44	3.3	2.5	437	4	1748	-	
CS45	2.2	2.5	1879	4	7516	1060	353
CS46	2.9	2.5	43	4	172	<200	<200
CS47	2.0	2.5	0	4	<10	<200	<200
CS48	2.9	2.5	78	4	312	-	-
CS49	2.0	2.5	410	4	1640	-	-
CS50	3.6	2.5	292	4	1168	835	<200
CS51	3.6	2.5	2364	4	9456	5000	<200
CS52	3.6	2.5	1313	4	5252	-	-
CS53	3.6	2.5	0	4	<10	<200	<200
CS54	2.8	2.5	0	4	<10	<200	<200
CS55	2.9	2.5	0	4	<10	<200	<200
CS56	2.9	2.5	0	4	<10	<200	<200
CS57	2.2	2.5	1795	4	7180	-	-
CS58	2.8	2.5	705	4	2820	-	-
CS59	2.2	2.5	37	4	148	-	-
CS60	2.8	2.5	1045	4	4180	4300	<200
CS61	2.2	2.5	59	4	236	<200	<200
CS62	2.2	2.5	100	4	400	-	-
CS63	2.8	2.5	451	4	1804	1470	<200
CS64	2.8	2.5	1649	4	6596	-	-
CS65	2.2	2.5	295	4	1180	-	-
CS66	2.8	2.5	1863	4	7452	-	-

Confirmatory samples from the northeastern side of the pit, CS44, CS46, CS47, CS48 and CS49 contained EPH at levels that were below the standard; however, concentrations in CS43 and CS45 exceeded the standard. Location CS43 was near the light standard. Additional excavation would involve decommissioning or re-location of this light fixture. Following consultation with the Blanchard River Station Supervisor, this was not deemed feasible as such no additional excavation was conducted. Furthermore laboratory analysis indicated CS45 was below the standard.

EPH concentrations in confirmatory samples from the western side (CS55 and CS56) and northern edge (CS54) indicated successful removal of contamination in those areas of the burn pit.

Since EPH levels in CS10, CS-11, CS-12, CS13 and CS14 exceeded the standard, further excavation was conducted on the southern edge. Following this, samples CS57, CS58, CS59 and CS60 were collected. The concentrations of EPH in all but one of these samples (CS59) were still greater than the criteria as such further excavation was conducted. Following this samples CS62, CS63, CS64, CS65 and CS66 were taken. Since EPH concentrations in CS64 and CS66 exceeded the standard, the excavation was continued on September 27. Confirmatory samples CS67 to CS71 were collected and EPH concentrations in the samples were below the criteria except for that of CS68 (Table 6.4). Soils around CS68 were removed to the 3.3 m depth to complete excavation on the southern edge. Groundwater seep was encountered near this location, which flooded the pit and prevented further confirmatory sampling.

Table 6.4: Concentrations of Hydrocarbons in Soil Samples Collected from the Burn Pit after Additional Excavations on September 27, 1999.

Sample ID	Depth	Field PetroFLAG Analysis				Laboratory Analysis	
		Weight Used (g)	Analyzer Reading	Dilution Factor	Actual Conc. (µg/g)	EPH 10-19 (µg/g)	EPH 19-32 (µg/g)
CS67	3.3	2.5	<0	4	<10	<200	<200
CS68	2.9	2.5	500	4	2000	2390	<200
CS69	3.2	2.5	0	4	<10	-	-
CS70	2.8	2.5	0	4	<10	-	-
CS71	2.8	2.5	0	4	<10	<200	<200

6.2.2.3 Backfilling

Once confirmatory sampling and analysis of the soils had indicated that the established remediation levels were achieved, the excavations were backfilled with granular fill. The bottom of the excavation was surveyed using a rod and level before backfilling. Backfill materials either were obtained from the on-site stockpile of overlying clean soil excavated during the remediation or from an off-site borrow area, which is an existing YTG gravel pit located at Mile 157 on the Haines Road.

Backfilling of the excavations followed common construction practices. The backfill material was transported to the excavation area, end dumped and compacted with the bucket of the excavator. Additional compaction was carried out with multiple passes of the excavator over each excavation area. The entire area was then regraded to conform to the contours of the yard.

6.2.2.4 Temporary Soil Containment

Once excavated, hydrocarbon impacted soils were placed directly into trucks and transported to a temporary containment cell located on the Old Haines Road right-of-way, northeast of the site (see Drawing 1). Approximately 700 m^3 (1,400 tonnes) of hydrocarbon-impacted soil from the burn pit area was placed in the containment cell for temporary storage pending construction of the proposed land farm treatment facility.

The containment cell was designed using established methods for temporary containment of hydrocarbon-contaminated soil. Construction involved preparation of approximately 900 m^2 of the existing right-of-way (Photograph 6.5). The containment utilizes a factory welded 25 mil oil-resistant reinforced polyethylene liner (OR-RPE) (Layfield Plastics) and 1 m high by 3 m wide perimeter berm to contain the impacted soil (Photograph 6.6). The liner was overlain with an LP 8oz non-woven geotextile cushion designed to provide protection and to ensure integrity of the underlying liner during placement of the contaminated soil.

The impacted soil was end dumped from the transport vehicles into the containment cell, evenly spread in 1 m lifts and lightly compacted using multiple passes of the tracked excavator. Special precautions and construction procedures were used during placement of the initial lift to minimize disturbance of the base liner system. A ramp was constructed at the south entrance point to the cell, which was used during the various stages of loading.

Following placement of the impacted soil, a 15 mil reinforced polyethylene cover liner was installed over the area of the cell and secured with placement of sand bags and granular material around the outside edge. The final stockpile and cover liner were graded in a manner that would provide positive drainage of precipitation and snowmelt away from the containment cell.

Photograph 6.5: Preparation of former highway right-of-way northeast of the maintenance building for the Temporary Containment Cell

Photograph 6.6: View of the Temporary Containment Cell from Haines Highway prior to covering it with a polyethylene liner.

6.2.3 Rust Coloured Drainage Ditch and Culvert Excavation

6.2.3.1 Culvert Excavation

Data obtained from samples collected during the 1995 and 1999 site investigations indicated the rust coloured substrate and shallow soils down slope of the drainage ditch were contaminated with heavy metals and heavy extractable hydrocarbons above the applicable *CSR* industrial land use standards. The source of the contaminants was presumed to be from an existing culvert that discharged hydrocarbon contaminated groundwater onto the slope at the northern edge of the site.

On September 19, 1999 additional investigations were completed to determine the purpose of the culvert and source of flows. Test pit and trench excavations were completed inside the compound and along the length of culvert between the north fence line and the drainage ditch on the north side of the site.

One test pit completed inside the compound (TP99-44) revealed a 1.2 m diameter utilidor formerly used to service the on-site residences. The utilidor was observed to contain one 175 mm asbestos pipe and two smaller diameter steel pipes wrapped in fibreglass insulation (See Chapter 3, Photograph 3.11). Staining along the interior base of the utilidor indicated the pipe was susceptible to groundwater seepage, however it was dry at the time of the site investigation.

Trench excavations completed immediately outside the north fence line (TP99-45 to TP99-47) revealed a 200 mm steel culvert, similar to that previously observed on the northern end of the site. Based on site observations, it was suspected the culvert was installed to improve natural drainage of several shallow groundwater springs found in the area. Consequently, the migration of dissolved petroleum contaminants from the Burn Pit intercepted the culvert, resulting in the redirection and discharge of contaminated groundwater down the bank on the north end of the site. To prevent further contaminant discharges from occurring, the entire length of culvert (45 linear m) north of the fence line was removed (Photograph 6-7, see also Chapter 3, Photographs 3.12 and 3.13) and the excavation backfilled with low permeability soils.

6.2.3.2 Excavation Along Drainage Ditch

The limits of the contaminated substrate in the Drainage Ditch were first established based on visual observations and point concentrations of contaminants recorded during the two site investigation programs. The contaminated substrate was then excavated and placed into polyethylene-lined, woven polypropylene bags (Photograph 6-8). The bags containing approximately 10 m^3 or 15 tonnes of material were placed in a temporary storage area pending removal for off-site disposal.

Remedial excavations were delineated to a 70 m^2 area, with a depth ranging between 0.3 m and 0.8 m below grade. Drawing 1 illustrates the areal extent of excavation down slope of the culvert discharge. A cross section of the excavation is included in Drawing 4-4.

Photograph 6.7: Trench excavated on the north side of the site to enable the removal of 200 mm diameter culvert

Photograph 6.8: Excavation of metal and hydrocarbon contaminated soils along the drainage ditch north of the site. Contaminated soil was placed into bags for off-site disposal.

6.2.3.3 Confirmatory Sampling and Analysis

A 3 m grid was established along the edge of excavated area. Eleven samples were collected along the grid transects alternating between the edge and bottom of the excavation (see Drawing 1). The samples were analyzed on site for hydrocarbons using the PetroFLAG test kits. Additional samples were collected from the confirmatory sampling locations and shipped to the laboratory for hydrocarbon analysis by GC-FID. The samples were also analyzed for metals. The laboratory report is included in Appendix E.

The concentrations of EPH, as determined by the field test kits, were between 13 and 802 µg/g (Table 6.5). This indicated the successful removal of the hydrocarbon-contaminated soils. EPH results obtained for the samples analyzed in the laboratory concurred with the field data. The excavated area was then re-graded to conform to the natural contours.

Table 6.5: Concentrations of Hydrocarbons in Soil Samples Collected After Excavation at the Rust Coloured Drainage Ditch

Sample ID	Depth	Field Analysis with PetroFLAG				Laboratory Analysis	
		Weight (gram)	Reading (µg/g)	Dilution Factor	Actual (µg/g)	EPH C10-19 (µg/g)	EPH C19-32 (µg/g)
BLS-10	0.4	5	237	2	474	423	<200
BLS-11	0.4	5	136	2	272	<200	<200
BLS-12	0.4	10	265	1	265	<200	<200
BLS-13	0.4	10	127	1	127	<200	<200
BLS-14	0.3	10	144	1	144	-	-
BLS-15	0.3	10	185	1	185	<200	<200
BLS-16	0.7	10	57	1	57	-	-
BLS-17	0.8	10	207	1	207	<200	<200
BLS-18	0.8	10	13	1	13	<200	<200
BLS-19	0.6	10	802	1	802	365	523
BLS-20	Field dup of BLS-19	-	-	1	-	289	427

Eight of the confirmatory samples were analyzed in the laboratory for metals (Table 6.6). Chromium concentrations in all the samples exceeded the Yukon CSR standard for residential/park land use. These elevated chromium levels were generally attributed to local geological conditions since comparable levels were found in other areas of the site. The concentrations of the remaining metals and metalloids were generally below the standard except for barium in BLS-10. Following the removal of the source of contamination, the residual barium concentration that is associated with a small amount of rust coloured stain remaining in the ditch is considered of minor concern.

Table 6.6: Concentrations of Metals in Soil Samples Collected After Excavation at the Rust Coloured Drainage Ditch

Sample #	BLS-10	BLS-11	BLS-12	BLS-14	BLS-16	BLS-18	BLS-19	BLS-20	Yukon Standard
Physical Tests									
Moisture %	61.2	34.5	28.7	33.4	23.6	18.1	46.7	39	
pH	7.4	6.93	6.1	6.21	6.8	6.52	6.1	6.17	
Total Metals									
Antimony	<40	<20	<20	<20	<20	<20	<20	<20	20
Arsenic	15	5	7	7	5	6	5	5	60^2
Barium	**774**	313	324	352	303	211	293	269	500
Beryllium	<1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4
Cadmium	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	0.6	2.5^3
Chromium	**71**	**63**	**74**	**88**	**87**	**68**	**60**	**65**	60^2
Cobalt	23	15	17	18	20	14	13	14	50
Copper	51	32	42	43	38	35	38	37	$1,500^3$
Lead	<100	<50	<50	<50	<50	<50	<50	<50	$2,000^3$
Mercury	0.088	0.045	0.059	0.06	0.035	0.029	0.046	0.041	2
Molybdenum	<8	<4	<4	<4	<4	<4	<4	<4	10
Nickel	50	32	41	44	45	40	35	35	100
Selenium	<2	<2	<2	<2	<2	<2	<2	<2	3
Silver	<4	<2	<2	<2	<2	<2	<2	<2	20
Tin	<20	<10	<10	<10	<10	<10	<10	<10	50
Vanadium	106	94	105	117	113	82	88	93	200
Zinc	369	87	89	99	97	75	509	428	$1,000^3$

Notes:

1. Shaded areas indicate parameters that are equal to or exceed the Yukon Renewable Resources CSR Generic Numerical Standards for Residential/Park Land use unless otherwise indicated.
2. Matrix numerical standard for groundwater flow to surface water used for aquatic life.
3. Matrix numerical standard for groundwater flow to surface water used for aquatic life (pH > 6.1)

6.2.3.4 Special Waste/Leachate Extraction Procedure (SWEP/LEP)

Three of the soil samples were subsequently subjected to the Special Waste/Leachate Extraction Procedure (SWEP/LEP) outlined in the Waste Management Act, British Columbia Special Waste Regulation to ascertain if the rust coloured stained soils in the drainage channel contained leachable toxic waste. A waste is considered "Special Waste" if it produces an extract with a contaminant concentration greater than those prescribed in the Leachate Quality Standards presented in Schedule 4 of the regulation.

Metal concentrations in the extracts for BLS-16 were all below the Leachate Quality Standards (Table 6.7) even though high levels of arsenic (218 μg/g), barium (2960 μg/g) and zinc (1790 µg/g) were detected in the soil sample. Similar results were obtained for BLS-10 and BLS-11. Thus the high metal concentrations present in the soil samples are tightly bound to the substrate and not readily leachable. Contaminated soils excavated from the rust coloured drainage channel are therefore, not considered as "Special Waste" under the BC Contaminated Sites Regulation.

Table 6.7: Concentration (mg/L) of Leachable Metals in Soil Samples Subjected to the Special Waste/Leachate Extraction Procedure

Year	**June 1999**	**September 1999**		**Leachate Quality Standard**
Sample ID	**BLS-16**	**BLS-10**	**BLS-11**	
Physical Tests				
Moisture %	78.7	63.4	30.6	
Initial SWEP pH	6.89	6.92	7.05	
Final SWEP pH	5.07	5.22	5.17	
Extractable Metals				
Arsenic	<1	<0.2	<0.2	5.0
Barium	11.2	0.24	0.14	100
Boron	<0.5	<0.1	<0.1	500
Cadmium	<0.05	<0.01	<0.01	0.5
Chromium	<0.05	<0.01	<0.01	5.0
Copper	<0.05	<0.01	<0.01	100
Lead	<0.3	<0.05	<0.05	5.0
Mercury	<0.00005	<0.00005	<0.00005	0.1
Selenium	<1	<0.2	<0.2	1.0
Silver	<0.03	<0.01	<0.01	5.0
Zinc	3.2	<0.05	<0.05	500

6.2.4 Decommissioning of Underground Storage Tanks (USTs)

6.2.4.1 Excavation

The underground fuel storage system, consisting of two single-walled steel tanks (11,360 L gasoline and 30,280 L diesel) and concrete pump island located on the northwest of the maintenance building was decommissioned in July 1999. This followed the installation of a new above grade system on the east side of the maintenance building. The excavation of the decommissioned tanks and associated pumps and piping was completed on September 27 and 28, 1999. Prior to excavating the USTs, all remaining fuels were transferred to the newly installed above ground storage tanks.

The top of both tanks was approximately 0.8 m below grade, and the invert of the gasoline and diesel tanks at 2.6 m and 3.3 m below grade, respectively. Upon exposing the top of the diesel tank, hydrocarbon stained soils were identified near the filler pipe and in the soils directly adjacent to the tanks. The tanks were removed from the excavation and inspected for perforations and structural integrity (Photograph 6.9). Both tanks were in relatively good structural condition with no noticeable oxidation or wear on the exterior surfaces. The tanks were stored on site pending off-site disposal.

After the USTs were removed from the tank bed, obviously contaminated backfill soils from around the tank, and/or adjacent native soils were removed before confirmatory samples were collected. The stratigraphy on the walls of the excavation consisted of intermixed sand and gravel with appreciable amounts of finer grained soils that extended to approximately 2.0 m below grade. These soils were underlain by poorly graded gravel and cobbles that extended to the depth of the excavation. Groundwater seepage was observed along the base of the excavation at 3 m below grade.

6.2.4.2 Confirmatory Sampling and Analysis

Visual and olfactory observations, and headspace vapour tests using a photoionization detector (PID) were made of the freshly excavated soil and the in-situ native material along the walls and base of the excavation. Soils immediately surrounding the fill pipe and directly below the west end of the diesel tank were discoloured and had a distinct hydrocarbon odour. Obviously contaminated soil was placed directly into trucks and end dumped into the temporary containment cell. Excavated clean soil and soil suspected of hydrocarbon contamination were segregated into two stockpiles (SPA and SPB, respectively) on the basis of these field screening methods. Elevated headspace readings were not detected in the near surface soils or tank backfill materials, with the exception of those soils proximate to the west end of the diesel tank.

In general, soils were removed from the wall or base of the excavation until hydrocarbon staining or odours were no longer detected before confirmatory soil samples were collected. Confirmatory samples were analyzed in the field for extractable petroleum hydrocarbons (EPH) with the PetroFLAG test kits and for volatile hydrocarbons with the PID. A subset of the samples were subsequently analysed in the laboratory for EPH and

BTEX. One to two samples were collected on each wall and from the base of the excavation. Confirmatory step out sampling was carried out below the former diesel tank location. The final excavation proceeded 0.9 m north, 0.4 m east, 0.4 m south and 1.8 m west of the walls of the former UST locations. The base of the excavation was extended 0.5 m below the invert of the diesel tank. In all, approximately 150 cubic metres of original backfill and native soil were excavated to a depth of 3.8 m.

Ten confirmatory samples were collected from the native soils on the walls and base of the excavation. Two representative soil samples were collected from the stockpiled materials, which were subsequently used as backfilled into the excavation. The remaining part of the excavation was backfill with the same clean granular fill material used to backfill the burn pit excavation.

Analytical test results of samples from the stockpile and confirmatory soil samples are provided in Table 6-8, below.

Table 6-8 Concentrations of Extractable Petroleum Hydrocarbons in Confirmatory Soil Samples Collected After Excavation of the USTs

Sample ID	Location	Depth (m)	Field Analysis		Laboratory Analysis	
			PID (ppm)	PetroFLAG (µg/g)	EPH C10-19 (µg/g)	EPH C19-32 (µg/g)
UST-1	West wall	2.0	1.1	<10	-	-
UST-2	Base	2.8	162	3894	4060	<200
UST-3	East wall	2.0	8	52	-	-
UST-4	Base	2.6	2	<10	<200	<200
UST-5	South wall	2.1	2.1	<10	-	-
UST-6	South wall	2.1	2.6	80	-	-
UST-7	North wall	2.2	1.4	<10	-	-
UST-8	North wall	2.2	3.1	<10	-	-
UST-9	East stockpile	SPA	7.6	50	-	-
UST-10	West stockpile	SPB	5.2	134	-	-
UST-11	Base	3.8	174	1630	2650	<200
UST-12	Base	3.7	63	10	-	-

Field analysis of soil samples obtained from the native soil on the base of the excavation around the diesel fill pipe (UST-2) indicated the presence of extractable petroleum hydrocarbon concentrations, which exceed the *CSR* IL standard of 2,000 µg/g. This contamination was probably due to spillage from tank filling activities. EPH concentrations in the remaining samples were below the standard indicating the successful removal of contaminated soils from these locations. Additional excavation was conducted from around the diesel fill pipe between 3.3 m and 3.8 m below grade. Approximately 20 cubic metres of hydrocarbon impacted soil, backfill materials, and native soils were excavated and transported to the temporary containment cell for storage (see Section 6.2). Two confirmatory samples UST-11 and UST-12 were then collected and analyzed on-site with the PetroFLAG test kits. Field data suggested the successful removal of the hydrocarbon contamination. However, laboratory data indicated sample UST-11 contained 2650 µg/g of EPH C10 – 19 that exceed the standard. This contamination is considered of minor concern since it is limited to a small area.

Field determination of the stockpile samples (SPA and SPB) indicated extractable hydrocarbon concentrations well below the *CSR* IL standards. BTEX components were not detected in any of the confirmatory samples submitted for chemical analysis. Laboratory reports are included in Appendix E.

6.3 Floor Drains, Oil/Water Separator and Soak Away Pit

The maintenance building has two floor drainage systems which discharge to separate leaching pits. Floor drainage from the main area of the maintenance building is conveyed through a pipe to a rock pit established on the northwestern side of the building in 1985 while that from the welding shop is directed through an oil/water separator to the southwest side of the site.

The oil/water separator was uncovered and inspected during the September program. Two 50 mm pipes had been installed through 75 mm holes to serve as vents. The opening around the pipes was not sealed and the level of staining around the vents indicated the possibility that a build-up of oil in the separator would run through these openings (Photograph 6.10). Prior to this inspection, a trench was excavated in June 1999 along the discharge line from the oil/water separator to a point where the pipe was supported on barrels (see Photograph 3.1). A close examination of the pipe revealed cuts at the bottom that allowed wastewater discharged through the pipe to flow into the barrels that were also perforated (Photograph 3.2). Thus any liquid introduced into the barrel would infiltrate into the surrounding substrate that comprised sandy gravel with cobbles. Thus, historical and ongoing use of the oil/water separator and the soak away pit may have contributed to the hydrocarbon contamination detected on the south side of the site during various site investigations.

The rock pit for the main floor drainage was also uncovered during the June 1999 site investigation program. It consisted of a 3 m diameter culvert filled with boulders and surrounded by native fill comprising sandy gravel with cobbles. There was no direct evidence that the rock pit was causing substantial subsurface contamination.

The September 1999 remediation planning included the investigation of options for replacement of the current floor drain disposal system with a modern separator/treatment unit. UMA Engineering conducted evaluation of different systems, vendors, costs, and performance. The results have been presented in a separate document (UMA, 1999).

Photograph 6.9: Excavation of Underground Storage Tank northwest of the Maintenance Building

Photograph 6.10: Existing oil/water separator which receives floor drainage from the southern end of the maintenance building including the welding shop

6.4 Comparison of PetroFLAG Test Kits and Laboratory Results

PetroFLAG™ (Dexsil) test kits were employed for delineation of the spatial extent of hydrocarbon contamination and confirmatory sampling during site restoration activities. The turbidimetric approach in this method is designed to quickly screen soil samples using a system calibrated with a blank and a single calibration standard for petroleum hydrocarbon contamination in soil including a wide range of fuels, oils, and greases. Analysis range is 10-2000 µg/g. The method has been incorporated into Draft Update IVA of US EPA SW-846 Method 9074 (US EPA, 2000b).

Ninety-three soil samples were analyzed with the PetroFLAG test kits during remedial activities in September. Experimental procedures are described in details in Section 3.2.2.3. As part of the quality assurance/quality control program, sub-sets of split replicate samples were submitted to Analytical Services Laboratory (ASL) for hydrocarbon analysis. ASL conducted the analysis using procedures adapted from the US EPA Methods 3540, 3610 and 8081 (Publ. # SW-846, 3rd ed., Washington DC 20460). The procedure involved hexane/acetone extraction and analysis using GC/FID. EPH results are presented for components in the C10 to C18 and C19 to C31 ranges.

Thirty-nine soil samples were analyzed using both field and laboratory methods that represents over 40% of total analyzed by test kits. A comparison of the results is given in Table 6.9. The majority of the concentrations obtained using the PetroFLAG test kit agreed with the laboratory data using the remediation standard of 2000 µg/g as a basis for comparison. However, there were two false negatives (0.5% occurrence) and three false positives (0.7% occurrence). The results obtained in this investigation are therefore, within acceptable limits. For the false negatives, the concentration of extractable hydrocarbons as determined by the field test kit was below the action level of 2000 µg/g while laboratory analysis indicated the level exceeded the trigger. A false positive is defined as a positive response by the field test kit for a sample that contained hydrocarbons below the action level as determined by laboratory analysis.

The first false negative result was for sample CS-15, which was collected from the southwestern edge of the burn pit excavation. This is of minimal concern since additional excavation was conducted in the vicinity of this sample and hydrocarbon concentration in sample (CS61) obtained subsequently was below detection. The second false negative (UST-11) was for a sample collected from a small area below the former location of the underground storage tank (Section 6.2.4.2). This area was also considered of minor concern. Similarly, false positive results are of no environmental concern since they indicate the hydrocarbon concentrations as determined by laboratory analysis are below the action level.

Table 6.9: Comparison of PetroFLAG Field test Kit Results to Laboratory Data

Sample ID	Field Analysis PetroFLAG (µg/g)	Laboratory Analysis (µg/g)		Results Agree?
		EPH 10 -19	EPH 19-32	
BLS-10	474	423	<200	Yes
BLS-11	272	<200	<200	Yes
BLS-12	265	<200	<200	Yes
BLS-13	127	<200	<200	Yes
BLS-15	185	<200	<200	Yes
BLS-17	207	<200	<200	Yes
BLS-18	13	<200	<200	Yes
BLS-19	802	365	523	Yes
CS-5	4304	818	<200	False Positive
CS-9	764	<200	<200	Yes
CS-15	1156	2260	<200	False Negative
CS-18	116	<200	<200	Yes
CS-20	12	<200	<200	Yes
CS-22	752	1730	<200	Yes
CS-26	2984	2080	<200	Yes
CS-27	88	<200	<200	Yes
CS-31	164	<200	<200	Yes
CS-36	7788	2620	<200	Yes
CS-37	9296	1870	<200	False Positive
CS-41	>8000	8180	<200	Yes
CS-42	6496	9130	<200	Yes
CS-43	3500	2420	<200	Yes
CS-45	7516	1060	353	False Positive
CS-46	172	<200	<200	Yes
CS-47	<0	<200	<200	Yes
CS-50	1168	835	<200	Yes
CS-51	9456	5000	<200	Yes
CS-53	<10	<200	<200	Yes
CS-54	<10	<200	<200	Yes
CS-55	<10	<200	<200	Yes
CS-56	<10	<200	<200	Yes
CS-60	4180	4300	<200	Yes
CS-61	236	<200	<200	Yes
CS-63	1804	1470	<200	Yes
CS-67	<10	<200	<200	Yes
CS-68	2000	2390	<200	Yes
UST-2	3894	4060	<200	Yes
UST-4	<0	<200	<200	Yes
UST-11	1630	2650	<200	False Negative

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Synopsis of Site Investigations

Over 250 soil/sediment and 50 ground water/Blanchard River surface water samples were collected over the course of the initial site investigations in 1995 and Detail Site Assessment in 1999. Using a combination of field and laboratory analytical techniques these samples were analyzed for one or more of the following parameters - metals/metalloids, petroleum hydrocarbon constituents (VPH, LEPH, HEPH, PAHs, BTEX), halogenated volatile organic compounds, chlorinated pesticides, herbicides, chlorobenzenes, and Polychlorinated Biphenyls (PCBs).

The major conclusions based on these site investigations are described briefly below:

- Volatile Organic Compounds (VOCs), Polychlorinated Biphenyls (PCBs), chlorobenzenes and pesticides such as DDT were not contaminants of concern at Blanchard River in that they were found to be either less than the appropriately low method detection limit, or well below the relevant environmental quality benchmarks.

- Potable water samples collected from the camp water well did not contain metals/metalloids, the monoaromatic hydrocarbons benzene, ethylbenzene, toluene, and xylenes at levels exceeding the Yukon CSR drinking water standards.

- Apart from one area of the site (Rust-Coloured Drainage Ditch), the concentrations of most metals/metalloids were not of concern (i.e., did not exceed the relevant Yukon CSR standard). Arsenic and zinc were measured at concentrations in excess of Yukon CSR residential/parkland standards in sediments of the rust-coloured drainage ditch identified at the north end of the site. There are naturally elevated levels of chromium in the Blanchard River site soils, and ten soil samples contained chromium in excess of the Yukon CSR standard.

- Some of the surface water samples, colleted from either along the rust coloured drainage pathway or from the Blanchard River itself, contained aluminum, iron, and manganese at levels that exceeded the Yukon CSR water quality standards for the protection of aquatic life. This was interpreted to result from a combination of natural conditions and redox-related dissolution into groundwater where hydrocarbon contamination occurs. It was not deemed to pose any environmental risks *per se.*

- **The major contaminant issues at Blanchard River identified to the present time are all based on petroleum hydrocarbon releases of various sizes.** Hydrocarbon contamination and areas of potential concern are discussed in the next section.

7.2 Areas of Potential Concern at Blanchard River

A number of subsurface soil samples, from boreholes and test pits, had hydrocarbon concentrations in excess of the Yukon CSR standards for residential/parkland land use (1,000 µg/g for each of light- and heavy extractable petroleum hydrocarbons). A few samples also exceeded the commercial/industrial standard of 2,000 µg/g LEPHs and 5,000 µg/g HEPHs. Some of the water samples contained one or more hydrocarbon components at concentrations in excess of the Yukon CSR water standards for aquatic life or drinking water. The major issues associated with these areas of the site are given in order of priority in Chapter 5 (see Table 5.5). A summary is provided below:

1. **North of Maintenance Building (Burn Pit)** – A burn pit was operated from 1962 to 1971 north of the pump house and present day maintenance garage. Subsurface soils and groundwater collected from this area were contaminated with hydrocarbons. The overall pattern of contamination reinforces the hypothesis that the subsurface soils and groundwater at the north end of the site have been influenced by the historical release of a relatively light petroleum hydrocarbon mixture from the former burn pit. The hydrocarbon distribution suggested a slightly weathered gasoline-like mixture, possibility with contributions of a lighter diesel-like mixture. For the vast majority of samples, higher molecular weight fractions, including five- and six-ring PAHs, were not detected, and were not deemed be of concern at the north end of the site. Elevated concentrations of BTEX constituents, naphthalene and LEPHs in groundwater samples beneath or down gradient from the former burn pit indicate that the subsurface soils have been a source of petroleum hydrocarbon contamination to the groundwater.

2. **Rust-Coloured Drainage Ditch North of Site** – Hydrocarbons and metal-contamination were found in soil and surface water samples collected from a rust-coloured stained drainage ditch at the north end of the site, and leading down to the Blanchard River. Detailed investigations in 1999 showed that a culvert, which was previously identified in 1995 using an EM survey, was serving as a conduit for the diversion of hydrocarbon-contaminated groundwater from the burn pit to the rust-coloured draw. The source of the metals/metalloids was likely due to the dissolution from naturally occurring minerals in the subsurface environment, within the hydrocarbon contaminated groundwater plume associated with the burn pit.

3. **Southwest of Maintenance Building** – Contaminants include extractable petroleum hydrocarbons, BTEX components, and PAHs in either subsurface soils or groundwater. The major source of hydrocarbons to the subsurface environment was the soak away pit, constructed as part of the original pumping station and continued in use, via an oil/water separator, after conversion of the site to a highways maintenance camp. There is also some possibility that additional input to the contaminant plume might have occurred via leakage from the oil/water separator through the building foundation and into soils at the outside edge of the

foundation. This area of the site is connected to where hydrocarbon releases to the Blanchard River have been visually observed on occasion as a small, intermittent sheen. There was some evidence of the introduction of low levels of hydrocarbons into the river. The available data however suggested that, based on current site conditions, the risks to aquatic life were not elevated.

4. **Floor Drains of the Northern Portion of the Maintenance Building** – Hydrocarbons and materials introduced in the past and on an ongoing basis to floor drain and then to a rock-filled soak away pit west of the maintenance building. The rock soak away pit was not deemed to have contributed to extensive hydrocarbon contamination in the subsurface environment. There were hydrocarbon-contaminated soils and rock within the perforated culvert from which the rock pit was constructed, as well as in the immediate vicinity of the pit.

5. **Historical Release from the Largest Above Ground Storage Tank** (still present, but empty) south of the maintenance building (contaminant data provided in Section 4.7). Test pit excavations in the vicinity of the larger of two existing above-ground storage tanks (ASTs), at the southeast corner of the maintenance yard, and the associated analysis of soils, provided evidence of detectable hydrocarbons in subsurface soils. The analytical data from all boreholes and test pits samples in the vicinity of the larger AST, however, demonstrated that the concentration of hydrocarbons did not exceed the Yukon CSR standards. In addition, there was no evidence that this minimally contaminated soil mass was creating appreciable groundwater contamination, or the movement of hydrocarbons to adjacent surface areas where humans or ecological receptors might be exposed. This area, therefore, is excluded as an area of potential concern.

6. **Historical release from a smaller above ground storage tank to the east of the present-day office** of the maintenance building, and up gradient of the drinking water well for the camp. The detailed site investigation indicated that a historical release from this tank had occurred, but that soil or groundwater concentrations for various petroleum hydrocarbon constituents were lower than the applicable environmental quality benchmarks. The depth and lateral extent of contaminated soils was clearly delineated. A possibility that the historical release might be adversely affected the drinking water supply for the camp was ruled out. In light of the detailed site investigation, this portion of the site was not deemed to be of concern, and no mitigative actions are advocated at the present time.

7. **East of Maintenance Building** – Localized hydrocarbon contaminated soil in the subsurface environment just inside the maintenance yard fence line, and at the location where the original Haines-Fairbanks pipeline entered the pump station yard. It is evident that free product in at least some portions of the line was not removed prior to decommissioning. There is no evidence that limited free product releases from remaining buried pipeline have adversely impacted the site, except through the contamination of very small subsurface soil masses.

8. **Rafters Camp and Storage Area** – Surficial hydrocarbon contamination in the parking area near the Rafter's Camp, and to the south of the maintenance camp. It was evident from the analytical results that the staining was recent, and limited to shallow soils, with a decline at depths of 2 to 3 m or less. The presence of localized hydrocarbon-contaminated soils in this area of the site suggests recent release, probably associated with draining of and the inappropriate discarding of used crankcase oils from motor vehicles.

7.3 Remedial Activities

Based on the pattern of distribution of various hydrocarbon constituents in subsurface soils and groundwater in different areas of the site (summarized in Section 7.2 above), appropriate mitigative strategies were developed and implemented for two areas of the site. These were the burn pit and the rust coloured drainage ditch. The strategies included:

- Excavation of petroleum hydrocarbon contaminated soils in the vicinity of the former burn pit to curtail the release of contaminants into groundwater on the north side of the site;
- Curtailment of contaminated groundwater discharge from the culvert at the top of the rust-coloured drainage ditch at the northern end of the site; and
- Removal of metal and hydrocarbon contaminated sediments in the rust-coloured stain at the northern end of the site for off-site disposal.

7.3.1 Remediation of Burn Pit

The maximum observed concentration of petroleum hydrocarbons in shallow subsurface soils beneath the former burn pit area was 19,000 μg/g HEPHs and 2,500 μg/g LEPHs. This occurred in a test pit sample collected from near the centre of the former location of the burn pit, at a depth from the present-day surface of 0.6 m. These concentrations exceed both the Yukon industrial and residential/parkland standards for extractable petroleum hydrocarbons. The maximum LEPH concentration observed in borehole TH-12 was 1,300 μg/g in sample TH12-5, at a depth of 2.5 to 3 meters. Soil samples collected below the presumed bottom of the burn pit prior to burial did not exhibit concentrations of LEPHs, HEPHs or other petroleum hydrocarbon constituents at concentrations in excess of industrial standards.

Based on discussions with major stakeholders, it was deemed appropriate to apply industrial soil remediation standards to this portion of the site, which was used almost exclusively for non-residential activities, associated with the highways maintenance camp. The objective of the remediation program was, therefore, to reduce on-site contaminant concentrations in excess of current applicable Industrial Land use standards (2000 μg/g LEPH and 5000 μg/g HEPH).

Remedial excavations were delineated over a 400 m^2 area surrounding the former burn pit, with an average depth of between approximately 1.5 and 3 m below grade. Soils at depths less than 1.5 m generally exhibited concentrations of various hydrocarbon constituents that were lower than Yukon CSR residential/parkland standards. The contaminated soils were then excavated using a track-excavator and dump trucks. Approximately 700 m^3 (1,400 tonnes) of hydrocarbon-impacted soil from the burn pit area was placed in the containment cell for temporary storage pending construction of the proposed land farm treatment facility.

Seventy-one confirmatory samples were collected following the excavation. These were analyzed on site using PetroFLAG™ test kits. For QA/QC purposes, a subset of the samples was submitted to ASL for laboratory analysis. Detailed results are given in Chapter 6. Once confirmatory sampling and analysis of the soils had indicated that the established remediation levels were achieved, the excavations were backfilled with clean granular fill.

7.3.2 Remediation of Rust Coloured Stain

Heavy metals and extractable hydrocarbons above the applicable *CSR* industrial land use standards were found in soil and water samples from the rust coloured substrate and shallow soils down slope of the drainage ditch. The source of the contaminants was presumed to be from an existing culvert that discharged hydrocarbon contaminated groundwater onto the slope at the northern edge of the site. The limits of the contaminated substrate in the drainage ditch were first established based on visual observations and point concentrations of contaminants recorded during the two site investigation programs. The contaminated substrate was then excavated and placed into polyethylene-lined, woven polypropylene bags. The bags containing approximately 10 m^3 (15 tonnes) of material were placed in a temporary storage area pending removal for off-site disposal.

Remedial excavations were conducted to a 70 m^2 area, with a depth ranging between 0.3 m and 0.8 m below grade. Following this, 11 confirmatory samples were collected and analyzed for metals and hydrocarbon. The results indicated successful removal of the hydrocarbon and metal contaminated soils.

Site observations suggested that the culvert was installed to improve natural drainage of several shallow, seasonally variable groundwater springs in the maintenance yard. Consequently, the migration of dissolved petroleum contaminants from the burn pit intercepted the culvert, resulting in the redirection and discharge of contaminated groundwater down the bank on the north end of the site. To prevent further contaminant discharges from occurring, the entire length of culvert north of the fence line was removed and the excavation backfilled with native soils.

7.3.3 Floor Drains, Oil/Water Separator and Soak Away Pit

The September 1999 remediation planning included the investigation of options for replacement of the current floor drain disposal system with a modern separator/treatment unit. UMA Engineering conducted evaluation of different systems, vendors, costs, and performance and have presented the results in a separate document (UMA, 1999). It is anticipated that a new system will be installed in the near future. This will curtail the discharge of hydrocarbons from the current system into the subsurface environments southwest and west of the maintenance building.

7.3.4 Decommissioning of Underground Storage Tanks (USTs)

The underground storage system, consisting of two single-walled steel tanks (11,360 L gasoline and 30,280 L diesel) and concrete pump island located on the northwest of the maintenance building was decommissioned in July 1999. The excavation of the decommissioned tanks and associated pumps and piping was completed on September 27 and 28, 1999.

7.4 Recommendations

Based on the conclusions derived from the site investigations and remediation and the pattern of distribution of various hydrocarbon constituents in subsurface soils and groundwater, recommendations for the management of the Blanchard River Maintenance Camp are provided below. Detailed discussions and rationale for these recommendations are given in Chapter 5.

- **North of Site (Burn Pit)** – The source of the hydrocarbon contaminant plume at the north end of the site has been removed and presently offers no viable exposure pathway for humans or other organisms except when the residual contaminated groundwater emerges with concentrations exceeding appropriate benchmarks. Based on the array of groundwater monitoring wells installed, the groundwater data indicate that the petroleum hydrocarbon contaminated groundwater did not extend sufficiently far to the north or west for it to emerge at the surface, along the edges of the plateau along which the pumping station was constructed. Current hydrogeological conditions, coupled with subsurface attenuation, probably preclude the introduction of contaminated groundwater to areas where humans or ecological receptors might be exposed. In addition, major portion of the source area for the hydrocarbons (under and immediately down-gradient from the original burn pit location) have been removed. It is recommended that a monitoring program be initiated to verify the expected decrease in hydrocarbon concentrations in the groundwater plume following removal of contaminated substrate from the burn pit. The monitoring program would consist of –

    ⇒ Sampling of groundwater from **MW-1, MW-2 and MW-8**; and

⇒ Laboratory analysis for **hydrocarbons (BTEX, VPH, LEPH and HEPH, PAHs)**.

- **Remediation of Excavated Soils from Burn Pit Area** – Petroleum hydrocarbon contaminated soils excavated from the burn pit area (approximately 700 m^3 or 1,400 tonnes) were placed in the containment cell for temporary storage pending construction of the proposed land farm treatment facility. Land farming was identified as the most cost effective remedial option, based on the availability of sufficient land area along the former highway right-of-way, immediately adjacent to the site.

Detailed laboratory analytical data for the soils to be remediated are provided in Chapter 6. The documented concentrations, as EPH (C10-19) ranged from < 200 to 9,100 µg/g; however, the upper value may be lower than the upper concentration limit for the soil as a whole, since the laboratory analytical data is based on samples collected for the purposes of confirmatory sampling and guiding excavation. Grossly contaminated soils were not targeted for sampling since they could be identified through olfactory and visual cues. The highest value for LEPHs documented from the test pit or borehole samples collected, as part of the Detailed Site Investigation, was 19,000 µg/g. The heavier hydrocarbon fraction (i.e. EPH C19-32) in the excavated soils was < 200 µg/g in 22 of 23 samples (Tables 6.2, 6.3). The remaining sample had a concentration of 353 µg/g. The highest HEPH concentration documented as part of the DSI was in a sample collected at the base of the original burn pit, with a concentration of only 2,500 µg/g. Overall, the documented hydrocarbon levels in the excavated soils suggest reductions should be readily achievable to residential/parkland concentrations for LEPH and HEPH.

A reduction in concentration of all contaminants of concern to below Yukon CSR residential/parkland standards would be advantageous in allowing the soil to be left in place following final bioremediation, without appreciable risks to soil invertebrates, plants or wildlife. A proposed design for land farm construction will be provided under separate cover. Overall, the remediation of soils using land farming should be accompanied by a sampling and analysis program to ensure the remediation of soils to acceptable levels, possibly over a period of 2 to 4 years.

The soil remediation-monitoring program would consist of –

⇒ Initial sample collection and detailed analytical characterization of the soil mass to be remediated (comprising 15 soil samples, or one sample for each 50 m^3 of soil mass plus one field duplicate);

⇒ Annual monitoring each August or September following the first year based on the same number of samples and analytical suite;

  - ⇒ Possible monitoring for additional substances which might increase in concentration in the soils as intermediate microbial metabolites; and

  - ⇒ Possible inclusion of soil invertebrate or plant toxicity tests of the final bioremediated soils or observations of recolonization of the soils post-remediation relative to colonization of adjacent, clean reference soils that have been disturbed.

- **Southwest of Maintenance Building** – The petroleum hydrocarbon plume at the south end of the site contained concentrations of BTEX components in excess of Yukon CSR drinking water standards. The actual samples of drinking water from the station, however, did not contain detectable BTEX concentrations. Elevated human health risks, therefore, would not be plausible at the present time, unless recreational or other users derived drinking water from some point along the southern hydrocarbon plume where these substances were elevated. Groundwater samples from wells installed in this southern hydrocarbon plume also had a limited number of PAHs (naphthalene, phenanthrene, pyrene) at concentrations in excess of the Yukon CSR water standards for aquatic life. Analytical data for river water and sediment samples, however, do not provide any evidence for concentrations in the aquatic environment that would result in risks to aquatic life. Because there was no evidence of exceedances of aquatic life standards within the river itself, and because the input source for the contaminant plume would no longer be active following installation of a new floor drain system, the removal of the remaining deep, subsurface soils within the contaminant plume may not be necessary. An annual monitoring program should be initiated. As a minimum this would consist of –

  - ⇒ Sampling of groundwater from **MW-5, MW-9, MW-10, MW-13, MW-18, MW-19, MP-3 and MP-4** (it will probably be necessary to re-establish the two mini-piezometers each year, since they may be removed or destroyed annually through ice scour);

  - ⇒ Collection of sediment and surface water from Blanchard River; and

  - ⇒ Laboratory analysis for **hydrocarbons (BTEX, VPH, LEPH and HEPH, PAHs)**.

  Should the results suggest this potentially ongoing contaminant source is resulting in unacceptable risks to Blanchard River ecological receptors, there are at least three major risk management or risk reduction strategies which merit further investigation. These are (i) contaminated soil removal, (ii) in situ remediation, and (iii) construction of an active or passive barrier upgradient from the outflow face in order to eliminate contamination of the river.

- **Floor Drains, Rock Pit and Soak away** – It is anticipated that the current floor drains in the maintenance building would be decommissioned and replaced with more up-to-date oil/water separation technology, with offsite disposal of recovered oily waste for recycling. This would curtail the chronic discharge of hydrocarbon-contaminated water into the subsurface environment. The localized hydrocarbon-contaminated materials within and around the pits do not appear to have resulted in a more widespread lateral or down-gradient contamination of the subsurface environment. Removal or isolation of the decommissioned rock pit, therefore, is not deemed to be necessary based on the expected limited risks to the environment.

- **East of Maintenance Building** - It is evident that free product in at least some portions of the six-inch line was not removed prior to decommissioning of the pipeline. There is no evidence that limited free product releases from remaining buried pipeline have adversely impacted the site, except through the contamination of very small subsurface soil masses. It is recommended therefore that the presence of free product be carefully documented. Should an opportunity present itself, it might be prudent to recover the remaining free product through use of a vacuum truck or similar method. No further mitigative action appears to be warranted.

- **Rafters Camp and Storage Area** - The presence of localized hydrocarbon-contaminated soils in this area of the site suggests recent release, probably associated with draining of and the inappropriate discarding of used crankcase oils from motor vehicles. It is recommended that measures be taken to control the unauthorized disposal of used oil in the future.

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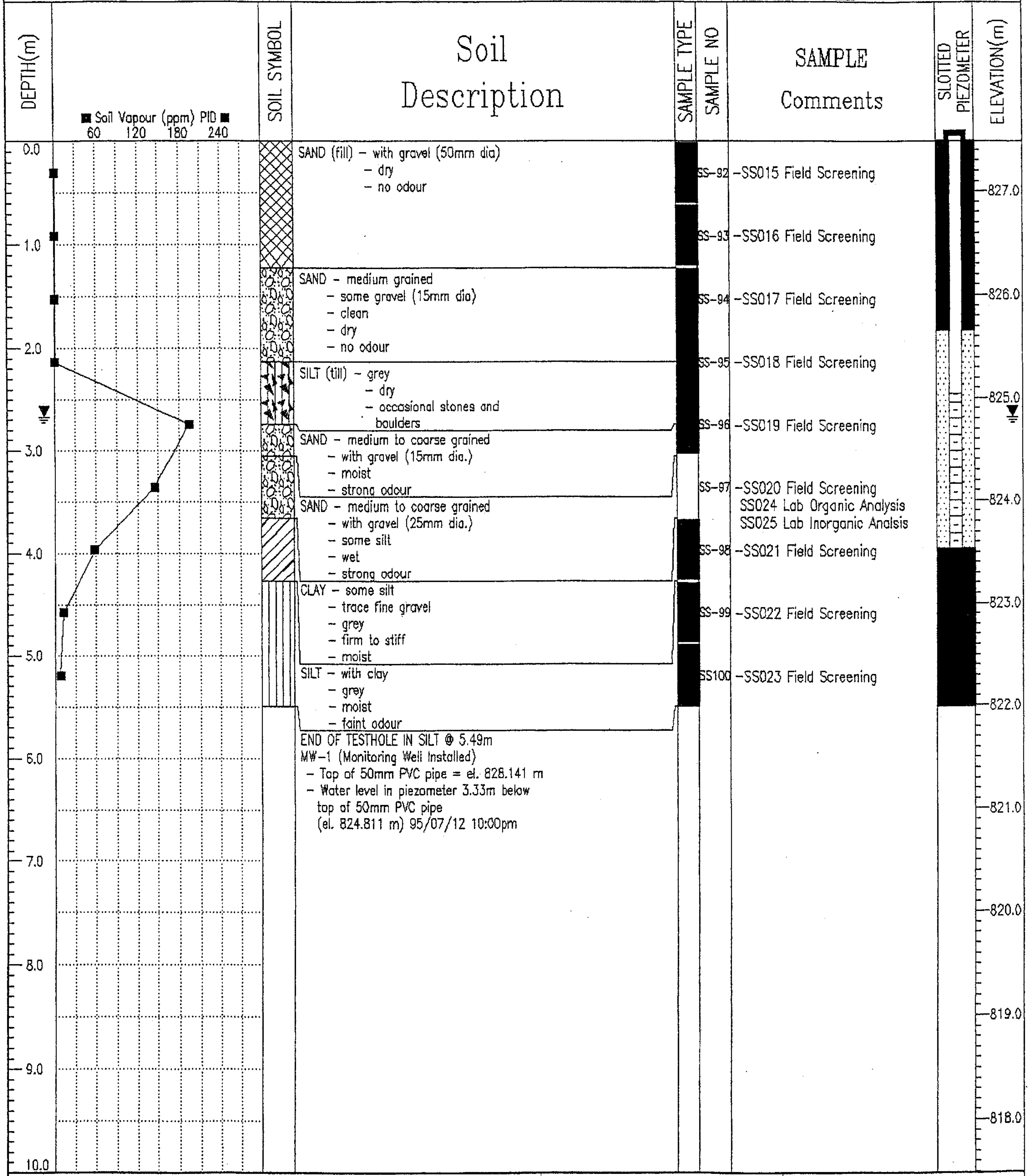
APPENDIX A:
Borehole Logs

Project: HAINES-FAIRBANKS PIPELINE ESA	DRILLED BY: MIDNIGHT SUN DRILLING	TEST HOLE NO: TH95-1
Client: DIAND	Drill Type: ROTARY CASING HAMMER	PROJECT NO: 4440-034-00-02
PROJECT ENGINEER: TW	BLANCHARD RIVER PUMP STATION	ELEVATION: 827.481 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	‖ Split Spoon	▌ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁖ PEA GRAVEL	‖ SLOUGH	⁖ GROUT	▨ DRILL CUTTINGS	⁘ SAND



Soil Description

SAND (fill) – with gravel (50mm dia)
- dry
- no odour

SAND – medium grained
- some gravel (15mm dia)
- clean
- dry
- no odour

SILT (till) – grey
- dry
- occasional stones and boulders

SAND – medium to coarse grained
- with gravel (15mm dia.)
- moist
- strong odour

SAND – medium to coarse grained
- with gravel (25mm dia.)
- some silt
- wet
- strong odour

CLAY – some silt
- trace fine gravel
- grey
- firm to stiff
- moist

SILT – with clay
- grey
- moist
- faint odour

END OF TESTHOLE IN SILT @ 5.49m
MW-1 (Monitoring Well Installed)
- Top of 50mm PVC pipe = el. 828.141 m
- Water level in piezometer 3.33m below top of 50mm PVC pipe (el. 824.811 m) 95/07/12 10:00pm

SAMPLE NO	SAMPLE Comments
SS-92	-SS015 Field Screening
SS-93	-SS016 Field Screening
SS-94	-SS017 Field Screening
SS-95	-SS018 Field Screening
SS-96	-SS019 Field Screening
SS-97	-SS020 Field Screening SS024 Lab Organic Analysis SS025 Lab Inorganic Analsis
SS-98	-SS021 Field Screening
SS-99	-SS022 Field Screening
SS100	-SS023 Field Screening

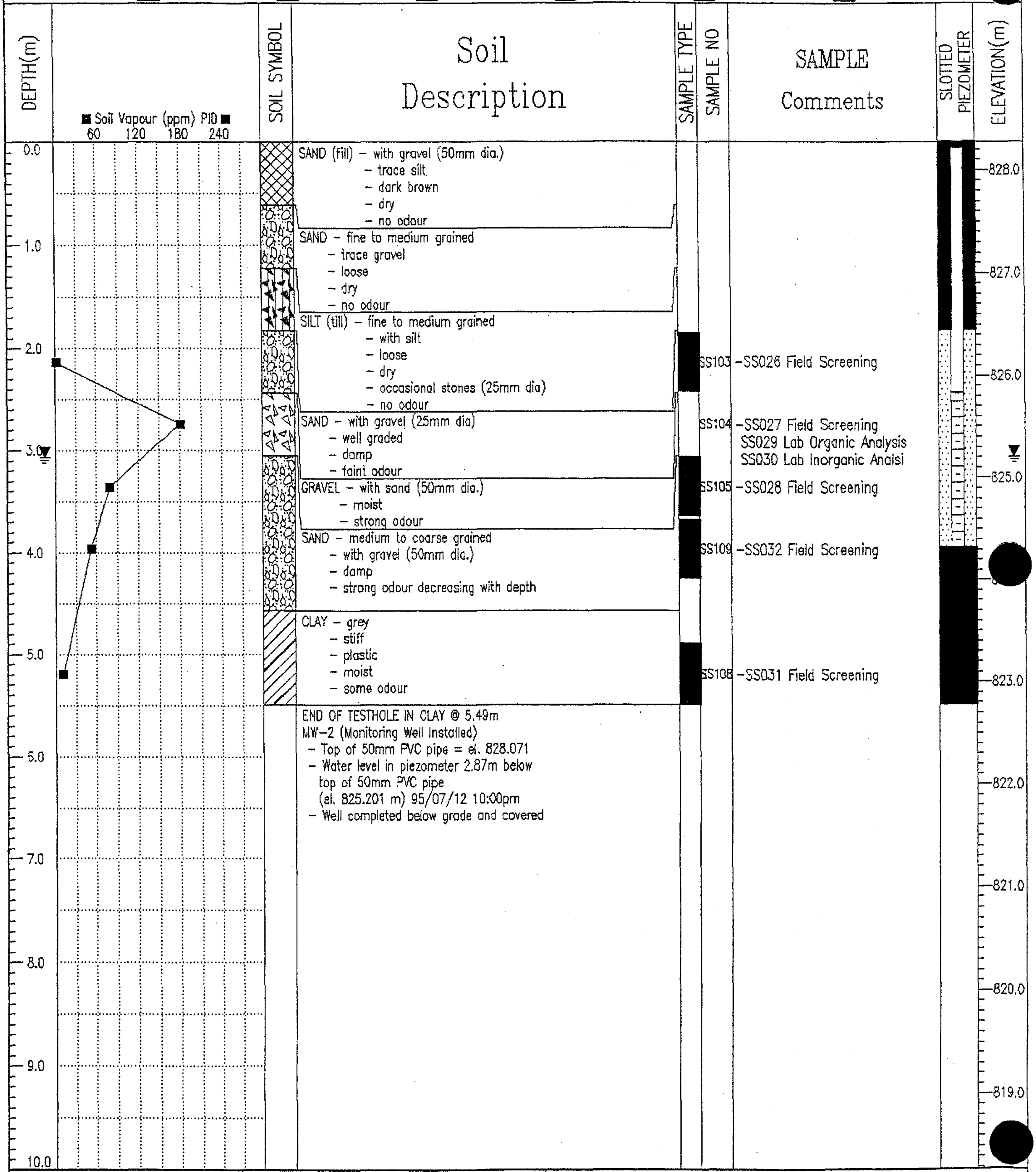
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 5.5 m
	REVIEWED BY:	COMPLETE: 95/07/11
	Fig. No:	Page 1 of 1

00/02/14 03:18PM (ENVR03)

Project: HAINES-FAIRBANKS PIPELINE ESA	DRILLED BY: MIDNIGHT SUN DRILLING	TEST HOLE NO: TH95-2
Client: DIAND	Drill Type: ROTARY CASING HAMMER	PROJECT NO: 4440-034-00-02
PROJECT ENGINEER: TW	BLANCHARD RIVER PUMP STATION	ELEVATION: 828.271 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ▨ GROUT ▨ DRILL CUTTINGS ⁘ SAND



Soil Description	SAMPLE NO	SAMPLE Comments
SAND (fill) – with gravel (50mm dia.) – trace silt – dark brown – dry – no odour		
SAND – fine to medium grained – trace gravel – loose – dry – no odour		
SILT (till) – fine to medium grained – with silt – loose – dry – occasional stones (25mm dia) – no odour	SS103	–SS026 Field Screening
SAND – with gravel (25mm dia) – well graded – damp – faint odour	SS104	–SS027 Field Screening SS029 Lab Organic Analysis SS030 Lab Inorganic Analsi
GRAVEL – with sand (50mm dia.) – moist – strong odour	SS105	–SS028 Field Screening
SAND – medium to coarse grained – with gravel (50mm dia.) – damp – strong odour decreasing with depth	SS109	–SS032 Field Screening
CLAY – grey – stiff – plastic – moist – some odour	SS108	–SS031 Field Screening

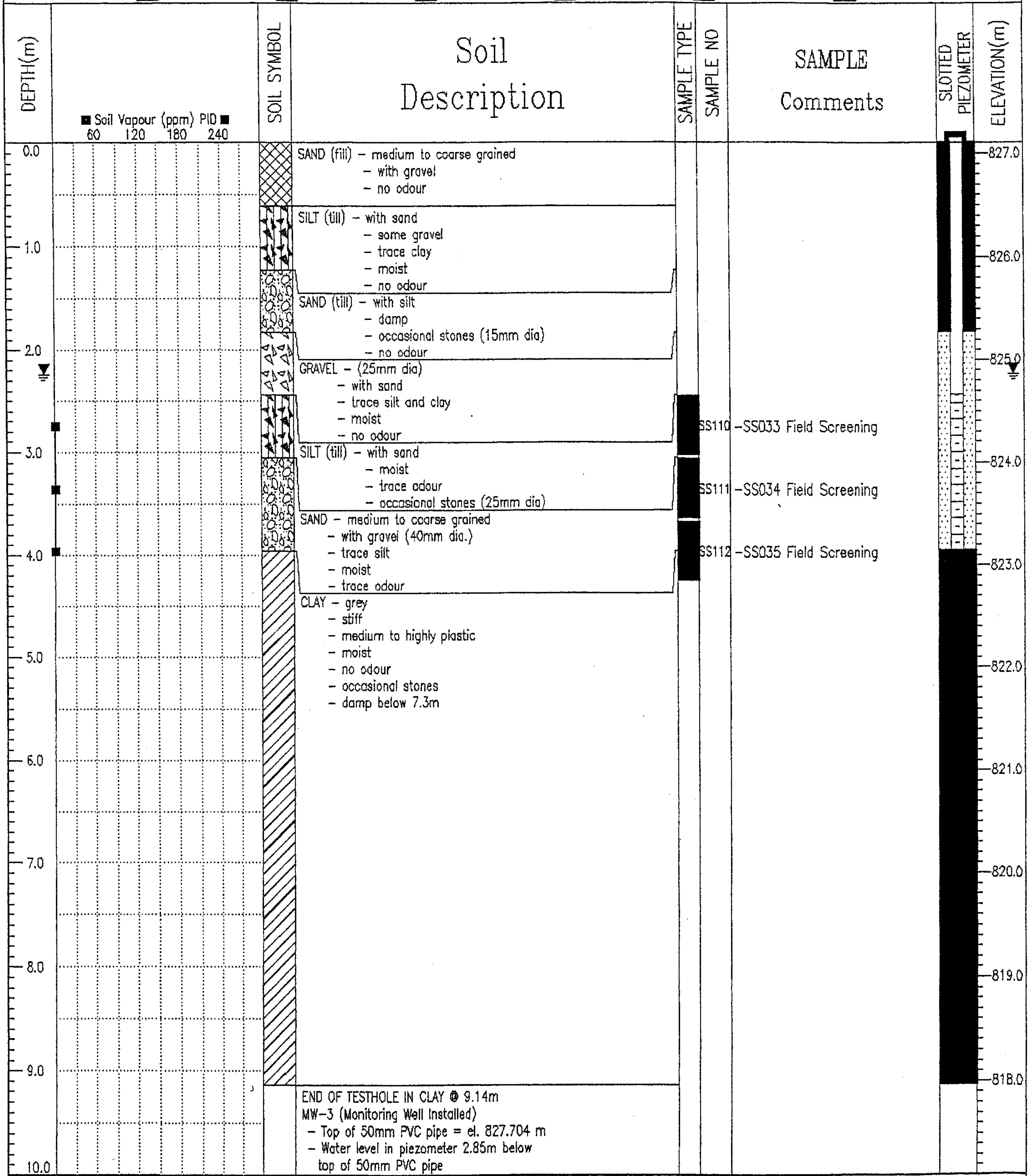
END OF TESTHOLE IN CLAY @ 5.49m
MW-2 (Monitoring Well Installed)
– Top of 50mm PVC pipe = el. 828.071
– Water level in piezometer 2.87m below top of 50mm PVC pipe (el. 825.201 m) 95/07/12 10:00pm
– Well completed below grade and covered

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 5.5 m
	REVIEWED BY:	COMPLETE: 95/07/11
	Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA	DRILLED BY: MIDNIGHT SUN DRILLING	TEST HOLE NO: TH95-3
Client: DIAND	Drill Type: ROTARY CASING HAMMER	PROJECT NO: 4440-034-00-02
PROJECT ENGINEER: TW	BLANCHARD RIVER PUMP STATION	ELEVATION: 827.1 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ⁘ GROUT ▨ DRILL CUTTINGS ░ SAND



Soil Description

SAND (fill) - medium to coarse grained
- with gravel
- no odour

SILT (till) - with sand
- some gravel
- trace clay
- moist
- no odour

SAND (till) - with silt
- damp
- occasional stones (15mm dia)
- no odour

GRAVEL - (25mm dia)
- with sand
- trace silt and clay
- moist
- no odour

SILT (till) - with sand
- moist
- trace odour
- occasional stones (25mm dia)

SAND - medium to coarse grained
- with gravel (40mm dia.)
- trace silt
- moist
- trace odour

CLAY - grey
- stiff
- medium to highly plastic
- moist
- no odour
- occasional stones
- damp below 7.3m

END OF TESTHOLE IN CLAY @ 9.14m
MW-3 (Monitoring Well Installed)
- Top of 50mm PVC pipe = el. 827.704 m
- Water level in piezometer 2.85m below top of 50mm PVC pipe

SAMPLE Comments

SAMPLE NO	SAMPLE Comments
SS110	-SS033 Field Screening
SS111	-SS034 Field Screening
SS112	-SS035 Field Screening

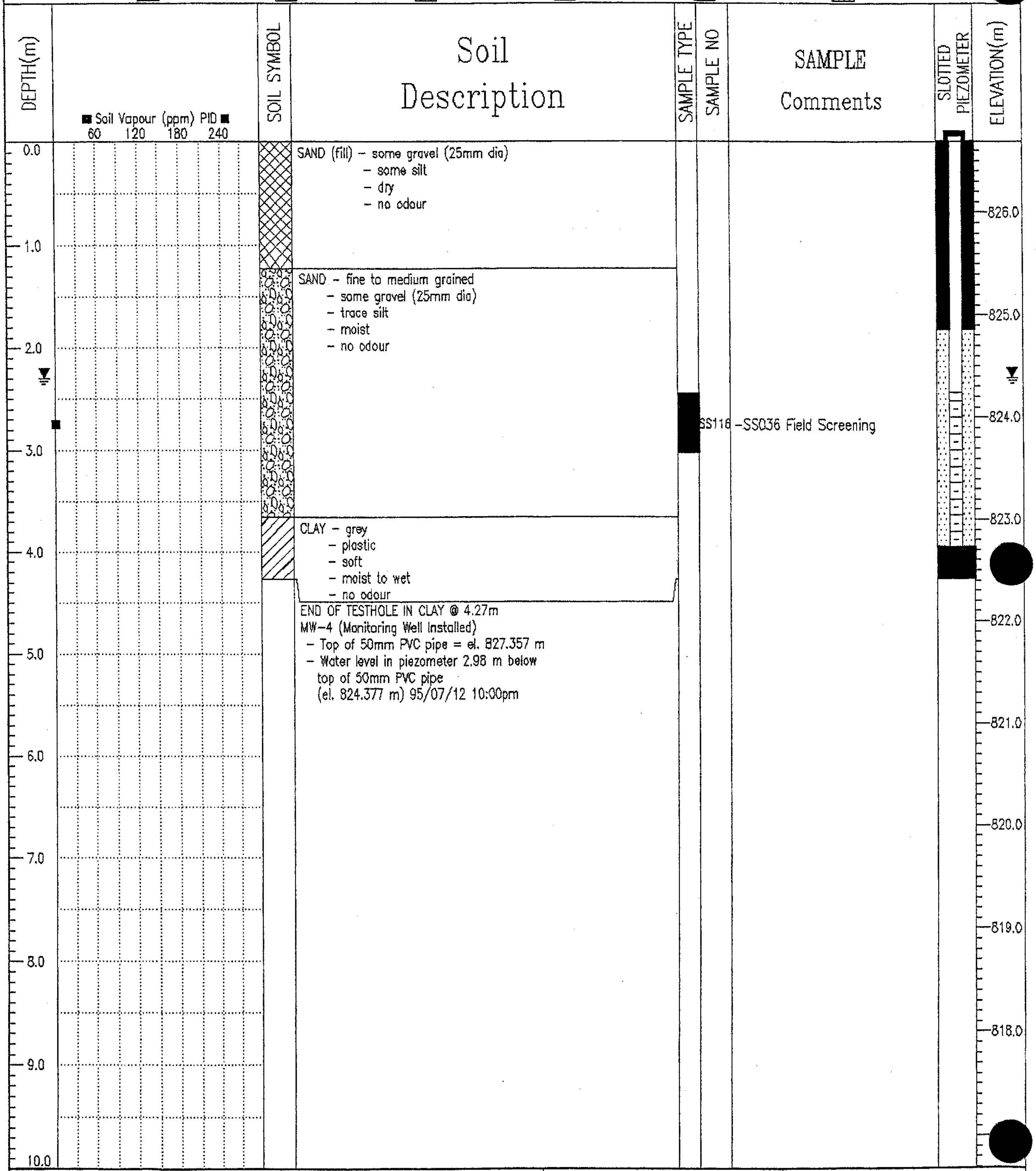
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 9.1 m
	REVIEWED BY:	COMPLETE: 95/07/11
	Fig. No:	Page 1 of 1

00/02/14 03:19PM (ENVR03)

Project: HAINES-FAIRBANKS PIPELINE ESA	DRILLED BY: MIDNIGHT SUN DRILLING	TEST HOLE NO: TH95-4
Client: DIAND	Drill Type: ROTARY CASING HAMMER	PROJECT NO: 4440-034-00-02
PROJECT ENGINEER: TW	BLANCHARD RIVER PUMP STATION	ELEVATION: 826.682 (m)

SAMPLE TYPE ■ Grab Sample ◿ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ⁖ GROUT ▨ DRILL CUTTINGS ▒ SAND



SAND (fill) – some gravel (25mm dia)
- some silt
- dry
- no odour

SAND – fine to medium grained
- some gravel (25mm dia)
- trace silt
- moist
- no odour

SS116 –SS036 Field Screening

CLAY – grey
- plastic
- soft
- moist to wet
- no odour

END OF TESTHOLE IN CLAY @ 4.27m
MW-4 (Monitoring Well Installed)
- Top of 50mm PVC pipe = el. 827.357 m
- Water level in piezometer 2.98 m below top of 50mm PVC pipe (el. 824.377 m) 95/07/12 10:00pm

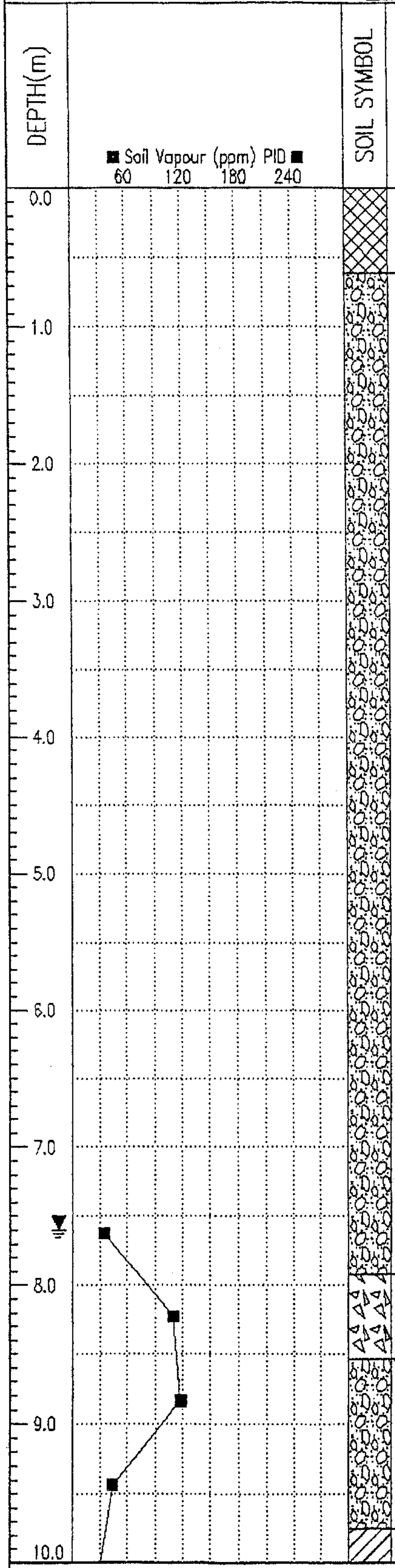
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 4.3 m
	REVIEWED BY:	COMPLETE: 95/07/12
	Fig. No:	Page 1 of 1

00/02/14 03:19PM (ENVIR03)

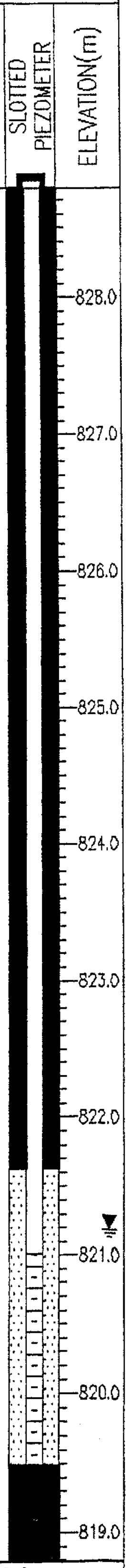
Project: HAINES-FAIRBANKS PIPELINE ESA	DRILLED BY: MIDNIGHT SUN DRILLING	TEST HOLE NO: TH95-5
Client: DIAND	Drill Type: ROTARY CASING HAMMER	PROJECT NO: 4440-034-00-02
PROJECT ENGINEER: TW	BLANCHARD RIVER PUMP STATION	ELEVATION: 828.784 (m)

SAMPLE TYPE: ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE: ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ▦ GROUT ▨ DRILL CUTTINGS ⁙ SAND



Soil Description	SAMPLE TYPE	SAMPLE NO	SAMPLE Comments
GRAVEL (fill) - with sand - trace silt - no odour			
SAND - medium to coarse grained - some gravel (25mm dia.) - trace silt - damp - trace odour 1.2m to 1.8m - moist at 7.3m	■	SS117	-SS037 Field Screening SS044 Lab Organic Analysis
GRAVEL - with sand (25mm dia) - trace silt - moist - strong odour	■	SS118	-SS038 Field Screening
SAND - medium to coarse grained - with gravel (25mm dia) - wet - strong odour	■	SS119	-SS039 Field Screening
		SS120	-SS040 Field Screening SS043 Lab Organic Analysis SS042 Lab Inorganic Analsis
CLAY - grey	■	SS121	



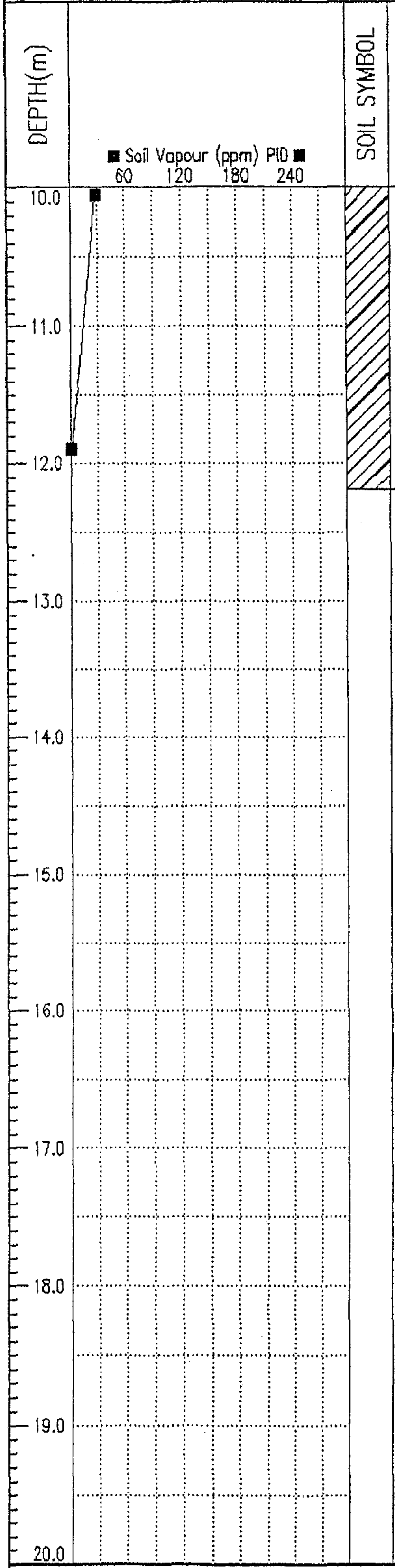
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 12.2 m
	REVIEWED BY:	COMPLETE: 95/07/12
	Fig. No:	Page 1 of 2

00/02/14 03:19PM (ENVIR03)

Project: HAINES-FAIRBANKS PIPELINE ESA	DRILLED BY: MIDNIGHT SUN DRILLING	TEST HOLE NO: TH95-5
Client: DIAND	Drill Type: ROTARY CASING HAMMER	PROJECT NO: 4440-034-00-02
PROJECT ENGINEER: TW	BLANCHARD RIVER PUMP STATION	ELEVATION: 828.784 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁖ GROUT ▨ DRILL CUTTINGS ░ SAND

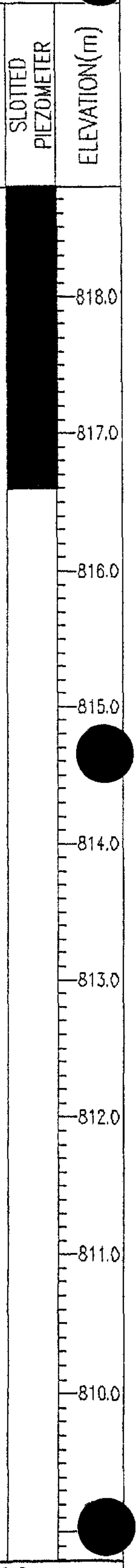


Soil Description

- firm
- plastic
- moist decreasing with depth to dry @ 11.0m

END OF TESTHOLE IN CLAY @ 12.19m
MW-5 (Monitoring Well Installed)
- Top of 50mm PVC pipe = el. 829.434 m
- Water level in piezometer 8.25 m below top of 50mm PVC pipe (el. 821.184 m) 95/07/12 10:00pm

SAMPLE TYPE	SAMPLE NO	SAMPLE Comments
■	SS121	-SS041 Field Screening
■	SS125	-SS045 Field Screening

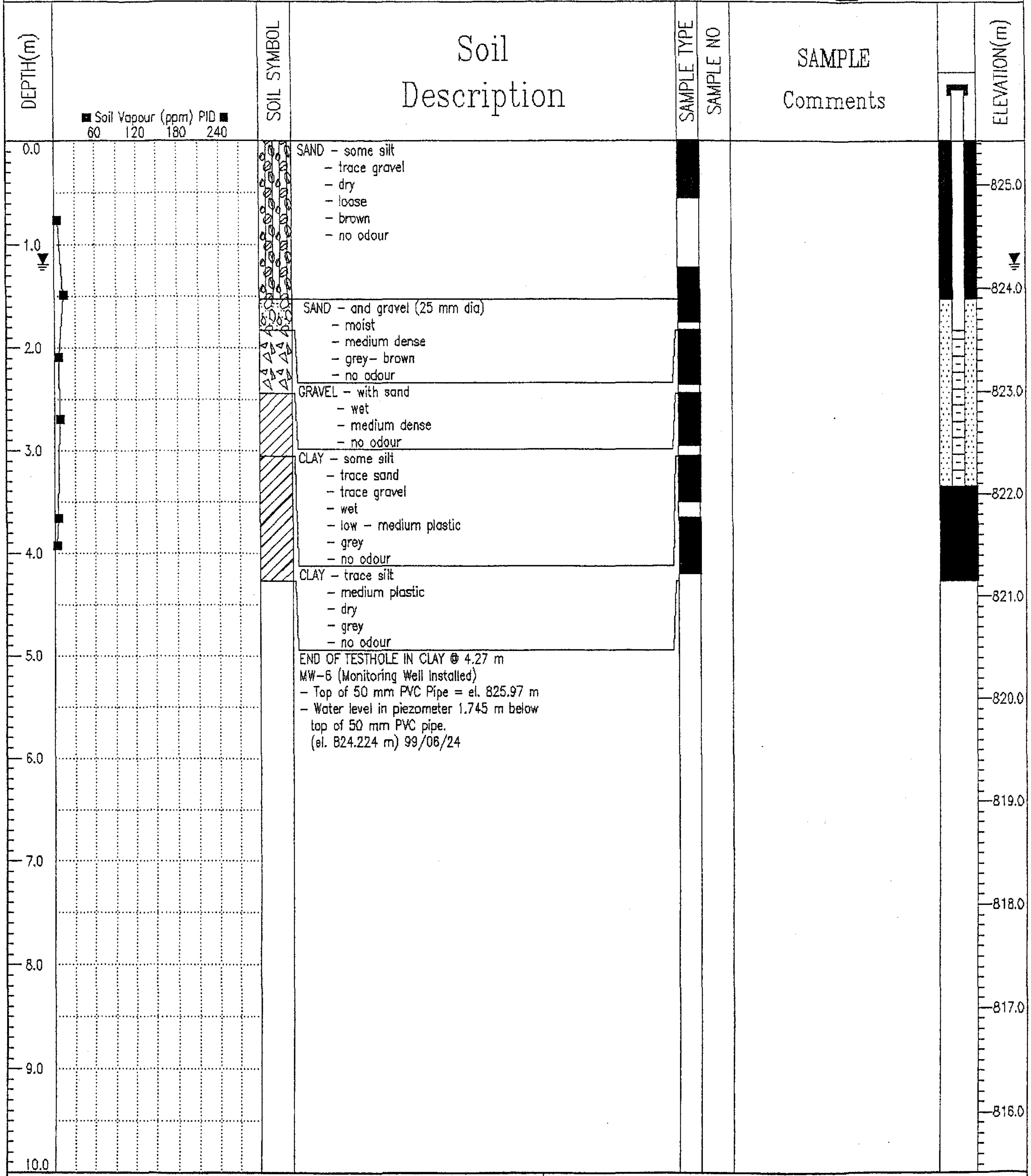


UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 12.2 m
	REVIEWED BY:	COMPLETE: 95/07/12
	Fig. No:	Page 2 of 2

00/02/14 03:19PM (ENVR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-6
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 825.419 (m)

SAMPLE TYPE	■ Grab Sample	◪ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▥ Split Spoon	▮ Wire Line–Type
BACKFILL TYPE	■ BENTONITE	⛶ PEA GRAVEL	▥ SLOUGH	⛶ GROUT	▨ DRILL CUTTINGS	░ SAND



SAND – some silt
- – trace gravel
- – dry
- – loose
- – brown
- – no odour

SAND – and gravel (25 mm dia)
- – moist
- – medium dense
- – grey– brown
- – no odour

GRAVEL – with sand
- – wet
- – medium dense
- – no odour

CLAY – some silt
- – trace sand
- – trace gravel
- – wet
- – low – medium plastic
- – grey
- – no odour

CLAY – trace silt
- – medium plastic
- – dry
- – grey
- – no odour

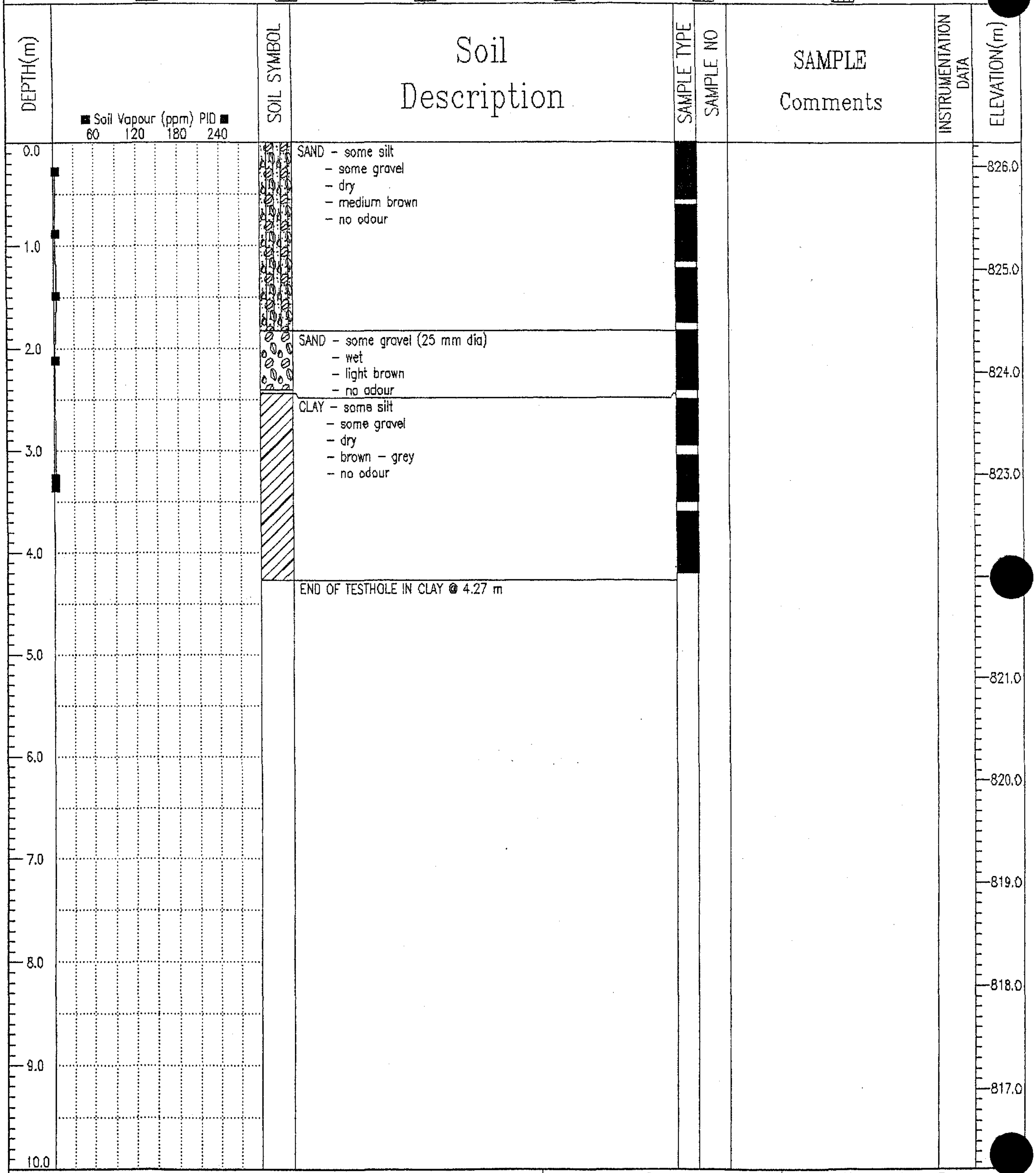
END OF TESTHOLE IN CLAY @ 4.27 m
MW–6 (Monitoring Well Installed)
– Top of 50 mm PVC Pipe = el. 825.97 m
– Water level in piezometer 1.745 m below top of 50 mm PVC pipe. (el. 824.224 m) 99/06/24

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 4.3 m
	REVIEWED BY: ANP	COMPLETE: 06/15/99
	Fig. No:	Page 1 of 1

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-7
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 826.23 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line–Type

BACKFILL TYPE ■ BENTONITE ☐ PEA GRAVEL ▥ SLOUGH ☐ GROUT ▨ DRILL CUTTINGS ☐ SAND



SAND – some silt
- some gravel
- dry
- medium brown
- no odour

SAND – some gravel (25 mm dia)
- wet
- light brown
- no odour

CLAY – some silt
- some gravel
- dry
- brown – grey
- no odour

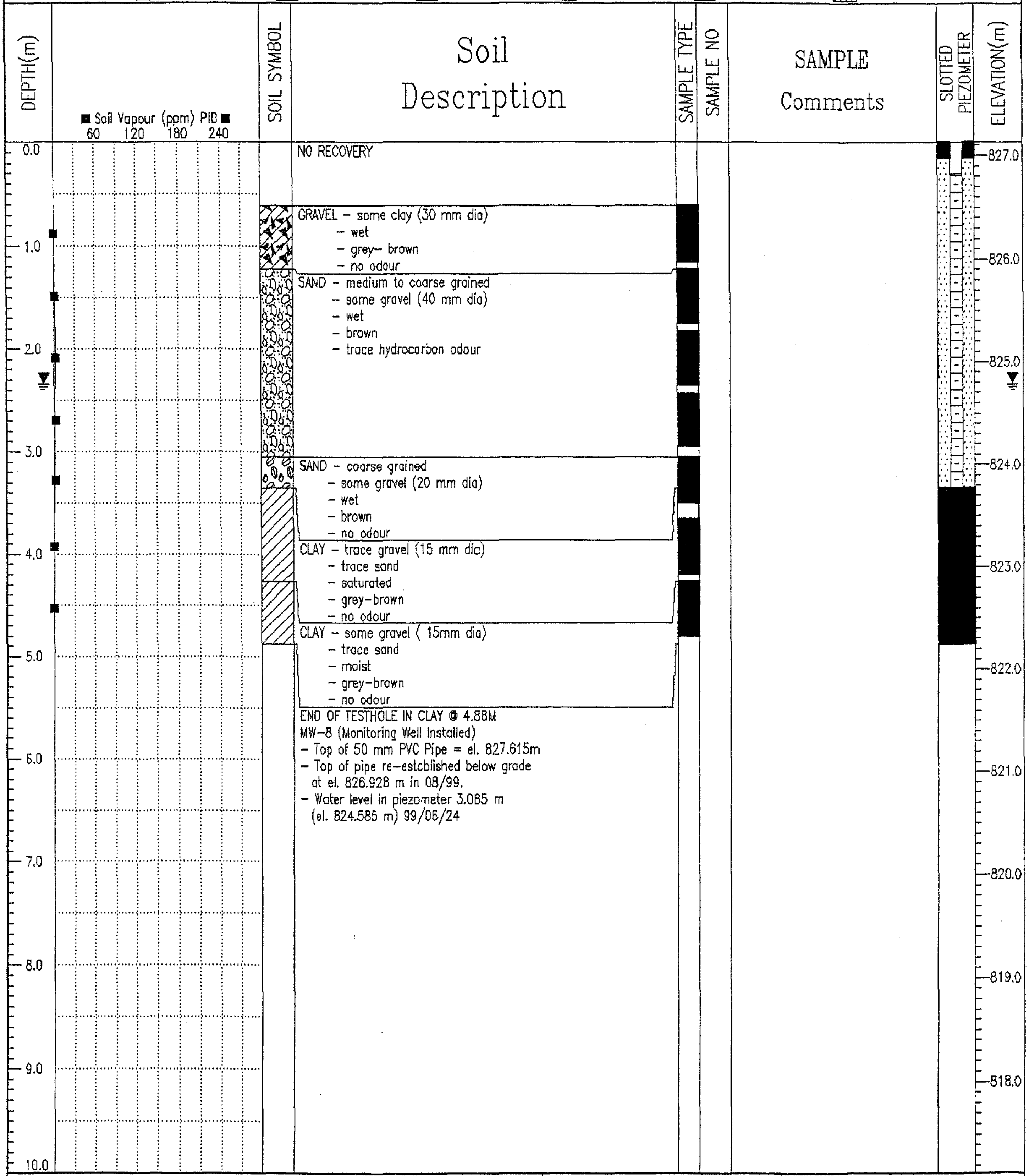
END OF TESTHOLE IN CLAY @ 4.27 m

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 4.3 m
	REVIEWED BY: ANP	COMPLETE: 06/15/99
	Fig. No:	Page 1 of 1

00/02/14 04:17PM (ENVIRO3)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-8
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 827.125 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	Split Spoon	Wire Line-Type
BACKFILL TYPE	■ BENTONITE	PEA GRAVEL	SLOUGH	GROUT	DRILL CUTTINGS	SAND



NO RECOVERY

GRAVEL - some clay (30 mm dia)
- wet
- grey- brown
- no odour

SAND - medium to coarse grained
- some gravel (40 mm dia)
- wet
- brown
- trace hydrocarbon odour

SAND - coarse grained
- some gravel (20 mm dia)
- wet
- brown
- no odour

CLAY - trace gravel (15 mm dia)
- trace sand
- saturated
- grey-brown
- no odour

CLAY - some gravel (15mm dia)
- trace sand
- moist
- grey-brown
- no odour

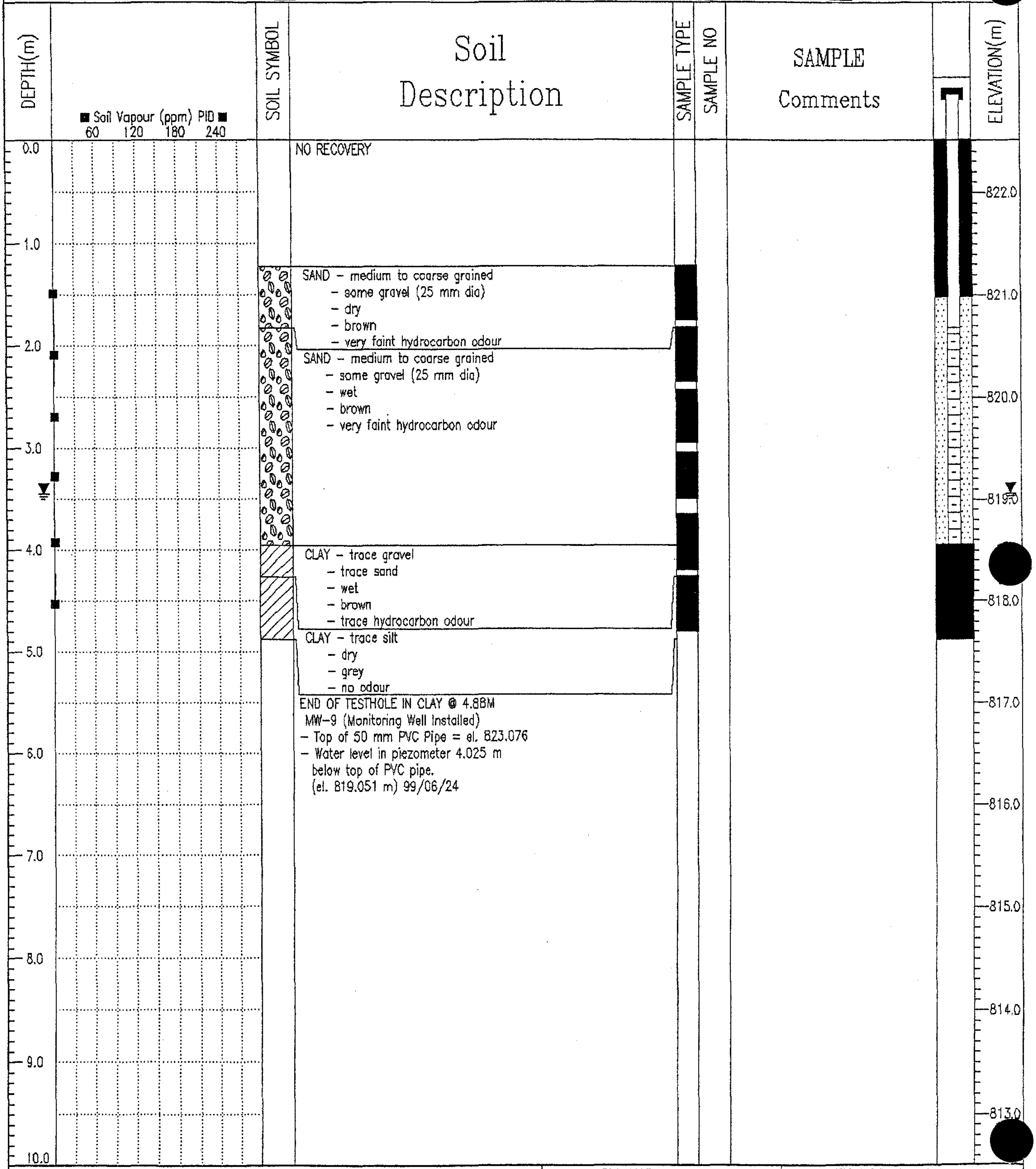
END OF TESTHOLE IN CLAY @ 4.88M
MW-8 (Monitoring Well Installed)
- Top of 50 mm PVC Pipe = el. 827.615m
- Top of pipe re-established below grade at el. 826.928 m in 08/99.
- Water level in piezometer 3.085 m (el. 824.585 m) 99/06/24

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 4.9 m
	REVIEWED BY: ANP	COMPLETE: 06/16/99
	Fig. No:	Page 1 of 1

00/02/14 04:43PM (ENVIR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-9
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 822.506 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▯ Split Spoon	▮ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁚ PEA GRAVEL	▥ SLOUGH	▩ GROUT	▨ DRILL CUTTINGS	⁘ SAND



NO RECOVERY

SAND - medium to coarse grained
- some gravel (25 mm dia)
- dry
- brown
- very faint hydrocarbon odour

SAND - medium to coarse grained
- some gravel (25 mm dia)
- wet
- brown
- very faint hydrocarbon odour

CLAY - trace gravel
- trace sand
- wet
- brown
- trace hydrocarbon odour

CLAY - trace silt
- dry
- grey
- no odour

END OF TESTHOLE IN CLAY @ 4.88M
MW-9 (Monitoring Well Installed)
- Top of 50 mm PVC Pipe = el. 823.076
- Water level in piezometer 4.025 m
below top of PVC pipe.
(el. 819.051 m) 99/06/24

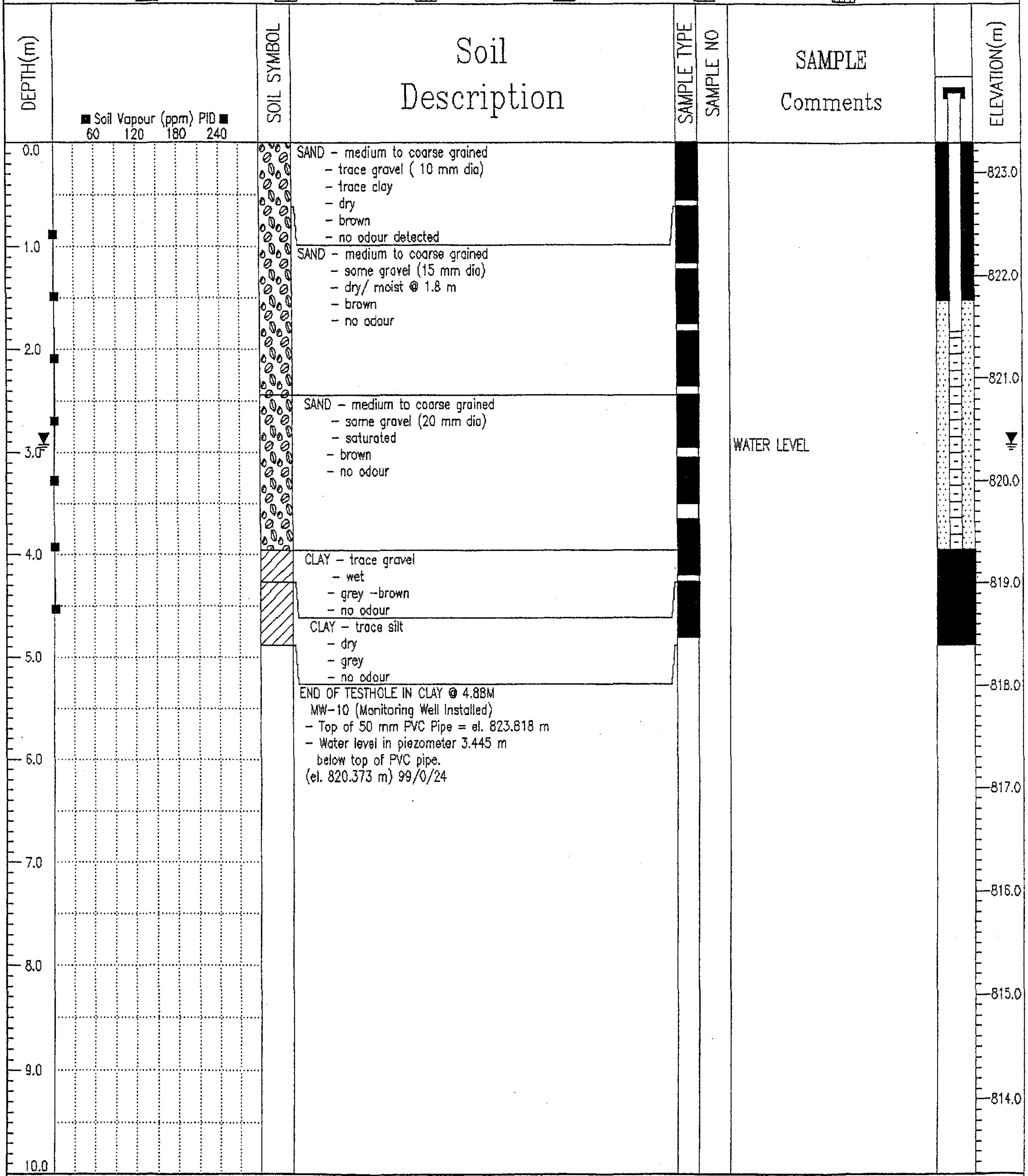
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 4.9 m
	REVIEWED BY: ANP	COMPLETE: 06/16/99
	Fig. No:	Page 1 of 1

00/02/14 04:43PM (ENVIR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-10
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 823.278 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▥ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ▩ GROUT ▨ DRILL CUTTINGS ⁚ SAND



SAND – medium to coarse grained
– trace gravel (10 mm dia)
– trace clay
– dry
– brown
– no odour detected

SAND – medium to coarse grained
– some gravel (15 mm dia)
– dry/ moist @ 1.8 m
– brown
– no odour

SAND – medium to coarse grained
– some gravel (20 mm dia)
– saturated
– brown
– no odour

WATER LEVEL

CLAY – trace gravel
– wet
– grey –brown
– no odour

CLAY – trace silt
– dry
– grey
– no odour

END OF TESTHOLE IN CLAY @ 4.88M
MW-10 (Monitoring Well Installed)
– Top of 50 mm PVC Pipe = el. 823.818 m
– Water level in piezometer 3.445 m
below top of PVC pipe.
(el. 820.373 m) 99/0/24

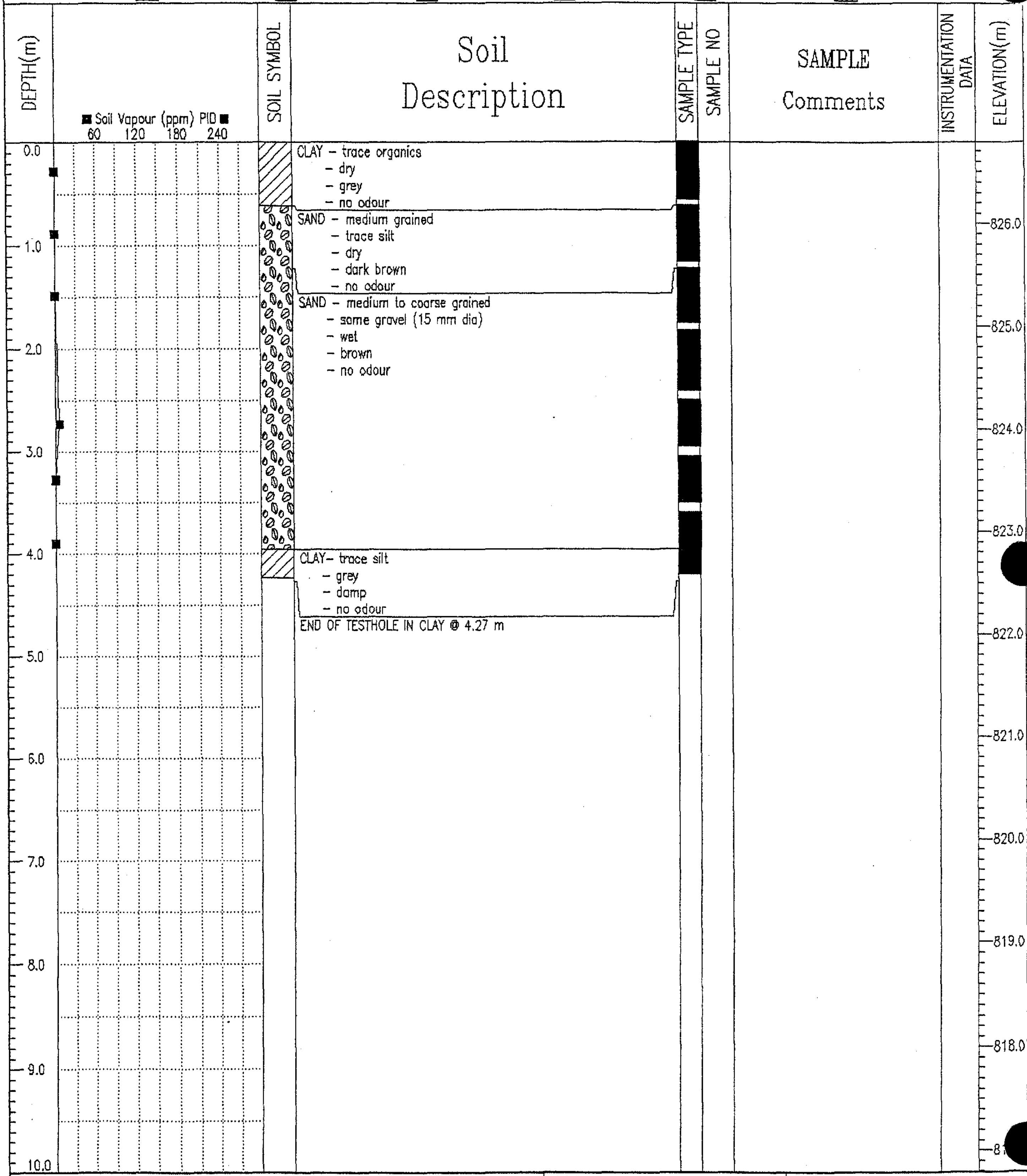
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 4.9 m
	REVIEWED BY: ANP	COMPLETE: 06/16/99
	Fig. No:	Page 1 of 1

00/02/14 04:44PM (ENMR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-11
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 826.785 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁘ GROUT ▨ DRILL CUTTINGS ░ SAND



CLAY – trace organics
- dry
- grey
- no odour

SAND – medium grained
- trace silt
- dry
- dark brown
- no odour

SAND – medium to coarse grained
- some gravel (15 mm dia)
- wet
- brown
- no odour

CLAY– trace silt
- grey
- damp
- no odour

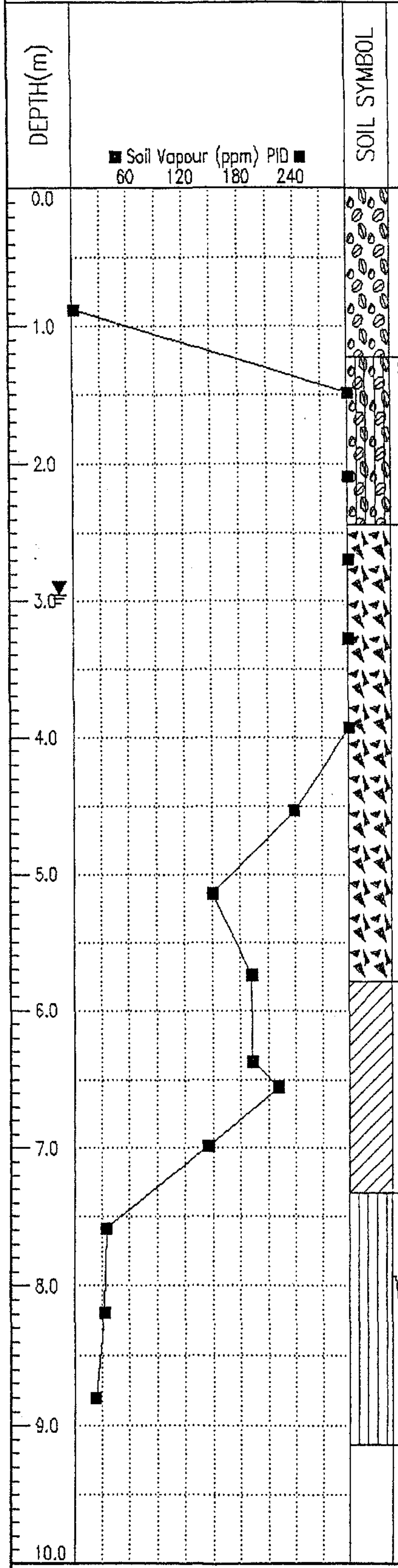
END OF TESTHOLE IN CLAY @ 4.27 m

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 4.3 m
	REVIEWED BY: ANP	COMPLETE: 06/15/99
	Fig. No:	Page 1 of 1

00/02/14 04:44PM (ENVR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-12
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 828.872 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▯ Split Spoon	▮ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	▨ GROUT	▨ DRILL CUTTINGS	⁘ SAND



Soil Description

SAND – medium to coarse grained
- trace gravel (10 mm dia)
- damp
- brown
- faint hydrocarbon odour
- low sample recovery

SAND – some silt; some clay
- trace gravel (10 mm dia)
- wet
- brown – black
- strong hydrocarbon odour

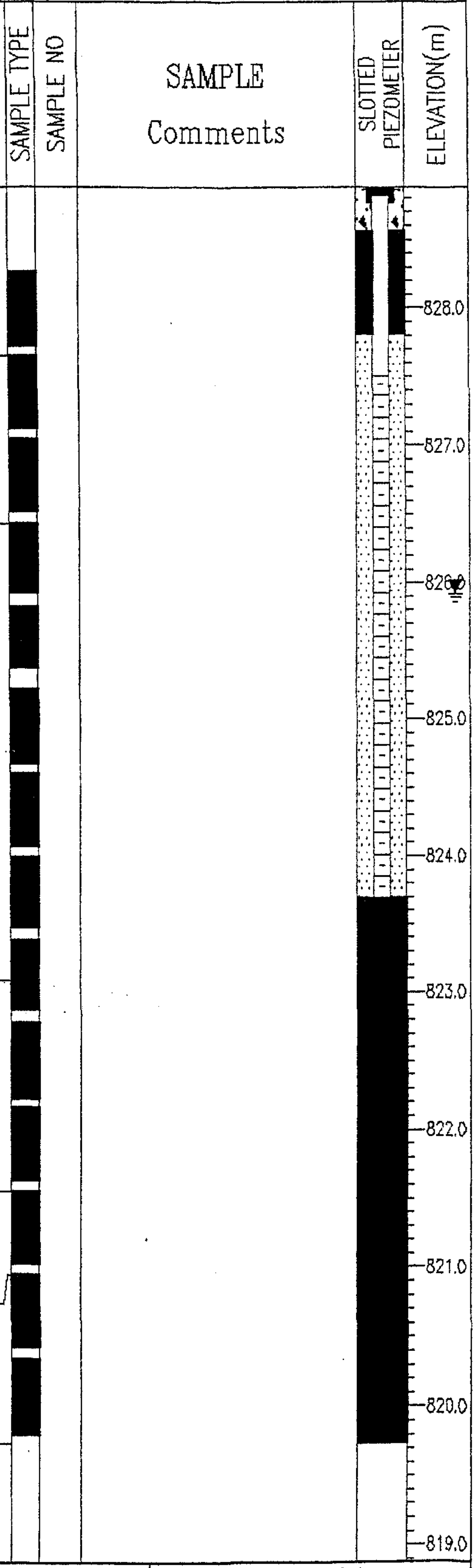
GRAVEL – and sand
- trace silt and clay
- wet; saturated @ 4.8 m
- brown– black
- strong hydrocarbon odour

CLAY – and silt
- some sand
- trace gravel
- saturated
- brown
- hydrocarbon odour

SILT – and clay
- trace sand; trace gravel
- dry
- green – grey
- faint hydrocarbon odour

SILT – and clay
- trace sand; trace gravel
- moist
- green – grey
- no odour

END OF TESTHOLE IN SILT and CLAY @ 9.14 M
MW-12 (monitoring Well Installed)
– Top of 50 mm PVC Pipe = el. 828.792 m
– Water level in piezometer 2.875 m
below top of PVC pipe.

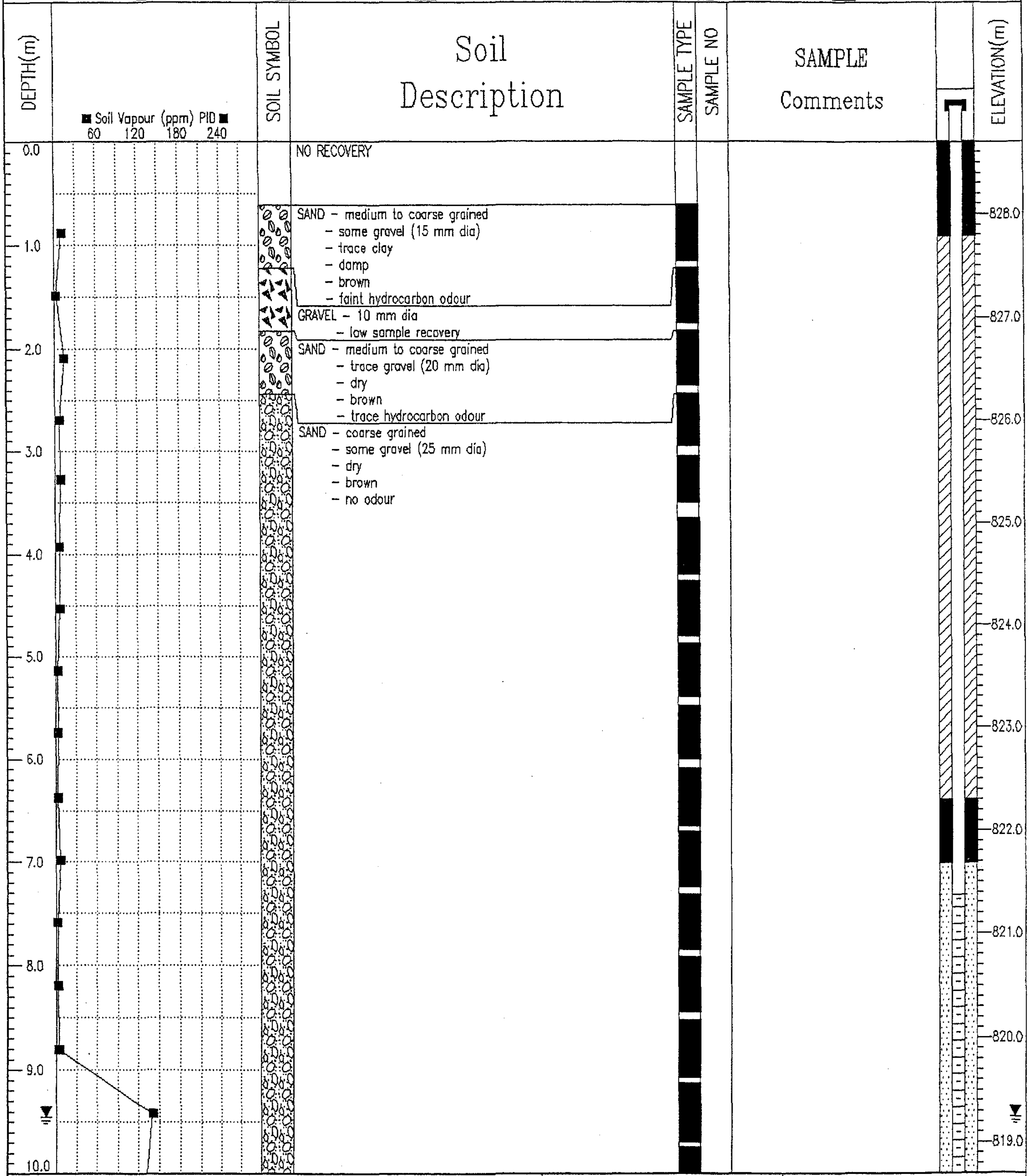


UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 9.1 m
	REVIEWED BY: ANP	COMPLETE: 06/17/99
	Fig. No:	Page 1 of 1

00/02/14 04:44PM (ENVIR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-13
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 828.695 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▯ Split Spoon	▮ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	⁘ GROUT	▨ DRILL CUTTINGS	⁙ SAND



NO RECOVERY

SAND – medium to coarse grained
- some gravel (15 mm dia)
- trace clay
- damp
- brown
- faint hydrocarbon odour

GRAVEL – 10 mm dia
- low sample recovery

SAND – medium to coarse grained
- trace gravel (20 mm dia)
- dry
- brown
- trace hydrocarbon odour

SAND – coarse grained
- some gravel (25 mm dia)
- dry
- brown
- no odour

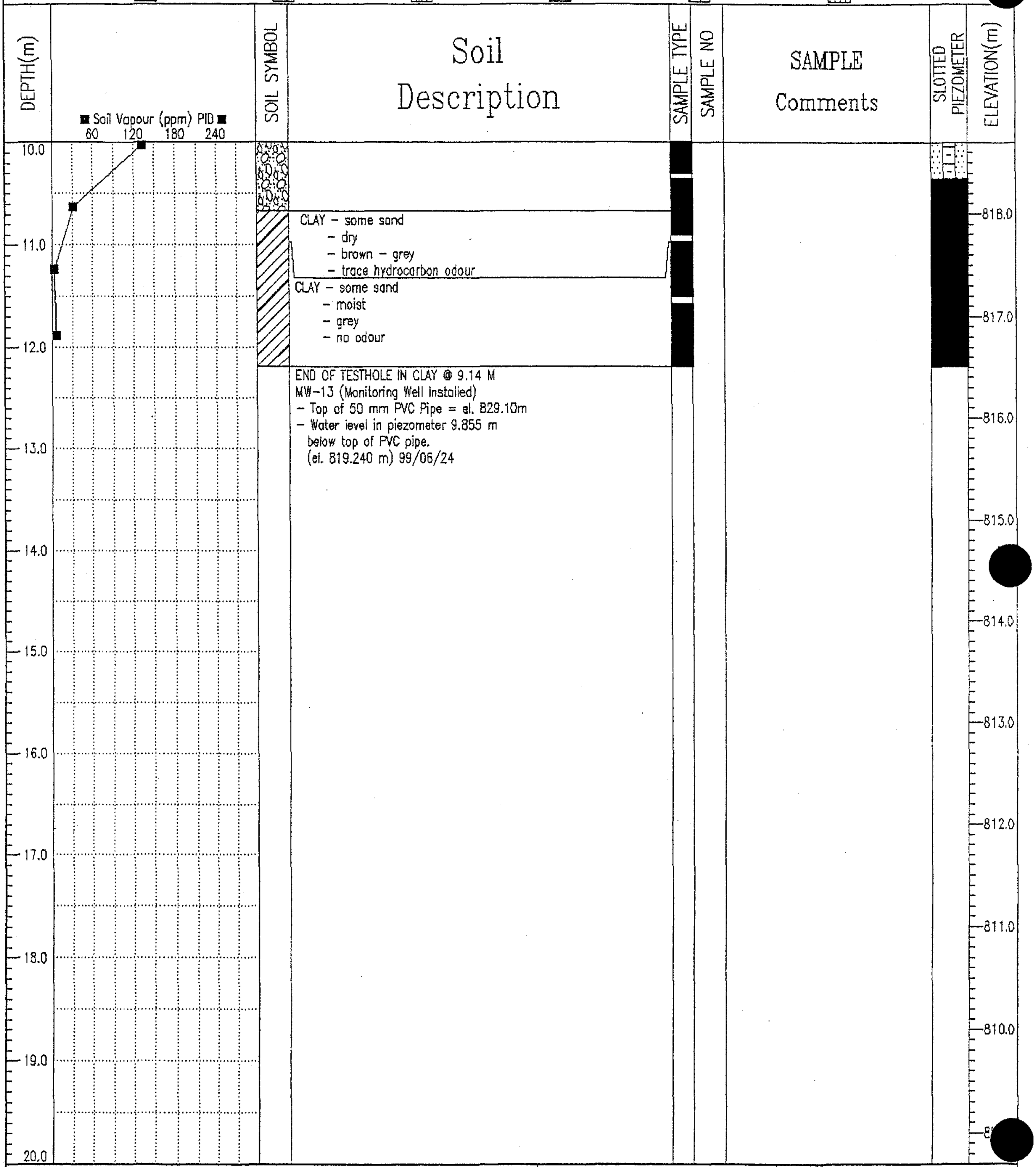
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 12.2 m
	REVIEWED BY: ANP	COMPLETE: 06/17/99
	Fig. No:	Page 1 of 2

00/02/14 04:44PM (ENVIR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-13
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 828.695 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▥ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ⁖ GROUT ▨ DRILL CUTTINGS ⁙ SAND



CLAY – some sand
- dry
- brown – grey
- trace hydrocarbon odour

CLAY – some sand
- moist
- grey
- no odour

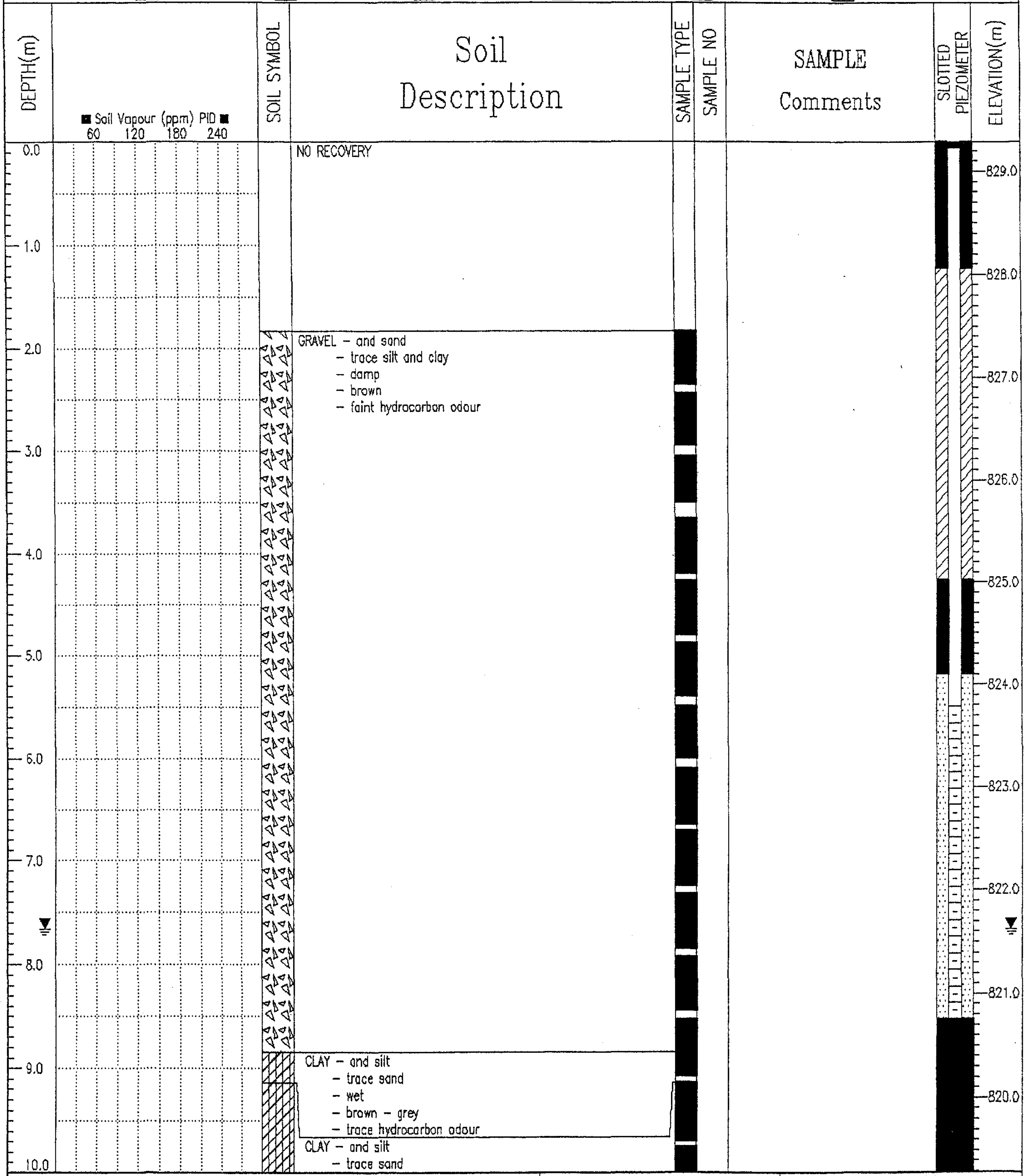
END OF TESTHOLE IN CLAY @ 9.14 M
MW-13 (Monitoring Well Installed)
– Top of 50 mm PVC Pipe = el. 829.10m
– Water level in piezometer 9.855 m below top of PVC pipe.
(el. 819.240 m) 99/06/24

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 12.2 m
	REVIEWED BY: ANP	COMPLETE: 06/17/99
	Fig. No:	Page 2 of 2

00/02/14 04:44PM (ENMR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-14
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 829.281 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▥ Split Spoon	▮ Wire Line–Type
BACKFILL TYPE	■ BENTONITE	⁚ PEA GRAVEL	▥ SLOUGH	⁖ GROUT	▨ DRILL CUTTINGS	⁚ SAND



NO RECOVERY

GRAVEL – and sand
- trace silt and clay
- damp
- brown
- faint hydrocarbon odour

CLAY – and silt
- trace sand
- wet
- brown – grey
- trace hydrocarbon odour

CLAY – and silt
- trace sand

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 10.4 m
	REVIEWED BY: ANP	COMPLETE: 06/18/99
	Fig. No:	Page 1 of 2

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-14
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 829.281 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▥ Split Spoon ▮ Wire Line–Type

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ⁘ GROUT ▨ DRILL CUTTINGS ⁘ SAND

DEPTH(m)	■ Soil Vapour (ppm) PID ■ 60 120 180 240	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SAMPLE NO	SAMPLE Comments	SLOTTED PIEZOMETER	ELEVATION(m)
10.0		▨	- damp - grey – green - sweet odour	■			■	819.0
			END OF TESTHOLE IN CLAY @ 10.36 M MW-14 (Monitoring Well Installed) - Top of 50 mm PVC Pipe = el. 829.16m - Water level in piezometer 7.435 m below top of PVC pipe (el. 821.626 m) 99/06/24					
11.0								818.0
12.0								817.0
13.0								816.0
14.0								815.0
15.0								814.0
16.0								813.0
17.0								812.0
18.0								811.0
19.0								810.0
20.0								

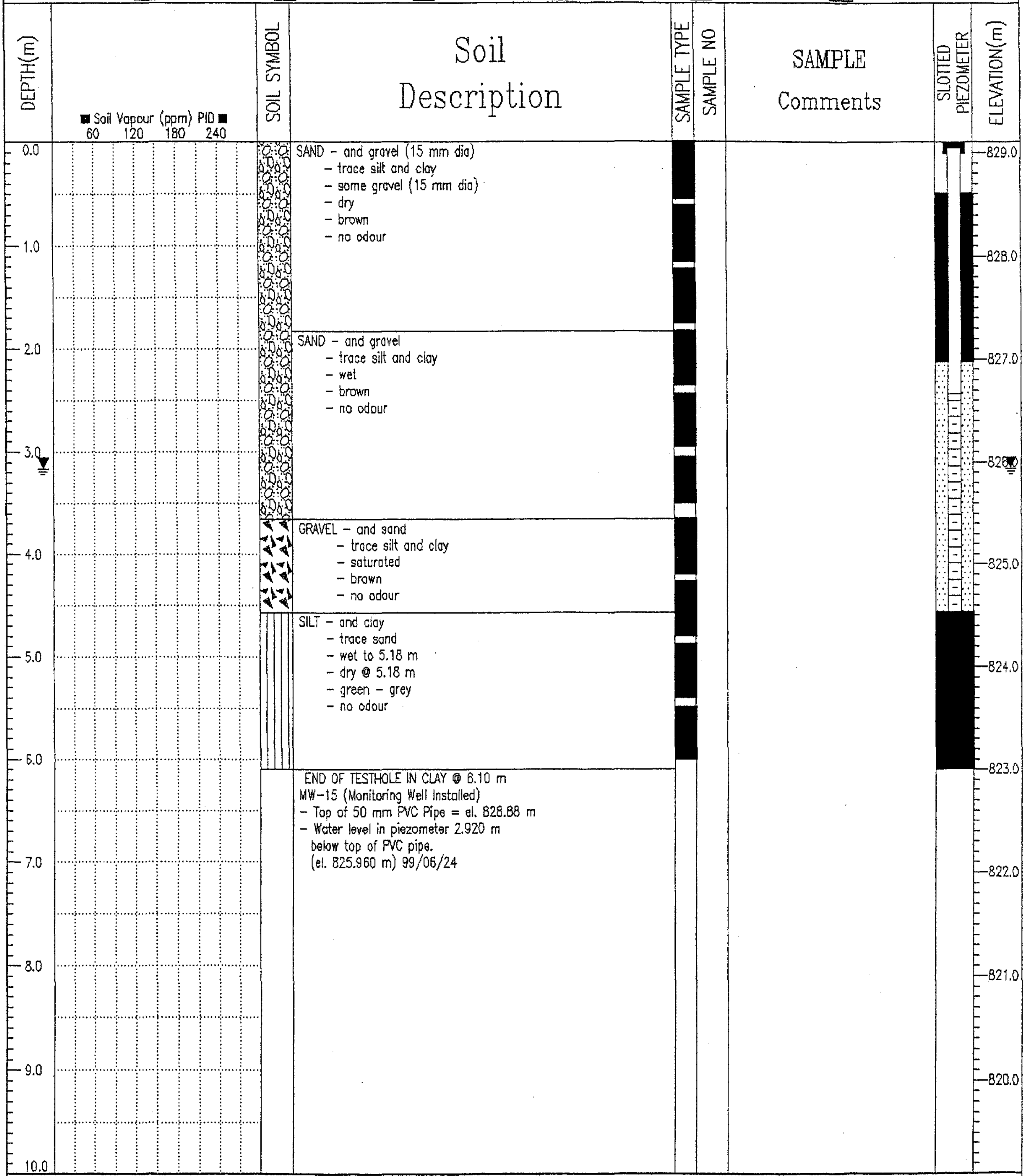
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 10.4 m
	REVIEWED BY: ANP	COMPLETE: 06/18/99
	Fig. No:	Page 2 of 2

00/02/14 04:45PM (ENVIR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-15
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 829.1 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ‖ Split Spoon ▐ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁖ GROUT ▨ DRILL CUTTINGS ⁚ SAND



SAND – and gravel (15 mm dia)
- trace silt and clay
- some gravel (15 mm dia)
- dry
- brown
- no odour

SAND – and gravel
- trace silt and clay
- wet
- brown
- no odour

GRAVEL – and sand
- trace silt and clay
- saturated
- brown
- no odour

SILT – and clay
- trace sand
- wet to 5.18 m
- dry @ 5.18 m
- green – grey
- no odour

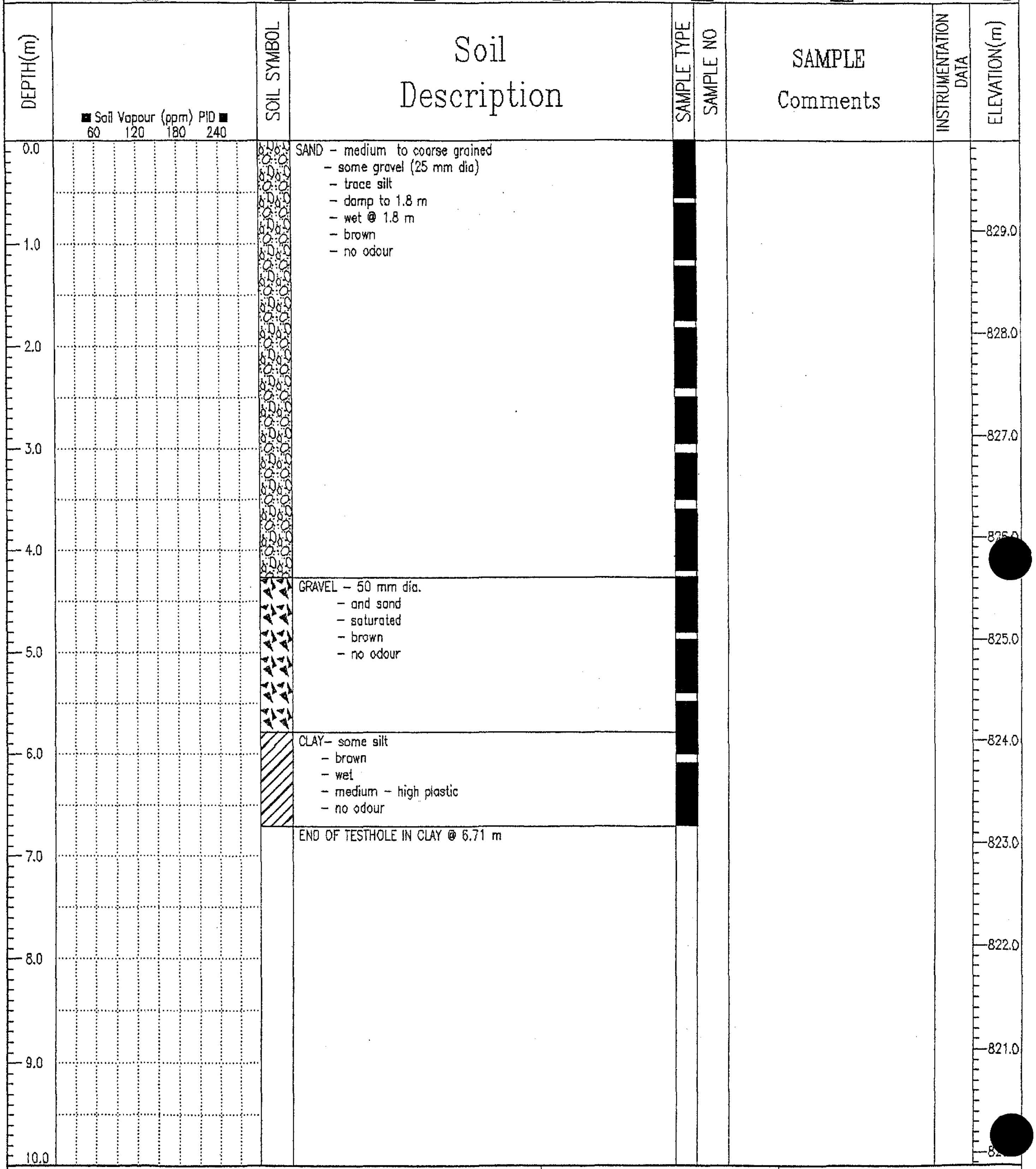
END OF TESTHOLE IN CLAY @ 6.10 m
MW-15 (Monitoring Well Installed)
- Top of 50 mm PVC Pipe = el. 828.88 m
- Water level in piezometer 2.920 m below top of PVC pipe. (el. 825.960 m) 99/06/24

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 6.1 m
	REVIEWED BY: ANP	COMPLETE: 06/18/99
	Fig. No:	Page 1 of 1

00/02/14 04:45PM (ENVIR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-16
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 829.869 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▯ Split Spoon	▮ Wire Line–Type
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	⁘ GROUT	▨ DRILL CUTTINGS	⁘ SAND



SAND – medium to coarse grained
- some gravel (25 mm dia)
- trace silt
- damp to 1.8 m
- wet @ 1.8 m
- brown
- no odour

GRAVEL – 50 mm dia.
- and sand
- saturated
- brown
- no odour

CLAY– some silt
- brown
- wet
- medium – high plastic
- no odour

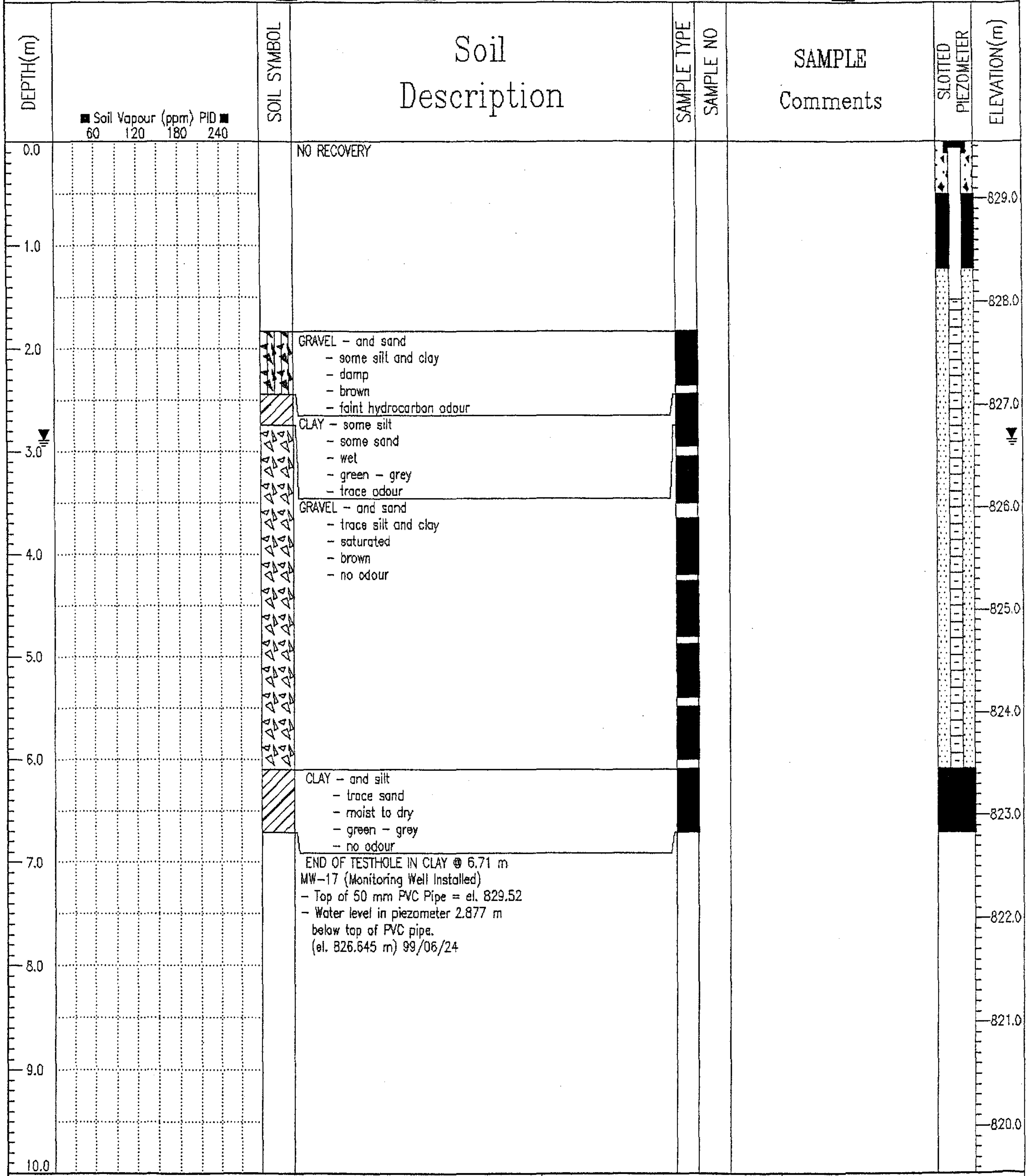
END OF TESTHOLE IN CLAY @ 6.71 m

UMA Engineering Ltd.	LOGGED BY: NAP	COMPLETION DEPTH: 6.7 m
Winnipeg, Manitoba	REVIEWED BY: ANP	COMPLETE: 06/18/99
	Fig. No:	Page 1 of 1

00/02/14 04:45PM (ENVR03)

Project: Blanchard River Pump Station	Driller: Midnight Sun	TEST HOLE NO: TH99-17
Client: DIAND Yukon	Drilling Method: Reverse Circulation	PROJECT NO: C799-004-00-02
PROJECT ENGINEER: NAP		ELEVATION: 829.542 (m)

SAMPLE TYPE	■ Grab Sample	◪ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▯ Split Spoon	▮ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	▨ GROUT	▧ DRILL CUTTINGS	⁙ SAND



Soil Description

SAMPLE Comments

NO RECOVERY

GRAVEL – and sand
- some silt and clay
- damp
- brown
- faint hydrocarbon odour

CLAY – some silt
- some sand
- wet
- green – grey
- trace odour

GRAVEL – and sand
- trace silt and clay
- saturated
- brown
- no odour

CLAY – and silt
- trace sand
- moist to dry
- green – grey
- no odour

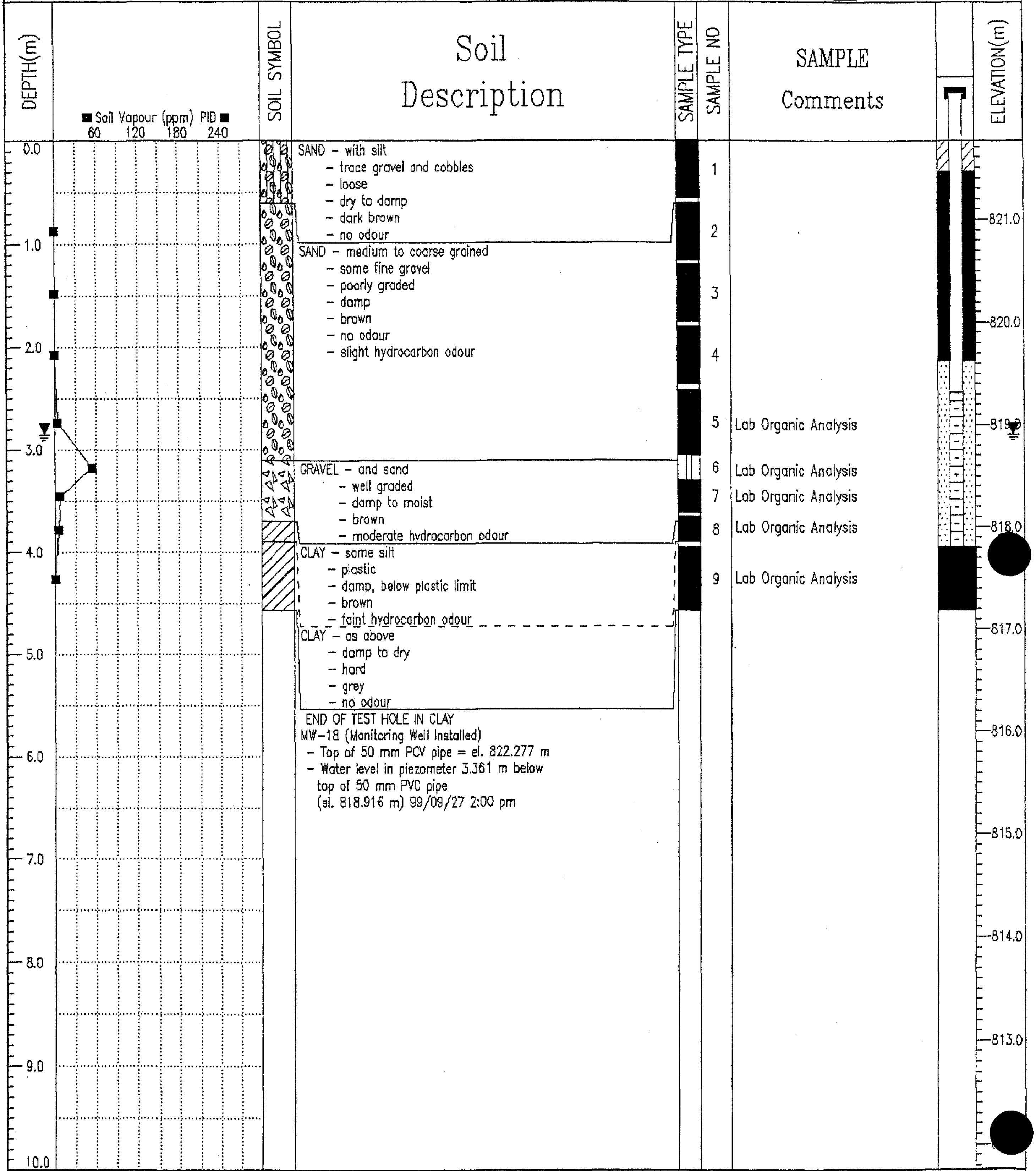
END OF TESTHOLE IN CLAY @ 6.71 m
MW-17 (Monitoring Well Installed)
- Top of 50 mm PVC Pipe = el. 829.52
- Water level in piezometer 2.877 m
below top of PVC pipe.
(el. 826.645 m) 99/06/24

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: NAP	COMPLETION DEPTH: 6.7 m
	REVIEWED BY: ANP	COMPLETE: 06/18/99
	Fig. No:	Page 1 of 1

00/02/14 04:45PM (ENVIR03)

Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-18
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 821.755 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▥ Split Spoon	▮ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	▩ GROUT	▨ DRILL CUTTINGS	░ SAND



Soil Description

SAND - with silt
- trace gravel and cobbles
- loose
- dry to damp
- dark brown
- no odour

SAND - medium to coarse grained
- some fine gravel
- poorly graded
- damp
- brown
- no odour
- slight hydrocarbon odour

GRAVEL - and sand
- well graded
- damp to moist
- brown
- moderate hydrocarbon odour

CLAY - some silt
- plastic
- damp, below plastic limit
- brown
- faint hydrocarbon odour

CLAY - as above
- damp to dry
- hard
- grey
- no odour

END OF TEST HOLE IN CLAY
MW-18 (Monitoring Well Installed)
- Top of 50 mm PCV pipe = el. 822.277 m
- Water level in piezometer 3.361 m below top of 50 mm PVC pipe (el. 818.916 m) 99/09/27 2:00 pm

SAMPLE NO	SAMPLE Comments
1	
2	
3	
4	
5	Lab Organic Analysis
6	Lab Organic Analysis
7	Lab Organic Analysis
8	Lab Organic Analysis
9	Lab Organic Analysis

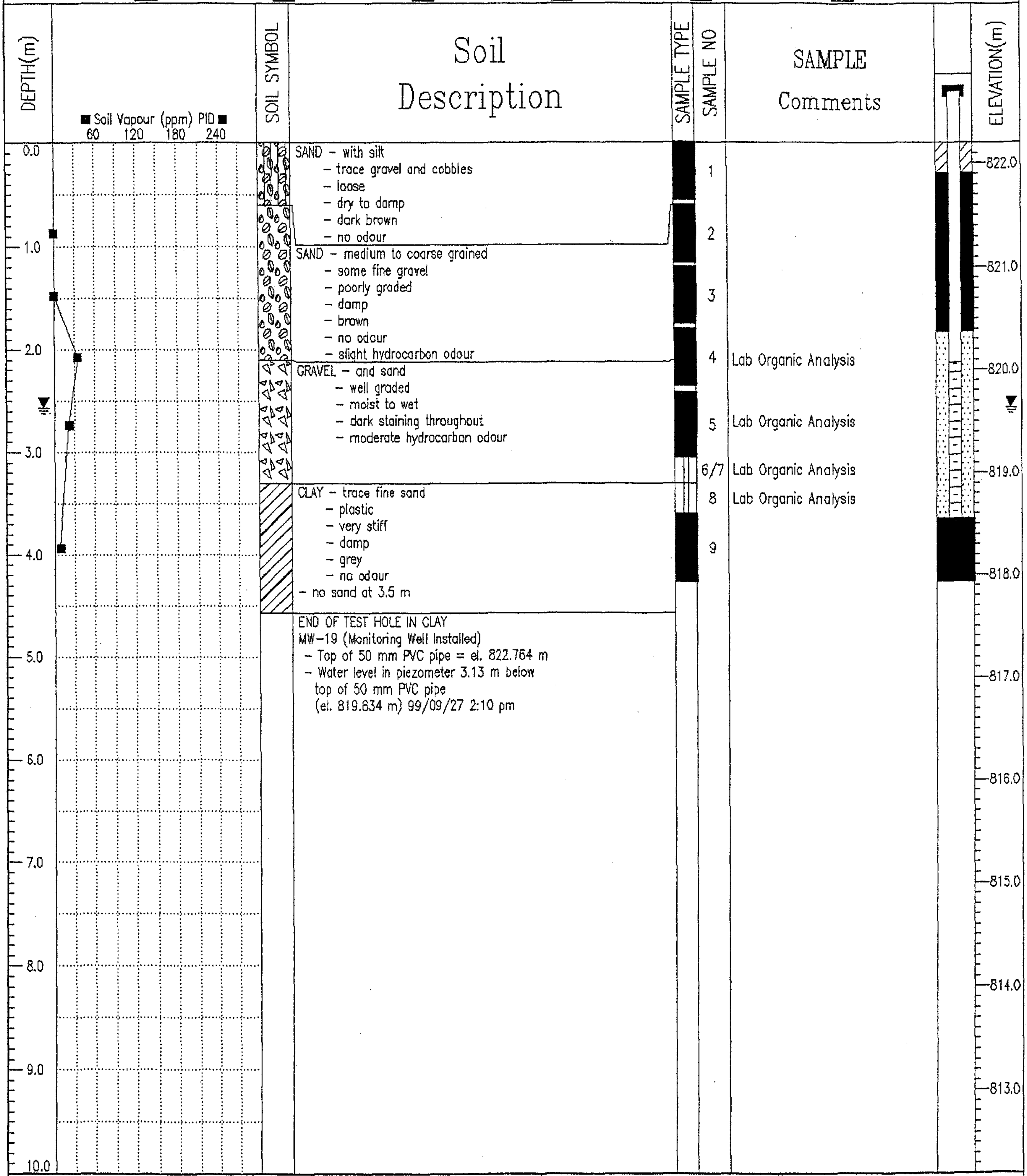
UMA Engineering Ltd.
Winnipeg, Manitoba

LOGGED BY: ANP	COMPLETION DEPTH: 4.6 m
REVIEWED BY: TW	COMPLETE: 09/21/99
Fig. No:	Page 1 of 1

00/02/14 04:45PM (ENVIR03)

Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-19
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 822.199 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▥ Split Spoon	▮ Wire Line-Type
BACKFILL TYPE	■ BENTONITE	⁘ PEA GRAVEL	▥ SLOUGH	⁘ GROUT	▨ DRILL CUTTINGS	⁘ SAND



Soil Description

SAND - with silt
- trace gravel and cobbles
- loose
- dry to damp
- dark brown
- no odour

SAND - medium to coarse grained
- some fine gravel
- poorly graded
- damp
- brown
- no odour
- slight hydrocarbon odour

GRAVEL - and sand
- well graded
- moist to wet
- dark staining throughout
- moderate hydrocarbon odour

CLAY - trace fine sand
- plastic
- very stiff
- damp
- grey
- no odour

- no sand at 3.5 m

END OF TEST HOLE IN CLAY
MW-19 (Monitoring Well Installed)
- Top of 50 mm PVC pipe = el. 822.764 m
- Water level in piezometer 3.13 m below top of 50 mm PVC pipe (el. 819.634 m) 99/09/27 2:10 pm

SAMPLE NO	SAMPLE Comments
4	Lab Organic Analysis
5	Lab Organic Analysis
6/7	Lab Organic Analysis
8	Lab Organic Analysis

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: ANP	COMPLETION DEPTH: 4.6 m
	REVIEWED BY: TW	COMPLETE: 09/21/99
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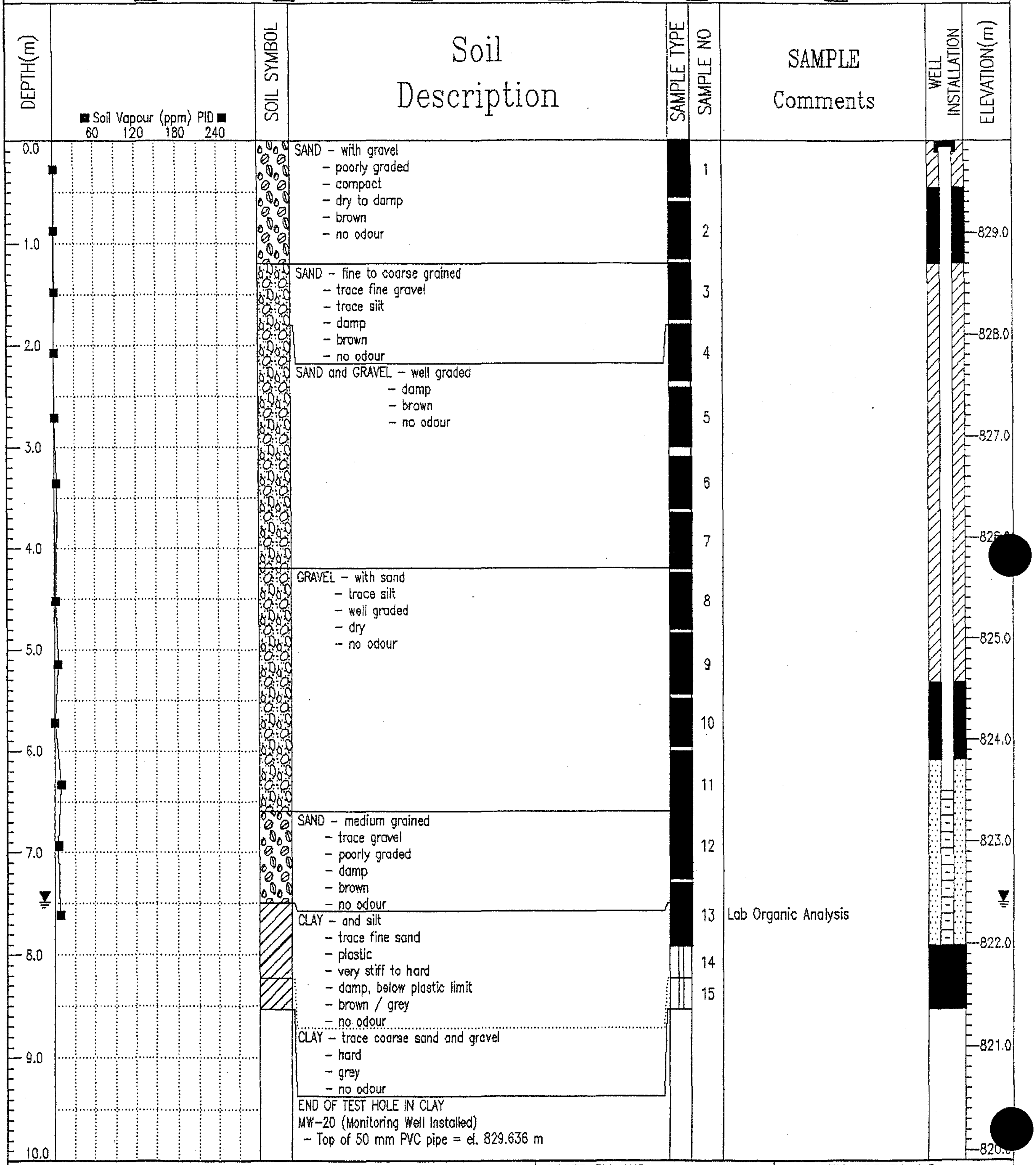
Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-20
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 829.893 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▯ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ▦ GROUT ▨ DRILL CUTTINGS ⁚ SAND



Soil Description

SAND - with gravel
- poorly graded
- compact
- dry to damp
- brown
- no odour

SAND - fine to coarse grained
- trace fine gravel
- trace silt
- damp
- brown
- no odour

SAND and GRAVEL - well graded
- damp
- brown
- no odour

GRAVEL - with sand
- trace silt
- well graded
- dry
- no odour

SAND - medium grained
- trace gravel
- poorly graded
- damp
- brown
- no odour

CLAY - and silt
- trace fine sand
- plastic
- very stiff to hard
- damp, below plastic limit
- brown / grey
- no odour

CLAY - trace coarse sand and gravel
- hard
- grey
- no odour

END OF TEST HOLE IN CLAY
MW-20 (Monitoring Well Installed)
- Top of 50 mm PVC pipe = el. 829.636 m

SAMPLE NO	SAMPLE Comments
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	Lab Organic Analysis
14	
15	

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: ANP	COMPLETION DEPTH: 8.5 m
	REVIEWED BY: TW	COMPLETE: 09/21/99
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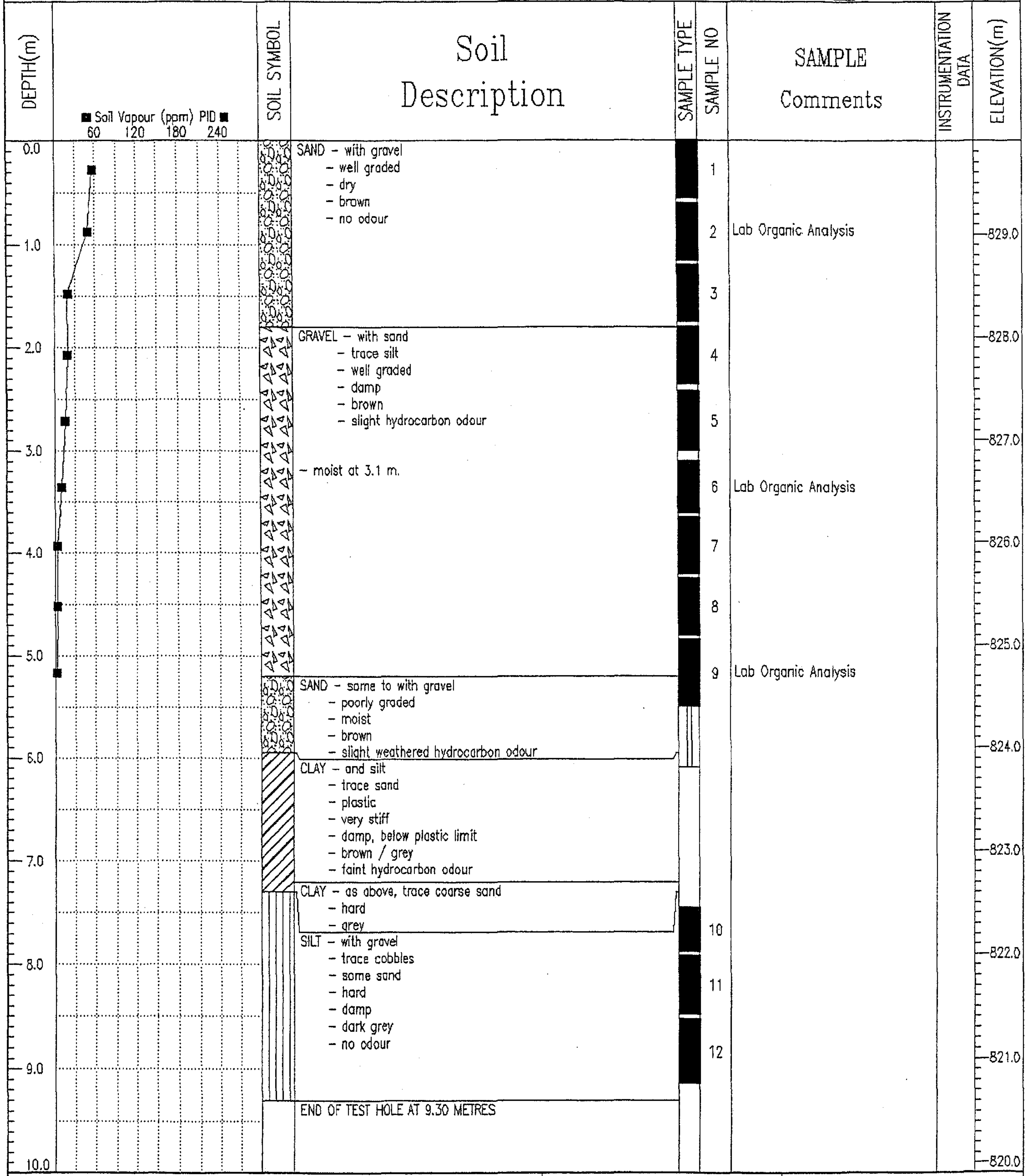
Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-21
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 829.9 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ▥ Split Spoon ▮ Wire Line–Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ▥ SLOUGH ⁖ GROUT ▨ DRILL CUTTINGS ░ SAND



Soil Description

SAND – with gravel
- well graded
- dry
- brown
- no odour

GRAVEL – with sand
- trace silt
- well graded
- damp
- brown
- slight hydrocarbon odour

– moist at 3.1 m.

SAND – some to with gravel
- poorly graded
- moist
- brown
- slight weathered hydrocarbon odour

CLAY – and silt
- trace sand
- plastic
- very stiff
- damp, below plastic limit
- brown / grey
- faint hydrocarbon odour

CLAY – as above, trace coarse sand
- hard
- grey

SILT – with gravel
- trace cobbles
- some sand
- hard
- damp
- dark grey
- no odour

END OF TEST HOLE AT 9.30 METRES

SAMPLE NO	SAMPLE Comments
1	
2	Lab Organic Analysis
3	
4	
5	
6	Lab Organic Analysis
7	
8	
9	Lab Organic Analysis
10	
11	
12	

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: ANP	COMPLETION DEPTH: 9.3 m
	REVIEWED BY: TW	COMPLETE: 09/22/99
	Fig. No:	Page 1 of 1

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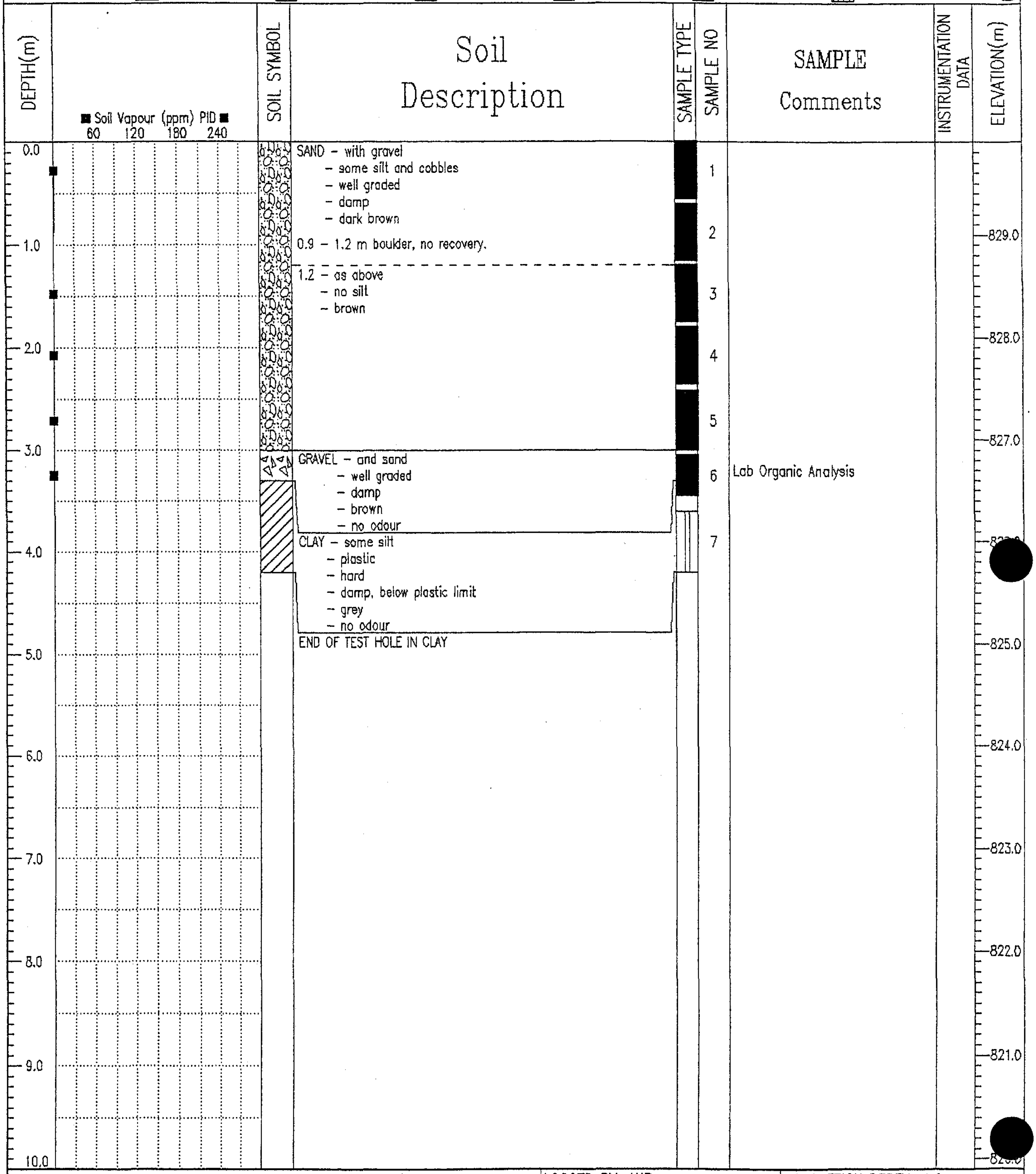
Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-22
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 829.9 (m)

SAMPLE TYPE	■ Grab Sample	▨ Shelby Tube	☒ Lab Submitted	☰ No Recovery	▯ Split Spoon	▮ Wire Line–Type
BACKFILL TYPE	■ BENTONITE	⁖ PEA GRAVEL	▥ SLOUGH	⁖ GROUT	▨ DRILL CUTTINGS	⁙ SAND



Soil Description

SAND – with gravel
– some silt and cobbles
– well graded
– damp
– dark brown

0.9 – 1.2 m boulder, no recovery.

1.2 – as above
– no silt
– brown

GRAVEL – and sand
– well graded
– damp
– brown
– no odour

CLAY – some silt
– plastic
– hard
– damp, below plastic limit
– grey
– no odour

END OF TEST HOLE IN CLAY

SAMPLE Comments

6 – Lab Organic Analysis

UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: ANP	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: TW	COMPLETE: 09/22/99
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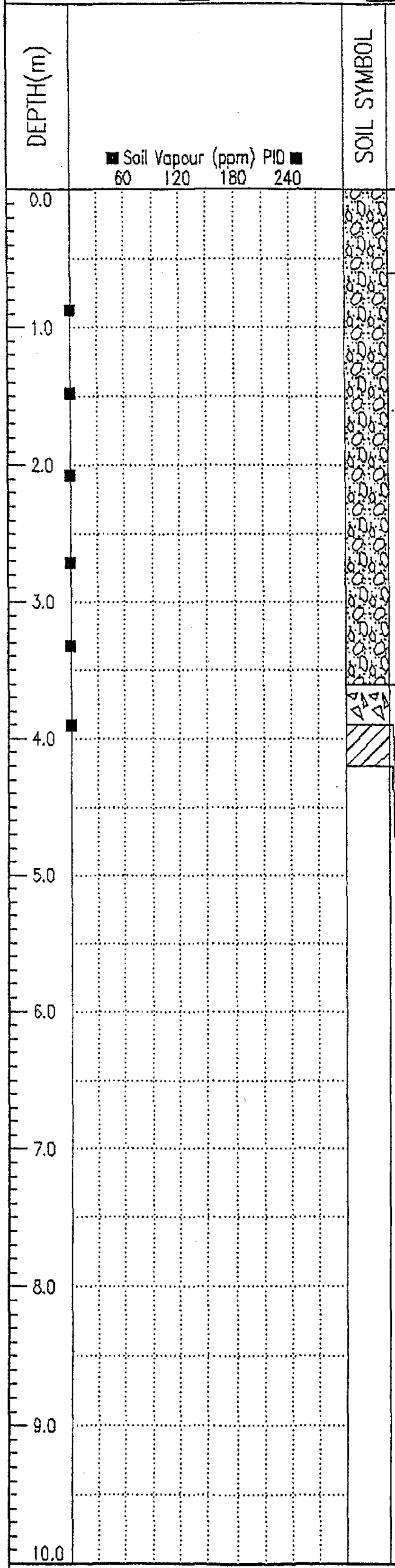
Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-23
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 829.8 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ☰ No Recovery ‖ Split Spoon ▮ Wire Line-Type

BACKFILL TYPE ■ BENTONITE ⁚ PEA GRAVEL ||| SLOUGH ∴ GROUT ▨ DRILL CUTTINGS ░ SAND



Soil Description

No Recovery

SAND – medium grained
– and gravel
– with cobbles and boulders
– well graded
– damp
– brown

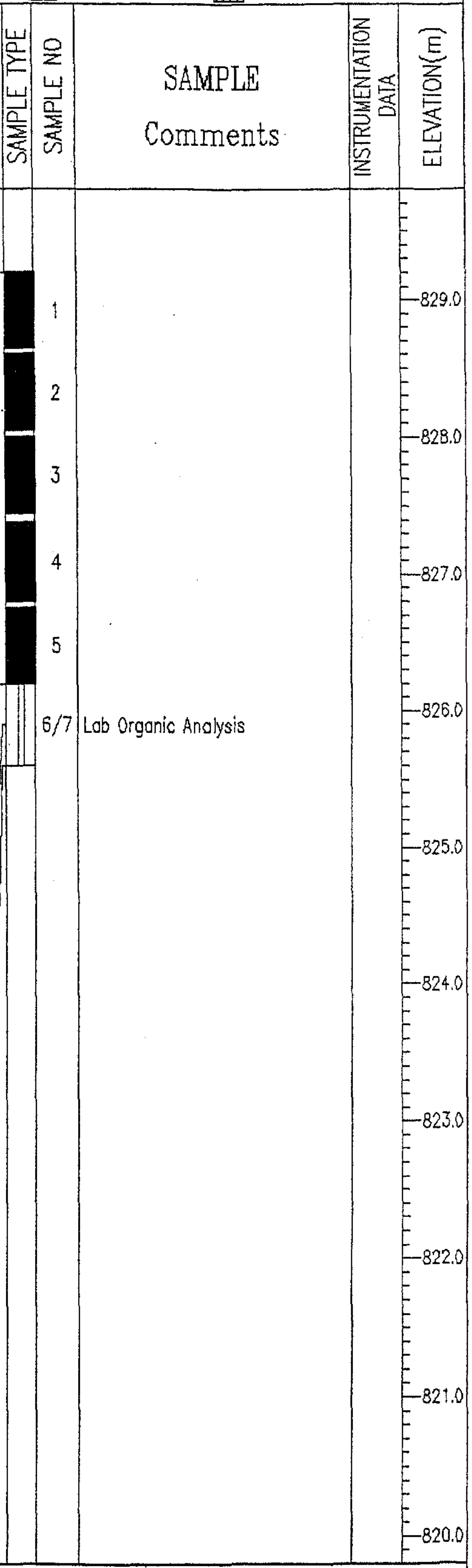
SAND – as above
– with gravel

2.4 m – some gravel

GRAVEL – some sand
– well graded
– damp
– brown
– no odour

CLAY – some silt
– plastic
– damp, below plastic limit
– grey
– no odour

END OF TEST HOLE IN CLAY



SAMPLE NO	SAMPLE Comments
1	
2	
3	
4	
5	
6/7	Lab Organic Analysis

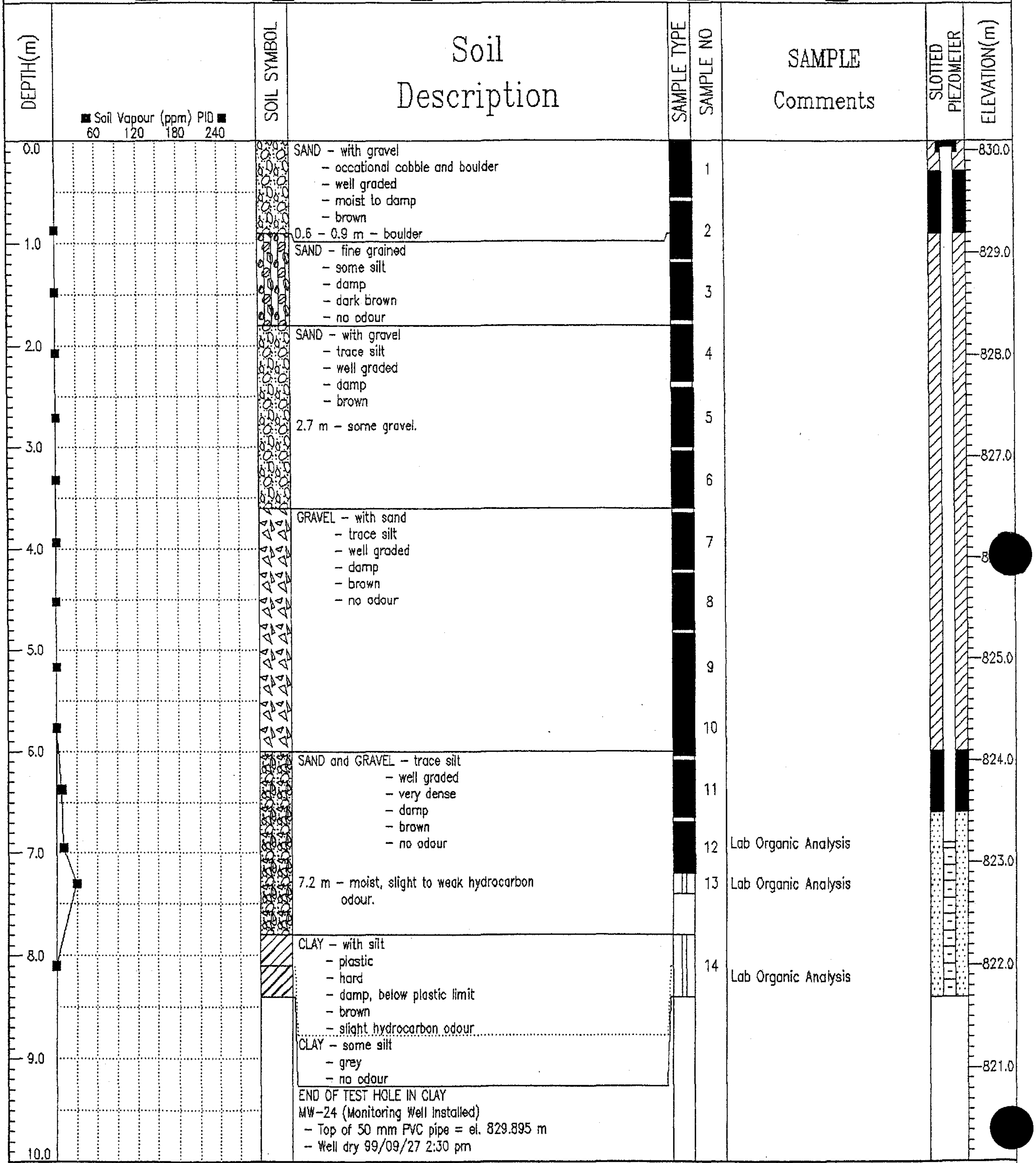
UMA Engineering Ltd. Winnipeg, Manitoba	LOGGED BY: ANP	COMPLETION DEPTH: 4.2 m
	REVIEWED BY: TW	COMPLETE: 09/22/99
	Fig. No:	Page 1 of 1

00/02/14 04:46PM (ENVIR03)

Project: Blanchard River Stage III ESA	Drilled by: Midnight Sun Drilling Ltd.	TEST HOLE NO: TH99-24
Client: DIAND	Drill Type: Odex Reverse Circulation	PROJECT NO: C799-004-01-02
PROJECT ENGINEER: TW	Drill Size: 150 mm	ELEVATION: 830.091 (m)

SAMPLE TYPE ■ Grab Sample ▨ Shelby Tube ☒ Lab Submitted ▤ No Recovery ▥ Split Spoon ▮ Wire Line–Type

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ▦ GROUT ▨ DRILL CUTTINGS ⁘ SAND



Soil Description

SAND – with gravel
- occational cobble and boulder
- well graded
- moist to damp
- brown

0.6 – 0.9 m – boulder

SAND – fine grained
- some silt
- damp
- dark brown
- no odour

SAND – with gravel
- trace silt
- well graded
- damp
- brown

2.7 m – some gravel.

GRAVEL – with sand
- trace silt
- well graded
- damp
- brown
- no odour

SAND and GRAVEL – trace silt
- well graded
- very dense
- damp
- brown
- no odour

7.2 m – moist, slight to weak hydrocarbon odour.

CLAY – with silt
- plastic
- hard
- damp, below plastic limit
- brown
- slight hydrocarbon odour

CLAY – some silt
- grey
- no odour

END OF TEST HOLE IN CLAY

MW-24 (Monitoring Well Installed)
- Top of 50 mm PVC pipe = el. 829.895 m
- Well dry 99/09/27 2:30 pm

SAMPLE Comments

SAMPLE NO	Comments
12	Lab Organic Analysis
13	Lab Organic Analysis
14	Lab Organic Analysis

UMA Engineering Ltd.	LOGGED BY: ANP	COMPLETION DEPTH: 8.4 m
Winnipeg, Manitoba	REVIEWED BY: TW	COMPLETE: 09/22/99
	Fig. No:	Page 1 of 1

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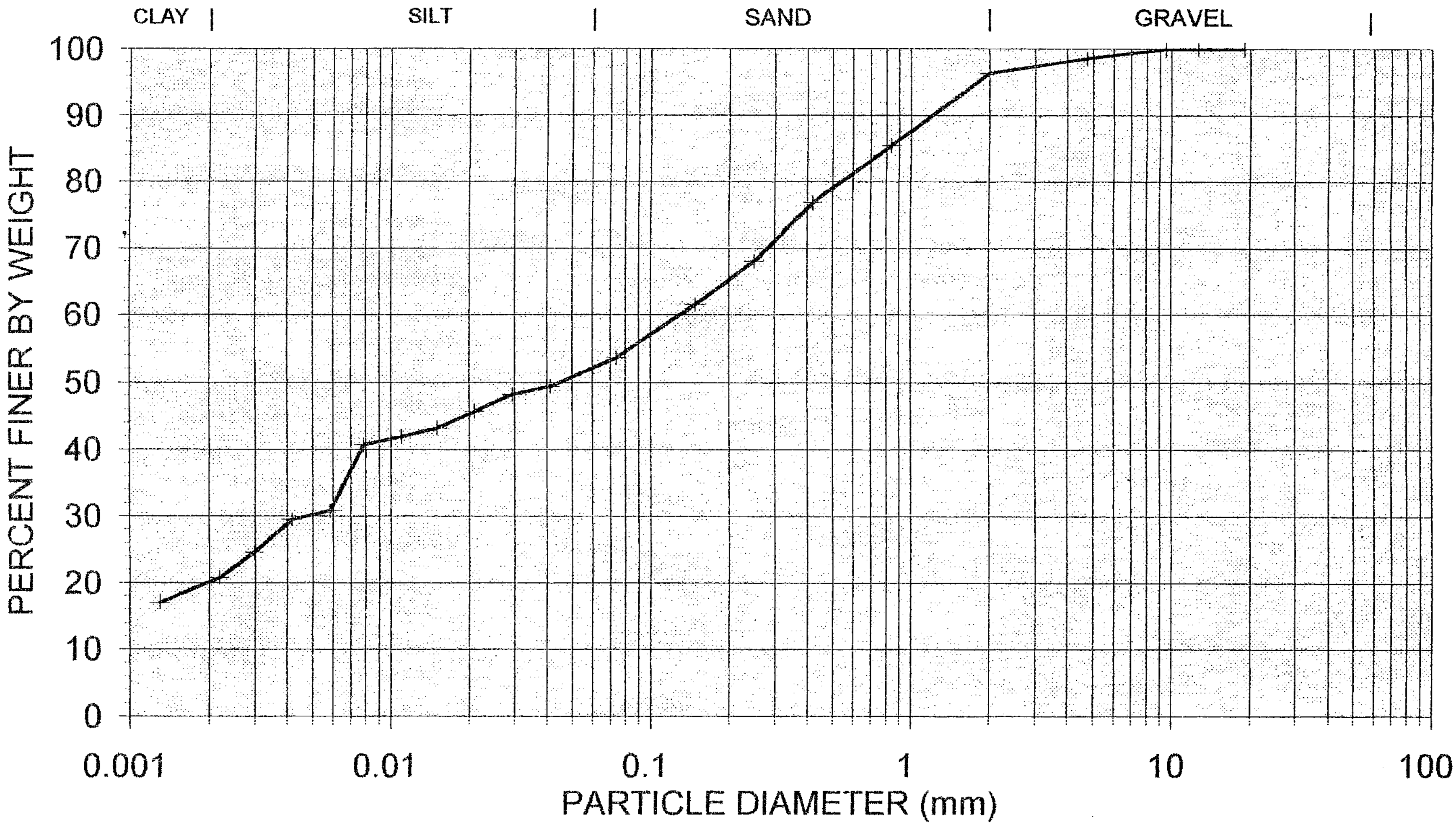
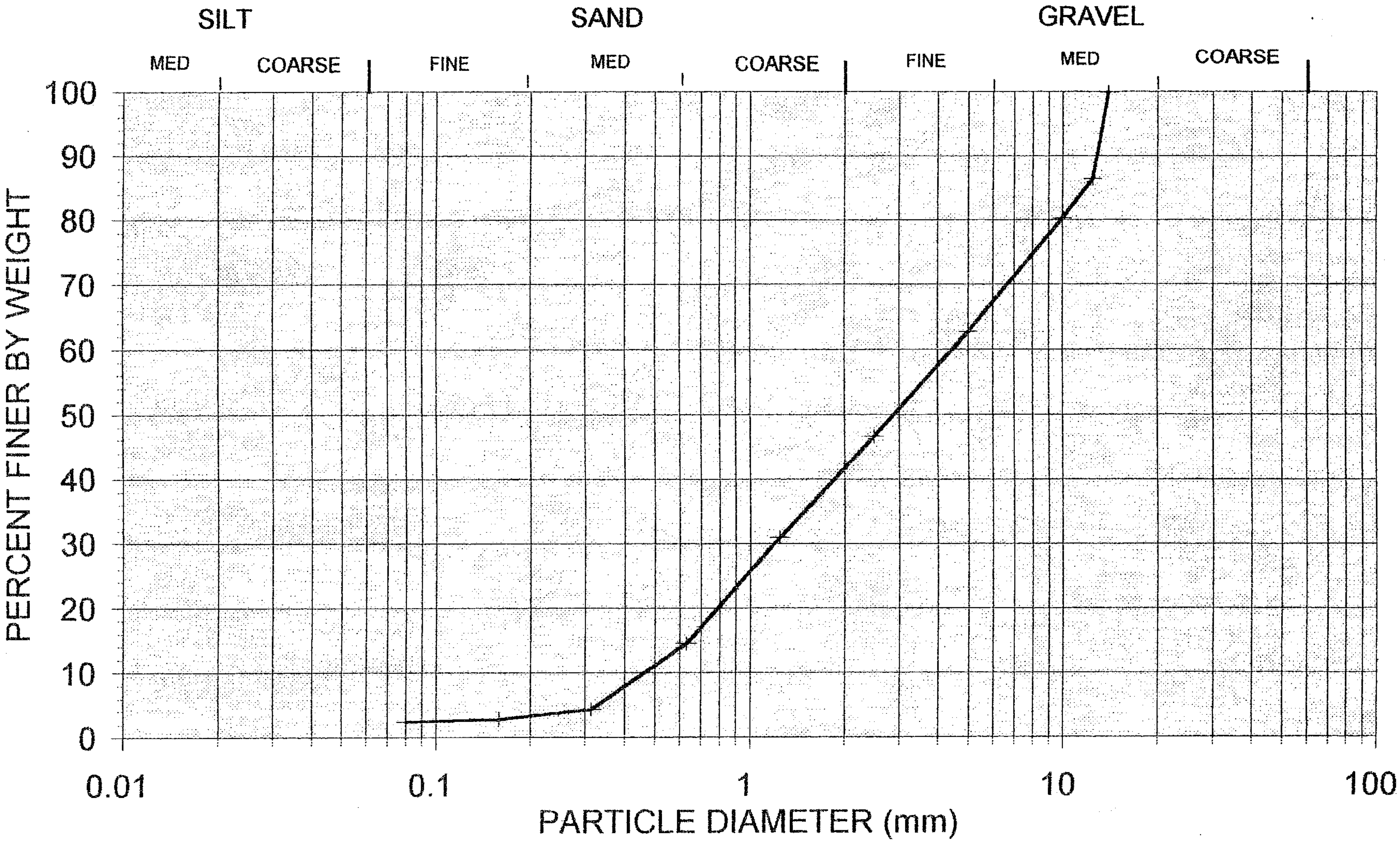
APPENDIX B:
SOIL GRADATION ANALYSIS

UMA ENGINEERING - GRADATION ANALYSIS



CLIENT: Royal Roads University PROJECT: Blanchard River JOB No.: C799 004 00 02	TEST HOLE No: 99-12 DEPTH: 4 - 6 Ft. DATE TESTED: June 24, 1999	SAMPLE DESCRIPTION: Silty (31.3%), Clayey (20.5%) Sand (44.7%),Trace Gravel (3.5%).

UMA ENGINEERING - GRADATION ANALYSIS

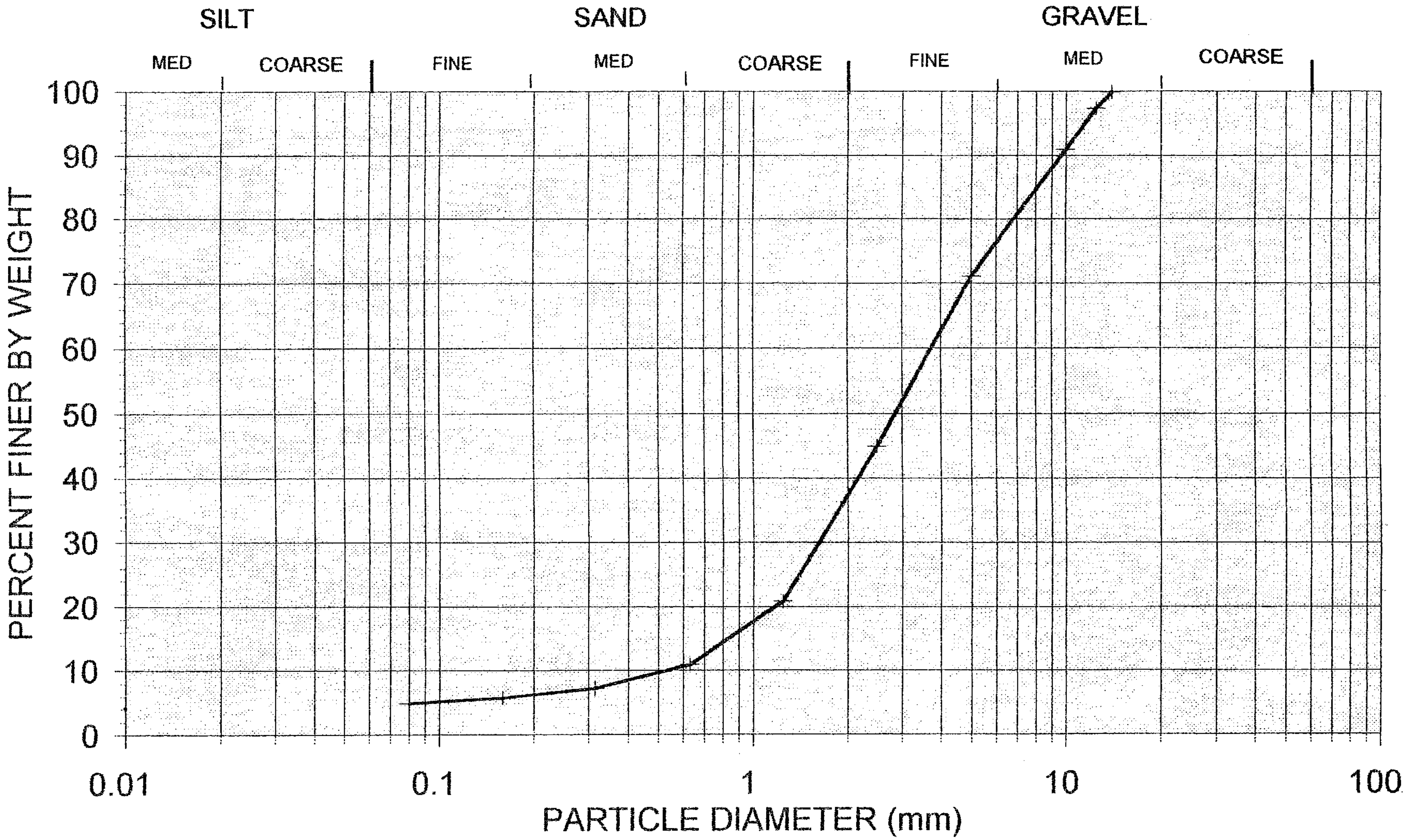


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-12
DEPTH: 10 - 12 Ft.
DATE TESTED: June 24, 1999

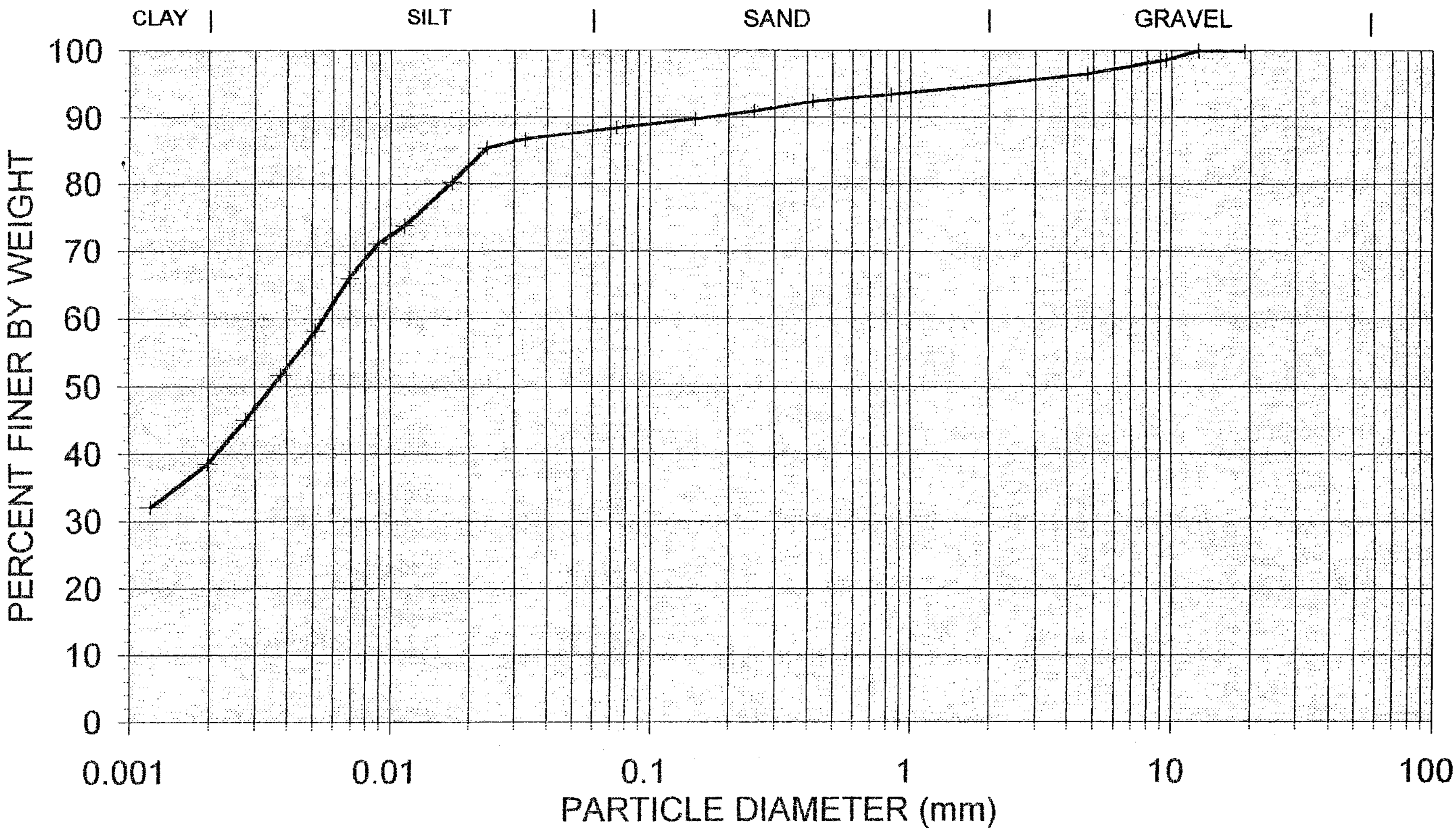
SAMPLE DESCRIPTION:
Gravel (57.5%) and Sand (40.0%),
Trace Silt & Clay (2.5%).

UMA ENGINEERING - GRADATION ANALYSIS



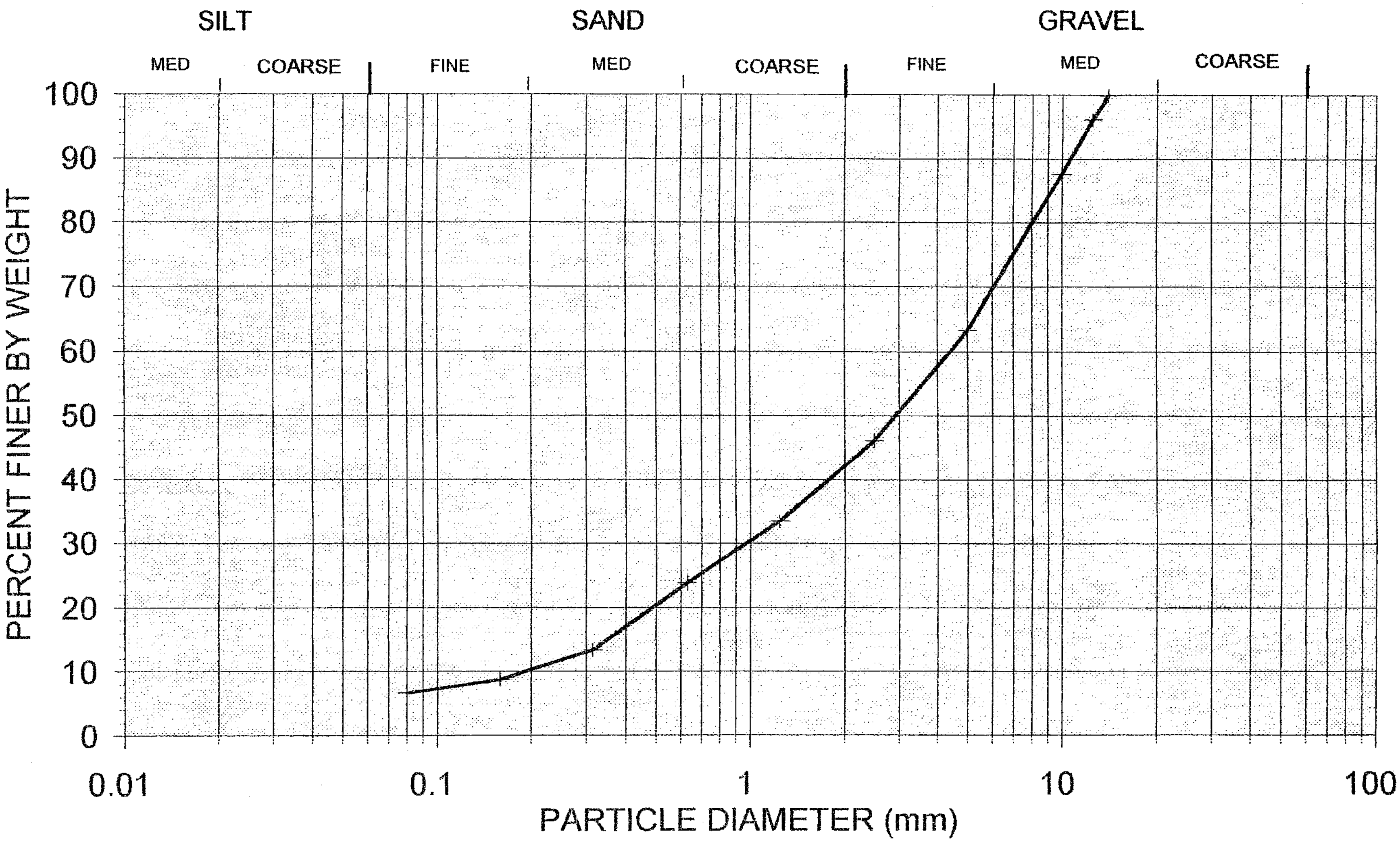
CLIENT: Royal Roads University PROJECT: Blanchard River JOB No.: C799 004 00 02	TEST HOLE No: 99-12 DEPTH: 16 - 18 Ft. DATE TESTED: June 24, 1999	SAMPLE DESCRIPTION: Gravel (62.5%) and Sand (32.5%), Trace Silt & Clay (5.0%).

UMA ENGINEERING - GRADATION ANALYSIS



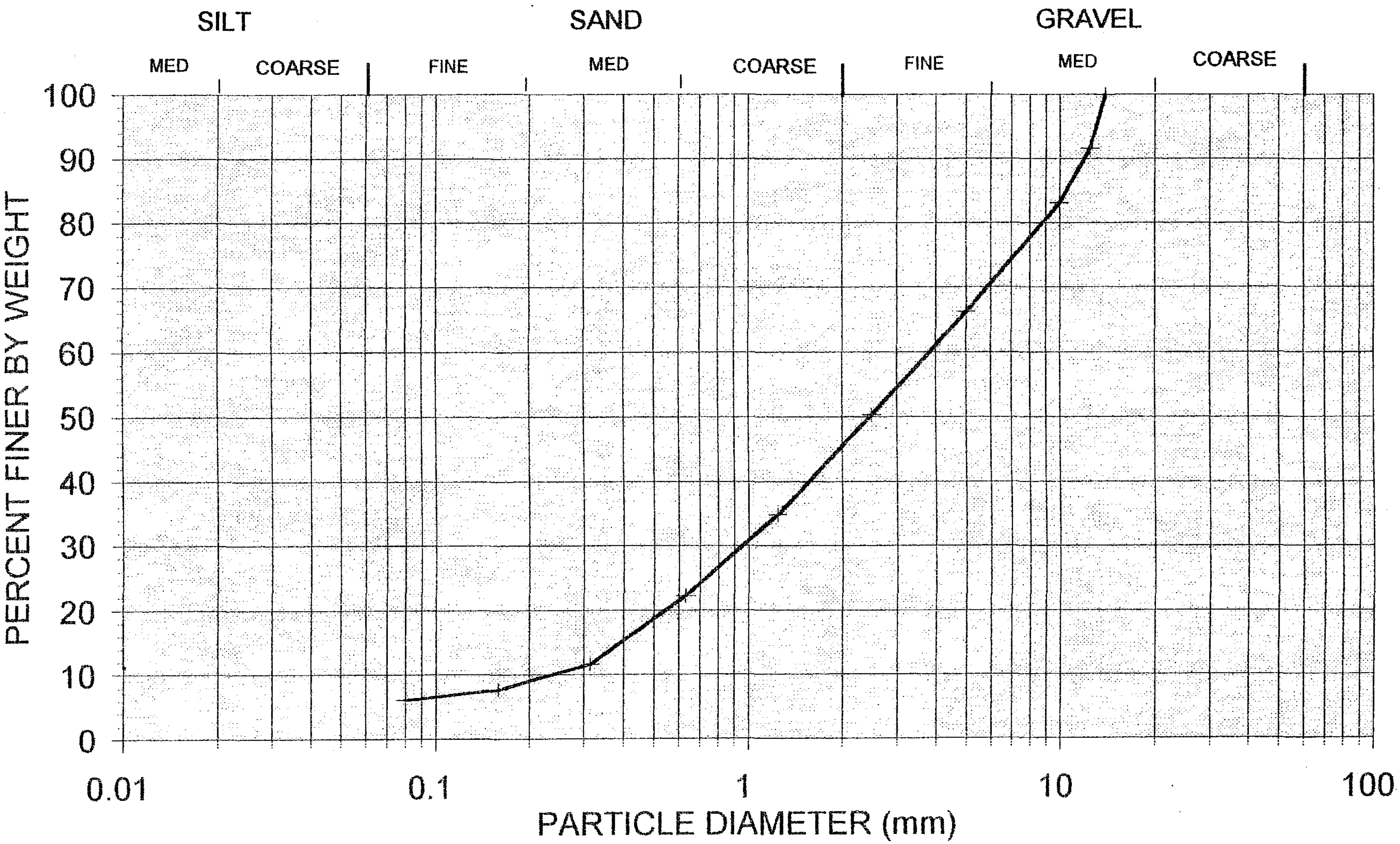
CLIENT: Royal Roads University PROJECT: Blanchard River JOB No.: C799 004 00 02	TEST HOLE No: 99-12 DEPTH: 26 - 28 Ft. DATE TESTED: June 24, 1999	SAMPLE DESCRIPTION: Silt (49.4%) and Clay (38.6%), Trace Sand (7.0%), Trace Gravel (5.0%)

UMA ENGINEERING - GRADATION ANALYSIS



CLIENT: Royal Roads University PROJECT: Blanchard River JOB No.: C799 004 00 02	TEST HOLE No: 99-14 DEPTH: 20 - 22 Ft. DATE TESTED: June 24, 1999	SAMPLE DESCRIPTION: Gravel (57.5%) and Sand (35.8%), Trace Silt & Clay (6.7%).

UMA ENGINEERING - GRADATION ANALYSIS

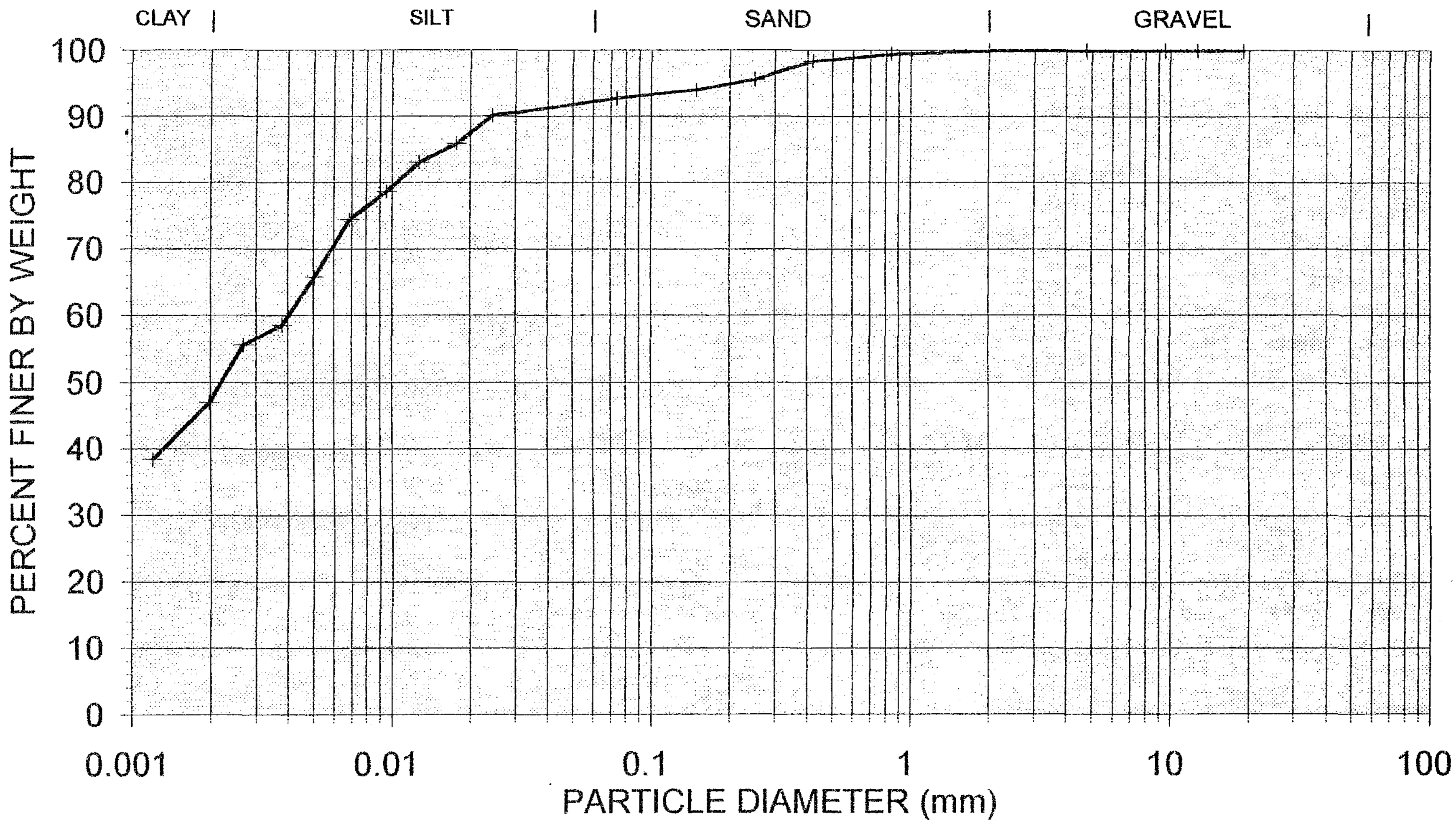


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-14
DEPTH: 26 - 28 Ft.
DATE TESTED: June 24, 1999

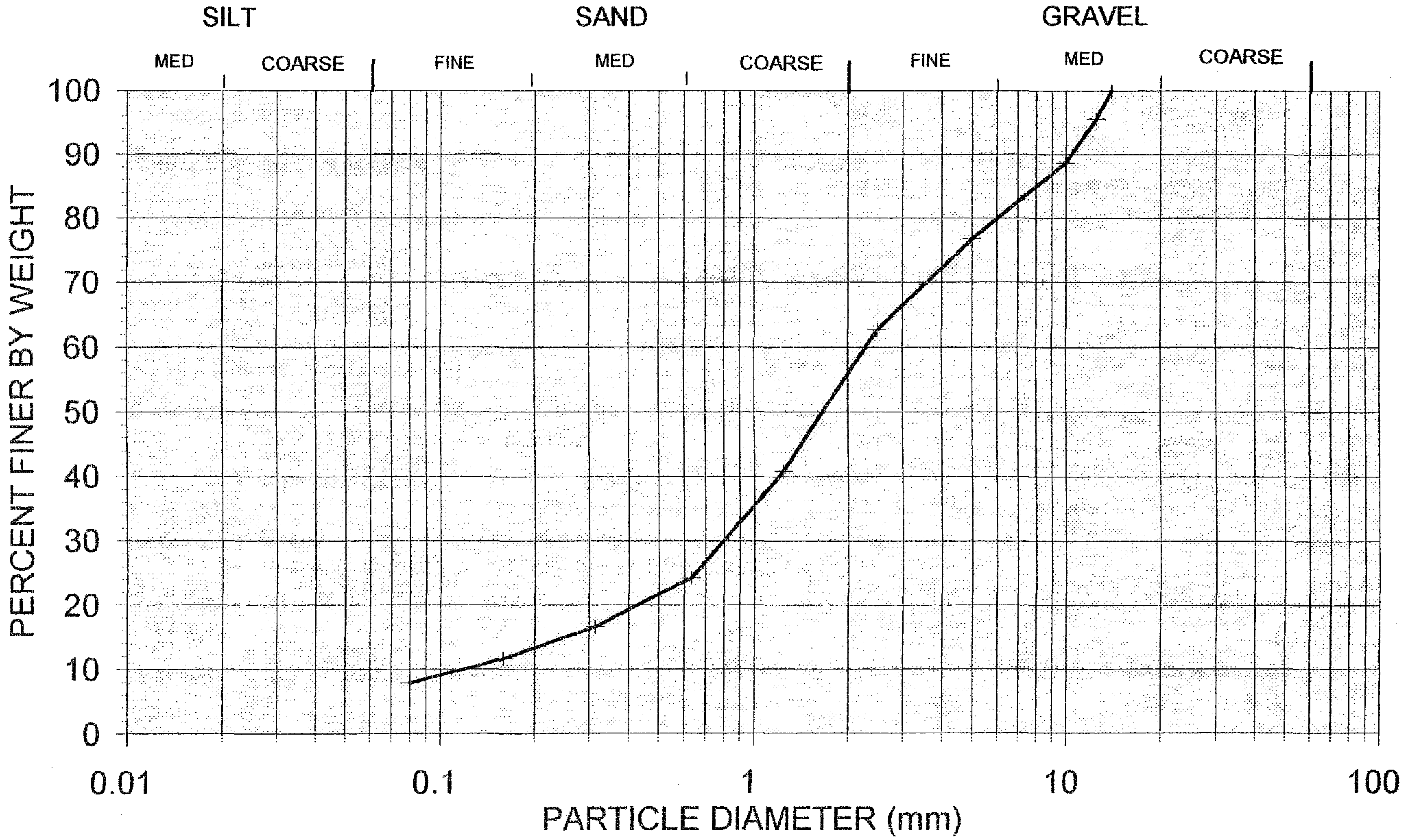
SAMPLE DESCRIPTION:
Gravel (55.0%) and Sand (38.8%),
Trace Silt & Clay (6.2%).

UMA ENGINEERING - GRADATION ANALYSIS



CLIENT: Royal Roads University PROJECT: Blanchard River JOB No.: C799 004 00 02	TEST HOLE No: 99-14 DEPTH: 30 - 32 Ft. DATE TESTED: June 24, 1999	SAMPLE DESCRIPTION: Clay (47.0%) and Silt (45.6%), Trace Sand (7.4%).

UMA ENGINEERING - GRADATION ANALYSIS

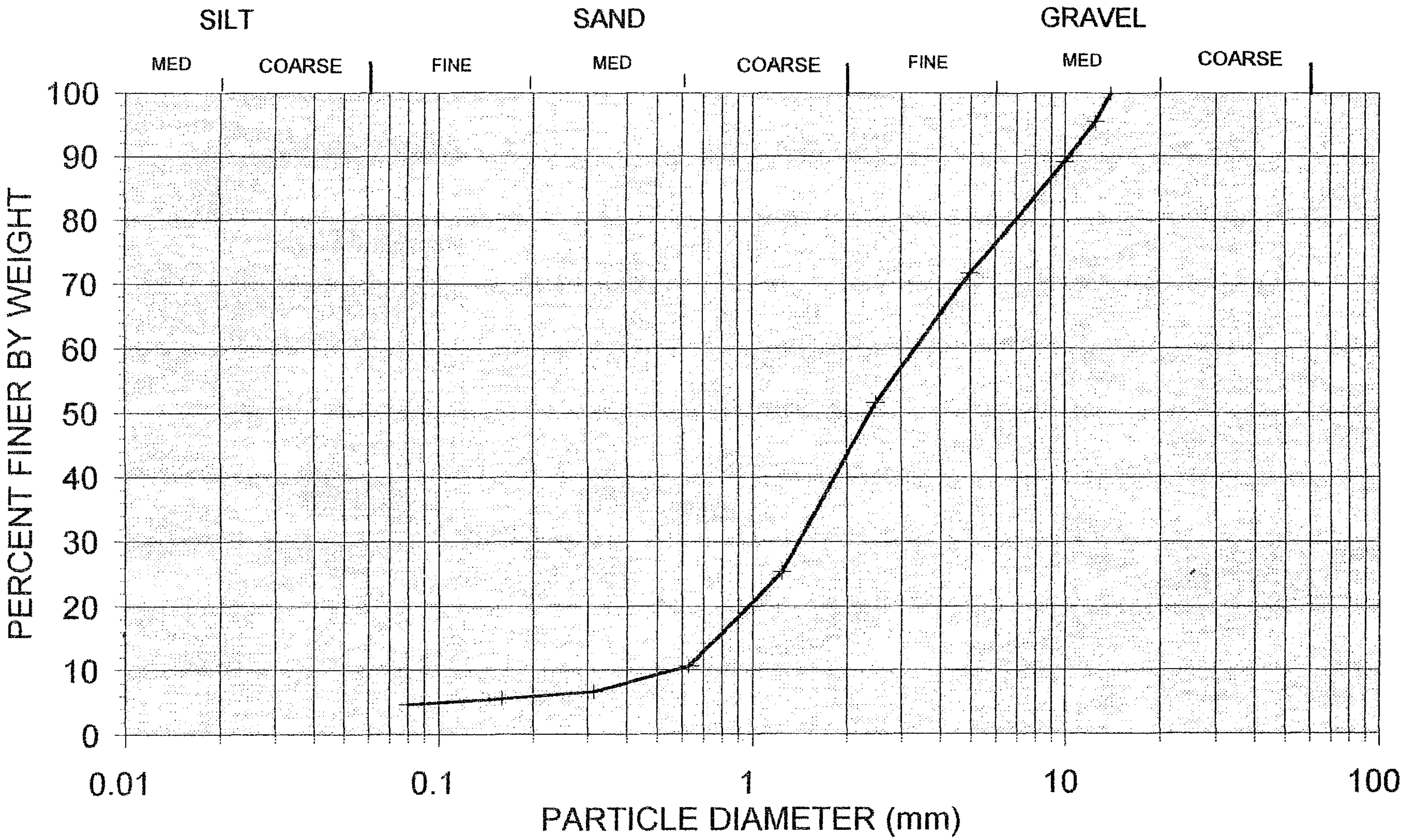


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-15
DEPTH: 8 - 10 Ft.
DATE TESTED: June 24, 1999

SAMPLE DESCRIPTION:
Sand (48.1%) and Gravel (44.0%),
Trace Silt & Clay (7.9%).

UMA ENGINEERING - GRADATION ANALYSIS

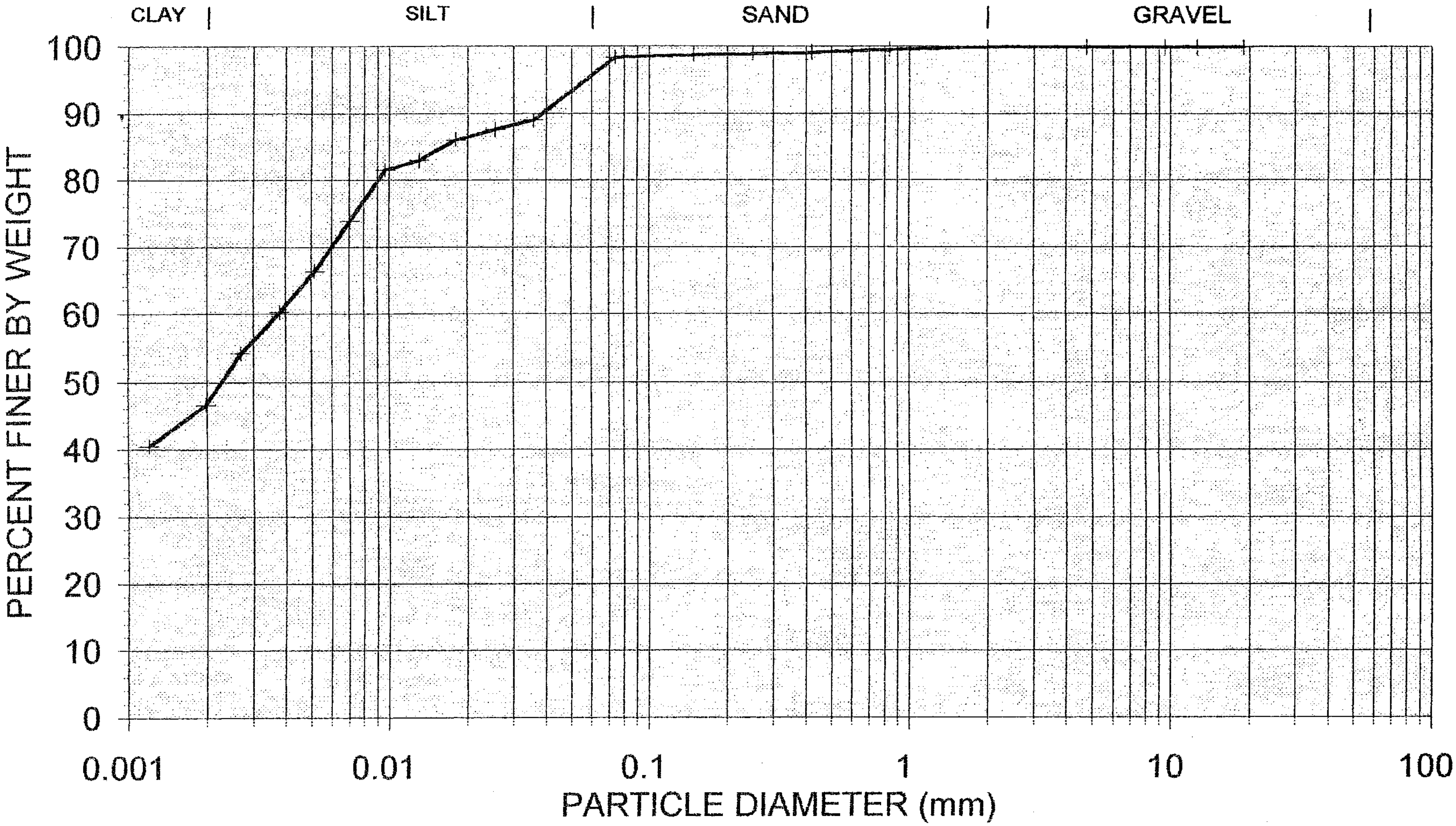


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-15
DEPTH: 12 - 14 Ft.
DATE TESTED: June 24, 1999

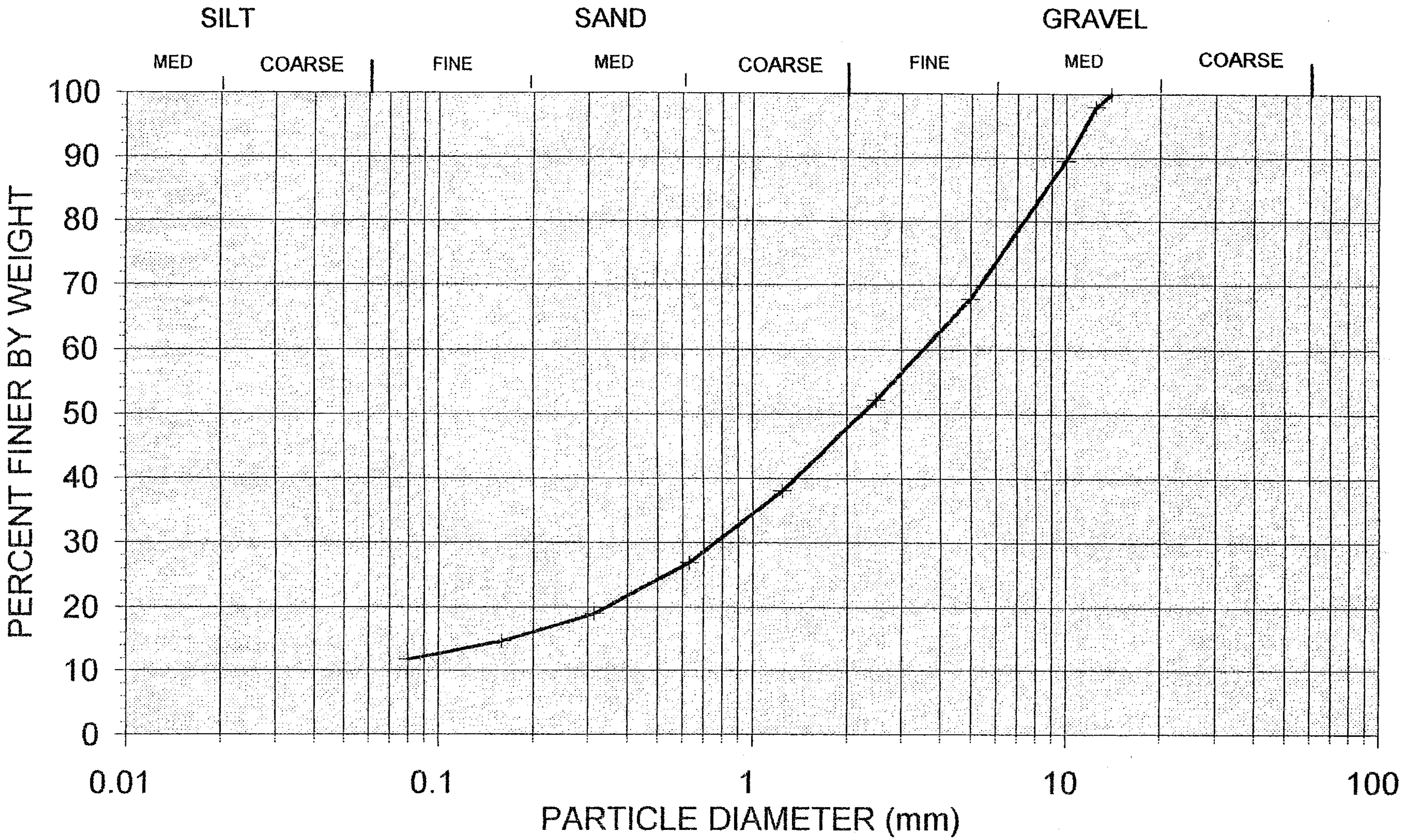
SAMPLE DESCRIPTION:
Gravel (56.5%) and Sand (38.8%),
Trace Silt & Clay (4.7%).

UMA ENGINEERING - GRADATION ANALYSIS



CLIENT: Royal Roads University PROJECT: Blanchard River JOB No.: C799 004 00 02	TEST HOLE No: 99-15 DEPTH: 18 - 20 Ft. DATE TESTED: June 24, 1999	SAMPLE DESCRIPTION: Silt (48.9%) and Clay (46.6%), Trace Sand (4.5%).

UMA ENGINEERING - GRADATION ANALYSIS

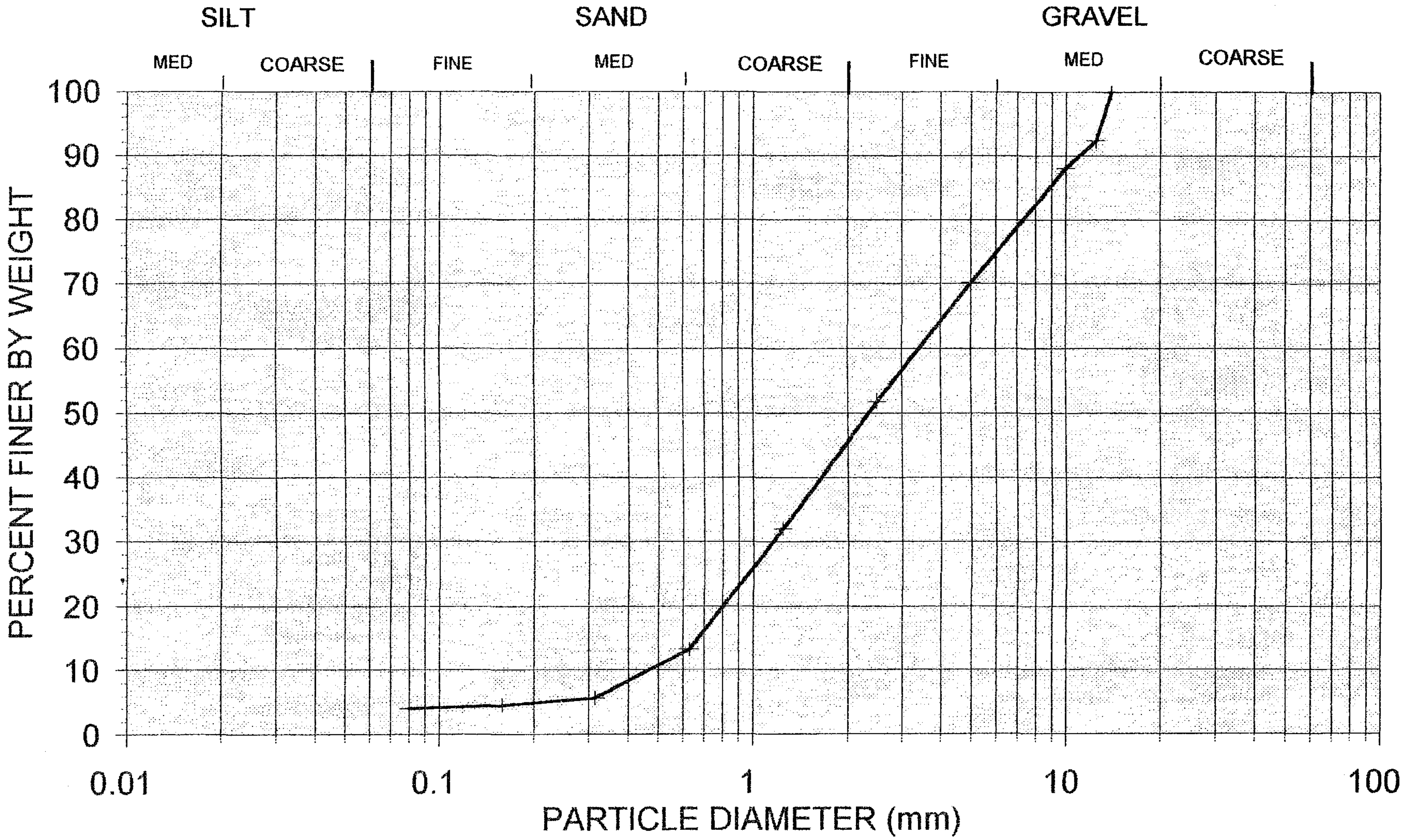


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-17
DEPTH: 6 - 8 Ft.
DATE TESTED: June 24, 1999

SAMPLE DESCRIPTION:
Gravel (52.0%) and Sand (36.1%),
Some Silt & Clay (11.9%).

UMA ENGINEERING - GRADATION ANALYSIS

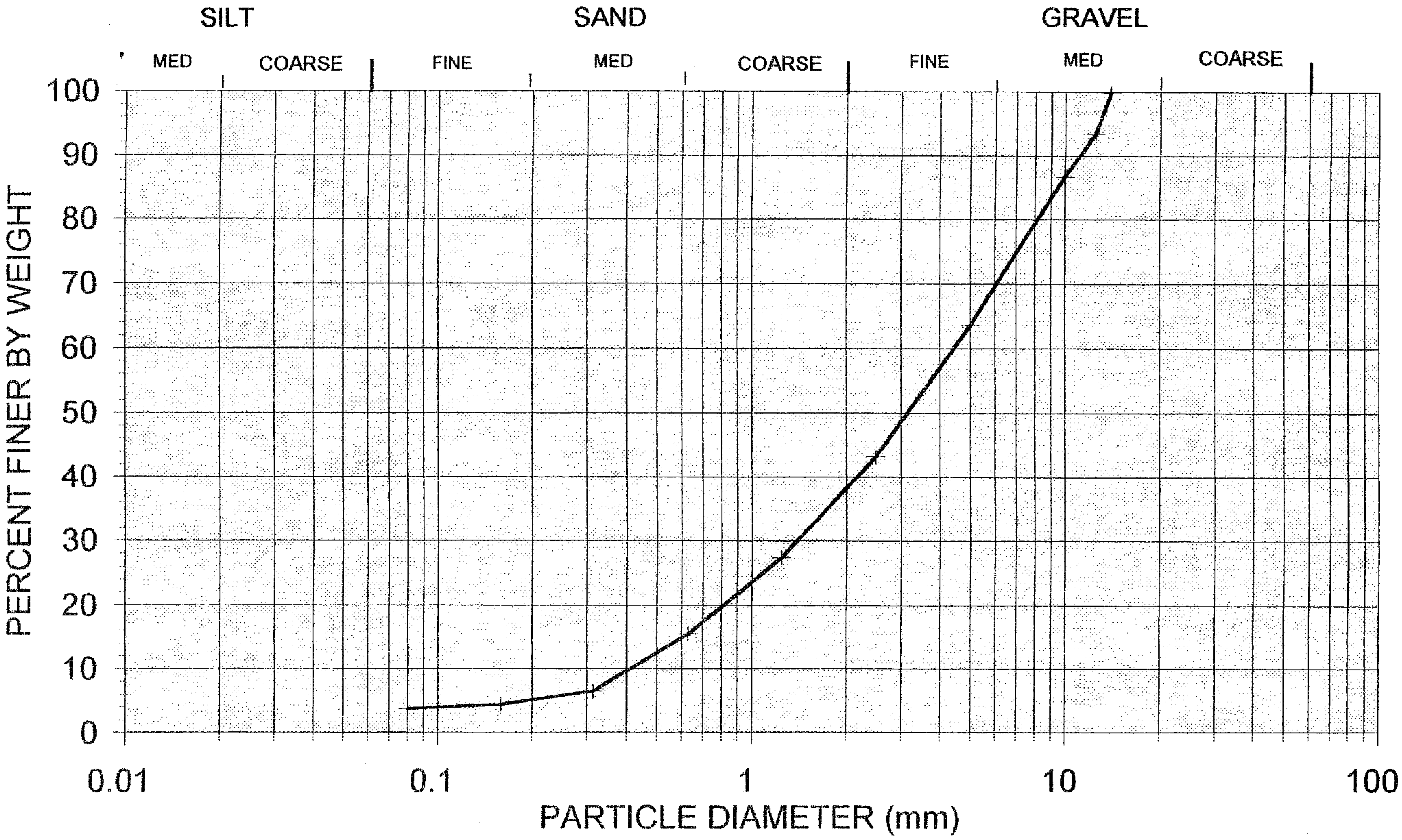


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-17
DEPTH: 12 - 14 Ft.
DATE TESTED: June 24, 1999

SAMPLE DESCRIPTION:
Gravel (54.0%) and Sand (41.9%),
Tace Silt & Clay (4.1%).

UMA ENGINEERING - GRADATION ANALYSIS

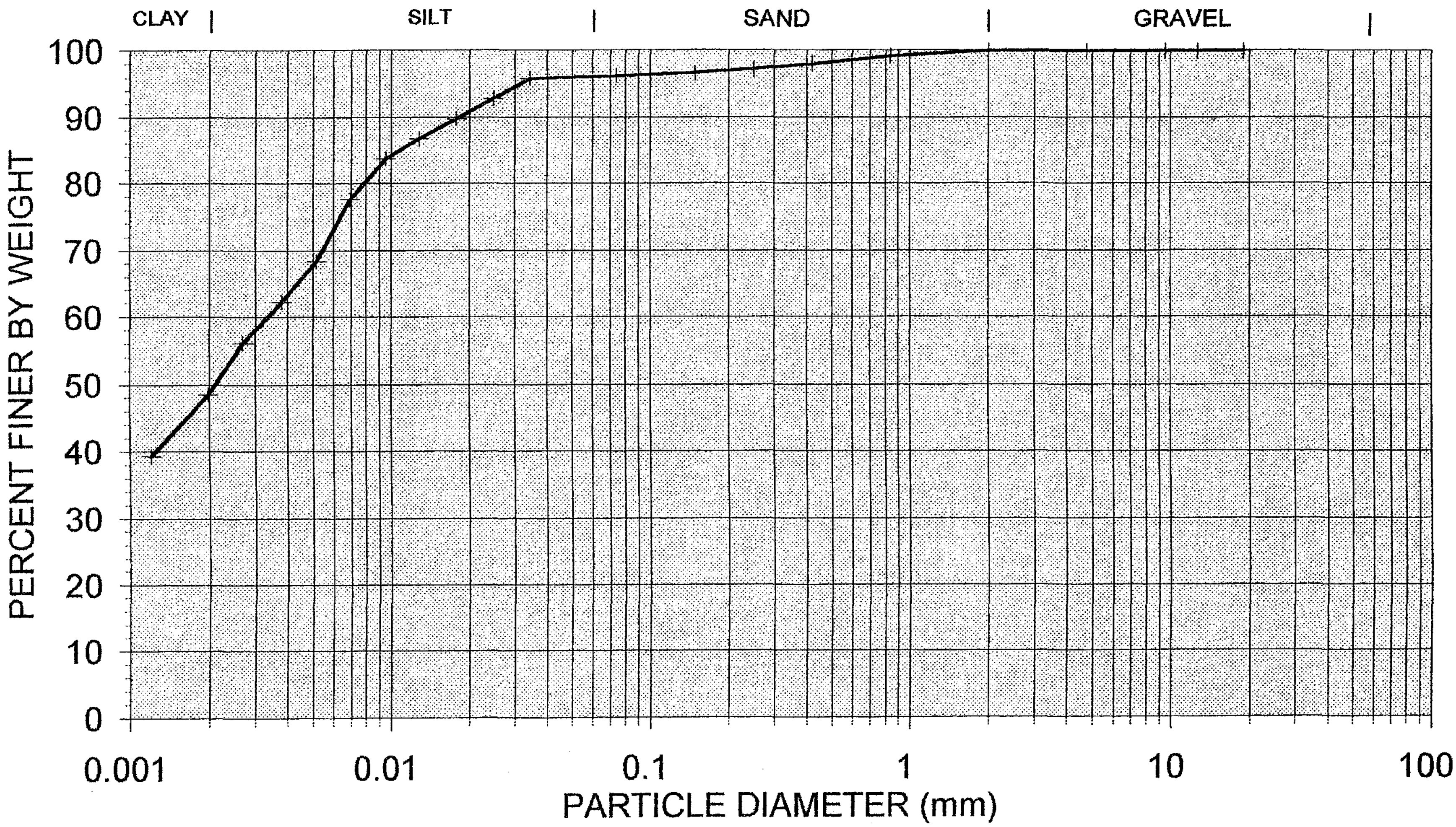


CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-17
DEPTH: 16 - 18 Ft.
DATE TESTED: June 24, 1999

SAMPLE DESCRIPTION:
Sandy (34.2%) Gravel (62.0%),
Tace Silt & Clay (3.8%).

UMA ENGINEERING - GRADATION ANALYSIS



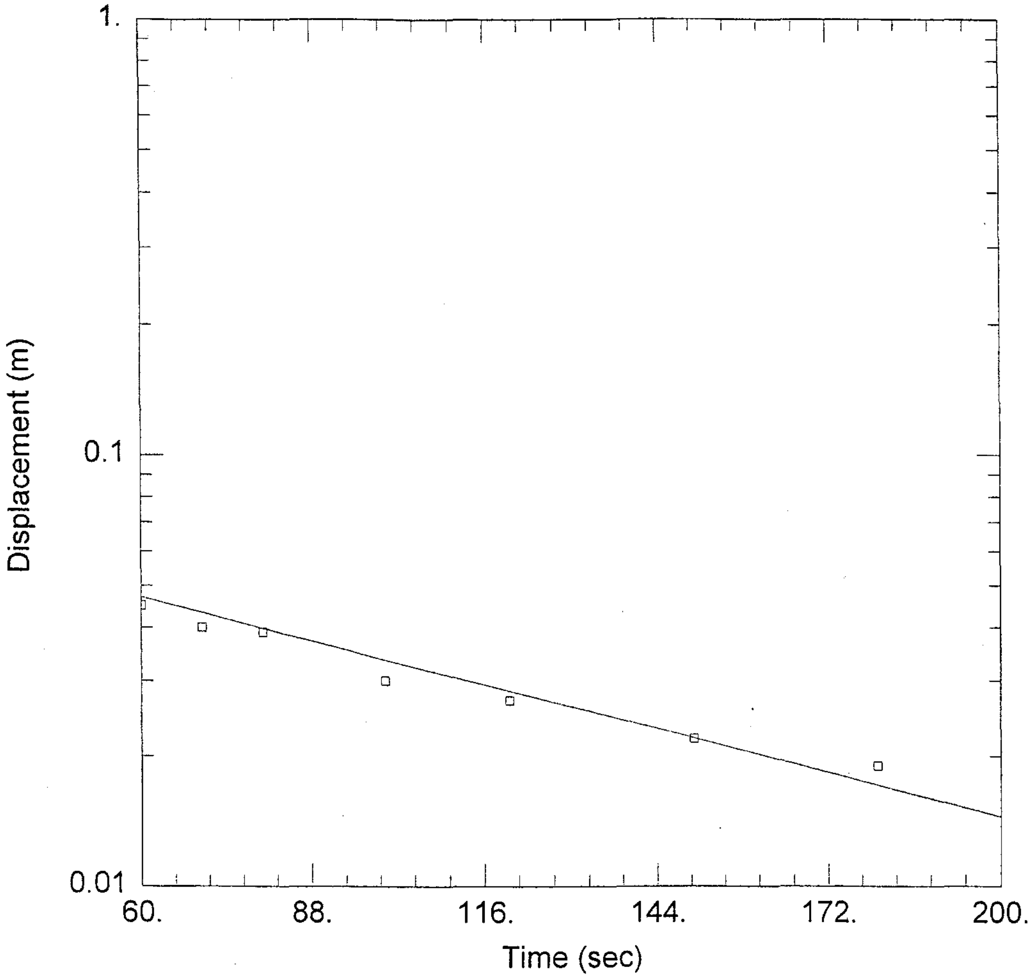
CLIENT: Royal Roads University
PROJECT: Blanchard River
JOB No.: C799 004 00 02

TEST HOLE No: 99-17
DEPTH: 20 - 22 Ft.
DATE TESTED: June 24, 1999

SAMPLE DESCRIPTION:
Clay (48.5%) and Silt (47.8%),
Trace Sand (3.7%).

APPENDIX C:

ESTIMATION OF GROUNDWATER PERMEABILITY, INCLUDING RESPONSE TESTING



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW1
Test Date: Sept. 2, 1999

AQUIFER DATA

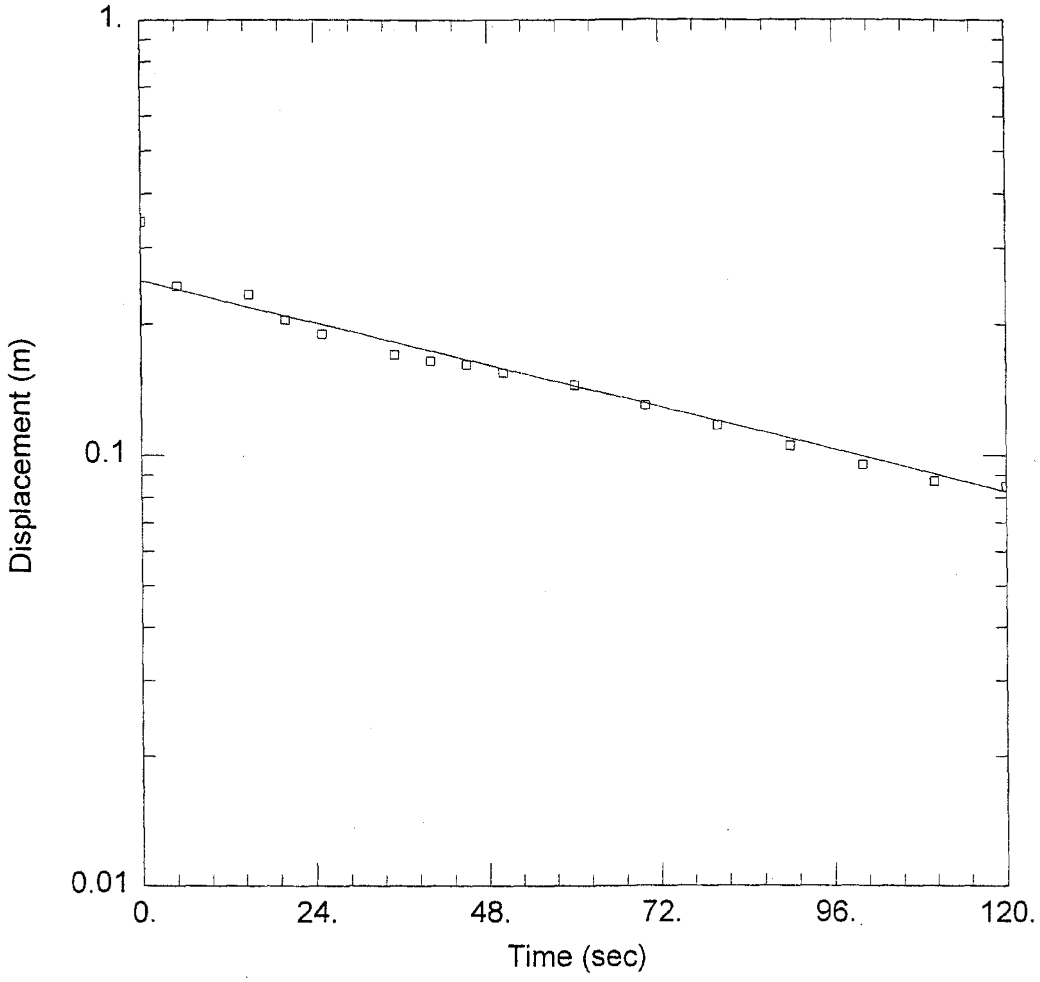
Saturated Thickness: 1.065 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.445 m
Water Column Height: 1.065 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 1.2 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.001459 cm/sec
Solution Method: Bouwer-Rice
y0 = 0.07806 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW2
Test Date: Sept. 2, 1999

AQUIFER DATA

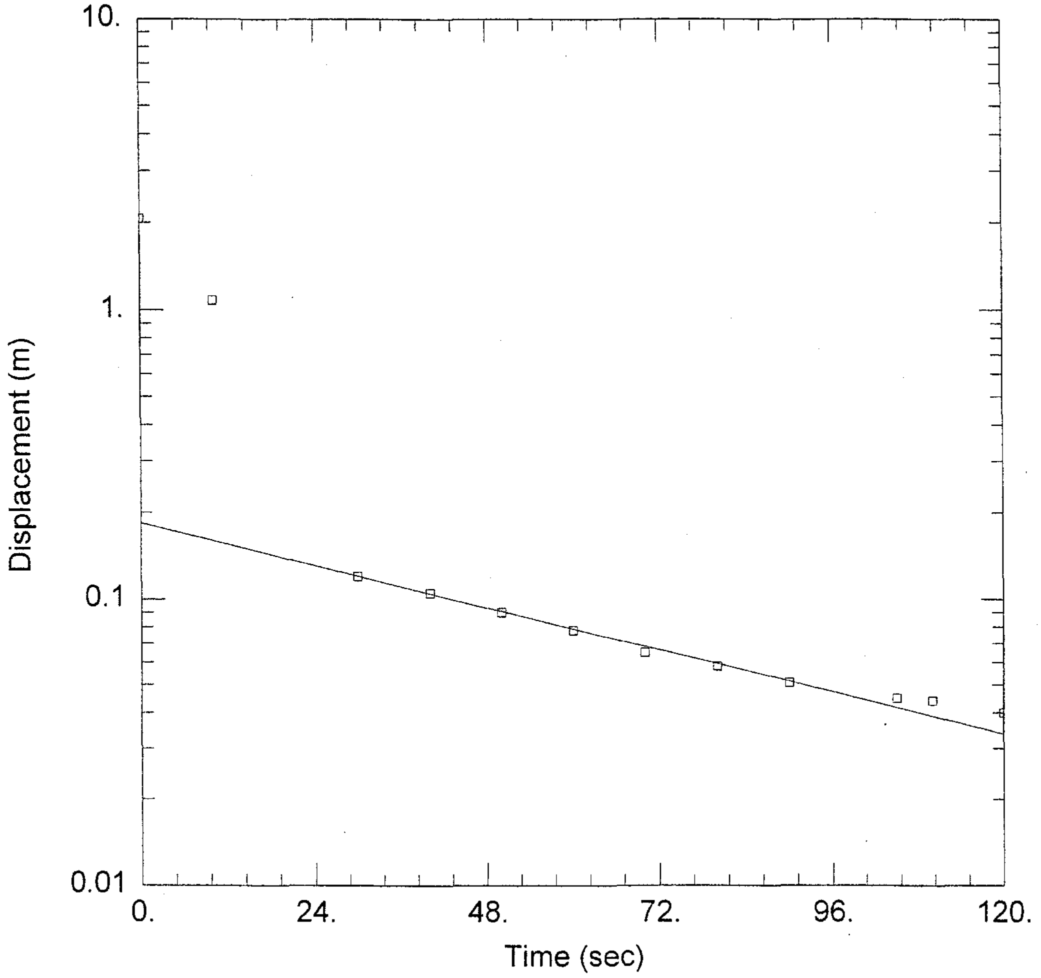
Saturated Thickness: 1.655 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.345 m
Water Column Height: 1.055 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 1.5 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.001182 cm/sec
Solution Method: Bouwer-Rice
y0 = 0.2528 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW4
Test Date: Sept. 2, 1999

AQUIFER DATA

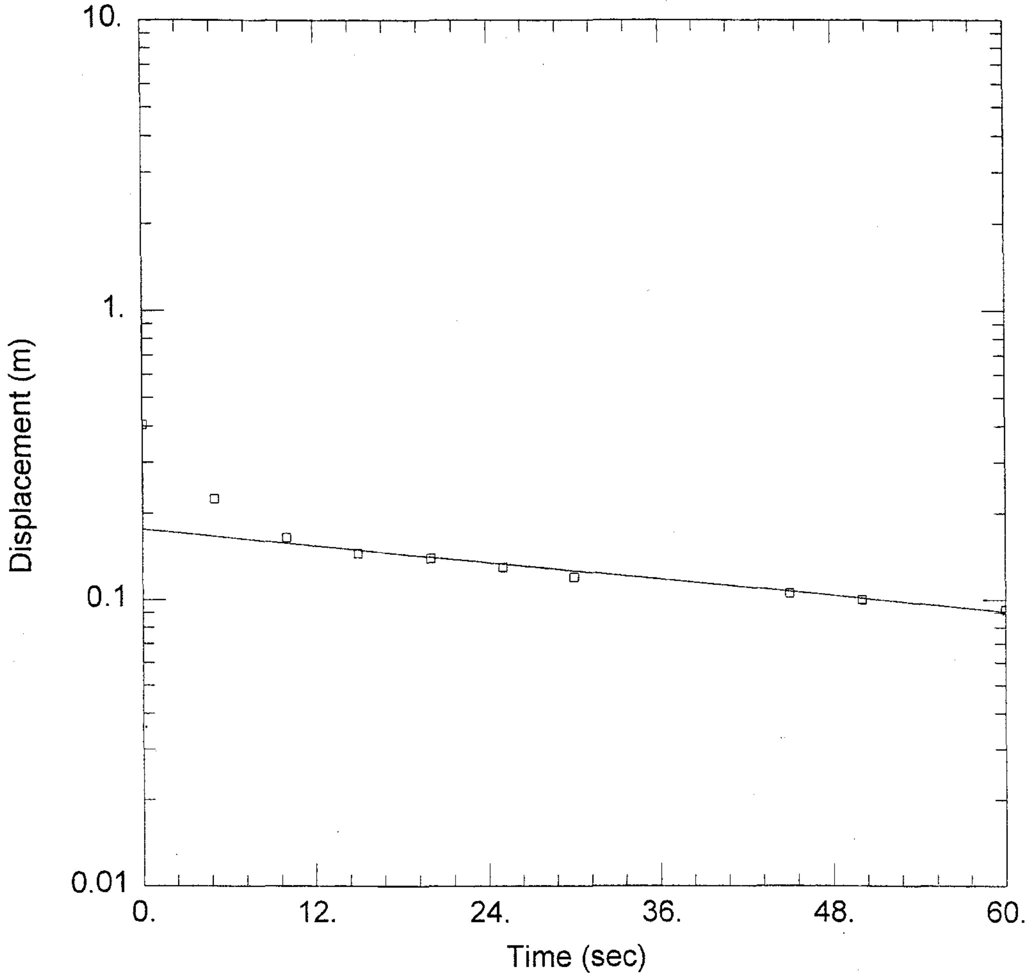
Saturated Thickness: 1.4 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 2.06 m
Water Column Height: 1.4 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 1.2 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.002655 cm/sec
Solution Method: Bouwer-Rice
y0 = 0.1843 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW5
Test Date: Sept. 2, 1999

AQUIFER DATA

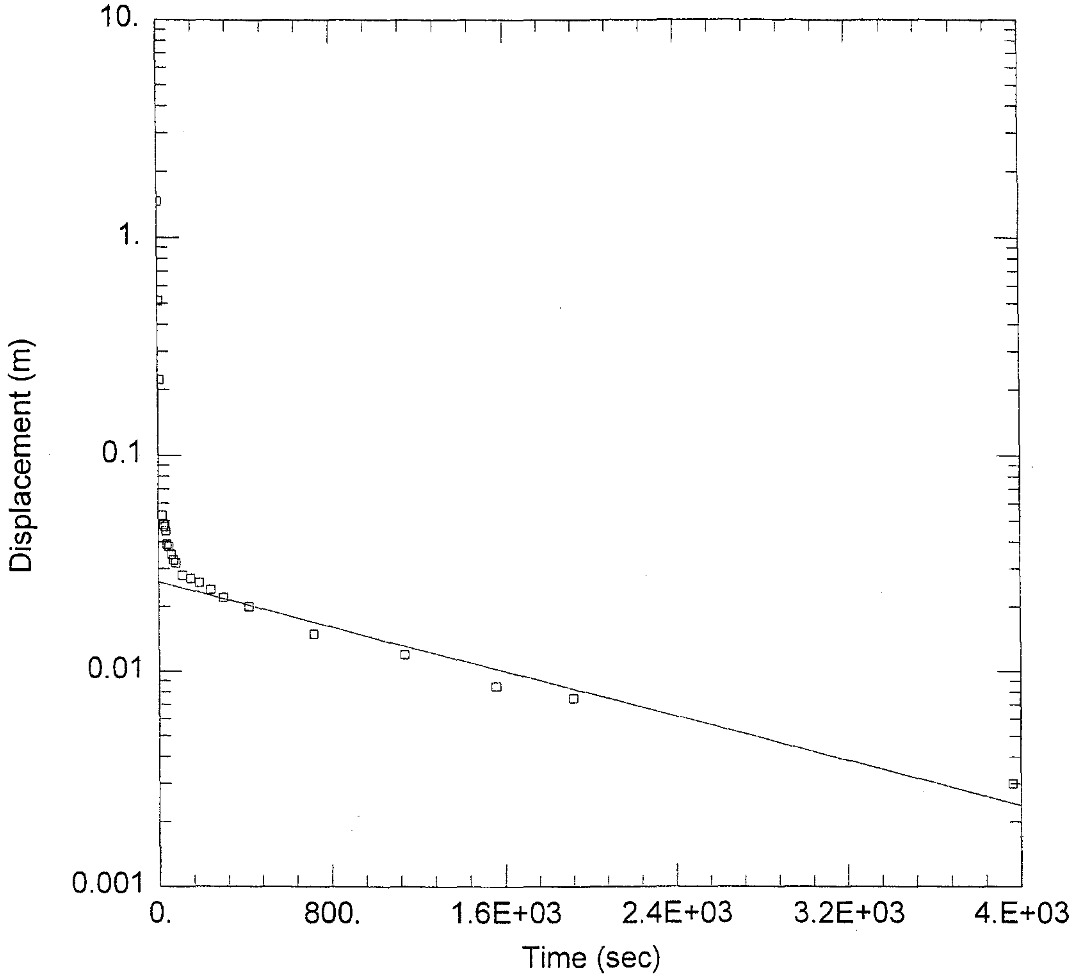
Saturated Thickness: 1.295 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.405 m
Water Column Height: 0.845 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 1.5 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.001329 cm/sec
Solution Method: Bouwer-Rice
y0 = 0.1764 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW6
Test Date: Sept. 2, 1999

AQUIFER DATA

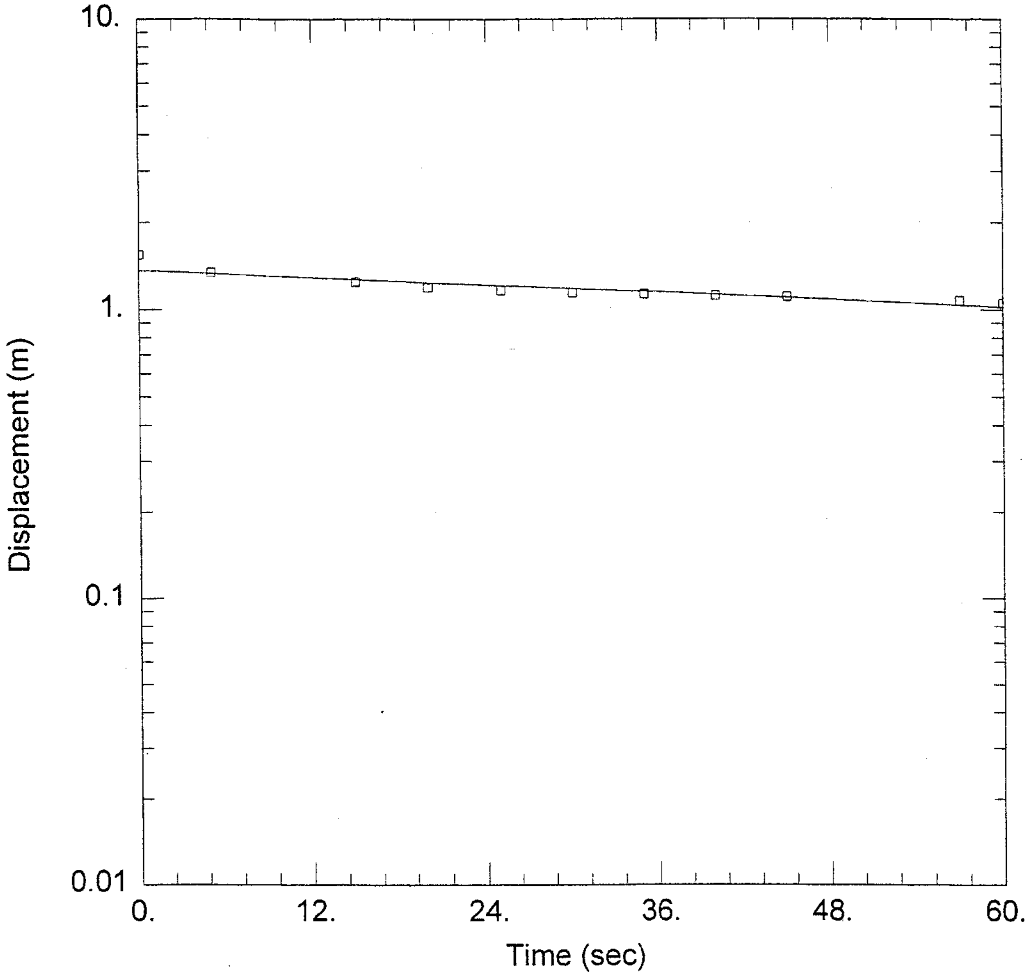
Saturated Thickness: 1.038 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 1.463 m
Water Column Height: 1.038 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 0.9 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.0001323 cm/sec
Solution Method: Bouwer-Rice
y0 = 0.0261 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW8
Test Date: Sept. 2, 1999

AQUIFER DATA

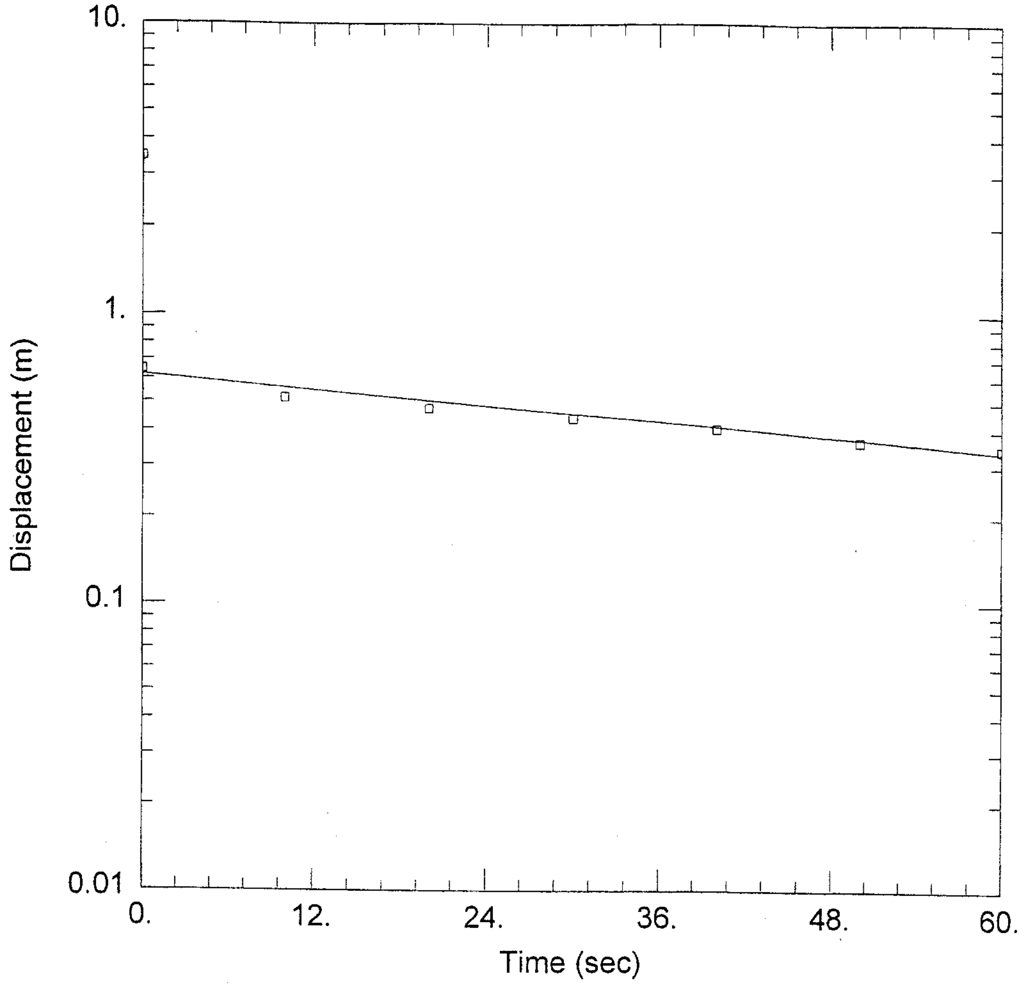
Saturated Thickness: 0.78 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 1.543 m
Water Column Height: 0.78 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 3.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.0003184 cm/sec
Solution Method: Bouwer-Rice
y0 = 1.366 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW9
Test Date: Sept. 2, 1999

AQUIFER DATA

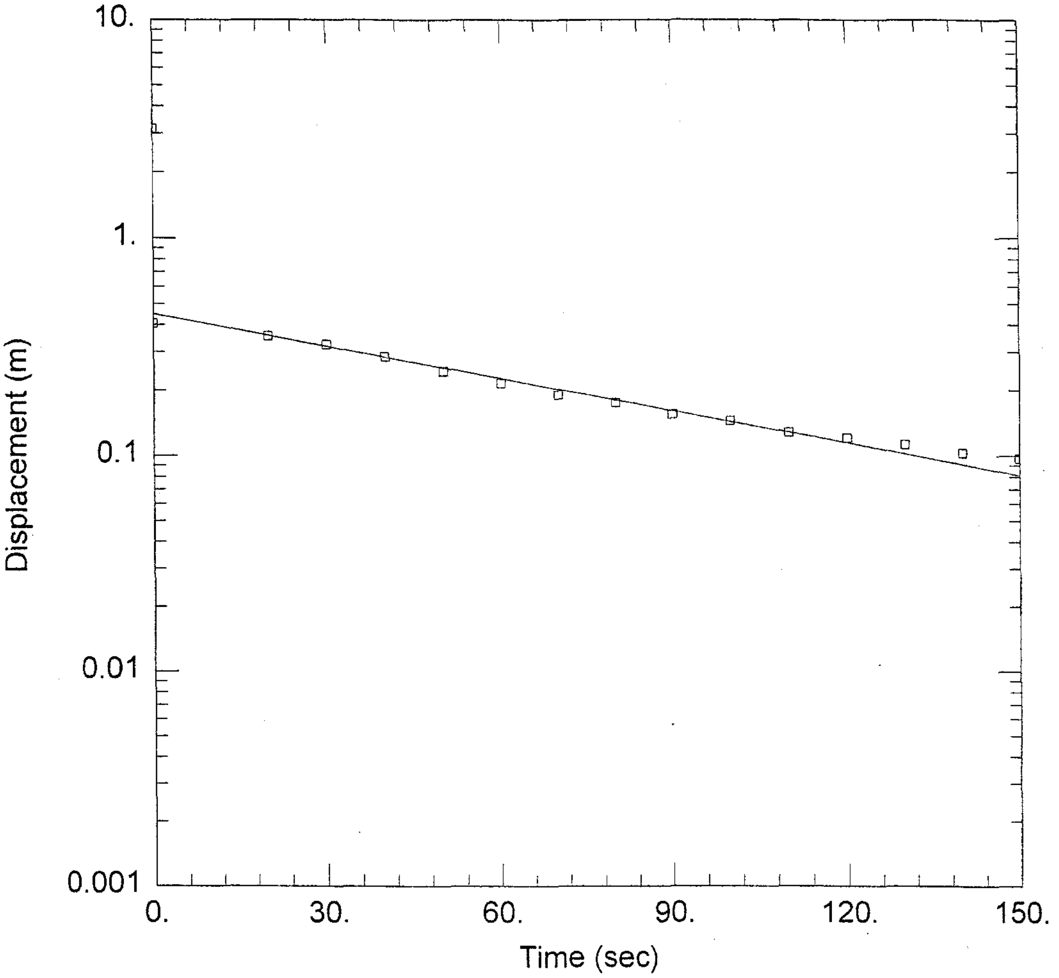
Saturated Thickness: 0.405 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 3.47 m
Casing Radius: 0.025 m
Screen Length: 1.5 m
Water Column Height: 0.405 m
Wellbore Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.000973 cm/sec
y0 = 0.619 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW10
Test Date: Sept. 2, 1999

AQUIFER DATA

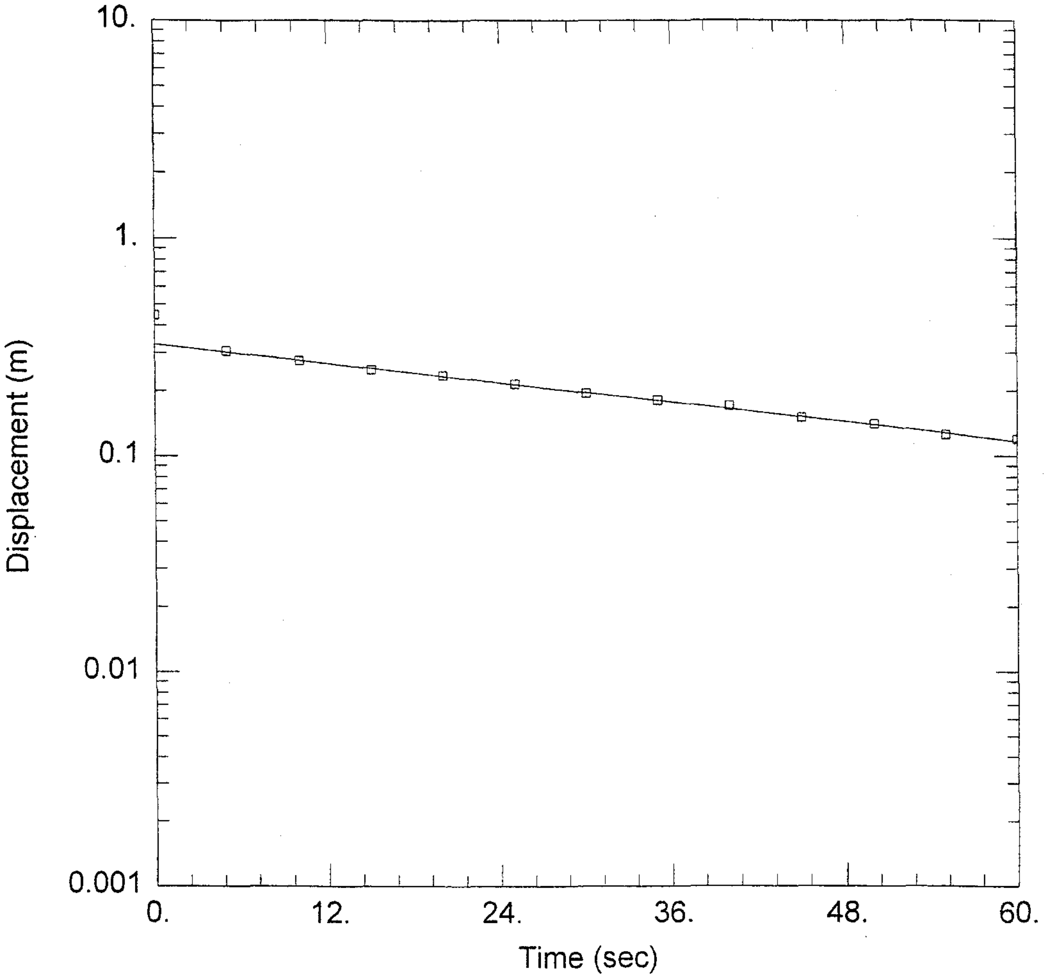
Saturated Thickness: 0.935 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 3.15 m
Water Column Height: 0.935 m
Casing Radius: 0.025 m
Wellbore Radius: 0.075 m
Screen Length: 1.5 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 0.001555 cm/sec
Solution Method: Bouwer-Rice
y0 = 0.4495 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW12
Test Date: Sept. 2, 1999

AQUIFER DATA

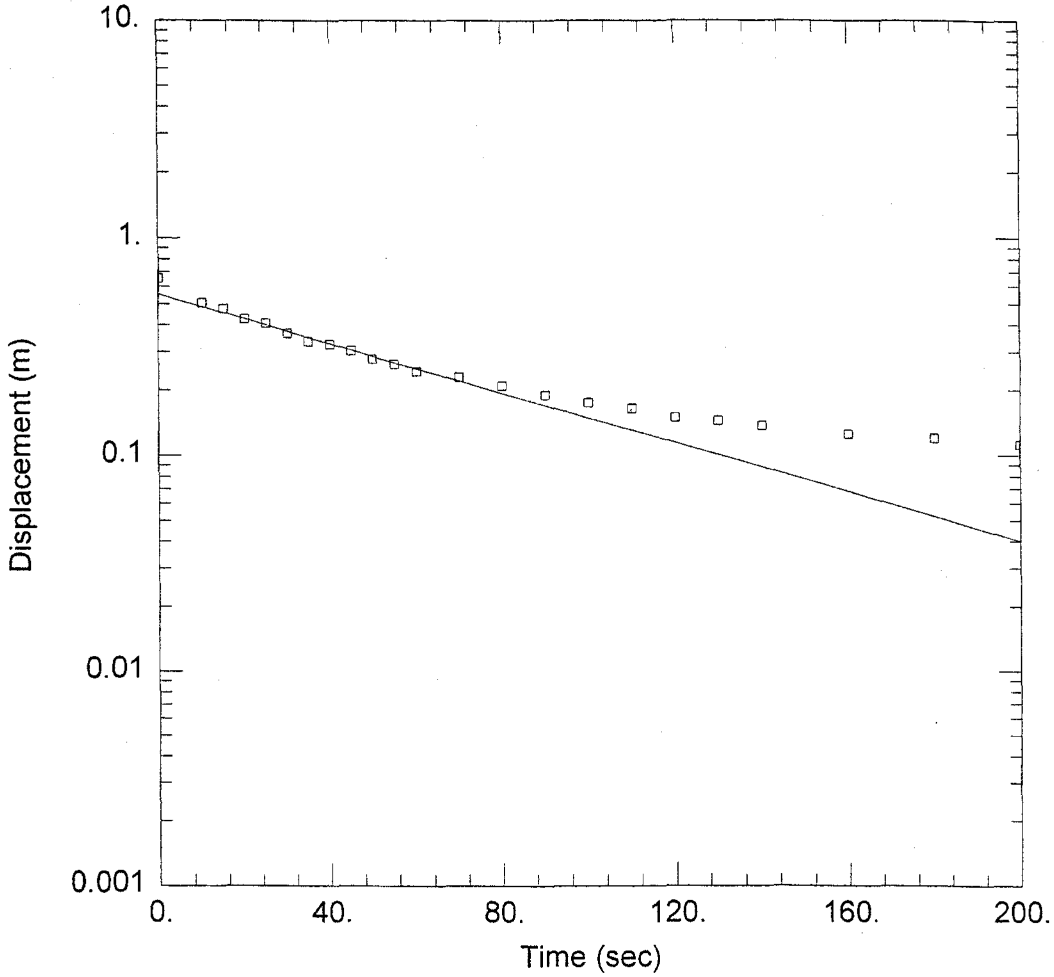
Saturated Thickness: 2.775 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.445 m
Casing Radius: 0.025 m
Screen Length: 3.05 m
Water Column Height: 2.125 m
Wellbore Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.001426 cm/sec
y0 = 0.3289 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW13
Test Date: Sept. 2, 1999

AQUIFER DATA

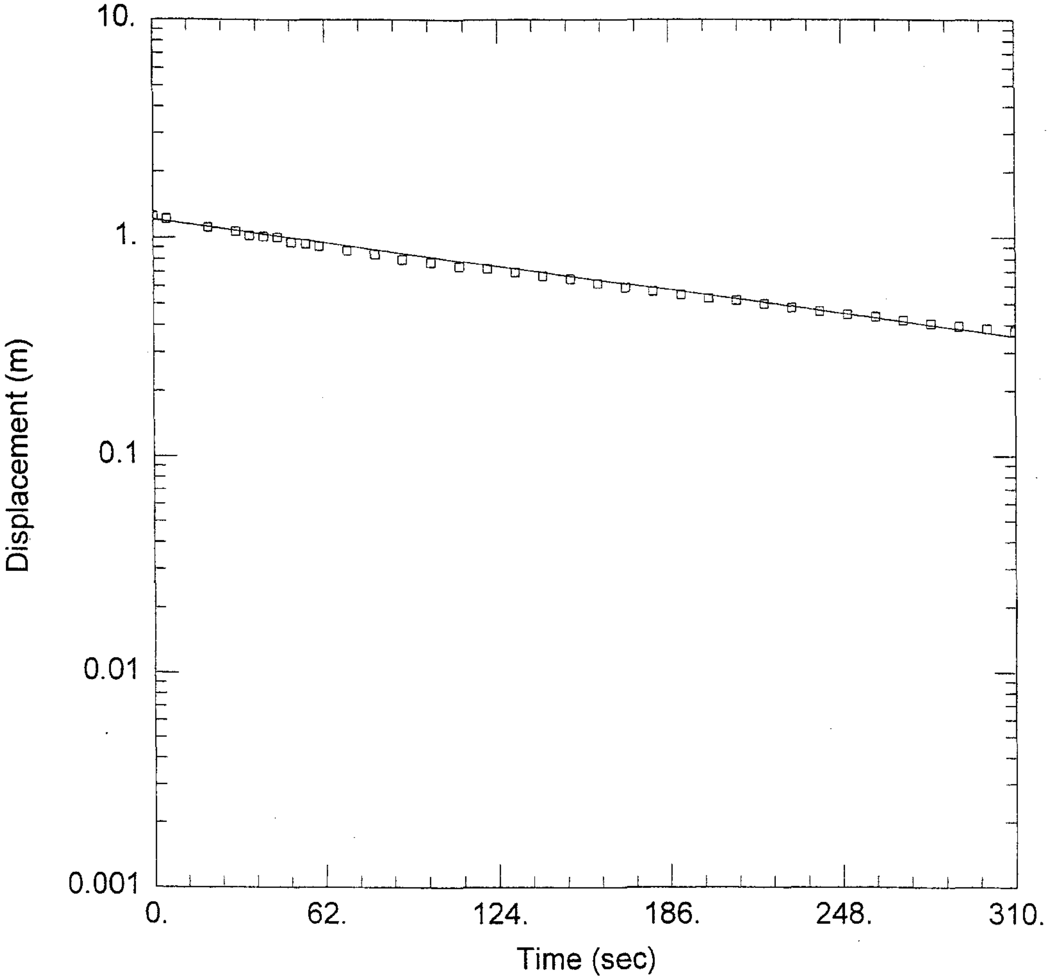
Saturated Thickness: 1.125 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.655 m
Casing Radius: 0.025 m
Screen Length: 3.1 m
Water Column Height: 0.825 m
Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.000244 cm/sec
y0 = 0.5547 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW14
Test Date: Sept. 2, 1999

AQUIFER DATA

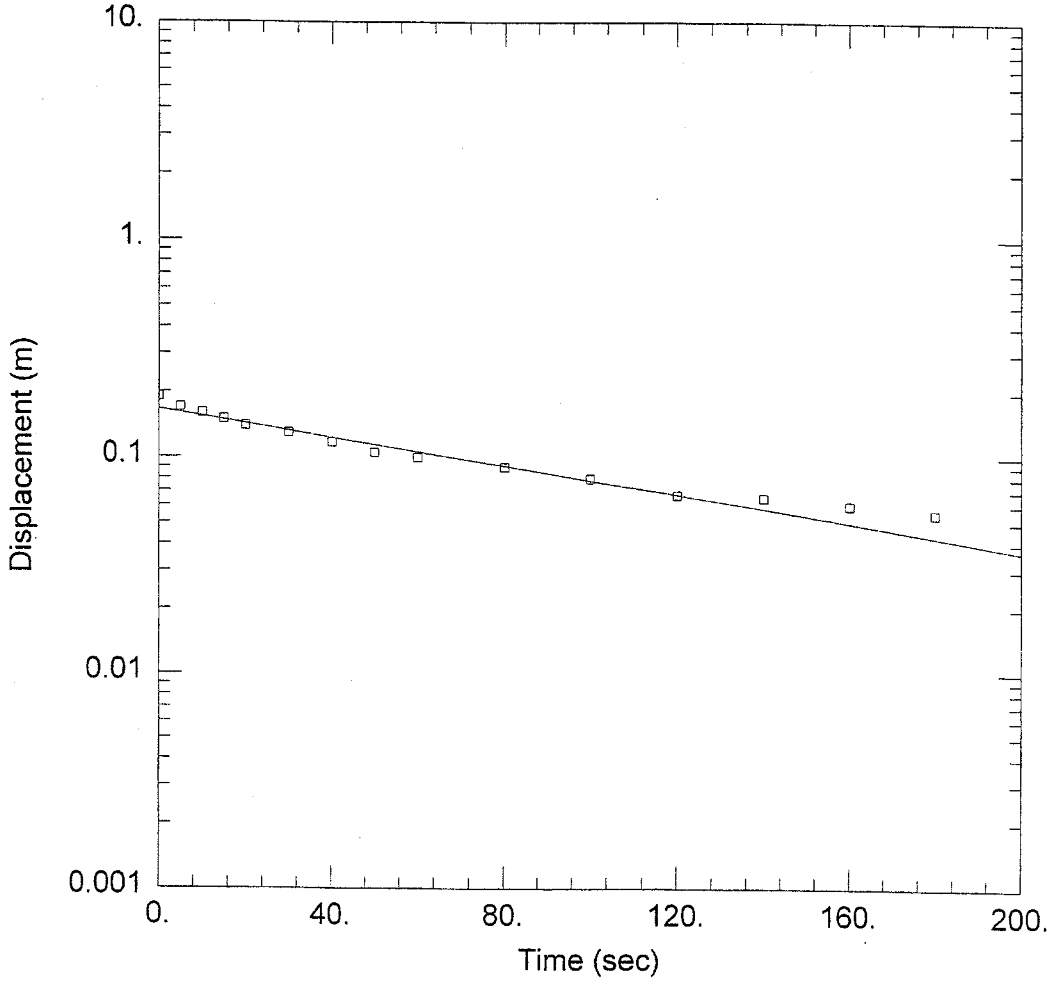
Saturated Thickness: 1.08 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 1.25 m
Casing Radius: 0.025 m
Screen Length: 3.05 m
Water Column Height: 0.73 m
Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 7.136E-05 cm/sec
y0 = 1.212 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW15
Test Date: Sept. 2, 1999

AQUIFER DATA

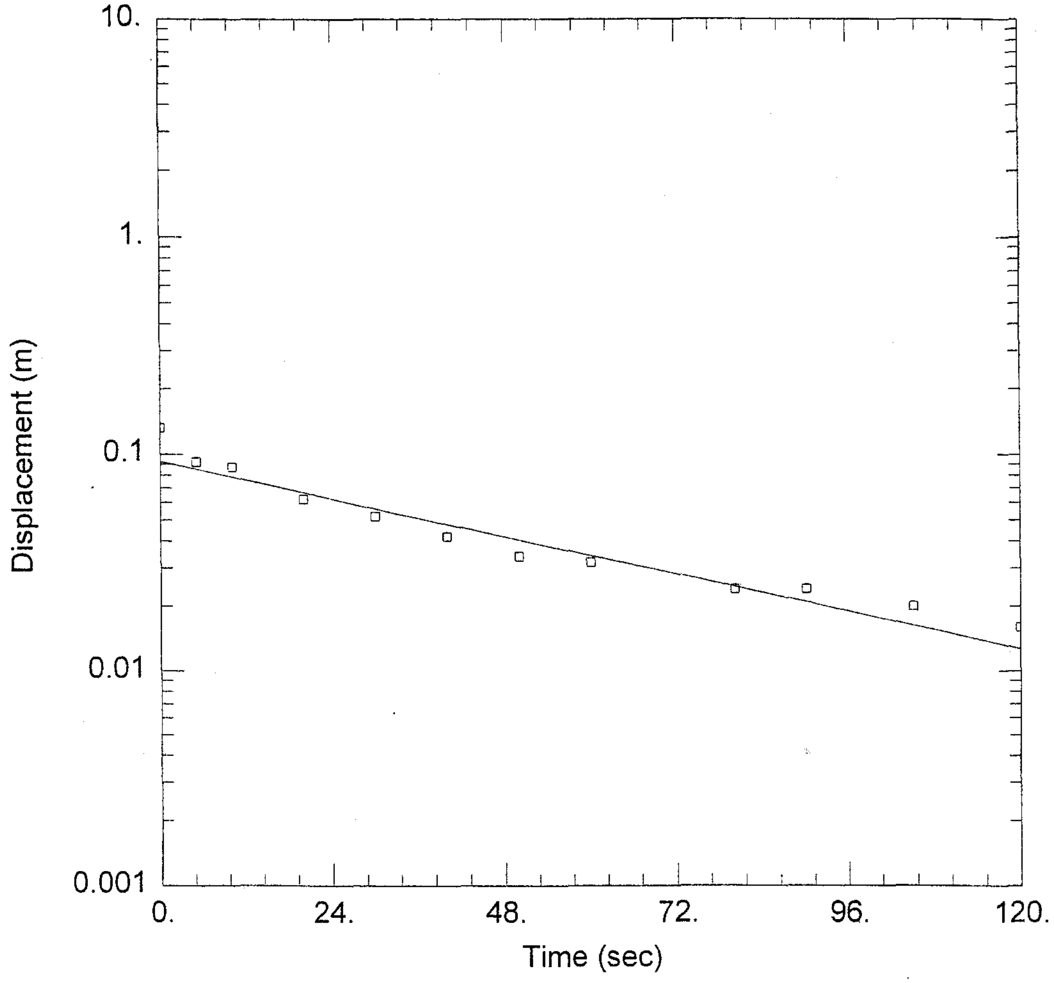
Saturated Thickness: 1.29 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.19 m
Casing Radius: 0.025 m
Screen Length: 2.1 m
Water Column Height: 1.29 m
Wellbore Radius: 0.075 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0008389 cm/sec
y0 = 0.1668 m



PROJECT INFORMATION

Company: UMA Engineering Ltd.
Client: DIAND
Project: 2977-04-01
Test Location: Blanchard River Station
Test Well: MW17
Test Date: Sept. 2, 1999

AQUIFER DATA

Saturated Thickness: 3.148 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Initial Displacement: 0.132 m
Casing Radius: 0.025 m
Screen Length: 3.05 m
Water Column Height: 3.148 m
Wellbore Radius: 0.075 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0004825 cm/sec
y0 = 0.09275 m

APPENDIX D:
GROUNDWATER SAMPLING SHEETS

Groundwater Sampling Data Sheet
Royal Roads University - Applied Research Division

Well No: MW 4
Date: June 18, 1999
Time: 9.25
Samples Collected by: ____

Location: Blanchard River
Weather: Sunny
Temperature: 15 °C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	3.289	meters
Depth to bottom of well from top of casing	B	40540	meters
Diameter of standpipe	C	1.2	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		3 L	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start ____
Finish ____
Volume purged (well vol x 3) ____ litres
Method ____

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
9.30	9L	4.7	6.28	311	
9.40	2L	2.4	6.39	299	
9.47	2L	2.8	6.41	300	slight shine, slightly turbide

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	9.53 a	glass,	40 ml x2	no	H_2SO_4	BTEX
2	9.57 am	glass	500 ml	no	no	HEPH
3	10.02 am	plastic	250 ml	0.45	4ml nitric acid	disolved metal
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) ____ Calibration ____
Cond. meter (model & serial #): ____ Calibration ____
Water Level Meter: ____
Pump: ____
Other: ____

Groundwater Sampling Data Sheet
Royal Roads University - Applied Research Division

Well No: MW-2
Date: June 18 1999
Time: 10:10 am
Location:
Weather: sunny
Temperature: 15°C
Samples Collected by: Susan, Karin

MONITORING WELL INFORMATION

Depth to water from top of casing	A	2.80	meters
Depth to bottom of well from top of casing	B	3.815	meters
Diameter of standpipe	C	1.015	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		2L	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish
Volume purged (well vol x 3) litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
10:15	6L	3.8	5.85	322	
10:20	2L	3.6	5.77	327	slight
10:23	2L	3.0	5.77	328	~~no~~ sheen, clear

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	10:26	glass	40ml x 2		H_2SO_4	
2	10:28	glass	500ml		none	BTEX
3	10:33	plastic	250ml	0.45	Nitric acid	HEPH
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-3
Date: June 18, 1999
Time: 1:30 pm
Samples Collected by:
Location:
Weather: Sunny, Windy
Temperature: 21°C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	2.84	meters
Depth to bottom of well from top of casing	B	4.62	meters
Diameter of standpipe	C	1.78	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		3.56	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish
Volume purged (well vol x 3) litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
13:35	4L	4.7	6.40	1330	
13:40	2L	3.9	6.47	1311	
13:43	2L	4.1	6.53	1326	
13:45	2L	3.7	6.58	1300	no sheen, no odor, turbid

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	13:47	glass	500 mL	—	—	
2	13:50	plastic	250 mL	0.45	Nitric Acid	
3						
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW - 4

Location: Blanchard River

Date: June 18, 1999

Weather: sunny windy

Time: 2:00 pm

Temperature: 22°C

Samples Collected by: Suzanne Aichele, Karen Bell

MONITORING WELL INFORMATION

Depth to water from top of casing	A	2.927	meters
Depth to bottom of well from top of casing	B	4.62	meters
Diameter of standpipe	C	1.693	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		3.4	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start ________ Volume purged (well vol x 3) ________ litres

Finish ________ Method ________

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
2.06 pm	10.2 L	6.6	6.41	1123	
2.08 pm	2 L	4.0	6.51	1102	
2.10 pm	2 L	4.7	6.40	1114	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	2:10 p	glass	500 ml	—	none	
2	2:14 pm	plastic	250 ml	0.45	nitric acid	
3						
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☐ Yes If yes ________

Sheen ☐ No ☐ Yes If yes ________

Other: ________

EQUIPMENT LIST

pH Meter (model & serial #) ________ Calibration ________

Cond. meter (model & serial #): ________ Calibration ________

Water Level Meter: ________

Pump: ________

Other: ________

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-5

Location: Blanchard River

Date: June 18, 1999

Weather: Sunny

Time: 5.15 pm

Temperature: 27°C

Samples Collected by: Suzanne Aichele, Karen Svec

MONITORING WELL INFORMATION

Depth to water from top of casing	A	8.89	meters
Depth to bottom of well from top of casing	B	10.32	meters
Diameter of standpipe	C	1.57	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		3.14	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start

Finish

Volume purged (well vol x 3) 9.42 litres

Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
17:20	10L	8.0	6.94	819	
17:30	2L	5.8	6.91	814	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	17:35	glass	40ml x2	—	H_2SO_4	
2		glass	40ml x2	—	H_2SO_4	
3	17:40	glass	500ml	—	—	
4		glass	500ml	—	—	
5	17:45	plastic	250ml	0.45	Nitric Acid	
6		plastic	250ml	0.45	Nitric Acid	
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☑ Yes If yes strong

Sheen ☐ No ☑ Yes If yes

Other:

Slightly turbid

EQUIPMENT LIST

pH Meter (model & serial #) Calibration

Cond. meter (model & serial #): Calibration

Water Level Meter:

Pump:

Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-6
Location:
Date: June 18, 1999
Weather: sunny, windy
Time: 14:25
Temperature: 25°C
Samples Collected by: Karin, Susan

MONITORING WELL INFORMATION

Depth to water from top of casing	A	1.785	meters
Depth to bottom of well from top of casing	B	3.935	meters
Diameter of standpipe	C	2.150	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		4.3	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish
Volume purged (well vol x 3) 12.9 litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
14:30	13L	5.3	6.54	983	
14:35	2L	4.7	6.47	986	
14:40	2L	5.0	6.48	984	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1		glass	40ml x2	–	H_2SO_4	
2		plastic	500ml	–	–	
3		plastic	250ml	0.45	Nitric Acid	
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-8
Location: Blanchard River
Date: June 18, 1999
Weather: sunny
Time: 10.56 am
Temperature: 19 °C
Samples Collected by: Susanne Aichele, Karen Svec

MONITORING WELL INFORMATION

Depth to water from top of casing	A	3.08	meters
Depth to bottom of well from top of casing	B	3.828	meters
Diameter of standpipe	C	0.048	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		1.6	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Volume purged (well vol x 3) litres
Finish
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
11.38 am	5 l	8.8	6.66	409	turbid, slight sheen
11.41 am	2 l	3.9	6.71	389	
11.43 am	2 l	3.9	6.71	397	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	11.50	glass	40 ml(x2	—	H_2SO_4	
2	11.52	glass	500 ml	—	none	BTEX
3	11.55	plastic	250 ml	0.45	nitric acid	HEPH
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-9
Date: June 18, 1999
Time: 3.07 pm
Location: Blanchard River
Weather: Sunny
Temperature: 27°C
Samples Collected by: Susanne Nichole, Karen Sree

MONITORING WELL INFORMATION

Depth to water from top of casing	A	4.00	meters
Depth to bottom of well from top of casing	B	4.50	meters
Diameter of standpipe	C	0.50	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		1.00	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start ____________
Finish ____________
Volume purged (well vol x 3) ____________ litres
Method ____________

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
3.09 pm	3.00	9.3	7.42	677	
3.17 pm	0.5	8.2	7.45	664	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	3:20 pm	glass	40 ml x 2	–	H_2SO_4	
2	3:30 pm	glass	500 ml	–	–	
3	3:33 pm	plastic	250 ml	0.45µ	Nitric acid	
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☒ No ☐ Yes If yes ____________
Sheen ☒ No ☐ Yes If yes ____________
Other: well didn't recover very well

EQUIPMENT LIST

pH Meter (model & serial #) ____________ Calibration ____________
Cond. meter (model & serial #): ____________ Calibration ____________
Water Level Meter: ____________
Pump: ____________
Other: ____________

Groundwater Sampling Data Sheet
Royal Roads University - Applied Research Division

Well No:	MW-10	Location:	
Date:	June 18, 1999	Weather:	overcast, windy
Time:	15:37	Temperature:	25°C

Samples Collected by: Karin, Susan

MONITORING WELL INFORMATION

Depth to water from top of casing	A	3.445	meters
Depth to bottom of well from top of casing	B	4.515	meters
Diameter of standpipe	C	1.070	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		2	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start ______

Finish ______

Volume purged (well vol x 3) 6 litres

Method ______

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
15:40	6L	5.2	6.97	345	
15:46	2L	4.6	7.05	347	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	15:50	glass	500ml	—	—	turbid,
2	15:55	plastic	250ml	0.45	Nitric acid	
3						
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☑ No ☐ Yes If yes ______

Sheen ☑ No ☐ Yes If yes ______

Other: ______

EQUIPMENT LIST

pH Meter (model & serial #) ______ Calibration ______

Cond. meter (model & serial #): ______ Calibration ______

Water Level Meter: ______

Pump: ______

Other: ______

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-12
Location: Blanchard River
Date: June 18, 1999
Weather: overcast, raining
Time:
Temperature:
Samples Collected by: Susanne Aichele, Karen Svec

MONITORING WELL INFORMATION

Depth to water from top of casing	A	2.98	meters
Depth to bottom of well from top of casing	B	4.71	meters
Diameter of standpipe	C	1.73	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		2.46	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish
Volume purged (well vol x 3) 7.38 litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
11:15	8L	2.8	5.96	206	
11:23	2L	2.9	5.87	172	
11:27	2L	2.8	5.90	162	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1		glass	2x40 ml	–	H_2SO_4	BTEX x 2
2		glass	500 ml	–	–	HEPH x 2
3		plastic	250 ml	0.45	nitric acid	dissolved metals x 2
4						for
5						duplicate
6						Labelled MW-D2
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☑ Yes If yes very strong
Sheen ☐ No ☑ Yes If yes
Other: turbid

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other: FIELD DUPLICATE COLLECTED AND LABELLED MW-D2

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW - 13
Date: June 18, 1999
Time: 4.41 pm
Samples Collected by: Susanne Aichele, Karen Sree
Location: Blanchard River
Weather: cloudy
Temperature: 25°C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	9.84	meters
Depth to bottom of well from top of casing	B	11.65	meters
Diameter of standpipe	C	1.81	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		3.6	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start ______
Finish ______
Volume purged (well vol x 3) ______ litres
Method ______

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
4.56	11 l	7.0	7.11	532	
4.58 pm	2 l	6.6	7.30	522	
5.01 pm	2 l	6.9	7.22	530	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	5.03 pm	glass	40ml x2	—	H_2SO_4	
2	5.07 pm	glass	500 ml	—	—	
3	5.011 pm	plastic	250ml	0.45	nitric acid	
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☒ Yes If yes ______
Sheen ☐ No ☒ Yes If yes ______
Other: very turbid

EQUIPMENT LIST

pH Meter (model & serial #) ______ Calibration ______
Cond. meter (model & serial #): ______ Calibration ______
Water Level Meter: ______
Pump: ______
Other: ______

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW - 14

Date: June 19, 1999

Time:

Samples Collected by: Susanne Michele, Karen Rice

Location:

Weather: overcast, raining

Temperature:

MONITORING WELL INFORMATION

Depth to water from top of casing	A	7.455	meters
Depth to bottom of well from top of casing	B	8.120	meters
Diameter of standpipe	C	.665	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		1.330	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start

Finish

Volume purged (well vol x 3) 3.99 litres

Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
10:10	4L	5.7	6.59	366	
10:17	1L	5.5	6.61	368	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	10:25	glass	2x40 ml		H_2SO_4	BTEX
2	10:30	glass	500 ml		–	HEPH
3	10:35	plastic	250 ml	0.45	nitric acid	dissolved metals
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☑ Yes If yes strong

Sheen ☐ No ☑ Yes If yes

Other: very turbid, white foam on top

EQUIPMENT LIST

pH Meter (model & serial #) Calibration

Cond. meter (model & serial #): Calibration

Water Level Meter:

Pump:

Other:

Groundwater Sampling Data Sheet
Royal Roads University - Applied Research Division

Well No: MW - 15
Date: June 14.1999
Time: 9.40 am
Samples Collected by: Susanne Michele, Karen Pree

Location: Blanchard River
Weather: raing
Temperature: 12°C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	2.95	meters
Depth to bottom of well from top of casing	B	4.535	meters
Diameter of standpipe	C	1.575	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		3.2	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start ______
Finish ______

Volume purged (well vol x 3) 9.6 litres
Method ______

TIME	Volume Removed	TEMP (^{o}C)	pH	Conductivity (µS/cm)	Remarks
9.40 am	10 l	7.6	6.35	753	
9.44 am	2 l	7.9	6.4	688	
9.48 am	2 l	7.9	6.42	696	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	9.49 am	glass	2x 40ml	—	H_2SO_4	BTEX
2	9.52 am	glass	500 ml	—	–	HEPH
3	9.54 am	plastic	250 ml	0.45	nitric acid	Dissolved Metal
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☒ Yes If yes slight
Sheen ☒ No ☐ Yes If yes but hard to
Other:
very turbid

EQUIPMENT LIST

pH Meter (model & serial #) ______ Calibration ______
Cond. meter (model & serial #): ______ Calibration ______
Water Level Meter: ______
Pump: ______
Other: ______

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: MW-17
Date: June 19, 1999
Time:
Samples Collected by: Suzanne Michele, Maren Svec

Location: Blanchard Rdve
Weather:
Temperature:

MONITORING WELL INFORMATION

Depth to water from top of casing	A	~~6.035~~	meters	2.910
Depth to bottom of well from top of casing	B	~~2.910~~	meters	6.035
Diameter of standpipe	C	~~.875~~	meters	3.125
One well volume (B-A)*2 (for 2 inch i.d. well)		6.25	litres	
(B-A)*1.1(for 1 inch i.d. well)			litres	

WELL PURGING

Start
Finish

Volume purged (well vol x 3) 18.75 litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
10:45	19 L	4.0	6.91	301	
10:50	2 L	3.7	7.02	302	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	10:53	glass	2×40ml	–	H_2SO_4	BTEX
2	10:57	glass	500ml	–	–	HEPH
3	11:05	plastic	250ml	0.45	nitric acid	dissolved metal
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet
Royal Roads University - Applied Research Division

Well No: MP - 3
Date: June 18 1999
Time: 8:50 pm
Samples Collected by: Susanne Michele, Tom
Location: Blanchard Pipes by River
Weather: Sunny
Temperature: 20 °C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	1.31	meters
Depth to bottom of well from top of casing	B	1.56	meters
Diameter of standpipe	C	0.25	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		0.5	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish
Volume purged (well vol x 3) litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: 10
Date: Sept 23, 99
Time: 2:40 pm
Samples Collected by: Doug Bright + Susanne Aichele
Location: Blanchard River
Weather: windy, cloudy, rainy
Temperature: 5°C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	3.532	meters
Depth to bottom of well from top of casing	B	4.524	meters
Diameter of standpipe	C	0.992	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		2.0	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start 2:30
Finish
Volume purged (well vol x 3) 10 litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
2:40	2	7.0	6.62	311	
2:42	2	5.7	6.85	299	
2:44	2	5.4	6.95	297	
2:46	2	54	6.95	297	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	2:46	glass	2x40 ml	—	sulfuric acid	BTEX
2	2:47	amber gl.	2x 500ml	—	—	LEP - HEP
3	2:48	plastic	250 ml	0.22	nitric acid	metal
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: 19
Date: Sept 23, 99
Time:
Samples Collected by:

Location: Blanchard River
Weather: cloudy, windy, rainy
Temperature: 5 C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	3.172	meters
Depth to bottom of well from top of casing	B	4.083	meters
Diameter of standpipe	C	0.991	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		2.0	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish
Volume purged (well vol x 3) 10 litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
2:52	2	6.5	6.70	549	
2:54	2	6.2	6.66	561	
2:57	2	6.1	6.61	552	
2:58	2	6.1	6.64	556	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	2:59	septa vial	2 x 40ml	–	sulphuric acid	BTEX
2	3:01	amber glass	2 x 500ml	–	–	LEP
3	3:03	plastic	250ml	0.22	nitric acid	Metals
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

Odour ☐ No ☒ Yes If yes strong
Sheen ☒ No ☐ Yes If yes
Other: brown colour, soapy

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: 9
Date: Sept 23.99
Time:
Samples Collected by:

Location: Blandard River
Weather: cloudy, rainy, windy
Temperature: 5°C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	4.053	meters
Depth to bottom of well from top of casing	B	4.500	meters
Diameter of standpipe	C	0.447	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		1.0	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish

Volume purged (well vol x 3) litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
3:06 pm	1 l	6.0	7.16	543	
3:08 pm	1 l	6.0	7.12	531	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	3:09	septa vial	2×40ml	—	sulphuric acid	BTEX
2	3:10	amberglass	2×500ml	—	—	LEP
3	3:28	plastic	250 ml	0.22	nitric acid	Metal
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

Groundwater Sampling Data Sheet

Royal Roads University - Applied Research Division

Well No: 18
Date: Sept 23 99
Time:
Samples Collected by:

Location: Blandard River
Weather: cloudy, windy, raining
Temperature: 5°C

MONITORING WELL INFORMATION

Depth to water from top of casing	A	3.663	meters
Depth to bottom of well from top of casing	B	4.207	meters
Diameter of standpipe	C	0.594	meters
One well volume (B-A)*2 (for 2 inch i.d. well)		1.1	litres
(B-A)*1.1(for 1 inch i.d. well)			litres

WELL PURGING

Start
Finish

Volume purged (well vol x 3) litres
Method

TIME	Volume Removed	TEMP (°C)	pH	Conductivity (µS/cm)	Remarks
3:22	1 l	6.0	7.29	293	
3:24	1 l	5.5	7.20	283	
3:26	1 l	5.5	7.24	280	

SAMPLE BOTTLES FILLED

No	Time Collected	Type of Container	Volume	Filter (µm)	Preservative	Remarks
1	3:28	septa vial	2 x 40 ml	–	sulphuric acid	BTEX
2	3:30	amber glass	2x500 ml	–	–	LEP
3	3:32	plastic	250 ml	0.22	nitric acid	metal
4						
5						
6						
7						
8						
9						
10						

OBSERVATIONS

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

EQUIPMENT LIST

pH Meter (model & serial #) Calibration
Cond. meter (model & serial #): Calibration
Water Level Meter:
Pump:
Other:

APPENDIX E:
LABORATORY REPORTS

LABORATORY REPORT FOR
JUNE 1999
DETAILED SITE INVESTIGATIONS

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 16, 1999
ASL File No.	K6884
Report On:	Blanchard River Water & Sediment Analysis
Report To:	**Royal Roads University** Applied Research Division 2005 Sooke Road Victoria, BC V9B 5Y2
Attention:	**Dr. Matthew Dodd**, Professor
Received:	June 21, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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SECTION 1

Water

Sub-Section 1

Physical Tests
Total Metals

RESULTS OF ANALYSIS - Water[1]

File No. K6884

		BLW-2	BLW-3	BLW-4	BLW-5	BLW-6
		99 06 18 17:30	99 06 18 19:30	99 06 18 17:40	99 06 18 18:00	99 06 18 21:25
Physical Tests						
Hardness	CaCO3	147	386	86.2	202	6.91
Total Metals						
Aluminum	T-Al	1.74	<0.03	0.096	0.147	-
Antimony	T-Sb	<0.2	<0.2	<0.2	<0.2	-
Arsenic	T-As	<0.2	<0.2	<0.2	<0.2	-
Barium	T-Ba	0.16	0.62	0.08	0.19	-
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005	-
Boron	T-B	<0.1	<0.1	<0.1	<0.1	-
Cadmium	T-Cd	<0.0002	<0.001	<0.0002	<0.0002	-
Calcium	T-Ca	46.8	124	27.7	57.7	-
Chromium	T-Cr	<0.01	<0.01	<0.01	<0.01	-
Cobalt	T-Co	<0.01	<0.01	<0.01	<0.01	-
Copper	T-Cu	<0.01	<0.01	<0.01	<0.01	-
Iron	T-Fe	5.73	0.23	0.18	0.46	-
Lead	T-Pb	0.001	<0.005	<0.001	<0.001	-
Magnesium	T-Mg	7.1	18.6	4.2	8.9	-
Manganese	T-Mn	2.16	0.303	0.551	0.706	-
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	-
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	-
Nickel	T-Ni	<0.05	<0.05	<0.05	<0.05	-
Selenium	T-Se	<0.001	<0.005	<0.001	<0.001	-
Silver	T-Ag	<0.0001	<0.0005	<0.0001	<0.0001	-
Sodium	T-Na	12	150	17	49	-
Thallium	T-Tl	<0.0001	<0.0005	<0.0001	<0.0001	-
Uranium	T-U	0.00020	0.00017	0.00016	0.00019	-
Zinc	T-Zn	0.045	0.011	<0.005	0.009	-

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

		BLW-7	BLDW-2	BLDW-1	MW-1	MW-2
		99 06 19 10:00	99 06 18 09:00	99 06 18 09:35	99 06 18 09:30	99 06 18 10:30
Physical Tests						
Hardness	CaCO3	6.57	0.13	62.3	135	109
Total Metals						
Aluminum	T-Al	-	<0.005	<0.005	-	-
Antimony	T-Sb	-	<0.2	<0.2	-	-
Arsenic	T-As	-	<0.2	<0.2	-	-
Barium	T-Ba	-	<0.01	0.05	-	-
Beryllium	T-Be	-	<0.005	<0.005	-	-
Boron	T-B	-	<0.1	<0.1	-	-
Cadmium	T-Cd	-	0.0036	<0.0002	-	-
Calcium	T-Ca	-	0.05	18.8	-	-
Chromium	T-Cr	-	<0.01	<0.01	-	-
Cobalt	T-Co	-	<0.01	<0.01	-	-
Copper	T-Cu	-	0.02	<0.01	-	-
Iron	T-Fe	-	<0.03	<0.03	-	-
Lead	T-Pb	-	0.009	0.002	-	-
Magnesium	T-Mg	-	<0.1	3.7	-	-
Manganese	T-Mn	-	<0.005	<0.005	-	-
Mercury	T-Hg	-	<0.00005	<0.00005	-	-
Molybdenum	T-Mo	-	<0.03	<0.03	-	-
Nickel	T-Ni	-	<0.05	<0.05	-	-
Selenium	T-Se	-	<0.001	0.006	-	-
Silver	T-Ag	-	<0.0001	<0.0001	-	-
Sodium	T-Na	-	<2	<2	-	-
Thallium	T-Tl	-	<0.0001	<0.0001	-	-
Uranium	T-U	-	<0.00001	0.00139	-	-
Zinc	T-Zn	-	0.009	0.064	-	-

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

		MW-3	MW-4	MW-5	MW-6	MW-8
		99 06 18 13:50	99 06 18 14:10	99 06 18 17:15	99 06 18 14:30	99 06 18 11:50
Physical Tests						
Hardness	CaCO3	393	332	456	366	183

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

		MW-12	MW-17	MW-D1	MW-D2
		99 06 19 11:15	99 06 19 11:00	99 06 18 17:45	99 06 19 11:30
Physical Tests					
Hardness	CaCO3	58.4	191	477	59.5

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SECTION 1

Water

Sub-Section 2

Dissolved Metals

RESULTS OF ANALYSIS - Water[1]

File No. K6884

		BLW-2	BLW-5	BLW-6	BLW-7	MW-1
		99 06 18 17:30	99 06 18 18:00	99 06 18 21:25	99 06 19 10:00	99 06 18 09:30
Dissolved Metals						
Aluminum	D-Al	0.007	0.024	0.072	0.066	0.069
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	0.13	0.20	<0.01	<0.01	0.19
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	D-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	D-Cd	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Calcium	D-Ca	47.7	64.7	2.16	2.05	44.4
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	3.71	0.10	0.08	0.07	20.8
Lead	D-Pb	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium	D-Mg	6.7	9.9	0.4	0.4	6.0
Manganese	D-Mn	2.15	0.493	0.009	0.010	4.45
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	D-Se	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	D-Ag	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	D-Na	13	55	<2	<2	4
Thallium	D-Tl	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Uranium	D-U	0.00012	0.00017	0.00010	0.00009	0.00017
Zinc	D-Zn	0.042	<0.005	<0.005	0.009	<0.005

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

		MW-2	MW-3	MW-4	MW-5	MW-6
		99 06 18 10:30	99 06 18 13:50	99 06 18 14:10	99 06 18 17:15	99 06 18 14:30
Dissolved Metals						
Aluminum	D-Al	0.050	0.04	0.21	<0.03	0.32
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	0.28	0.49	0.35	0.49	0.30
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	D-B	<0.1	<0.1	<0.1	0.3	<0.1
Cadmium	D-Cd	<0.0002	<0.001	<0.001	<0.001	<0.0004
Calcium	D-Ca	35.0	123	103	151	113
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	0.02	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	45.9	0.05	0.26	19.0	0.35
Lead	D-Pb	<0.001	<0.005	<0.005	<0.005	<0.002
Magnesium	D-Mg	5.3	20.6	18.1	19.2	20.3
Manganese	D-Mn	8.79	<0.005	0.007	1.93	0.023
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	D-Se	<0.001	<0.005	<0.005	<0.005	<0.002
Silver	D-Ag	<0.0001	<0.0005	<0.0005	<0.0005	<0.0002
Sodium	D-Na	2	160	127	14	80
Thallium	D-Tl	<0.0001	<0.0005	<0.0005	<0.0005	<0.0002
Uranium	D-U	0.00015	0.00017	0.00010	0.00034	0.00021
Zinc	D-Zn	<0.005	<0.005	0.006	<0.005	0.015

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

		MW-8	MW-12	MW-17	MW-D1	MW-D2
		99 06 18 11:50	99 06 19 11:15	99 06 19 11:00	99 06 18 17:45	99 06 19 11:30
Dissolved Metals						
Aluminum	D-Al	0.268	0.100	0.235	<0.01	0.107
Antimony	D-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	D-Ba	0.12	0.14	0.10	0.48	0.15
Beryllium	D-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Boron	D-B	<0.1	<0.1	<0.1	0.4	<0.1
Cadmium	D-Cd	<0.0002	<0.0002	<0.0002	<0.0004	<0.0002
Calcium	D-Ca	59.1	18.5	60.3	158	18.9
Chromium	D-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	D-Co	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	D-Fe	0.44	16.1	0.42	18.5	16.4
Lead	D-Pb	<0.001	<0.001	<0.001	<0.002	<0.001
Magnesium	D-Mg	8.6	3.0	9.8	19.7	3.0
Manganese	D-Mn	0.351	2.50	0.028	2.09	2.54
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05	<0.05	<0.05	<0.05
Selenium	D-Se	<0.001	<0.001	<0.001	<0.002	<0.001
Silver	D-Ag	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001
Sodium	D-Na	14	3	3	15	3
Thallium	D-Tl	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001
Uranium	D-U	0.00027	0.00022	0.00035	0.00037	0.00022
Zinc	D-Zn	<0.005	0.006	<0.005	<0.005	0.006

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File No. K6884

SECTION 1

Water

Sub-Section 3

Halogenated Volatiles
Non-halogenated Volatiles

RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MP-3	MP-4	BLW-2	BLW-5	BLDW-2
	99 06 18 09:30	99 06 19 09:00	99 06 18 17:30	99 06 18 18:00	99 06 18 09:00
Non-halogenated Volatiles					
Benzene	<0.0005	<0.0005	0.0014	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005	0.0065	<0.0005	<0.0005
Toluene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
meta- & para-Xylene	<0.0005	<0.0005	0.0028	<0.0005	<0.0005
ortho-Xylene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Volatile Hydrocarbons (VH) C6-10	<0.1	<0.1	0.2	<0.1	<0.1
VPH C6-10 (calculated)	<0.1	<0.1	0.2	<0.1	<0.1

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	BLDW-1	MW-1	MW-2	MW-5	MW-8
	99 06 18 09:35	99 06 18 09:30	99 06 18 10:30	99 06 18 17:15	99 06 18 11:50
Halogenated Volatiles					
Bromodichloromethane	-	-	-	<0.001	-
Bromoform	-	-	-	<0.001	-
Carbon Tetrachloride	-	-	-	<0.001	-
Chlorobenzene	-	-	-	<0.001	-
Chloroethane	-	-	-	<0.001	-
Chloroform	-	-	-	<0.001	-
Chloromethane	-	-	-	<0.002	-
Dibromochloromethane	-	-	-	<0.001	-
1,2-Dichlorobenzene	-	-	-	<0.001	-
1,3-Dichlorobenzene	-	-	-	<0.001	-
1,4-Dichlorobenzene	-	-	-	<0.001	-
1,1-Dichloroethane	-	-	-	<0.001	-
1,2-Dichloroethane	-	-	-	<0.001	-
cis-1,2-Dichloroethylene	-	-	-	<0.001	-
trans-1,2-Dichloroethylene	-	-	-	<0.001	-
1,1-Dichloroethylene	-	-	-	<0.001	-
Dichloromethane	-	-	-	<0.02	-
1,2-Dichloropropane	-	-	-	<0.001	-
cis-1,3-Dichloropropylene	-	-	-	<0.001	-
trans-1,3-Dichloropropylene	-	-	-	<0.001	-
1,1,1,2-Tetrachloroethane	-	-	-	<0.001	-
1,1,2,2-Tetrachloroethane	-	-	-	<0.001	-
Tetrachloroethylene	-	-	-	<0.001	-
1,1,1-Trichloroethane	-	-	-	<0.001	-
1,1,2-Trichloroethane	-	-	-	<0.001	-
Trichloroethylene	-	-	-	<0.001	-
Trichlorofluoromethane	-	-	-	<0.001	-
Vinyl Chloride	-	-	-	<0.001	-
Non-halogenated Volatiles					
Benzene	<0.0005	0.0198	0.0427	0.0010	<0.0005
Ethylbenzene	<0.0005	0.0769	0.160	0.0261	<0.0005
Styrene	-	-	-	0.0011	-
Toluene	<0.0005	0.0008	0.0115	0.0019	<0.0005
meta- & para-Xylene	<0.0005	0.0546	0.319	0.0623	<0.0005
ortho-Xylene	<0.0005	0.0022	0.195	0.0452	<0.0005
Volatile Hydrocarbons (VH) C6-10	<0.1	1.0	2.1	1.0	<0.1
VPH C6-10 (calculated)	<0.1	0.8	1.4	0.9	<0.1

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MW-9	MW-13	MW-14	MW-15	MW-17
	99 06 18 15:20	99 06 18 17:00	99 06 19 10:25	99 06 19 09:40	99 06 19 11:00
Halogenated Volatiles					
Bromodichloromethane	-	-	<0.001	-	<0.001
Bromoform	-	-	<0.001	-	<0.001
Carbon Tetrachloride	-	-	<0.001	-	<0.001
Chlorobenzene	-	-	<0.001	-	<0.001
Chloroethane	-	-	<0.001	-	<0.001
Chloroform	-	-	<0.001	-	<0.001
Chloromethane	-	-	<0.002	-	<0.001
Dibromochloromethane	-	-	<0.001	-	<0.001
1,2-Dichlorobenzene	-	-	<0.001	-	<0.001
1,3-Dichlorobenzene	-	-	<0.001	-	<0.001
1,4-Dichlorobenzene	-	-	<0.001	-	<0.001
1,1-Dichloroethane	-	-	<0.001	-	<0.001
1,2-Dichloroethane	-	-	<0.001	-	<0.001
cis-1,2-Dichloroethylene	-	-	<0.001	-	<0.001
trans-1,2-Dichloroethylene	-	-	<0.001	-	<0.001
1,1-Dichloroethylene	-	-	<0.001	-	<0.001
Dichloromethane	-	-	<0.02	-	<0.005
1,2-Dichloropropane	-	-	<0.001	-	<0.001
cis-1,3-Dichloropropylene	-	-	<0.001	-	<0.001
trans-1,3-Dichloropropylene	-	-	<0.001	-	<0.001
1,1,1,2-Tetrachloroethane	-	-	<0.001	-	<0.001
1,1,2,2-Tetrachloroethane	-	-	<0.001	-	<0.001
Tetrachloroethylene	-	-	<0.001	-	<0.001
1,1,1-Trichloroethane	-	-	<0.001	-	<0.001
1,1,2-Trichloroethane	-	-	<0.001	-	<0.001
Trichloroethylene	-	-	<0.001	-	<0.001
Trichlorofluoromethane	-	-	<0.001	-	<0.001
Vinyl Chloride	-	-	<0.001	-	<0.001
Non-halogenated Volatiles					
Benzene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005	0.0048	<0.0005	<0.0005
Styrene	-	-	<0.0005	-	<0.0005
Toluene	<0.0005	<0.0005	0.0015	<0.0005	<0.0005
meta- & para-Xylene	<0.0005	0.0005	0.0121	<0.0005	<0.0005
ortho-Xylene	<0.0005	0.0103	0.0394	0.0008	<0.0005
Volatile Hydrocarbons (VH) C6-10	<0.1	0.1	0.5	0.1	<0.1
VPH C6-10 (calculated)	<0.1	0.1	0.4	0.1	<0.1

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MW-D1	MW-D2
	99 06 18 17:45	99 06 19 11:30
Halogenated Volatiles		
Bromodichloromethane	<0.001	<0.001
Bromoform	<0.001	<0.001
Carbon Tetrachloride	<0.001	<0.001
Chlorobenzene	<0.001	<0.001
Chloroethane	<0.001	<0.001
Chloroform	<0.001	<0.001
Chloromethane	<0.001	<0.001
Dibromochloromethane	<0.001	<0.001
1,2-Dichlorobenzene	<0.001	<0.001
1,3-Dichlorobenzene	<0.001	<0.001
1,4-Dichlorobenzene	<0.001	<0.001
1,1-Dichloroethane	<0.001	<0.001
1,2-Dichloroethane	<0.001	<0.001
cis-1,2-Dichloroethylene	<0.001	<0.001
trans-1,2-Dichloroethylene	<0.001	<0.001
1,1-Dichloroethylene	<0.001	<0.001
Dichloromethane	<0.005	<0.005
1,2-Dichloropropane	<0.001	<0.001
cis-1,3-Dichloropropylene	<0.001	<0.001
trans-1,3-Dichloropropylene	<0.001	<0.001
1,1,1,2-Tetrachloroethane	<0.001	<0.001
1,1,2,2-Tetrachloroethane	<0.001	<0.001
Tetrachloroethylene	<0.001	0.009
1,1,1-Trichloroethane	<0.001	<0.001
1,1,2-Trichloroethane	<0.001	<0.001
Trichloroethylene	<0.001	<0.001
Trichlorofluoromethane	<0.001	<0.001
Vinyl Chloride	<0.001	<0.001
Non-halogenated Volatiles		
Benzene	0.0010	0.0344
Ethylbenzene	0.0275	0.0622
Styrene	0.0011	0.0036
Toluene	0.0014	0.457
meta- & para-Xylene	0.0680	0.376
ortho-Xylene	0.0432	0.137
Volatile Hydrocarbons (VH) C6-10	1.0	4.3
VPH C6-10 (calculated)	0.8	3.3

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SECTION 1

Water

Sub-Section 4

Polycyclic Aromatic Hydrocarbons

RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MP-3	MP-4	BLW-2	BLW-5	BLW-6
	99 06 18 09:30	99 06 19 09:00	99 06 18 17:30	99 06 18 18:00	99 06 18 21:25
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.00009	<0.00005	0.00008	<0.00005	<0.00005
Acenaphthylene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Acridine	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Fluorene	<0.00005	<0.00005	0.00006	<0.00005	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Naphthalene	<0.0007	<0.00005	0.00177	<0.00005	<0.00005
Phenanthrene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Pyrene	0.00014	<0.00005	<0.00005	<0.00005	<0.00005

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RESULTS OF ANALYSIS - Water[1]

	BLW-7	MW-1	MW-2	MW-5	MW-8
	99 06 19 10:00	99 06 18 09:30	99 06 18 10:30	99 06 18 17:15	99 06 18 11:50
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.00005	0.00018	<0.0004	0.00184	<0.00005
Acenaphthylene	<0.00005	<0.00005	<0.00005	0.00041	<0.00005
Acridine	<0.00005	<0.00005	<0.00005	<0.0001	<0.00005
Anthracene	<0.00005	<0.00005	<0.00005	0.00014	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.00005	<0.00005	0.00005	0.00011	<0.00005
Fluorene	<0.00005	0.00011	0.00019	0.00180	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Naphthalene	<0.00005	0.0165	0.0347	0.197	<0.00005
Phenanthrene	<0.00005	<0.00005	<0.00006	0.00230	<0.00005
Pyrene	<0.00005	<0.00005	<0.00005	0.00049	<0.00005

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RESULTS OF ANALYSIS - Water[1] File No. K6884

	MW-9	MW-12	MW-13	MW-14	MW-15
	99 06 18 15:20	99 06 19 11:15	99 06 18 17:00	99 06 19 10:25	99 06 19 09:40
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.00005	0.00106	0.00122	0.0018	<0.00005
Acenaphthylene	<0.00005	0.00026	0.00019	<0.0005	<0.00005
Acridine	<0.00005	<0.00005	<0.0001	<0.0001	<0.00005
Anthracene	<0.00005	<0.00005	0.00013	<0.0005	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.00005	<0.00005	<0.00005	<0.0005	<0.00005
Fluorene	<0.00005	0.00097	0.00173	0.0023	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Naphthalene	<0.0002	0.0638	0.00948	0.0355	0.00019
Phenanthrene	<0.00005	0.00014	0.00092	0.0023	<0.00005
Pyrene	<0.00005	<0.00005	0.00017	0.00019	<0.00005

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MW-17	MW-D1	MW-D2
	99 06 19 11:00	99 06 18 17:45	99 06 19 11:30
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	<0.00005	0.003	0.0210
Acenaphthylene	<0.00005	<0.001	0.0030
Acridine	<0.00005	<0.001	<0.002
Anthracene	<0.00005	<0.001	0.0048
Benz(a)anthracene	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	0.00002
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.0002
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.00005	0.00008	0.00053
Fluorene	<0.00005	0.004	0.0295
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005
Naphthalene	<0.00005	0.175	0.0658
Phenanthrene	<0.00005	0.005	0.0511
Pyrene	<0.00005	0.00047	0.00360

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SECTION 1

Water

Sub-Section 5

Extractables

RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MP-3	MP-4	BLW-2	BLW-3	BLW-4
	99 06 18 09:30	99 06 19 09:00	99 06 18 17:30	99 06 18 19:30	99 06 18 17:40
Extractables					
EPH (C10-18)	1.8	<0.3	0.4	<0.3	<0.3
EPH (C19-31)	<1	<1	<1	<1	<1
LEPH	1.8	<0.3	0.4	-	-
HEPH	<1	<1	<1	-	-

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	BLW-5	BLW-6	BLW-7	MW-1	MW-2
	99 06 18 18:00	99 06 18 21:25	99 06 19 10:00	99 06 18 09:30	99 06 18 10:30
Extractables					
EPH (C10-18)	<0.3	<0.3	<0.3	1.1	5.8
EPH (C19-31)	<1	<1	<1	<1	<1
LEPH	<0.3	<0.3	<0.3	1.1	5.8
HEPH	<1	<1	<1	<1	<1

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RESULTS OF ANALYSIS - Water[1] File No. K6884

	MW-3	MW-4	MW-5	MW-6	MW-8
	99 06 18 13:50	99 06 18 14:10	99 06 18 17:15	99 06 18 14:30	99 06 18 11:50
Extractables					
EPH (C10-18)	<0.3	<0.3	13.6	<0.3	<0.3
EPH (C19-31)	<1	<1	2	<1	<1
LEPH	-	-	13.4	-	<0.3
HEPH	-	-	2	-	<1

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MW-9	MW-10	MW-12	MW-13	MW-14
	99 06 18 15:20	99 06 18 15:50	99 06 19 11:15	99 06 18 17:00	99 06 19 10:25
Extractables					
EPH (C10-18)	0.7	<0.3	3.5	2.1	12.4
EPH (C19-31)	<1	<1	<1	<1	2
LEPH	0.7	-	3.4	2.1	12.3
HEPH	<1	-	<1	<1	2

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RESULTS OF ANALYSIS - Water[1]

File No. K6884

	MW-15	MW-17	MW-D1	MW-D2
	99 06 19 09:40	99 06 19 11:00	99 06 18 17:45	99 06 19 11:30
Extractables				
EPH (C10-18)	<0.3	<0.3	13.3	38.5
EPH (C19-31)	<1	<1	2	12
LEPH	<0.3	<0.3	13.1	38.3
HEPH	<1	<1	2	12

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SECTION 2

Sediment/Soil

Sub-Section 1

Physical Tests
Total Metals

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TH10-2	TH12-5	TH12-10	TH12-16	TH12-15
		99 06 16 15:30	99 06 16 09:00	99 06 16 09:15	99 06 16 09:05	99 06 16 09:30
Physical Tests						
Moisture	%	5.0	4.2	16.9	4.1	16.8
pH		8.05	7.66	-	-	-
Total Metals						
Antimony	T-Sb	<20	<20	-	-	-
Arsenic	T-As	1.8	3.0	-	-	-
Barium	T-Ba	190	139	-	-	-
Beryllium	T-Be	<0.5	<0.5	-	-	-
Cadmium	T-Cd	0.2	0.1	-	-	-
Chromium	T-Cr	49	57	-	-	-
Cobalt	T-Co	12	11	-	-	-
Copper	T-Cu	33	29	-	-	-
Lead	T-Pb	<50	<50	-	-	-
Mercury	T-Hg	0.024	0.044	-	-	-
Molybdenum	T-Mo	<4	<4	-	-	-
Nickel	T-Ni	31	30	-	-	-
Selenium	T-Se	<0.1	<0.1	-	-	-
Silver	T-Ag	<2	<2	-	-	-
Tin	T-Sn	<10	<10	-	-	-
Vanadium	T-V	77	72	-	-	-
Zinc	T-Zn	67	62	-	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TH13-16	TH13-20	TH13-21	TH14-4	TH14-14
		99 06 16 19:00	99 06 16 19:25	99 06 16 19:05	99 06 17	99 06 17
Physical Tests						
Moisture	%	4.3	17.8	3.8	6.4	4.6
pH		8.51	-	-	8.10	8.46
Total Metals						
Antimony	T-Sb	<20	-	-	<20	<20
Arsenic	T-As	4.2	-	-	1.1	3.4
Barium	T-Ba	149	-	-	274	186
Beryllium	T-Be	<0.5	-	-	<0.5	<0.5
Cadmium	T-Cd	0.2	-	-	0.2	0.2
Chromium	T-Cr	40	-	-	55	43
Cobalt	T-Co	11	-	-	14	12
Copper	T-Cu	41	-	-	48	43
Lead	T-Pb	<50	-	-	<50	<50
Mercury	T-Hg	0.054	-	-	0.037	0.041
Molybdenum	T-Mo	<4	-	-	<4	<4
Nickel	T-Ni	29	-	-	36	31
Selenium	T-Se	0.2	-	-	0.1	0.3
Silver	T-Ag	<2	-	-	<2	<2
Tin	T-Sn	<10	-	-	<10	<10
Vanadium	T-V	64	-	-	85	68
Zinc	T-Zn	63	-	-	76	60

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TH14-17	TH15-7	TH15-9	TH6-4	TH6-7
		99 06 17	99 06 17 14:50	99 06 17 15:15	99 06 15 16:30	99 06 15 16:35
Physical Tests						
Moisture	%	18.4	4.0	19.3	3.7	15.9
pH		8.12	8.60	-	8.46	8.29
Total Metals						
Antimony	T-Sb	<20	<20	-	<20	<20
Arsenic	T-As	1.5	2.6	-	4.0	1.2
Barium	T-Ba	402	118	-	106	307
Beryllium	T-Be	0.7	<0.5	-	<0.5	<0.5
Cadmium	T-Cd	0.5	0.2	-	0.2	0.4
Chromium	T-Cr	113	52	-	41	90
Cobalt	T-Co	26	13	-	11	21
Copper	T-Cu	79	48	-	36	70
Lead	T-Pb	<50	<50	-	<50	<50
Mercury	T-Hg	0.069	0.043	-	0.051	0.165
Molybdenum	T-Mo	<4	<4	-	<4	<4
Nickel	T-Ni	69	35	-	30	58
Selenium	T-Se	0.3	<0.1	-	0.1	0.3
Silver	T-Ag	<2	<2	-	<2	<2
Tin	T-Sn	<10	<10	-	<10	<10
Vanadium	T-V	136	85	-	64	127
Zinc	T-Zn	127	69	-	79	97

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		BLS-16	BLS-17	TH7-3	TH8-4	TP9-1
		99 06 15 17:10	99 06 15 17:15	99 06 15 17:40	99 06 16 09:00	99 06 16 09:30
Physical Tests						
Moisture	%	82.3	29.0	4.5	5.3	13.6
pH		7.39	6.89	8.46	8.35	-
Total Metals						
Antimony	T-Sb	<100	<20	<20	<20	-
Arsenic	T-As	218	4.2	0.7	0.42	-
Barium	T-Ba	2960	177	298	193	-
Beryllium	T-Be	<3	<0.5	<0.5	<0.5	-
Cadmium	T-Cd	1.6	0.4	0.1	<0.1	-
Chromium	T-Cr	28	42	57	31	-
Cobalt	T-Co	58	10	12	10	-
Copper	T-Cu	33	31	39	38	-
Lead	T-Pb	<300	<50	<50	<50	-
Mercury	T-Hg	0.179	0.025	0.067	0.015	-
Molybdenum	T-Mo	<20	<4	<4	<4	-
Nickel	T-Ni	30	27	33	20	-
Selenium	T-Se	1.8	0.3	<0.1	<0.1	-
Silver	T-Ag	<10	<2	<2	<2	-
Tin	T-Sn	<50	<10	<10	<10	-
Vanadium	T-V	<200	71	69	64	-
Zinc	T-Zn	1790	72	61	59	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TP9-2	TP11-1	TP11-2	TP12-2	TH11-5
		99 06 16 09:35	99 06 16 11:00	99 06 16 11:15	99 06 16 12:20	99 06 16 17:00
Physical Tests						
Moisture	%	19.5	6.2	11.4	14.0	4.5
pH		-	8.14	-	-	8.15
Total Metals						
Antimony	T-Sb	-	<20	-	-	<20
Arsenic	T-As	-	1.8	-	-	5
Barium	T-Ba	-	477	-	-	167
Beryllium	T-Be	-	<0.5	-	-	<0.5
Cadmium	T-Cd	-	0.5	-	-	0.2
Chromium	T-Cr	-	78	-	-	44
Cobalt	T-Co	-	17	-	-	14
Copper	T-Cu	-	49	-	-	36
Lead	T-Pb	-	<50	-	-	<50
Mercury	T-Hg	-	0.049	-	-	0.048
Molybdenum	T-Mo	-	<4	-	-	<4
Nickel	T-Ni	-	48	-	-	32
Selenium	T-Se	-	0.3	-	-	<0.1
Silver	T-Ag	-	<2	-	-	<2
Tin	T-Sn	-	<10	-	-	<10
Vanadium	T-V	-	95	-	-	77
Zinc	T-Zn	-	269	-	-	70

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TH11-7	TH8-8	TH9-4	TH9-7	TP28-3
		99 06 16 17:10	99 06 16 09:55	99 06 16 14:00	99 06 16 14:05	99 06 19 11:00
Physical Tests						
Moisture	%	5.5	20.6	3.6	14.0	4.5
pH		-	-	8.56	-	7.06
Total Metals						
Antimony	T-Sb	-	-	<20	-	<20
Arsenic	T-As	-	-	3.6	-	4.0
Barium	T-Ba	-	-	118	-	117
Beryllium	T-Be	-	-	<0.5	-	<0.5
Cadmium	T-Cd	-	-	0.2	-	0.1
Chromium	T-Cr	-	-	39	-	32
Cobalt	T-Co	-	-	11	-	9
Copper	T-Cu	-	-	37	-	27
Lead	T-Pb	-	-	<50	-	<50
Mercury	T-Hg	-	-	0.046	-	0.022
Molybdenum	T-Mo	-	-	<4	-	<4
Nickel	T-Ni	-	-	32	-	24
Selenium	T-Se	-	-	<0.1	-	<0.1
Silver	T-Ag	-	-	<2	-	<2
Tin	T-Sn	-	-	<10	-	<10
Vanadium	T-V	-	-	62	-	52
Zinc	T-Zn	-	-	58	-	51

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		BLW-6	BLW-3	BLW-4	BLW-5	TH16-4
		99 06 18 21:30	99 06 18 19:00	99 06 18 17:00	99 06 18 17:30	99 06 18 18:00
Physical Tests						
Moisture	%	31.7	40.8	44.8	8.6	4.8
pH		7.80	7.43	7.14	7.24	-
Total Metals						
Antimony	T-Sb	<20	<20	<20	<20	-
Arsenic	T-As	11.8	4	9	5.2	-
Barium	T-Ba	256	381	485	218	-
Beryllium	T-Be	<0.5	<0.5	<0.5	<0.5	-
Cadmium	T-Cd	0.2	0.9	0.6	0.2	-
Chromium	T-Cr	46	37	55	64	-
Cobalt	T-Co	12	14	16	12	-
Copper	T-Cu	30	29	32	34	-
Lead	T-Pb	<50	<50	<50	<50	-
Mercury	T-Hg	0.033	0.033	0.052	0.032	-
Molybdenum	T-Mo	<4	<4	<4	<4	-
Nickel	T-Ni	31	30	36	34	-
Selenium	T-Se	0.4	0.3	0.5	0.2	-
Silver	T-Ag	<2	<2	<2	<2	-
Tin	T-Sn	<10	<10	<10	<10	-
Vanadium	T-V	70	61	79	76	-
Zinc	T-Zn	79	187	196	74	-

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TH16-6	TH17-4	TH17-10	BLW-7	TP24-1
		99 06 18 18:30	99 06 18 18:35	99 06 18 18:30	99 06 19 10:00	99 06 19 11:00
Physical Tests						
Moisture	%	4.3	7.6	4.7	12.6	20.9
pH		-	8.31	-	7.35	-
Total Metals						
Antimony	T-Sb	-	<20	-	<20	-
Arsenic	T-As	-	2.1	-	2.2	-
Barium	T-Ba	-	170	-	154	-
Beryllium	T-Be	-	<0.5	-	<0.5	-
Cadmium	T-Cd	-	0.2	-	0.1	-
Chromium	T-Cr	-	46	-	45	-
Cobalt	T-Co	-	12	-	11	-
Copper	T-Cu	-	44	-	25	-
Lead	T-Pb	-	<50	-	<50	-
Mercury	T-Hg	-	0.044	-	0.031	-
Molybdenum	T-Mo	-	<4	-	<4	-
Nickel	T-Ni	-	32	-	27	-
Selenium	T-Se	-	0.1	-	<0.1	-
Silver	T-Ag	-	<2	-	<2	-
Tin	T-Sn	-	<10	-	<10	-
Vanadium	T-V	-	72	-	64	-
Zinc	T-Zn	-	67	-	60	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TP24-2	TP12-1	TP13-2	TP13-1	TP14-1
		99 06 19 11:05	99 06 16	99 06 16	99 06 16	99 06 16 14:00
Physical Tests						
Moisture	%	21.4	5.6	5.8	5.2	4.1
pH		-	7.21	-	-	-
Total Metals						
Antimony	T-Sb	-	<20	-	-	-
Arsenic	T-As	-	4.3	-	-	-
Barium	T-Ba	-	98	-	-	-
Beryllium	T-Be	-	<0.5	-	-	-
Cadmium	T-Cd	-	0.2	-	-	-
Chromium	T-Cr	-	29	-	-	-
Cobalt	T-Co	-	9	-	-	-
Copper	T-Cu	-	35	-	-	-
Lead	T-Pb	-	<50	-	-	-
Mercury	T-Hg	-	0.042	-	-	-
Molybdenum	T-Mo	-	<4	-	-	-
Nickel	T-Ni	-	20	-	-	-
Selenium	T-Se	-	<0.1	-	-	-
Silver	T-Ag	-	<2	-	-	-
Tin	T-Sn	-	<10	-	-	-
Vanadium	T-V	-	53	-	-	-
Zinc	T-Zn	-	48	-	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TP15-1	TP16-1	TP17-1	TP19-1	TP23-1
		99 06 16 14:20	99 06 16 14:40	99 06 16 15:00	99 06 16 15:10	99 06 17 16:00
Physical Tests						
Moisture	%	6.9	9.9	7.6	6.9	10.5
pH		-	-	7.23	7.92	-
Total Metals						
Antimony	T-Sb	-	-	<20	<20	-
Arsenic	T-As	-	-	4.5	1.5	-
Barium	T-Ba	-	-	148	113	-
Beryllium	T-Be	-	-	<0.5	<0.5	-
Cadmium	T-Cd	-	-	0.2	0.1	-
Chromium	T-Cr	-	-	42	38	-
Cobalt	T-Co	-	-	11	9	-
Copper	T-Cu	-	-	42	31	-
Lead	T-Pb	-	-	<50	<50	-
Mercury	T-Hg	-	-	0.033	0.020	-
Molybdenum	T-Mo	-	-	<4	<4	-
Nickel	T-Ni	-	-	28	23	-
Selenium	T-Se	-	-	<0.1	<0.1	-
Silver	T-Ag	-	-	<2	<2	-
Tin	T-Sn	-	-	<10	<10	-
Vanadium	T-V	-	-	65	53	-
Zinc	T-Zn	-	-	61	55	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TP30-1	TP32-1	TP33-4	TP35-3	TP28-1
		99 06 18 10:00	99 06 19 10:30	99 06 19		
Physical Tests						
Moisture	%	6.6	5.0	5.4	6.2	7.2
pH		-	6.36	-	-	-
Total Metals						
Antimony	T-Sb	-	<20	-	-	-
Arsenic	T-As	-	5.1	-	-	-
Barium	T-Ba	-	121	-	-	-
Beryllium	T-Be	-	<0.5	-	-	-
Cadmium	T-Cd	-	0.1	-	-	-
Chromium	T-Cr	-	38	-	-	-
Cobalt	T-Co	-	10	-	-	-
Copper	T-Cu	-	34	-	-	-
Lead	T-Pb	-	<50	-	-	-
Mercury	T-Hg	-	0.033	-	-	-
Molybdenum	T-Mo	-	<4	-	-	-
Nickel	T-Ni	-	31	-	-	-
Selenium	T-Se	-	0.2	-	-	-
Silver	T-Ag	-	<2	-	-	-
Tin	T-Sn	-	<10	-	-	-
Vanadium	T-V	-	61	-	-	-
Zinc	T-Zn	-	51	-	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

		TP28-2
Physical Tests		
Moisture	%	5.5

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SECTION 2

Sediment/Soil

Sub-Section 2

Halogenated Volatiles
Non-halogenated Volatiles

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH12-5	TH12-10	TH12-16	TH12-15	TH13-16
	99 06 16 09:00	99 06 16 09:15	99 06 16 09:05	99 06 16 09:30	99 06 16 19:00
Halogenated Volatiles					
Bromodichloromethane	-	-	-	-	<0.01
Bromoform	-	-	-	-	<0.01
Carbon Tetrachloride	-	-	-	-	<0.01
Chlorobenzene	-	-	-	-	<0.01
Chloroethane	-	-	-	-	<0.01
Chloroform	-	-	-	-	<0.01
Chloromethane	-	-	-	-	<0.01
Dibromochloromethane	-	-	-	-	<0.01
1,2-Dichlorobenzene	-	-	-	-	<0.01
1,3-Dichlorobenzene	-	-	-	-	<0.01
1,4-Dichlorobenzene	-	-	-	-	<0.01
1,1-Dichloroethane	-	-	-	-	<0.01
1,2-Dichloroethane	-	-	-	-	<0.01
cis-1,2-Dichloroethylene	-	-	-	-	<0.01
trans-1,2-Dichloroethylene	-	-	-	-	<0.01
1,1-Dichloroethylene	-	-	-	-	<0.01
Dichloromethane	-	-	-	-	<0.2
1,2-Dichloropropane	-	-	-	-	<0.01
cis-1,3-Dichloropropylene	-	-	-	-	<0.01
trans-1,3-Dichloropropylene	-	-	-	-	<0.01
1,1,1,2-Tetrachloroethane	-	-	-	-	<0.01
1,1,2,2-Tetrachloroethane	-	-	-	-	<0.01
Tetrachloroethylene	-	-	-	-	<0.01
1,1,1-Trichloroethane	-	-	-	-	<0.01
1,1,2-Trichloroethane	-	-	-	-	<0.01
Trichloroethylene	-	-	-	-	<0.01
Trichlorofluoromethane	-	-	-	-	<0.01
Vinyl Chloride	-	-	-	-	<0.01
Non-halogenated Volatiles					
Benzene	<0.04	<0.04	<0.04	<0.04	<0.04
Ethylbenzene	0.49	0.06	0.61	<0.05	<0.05
Styrene	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	0.89	0.18	1.11	<0.05	<0.05
meta- & para-Xylene	2.74	0.38	3.42	0.05	<0.05
ortho-Xylene	1.55	0.20	1.92	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	117	<100	130	<100	<100
VPH C6-10 (calculated)	111	<100	123	<100	<100

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH13-21	TH14-4	TH15-7	BLS-16	BLS-17
	99 06 16 19:05	99 06 17	99 06 17 14:50	99 06 15 17:10	99 06 15 17:15
Halogenated Volatiles					
Bromodichloromethane	<0.01	<0.01	-	<0.01	<0.01
Bromoform	<0.01	<0.01	-	<0.01	<0.01
Carbon Tetrachloride	<0.01	<0.01	-	<0.01	<0.01
Chlorobenzene	<0.01	<0.01	-	<0.01	<0.01
Chloroethane	<0.01	<0.01	-	<0.01	<0.01
Chloroform	<0.01	<0.01	-	<0.01	<0.01
Chloromethane	<0.01	<0.01	-	<0.01	<0.01
Dibromochloromethane	<0.01	<0.01	-	<0.01	<0.01
1,2-Dichlorobenzene	<0.01	<0.01	-	<0.01	<0.01
1,3-Dichlorobenzene	<0.01	<0.01	-	<0.01	<0.01
1,4-Dichlorobenzene	<0.01	<0.01	-	<0.01	<0.01
1,1-Dichloroethane	<0.01	<0.01	-	<0.01	<0.01
1,2-Dichloroethane	<0.01	<0.01	-	<0.01	<0.01
cis-1,2-Dichloroethylene	<0.01	<0.01	-	<0.01	<0.01
trans-1,2-Dichloroethylene	<0.01	<0.01	-	<0.01	<0.01
1,1-Dichloroethylene	<0.01	<0.01	-	<0.01	<0.01
Dichloromethane	<0.1	<0.05	-	<0.4	<0.1
1,2-Dichloropropane	<0.01	<0.01	-	<0.01	<0.01
cis-1,3-Dichloropropylene	<0.01	<0.01	-	<0.01	<0.01
trans-1,3-Dichloropropylene	<0.01	<0.01	-	<0.01	<0.01
1,1,1,2-Tetrachloroethane	<0.01	<0.01	-	<0.01	<0.01
1,1,2,2-Tetrachloroethane	<0.01	<0.01	-	<0.01	<0.01
Tetrachloroethylene	<0.01	<0.01	-	<0.01	<0.01
1,1,1-Trichloroethane	<0.01	<0.01	-	<0.01	<0.01
1,1,2-Trichloroethane	<0.01	<0.01	-	<0.01	<0.01
Trichloroethylene	<0.01	<0.01	-	<0.01	<0.01
Trichlorofluoromethane	<0.01	<0.01	-	<0.01	<0.01
Vinyl Chloride	<0.01	<0.01	-	<0.01	<0.01
Non-halogenated Volatiles					
Benzene	<0.04	<0.04	<0.04	<0.04	<0.04
Ethylbenzene	<0.05	<0.05	<0.05	<0.05	<0.05
Styrene	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	<0.05	<0.05	<0.05	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05	<0.05	<0.05	<0.05
ortho-Xylene	<0.05	<0.05	<0.05	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	<100	<100	<100	<500	<100
VPH C6-10 (calculated)	<100	<100	<100	<500	<100

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH8-4	TP11-1	TP11-2	TP12-2	TH9-4
	99 06 16 09:00	99 06 16 11:00	99 06 16 11:15	99 06 16 12:20	99 06 16 14:00
Halogenated Volatiles					
Bromodichloromethane	-	<0.01	<0.01	-	-
Bromoform	-	<0.01	<0.01	-	-
Carbon Tetrachloride	-	<0.01	<0.01	-	-
Chlorobenzene	-	<0.01	<0.01	-	-
Chloroethane	-	<0.01	<0.01	-	-
Chloroform	-	<0.01	<0.01	-	-
Chloromethane	-	<0.01	<0.01	-	-
Dibromochloromethane	-	<0.01	<0.01	-	-
1,2-Dichlorobenzene	-	<0.01	<0.01	-	-
1,3-Dichlorobenzene	-	<0.01	<0.01	-	-
1,4-Dichlorobenzene	-	<0.01	<0.01	-	-
1,1-Dichloroethane	-	<0.01	<0.01	-	-
1,2-Dichloroethane	-	<0.01	<0.01	-	-
cis-1,2-Dichloroethylene	-	<0.01	<0.01	-	-
trans-1,2-Dichloroethylene	-	<0.01	<0.01	-	-
1,1-Dichloroethylene	-	<0.01	<0.01	-	-
Dichloromethane	-	<0.2	<0.1	-	-
1,2-Dichloropropane	-	<0.01	<0.01	-	-
cis-1,3-Dichloropropylene	-	<0.01	<0.01	-	-
trans-1,3-Dichloropropylene	-	<0.01	<0.01	-	-
1,1,1,2-Tetrachloroethane	-	<0.01	<0.01	-	-
1,1,2,2-Tetrachloroethane	-	<0.01	<0.01	-	-
Tetrachloroethylene	-	<0.01	<0.01	-	-
1,1,1-Trichloroethane	-	<0.01	<0.01	-	-
1,1,2-Trichloroethane	-	<0.01	<0.01	-	-
Trichloroethylene	-	<0.01	<0.01	-	-
Trichlorofluoromethane	-	<0.01	<0.01	-	-
Vinyl Chloride	-	<0.01	<0.01	-	-
Non-halogenated Volatiles					
Benzene	<0.04	<0.04	0.71	<0.04	<0.04
Ethylbenzene	<0.05	<0.05	7.06	<0.05	<0.05
Styrene	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	<0.05	<0.05	2.35	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05	29.8	<0.05	<0.05
ortho-Xylene	<0.05	<0.05	49.8	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	<100	<100	2680	168	<100
VPH C6-10 (calculated)	<100	<100	2590	168	<100

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP28-3	BLW-6	TH16-4	TH17-4	TH17-10
	99 06 19 11:00	99 06 18 21:30	99 06 18 18:00	99 06 18 18:35	99 06 18 18:30
Halogenated Volatiles					
Bromodichloromethane	-	<0.01	-	<0.01	<0.01
Bromoform	-	<0.01	-	<0.01	<0.01
Carbon Tetrachloride	-	<0.01	-	<0.01	<0.01
Chlorobenzene	-	<0.01	-	<0.01	<0.01
Chloroethane	-	<0.01	-	<0.01	<0.01
Chloroform	-	<0.01	-	<0.01	<0.01
Chloromethane	-	<0.01	-	<0.01	<0.01
Dibromochloromethane	-	<0.01	-	<0.01	<0.01
1,2-Dichlorobenzene	-	<0.01	-	<0.01	<0.01
1,3-Dichlorobenzene	-	<0.01	-	<0.01	<0.01
1,4-Dichlorobenzene	-	<0.01	-	<0.01	<0.01
1,1-Dichloroethane	-	<0.01	-	<0.01	<0.01
1,2-Dichloroethane	-	<0.01	-	<0.01	<0.01
cis-1,2-Dichloroethylene	-	<0.01	-	<0.01	<0.01
trans-1,2-Dichloroethylene	-	<0.01	-	<0.01	<0.01
1,1-Dichloroethylene	-	<0.01	-	<0.01	<0.01
Dichloromethane	-	<0.3	-	<0.2	<0.2
1,2-Dichloropropane	-	<0.01	-	<0.01	<0.01
cis-1,3-Dichloropropylene	-	<0.01	-	<0.01	<0.01
trans-1,3-Dichloropropylene	-	<0.01	-	<0.01	<0.01
1,1,1,2-Tetrachloroethane	-	<0.01	-	<0.01	<0.01
1,1,2,2-Tetrachloroethane	-	<0.01	-	<0.01	<0.01
Tetrachloroethylene	-	<0.01	-	<0.01	<0.01
1,1,1-Trichloroethane	-	<0.01	-	<0.01	<0.01
1,1,2-Trichloroethane	-	<0.01	-	<0.01	<0.01
Trichloroethylene	-	<0.01	-	<0.01	<0.01
Trichlorofluoromethane	-	<0.01	-	<0.01	<0.01
Vinyl Chloride	-	<0.01	-	<0.01	<0.01
Non-halogenated Volatiles					
Benzene	<0.04	<0.04	<0.04	<0.04	<0.04
Ethylbenzene	0.97	<0.05	<0.05	<0.05	<0.05
Styrene	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	0.72	<0.05	<0.05	<0.05	<0.05
meta- & para-Xylene	4.86	<0.05	<0.05	<0.05	<0.05
ortho-Xylene	1.15	0.06	<0.05	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	441	<100	<100	<100	<100
VPH C6-10 (calculated)	433	<100	<100	<100	<100

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	BLW-7	TP12-1	TP19-1	TP33-4	TP35-3
	99 06 19 10:00	99 06 16	99 06 16 15:10	99 06 19	
Halogenated Volatiles					
Bromodichloromethane	-	-	-	<0.01	<0.01
Bromoform	-	-	-	<0.01	<0.01
Carbon Tetrachloride	-	-	-	<0.01	<0.01
Chlorobenzene	-	-	-	<0.01	<0.01
Chloroethane	-	-	-	<0.01	<0.01
Chloroform	-	-	-	<0.01	<0.01
Chloromethane	-	-	-	<0.01	<0.01
Dibromochloromethane	-	-	-	<0.01	<0.01
1,2-Dichlorobenzene	-	-	-	<0.01	<0.01
1,3-Dichlorobenzene	-	-	-	<0.01	<0.01
1,4-Dichlorobenzene	-	-	-	<0.01	<0.01
1,1-Dichloroethane	-	-	-	<0.01	<0.01
1,2-Dichloroethane	-	-	-	<0.01	<0.01
cis-1,2-Dichloroethylene	-	-	-	<0.01	<0.01
trans-1,2-Dichloroethylene	-	-	-	<0.01	<0.01
1,1-Dichloroethylene	-	-	-	<0.01	<0.01
Dichloromethane	-	-	-	<0.1	<0.1
1,2-Dichloropropane	-	-	-	<0.01	<0.01
cis-1,3-Dichloropropylene	-	-	-	<0.01	<0.01
trans-1,3-Dichloropropylene	-	-	-	<0.01	<0.01
1,1,1,2-Tetrachloroethane	-	-	-	<0.01	<0.01
1,1,2,2-Tetrachloroethane	-	-	-	<0.01	<0.01
Tetrachloroethylene	-	-	-	<0.01	<0.01
1,1,1-Trichloroethane	-	-	-	<0.01	<0.01
1,1,2-Trichloroethane	-	-	-	<0.01	<0.01
Trichloroethylene	-	-	-	<0.01	<0.01
Trichlorofluoromethane	-	-	-	<0.01	<0.01
Vinyl Chloride	-	-	-	<0.01	<0.01
Non-halogenated Volatiles					
Benzene	<0.04	<0.04	<0.04	<0.04	<0.04
Ethylbenzene	<0.05	<0.05	<0.05	<0.05	<0.05
Styrene	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	<0.05	<0.05	<0.05	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05	<0.05	<0.05	<0.05
ortho-Xylene	<0.05	<0.05	<0.05	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	<100	<100	162	<100	<100
VPH C6-10 (calculated)	<100	<100	162	<100	<100

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SECTION 2

Sediment/Soil

Sub-Section 3

Polycyclic Aromatic Hydrocarbons
Polychlorinated Biphenyls

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH12-5	TH12-10	TH12-16	TH12-15	TH13-16
	99 06 16 09:00	99 06 16 09:15	99 06 16 09:05	99 06 16 09:30	99 06 16 19:00
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.12	0.08	0.13	<0.01	<0.02
Acenaphthylene	0.03	0.03	0.04	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	0.01
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	0.17	0.10	0.16	<0.01	0.02
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	1.33	0.59	1.51	0.06	0.05
Phenanthrene	0.06	0.04	0.05	0.01	0.04
Pyrene	<0.01	<0.01	<0.01	<0.01	0.04
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	<0.05	-	<0.05	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH13-20	TH13-21	TH14-4	TH14-14	TH15-7
	99 06 16 19:25	99 06 16 19:05	99 06 17	99 06 17	99 06 17 14:50
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.02	<0.02	<0.03	-
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	-
Anthracene	<0.01	<0.02	<0.01	<0.02	-
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	-
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	-
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	-
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	-
Chrysene	<0.01	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	-
Fluoranthene	<0.01	<0.01	<0.01	<0.01	-
Fluorene	<0.01	<0.03	<0.03	<0.05	-
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	-
Naphthalene	<0.02	0.06	<0.03	<0.05	-
Phenanthrene	<0.04	<0.05	<0.08	<0.1	-
Pyrene	<0.02	<0.04	<0.03	<0.03	-
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	-	-	<0.05	-	<0.05

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	BLS-16	BLS-17	TH7-3	TH8-4	TP11-1
	99 06 15 17:10	99 06 15 17:15	99 06 15 17:40	99 06 16 09:00	99 06 16 11:00
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.05	<0.01	<0.01	<0.01	<0.5
Acenaphthylene	<0.05	<0.01	<0.01	<0.01	<0.5
Anthracene	<0.05	<0.01	<0.01	<0.01	<0.5
Benz(a)anthracene	<0.05	<0.01	<0.01	<0.01	<0.5
Benzo(a)pyrene	<0.05	<0.01	<0.01	<0.01	<0.5
Benzo(b)fluoranthene	<0.02	<0.01	<0.01	<0.01	<0.5
Benzo(g,h,i)perylene	<0.05	<0.01	<0.01	<0.01	<0.5
Benzo(k)fluoranthene	<0.05	<0.01	<0.01	<0.01	<0.5
Chrysene	<0.05	<0.01	<0.01	<0.01	<0.5
Dibenz(a,h)anthracene	<0.05	<0.01	<0.01	<0.01	<0.5
Fluoranthene	<0.05	<0.01	<0.01	<0.01	<0.5
Fluorene	<0.05	<0.01	<0.01	<0.01	<0.5
Indeno(1,2,3-c,d)pyrene	<0.05	<0.01	<0.01	<0.01	<0.5
Naphthalene	<0.1	<0.01	<0.01	<0.01	<0.5
Phenanthrene	<0.05	<0.01	<0.02	<0.02	<0.5
Pyrene	<0.05	<0.01	<0.02	<0.01	<0.5
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	-	-	-	-	<0.05

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP11-2	TP12-2	TH9-7	TP28-3	BLW-6
	99 06 16	99 06 16	99 06 16	99 06 19	99 06 18
	11:15	12:20	14:05	11:00	21:30
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.9	<0.02	<0.01	<0.2	<0.01
Acenaphthylene	0.4	<0.01	<0.01	<0.05	<0.01
Anthracene	0.1	<0.01	<0.01	<0.01	<0.01
Benz(a)anthracene	<0.5	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.5	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.5	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.5	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.5	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.5	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.5	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.2	<0.01	<0.02	<0.01	<0.01
Fluorene	1.4	<0.02	<0.01	0.14	<0.01
Indeno(1,2,3-c,d)pyrene	<0.5	<0.01	<0.01	<0.01	<0.01
Naphthalene	10.8	<0.03	<0.01	0.52	0.01
Phenanthrene	1.1	<0.02	<0.03	0.06	<0.01
Pyrene	0.5	<0.02	<0.02	<0.01	<0.01
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	<0.05	-	-	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	BLW-5	TH17-4	TH17-10	BLW-7	TP24-1
	99 06 18 17:30	99 06 18 18:35	99 06 18 18:30	99 06 19 10:00	99 06 19 11:00
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.1	<0.01	<0.01	-
Acenaphthylene	<0.01	<0.05	<0.01	<0.01	-
Anthracene	<0.01	0.05	<0.01	<0.01	-
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	-
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	-
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	-
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	-
Chrysene	<0.01	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	-
Fluoranthene	<0.01	<0.01	<0.01	<0.01	-
Fluorene	<0.01	<0.05	<0.01	<0.01	-
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	-
Naphthalene	<0.01	<0.02	<0.01	<0.01	-
Phenanthrene	<0.01	1.20	<0.01	<0.01	-
Pyrene	<0.01	<0.02	<0.01	<0.01	-
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	-	-	-	-	<0.05

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP24-2	TP23-1	TP31-1	TP33-4
	99 06 19 11:05	99 06 17 16:00	99 06 19 10:15	99 06 19
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	-	-	-	<0.05
Acenaphthylene	-	-	-	<0.05
Anthracene	-	-	-	0.04
Benz(a)anthracene	-	-	-	<0.01
Benzo(a)pyrene	-	-	-	<0.01
Benzo(b)fluoranthene	-	-	-	<0.01
Benzo(g,h,i)perylene	-	-	-	<0.01
Benzo(k)fluoranthene	-	-	-	<0.01
Chrysene	-	-	-	<0.01
Dibenz(a,h)anthracene	-	-	-	<0.01
Fluoranthene	-	-	-	<0.01
Fluorene	-	-	-	<0.02
Indeno(1,2,3-c,d)pyrene	-	-	-	<0.01
Naphthalene	-	-	-	0.04
Phenanthrene	-	-	-	0.92
Pyrene	-	-	-	0.02
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls	<0.05	<0.05	<0.05	-

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SECTION 2

Sediment/Soil

Sub-Section 4

Organochloride Pesticides
Extractables

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH10-2	TH12-5	TH12-10	TH12-16	TH12-15
	99 06 16 15:30	99 06 16 09:00	99 06 16 09:15	99 06 16 09:05	99 06 16 09:30
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	-	<0.001	-	<0.001	-
4,4'-DDD	-	<0.001	-	<0.001	-
2,4'-DDE	-	<0.002	-	<0.002	-
4,4'-DDE	-	<0.001	-	<0.001	-
2,4'-DDT	-	<0.001	-	<0.001	-
4,4'-DDT	-	<0.002	-	<0.002	-
Dieldrin	-	<0.001	-	<0.001	-
Endosulfan I	-	<0.001	-	<0.001	-
Endosulfan II	-	<0.001	-	<0.001	-
Endosulfan Sulfate	-	<0.001	-	<0.001	-
Endrin	-	<0.005	-	<0.005	-
Endrin Aldehyde	-	<0.001	-	<0.001	-
Heptachlor	-	<0.002	-	<0.002	-
Heptachlor Epoxide	-	<0.001	-	<0.001	-
Lindane (gamma - BHC)	-	<0.001	-	<0.001	-
Methoxychlor	-	<0.005	-	<0.005	-
Mirex	-	<0.001	-	<0.001	-
cis-Nonachlor	-	<0.001	-	<0.001	-
trans-Nonachlor	-	<0.001	-	<0.001	-
Extractables					
EPH (C10-18)	<200	912	1260	962	<200
EPH (C19-31)	499	<200	<200	<200	302
LEPH	-	911	1250	960	<200
HEPH	-	<200	<200	<200	302

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH13-16	TH13-20	TH13-21	TH14-4	TH14-14
	99 06 16 19:00	99 06 16 19:25	99 06 16 19:05	99 06 17	99 06 17
Organochloride Pesticides					
Aldrin	-	-	-	<0.001	-
alpha-BHC	-	-	-	<0.001	-
beta-BHC	-	-	-	<0.002	-
delta-BHC	-	-	-	<0.001	-
cis-Chlordane (alpha)	-	-	-	<0.001	-
trans-Chlordane (gamma)	-	-	-	<0.001	-
2,4'-DDD	-	-	-	<0.001	-
4,4'-DDD	-	-	-	<0.001	-
2,4'-DDE	-	-	-	<0.002	-
4,4'-DDE	-	-	-	<0.001	-
2,4'-DDT	-	-	-	<0.001	-
4,4'-DDT	-	-	-	<0.002	-
Dieldrin	-	-	-	<0.001	-
Endosulfan I	-	-	-	<0.001	-
Endosulfan II	-	-	-	<0.001	-
Endosulfan Sulfate	-	-	-	<0.001	-
Endrin	-	-	-	<0.005	-
Endrin Aldehyde	-	-	-	<0.001	-
Heptachlor	-	-	-	<0.002	-
Heptachlor Epoxide	-	-	-	<0.001	-
Lindane (gamma - BHC)	-	-	-	<0.001	-
Methoxychlor	-	-	-	<0.005	-
Mirex	-	-	-	<0.001	-
cis-Nonachlor	-	-	-	<0.001	-
trans-Nonachlor	-	-	-	<0.001	-
Extractables					
EPH (C10-18)	<200	<200	246	<200	261
EPH (C19-31)	<200	<200	<200	461	<200
LEPH	<200	<200	246	<200	261
HEPH	<200	<200	<200	461	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

	TH14-17	TH15-7	TH15-9	TH6-4	TH6-7
	99 06 17	99 06 17 14:50	99 06 17 15:15	99 06 15 16:30	99 06 15 16:35
Organochloride Pesticides					
Aldrin	-	<0.001	-	-	-
alpha-BHC	-	<0.001	-	-	-
beta-BHC	-	<0.002	-	-	-
delta-BHC	-	<0.001	-	-	-
cis-Chlordane (alpha)	-	<0.001	-	-	-
trans-Chlordane (gamma)	-	<0.001	-	-	-
2,4'-DDD	-	<0.001	-	-	-
4,4'-DDD	-	<0.001	-	-	-
2,4'-DDE	-	<0.002	-	-	-
4,4'-DDE	-	<0.001	-	-	-
2,4'-DDT	-	<0.001	-	-	-
4,4'-DDT	-	<0.002	-	-	-
Dieldrin	-	<0.001	-	-	-
Endosulfan I	-	<0.001	-	-	-
Endosulfan II	-	<0.001	-	-	-
Endosulfan Sulfate	-	<0.001	-	-	-
Endrin	-	<0.005	-	-	-
Endrin Aldehyde	-	<0.001	-	-	-
Heptachlor	-	<0.002	-	-	-
Heptachlor Epoxide	-	<0.001	-	-	-
Lindane (gamma - BHC)	-	<0.001	-	-	-
Methoxychlor	-	<0.005	-	-	-
Mirex	-	<0.001	-	-	-
cis-Nonachlor	-	<0.001	-	-	-
trans-Nonachlor	-	<0.001	-	-	-
Extractables					
EPH (C10-18)	<200	<200	<200	<200	<200
EPH (C19-31)	240	<200	<200	<200	<200

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VPH = Volatile Petroleum Hydrocarbons.
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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	BLS-16	BLS-17	TH7-3	TH8-4	TP9-1
	99 06 15 17:10	99 06 15 17:15	99 06 15 17:40	99 06 16 09:00	99 06 16 09:30
Extractables					
EPH (C10-18)	745	<200	<200	<200	<200
EPH (C19-31)	3760	<200	<200	205	508
LEPH	745	<200	<200	<200	-
HEPH	3760	<200	<200	205	-

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP9-2	TP11-1	TP11-2	TP12-2	TH11-5
	99 06 16 09:35	99 06 16 11:00	99 06 16 11:15	99 06 16 12:20	99 06 16 17:00
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	-	<0.001	<0.001	-	-
4,4'-DDD	-	<0.001	<0.001	-	-
2,4'-DDE	-	<0.002	<0.002	-	-
4,4'-DDE	-	<0.001	<0.001	-	-
2,4'-DDT	-	<0.001	<0.001	-	-
4,4'-DDT	-	<0.002	<0.002	-	-
Dieldrin	-	<0.001	<0.001	-	-
Endosulfan I	-	<0.001	<0.001	-	-
Endosulfan II	-	<0.001	<0.001	-	-
Endosulfan Sulfate	-	<0.001	<0.001	-	-
Endrin	-	<0.005	<0.005	-	-
Endrin Aldehyde	-	<0.001	<0.001	-	-
Heptachlor	-	<0.002	<0.002	-	-
Heptachlor Epoxide	-	<0.001	<0.001	-	-
Lindane (gamma - BHC)	-	<0.001	0.002	-	-
Methoxychlor	-	<0.005	<0.005	-	-
Mirex	-	<0.001	<0.001	-	-
cis-Nonachlor	-	<0.001	<0.001	-	-
trans-Nonachlor	-	<0.001	<0.001	-	-
Extractables					
EPH (C10-18)	<200	2520	<200	<200	<200
EPH (C19-31)	<200	19300	<200	<200	<200
LEPH	-	2520	<200	<200	-
HEPH	-	19300	<200	<200	-

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH11-7	TH8-8	TH9-4	TH9-7	TP28-3
	99 06 16 17:10	99 06 16 09:55	99 06 16 14:00	99 06 16 14:05	99 06 19 11:00
Extractables					
EPH (C10-18)	<200	<200	<200	11000	764
EPH (C19-31)	<200	<200	<200	28600	<200
LEPH	-	-	-	11000	763
HEPH	-	-	-	28600	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1] File No. K6884

	BLW-6	BLW-3	BLW-4	BLW-5	TH16-4
	99 06 18 21:30	99 06 18 19:00	99 06 18 17:00	99 06 18 17:30	99 06 18 18:00
Extractables					
EPH (C10-18)	258	<200	<200	<200	<200
EPH (C19-31)	266	<200	<200	<200	<200
LEPH	258	-	-	<200	-
HEPH	266	-	-	<200	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TH16-6	TH17-4	TH17-10	BLW-7	TP24-1
	99 06 18 18:30	99 06 18 18:35	99 06 18 18:30	99 06 19 10:00	99 06 19 11:00
Organochloride Pesticides					
Aldrin	-	-	-	-	<0.001
alpha-BHC	-	-	-	-	<0.001
beta-BHC	-	-	-	-	<0.002
delta-BHC	-	-	-	-	<0.001
cis-Chlordane (alpha)	-	-	-	-	<0.001
trans-Chlordane (gamma)	-	-	-	-	<0.001
2,4'-DDD	-	-	-	-	<0.001
4,4'-DDD	-	-	-	-	<0.001
2,4'-DDE	-	-	-	-	<0.002
4,4'-DDE	-	-	-	-	<0.001
2,4'-DDT	-	-	-	-	<0.001
4,4'-DDT	-	-	-	-	<0.002
Dieldrin	-	-	-	-	<0.001
Endosulfan I	-	-	-	-	<0.001
Endosulfan II	-	-	-	-	<0.001
Endosulfan Sulfate	-	-	-	-	<0.001
Endrin	-	-	-	-	<0.005
Endrin Aldehyde	-	-	-	-	<0.001
Heptachlor	-	-	-	-	<0.002
Heptachlor Epoxide	-	-	-	-	<0.001
Lindane (gamma - BHC)	-	-	-	-	<0.001
Methoxychlor	-	-	-	-	<0.005
Mirex	-	-	-	-	<0.001
cis-Nonachlor	-	-	-	-	<0.001
trans-Nonachlor	-	-	-	-	<0.001
Extractables					
EPH (C10-18)	<200	715	<200	<200	<200
EPH (C19-31)	<200	495	<200	<200	<200
LEPH	-	714	<200	<200	-
HEPH	-	495	<200	<200	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP24-2	TP12-1	TP13-2	TP13-1	TP14-1
	99 06 19 11:05	99 06 16	99 06 16	99 06 16	99 06 16 14:00
Organochloride Pesticides					
Aldrin	<0.001	-	-	-	-
alpha-BHC	<0.001	-	-	-	-
beta-BHC	<0.002	-	-	-	-
delta-BHC	<0.001	-	-	-	-
cis-Chlordane (alpha)	<0.001	-	-	-	-
trans-Chlordane (gamma)	<0.001	-	-	-	-
2,4'-DDD	<0.001	-	-	-	-
4,4'-DDD	<0.001	-	-	-	-
2,4'-DDE	<0.002	-	-	-	-
4,4'-DDE	<0.001	-	-	-	-
2,4'-DDT	<0.001	-	-	-	-
4,4'-DDT	<0.002	-	-	-	-
Dieldrin	<0.001	-	-	-	-
Endosulfan I	<0.001	-	-	-	-
Endosulfan II	<0.001	-	-	-	-
Endosulfan Sulfate	<0.001	-	-	-	-
Endrin	<0.005	-	-	-	-
Endrin Aldehyde	<0.001	-	-	-	-
Heptachlor	<0.002	-	-	-	-
Heptachlor Epoxide	<0.001	-	-	-	-
Lindane (gamma - BHC)	<0.001	-	-	-	-
Methoxychlor	<0.005	-	-	-	-
Mirex	<0.001	-	-	-	-
cis-Nonachlor	<0.001	-	-	-	-
trans-Nonachlor	<0.001	-	-	-	-
Extractables					
EPH (C10-18)	<200	<200	1470	1260	<200
EPH (C19-31)	<200	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP15-1	TP16-1	TP17-1	TP23-1	TP30-1
	99 06 16 14:20	99 06 16 14:40	99 06 16 15:00	99 06 17 16:00	99 06 18 10:00
Organochloride Pesticides					
Aldrin	-	-	-	<0.001	-
alpha-BHC	-	-	-	<0.001	-
beta-BHC	-	-	-	<0.002	-
delta-BHC	-	-	-	<0.001	-
cis-Chlordane (alpha)	-	-	-	<0.001	-
trans-Chlordane (gamma)	-	-	-	<0.001	-
2,4'-DDD	-	-	-	<0.001	-
4,4'-DDD	-	-	-	<0.001	-
2,4'-DDE	-	-	-	<0.002	-
4,4'-DDE	-	-	-	<0.001	-
2,4'-DDT	-	-	-	<0.001	-
4,4'-DDT	-	-	-	0.009	-
Dieldrin	-	-	-	<0.001	-
Endosulfan I	-	-	-	<0.001	-
Endosulfan II	-	-	-	<0.001	-
Endosulfan Sulfate	-	-	-	<0.001	-
Endrin	-	-	-	<0.005	-
Endrin Aldehyde	-	-	-	<0.001	-
Heptachlor	-	-	-	<0.002	-
Heptachlor Epoxide	-	-	-	<0.001	-
Lindane (gamma - BHC)	-	-	-	<0.001	-
Methoxychlor	-	-	-	<0.005	-
Mirex	-	-	-	<0.001	-
cis-Nonachlor	-	-	-	<0.001	-
trans-Nonachlor	-	-	-	<0.001	-
Extractables					
EPH (C10-18)	1430	<200	<200	<200	<200
EPH (C19-31)	264	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K6884

	TP31-1	TP33-4	TP35-3	TP28-1	TP28-2
	99 06 19 10:15	99 06 19			
Organochloride Pesticides					
Aldrin	<0.001	-	-	-	-
alpha-BHC	<0.001	-	-	-	-
beta-BHC	<0.002	-	-	-	-
delta-BHC	<0.001	-	-	-	-
cis-Chlordane (alpha)	<0.001	-	-	-	-
trans-Chlordane (gamma)	<0.001	-	-	-	-
2,4'-DDD	<0.001	-	-	-	-
4,4'-DDD	<0.001	-	-	-	-
2,4'-DDE	<0.002	-	-	-	-
4,4'-DDE	<0.001	-	-	-	-
2,4'-DDT	<0.001	-	-	-	-
4,4'-DDT	<0.002	-	-	-	-
Dieldrin	<0.001	-	-	-	-
Endosulfan I	<0.001	-	-	-	-
Endosulfan II	<0.001	-	-	-	-
Endosulfan Sulfate	<0.001	-	-	-	-
Endrin	<0.005	-	-	-	-
Endrin Aldehyde	<0.001	-	-	-	-
Heptachlor	<0.002	-	-	-	-
Heptachlor Epoxide	<0.001	-	-	-	-
Lindane (gamma - BHC)	<0.001	-	-	-	-
Methoxychlor	<0.005	-	-	-	-
Mirex	<0.001	-	-	-	-
cis-Nonachlor	<0.001	-	-	-	-
trans-Nonachlor	<0.001	-	-	-	-
Extractables					
EPH (C10-18)	-	598	<200	<200	1710
EPH (C19-31)	-	<200	<200	<200	<200
LEPH	-	597	-	-	-
HEPH	-	<200	-	-	-

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SECTION 3

Water

Sub-Section 1

Physical Tests
Total Metals

		Travel Blank
Physical Tests		
Hardness	CaCO3	<0.05
Total Metals		
Aluminum	T-Al	<0.005
Antimony	T-Sb	<0.2
Arsenic	T-As	<0.2
Barium	T-Ba	<0.01
Beryllium	T-Be	<0.005
Boron	T-B	<0.1
Cadmium	T-Cd	<0.0002
Calcium	T-Ca	<0.05
Chromium	T-Cr	<0.01
Cobalt	T-Co	<0.01
Copper	T-Cu	<0.01
Iron	T-Fe	<0.03
Lead	T-Pb	<0.001
Magnesium	T-Mg	<0.1
Manganese	T-Mn	<0.005
Mercury	T-Hg	<0.00005
Molybdenum	T-Mo	<0.03
Nickel	T-Ni	<0.05
Selenium	T-Se	<0.001
Silver	T-Ag	<0.0001
Sodium	T-Na	<2
Thallium	T-Tl	<0.0001
Uranium	T-U	<0.00001
Zinc	T-Zn	<0.005

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SECTION 3

Water

Sub-Section 2

Non-halogenated Volatiles

RESULTS OF ANALYSIS - Water[1]

File No. K6884

	Travel Blank
Non-halogenated Volatiles	
Benzene	<0.0005
Ethylbenzene	<0.0005
Toluene	<0.0005
meta- & para-Xylene	<0.0005
ortho-Xylene	<0.0005
Volatile Hydrocarbons (VH) C6-10	<0.1
VPH C6-10 (calculated)	<0.1

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APPENDIX 1

QUALITY CONTROL

Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Sediment/Soil[1]	**TH12-15**	**TH12-15**
	99 06 16 09:30	QC # 161608
Physical Tests		
Moisture %	16.8	16.9
Non-halogenated Volatiles		
Benzene	<0.04	<0.04
Ethylbenzene	<0.05	<0.05
Styrene	<0.05	<0.05
Toluene	<0.05	<0.05
meta- & para-Xylene	0.05	0.06
ortho-Xylene	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	<100	<100
VPH C6-10 (calculated)	<100	<100
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.01	<0.01
Acenaphthylene	<0.01	<0.01
Anthracene	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	0.06	0.06
Phenanthrene	0.01	0.01
Pyrene	<0.01	<0.01

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Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Sediment/Soil[1]		TH6-7 99 06 15 16:35	TH6-7 QC # 161616
Physical Tests			
Moisture	%	15.9	15.6
pH		8.29	8.30
Total Metals			
Antimony	T-Sb	<20	<20
Arsenic	T-As	1.2	0.9
Barium	T-Ba	307	306
Beryllium	T-Be	<0.5	<0.5
Cadmium	T-Cd	0.4	0.3
Chromium	T-Cr	90	90
Cobalt	T-Co	21	20
Copper	T-Cu	70	72
Lead	T-Pb	<50	<50
Mercury	T-Hg	0.165	0.149
Molybdenum	T-Mo	<4	<4
Nickel	T-Ni	58	58
Selenium	T-Se	0.3	0.3
Silver	T-Ag	<2	<2
Tin	T-Sn	<10	<10
Vanadium	T-V	127	124
Zinc	T-Zn	97	98
Extractables			
EPH (C10-18)		<200	<200
EPH (C19-31)		<200	<200

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Sediment/Soil[1]		**TH11-5**	**TH11-5**
		99 06 16 17:00	QC # 161620
Physical Tests			
Moisture	%	4.5	4.9
pH		8.15	8.04
Total Metals			
Antimony	T-Sb	<20	<20
Arsenic	T-As	5	4
Barium	T-Ba	167	115
Beryllium	T-Be	<0.5	<0.5
Cadmium	T-Cd	0.2	0.2
Chromium	T-Cr	44	49
Cobalt	T-Co	14	14
Copper	T-Cu	36	34
Lead	T-Pb	<50	<50
Mercury	T-Hg	0.048	0.038
Molybdenum	T-Mo	<4	<4
Nickel	T-Ni	32	32
Selenium	T-Se	<0.1	<0.1
Silver	T-Ag	<2	<2
Tin	T-Sn	<10	<10
Vanadium	T-V	77	78
Zinc	T-Zn	70	65
Extractables			
EPH (C10-18)		<200	<200
EPH (C19-31)		<200	<200

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Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Sediment/Soil[1]	TH16-4	TH16-4
	99 06 18 18:00	QC # 161622
Physical Tests		
Moisture %	4.8	4.9
Non-halogenated Volatiles		
Benzene	<0.04	<0.04
Ethylbenzene	<0.05	<0.05
Styrene	<0.05	<0.05
Toluene	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05
ortho-Xylene	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	<100	<100
VPH C6-10 (calculated)	<100	<100
Extractables		
EPH (C10-18)	<200	<200
EPH (C19-31)	<200	<200

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Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Sediment/Soil[1]		**TP15-1**	**TP15-1**
		99 06 16 14:20	QC # 161625
Physical Tests			
Moisture	%	6.9	7.6
Extractables			
EPH (C10-18)		1430	1360
EPH (C19-31)		264	238

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Sediment/Soil[1]	**TP35-3**	**TP35-3** QC # 161626
Physical Tests		
Moisture %	6.2	6.6
Halogenated Volatiles		
Bromodichloromethane	<0.01	<0.01
Bromoform	<0.01	<0.01
Carbon Tetrachloride	<0.01	<0.01
Chlorobenzene	<0.01	<0.01
Chloroethane	<0.01	<0.01
Chloroform	<0.01	<0.01
Chloromethane	<0.01	<0.01
Dibromochloromethane	<0.01	<0.01
1,2-Dichlorobenzene	<0.01	<0.01
1,3-Dichlorobenzene	<0.01	<0.01
1,4-Dichlorobenzene	<0.01	<0.01
1,1-Dichloroethane	<0.01	<0.01
1,2-Dichloroethane	<0.01	<0.01
cis-1,2-Dichloroethylene	<0.01	<0.01
trans-1,2-Dichloroethylene	<0.01	<0.01
1,1-Dichloroethylene	<0.01	<0.01
Dichloromethane	<0.1	<0.1
1,2-Dichloropropane	<0.01	<0.01
cis-1,3-Dichloropropylene	<0.01	<0.01
trans-1,3-Dichloropropylene	<0.01	<0.01
1,1,1,2-Tetrachloroethane	<0.01	<0.01
1,1,2,2-Tetrachloroethane	<0.01	<0.01
Tetrachloroethylene	<0.01	<0.01
1,1,1-Trichloroethane	<0.01	<0.01
1,1,2-Trichloroethane	<0.01	<0.01
Trichloroethylene	<0.01	<0.01
Trichlorofluoromethane	<0.01	<0.01
Vinyl Chloride	<0.01	<0.01

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Sediment/Soil[1]	**TP35-3**	**TP35-3** QC # 161626
Non-halogenated Volatiles		
Benzene	<0.04	<0.04
Ethylbenzene	<0.05	<0.05
Styrene	<0.05	<0.05
Toluene	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05
ortho-Xylene	<0.05	<0.05
Volatile Hydrocarbons (VH) C6-10	<100	<100
VPH C6-10 (calculated)	<100	<100
Extractables		
EPH (C10-18)	<200	<200
EPH (C19-31)	<200	<200

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
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Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Water[1]	**MP-3**	**MP-3**
	99 06 18 09:30	QC # 161592
Non-halogenated Volatiles		
Benzene	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005
Toluene	<0.0005	<0.0005
meta- & para-Xylene	<0.0005	<0.0005
ortho-Xylene	<0.0005	<0.0005
Volatile Hydrocarbons (VH) C6-10	<0.1	<0.1
VPH C6-10 (calculated)	<0.1	<0.1

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Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Water[1]		**MW-2**	**MW-2**
		99 06 18 10:30	QC # 161594
Physical Tests			
Hardness	CaCO3	109	114
Dissolved Metals			
Aluminum	D-Al	0.050	0.051
Antimony	D-Sb	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2
Barium	D-Ba	0.28	0.29
Beryllium	D-Be	<0.005	<0.005
Boron	D-B	<0.1	<0.1
Cadmium	D-Cd	<0.0002	<0.0002
Calcium	D-Ca	35.0	36.5
Chromium	D-Cr	<0.01	<0.01
Cobalt	D-Co	0.02	0.03
Copper	D-Cu	<0.01	<0.01
Iron	D-Fe	45.9	47.8
Lead	D-Pb	<0.001	<0.001
Magnesium	D-Mg	5.3	5.5
Manganese	D-Mn	8.79	9.15
Mercury	D-Hg	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05
Selenium	D-Se	<0.001	<0.001
Silver	D-Ag	<0.0001	<0.0001
Sodium	D-Na	2	2
Thallium	D-Tl	<0.0001	<0.0001
Uranium	D-U	0.00015	0.00015
Zinc	D-Zn	<0.005	<0.005
Non-halogenated Volatiles			
Benzene		0.0427	0.0478
Ethylbenzene		0.160	0.166
Toluene		0.0115	0.0104
meta- & para-Xylene		0.319	0.330
ortho-Xylene		0.195	0.133
Volatile Hydrocarbons (VH) C6-10		2.1	2.2
VPH C6-10 (calculated)		1.4	1.5

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VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K6884

Water[1]	MW-14 99 06 19 10:25	MW-14 QC # 161603
Halogenated Volatiles		
Bromodichloromethane	<0.001	<0.001
Bromoform	<0.001	<0.001
Carbon Tetrachloride	<0.001	<0.001
Chlorobenzene	<0.001	<0.001
Chloroethane	<0.001	<0.001
Chloroform	<0.001	<0.001
Chloromethane	<0.002	<0.002
Dibromochloromethane	<0.001	<0.001
1,2-Dichlorobenzene	<0.001	<0.001
1,3-Dichlorobenzene	<0.001	<0.001
1,4-Dichlorobenzene	<0.001	<0.001
1,1-Dichloroethane	<0.001	<0.001
1,2-Dichloroethane	<0.001	<0.001
cis-1,2-Dichloroethylene	<0.001	<0.001
trans-1,2-Dichloroethylene	<0.001	<0.001
1,1-Dichloroethylene	<0.001	<0.001
Dichloromethane	<0.02	<0.02
1,2-Dichloropropane	<0.001	<0.001
cis-1,3-Dichloropropylene	<0.001	<0.001
trans-1,3-Dichloropropylene	<0.001	<0.001
1,1,1,2-Tetrachloroethane	<0.001	<0.001
1,1,2,2-Tetrachloroethane	<0.001	<0.001
Tetrachloroethylene	<0.001	<0.001
1,1,1-Trichloroethane	<0.001	<0.001
1,1,2-Trichloroethane	<0.001	<0.001
Trichloroethylene	<0.001	<0.001
Trichlorofluoromethane	<0.001	<0.001
Vinyl Chloride	<0.001	<0.001

Remarks regarding the analyses appear at the beginning of this report.
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VPH = Volatile Petroleum Hydrocarbons.
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Appendix 1 - QUALITY CONTROL - Replicates

Water[1]	**MW-14**	**MW-14**
	99 06 19 10:25	QC # 161603
Non-halogenated Volatiles		
Benzene	<0.0005	<0.0005
Ethylbenzene	0.0048	0.0046
Styrene	<0.0005	0.0009
Toluene	0.0015	0.0014
meta- & para-Xylene	0.0121	0.0118
ortho-Xylene	0.0394	0.0388
Volatile Hydrocarbons (VH) C6-10	0.5	0.5
VPH C6-10 (calculated)	0.4	0.4

Remarks regarding the analyses appear at the beginning of this report.
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LABORATORY REPORT FOR
JULY 1999
INVESTIGATIONS AT THE RAFTER'S CAMP

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CHEMICAL ANALYSIS REPORT

Date:	August 10, 1999
ASL File No.	K8109
Report On:	Blanchard River Soil Analysis
Report To:	**Royal Roads University** Applied Research Division 2005 Sooke Road Victoria, BC V9B 5Y2
Attention:	**Dr. Matthew Dodd**, Professor
Received:	July 29, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Scott P. Hoekstra, B.Sc. - Project Chemist
Brent Makelki, B.Sc. - Supervisor, Client Services

REMARKS

File No. K8109

It should be noted that due to analytical interferences, it was necessary to increase the detection limits for Lindane (gamma - BHC) for the samples identified as "TP0799-4" and "TP0799-5".

Due to matrix interferences, all OCP and PCB detection limits have been increased for the sample identified as "TP0799-2".

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8109

Sample ID		TP0799-1	TP0799-2	TP0799-4	TP0799-5	TP0799-6
Physical Tests						
Moisture	%	9.8	9.1	6.3	8.1	3.2
pH		-	-	-	-	6.37
Total Metals						
Antimony	T-Sb	-	-	-	-	<20
Arsenic	T-As	-	-	-	-	<5
Barium	T-Ba	-	-	-	-	114
Beryllium	T-Be	-	-	-	-	<0.5
Cadmium	T-Cd	-	-	-	-	<0.5
Chromium	T-Cr	-	-	-	-	42
Cobalt	T-Co	-	-	-	-	12
Copper	T-Cu	-	-	-	-	30
Lead	T-Pb	-	-	-	-	<50
Mercury	T-Hg	-	-	-	-	0.027
Molybdenum	T-Mo	-	-	-	-	<4
Nickel	T-Ni	-	-	-	-	31
Selenium	T-Se	-	-	-	-	0.1
Silver	T-Ag	-	-	-	-	<2
Tin	T-Sn	-	-	-	-	<10
Vanadium	T-V	-	-	-	-	77
Zinc	T-Zn	-	-	-	-	63
Polychlorinated Biphenyls						
Total Polychlorinated Biphenyls		<0.05	<0.5	<0.05	<0.05	-

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. K8109

Sample ID	TP0799-1	TP0799-2	TP0799-4	TP0799-5
Organochloride Pesticides				
Aldrin	<0.001	<0.01	<0.001	<0.001
alpha-BHC	<0.001	<0.01	<0.003	<0.003
beta-BHC	<0.002	<0.02	<0.003	<0.003
delta-BHC	<0.001	<0.01	<0.003	<0.003
cis-Chlordane (alpha)	<0.001	<0.01	<0.001	<0.001
trans-Chlordane (gamma)	<0.001	<0.01	<0.001	<0.001
2,4'-DDD	<0.001	<0.01	<0.001	<0.001
4,4'-DDD	<0.001	<0.01	<0.001	<0.001
2,4'-DDE	<0.002	<0.02	<0.002	<0.002
4,4'-DDE	<0.001	<0.01	<0.001	<0.001
2,4'-DDT	<0.001	<0.01	<0.001	<0.001
4,4'-DDT	<0.002	<0.02	<0.002	<0.002
Dieldrin	<0.001	<0.01	<0.001	<0.001
Endosulfan I	<0.001	<0.01	<0.001	<0.001
Endosulfan II	<0.001	<0.01	<0.001	<0.001
Endosulfan Sulfate	<0.001	<0.01	<0.001	<0.001
Endrin	<0.005	<0.05	<0.005	<0.005
Endrin Aldehyde	<0.001	<0.01	<0.001	<0.001
Heptachlor	<0.002	<0.02	<0.002	<0.002
Heptachlor Epoxide	<0.001	<0.01	<0.001	<0.001
Lindane (gamma - BHC)	<0.001	<0.01	<0.003	<0.003
Methoxychlor	<0.005	<0.05	<0.005	<0.005
Mirex	<0.001	<0.01	<0.001	<0.001
cis-Nonachlor	<0.001	<0.01	<0.001	<0.001
trans-Nonachlor	<0.001	<0.01	<0.001	<0.001
Extractables				
EPH (C10-18)	<200	306	3730	1640
EPH (C19-31)	613	7970	3180	600

Remarks regarding the analyses appear at the beginning of this report.
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EPH = Extractable Petroleum Hydrocarbons.

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

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

pH in Soil

This analysis is carried out in accordance with procedures described in "Soil Sampling and Methods of Analysis" (CSSS). The procedure involves mixing the air-dried sample with deionized/distilled water. The pH of the solution is then measured using a standard pH probe. A one to two ratio of sediment to water is used for mineral soils and a one to ten ratio is used for highly organic soils.

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:

Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA

For more detail see: ASL "Collection & Sampling Guide"

Organochlorine Pesticides /Chlorinated Hydrocarbons/Phthalates and or Polychlorinated Biphenyls in Sediment/Soil by Soxhlet Extraction.

This analysis is carried out in accordance with U.S. EPA Method 3540, 3610 and 8080 (Publ.# SW-846 3rd ed., Washington, DC 20460). The procedure involves a soxhlet extraction using dichloromethane. The extract is then solvent exchanged to hexane followed by alumina and silica gel column clean-ups. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from U.S. EPA Methods 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID" (January 1996) The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

End of Report

LABORATORY REPORT FOR
SEPTEMBER 1999
ADDITIONAL SITE INVESTIGATIONS

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CHEMICAL ANALYSIS REPORT

Date:	October 20, 1999
ASL File No.	L1002
Report On:	Blanchard River Remediation Water Analysis
Report To:	**Royal Roads University** Applied Research Division 2005 Sooke Road Victoria, BC V9B 5Y2
Attention:	**Dr. Matthew Dodd**, Professor
Received:	September 27, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS

File No. L1002

Matrix interferences were encountered for several samples analyzed for polycyclic aromatic hydrocarbons (PAH's). As a consequence, the detection limits for a few PAH compounds were increased slightly.

RESULTS OF ANALYSIS - Water[1]

File No. L1002

Sample ID		BL-RS	TH-9	TH-10	TH-18	TH-19
Sample Date		99 09 23	99 09 23	99 09 23	99 09 23	99 09 23
Sample Time		11:10	13:20	13:40	13:50	13:30
Physical Tests						
Hardness	CaCO3	-	397	245	203	414
Total Metals						
Aluminum	T-Al	<0.2	-	-	-	-
Arsenic	T-As	0.0002	-	-	-	-
Barium	T-Ba	0.13	-	-	-	-
Boron	T-B	<0.1	-	-	-	-
Cadmium	T-Cd	0.0002	-	-	-	-
Chromium	T-Cr	<0.01	-	-	-	-
Copper	T-Cu	<0.01	-	-	-	-
Iron	T-Fe	<0.03	-	-	-	-
Lead	T-Pb	<0.001	-	-	-	-
Manganese	T-Mn	<0.005	-	-	-	-
Mercury	T-Hg	<0.00005	-	-	-	-
Molybdenum	T-Mo	<0.03	-	-	-	-
Selenium	T-Se	0.0006	-	-	-	-
Sodium	T-Na	2	-	-	-	-
Zinc	T-Zn	0.006	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
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VPH = Volatile Petroleum Hydrocarbons.
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RESULTS OF ANALYSIS - Water[1]

File No. L1002

Sample ID		BL-RS	TH-5	TH-13	TH-30	TH-9
Sample Date		99 09 23	99 09 23	99 09 23	99 09 23	99 09 23
Sample Time		11:10	11:50	11:45	11:55	13:20
Dissolved Metals						
Aluminum	D-Al	-	-	-	-	0.01
Antimony	D-Sb	-	-	-	-	<0.2
Arsenic	D-As	-	-	-	-	<0.2
Barium	D-Ba	-	-	-	-	0.27
Beryllium	D-Be	-	-	-	-	<0.005
Boron	D-B	-	-	-	-	0.1
Cadmium	D-Cd	-	-	-	-	<0.0004
Calcium	D-Ca	-	-	-	-	128
Chromium	D-Cr	-	-	-	-	<0.01
Cobalt	D-Co	-	-	-	-	<0.01
Copper	D-Cu	-	-	-	-	<0.01
Iron	D-Fe	-	-	-	-	<0.03
Lead	D-Pb	-	-	-	-	<0.002
Magnesium	D-Mg	-	-	-	-	18.8
Manganese	D-Mn	-	-	-	-	0.023
Mercury	D-Hg	-	-	-	-	<0.00005
Molybdenum	D-Mo	-	-	-	-	<0.03
Nickel	D-Ni	-	-	-	-	<0.05
Selenium	D-Se	-	-	-	-	<0.002
Silver	D-Ag	-	-	-	-	<0.0002
Sodium	D-Na	-	-	-	-	34
Thallium	D-Tl	-	-	-	-	<0.0002
Uranium	D-U	-	-	-	-	0.00170
Zinc	D-Zn	-	-	-	-	0.014
Non-halogenated Volatiles						
Benzene		<0.0005	0.0007	<0.0005	0.0009	<0.0005
Ethylbenzene		<0.0005	0.0414	<0.0005	0.0332	<0.0005
Toluene		<0.0005	0.0006	<0.0005	0.0017	<0.0005
meta- & para-Xylene		<0.0005	0.0605	<0.0005	0.0510	<0.0005
ortho-Xylene		<0.0005	0.0370	0.0136	0.0595	<0.0005
Volatile Hydrocarbons (VH6-10)		<0.1	0.9	0.1	1.1	<0.1
VPH		<0.1	0.7	<0.1	1.0	<0.1

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Water[1]

File No. L1002

Sample ID		TH-10	TH-18	TH-19	MP-3
Sample Date		99 09 23	99 09 23	99 09 23	99 09 23
Sample Time		13:40	13:50	13:30	15:00
Dissolved Metals					
Aluminum	D-Al	0.037	0.092	0.02	-
Antimony	D-Sb	<0.2	<0.2	<0.2	-
Arsenic	D-As	<0.2	<0.2	<0.2	-
Barium	D-Ba	0.12	0.16	0.66	-
Beryllium	D-Be	<0.005	<0.005	<0.005	-
Boron	D-B	<0.1	<0.1	0.3	-
Cadmium	D-Cd	<0.0002	<0.0002	0.0015	-
Calcium	D-Ca	78.0	66.5	137	-
Chromium	D-Cr	<0.01	<0.01	<0.01	-
Cobalt	D-Co	<0.01	<0.01	0.01	-
Copper	D-Cu	<0.01	<0.01	<0.01	-
Iron	D-Fe	0.06	0.16	2.24	-
Lead	D-Pb	<0.001	<0.001	<0.002	-
Magnesium	D-Mg	12.3	9.0	17.5	-
Manganese	D-Mn	<0.005	0.057	4.28	-
Mercury	D-Hg	<0.00005	<0.00005	0.00007	-
Molybdenum	D-Mo	<0.03	<0.03	<0.03	-
Nickel	D-Ni	<0.05	<0.05	<0.05	-
Selenium	D-Se	<0.001	0.002	<0.002	-
Silver	D-Ag	<0.0001	<0.0001	<0.0002	-
Sodium	D-Na	2	10	10	-
Thallium	D-Tl	<0.0001	<0.0001	<0.0002	-
Uranium	D-U	0.00078	0.00042	0.00035	-
Zinc	D-Zn	<0.005	<0.005	0.008	-
Non-halogenated Volatiles					
Benzene		<0.0005	<0.0005	0.0058	<0.0005
Ethylbenzene		<0.0005	<0.0005	0.0444	<0.0005
Toluene		<0.0005	<0.0005	0.0042	<0.0005
meta- & para-Xylene		<0.0005	<0.0005	0.0384	<0.0005
ortho-Xylene		<0.0005	<0.0005	0.0025	0.0018
Volatile Hydrocarbons (VH6-10)		<0.1	<0.1	0.3	0.1
VPH		<0.1	<0.1	0.2	0.1

Remarks regarding the analyses appear at the beginning of this report.
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EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Water[1]

File No. L1002

Sample ID	TH-5	TH-13	TH-9	TH-10	TH-18
Sample Date	99 09 23	99 09 23	99 09 23	99 09 23	99 09 23
Sample Time	11:50	11:45	13:20	13:40	13:50
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.0086	0.00028	<0.00005	<0.00005	<0.00005
Acenaphthylene	0.0024	<0.00005	<0.00005	<0.00005	<0.00005
Acridine	<0.0005	<0.00005	<0.00005	<0.00005	<0.0001
Anthracene	0.0016	<0.00005	<0.00005	<0.00005	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.0002	<0.00005	<0.00005	<0.00005	<0.00005
Fluorene	0.0132	0.00022	<0.00005	<0.00005	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Naphthalene	0.342	<0.002	<0.00005	<0.00005	<0.0005
Phenanthrene	0.0210	<0.00005	<0.00005	<0.00005	<0.00005
Pyrene	0.00098	0.00006	<0.00005	<0.00005	0.00012
Extractable Hydrocarbons					
EPH10-19	23.7	0.8	0.3	<0.1	1.7
EPH19-32	3.6	0.2	0.4	<0.1	0.4
LEPH	23.3	0.8	<0.3	<0.3	1.7
HEPH	4	<1	<1	<1	<1

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Water[1]

File No. L1002

Sample ID	TH-19	MP-3	TH-14
Sample Date	99 09 23	99 09 23	99 09 24
Sample Time	13:30	15:00	09:30
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	0.0015	<0.003	<0.00005
Acenaphthylene	<0.0005	<0.0005	<0.00005
Acridine	<0.0005	<0.0005	<0.00005
Anthracene	<0.0005	0.00058	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.00005	<0.0002	<0.00005
Fluorene	0.0012	0.00246	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005
Naphthalene	0.0537	<0.005	<0.0003
Phenanthrene	<0.0005	0.00346	<0.00005
Pyrene	<0.00005	0.00086	0.00013
Extractable Hydrocarbons			
EPH10-19	5.6	19.2	4.1
EPH19-32	0.8	3	2.0
LEPH	5.6	19.2	4.1
HEPH	<1	3	2

Remarks regarding the analyses appear at the beginning of this report.
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EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID		TP46-1	TP47-1	TP48-1	TP49-3	TP49-4
Sample Date		99 09 18	99 09 18	99 09 18	99 09 19	99 09 19
Sample Time						
Physical Tests						
Moisture	%	13.7	23.1	8.1	37.5	8.1
pH		-	-	-	5.94	6.61
Total Metals						
Antimony	T-Sb	-	-	-	<20	<20
Arsenic	T-As	-	-	-	<5	<5
Barium	T-Ba	-	-	-	442	148
Beryllium	T-Be	-	-	-	0.6	<0.5
Cadmium	T-Cd	-	-	-	<0.5	<0.5
Chromium	T-Cr	-	-	-	91	70
Cobalt	T-Co	-	-	-	13	14
Copper	T-Cu	-	-	-	101	29
Lead	T-Pb	-	-	-	<50	<50
Mercury	T-Hg	-	-	-	0.280	0.028
Molybdenum	T-Mo	-	-	-	<4	<4
Nickel	T-Ni	-	-	-	50	36
Selenium	T-Se	-	-	-	<2	<2
Silver	T-Ag	-	-	-	<2	<2
Tin	T-Sn	-	-	-	<10	<10
Vanadium	T-V	-	-	-	99	72
Zinc	T-Zn	-	-	-	126	58

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID		TP50-1	TP52-1	TH18-5	TH18-6	TH18-7
Sample Date Sample Time		99 09 19	99 09 19	99 09 21 09:00	99 09 21 09:10	99 09 21 09:20
Physical Tests						
Moisture	%	6.3	5.1	4.7	4.4	3.9

Remarks regarding the analyses appear at the beginning of this report.
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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID		TH18-8	TH18-9	TH19-4	TH19-5	TH19-6
Sample Date		99 09 21	99 09 21	99 09 21	99 09 21	99 09 21
Sample Time		09:30	09:40	11:30	11:40	11:45
Physical Tests						
Moisture	%	15.3	17.0	4.0	4.1	13.7

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EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID		TH19-7	TH19-8	TH20-13	TH21-2	TH21-6
Sample Date		99 09 21	99 09 21	99 09 21	99 09 21	99 09 21
Sample Time		11:50	12:00	15:00	16:10	16:20
Physical Tests						
Moisture	%	12.2	16.7	10.4	4.0	5.0

Remarks regarding the analyses appear at the beginning of this report.
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EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID		TH21-9	TH22-6	TH23-7	TH24-12	TH24-13
Sample Date Sample Time		99 09 21 16:30	99 09 22	99 09 22	99 09 22	99 09 22
Physical Tests						
Moisture	%	4.7	4.9	14.8	3.2	5.9

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID		TH24-14	TH24-20
Sample Date Sample Time		99 09 22	99 09 22
Physical Tests			
Moisture	%	18.2	5.7

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID	TP46-1	TP47-1	TP48-1	TP49-3	TP49-4
Sample Date	99 09 18	99 09 18	99 09 18	99 09 19	99 09 19
Sample Time					
Non-halogenated Volatiles					
Benzene	-	-	-	<0.04	<0.04
Ethylbenzene	-	-	-	<0.05	<0.05
Styrene	-	-	-	<0.05	<0.05
Toluene	-	-	-	<0.05	<0.05
meta- & para-Xylene	-	-	-	<0.05	<0.05
ortho-Xylene	-	-	-	<0.05	<0.05
Volatile Hydrocarbons (VH6-10)	-	-	-	<100	<100
VPH	-	-	-	<100	<100
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	-	-	-	<0.01	<0.04
Acenaphthylene	-	-	-	<0.01	<0.02
Anthracene	-	-	-	<0.01	<0.01
Benz(a)anthracene	-	-	-	<0.01	<0.01
Benzo(a)pyrene	-	-	-	<0.01	<0.01
Benzo(b)fluoranthene	-	-	-	<0.01	<0.01
Benzo(g,h,i)perylene	-	-	-	<0.01	<0.01
Benzo(k)fluoranthene	-	-	-	<0.01	<0.01
Chrysene	-	-	-	<0.01	<0.01
Dibenz(a,h)anthracene	-	-	-	<0.01	<0.01
Fluoranthene	-	-	-	<0.01	<0.01
Fluorene	-	-	-	<0.01	0.06
Indeno(1,2,3-c,d)pyrene	-	-	-	<0.01	<0.01
Naphthalene	-	-	-	<0.01	<0.3
Phenanthrene	-	-	-	<0.01	0.02
Pyrene	-	-	-	<0.01	<0.01
Extractable Hydrocarbons					
EPH10-19	<200	<200	<200	<200	455
EPH19-32	<200	<200	<200	281	<200
LEPH	-	-	-	<200	455
HEPH	-	-	-	281	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID	TP50-1	TP52-1	TH18-5	TH18-6	TH18-7
Sample Date Sample Time	99 09 19	99 09 19	99 09 21 09:00	99 09 21 09:10	99 09 21 09:20
Non-halogenated Volatiles					
Benzene	<0.04	-	-	-	-
Ethylbenzene	<0.05	-	-	-	-
Styrene	<0.05	-	-	-	-
Toluene	<0.05	-	-	-	-
meta- & para-Xylene	<0.05	-	-	-	-
ortho-Xylene	<0.05	-	-	-	-
Volatile Hydrocarbons (VH6-10)	<100	-	-	-	-
VPH	<100	-	-	-	-
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	-	<0.01	<0.1	<0.01
Acenaphthylene	<0.02	-	<0.01	<0.05	<0.01
Anthracene	<0.01	-	<0.01	0.03	<0.01
Benz(a)anthracene	<0.01	-	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	-	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	-	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	-	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	-	<0.01	<0.01	<0.01
Chrysene	<0.01	-	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	-	<0.01	<0.01	<0.01
Fluoranthene	<0.01	-	<0.01	<0.01	<0.01
Fluorene	<0.01	-	<0.01	0.17	<0.01
Indeno(1,2,3-c,d)pyrene	<0.01	-	<0.01	<0.01	<0.01
Naphthalene	<0.05	-	0.02	<0.2	0.04
Phenanthrene	<0.01	-	<0.01	0.26	<0.01
Pyrene	<0.01	-	<0.01	0.07	<0.01
Extractable Hydrocarbons					
EPH10-19	1200	<200	<200	1050	<200
EPH19-32	<200	<200	<200	<200	<200
LEPH	1200	-	<200	1050	<200
HEPH	<200	-	<200	<200	<200

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< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID	TH18-8	TH18-9	TH19-4	TH19-5	TH19-6
Sample Date	99 09 21	99 09 21	99 09 21	99 09 21	99 09 21
Sample Time	09:30	09:40	11:30	11:40	11:45
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	0.02	<0.01	<0.01	<0.01	0.01
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.04	<0.01	<0.03	0.17	0.23
Phenanthrene	0.05	0.01	<0.01	<0.01	<0.01
Pyrene	0.02	<0.01	0.03	0.03	0.03
Extractable Hydrocarbons					
EPH10-19	<200	<200	270	<200	<200
EPH19-32	<200	<200	<200	<200	<200
LEPH	<200	<200	270	<200	<200
HEPH	<200	<200	<200	<200	<200

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EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID	TH19-7	TH19-8	TH20-13	TH21-2	TH21-6
Sample Date	99 09 21	99 09 21	99 09 21	99 09 21	99 09 21
Sample Time	11:50	12:00	15:00	16:10	16:20
Non-halogenated Volatiles					
Benzene	-	-	<0.04	<0.04	<0.04
Ethylbenzene	-	-	<0.05	<0.05	<0.05
Styrene	-	-	<0.05	<0.05	<0.05
Toluene	-	-	<0.05	<0.05	<0.05
meta- & para-Xylene	-	-	<0.05	<0.05	<0.05
ortho-Xylene	-	-	<0.05	<0.05	<0.05
Volatile Hydrocarbons (VH6-10)	-	-	<100	<100	<100
VPH	-	-	<100	<100	<100
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.28	0.14	<0.01	0.04	<0.01
Phenanthrene	<0.01	<0.01	<0.01	0.02	<0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Extractable Hydrocarbons					
EPH10-19	<200	<200	<200	1030	<200
EPH19-32	<200	<200	<200	<200	<200
LEPH	<200	<200	<200	1030	<200
HEPH	<200	<200	<200	<200	<200

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VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID	TH21-9	TH22-6	TH23-7	TH24-12	TH24-13
Sample Date Sample Time	99 09 21 16:30	99 09 22	99 09 22	99 09 22	99 09 22
Non-halogenated Volatiles					
Benzene	<0.04	-	-	<0.04	<0.04
Ethylbenzene	<0.05	-	-	<0.05	<0.05
Styrene	<0.05	-	-	<0.05	<0.05
Toluene	<0.05	-	-	<0.05	<0.05
meta- & para-Xylene	<0.05	-	-	<0.05	<0.05
ortho-Xylene	<0.05	-	-	<0.05	<0.05
Volatile Hydrocarbons (VH6-10)	<100	-	-	<100	<100
VPH	<100	-	-	<100	<100
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	<0.01	<0.01	<0.01	0.02	<0.01
Phenanthrene	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	<0.01	<0.01	<0.01	<0.01	<0.01
Extractable Hydrocarbons					
EPH10-19	<200	<200	<200	<200	<200
EPH19-32	<200	<200	<200	<200	<200
LEPH	<200	<200	<200	<200	<200
HEPH	<200	<200	<200	<200	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1002

Sample ID	TH24-14	TH24-20
Sample Date	99 09 22	99 09 22
Sample Time		
Non-halogenated Volatiles		
Benzene	<0.04	<0.04
Ethylbenzene	<0.05	<0.05
Styrene	<0.05	<0.05
Toluene	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05
ortho-Xylene	<0.05	<0.05
Volatile Hydrocarbons (VH6-10)	<100	<100
VPH	<100	<100
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.01	<0.03
Acenaphthylene	<0.01	<0.01
Anthracene	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	<0.01	0.02
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	<0.01	<0.1
Phenanthrene	<0.01	0.06
Pyrene	<0.01	<0.01
Extractable Hydrocarbons		
EPH10-19	<200	256
EPH19-32	<200	<200
LEPH	<200	256
HEPH	<200	<200

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EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Water[1]

File No. L1002

Sample ID		Travel Blank
Sample Date		
Sample Time		
Physical Tests		
Hardness	CaCO3	<0.05
Total Metals		
Aluminum	T-Al	<0.005
Antimony	T-Sb	<0.2
Arsenic	T-As	<0.2
Barium	T-Ba	<0.01
Beryllium	T-Be	<0.005
Boron	T-B	<0.1
Cadmium	T-Cd	<0.0002
Calcium	T-Ca	<0.05
Chromium	T-Cr	<0.01
Cobalt	T-Co	<0.01
Copper	T-Cu	<0.01
Iron	T-Fe	<0.03
Lead	T-Pb	<0.001
Magnesium	T-Mg	<0.1
Manganese	T-Mn	<0.005
Mercury	T-Hg	<0.00005
Molybdenum	T-Mo	<0.03
Nickel	T-Ni	<0.05
Selenium	T-Se	<0.001
Silver	T-Ag	<0.0001
Sodium	T-Na	<2
Thallium	T-Tl	<0.0001
Uranium	T-U	<0.00001
Zinc	T-Zn	<0.005

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

Sediment/Soil[1]		**TP46-1**	**TP46-1**
		99 09 18	QC # 174202
Physical Tests			
Moisture	%	13.7	15.6
Extractable Hydrocarbons			
EPH10-19		<200	<200
EPH19-32		<200	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1002

Sediment/Soil[1]	**TH18-8**	**TH18-8**
	99 09 21 09:30	QC # 174203
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.01	<0.01
Acenaphthylene	<0.01	<0.01
Anthracene	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	0.02	0.02
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	0.04	0.04
Phenanthrene	0.05	0.05
Pyrene	0.02	0.02
Extractable Hydrocarbons		
EPH10-19	<200	<200
EPH19-32	<200	<200
LEPH	<200	<200
HEPH	<200	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Sediment/Soil[1]	**TH21-9**	**TH21-9**
	99 09 21 16:30	QC # 174204
Physical Tests		
Moisture %	4.7	4.0
Non-halogenated Volatiles		
Benzene	<0.04	<0.04
Ethylbenzene	<0.05	<0.05
Styrene	<0.05	<0.05
Toluene	<0.05	<0.05
meta- & para-Xylene	<0.05	<0.05
ortho-Xylene	<0.05	<0.05
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.01	<0.01
Acenaphthylene	<0.01	<0.01
Anthracene	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	<0.01	<0.01
Phenanthrene	<0.01	<0.01
Pyrene	<0.01	<0.01
Extractable Hydrocarbons		
EPH10-19	<200	<200
EPH19-32	<200	<200
LEPH	<200	<200
HEPH	<200	<200

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
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Water[1]	TH-5	TH-5
	99 09 23 11:50	QC # 174201
Non-halogenated Volatiles		
Benzene	0.0007	0.0006
Ethylbenzene	0.0414	0.0370
Toluene	0.0006	0.0006
meta- & para-Xylene	0.0605	0.0518
ortho-Xylene	0.0370	0.0319
Volatile Hydrocarbons (VH6-10)	0.9	0.8
VPH	0.7	0.7

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LABORATORY REPORT FOR
SEPTEMBER 1999
CONFIRMATORY SAMPLES

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CHEMICAL ANALYSIS REPORT

Date:	October 14, 1999
ASL File No.	L1131
Report On:	Blanchard River Remediation Soil and Water Analysis
Report To:	**Royal Roads University** Applied Research Division 2005 Sooke Road Victoria, BC V9B 5Y2
Attention:	**Dr. Matthew Dodd**, Professor
Received:	September 30, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

Specialists in Environmental Chemistry

REMARKS File No. L1131

Matrix interferences were encountered for several samples analyzed for polycyclic aromatic hydrocarbons (PAH's). As a consequence, the detection limits for a few PAH compounds were increased slightly. Also, the detection limits for metals on the sample identified as "BLS-10" were increased two-fold due the high moisture content of this particular sample.

RESULTS OF ANALYSIS - Water[1]

File No. L1131

Sample ID	Seep 1
Sample Date	99 09 27
Polycyclic Aromatic Hydrocarbons	
Acenaphthene	<0.003
Acenaphthylene	<0.001
Acridine	<0.0001
Anthracene	0.00006
Benz(a)anthracene	<0.00005
Benzo(a)pyrene	<0.00001
Benzo(b)fluoranthene	<0.00005
Benzo(g,h,i)perylene	<0.00005
Benzo(k)fluoranthene	<0.00005
Chrysene	<0.00005
Dibenz(a,h)anthracene	<0.00005
Fluoranthene	<0.00005
Fluorene	0.00283
Indeno(1,2,3-c,d)pyrene	<0.00005
Naphthalene	<0.04
Phenanthrene	0.00063
Pyrene	<0.00005
Extractable Hydrocarbons	
EPH10-19	37.2
EPH19-32	1
LEPH	37.2
HEPH	1

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		CS-51	CS-53	CS-54	CS-55	CS-56
Sample Date		99 09 26	99 09 26	99 09 26	99 09 26	99 09 26
Physical Tests						
Moisture	%	11.3	16.1	3.4	5.1	3.3

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		CS-63	CS-60	CS-61	CS-67	CS-68
Sample Date		99 09 26	99 09 26	99 09 26	99 09 26	99 09 27
Physical Tests						
Moisture	%	9.5	7.0	7.8	17.7	16.7

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		BLS-10	BLS-11	BLS-12	BLS-13	BLS-14
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
Physical Tests						
Moisture	%	61.2	34.5	28.7	39.4	33.4
pH		7.40	6.93	6.10	-	6.21
Total Metals						
Antimony	T-Sb	<40	<20	<20	-	<20
Arsenic	T-As	15	5	7	-	7
Barium	T-Ba	774	313	324	-	352
Beryllium	T-Be	<1	<0.5	<0.5	-	<0.5
Cadmium	T-Cd	0.5	<0.5	<0.5	-	<0.5
Chromium	T-Cr	71	63	74	-	88
Cobalt	T-Co	23	15	17	-	18
Copper	T-Cu	51	32	42	-	43
Lead	T-Pb	<100	<50	<50	-	<50
Mercury	T-Hg	0.088	0.045	0.059	-	0.060
Molybdenum	T-Mo	<8	<4	<4	-	<4
Nickel	T-Ni	50	32	41	-	44
Selenium	T-Se	<2	<2	<2	-	<2
Silver	T-Ag	<4	<2	<2	-	<2
Tin	T-Sn	<20	<10	<10	-	<10
Vanadium	T-V	106	94	105	-	117
Zinc	T-Zn	369	87	89	-	99

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		BLS-15	BLS-16	BLS-17	BLS-18	BLS-19
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
Physical Tests						
Moisture	%	31.9	23.6	3.8	18.1	46.7
pH		-	6.80	-	6.52	6.10
Total Metals						
Antimony	T-Sb	-	<20	-	<20	<20
Arsenic	T-As	-	5	-	6	5
Barium	T-Ba	-	303	-	211	293
Beryllium	T-Be	-	<0.5	-	<0.5	<0.5
Cadmium	T-Cd	-	<0.5	-	<0.5	0.7
Chromium	T-Cr	-	87	-	68	60
Cobalt	T-Co	-	20	-	14	13
Copper	T-Cu	-	38	-	35	38
Lead	T-Pb	-	<50	-	<50	<50
Mercury	T-Hg	-	0.035	-	0.029	0.046
Molybdenum	T-Mo	-	<4	-	<4	<4
Nickel	T-Ni	-	45	-	40	35
Selenium	T-Se	-	<2	-	<2	<2
Silver	T-Ag	-	<2	-	<2	<2
Tin	T-Sn	-	<10	-	<10	<10
Vanadium	T-V	-	113	-	82	88
Zinc	T-Zn	-	97	-	75	509

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		BLS-20	CS-5	CS-9	CS-15	CS-18
Sample Date		99 09 24	99 09 25	99 09 25	99 09 25	99 09 25
Physical Tests						
Moisture	%	39.0	17.1	18.9	12.0	13.0
pH		6.17	-	-	-	-
Total Metals						
Antimony	T-Sb	<20	-	-	-	-
Arsenic	T-As	5	-	-	-	-
Barium	T-Ba	269	-	-	-	-
Beryllium	T-Be	<0.5	-	-	-	-
Cadmium	T-Cd	0.6	-	-	-	-
Chromium	T-Cr	65	-	-	-	-
Cobalt	T-Co	14	-	-	-	-
Copper	T-Cu	37	-	-	-	-
Lead	T-Pb	<50	-	-	-	-
Mercury	T-Hg	0.041	-	-	-	-
Molybdenum	T-Mo	<4	-	-	-	-
Nickel	T-Ni	35	-	-	-	-
Selenium	T-Se	<2	-	-	-	-
Silver	T-Ag	<2	-	-	-	-
Tin	T-Sn	<10	-	-	-	-
Vanadium	T-V	93	-	-	-	-
Zinc	T-Zn	428	-	-	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		CS-20	CS-22	CS-26	CS-27	CS-31
Sample Date		99 09 25	99 09 25	99 09 25	99 09 25	99 09 25
Physical Tests						
Moisture	%	14.2	17.2	4.6	19.9	18.7

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	CS-36	CS-37	CS-40	CS-41	CS-42
Sample Date	99 09 25	99 09 25	99 09 26	99 09 26	99 09 26
Physical Tests					
Moisture %	17.0	15.1	15.9	14.6	17.1

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Sample ID		CS-43	CS-45	CS-46	CS-47	CS-50
Sample Date		99 09 26	99 09 26	99 09 26	99 09 26	99 09 26
Physical Tests						
Moisture	%	19.0	36.4	4.4	10.0	14.7

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID		CS-71	UST 2	UST 4	UST 11	TP56-2
Sample Date		99 09 27	99 09 27	99 09 27	99 09 28	99 09 28
Physical Tests						
Moisture	%	6.9	20.2	4.3	19.0	16.1
pH		-	-	-	-	7.56
Total Metals						
Antimony	T-Sb	-	-	-	-	<20
Arsenic	T-As	-	-	-	-	<5
Barium	T-Ba	-	-	-	-	123
Beryllium	T-Be	-	-	-	-	<0.5
Cadmium	T-Cd	-	-	-	-	<0.5
Chromium	T-Cr	-	-	-	-	44
Cobalt	T-Co	-	-	-	-	13
Copper	T-Cu	-	-	-	-	50
Lead	T-Pb	-	-	-	-	<50
Mercury	T-Hg	-	-	-	-	0.041
Molybdenum	T-Mo	-	-	-	-	<4
Nickel	T-Ni	-	-	-	-	33
Selenium	T-Se	-	-	-	-	<2
Silver	T-Ag	-	-	-	-	<2
Tin	T-Sn	-	-	-	-	<10
Vanadium	T-V	-	-	-	-	81
Zinc	T-Zn	-	-	-	-	60
Non-halogenated Volatiles						
Benzene		-	-	<0.04	-	-
Ethylbenzene		-	-	<0.05	-	-
Styrene		-	-	<0.05	-	-
Toluene		-	-	<0.05	-	-
meta- & para-Xylene		-	-	<0.05	-	-
ortho-Xylene		-	-	<0.05	-	-
Volatile Hydrocarbons (VH6-10)		-	-	<100	-	-
VPH		-	-	<100	-	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

Sample ID		TP58-1
Sample Date		99 09 28
Physical Tests		
Moisture	%	18.8
pH		6.12
Total Metals		
Antimony	T-Sb	<20
Arsenic	T-As	<5
Barium	T-Ba	180
Beryllium	T-Be	<0.5
Cadmium	T-Cd	<0.5
Chromium	T-Cr	57
Cobalt	T-Co	12
Copper	T-Cu	31
Lead	T-Pb	<50
Mercury	T-Hg	0.030
Molybdenum	T-Mo	<4
Nickel	T-Ni	32
Selenium	T-Se	<2
Silver	T-Ag	<2
Tin	T-Sn	<10
Vanadium	T-V	80
Zinc	T-Zn	60

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	CS-51	CS-53	CS-54	CS-55	CS-56
Sample Date	99 09 26	99 09 26	99 09 26	99 09 26	99 09 26
Extractable Hydrocarbons					
EPH10-19	5000	<200	<200	<200	<200
EPH19-32	<200	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1] File No. L1131

Sample ID	CS-63	CS-60	CS-61	CS-67	CS-68
Sample Date	99 09 26	99 09 26	99 09 26	99 09 26	99 09 27
Extractable Hydrocarbons					
EPH10-19	1470	4300	<200	<200	2390
EPH19-32	<200	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	BLS-10	BLS-11	BLS-13	BLS-15	BLS-17
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
Extractable Hydrocarbons					
EPH10-19	423	<200	<200	<200	<200
EPH19-32	<200	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	BLS-18	BLS-19	BLS-20	CS-5	CS-9
Sample Date	99 09 24	99 09 24	99 09 24	99 09 25	99 09 25
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	-	<0.04	<0.02	<0.03	-
Acenaphthylene	-	<0.02	<0.02	<0.01	-
Anthracene	-	<0.01	<0.01	<0.01	-
Benz(a)anthracene	-	<0.01	<0.01	<0.01	-
Benzo(a)pyrene	-	<0.01	<0.01	<0.01	-
Benzo(b)fluoranthene	-	<0.01	<0.01	<0.01	-
Benzo(g,h,i)perylene	-	<0.01	<0.01	<0.01	-
Benzo(k)fluoranthene	-	<0.01	<0.01	<0.01	-
Chrysene	-	<0.01	<0.01	<0.01	-
Dibenz(a,h)anthracene	-	<0.01	<0.01	<0.01	-
Fluoranthene	-	<0.01	<0.01	<0.01	-
Fluorene	-	0.05	0.07	<0.03	-
Indeno(1,2,3-c,d)pyrene	-	<0.01	<0.01	<0.01	-
Naphthalene	-	<0.07	<0.06	<0.2	-
Phenanthrene	-	0.04	0.06	<0.01	-
Pyrene	-	0.01	0.01	<0.01	-
Extractable Hydrocarbons					
EPH10-19	<200	365	289	818	<200
EPH19-32	<200	523	427	<200	<200
LEPH	-	365	289	818	-
HEPH	-	523	427	<200	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	CS-15	CS-18	CS-20	CS-22	CS-26
Sample Date	99 09 25	99 09 25	99 09 25	99 09 25	99 09 25
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	-	-	-	-	<0.3
Acenaphthylene	-	-	-	-	<0.07
Anthracene	-	-	-	-	<0.01
Benz(a)anthracene	-	-	-	-	<0.01
Benzo(a)pyrene	-	-	-	-	<0.01
Benzo(b)fluoranthene	-	-	-	-	<0.01
Benzo(g,h,i)perylene	-	-	-	-	<0.01
Benzo(k)fluoranthene	-	-	-	-	<0.01
Chrysene	-	-	-	-	<0.01
Dibenz(a,h)anthracene	-	-	-	-	<0.01
Fluoranthene	-	-	-	-	<0.01
Fluorene	-	-	-	-	<0.3
Indeno(1,2,3-c,d)pyrene	-	-	-	-	<0.01
Naphthalene	-	-	-	-	<2
Phenanthrene	-	-	-	-	<0.07
Pyrene	-	-	-	-	<0.01
Extractable Hydrocarbons					
EPH10-19	2260	<200	<200	1730	2080
EPH19-32	<200	<200	<200	<200	<200
LEPH	-	-	-	-	2080
HEPH	-	-	-	-	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	CS-27	CS-31	CS-36	CS-37	CS-40
Sample Date	99 09 25	99 09 25	99 09 25	99 09 25	99 09 26
Extractable Hydrocarbons					
EPH10-19	<200	<200	2620	1870	<200
EPH19-32	<200	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	CS-41	CS-42	CS-43	CS-45	CS-46
Sample Date	99 09 26	99 09 26	99 09 26	99 09 26	99 09 26
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	-	-	<0.4	<0.2	-
Acenaphthylene	-	-	<0.2	<0.05	-
Anthracene	-	-	<0.01	<0.01	-
Benz(a)anthracene	-	-	<0.01	<0.01	-
Benzo(a)pyrene	-	-	<0.01	<0.01	-
Benzo(b)fluoranthene	-	-	<0.01	<0.01	-
Benzo(g,h,i)perylene	-	-	<0.01	<0.01	-
Benzo(k)fluoranthene	-	-	<0.01	<0.01	-
Chrysene	-	-	<0.01	<0.01	-
Dibenz(a,h)anthracene	-	-	<0.01	<0.01	-
Fluoranthene	-	-	<0.01	<0.01	-
Fluorene	-	-	<0.5	0.20	-
Indeno(1,2,3-c,d)pyrene	-	-	<0.01	<0.01	-
Naphthalene	-	-	5.4	<4	-
Phenanthrene	-	-	<0.2	0.07	-
Pyrene	-	-	<0.01	<0.01	-
Extractable Hydrocarbons					
EPH10-19	8180	9830	2420	1060	<200
EPH19-32	<200	<200	<200	353	<200
LEPH	-	-	2420	1060	-
HEPH	-	-	<200	353	-

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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	CS-47	CS-50	CS-71	UST 2	UST 4
Sample Date	99 09 26	99 09 26	99 09 27	99 09 27	99 09 27
Extractable Hydrocarbons					
EPH10-19	<200	835	<200	4060	<200
EPH19-32	<200	<200	<200	<200	<200

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
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RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. L1131

Sample ID	UST 11	TP56-2	TP58-1
Sample Date	99 09 28	99 09 28	99 09 28
Extractable Hydrocarbons			
EPH10-19	2650	<200	<200
EPH19-32	<200	<200	<200

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VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

Sediment/Soil[1]	**CS-51**	**CS-51**
	99 09 26	QC # 174664
Extractable Hydrocarbons		
EPH10-19	5000	5020
EPH19-32	<200	<200

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

Sediment/Soil[1]		BLS-10 99 09 24	BLS-10 QC # 174665
Physical Tests			
Moisture	%	61.2	62.6
pH		7.40	7.37
Total Metals			
Antimony	T-Sb	<40	<40
Arsenic	T-As	15	11
Barium	T-Ba	774	648
Beryllium	T-Be	<1	<1
Cadmium	T-Cd	0.5	0.6
Chromium	T-Cr	71	83
Cobalt	T-Co	23	23
Copper	T-Cu	51	53
Lead	T-Pb	<100	<100
Mercury	T-Hg	0.088	0.101
Molybdenum	T-Mo	<8	<8
Nickel	T-Ni	50	49
Selenium	T-Se	<2	<2
Silver	T-Ag	<4	<4
Tin	T-Sn	<20	<20
Vanadium	T-V	106	118
Zinc	T-Zn	369	299
Extractable Hydrocarbons			
EPH10-19		423	231
EPH19-32		<200	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1131

Sediment/Soil[1]		BLS-20	BLS-20
		99 09 24	QC # 174666
Physical Tests			
Moisture	%	39.0	33.3
pH		6.17	6.10
Total Metals			
Antimony	T-Sb	<20	<20
Arsenic	T-As	5	<5
Barium	T-Ba	269	237
Beryllium	T-Be	<0.5	<0.5
Cadmium	T-Cd	0.6	0.6
Chromium	T-Cr	65	53
Cobalt	T-Co	14	12
Copper	T-Cu	37	34
Lead	T-Pb	<50	<50
Mercury	T-Hg	0.041	0.041
Molybdenum	T-Mo	<4	<4
Nickel	T-Ni	35	31
Selenium	T-Se	<2	<2
Silver	T-Ag	<2	<2
Tin	T-Sn	<10	<10
Vanadium	T-V	93	74
Zinc	T-Zn	428	474

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1131

Sediment/Soil[1]	**BLS-20**	**BLS-20**
	99 09 24	QC # 174666
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.02	<0.02
Acenaphthylene	<0.02	<0.02
Anthracene	<0.01	<0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.01	<0.01
Benzo(g,h,i)perylene	<0.01	<0.01
Benzo(k)fluoranthene	<0.01	<0.01
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	0.07	0.04
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	<0.06	<0.06
Phenanthrene	0.06	0.03
Pyrene	0.01	0.01
Extractable Hydrocarbons		
EPH10-19	289	293
EPH19-32	427	323
LEPH	289	293
HEPH	427	323

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1131

Sediment/Soil[1]		**CS-37**	**CS-37**
		99 09 25	QC # 174667
Physical Tests			
Moisture	%	15.1	13.3
Extractable Hydrocarbons			
EPH10-19		1870	1640
EPH19-32		<200	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per dry kilogram except where noted.

LABORATORY REPORT FOR
SWEP/LEP TESTS

Triumph Street, Vancouver, BC Canada V5L 1K5

Analytical
Service
Laboratories
Ltd.

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

CHEMICAL ANALYSIS REPORT

Date:	October 28, 1999
ASL File No.	L1782
Report On:	Blanchard River Soil Analysis
Report To:	**Royal Roads University** Applied Research Division 2005 Sooke Road Victoria, BC V9B 5Y2
Attention:	**Dr. Matthew Dodd**, Professor
Received:	September 30, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1782

Sample ID		BLS-10	BLS-11
Sample Date		99 09 24	99 09 24
Physical Tests			
Moisture	%	63.4	30.6
Initial SWEP pH		6.92	7.05
Final SWEP pH		5.22	5.17
Extractable Metals			
Arsenic	As	<0.2	<0.2
Barium	Ba	0.24	0.14
Boron	B	<0.1	<0.1
Cadmium	Cd	<0.01	<0.01
Chromium	Cr	<0.01	<0.01
Copper	Cu	<0.01	<0.01
Lead	Pb	<0.05	<0.05
Mercury	Hg	<0.00005	<0.00005
Selenium	Se	<0.2	<0.2
Silver	Ag	<0.01	<0.01
Zinc	Zn	<0.05	<0.05

Results are expressed as milligrams per litre, as per the requirements of the Special Waste Regulations, B.C. Reg.63/88.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1217

Sample ID		BLS-16
Sample Date		99 06 15
Sample Time		17:10
Physical Tests		
Moisture	%	78.7
Initial SWEP pH		6.98
Final SWEP pH		5.07
Extractable Metals		
Arsenic	As	<1
Barium	Ba	11.2
Boron	B	<0.5
Cadmium	Cd	<0.05
Chromium	Cr	<0.05
Copper	Cu	<0.05
Lead	Pb	<0.3
Mercury	Hg	<0.00005
Selenium	Se	<1
Silver	Ag	<0.05
Zinc	Zn	3.2

Results are expressed as milligrams per litre, as per the requirements of the Special Waste Regulations, B.C. Reg.63/88.
< = Less than the detection limit indicated.

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

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

Special Waste/Leachate Extraction Procedure (SWEP/LEP) for Metals

This analysis is carried out in accordance with the extraction procedure outlined in the Waste Management Act, British Columbia Special Waste Regulation - Schedule Reg. 63/88, February 29, 1988. In summary the sample is extracted for a 24 hour period using 0.5 N acetic acid to maintain the pH of the extract at 5.0. The resulting extract is then filtered through a 0.45 micron membrane filter and analysed by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Recommended Holding Time:

Sample:	6 months (Mercury = 28 days)
Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

End of Report

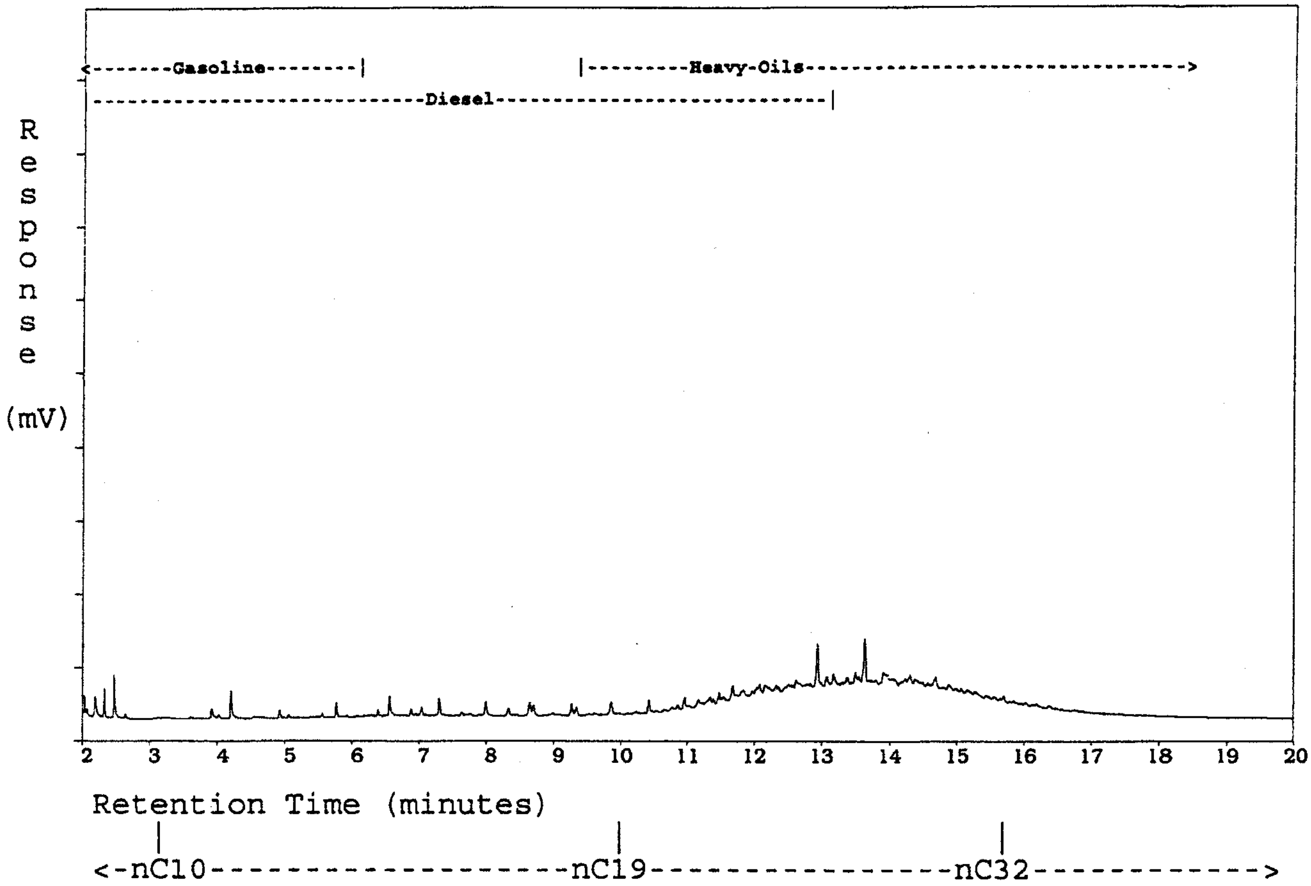
APPENDIX F:
HYDROCARBON DISTRIBUTION REPORTS

HYDROCARBON DISTRIBUTION REPORTS
FOR
SOIL/SEDIMENT SAMPLES

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: BLS-16

File Name: C:\TEH\JN25\EH1JN25.64R ASL Sample ID: K6884-T--42 Sample acquired: JUN 26, 1999 13:19:05
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 1.8 Dilution: 10.0

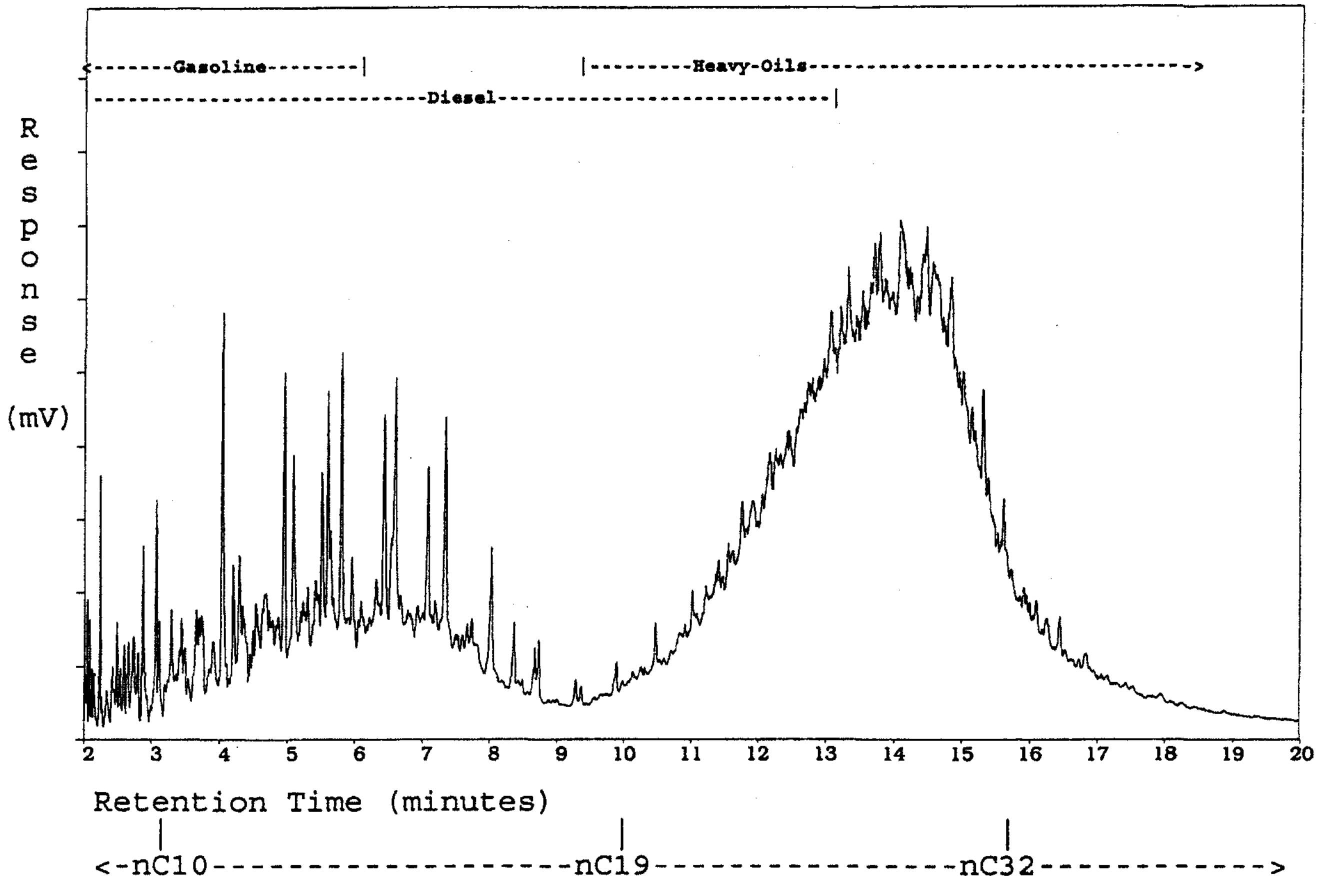
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TH9-7

File Name: C:\TEH\JN25\EH1JN25.72R   ASL Sample ID: K6884-T--55   Sample acquired: JUN 26, 1999 15:41:13
Chromatogram Scale: 200.0 millivolts



Sample Amt. (g or mL):   9.3   Dilution: 10.0

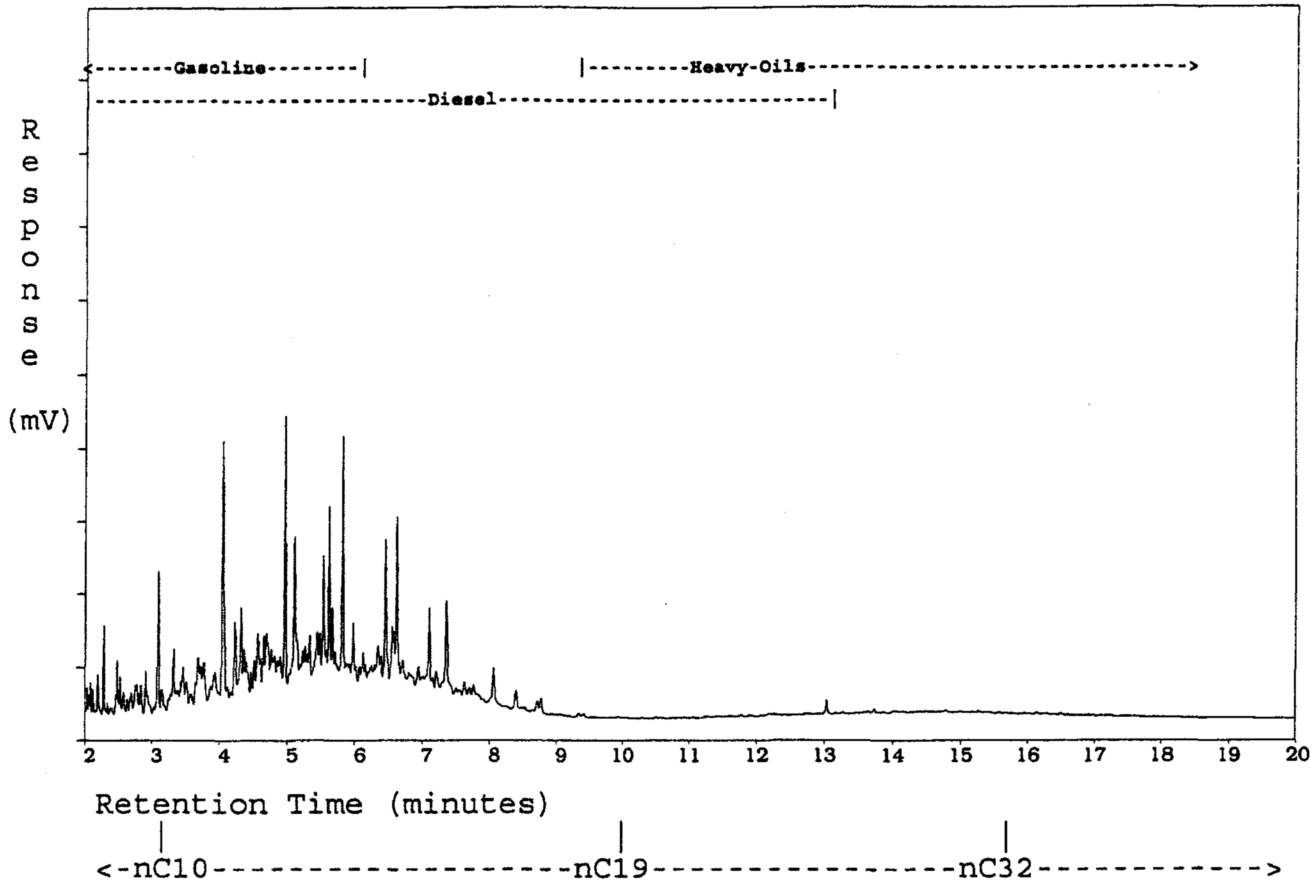
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TH12-5

File Name: C:\TEH\JN25\EH1JN25.23R ASL Sample ID: K6884-T--28 Sample acquired: JUN 25, 1999 20:03:35
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 10.8 Dilution: 10.0

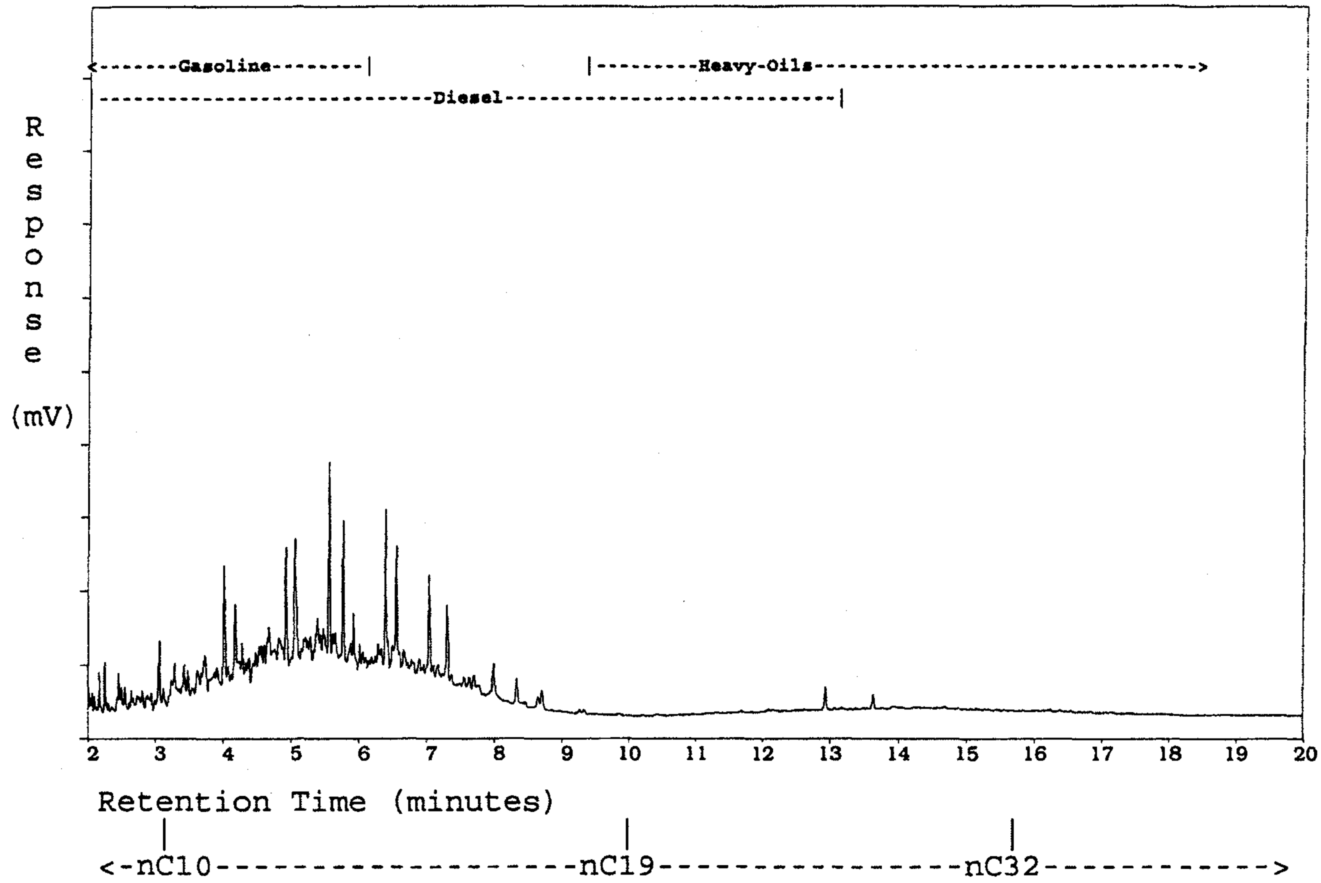
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TH12-10

File Name: C:\TEH\JN25\EH1JN25.24R   ASL Sample ID: K6884-T--29   Sample acquired: JUN 25, 1999 20:03:35
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL):   9.6   Dilution: 10.0

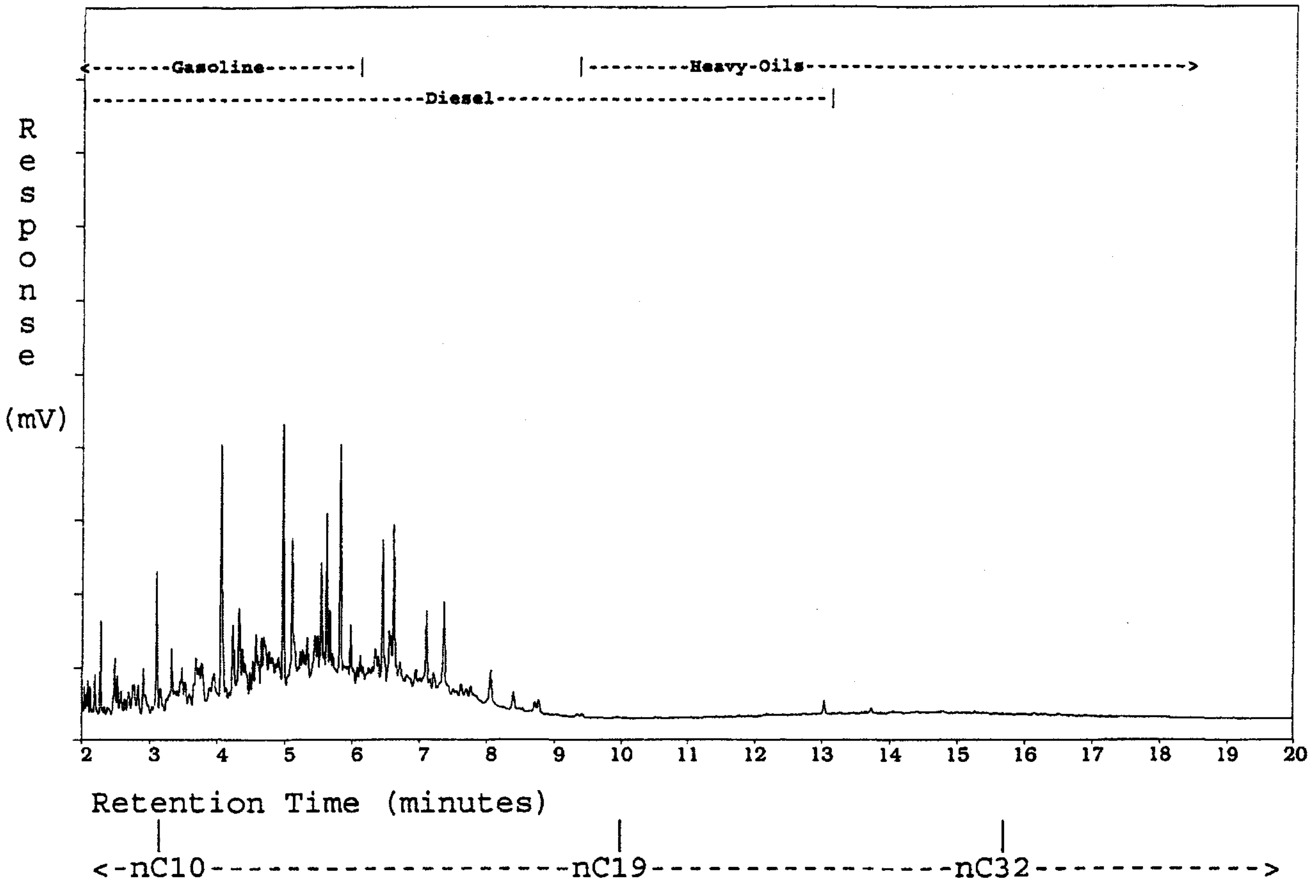
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TH12-16

File Name: C:\TEH\JN25\EH1JN25.25R ASL Sample ID: K6884-T--30 Sample acquired: JUN 25, 1999 20:38:49
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 10.1 Dilution: 10.0

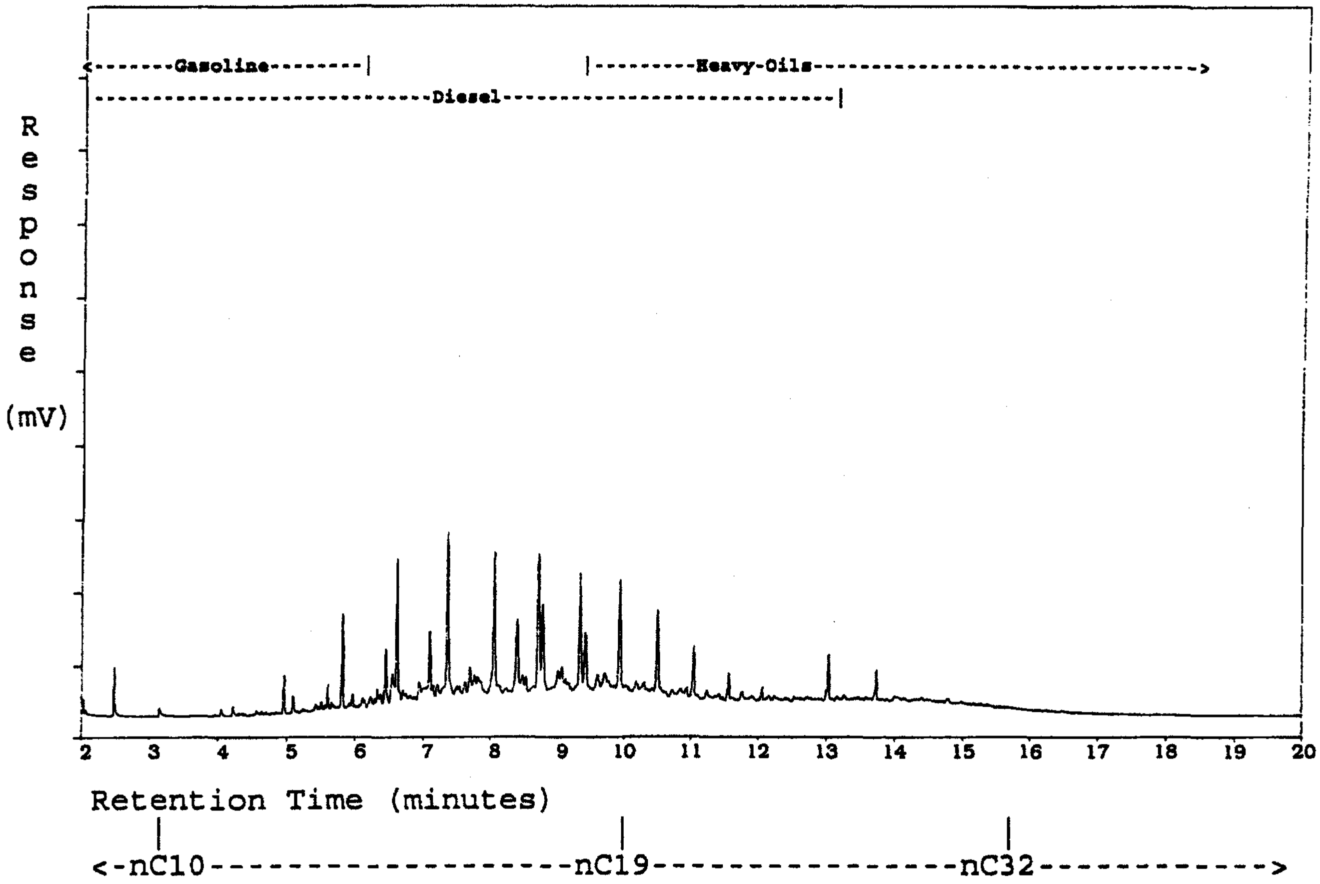
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TH17-4

File Name: C:\TEH\JN28\EH1JN28.11R **ASL Sample ID:** K6884-T--63 **Sample acquired:** JUN 28, 1999 18:04:11
Chromatogram Scale: 50.0 millivolts



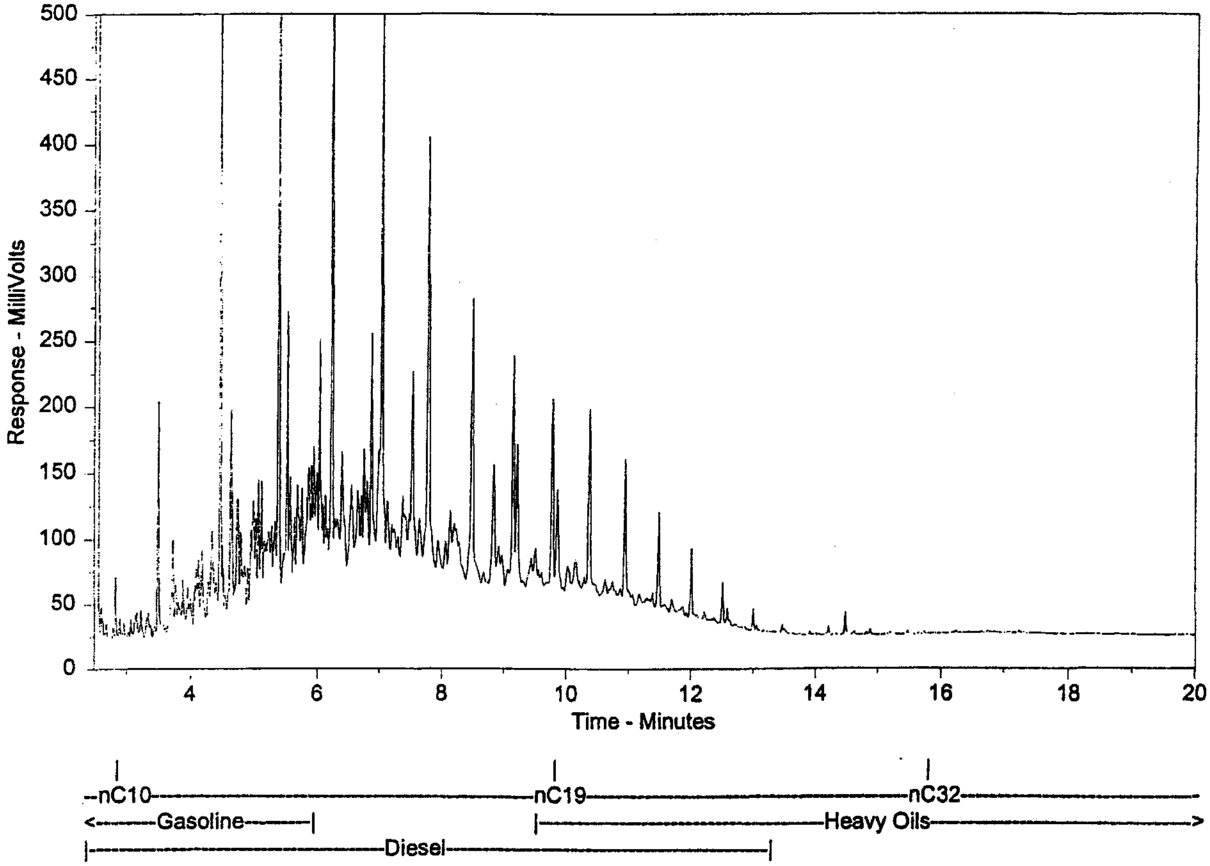
Sample Amt. (g or mL): 8.6 Dilution: 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH18-6
ASL Sample ID: L1002-T--19
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0011.RAW
Run Information: Acquired on GC04, 9/30/99 6:46:57 PM



Sample Amount = 8.4 (g or mL)

Dilution Factor = 10.0

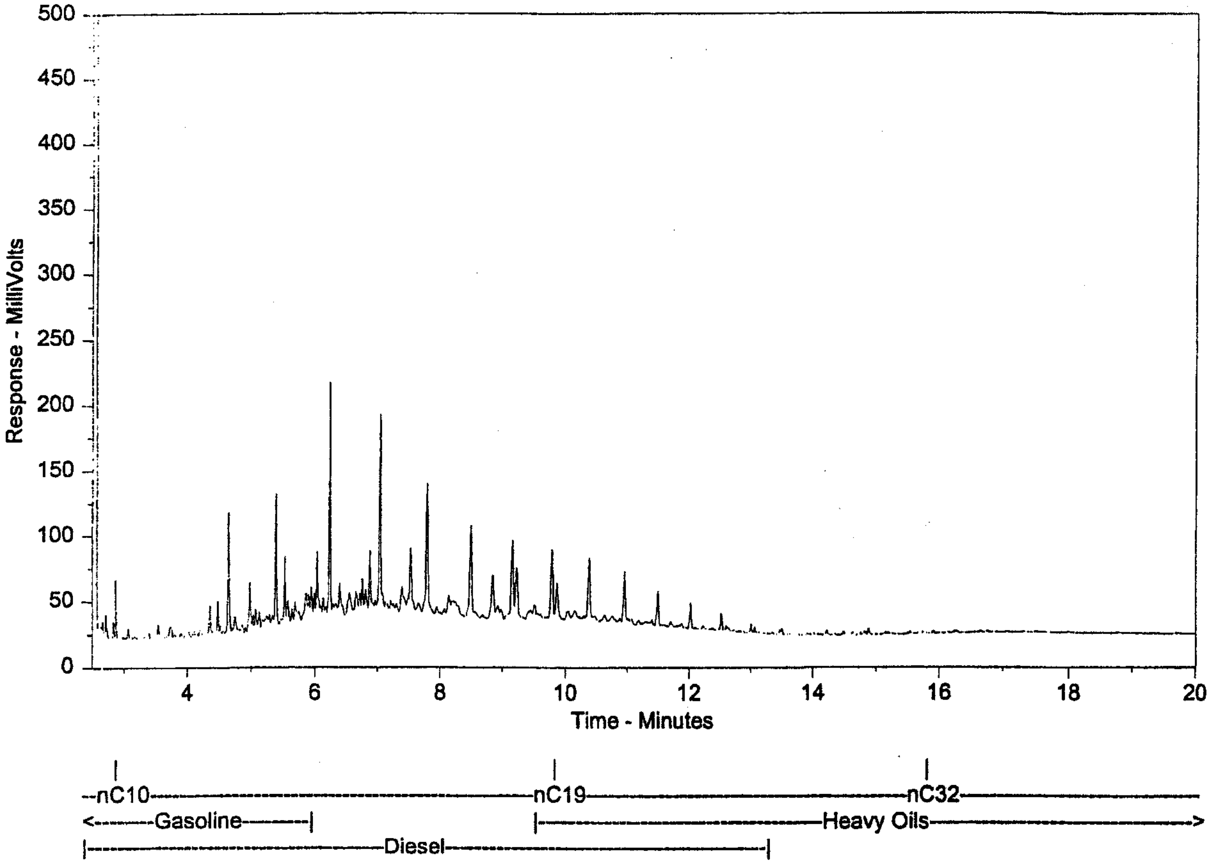
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH19-4
ASL Sample ID: L1002-T--23
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0014.RAW
Run Information: Acquired on GC04, 9/30/99 8:21:16 PM



Sample Amount = 8.7 (g or mL)

Dilution Factor = 10.0

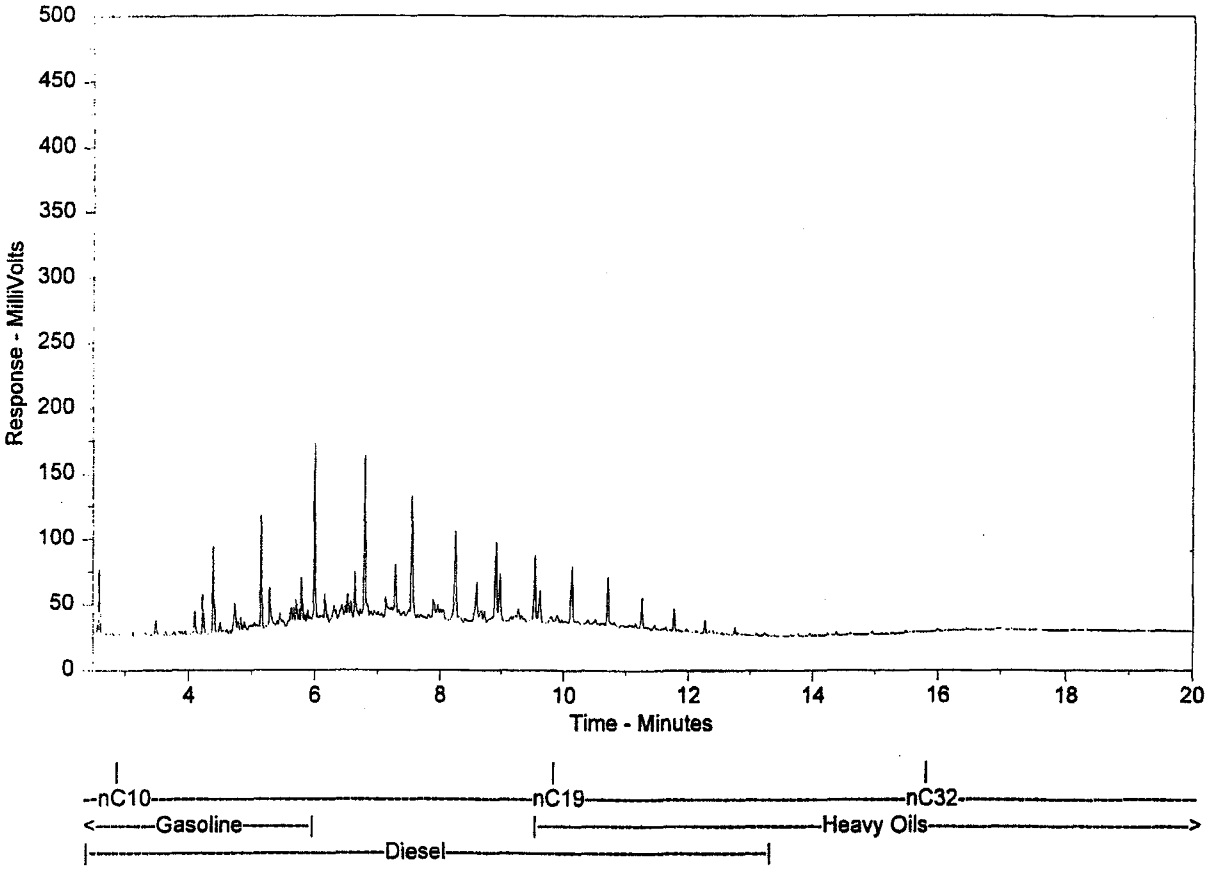
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH19-5
ASL Sample ID: **L1002-T--24#RE**
File Name: c:\chrom\gc04\data\gc04_06octA.0022.RAW
Run Information: Acquired on GC04, 10/7/99 12:31:03 AM



Sample Amount = 9.5 (g or mL) Dilution Factor = 10.0

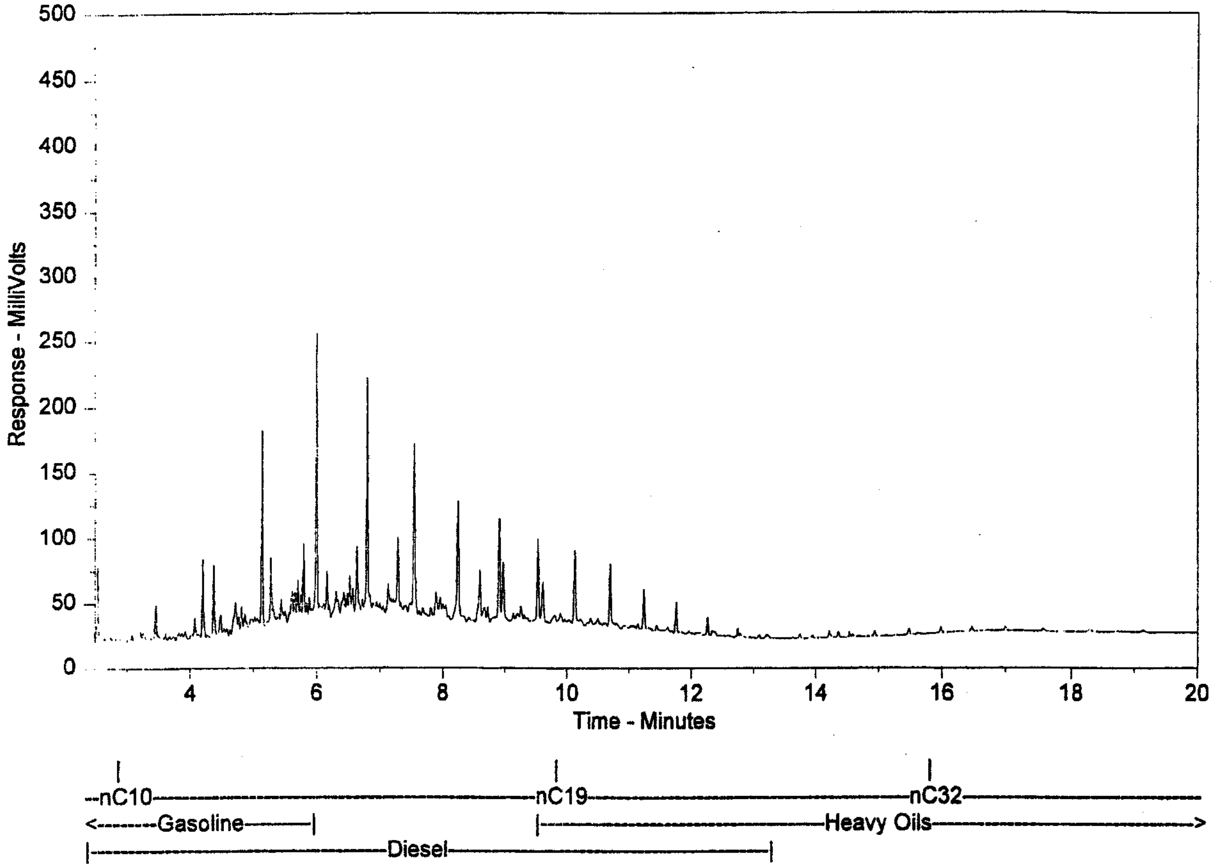
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH19-6
ASL Sample ID: **L1002-T--25#RR**
File Name: c:\chrom\gc04\data\gc04_05octA.0035.RAW
Run Information: Acquired on GC04, 10/6/99 9:44:34 AM



Sample Amount = 7.7 (g or mL) Dilution Factor = 10.0

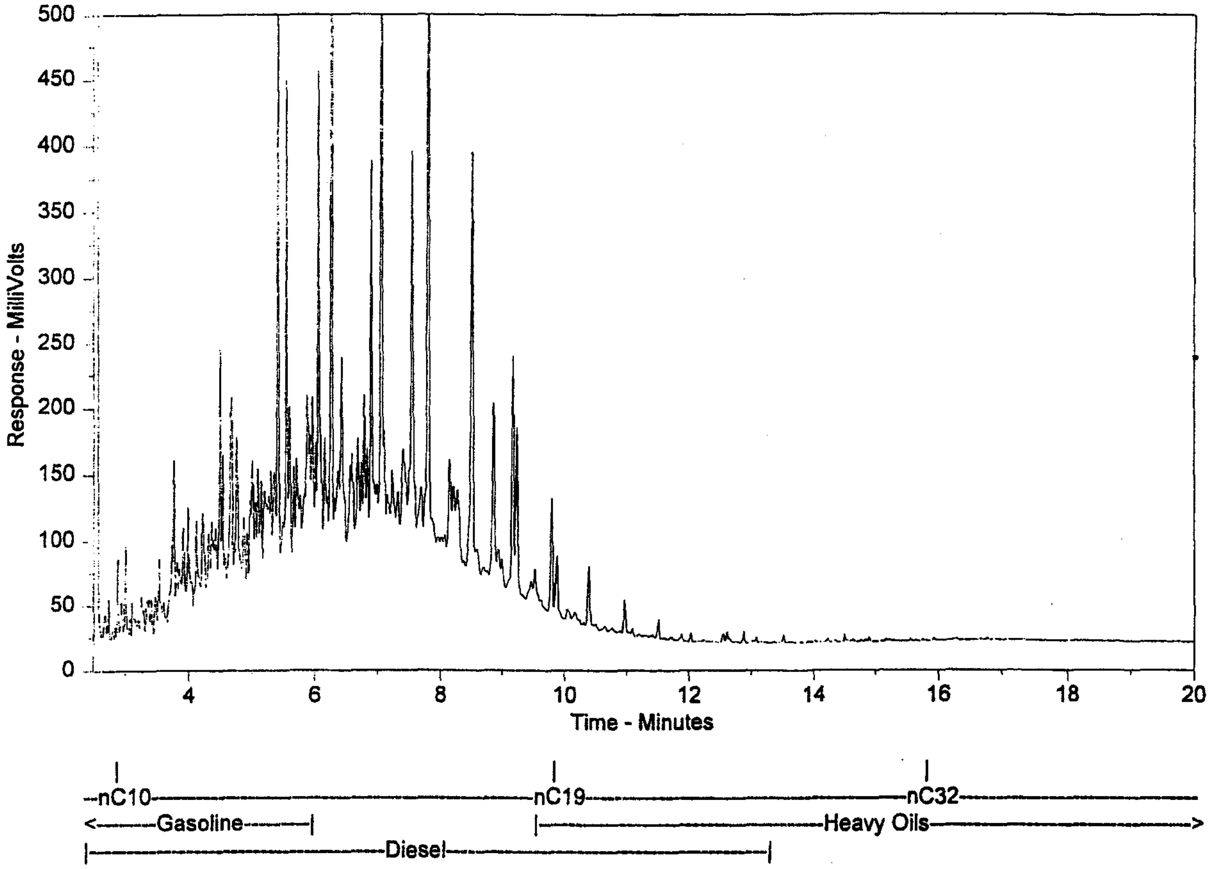
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH21-2
ASL Sample ID: **L1002-T--29**
File Name: c:\chrom\gc04\data\gc04_01octB.0011.RAW
Run Information: Acquired on GC04, 10/1/99 10:09:34 PM



Sample Amount = 10.9 (g or mL)

Dilution Factor = 10.0

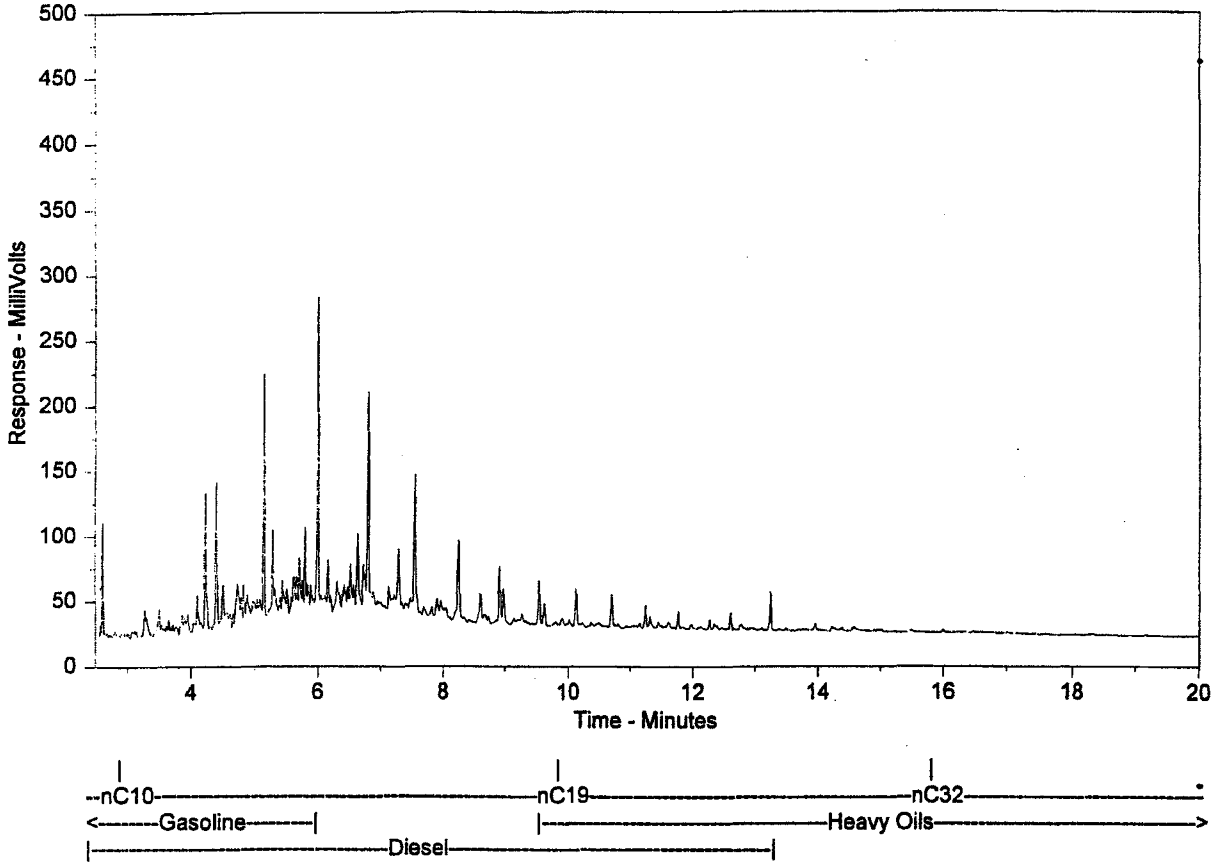
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	TH24-20
ASL Sample ID:	**L1002-T--37**
File Name:	C:\chrom\gc04\data\gc04_03octA.0017.RAW
Run Information:	Acquired on GC04, 10/4/99 1:12:16 AM



Sample Amount = 10.7 (g or mL) Dilution Factor = 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

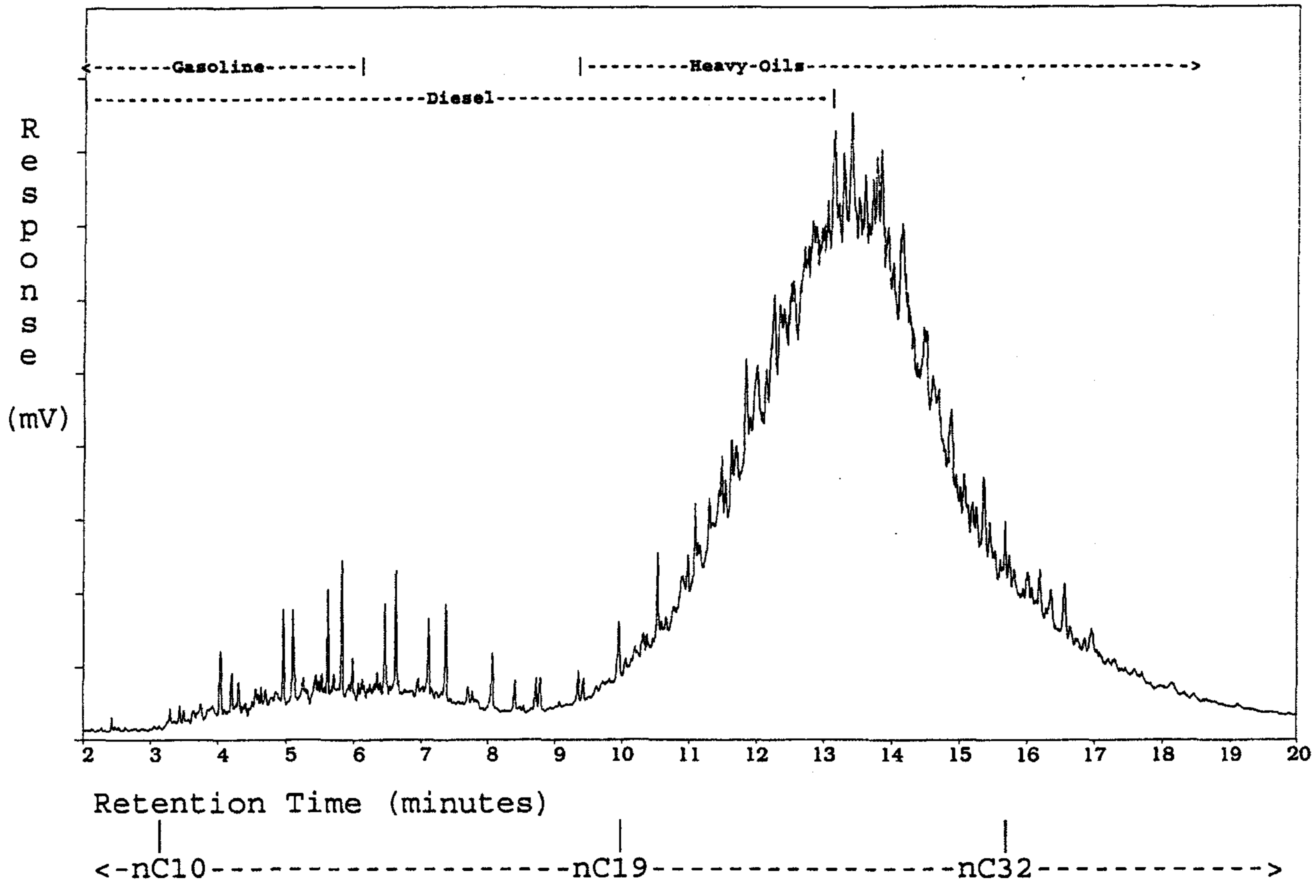
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP11-1

File Name: C:\TEH\JN25\EH1JN25.69R ASL Sample ID: K6884-T--48 Sample acquired: JUN 26, 1999 15:06:00
Chromatogram Scale: 150.0 millivolts



Sample Amt. (g or mL): 10.4 Dilution: 10.0

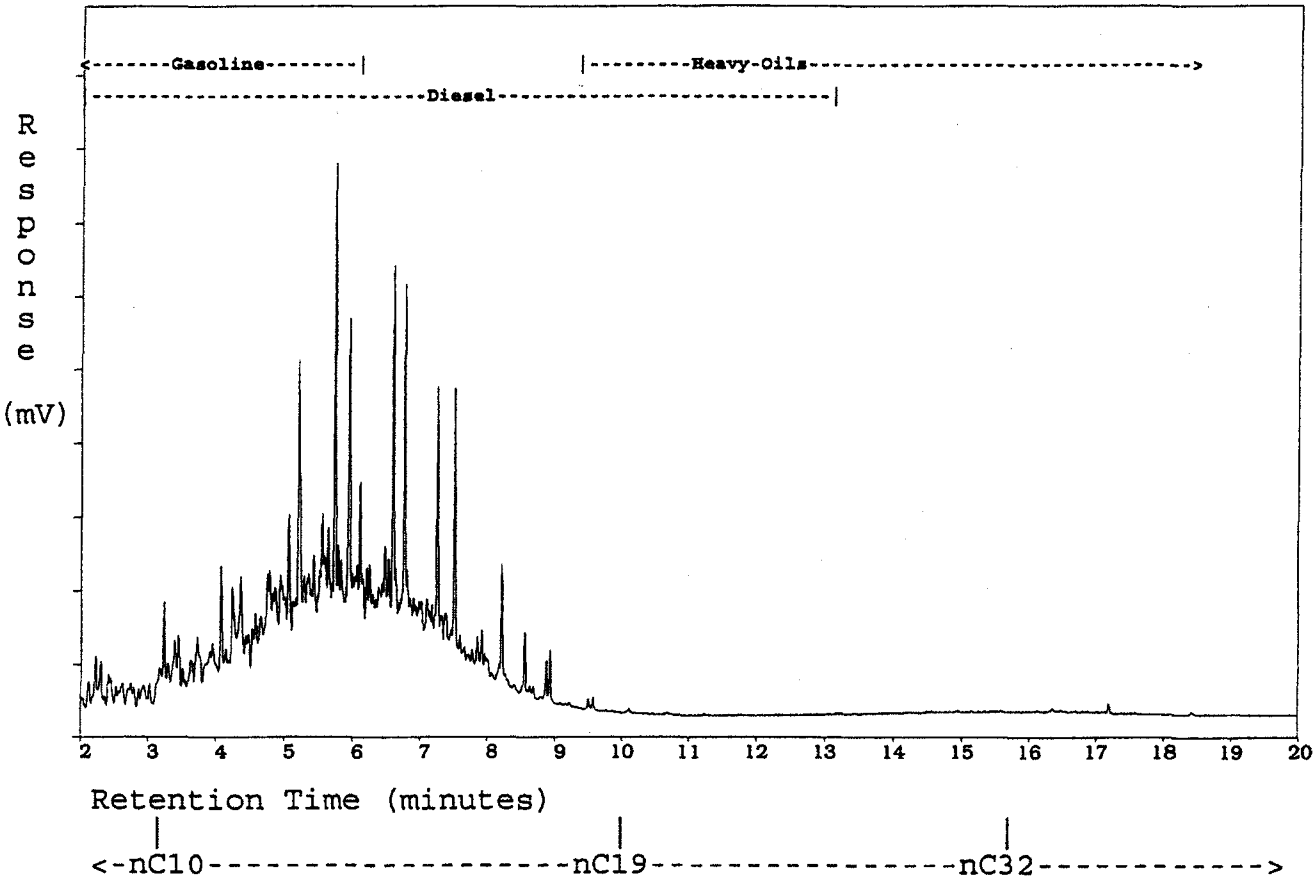
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP13-1

File Name: C:\TEH2\JN24\EH3JN24.54R   ASL Sample ID: K6884-T--70   Sample acquired: JUN 25, 1999 01:47:17
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL):   13.1   Dilution: 8.0

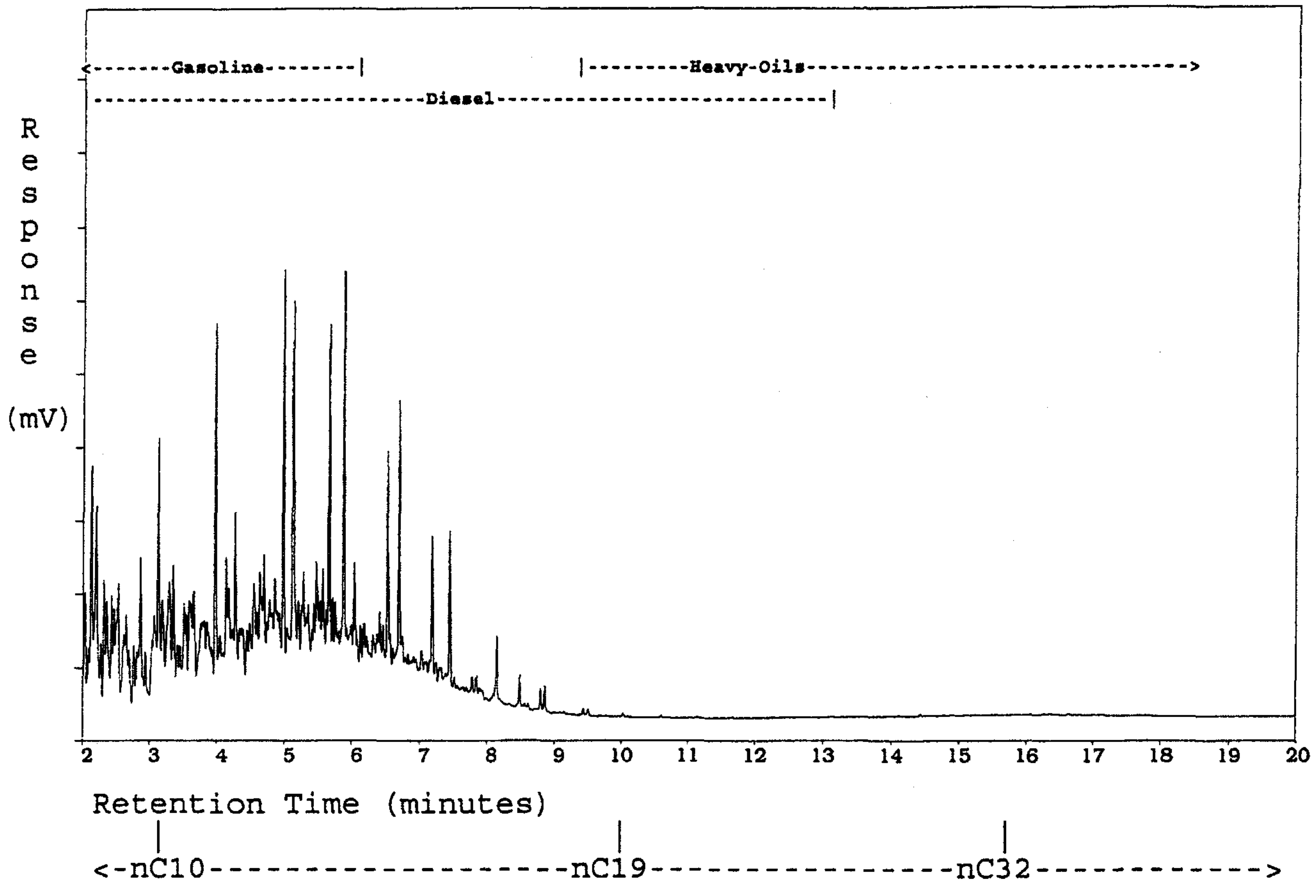
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP13-2

File Name: C:\TEH2\JN24\EH3JN24.53R ASL Sample ID: K6884-T--69 Sample acquired: JUN 25, 1999 01:47:17
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.6 Dilution: 8.0

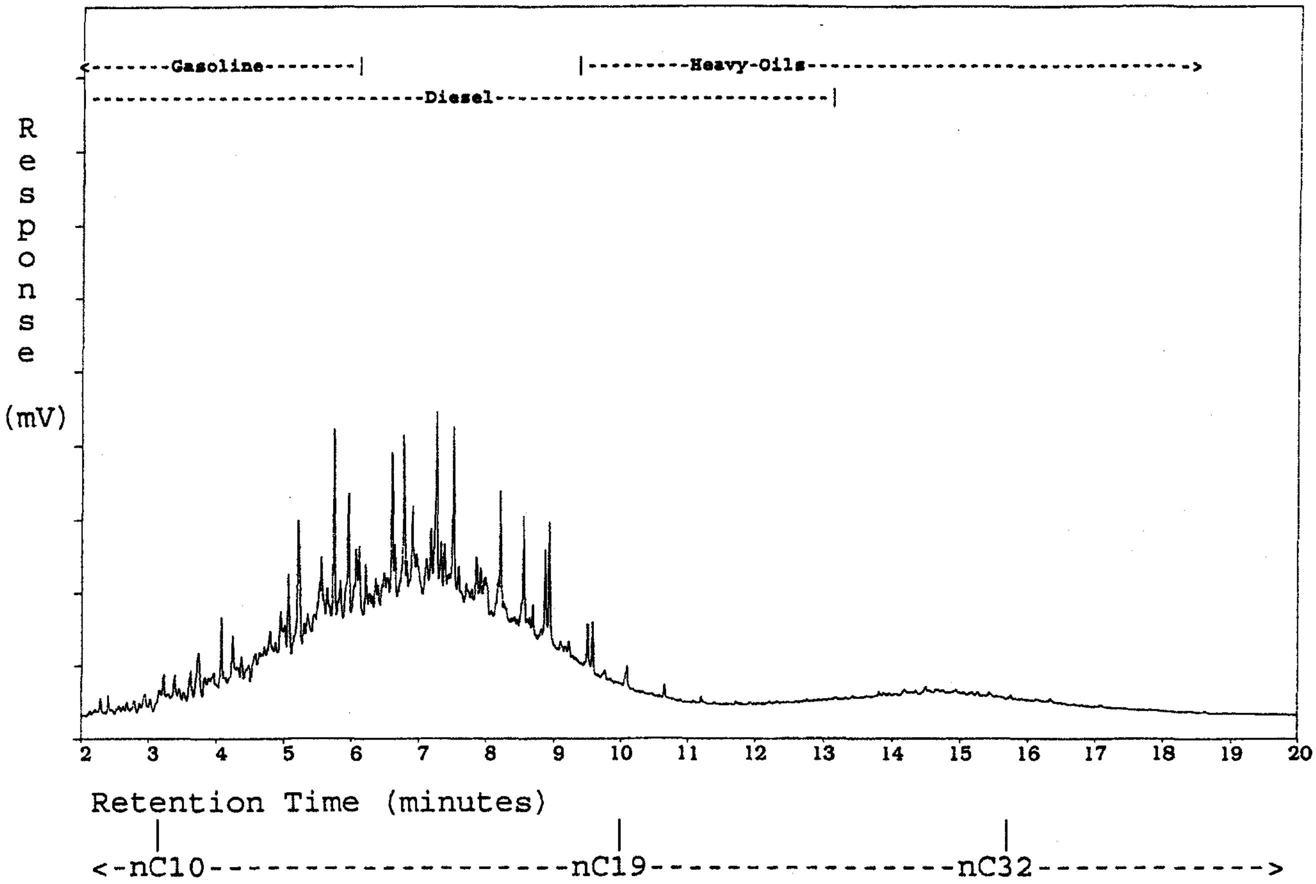
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE. NAME: TP15-1

File Name: C:\TEH2\JN24\EH3JN24.56R ASL Sample ID: K6884-T--72 Sample acquired: JUN 25, 1999 02:31:20
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 13.2 Dilution: 8.0

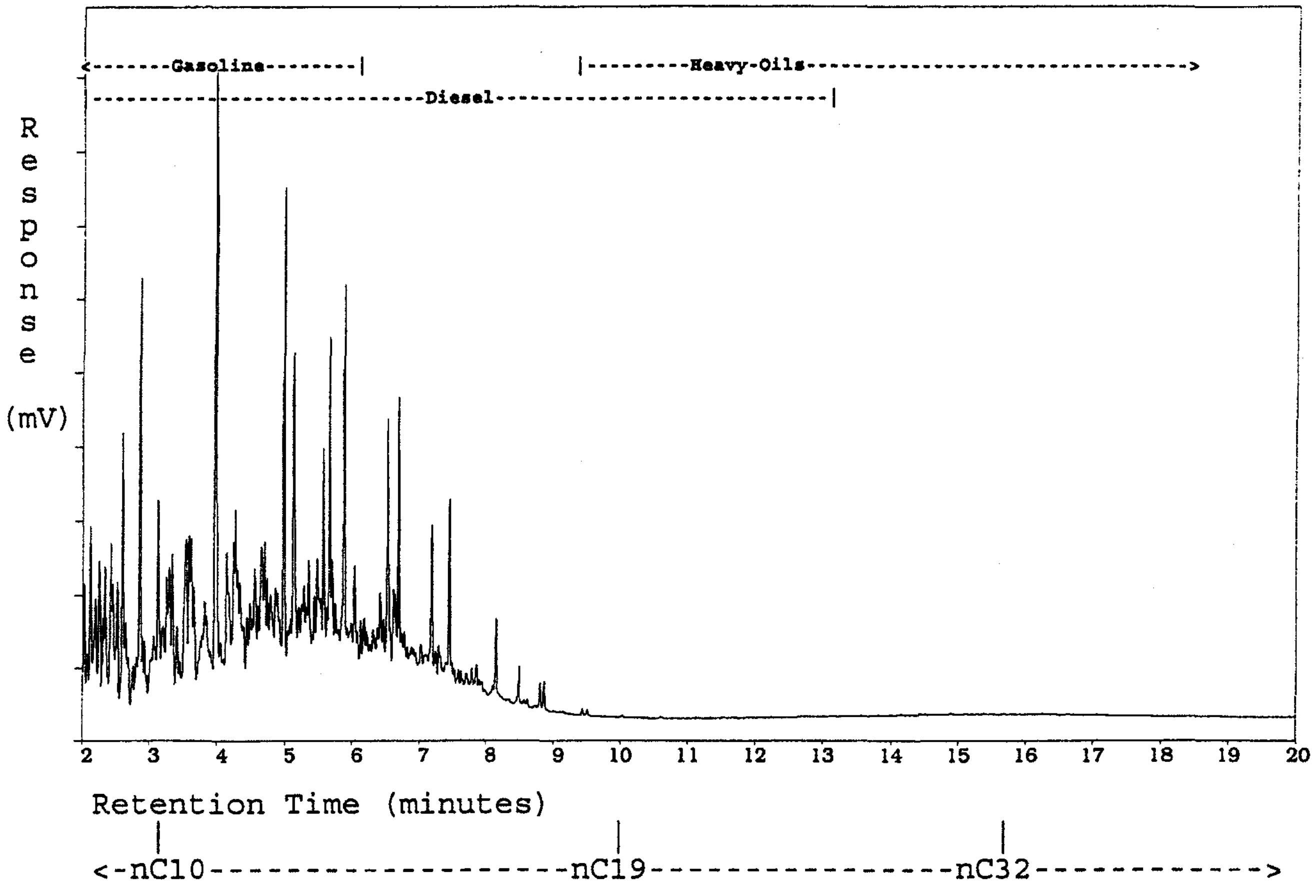
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP28-2

File Name: C:\TEH2\JN24\EH3JN24.69R ASL Sample ID: K6884-T--83 Sample acquired: JUN 25, 1999 07:08:14
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.2 Dilution: 8.0

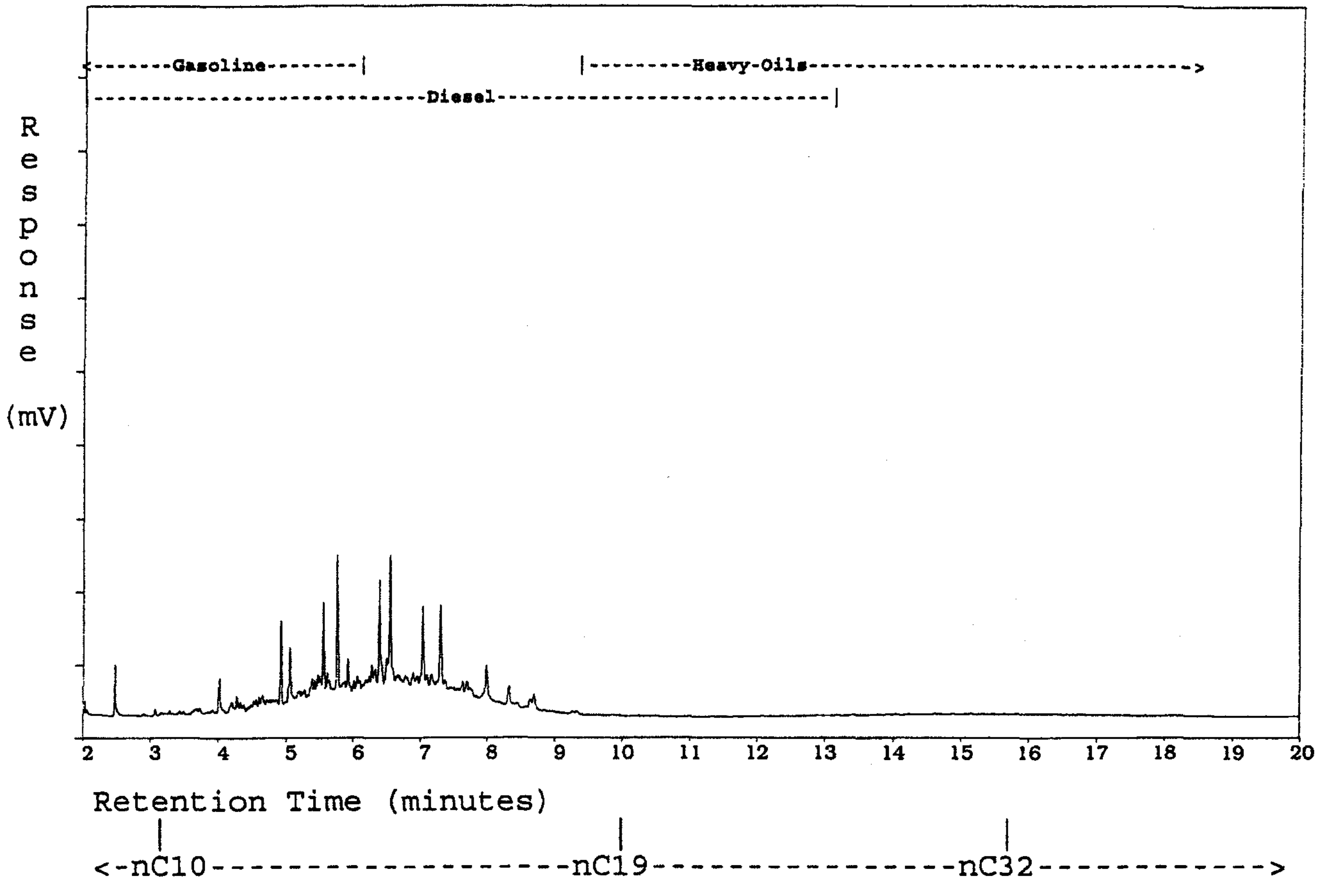
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP28-3

File Name: C:\TEH\JN28\EH1JN28.08R ASL Sample ID: K6884-T--56 Sample acquired: JUN 28, 1999 16:53:35
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 8.1 Dilution: 10.0

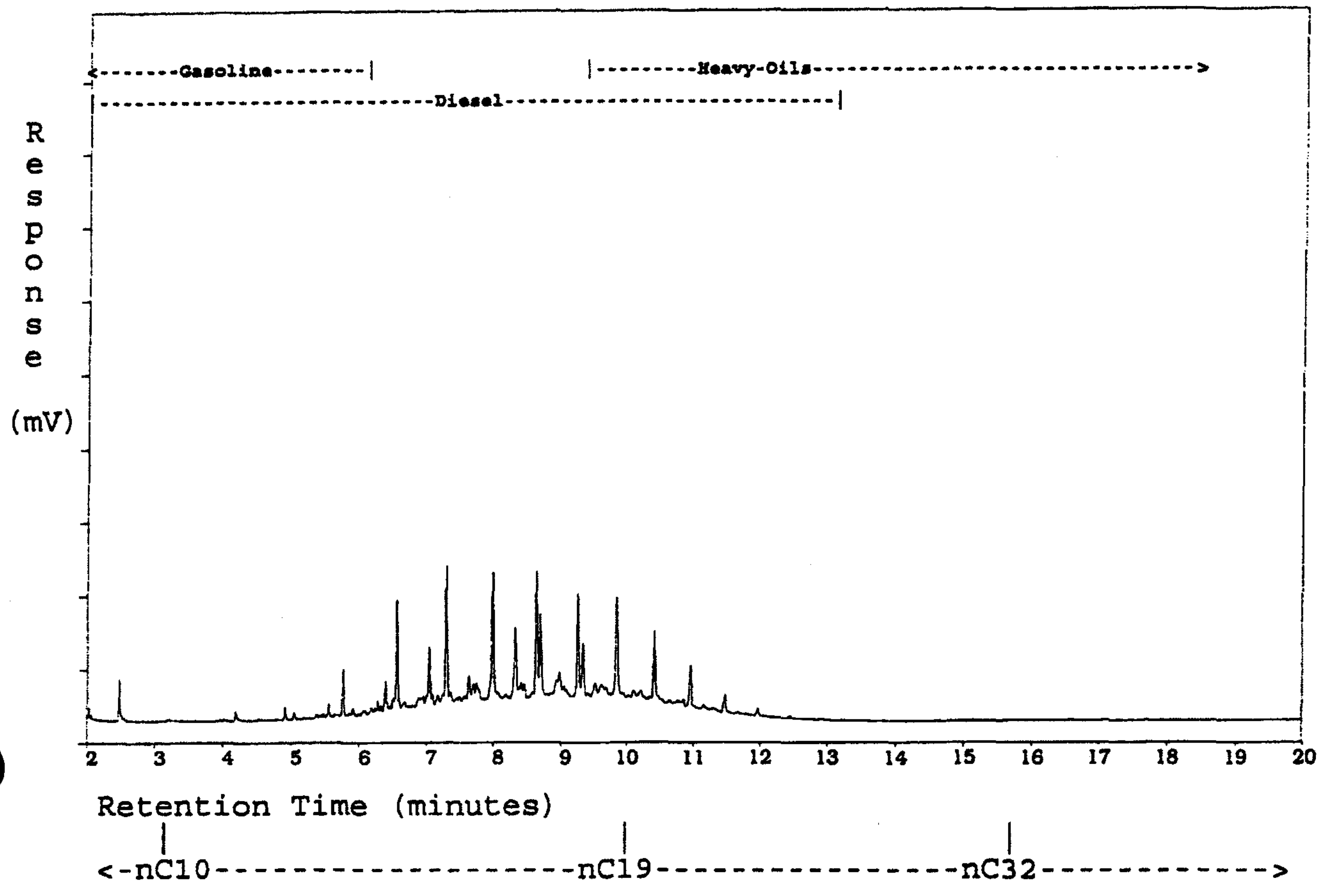
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP33-4

File Name: C:\TEH\JN28\EH1JN28.14R ASL Sample ID: K6884-T--80 Sample acquired: JUN 28, 1999 18:39:32
Chromatogram Scale: 50.0 millivolts



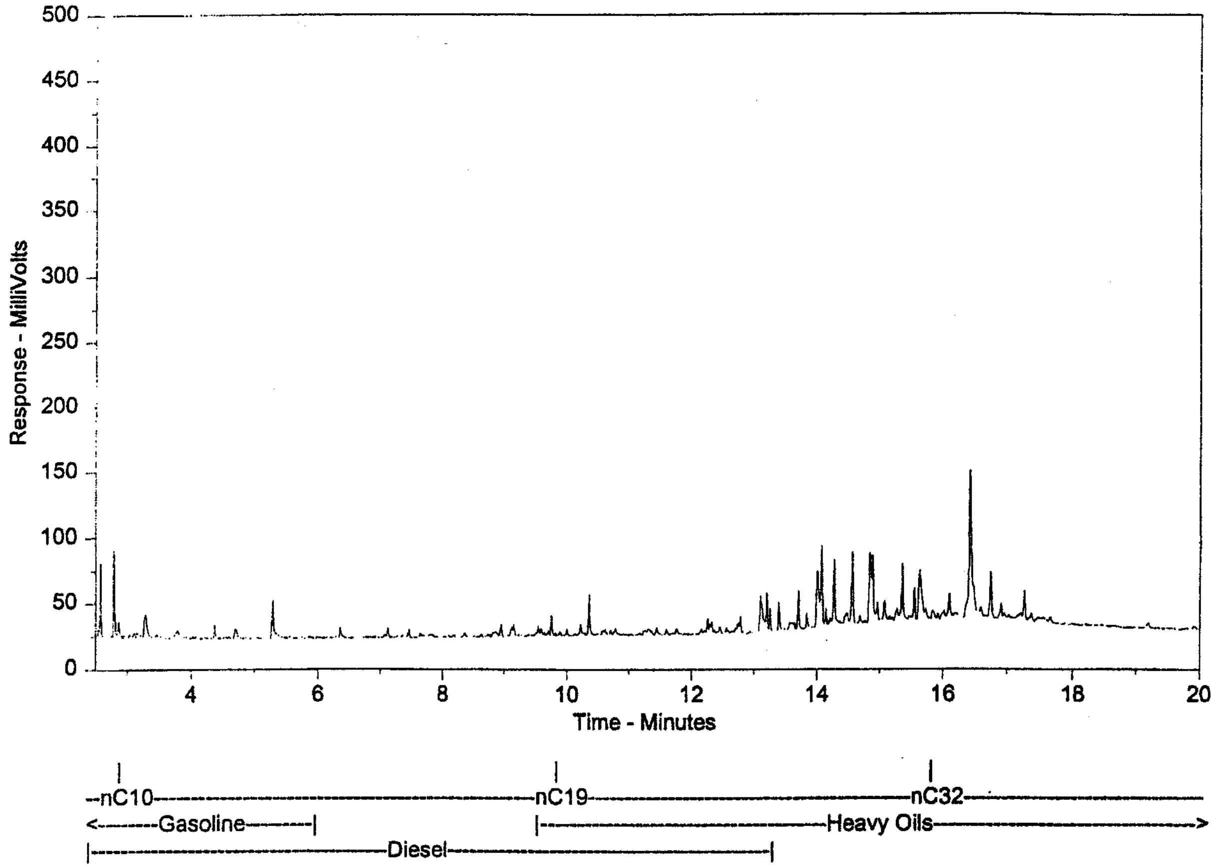
Sample Amt. (g or mL): 9.2 Dilution: 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	TP49-3
ASL Sample ID:	**L1002-T--14**
File Name:	M:\Chrom\gc04\data\30sep\gc04_30sepA.0009.RAW
Run Information:	Acquired on GC04, 9/30/99 5:43:48 PM



Sample Amount = 3.2 (g or mL)

Dilution Factor = 10.0

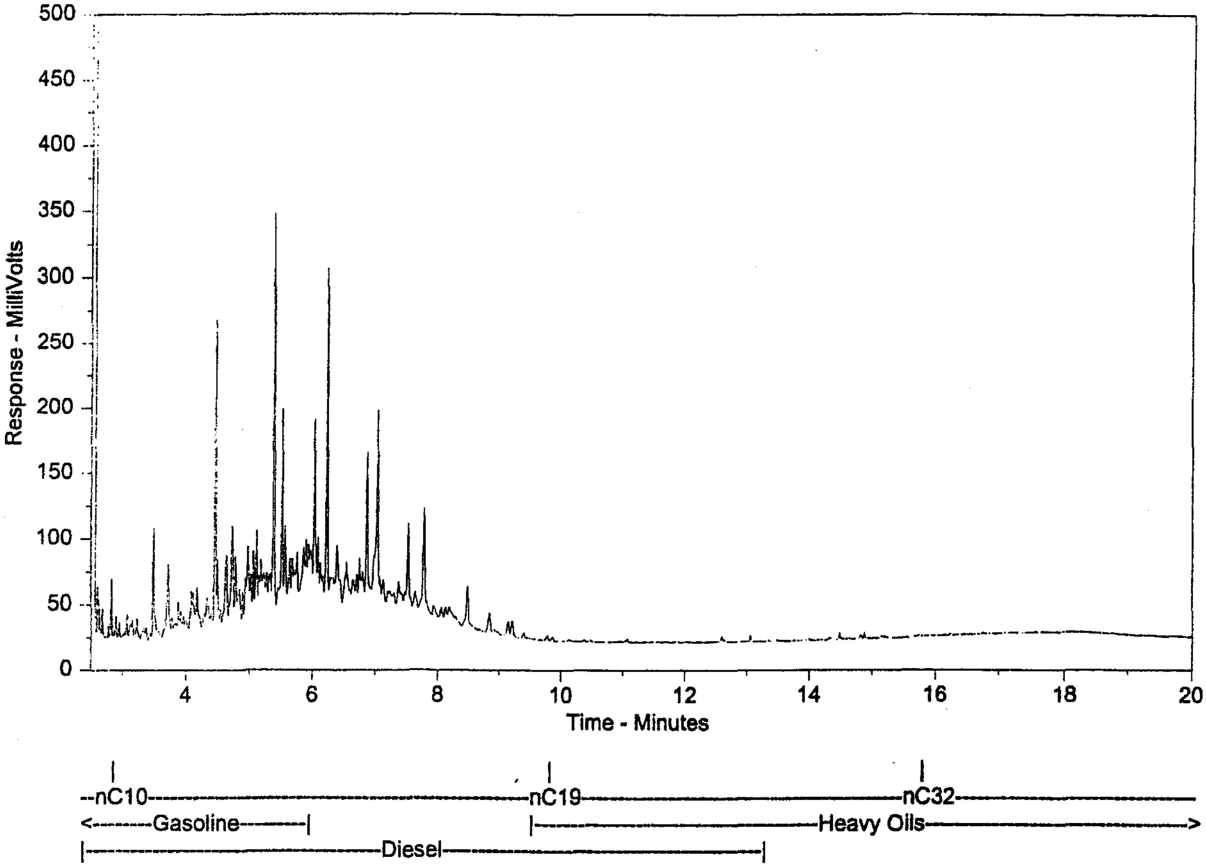
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TP49-4
ASL Sample ID: **L1002-T--15**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0010.RAW
Run Information: Acquired on GC04, 9/30/99 6:15:24 PM



Sample Amount = 7.9 (g or mL) Dilution Factor = 10.0

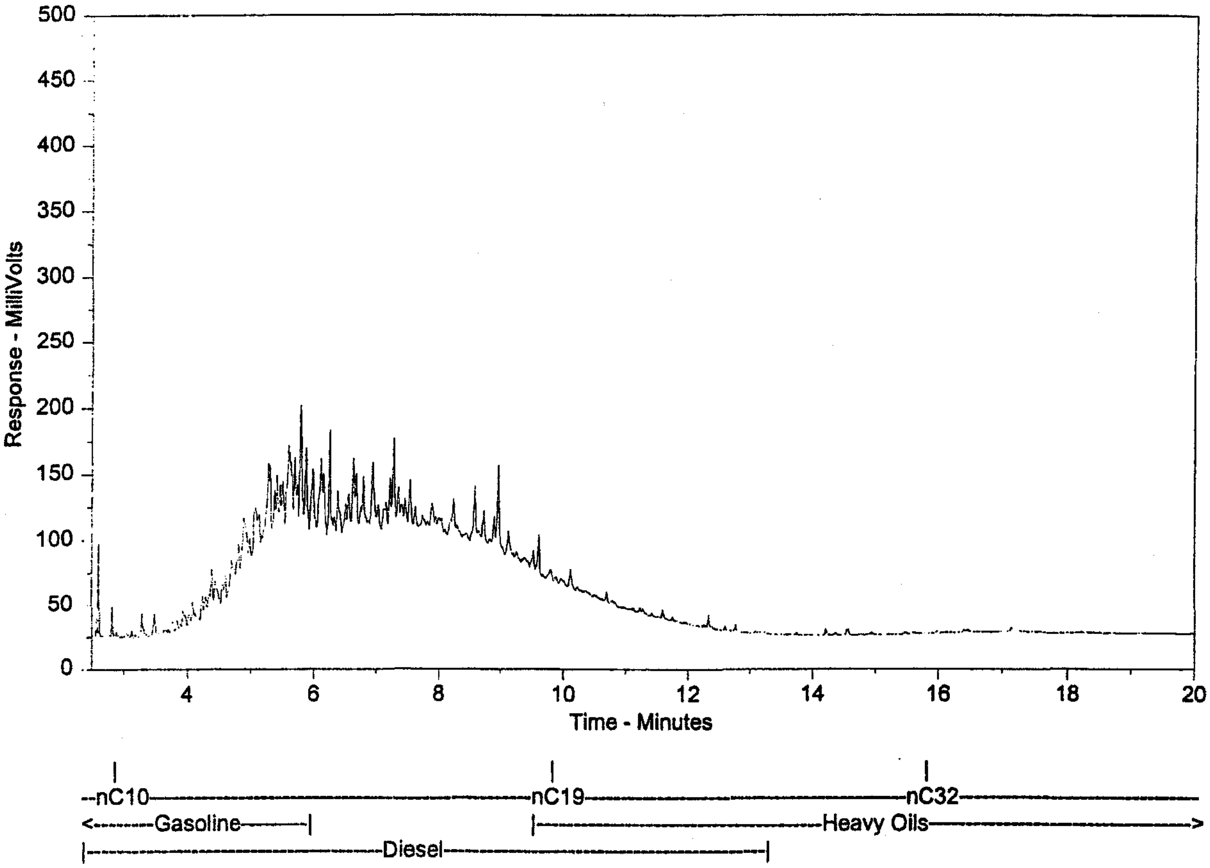
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TP50-1
ASL Sample ID: L1002-T--16
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepA.0010.RAW
Run Information: Acquired on GC04, 9/30/99 6:15:24 PM



Sample Amount = 6.4 (g or mL)

Dilution Factor = 10.0

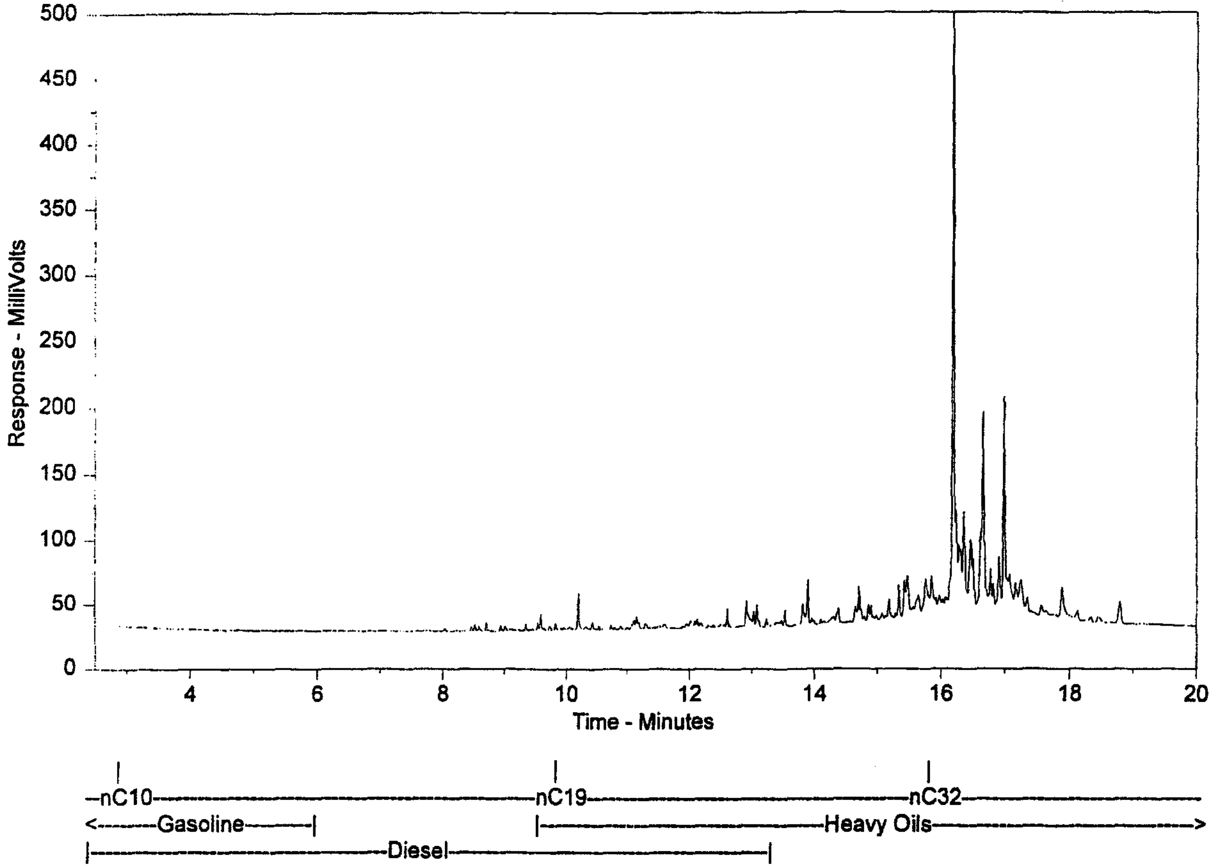
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TP58-1
ASL Sample ID: **L1131-T--47**
File Name: c:\chrom\gc12\data\gc12_06octA.0031.RAW
Run Information: Acquired on GC12, 10/7/99 7:54:33 AM



Sample Amount = 8.5 (g or mL)

Dilution Factor = 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

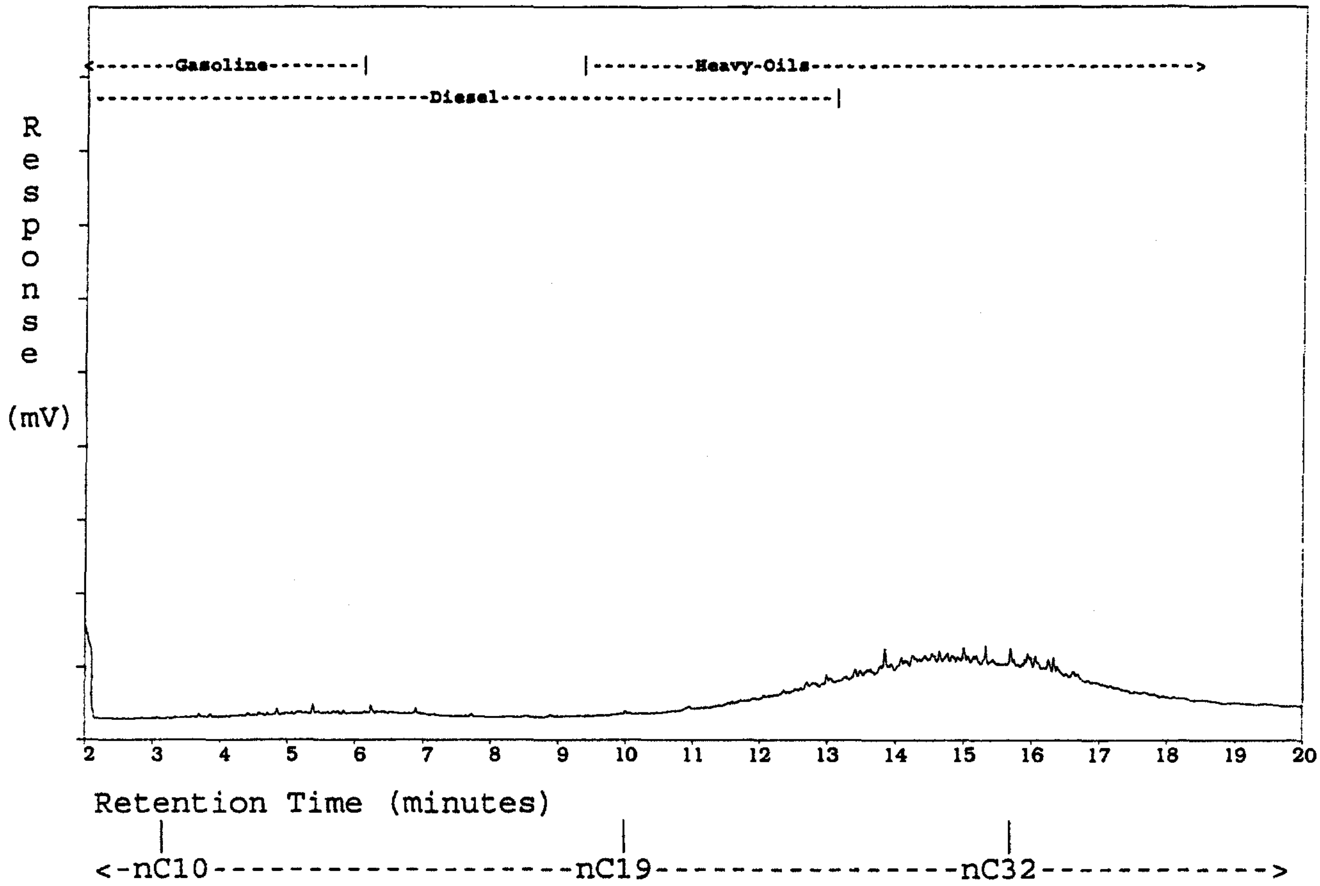
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP0799-1

File Name: C:\TEH\AU04\EH1AU04.32R **ASL Sample ID:** K8109-T--1 **Sample acquired:** AUG 5, 1999 00:59:26
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.5 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

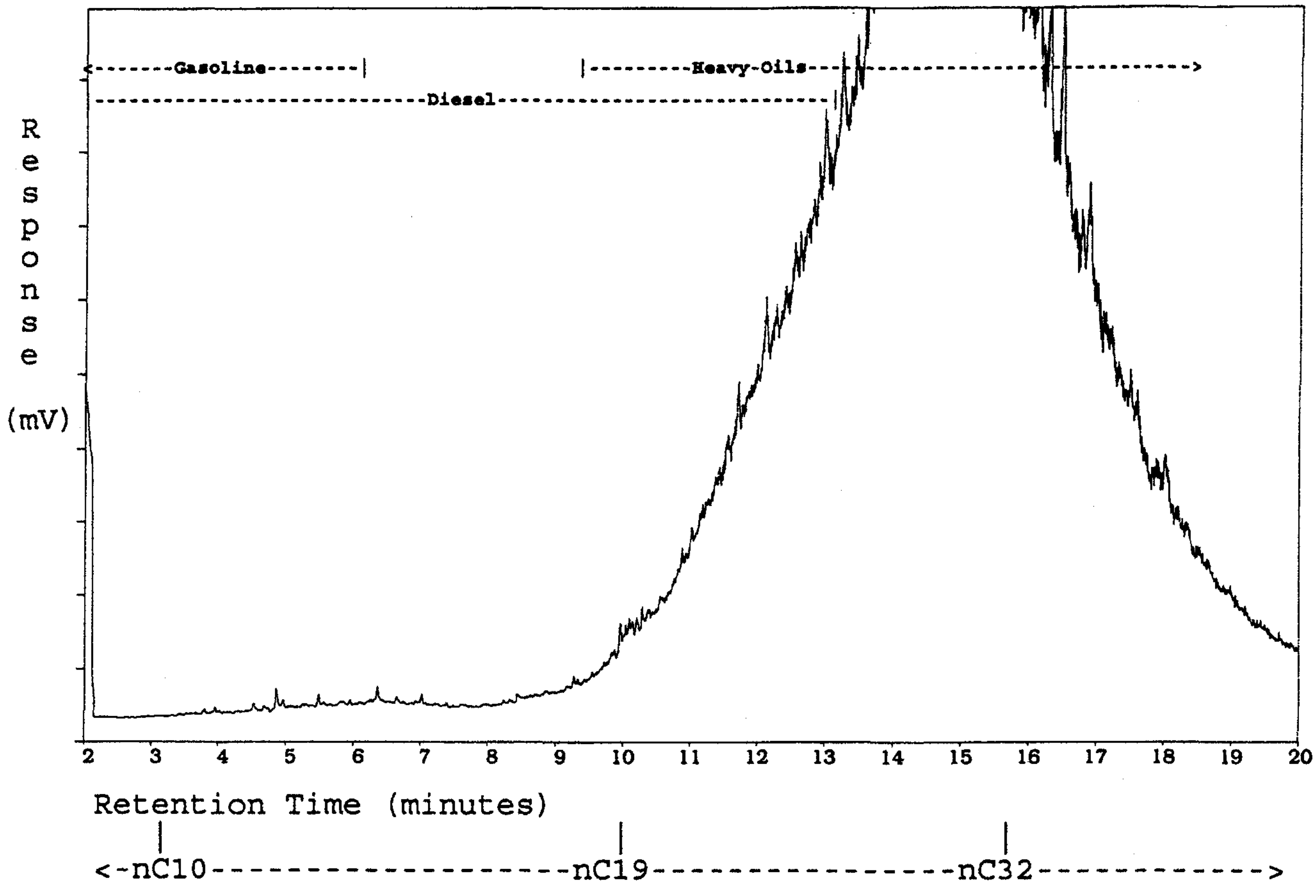
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP0799-2

File Name: C:\TEH\JL30\EH1JL30.91R ASL Sample ID: K8109-T--2 Sample acquired: AUG 4, 1999 12:36:11

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.4 Dilution: 8.0

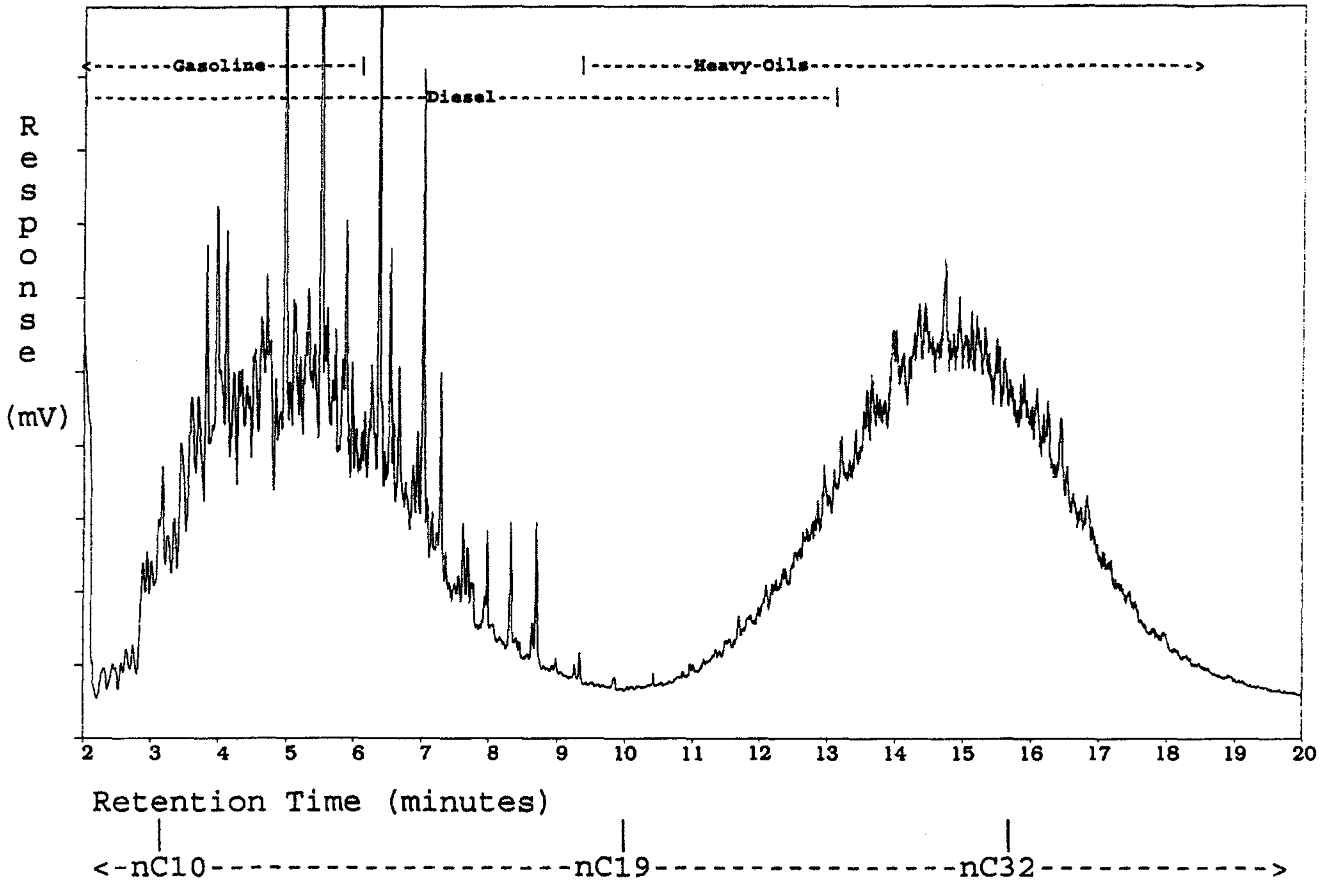
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP0799-4

File Name: C:\TEH\AU04\EH1AU04.31R **ASL Sample ID:** K8109-T--3 **Sample acquired:** AUG 5, 1999 00:59:26
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.8 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

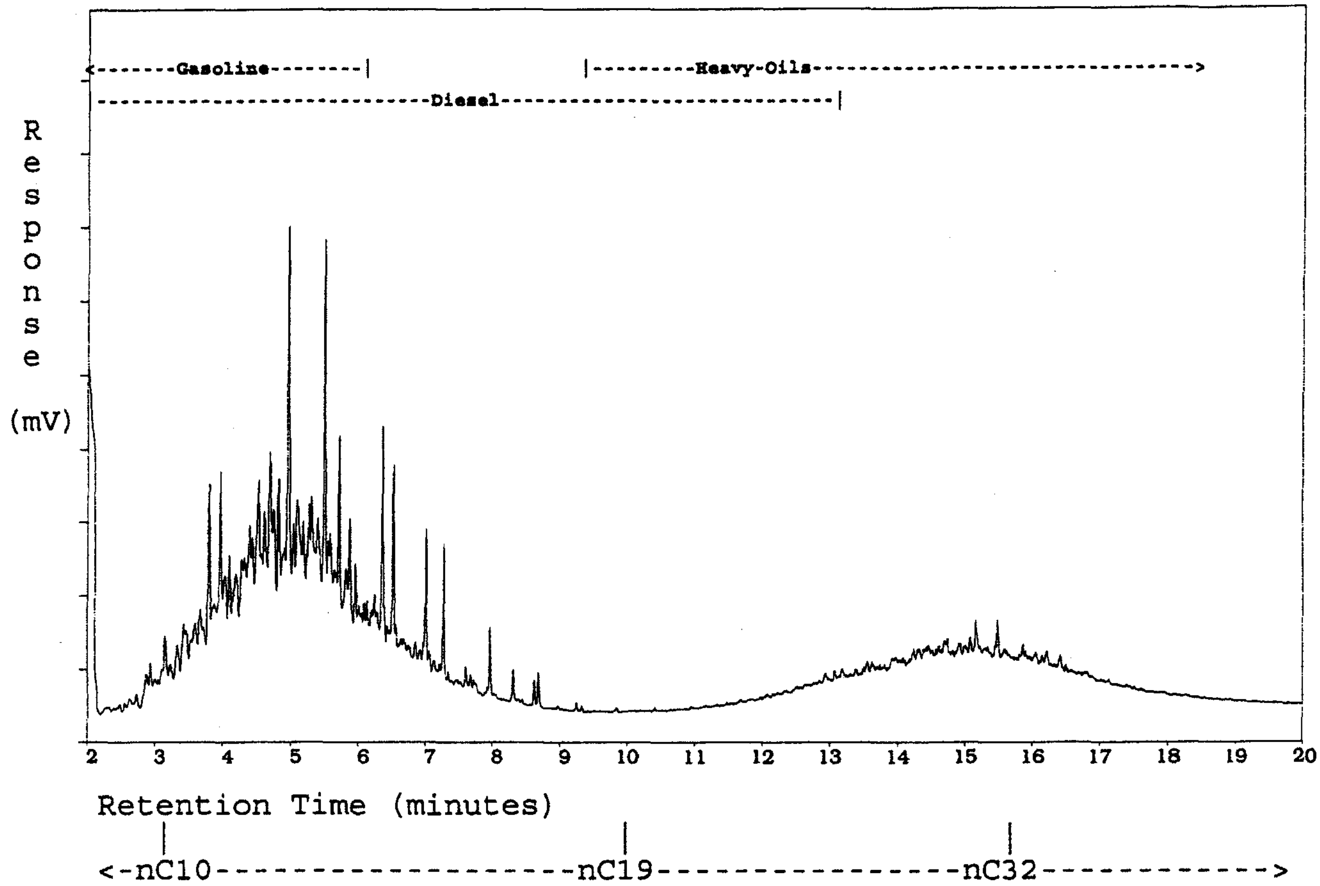
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: TP0799-5

File Name: C:\TEH\JL30\EH1JL30.93R ASL Sample ID: K8109-T--4 Sample acquired: AUG 4, 1999 13:11:47

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 11.9 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

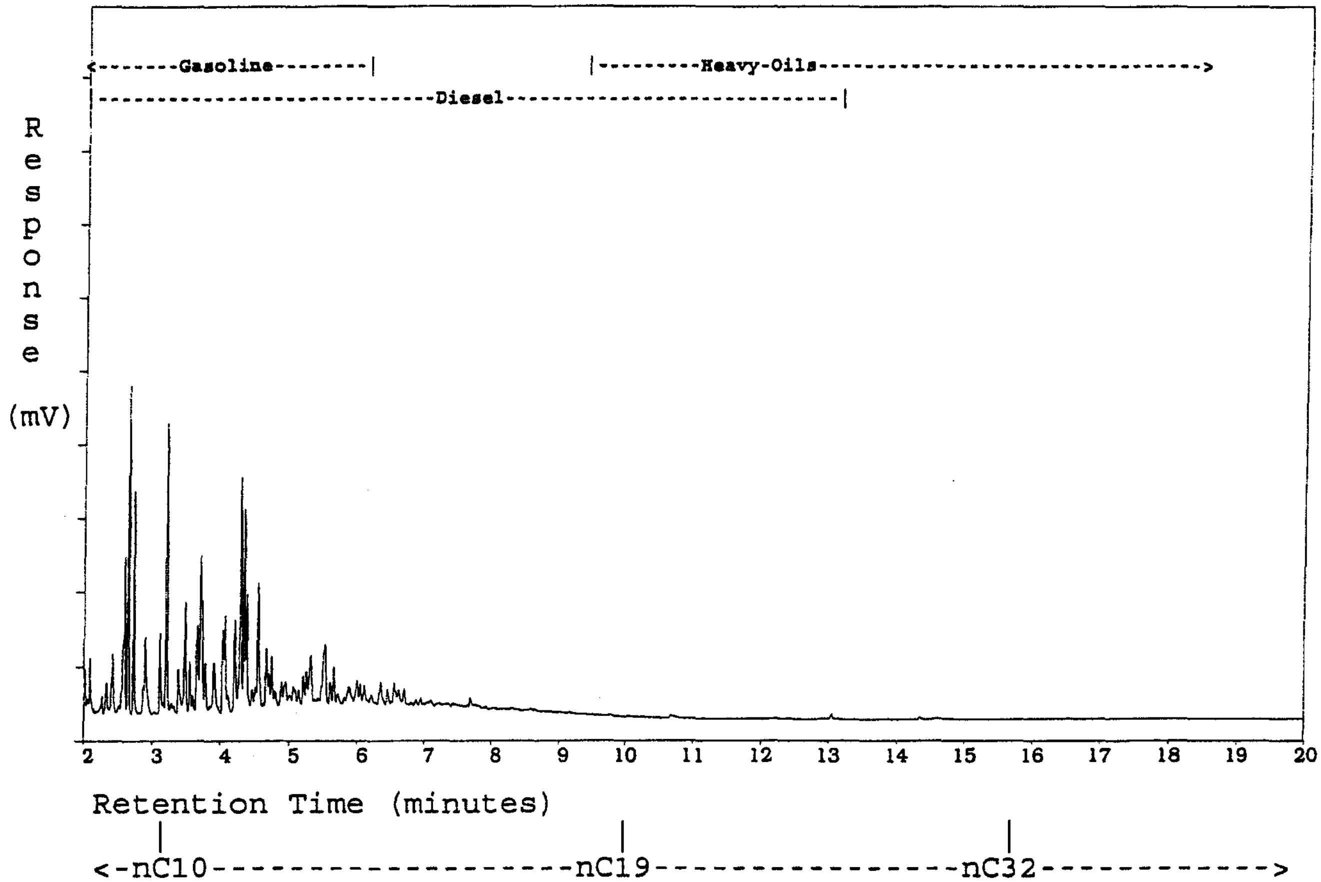
HYDROCARBON DISTRIBUTION REPORTS
FOR
WATER SAMPLES

HYDROCARBON DISTRIBUTION REPORT

SAMPLE.NAME: MW-1

File Name: C:\TEH\JN24\EH1JN24.43R ASL Sample ID: K6884-T--11 Sample acquired: JUN 25, 1999 00:11:01

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 520.0 Dilution: 1.0

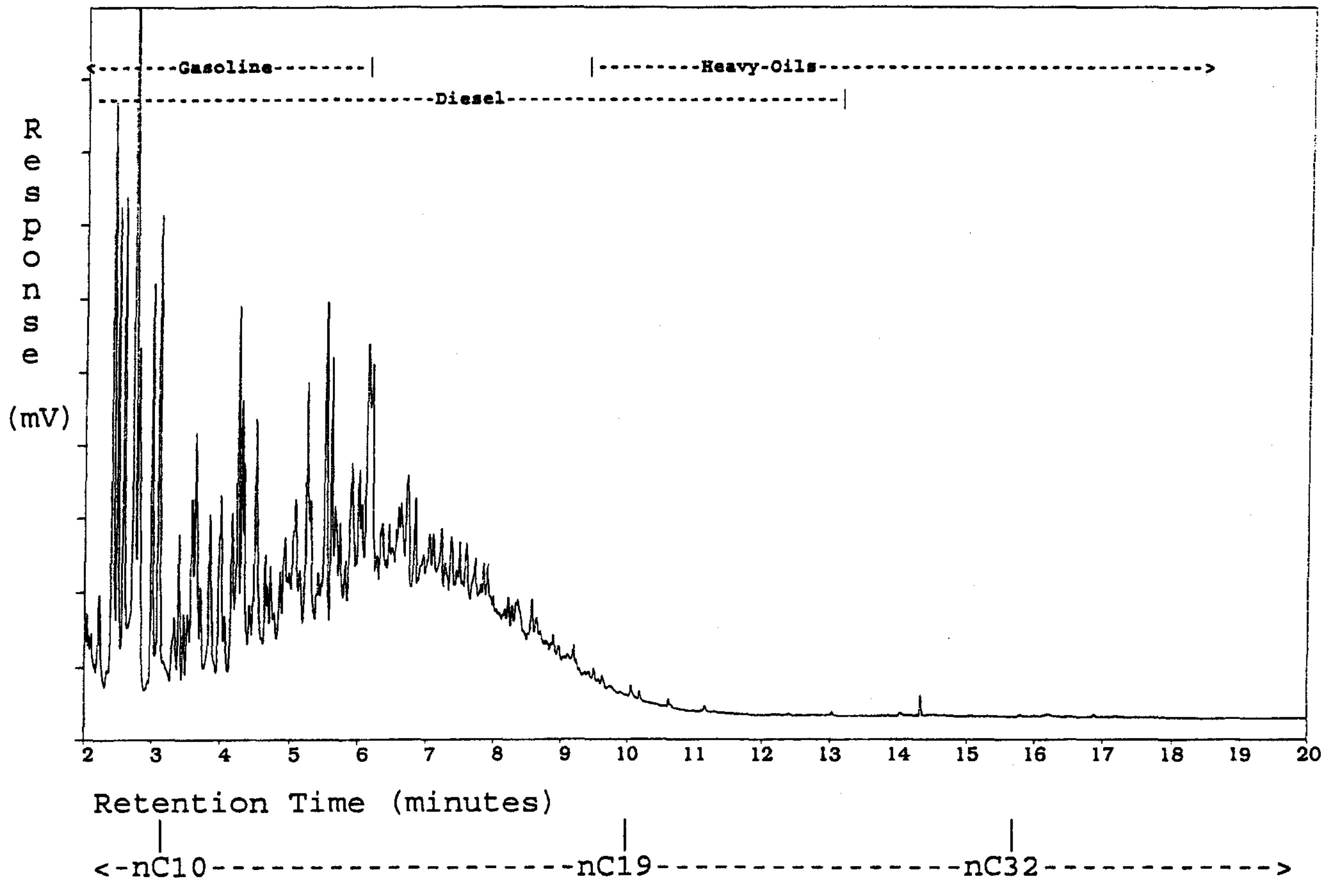
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-2

File Name: C:\TEH\JN25\EH1JN25.13R ASL Sample ID: K6884-T--12 Sample acquired: JUN 25, 1999 17:06:34
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 530.0 Dilution: 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

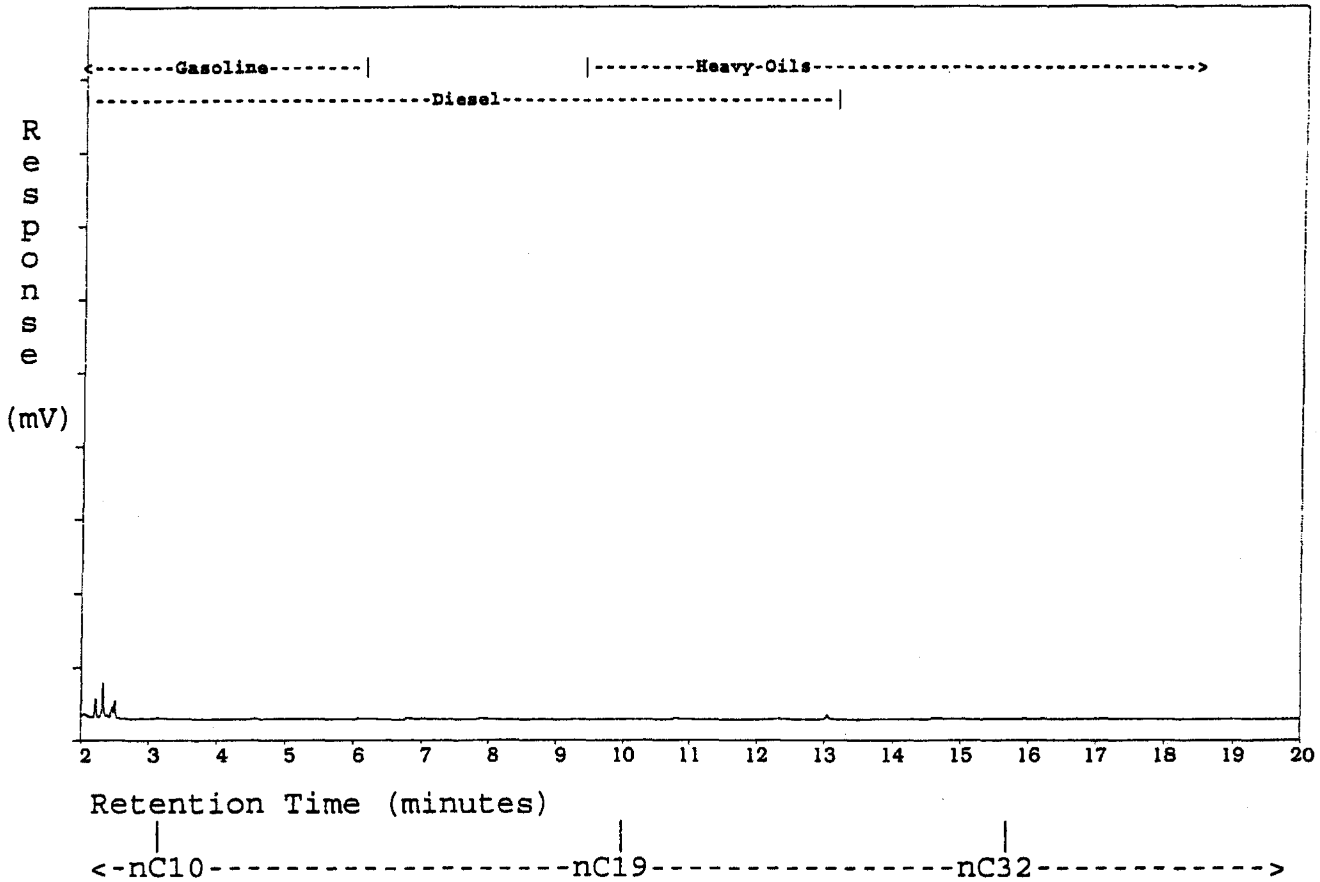
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-3

File Name: C:\TEH\JN24\EH1JN24.45R ASL Sample ID: K6884-T--13 Sample acquired: JUN 25, 1999 00:45:11

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 490.0 Dilution: 1.0

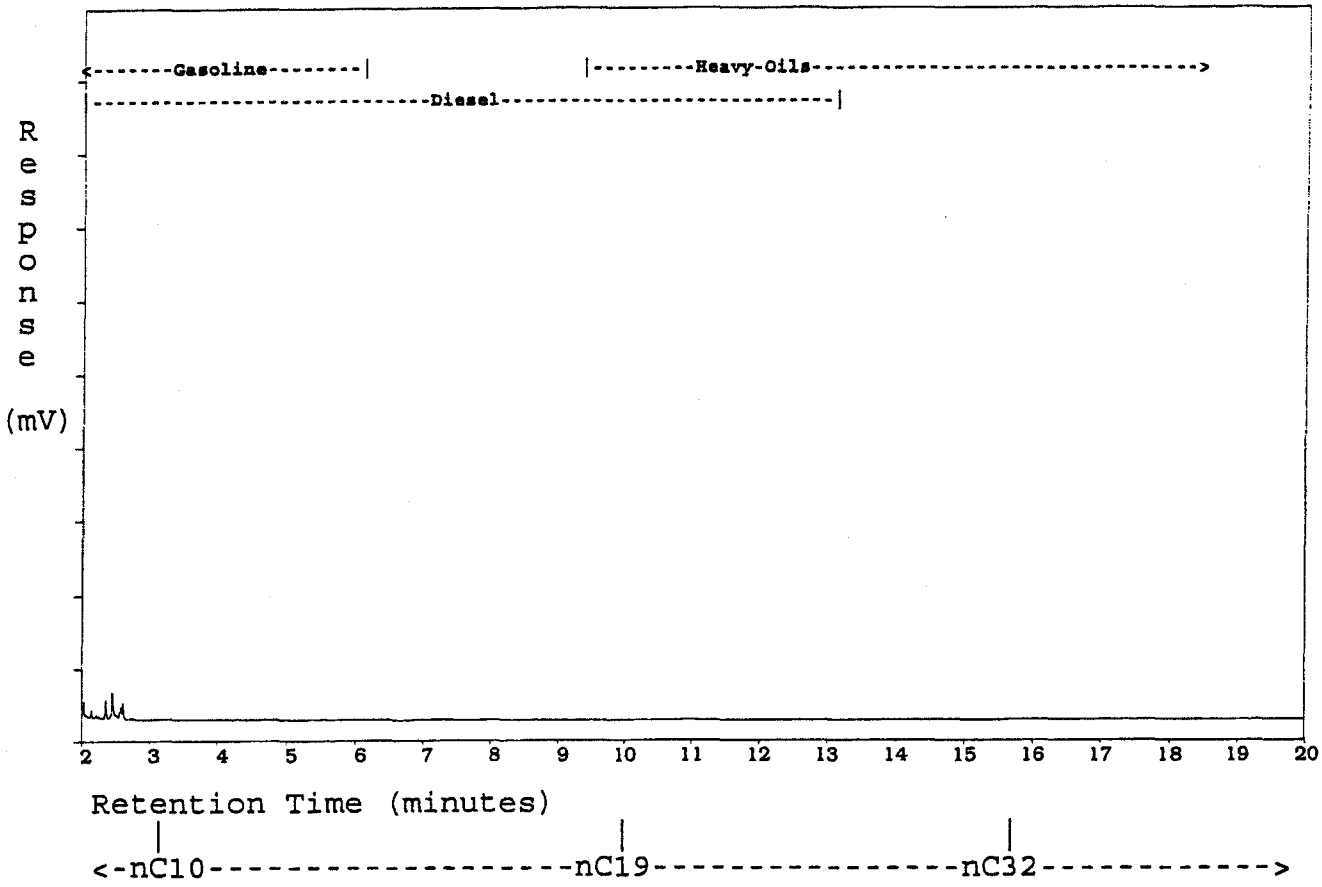
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-4

File Name: C:\TEH\JN25\EH1JN25.14R ASL Sample ID: K6884-T--14 Sample acquired: JUN 25, 1999 17:06:34
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 450.0 Dilution: 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

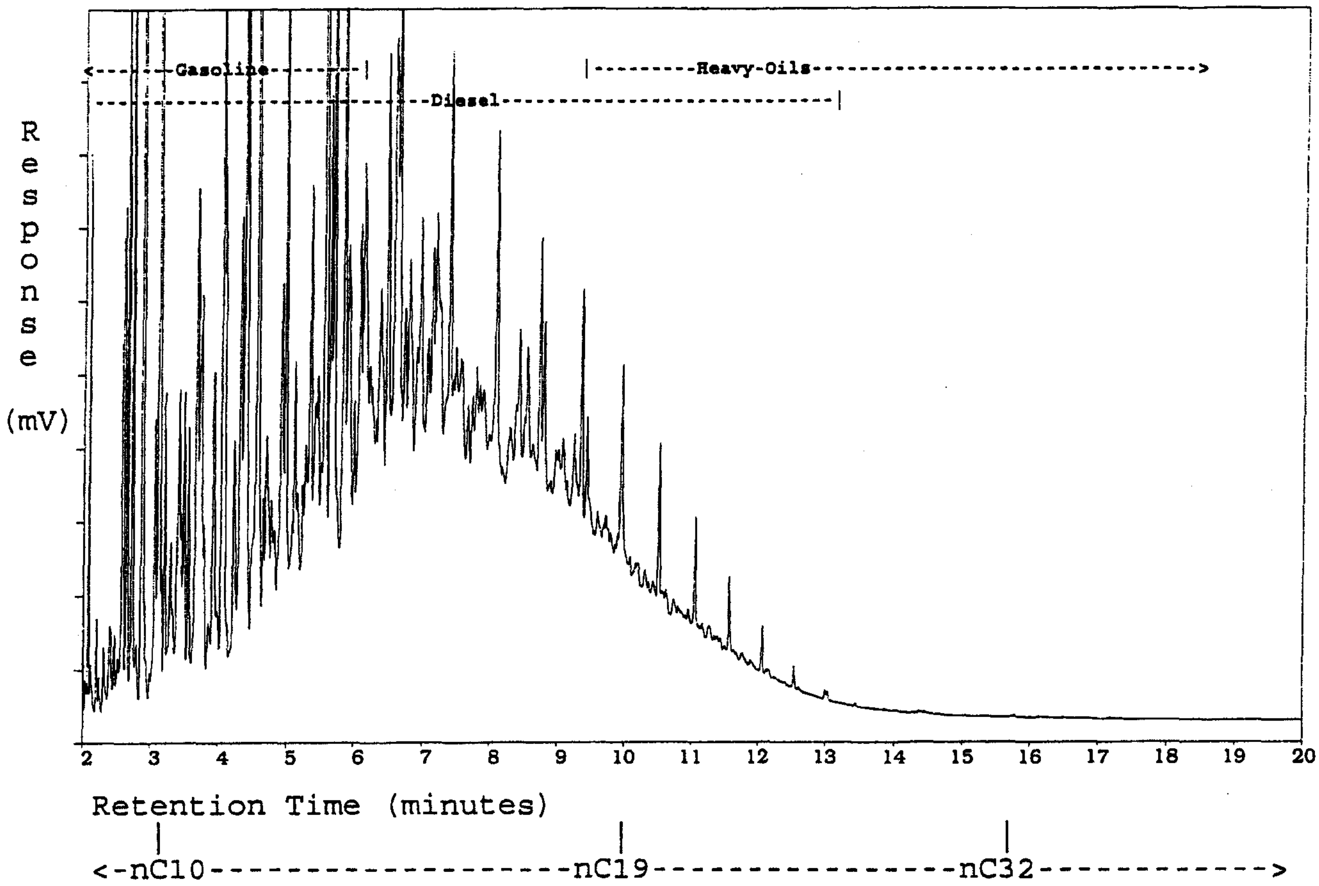
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE.NAME: MW-5

File Name: C:\TEH\JN24\EH1JN24.47R ASL Sample ID: K6884-T--15 Sample acquired: JUN 25, 1999 01:19:25

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 530.0 Dilution: 1.0

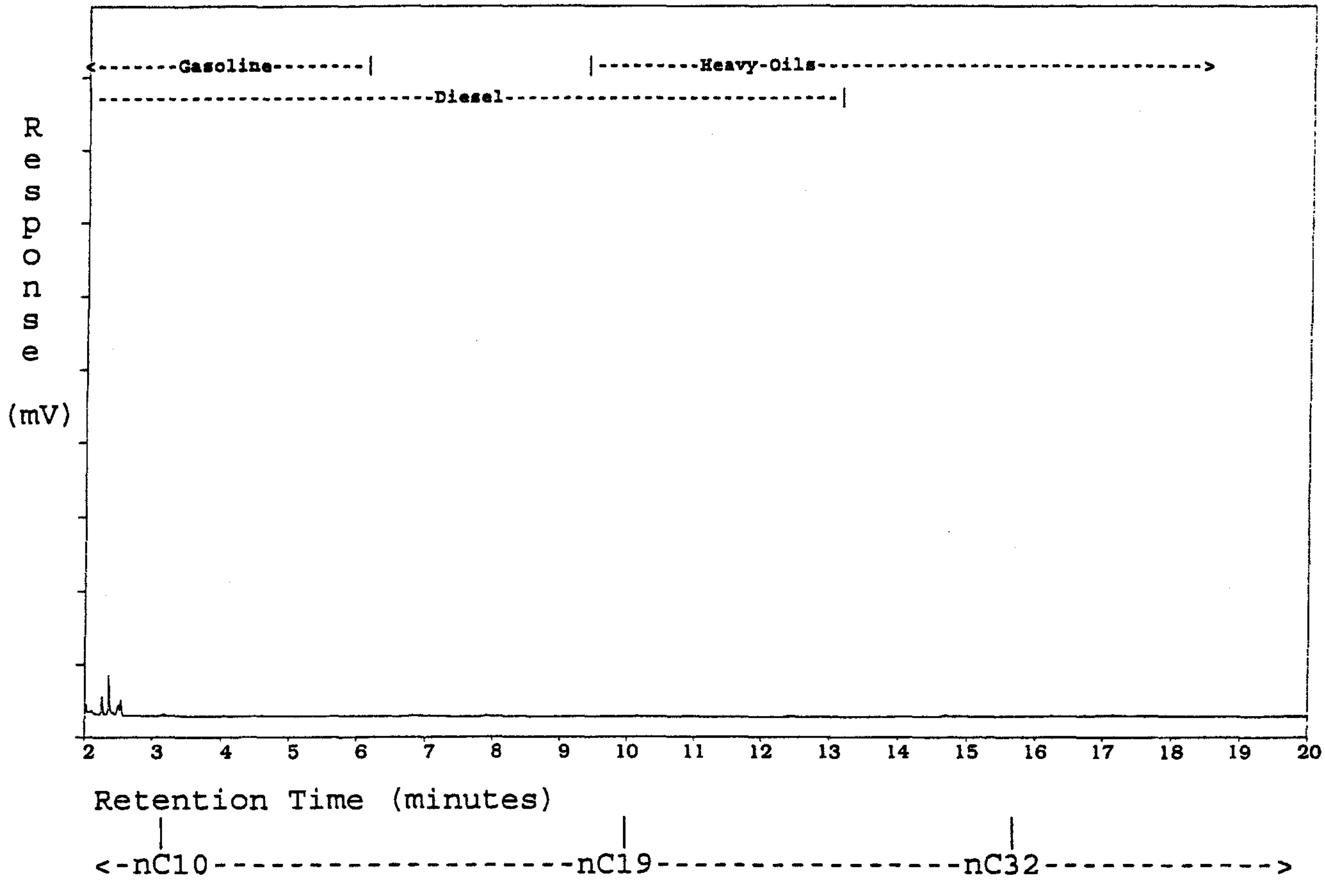
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-6

File Name: C:\TEH\JN25\EH1JN25.15R ASL Sample ID: K6884-T--16 Sample acquired: JUN 25, 1999 17:42:06
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 440.0 Dilution: 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

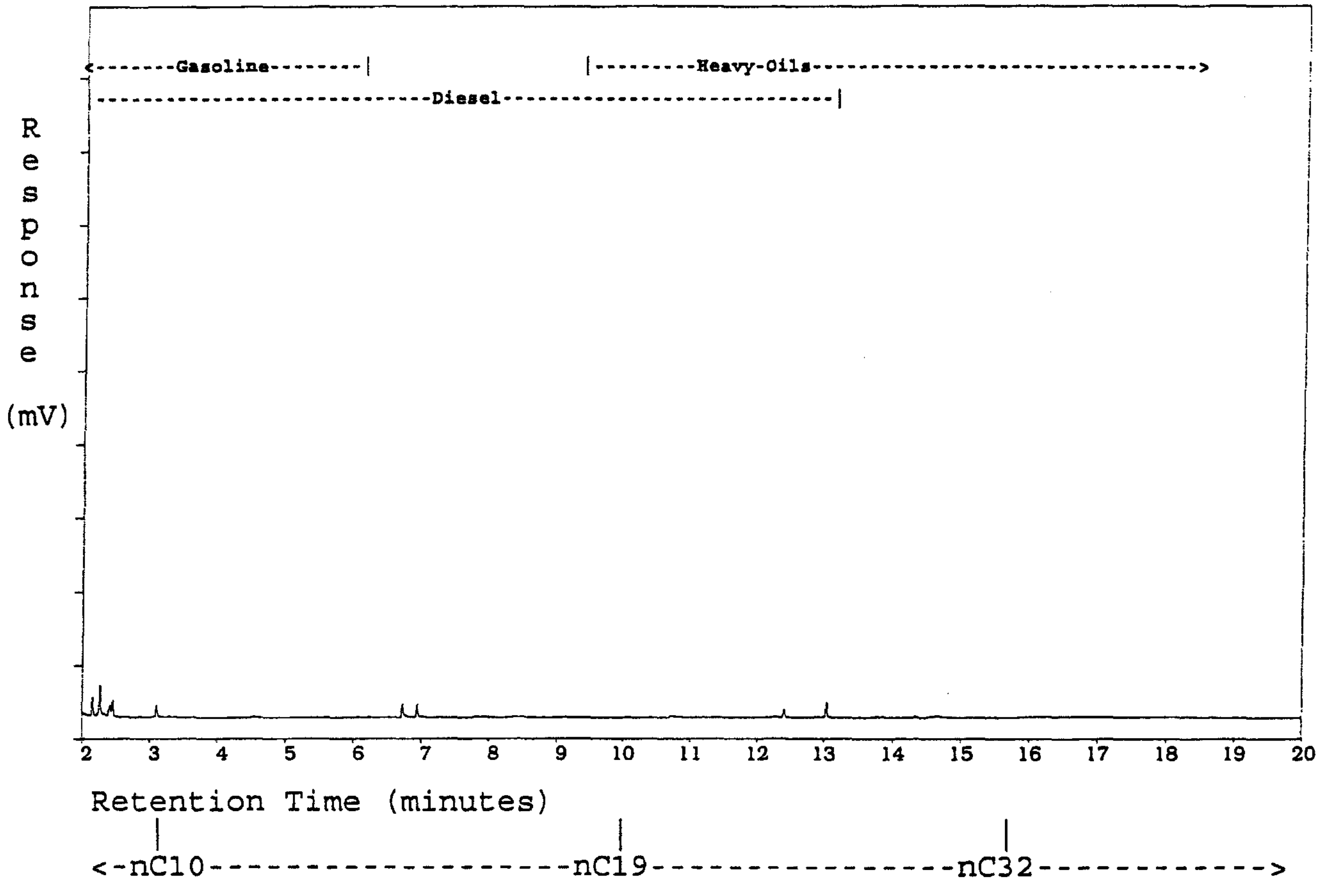
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-8

File Name: C:\TEH\JN24\EH1JN24.49R ASL Sample ID: K6884-T--17 Sample acquired: JUN 25, 1999 01:54:00

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 450.0 Dilution: 1.0

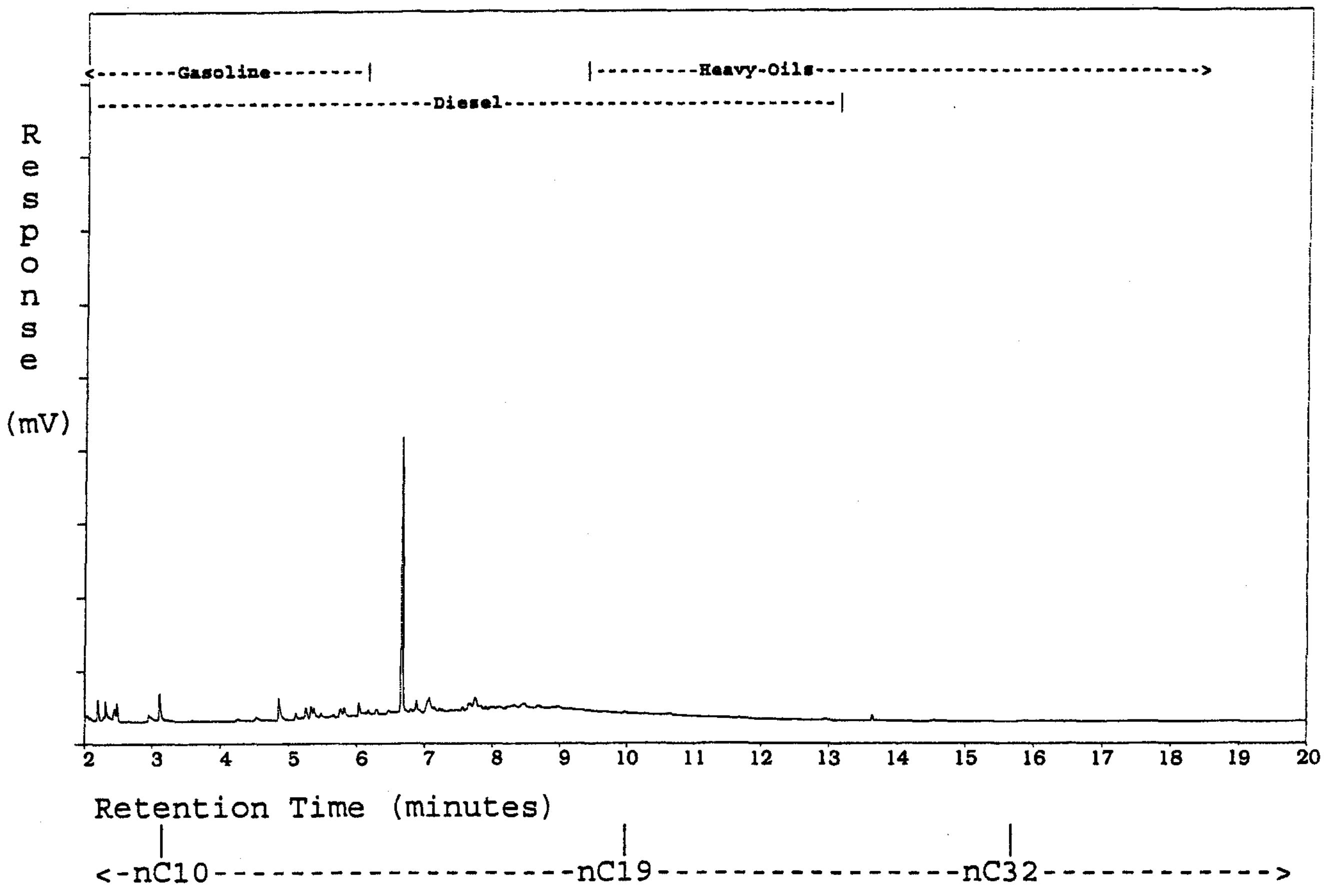
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-9

File Name: C:\TEH\JN25\EH1JN25.16R ASL Sample ID: K6884-T--18 Sample acquired: JUN 25, 1999 17:42:06
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 430.0 Dilution: 1.0

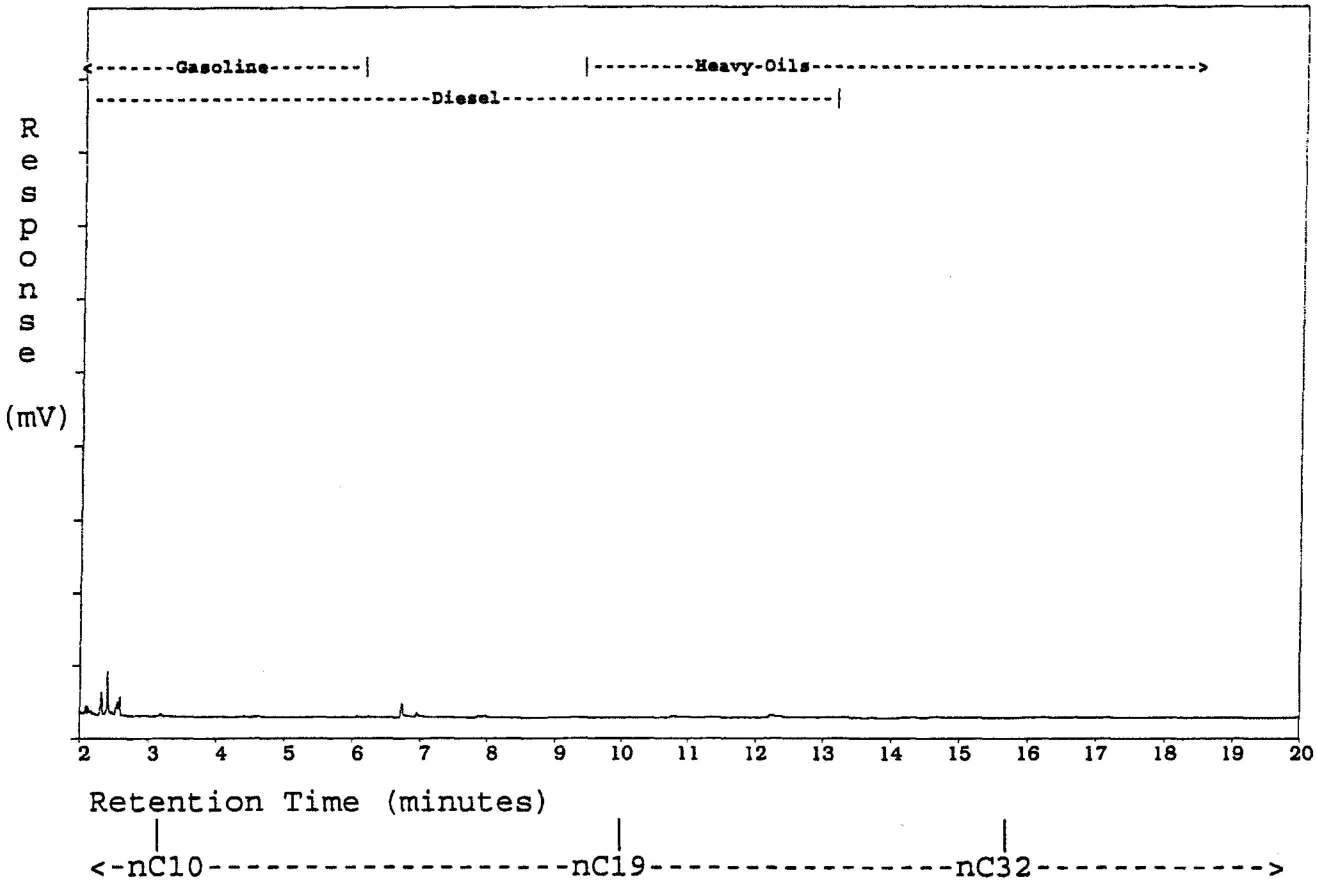
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-10

File Name: C:\TEH\JN24\EH1JN24.51R ASL Sample ID: K6884-T--19 Sample acquired: JUN 25, 1999 02:28:27
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 465.0 Dilution: 1.0

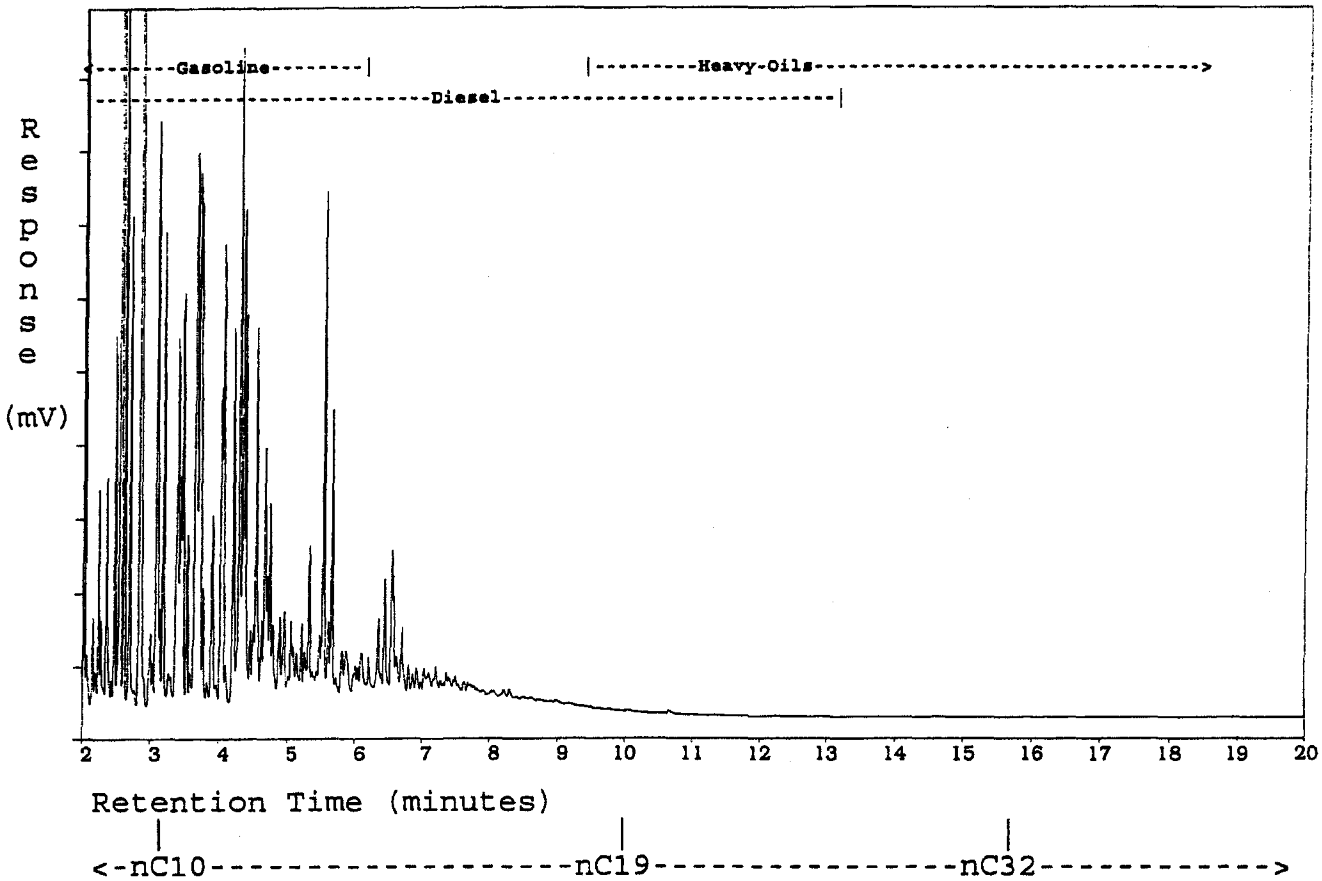
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-12

File Name: C:\TEH\JN25\EH1JN25.17R ASL Sample ID: K6884-T--20 Sample acquired: JUN 25, 1999 18:17:22
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 455.0 Dilution: 1.0

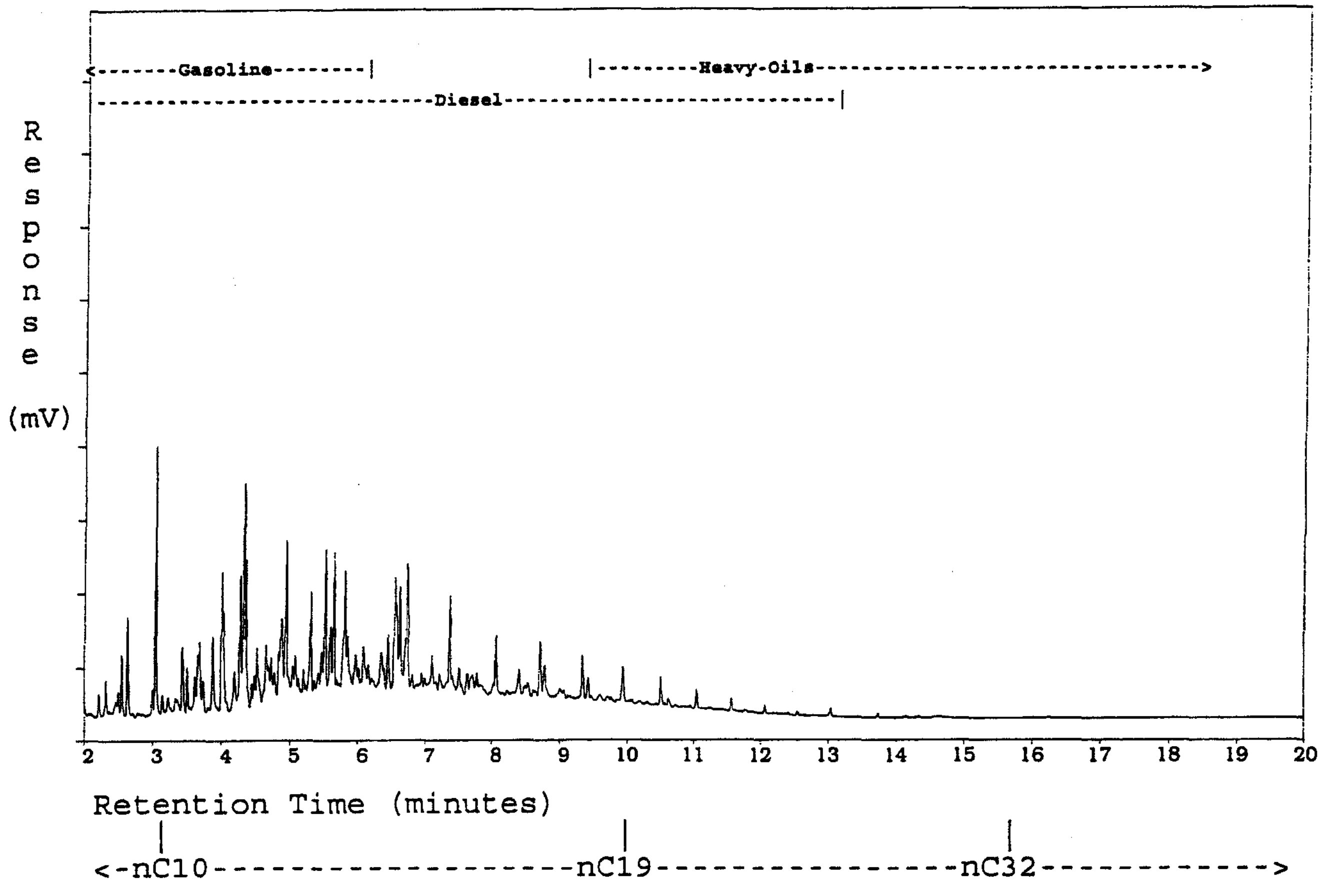
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-13

File Name: C:\TEH\JN24\EH1JN24.53R ASL Sample ID: K6884-T--21 Sample acquired: JUN 25, 1999 03:02:43
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 465.0 Dilution: 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

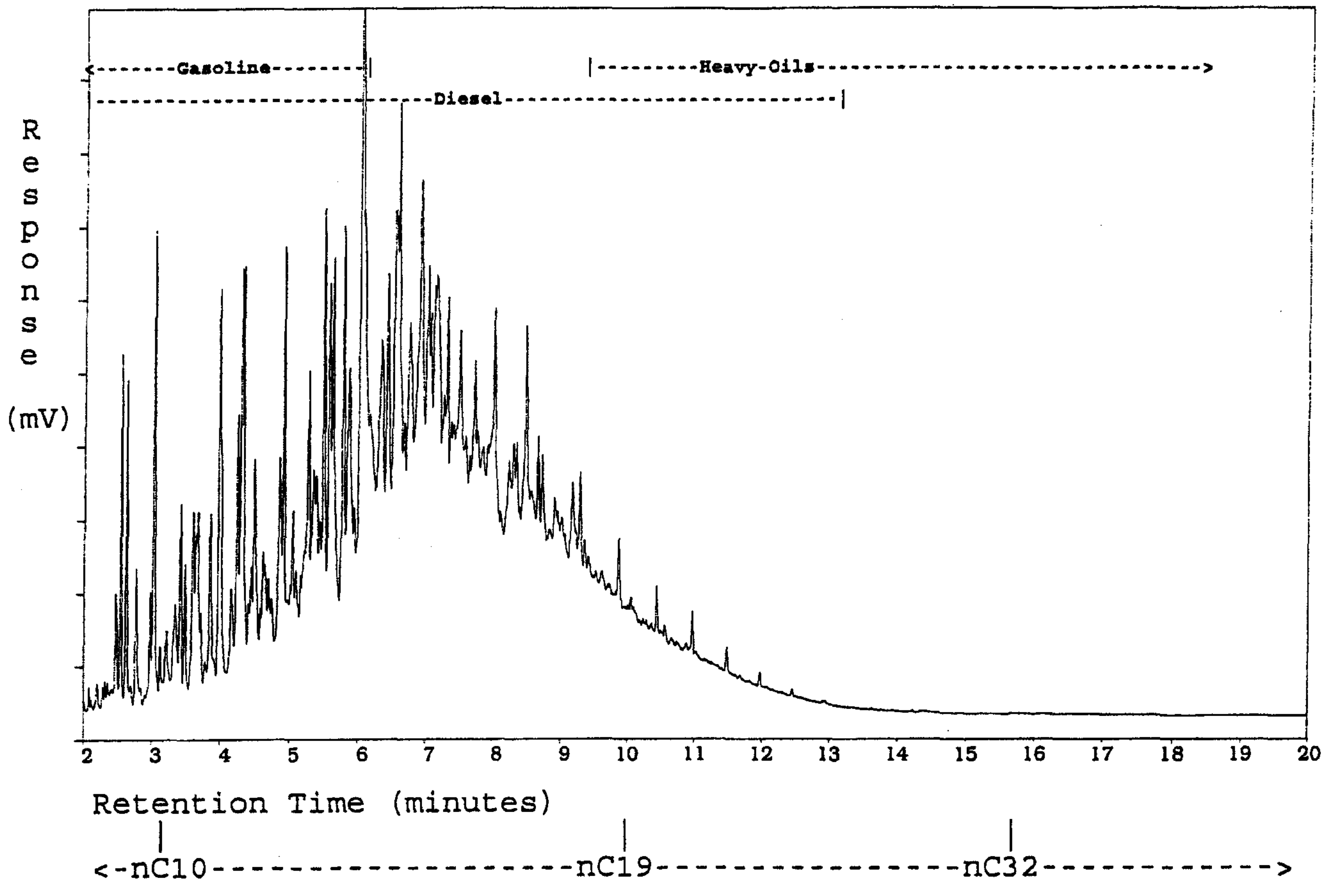
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-14

File Name: C:\TEH\JN25\EH1JN25.36R ASL Sample ID: K6884-T--22 Sample acquired: JUN 25, 1999 23:34:42

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 470.0 Dilution: 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

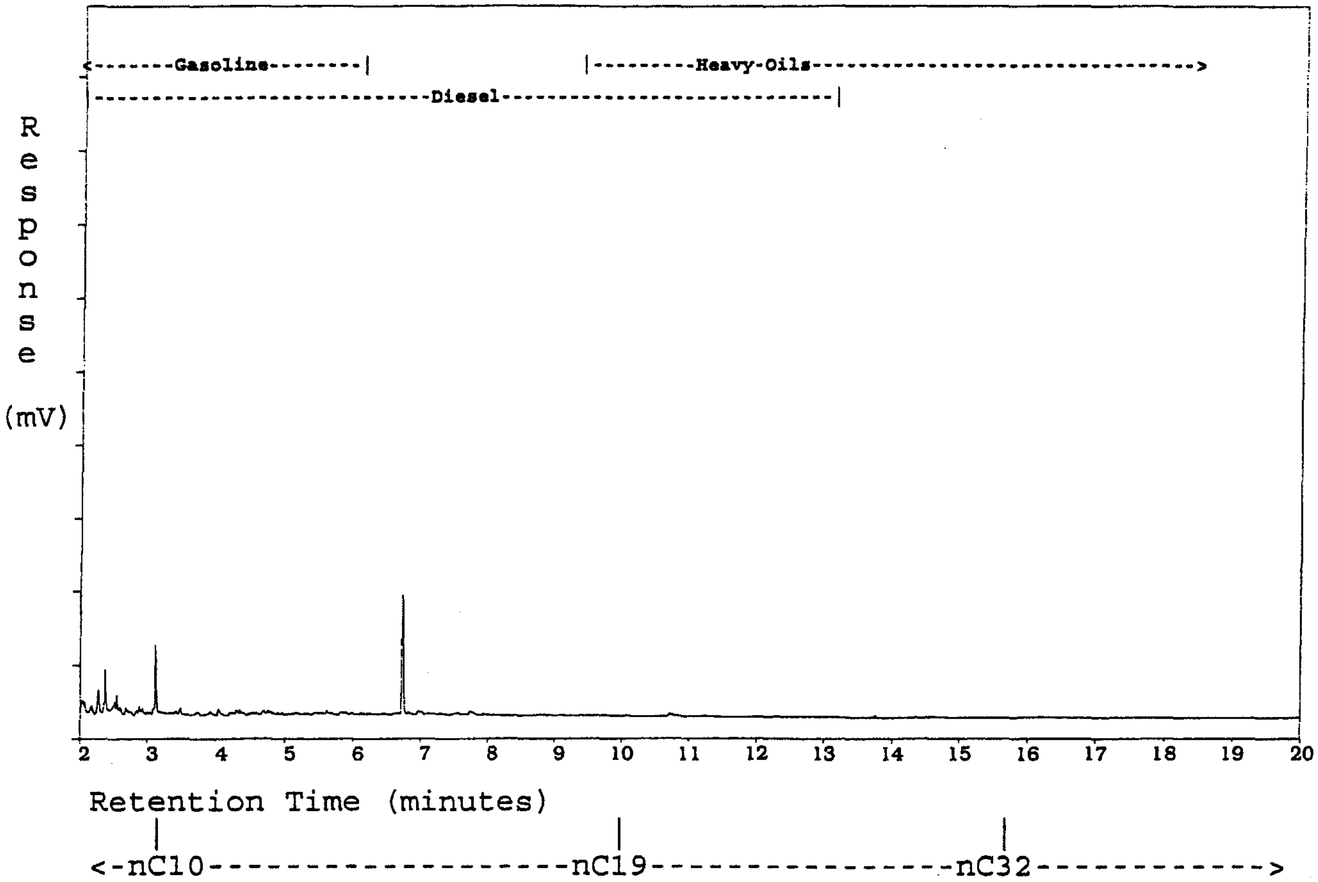
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-15

File Name: C:\TEH\JN25\EH1JN25.37R ASL Sample ID: K6884-T--23 Sample acquired: JUN 26, 1999 00:09:46

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 470.0 Dilution: 1.0

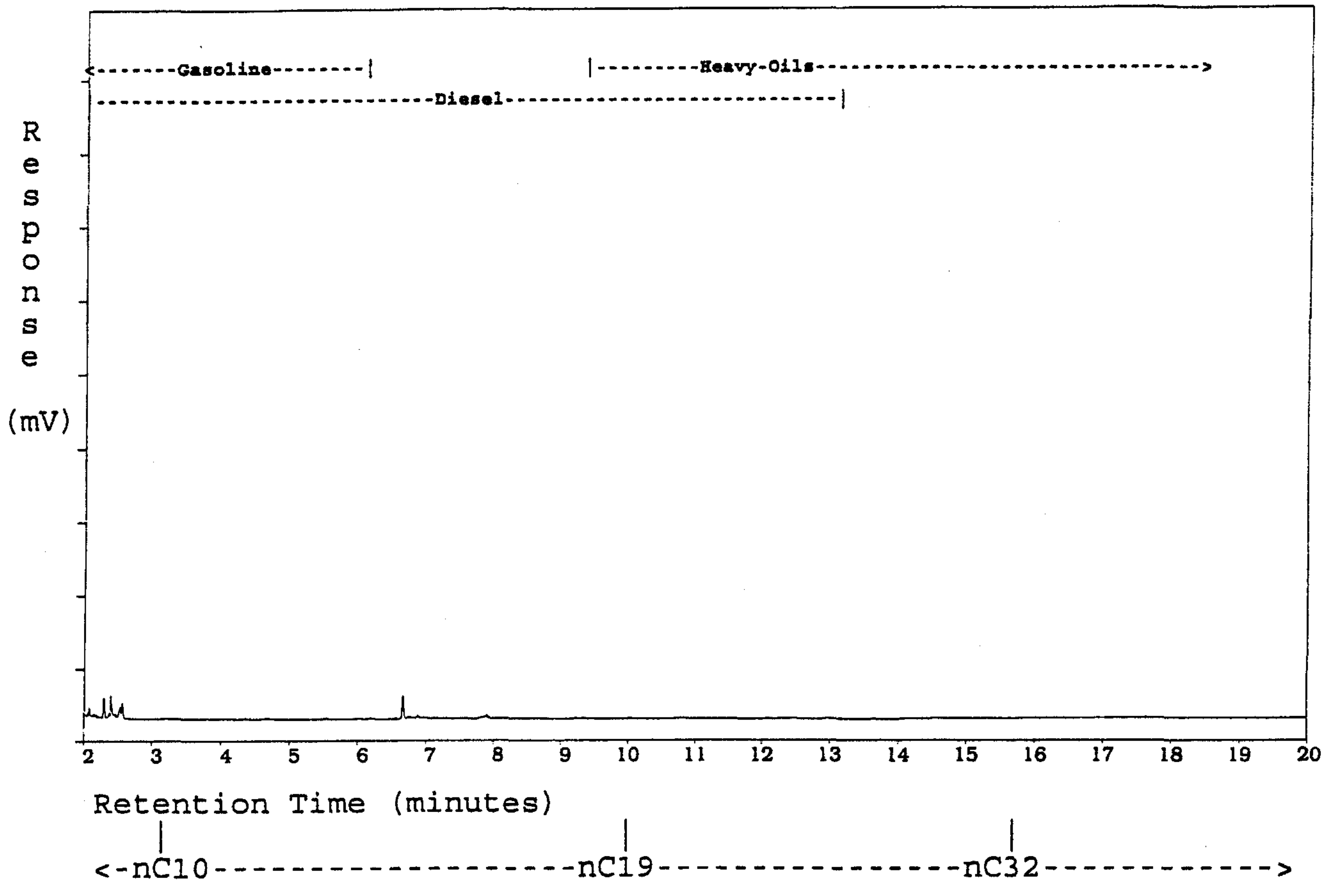
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-17

File Name: C:\TEH\JN25\EH1JN25.38R **ASL Sample ID:** K6884-T--24 **Sample acquired:** JUN 26, 1999 00:09:46
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 440.0 Dilution: 1.0

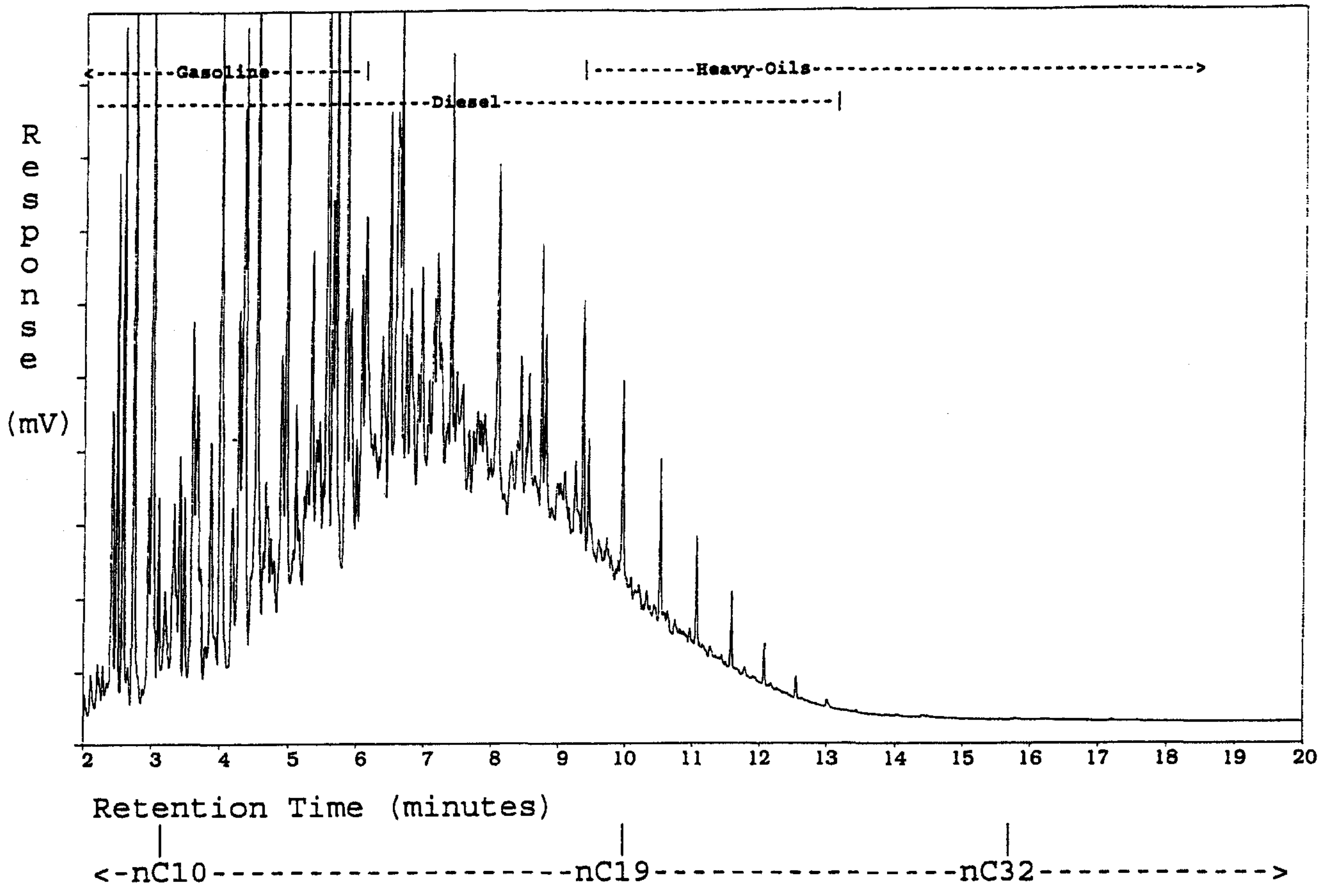
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-D1 /MW-5

File Name: C:\TEH\JN25\EH1JN25.39R ASL Sample ID: K6884-T--25 Sample acquired: JUN 26, 1999 00:44:40
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 475.0 Dilution: 1.0

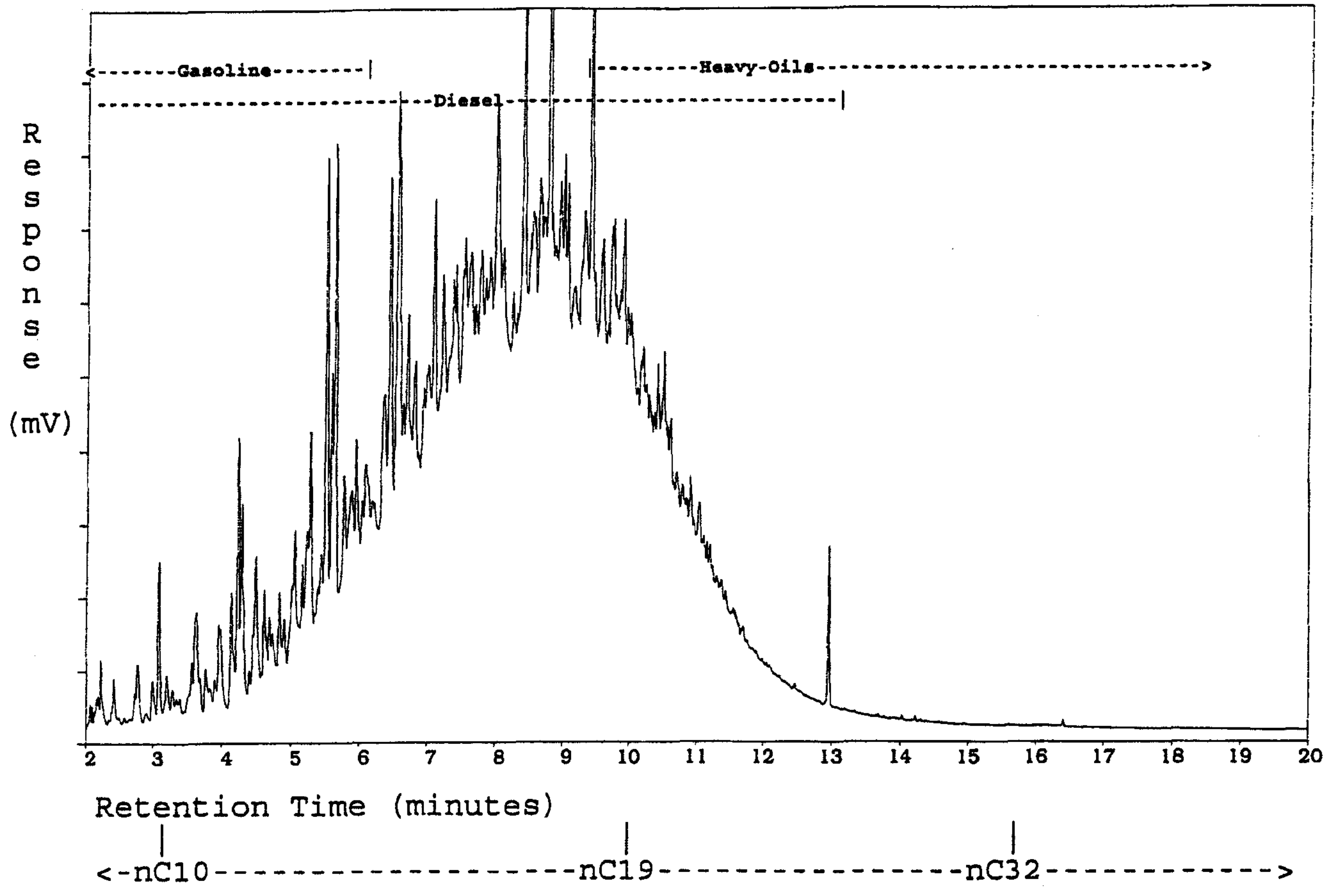
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MW-D2 [illegible]

File Name: C:\TEH\JN25\EH1JN25.40R ASL Sample ID: K6884-T--26 Sample acquired: JUN 26, 1999 00:44:40
Chromatogram Scale: 100.0 millivolts



Sample Amt. (g or mL): 405.0 Dilution: 1.0

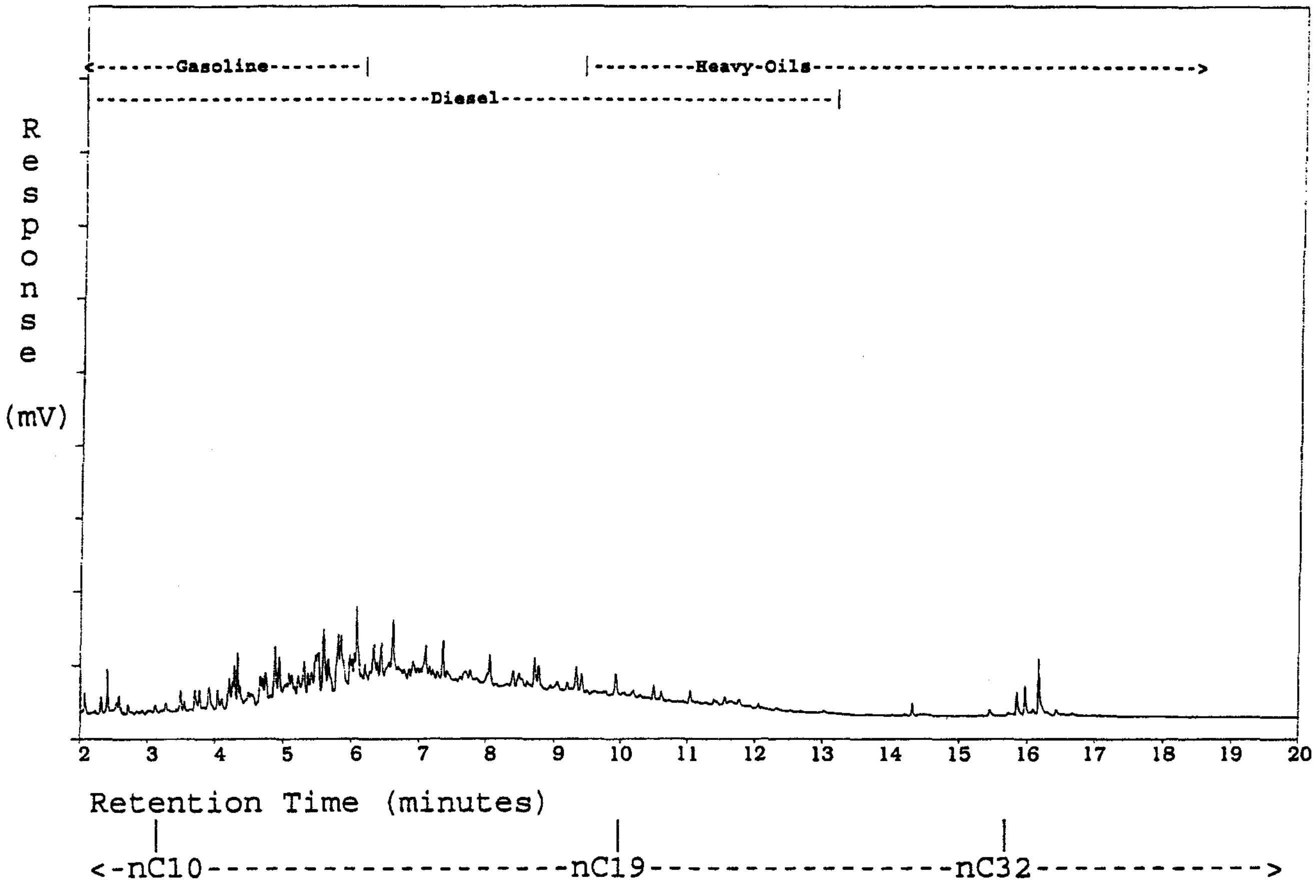
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: MP-3

File Name: C:\TEH\JN24\EH1JN24.35R ASL Sample ID: K6884-T--1 Sample acquired: JUN 24, 1999 21:53:39
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 480.0 Dilution: 1.0

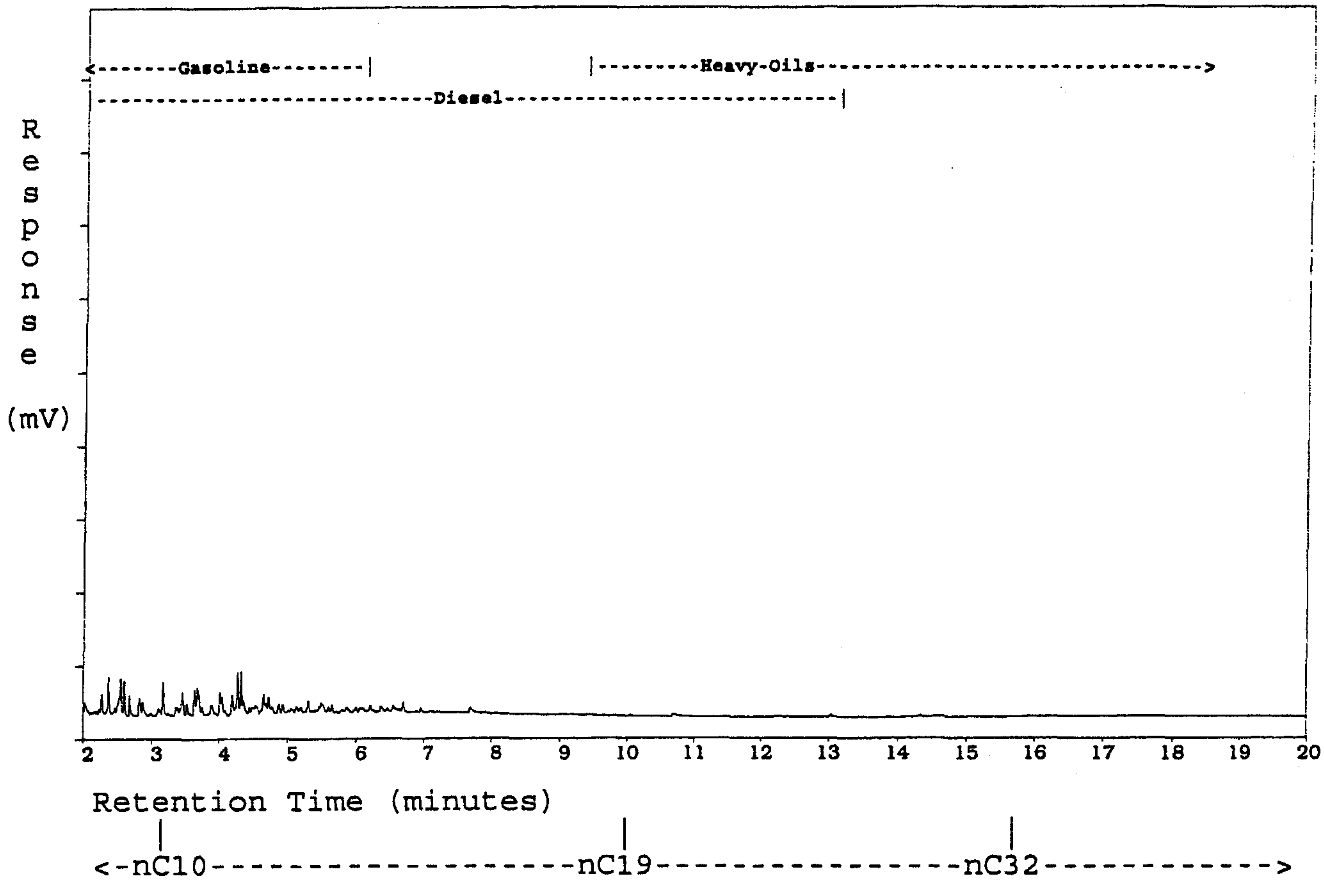
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE. NAME: BLW-2

File Name: C:\TEH\JN24\EH1JN24.37R ASL Sample ID: K6884-T--3 Sample acquired: JUN 24, 1999 22:28:12
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 480.0 Dilution: 1.0

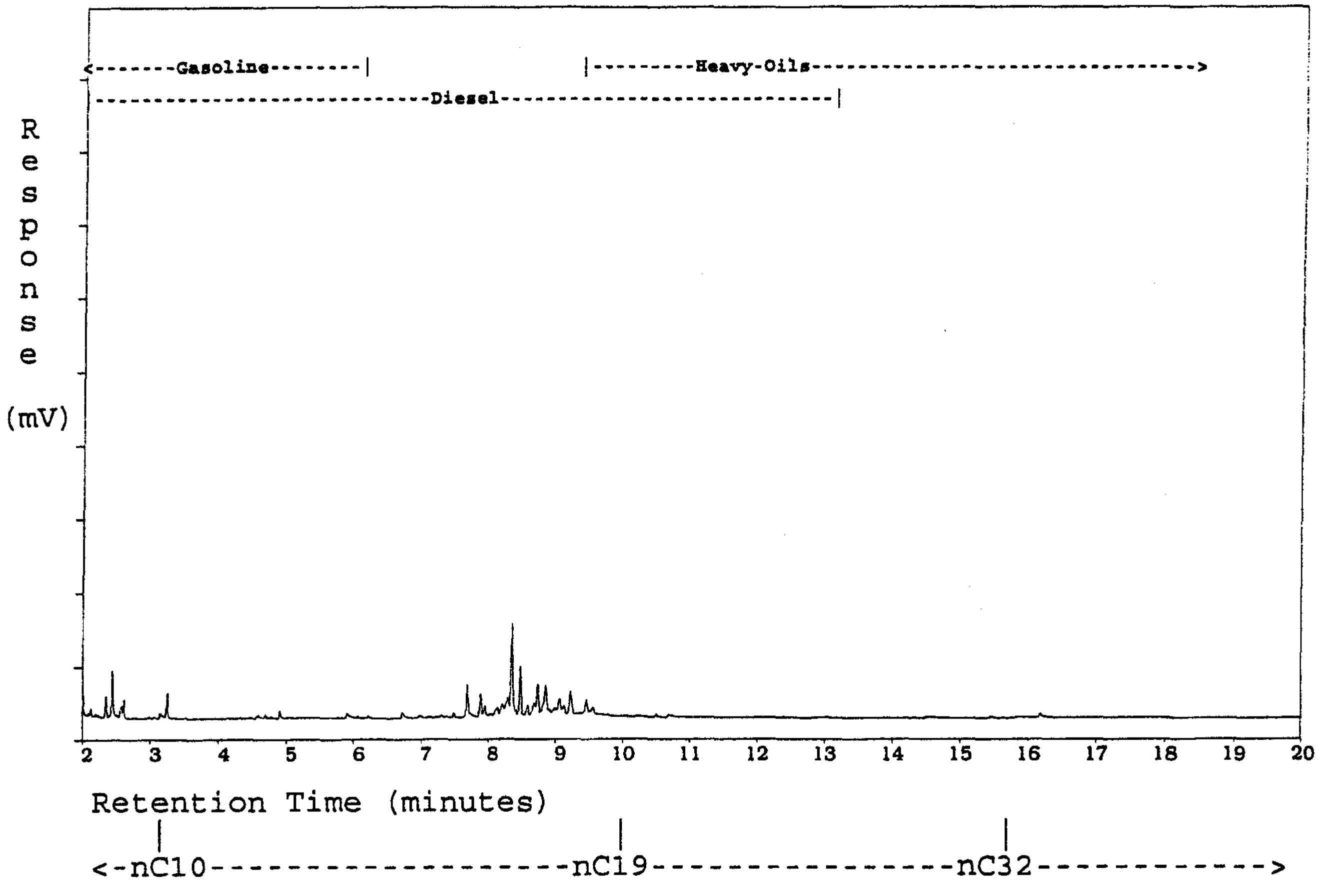
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: BLW-5

File Name: C:\TEH\JN25\EH1JN25.11R   ASL Sample ID: K6884-T--6   Sample acquired: JUN 25, 1999 16:31:09
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL):   530.0   Dilution: 1.0

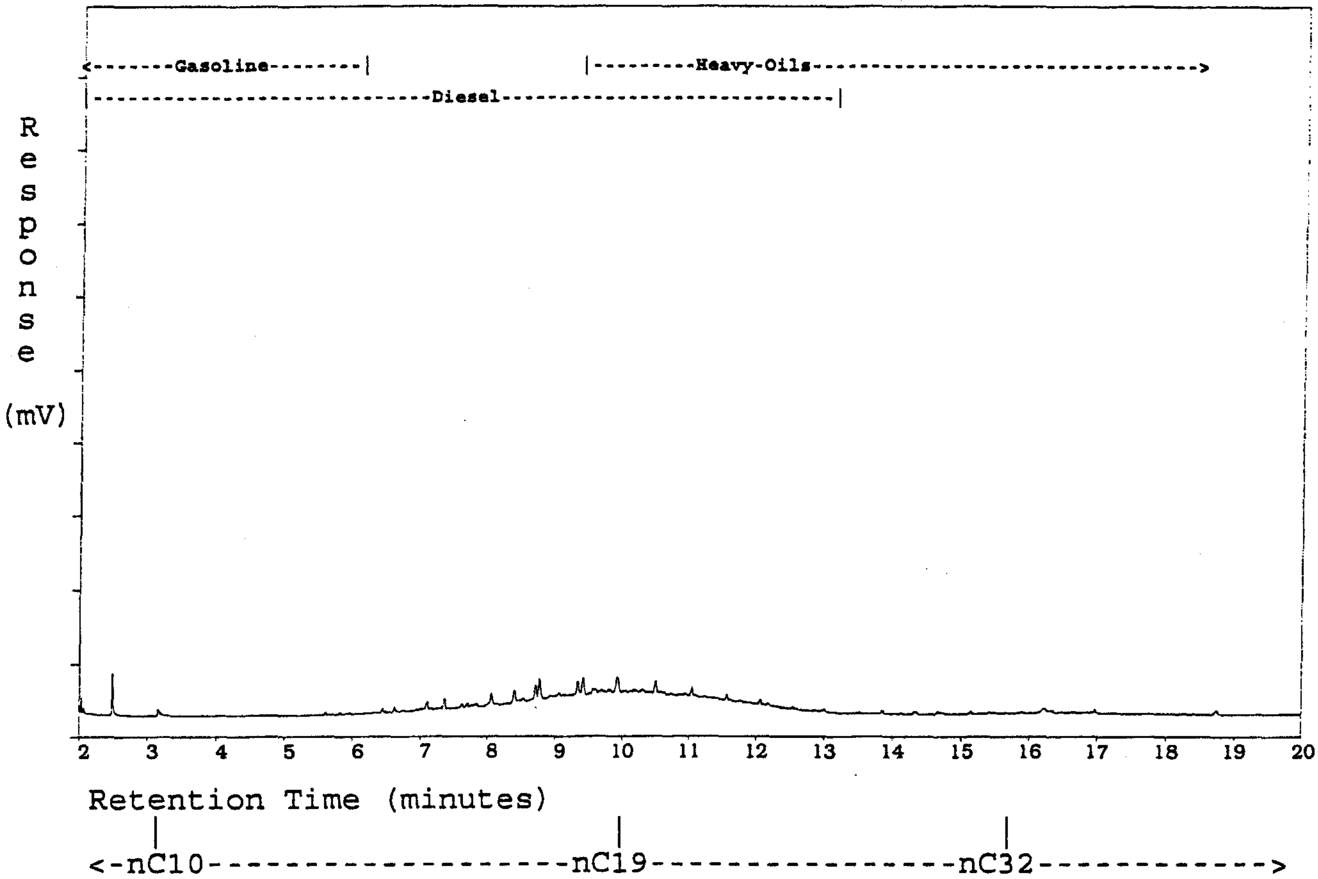
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE.NAME: BLW-6

File Name: C:\TEH\JN28\EH1JN28.09R ASL Sample ID: K6884-T--57 Sample acquired: JUN 28, 1999 17:28:52
Chromatogram Scale: 50.0 millivolts



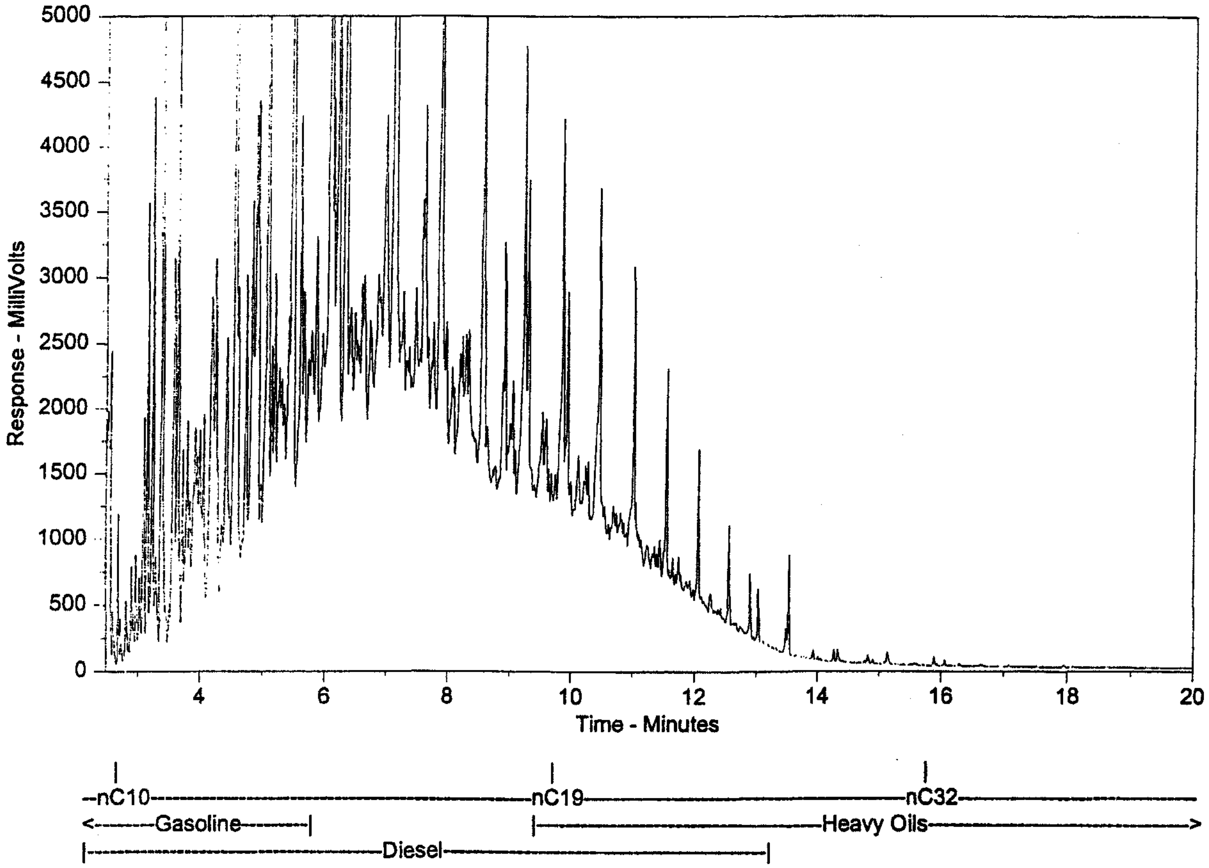
Sample Amt. (g or mL): 8.0 Dilution: 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH-5
ASL Sample ID: **L1002-T--2**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0021.RAW
Run Information: Acquired on GC04, 10/1/99 12:01:04 AM



Sample Amount = 535.0 (g or mL) Dilution Factor = 0.5

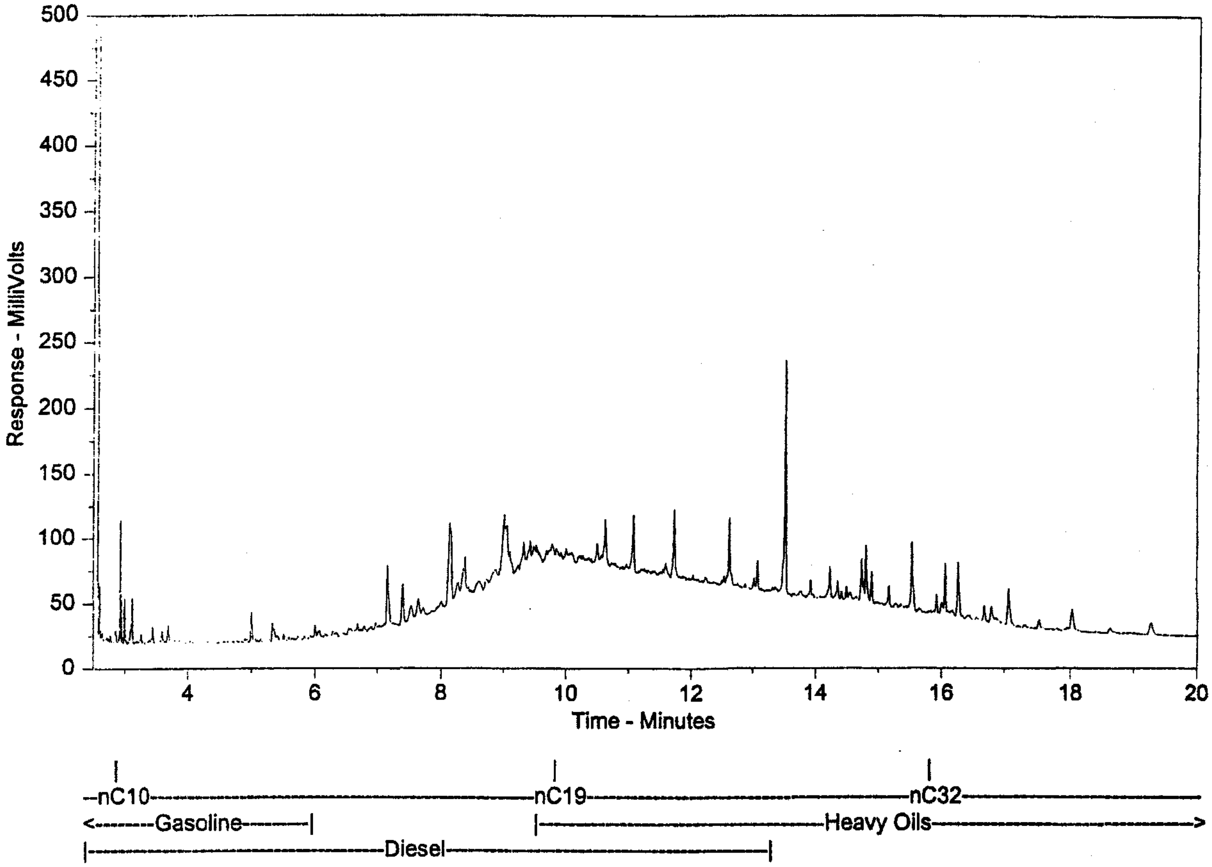
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH-9
ASL Sample ID: L1002-T--5
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0022.RAW
Run Information: Acquired on GC04, 10/1/99 12:32:30 AM



Sample Amount = 535.0 (g or mL) Dilution Factor = 0.5

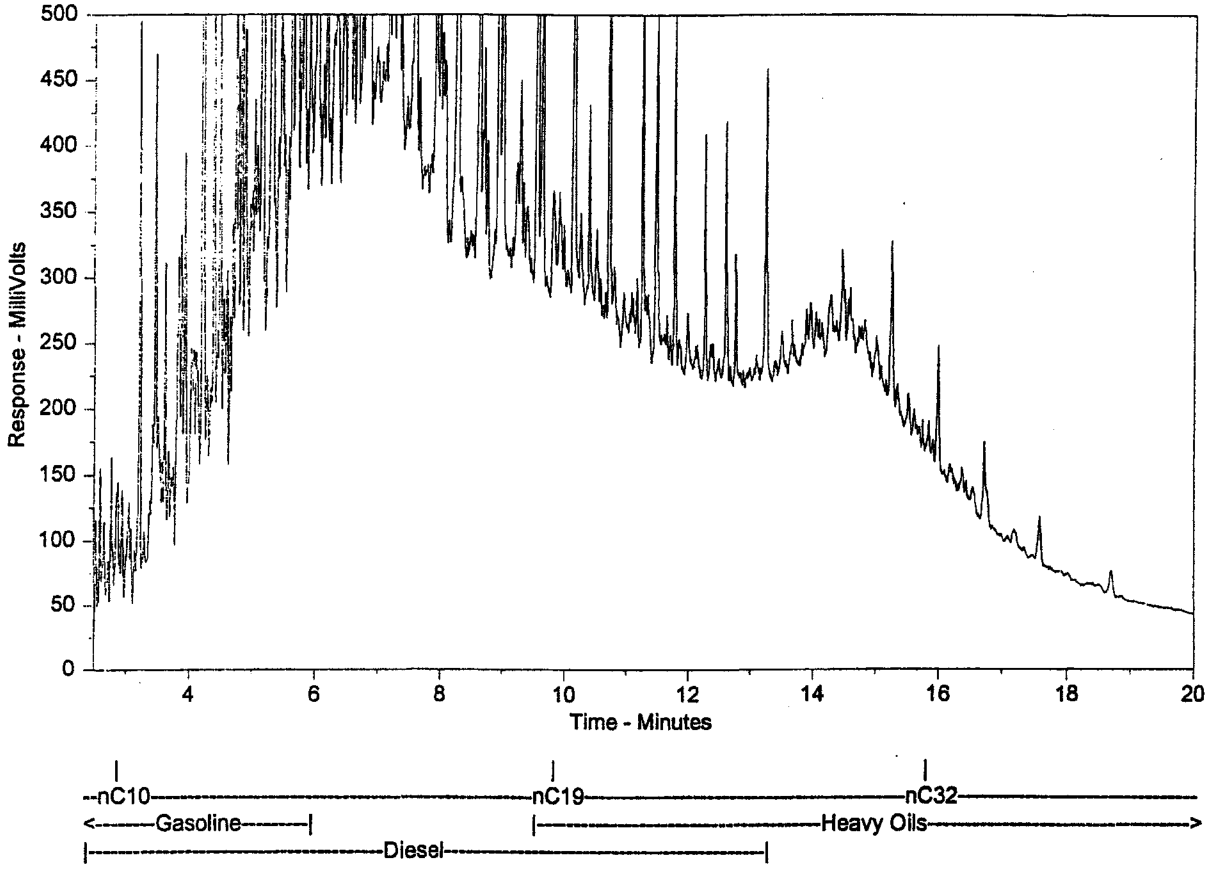
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH-14
ASL Sample ID: **L1002-T--10#LL**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepA.0020.RAW
Run Information: Acquired on GC04, 9/30/99 11:29:41 PM



Sample Amount = 1075.0 (g or mL)

Dilution Factor = 1.0

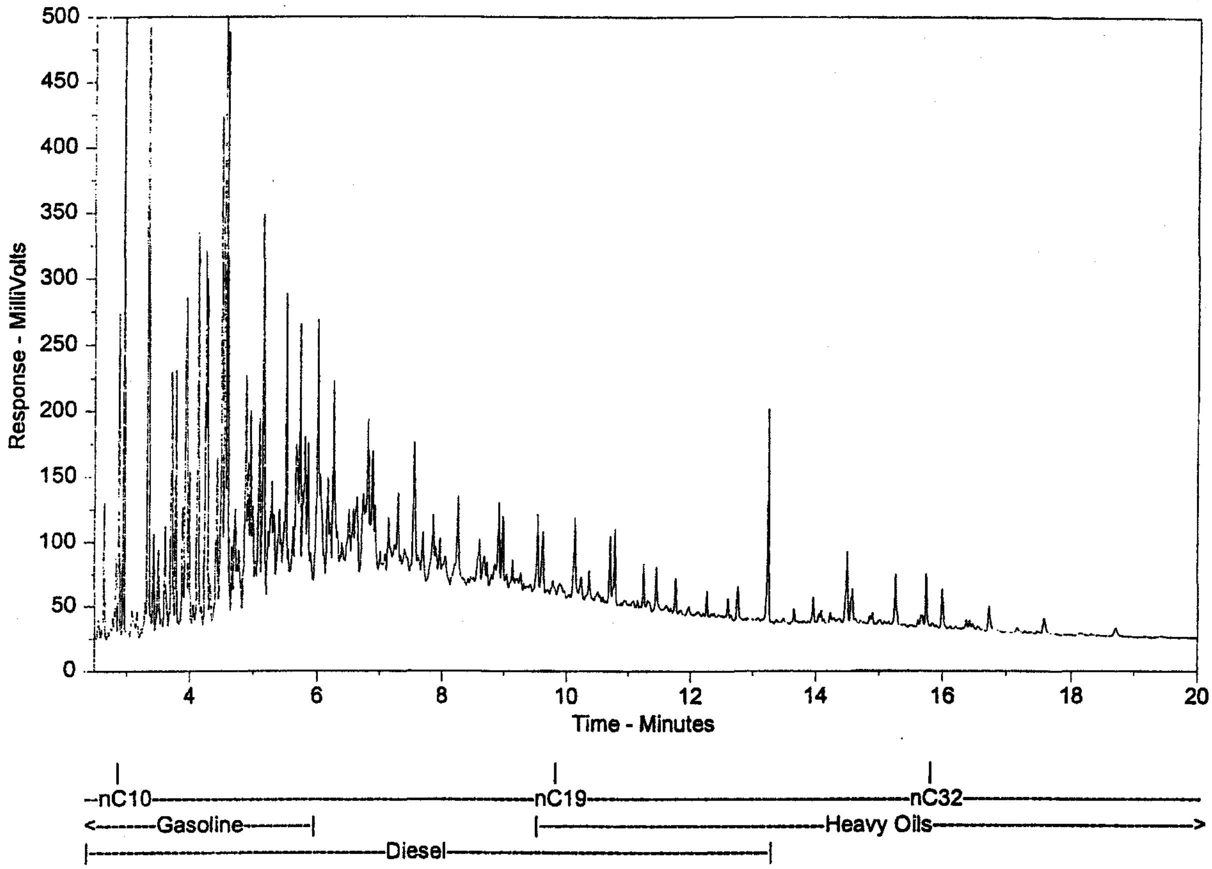
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH-13
ASL Sample ID: **L1002-T--3**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepA.0022.RAW
Run Information: Acquired on GC04, 10/1/99 12:32:30 AM



Sample Amount = 540.0 (g or mL)

Dilution Factor = 0.5

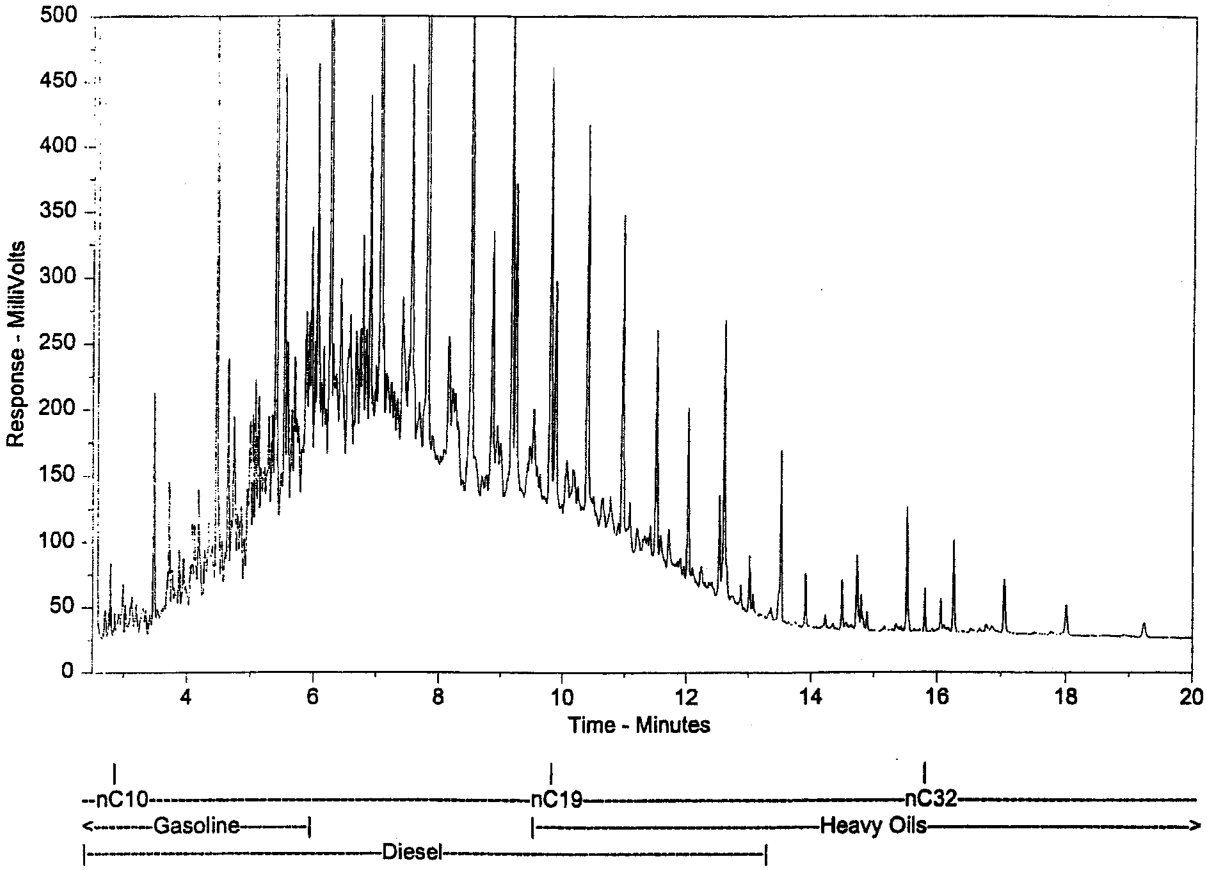
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH-18
ASL Sample ID: **L1002-T--7#LL**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0018.RAW
Run Information: Acquired on GC04, 9/30/99 10:26:59 PM



Sample Amount = 1075.0 (g or mL)

Dilution Factor = 1.0

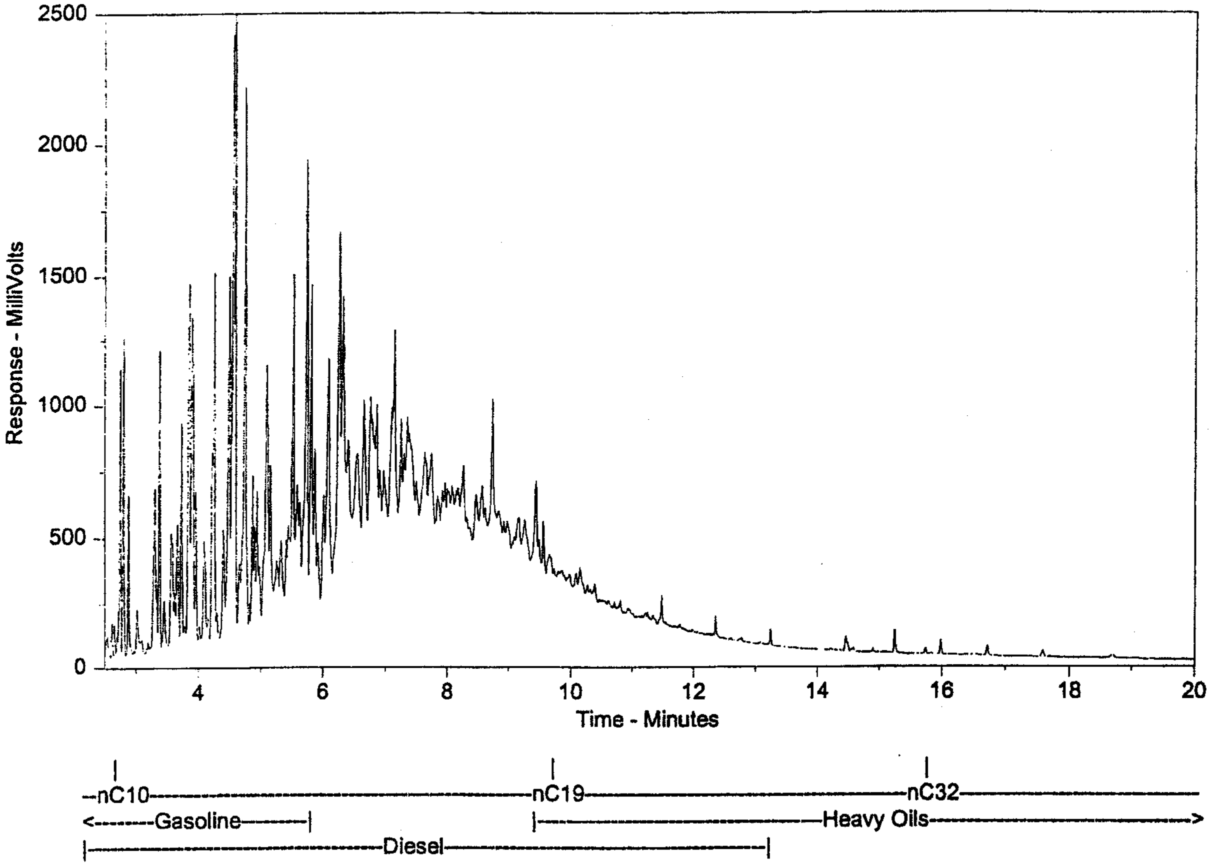
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: TH-19
ASL Sample ID: **L1002-T--8#LL**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepA.0019.RAW
Run Information: Acquired on GC04, 9/30/99 10:58:18 PM



Sample Amount = 1075.0 (g or mL)

Dilution Factor = 1.0

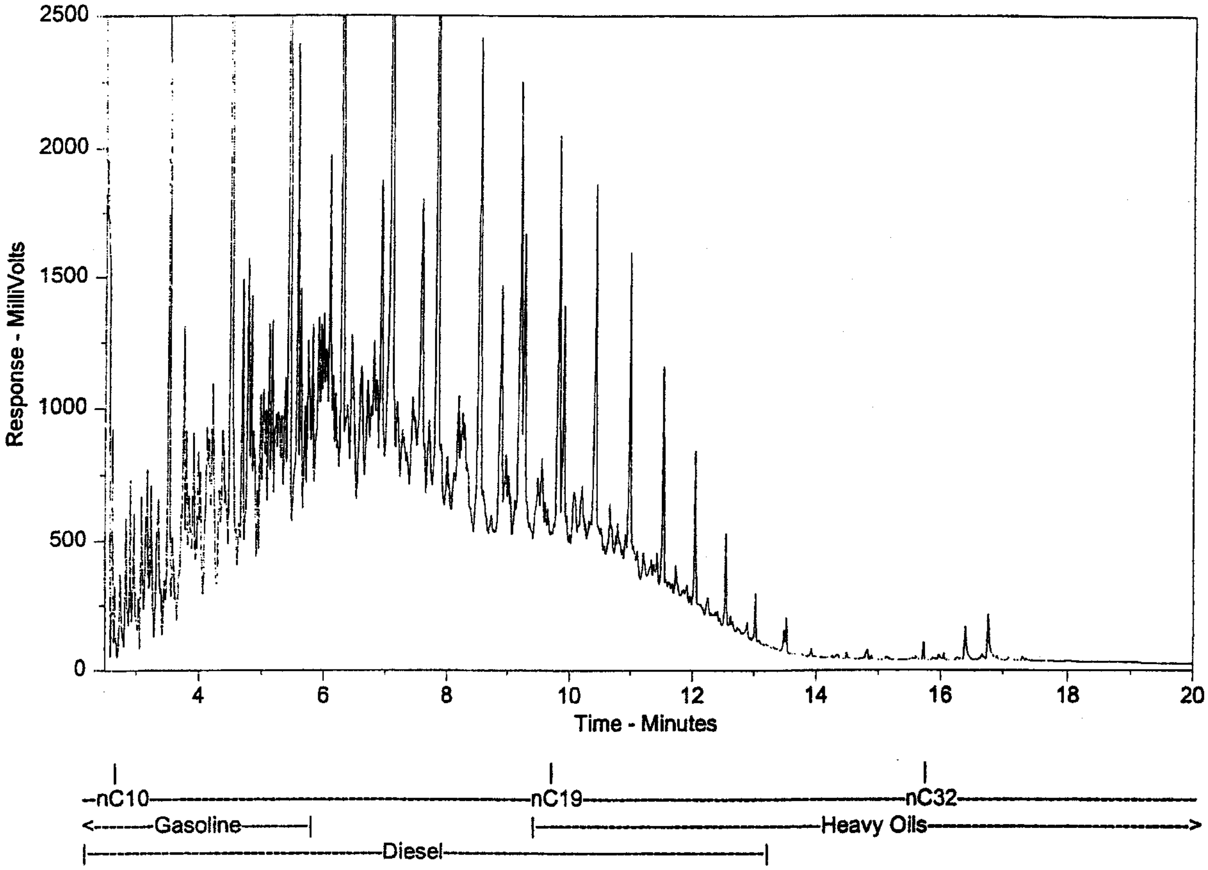
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: MP-3
ASL Sample ID: **L1002-T--9#**
File Name: M:\Chrom\gc04\data\30sep\gc04_30sepB.0019.RAW
Run Information: Acquired on GC04, 9/30/99 10:58:18 PM



Sample Amount = 515.0 (g or mL)

Dilution Factor = 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

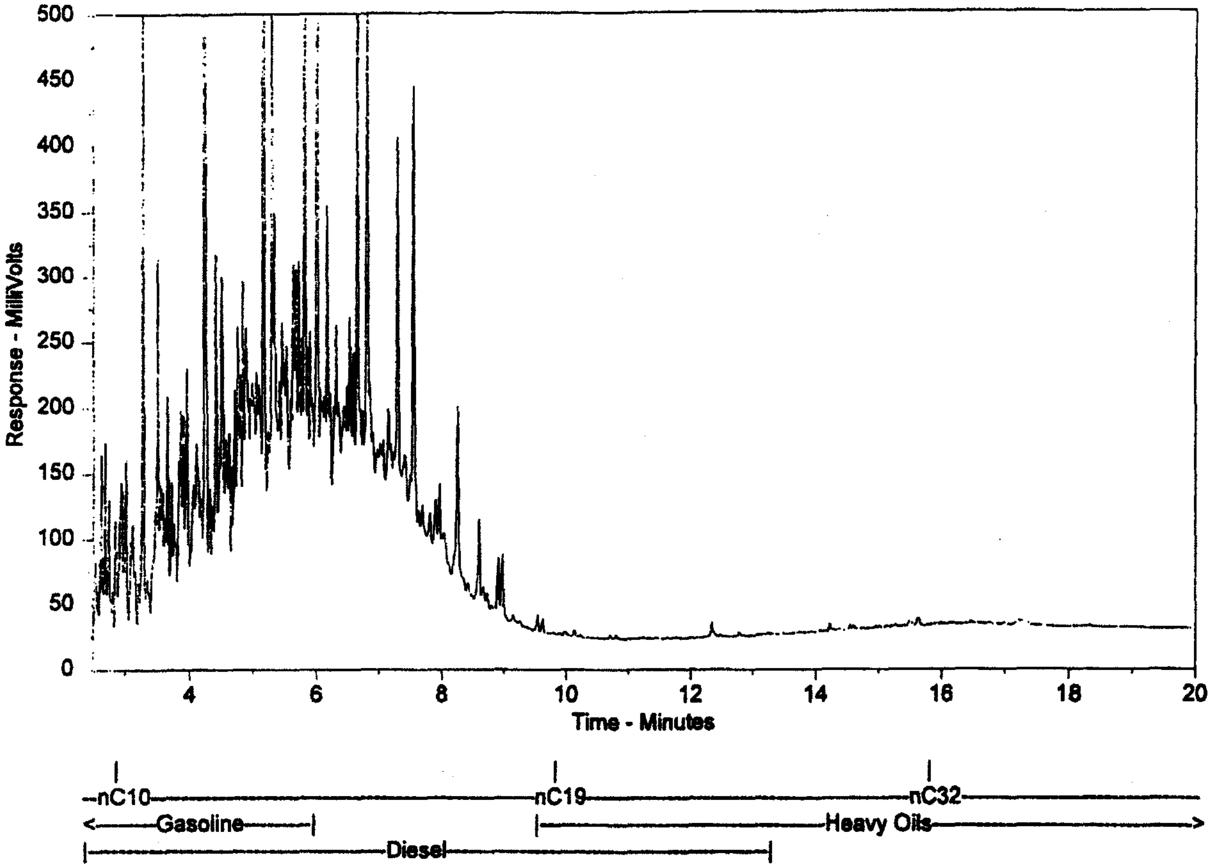
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORTS
FOR
CONFIRMATORY SAMPLES

ASL Hydrocarbon Distribution Report

Client Sample ID:	CS-5
ASL Sample ID:	**L1131-T--23**
File Name:	c:\chrom\gc04\data\gc04_05octA.0029.RAW
Run Information:	Acquired on GC04, 10/6/99 6:35:39 AM



Sample Amount = 16.4 (g or mL)

Dilution Factor = 10.0

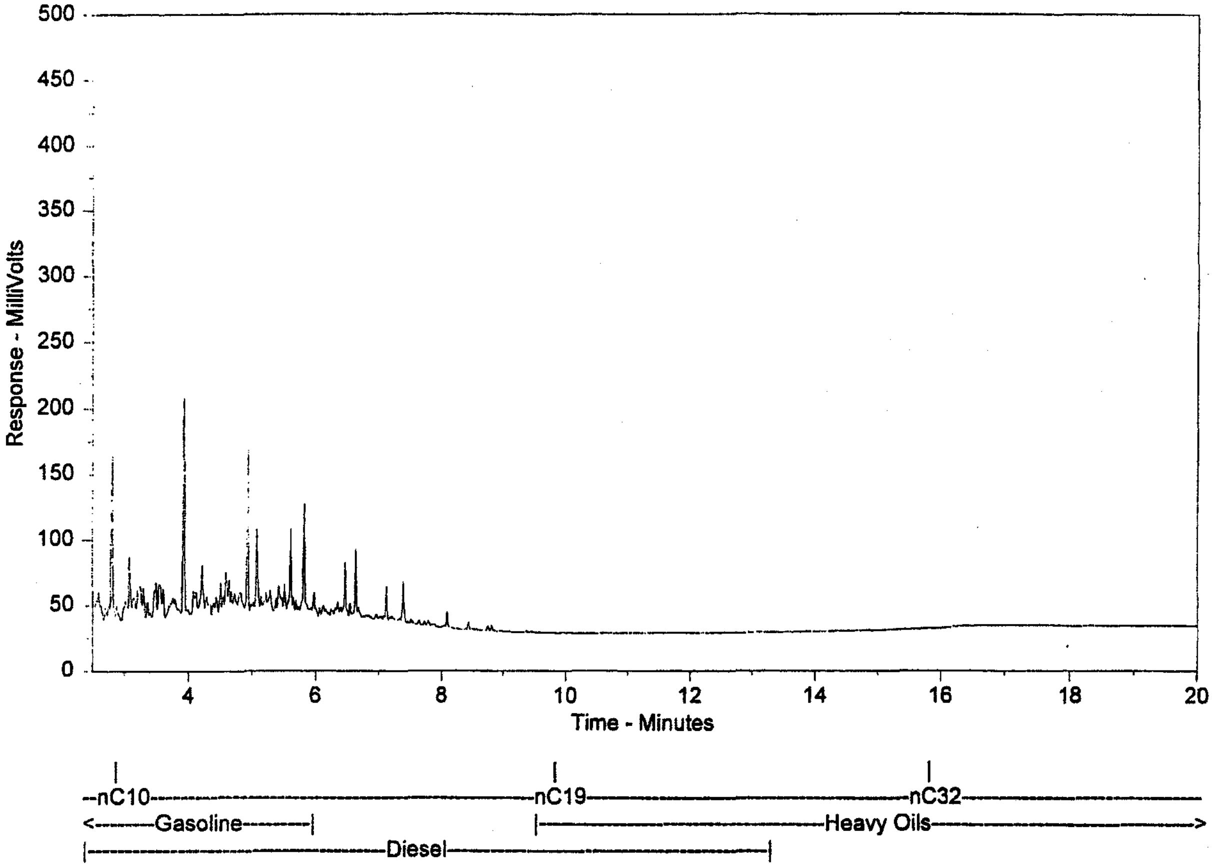
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-9
ASL Sample ID: **L1131-T--24**
File Name: M:\Chrom\gc12\data\06oct\gc12_06octA.0018.RAW
Run Information: Acquired on GC12, 10/7/99 1:06:43 AM



Sample Amount = 8.6 (g or mL)   Dilution Factor = 8.0

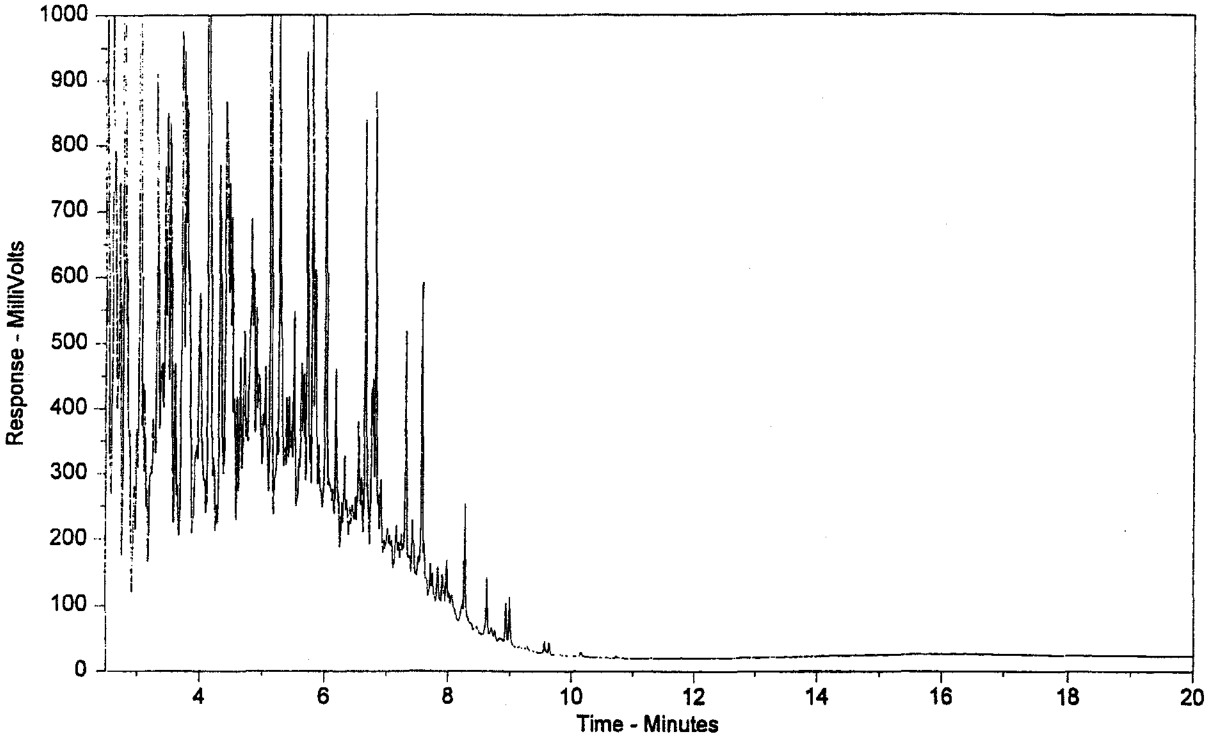
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-15
ASL Sample ID: **L1131-T--25**
File Name: c:\chrom\gc12\data\gc12_06octB.0018.RAW
Run Information: Acquired on GC12, 10/7/99 1:06:44 AM



--nC10---nC19--------------------------------nC32------------------------
<--------Gasoline--------| |---------------------------Heavy Oils---------------------------->
|------------------------------------Diesel------------------------------------|

Sample Amount = 10.6 (g or mL) Dilution Factor = 8.0

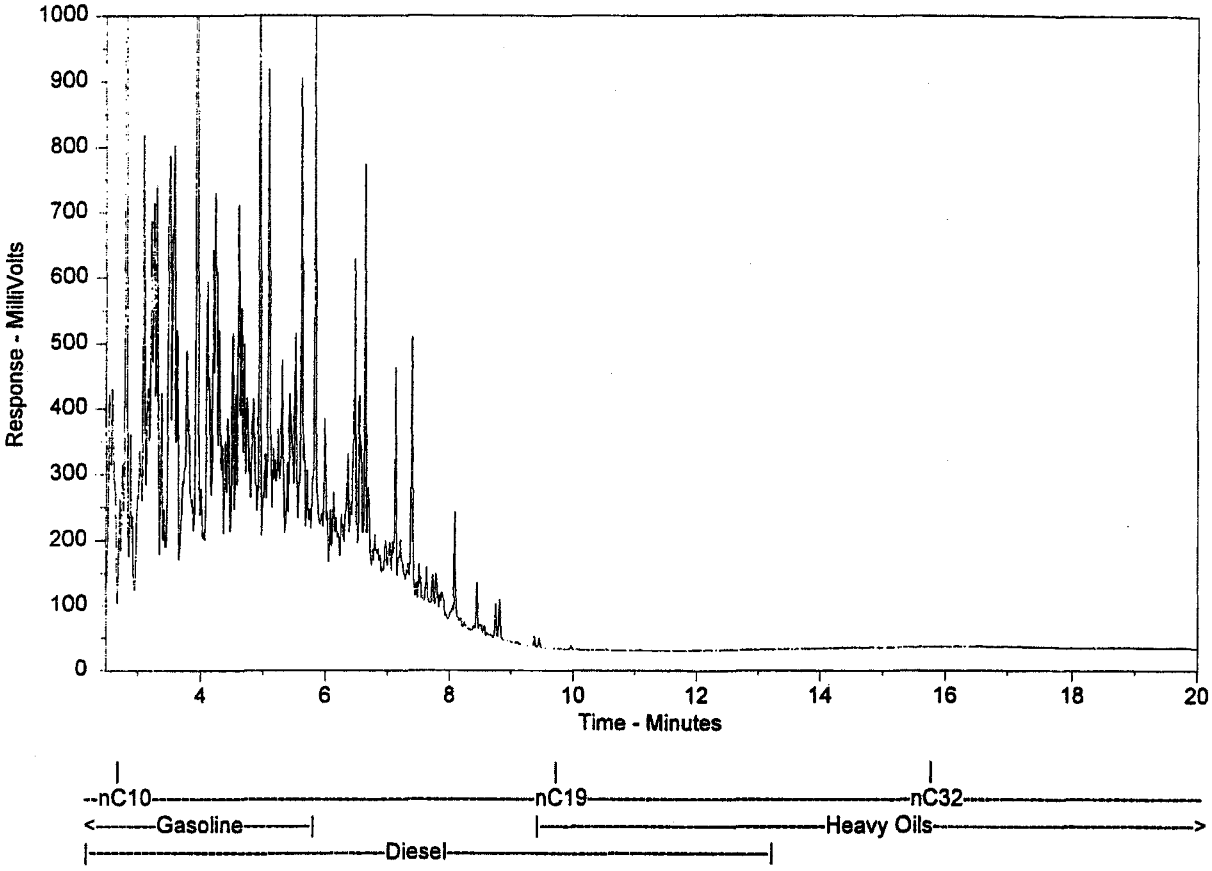
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-22
ASL Sample ID: **L1131-T--28**
File Name: c:\chrom\gc12\data\gc12_06octA.0020.RAW
Run Information: Acquired on GC12, 10/7/99 2:09:24 AM



Sample Amount = 9.3 (g or mL)

Dilution Factor = 8.0

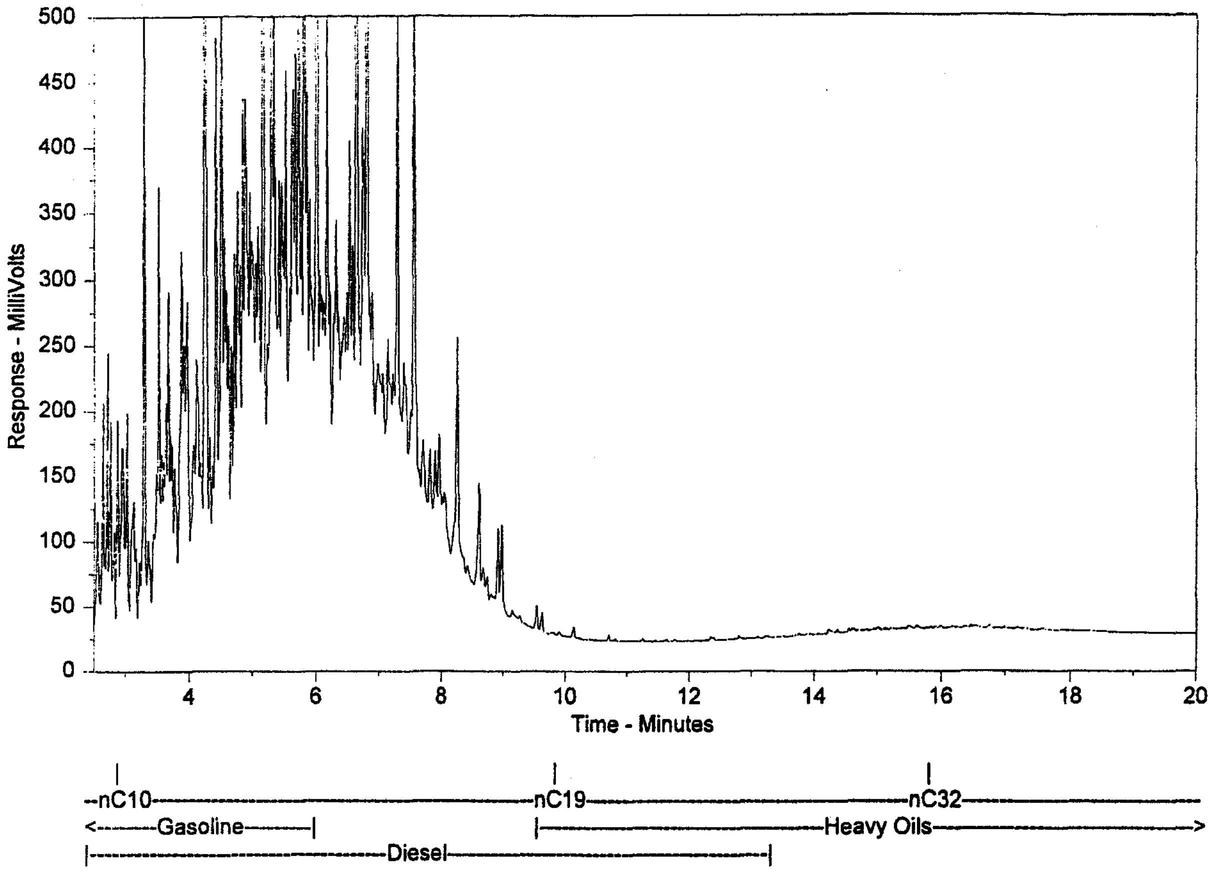
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-26
ASL Sample ID: **L1131-T--29**
File Name: c:\chrom\gc04\data\gc04_05octA.0031.RAW
Run Information: Acquired on GC04, 10/6/99 7:38:32 AM



Sample Amount = 9.3 (g or mL)

Dilution Factor = 10.0

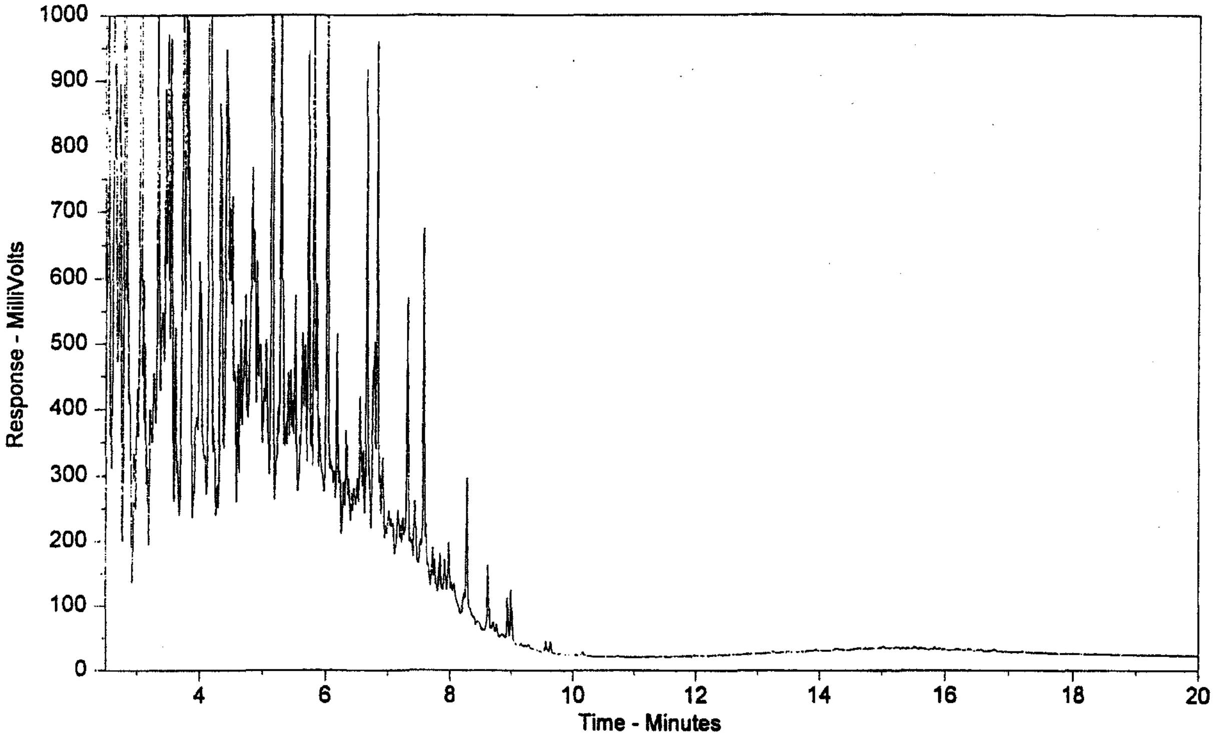
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-36
ASL Sample ID: **L1131-T--32**
File Name: c:\chrom\gc12\data\gc12_06octB.0021.RAW
Run Information: Acquired on GC12, 10/7/99 2:40:47 AM



--nC10------------------------------nC19------------------------------nC32------------------------------
<--------Gasoline--------| |------------------------------Heavy Oils------------------------------>
|------------------------------Diesel------------------------------|

Sample Amount = 10.3 (g or mL) Dilution Factor = 8.0

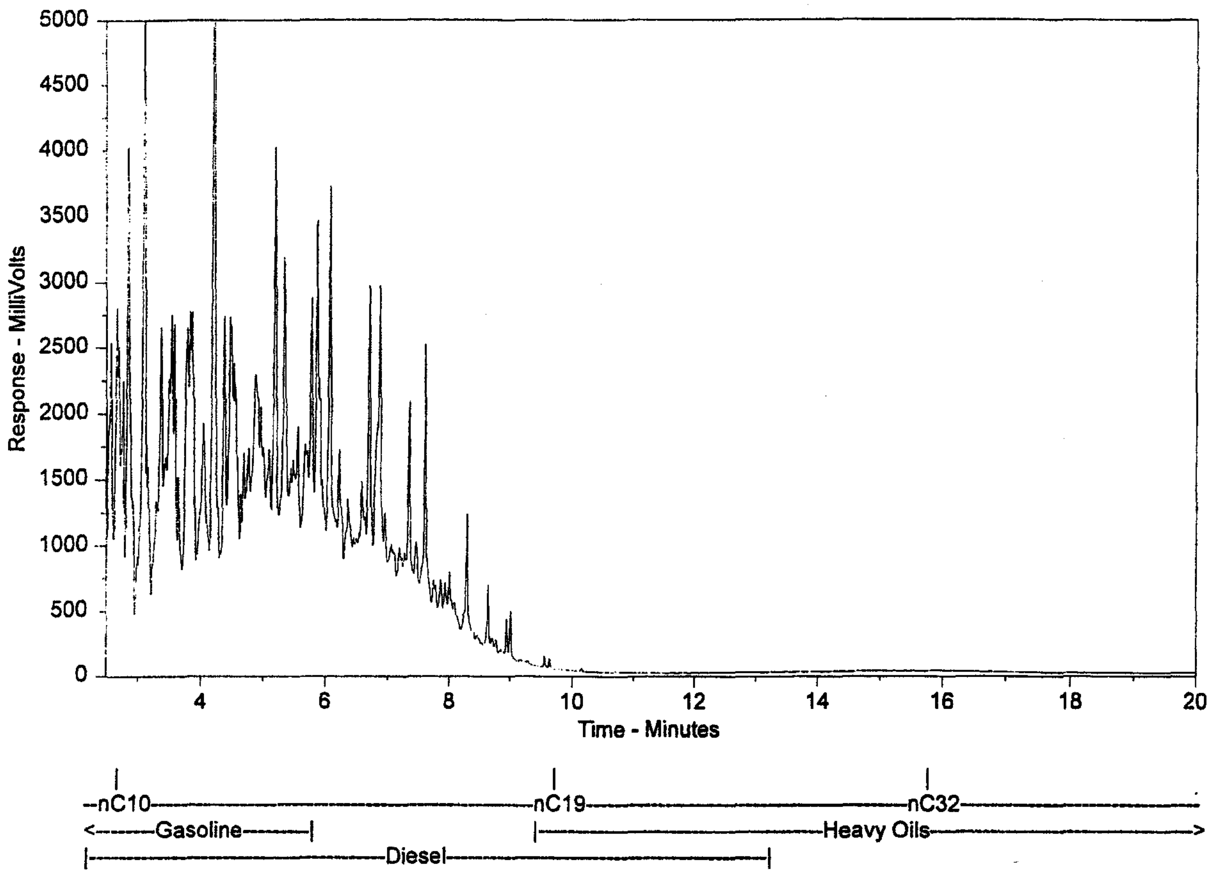
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-41
ASL Sample ID: **L1131-T--35**
File Name: c:\chrom\gc12\data\gc12_06octB.0023.RAW
Run Information: Acquired on GC12, 10/7/99 3:43:26 AM



Sample Amount = 12.3 (g or mL)

Dilution Factor = 8.0

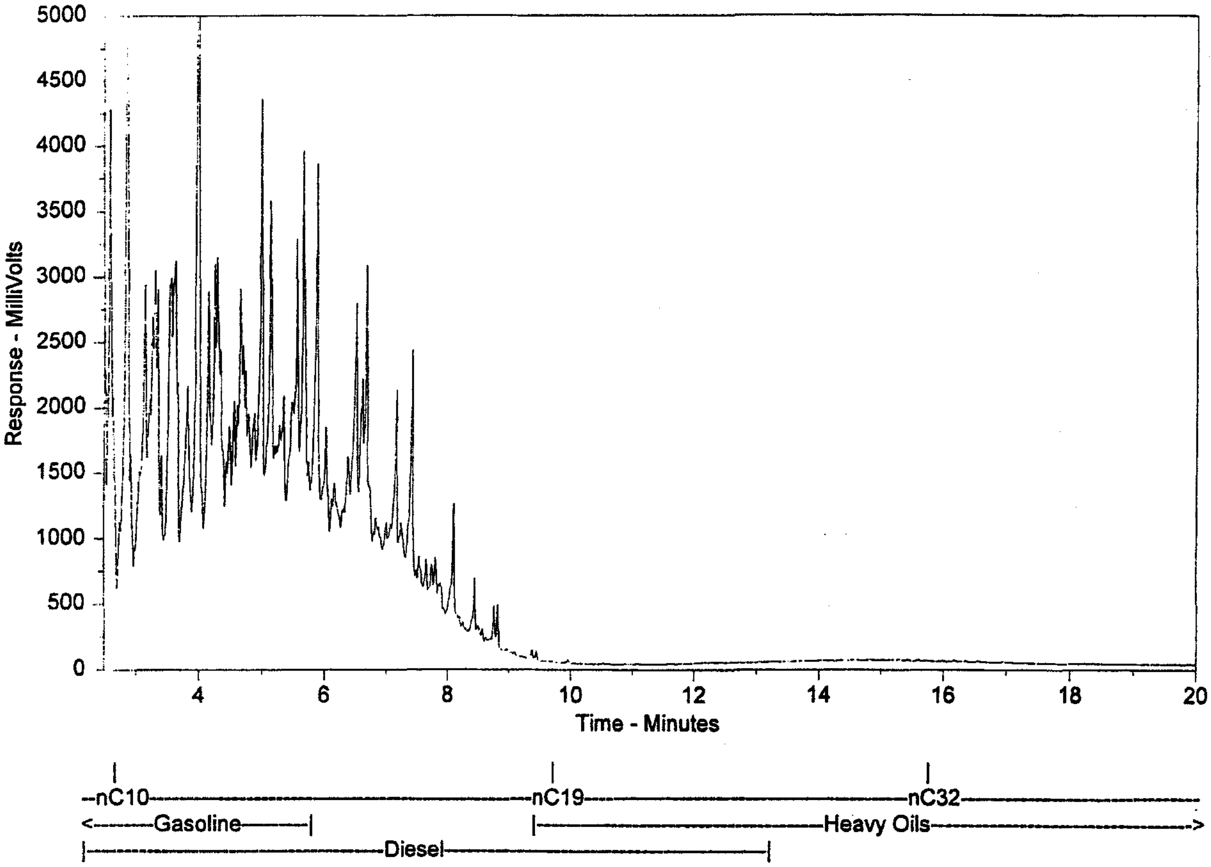
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-42
ASL Sample ID: **L1131-T--36**
File Name: c:\chrom\gc12\data\gc12_06octA.0024.RAW
Run Information: Acquired on GC12, 10/7/99 4:14:44 AM



Sample Amount = 9.4 (g or mL) Dilution Factor = 8.0

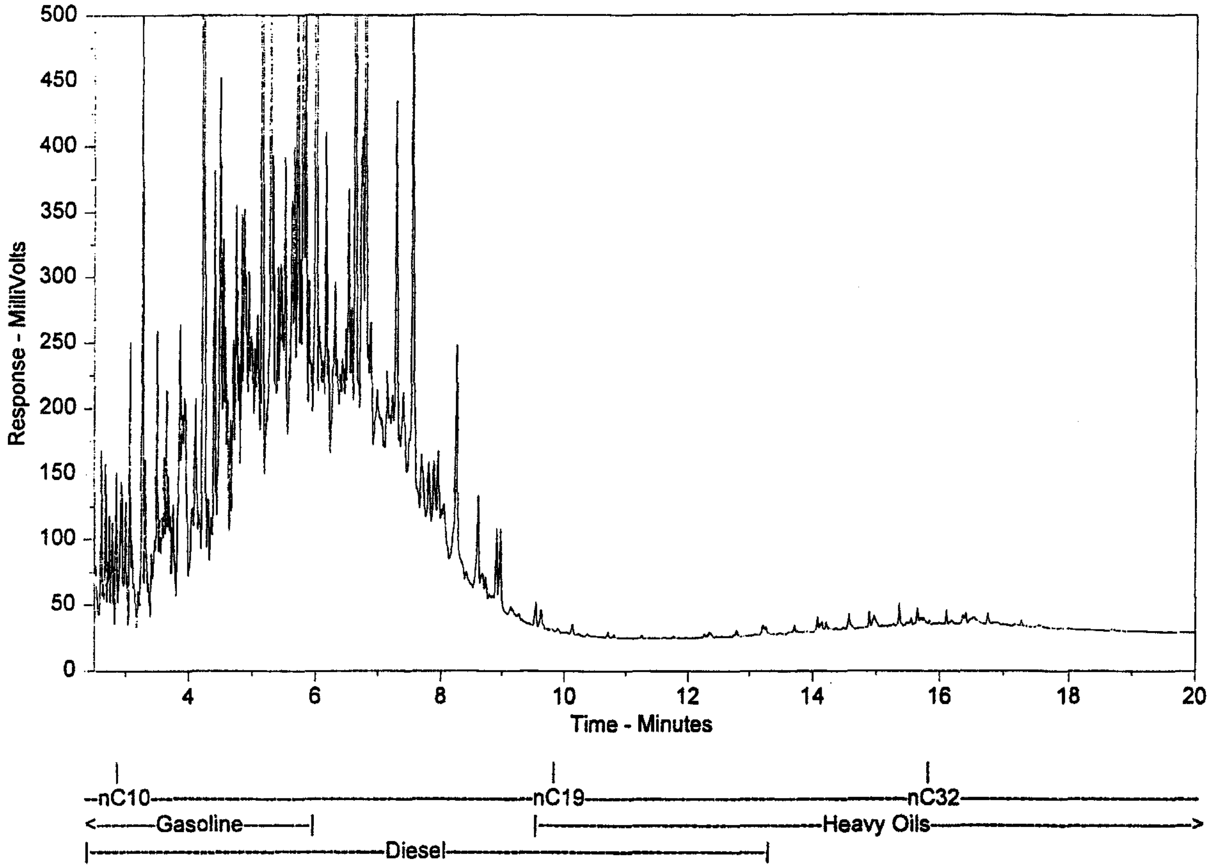
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-43
ASL Sample ID: **L1131-T--37**
File Name: c:\chrom\gc04\data\gc04_05octA.0032.RAW
Run Information: Acquired on GC04, 10/6/99 8:10:02 AM



Sample Amount = 6.7 (g or mL)

Dilution Factor = 10.0

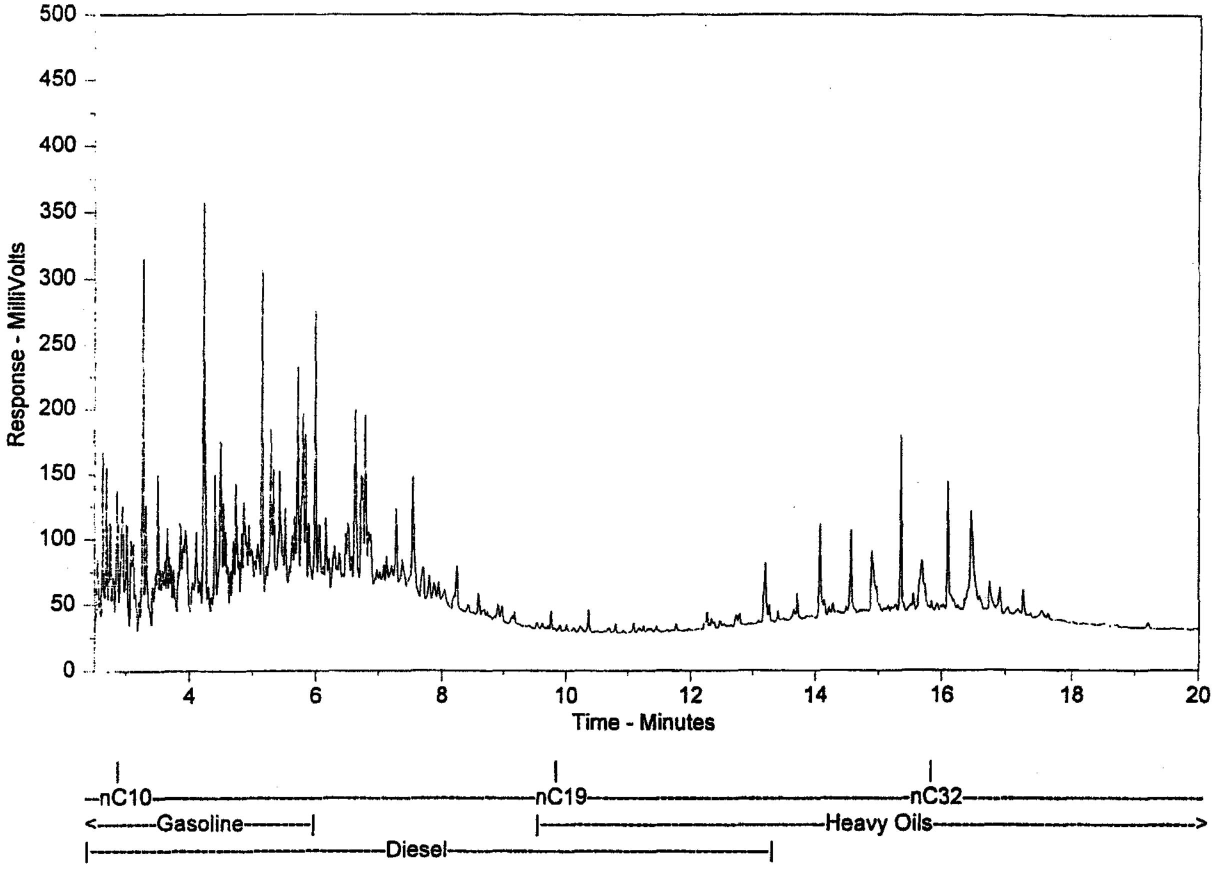
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-45
ASL Sample ID: **L1131-T--38**
File Name: c:\chrom\gc04\data\gc04_05octA.0033.RAW
Run Information: Acquired on GC04, 10/6/99 8:41:31 AM



Sample Amount = 5.2 (g or mL) Dilution Factor = 10.0

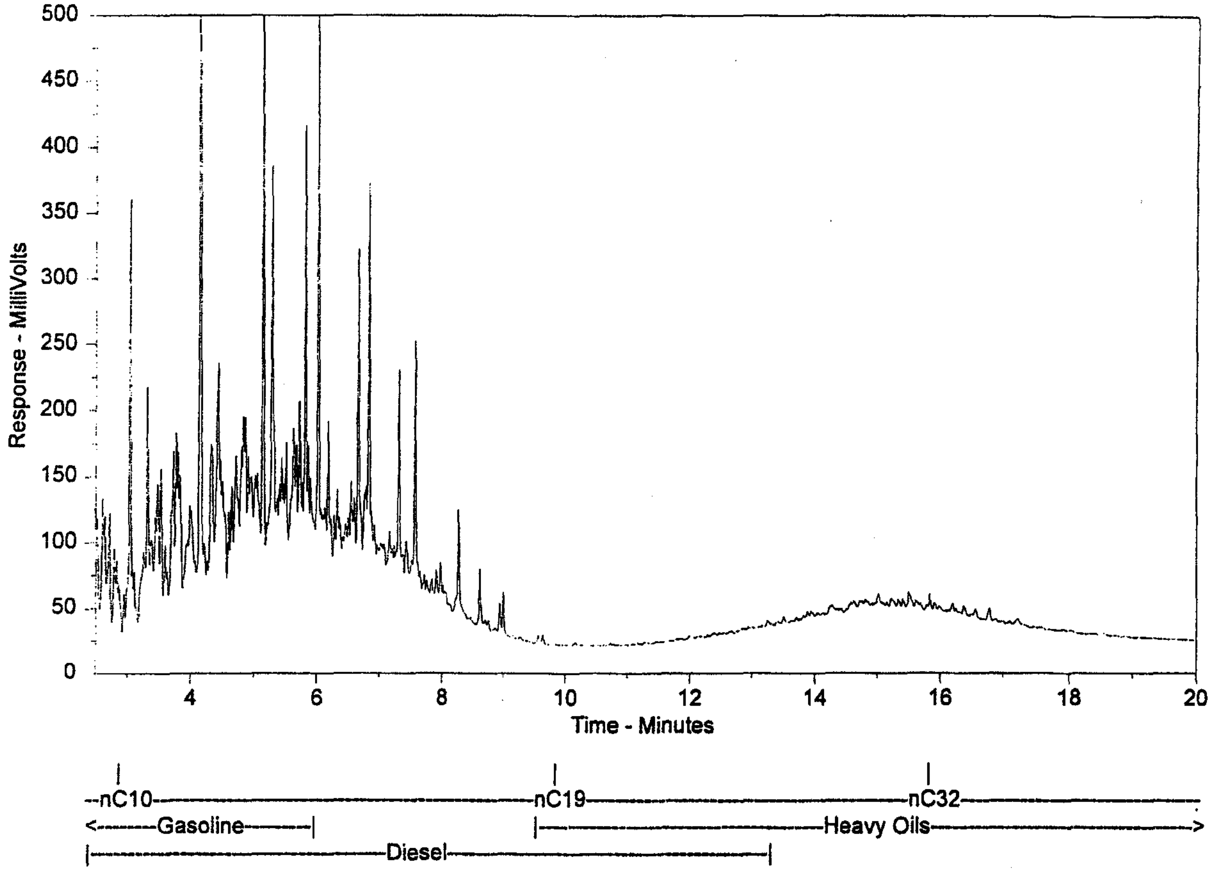
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-50
ASL Sample ID: L1131-T--41
File Name: c:\chrom\gc12\data\gc12_06octB.0025.RAW
Run Information: Acquired on GC12, 10/7/99 4:46:00 AM



Sample Amount = 8.7 (g or mL)

Dilution Factor = 8.0

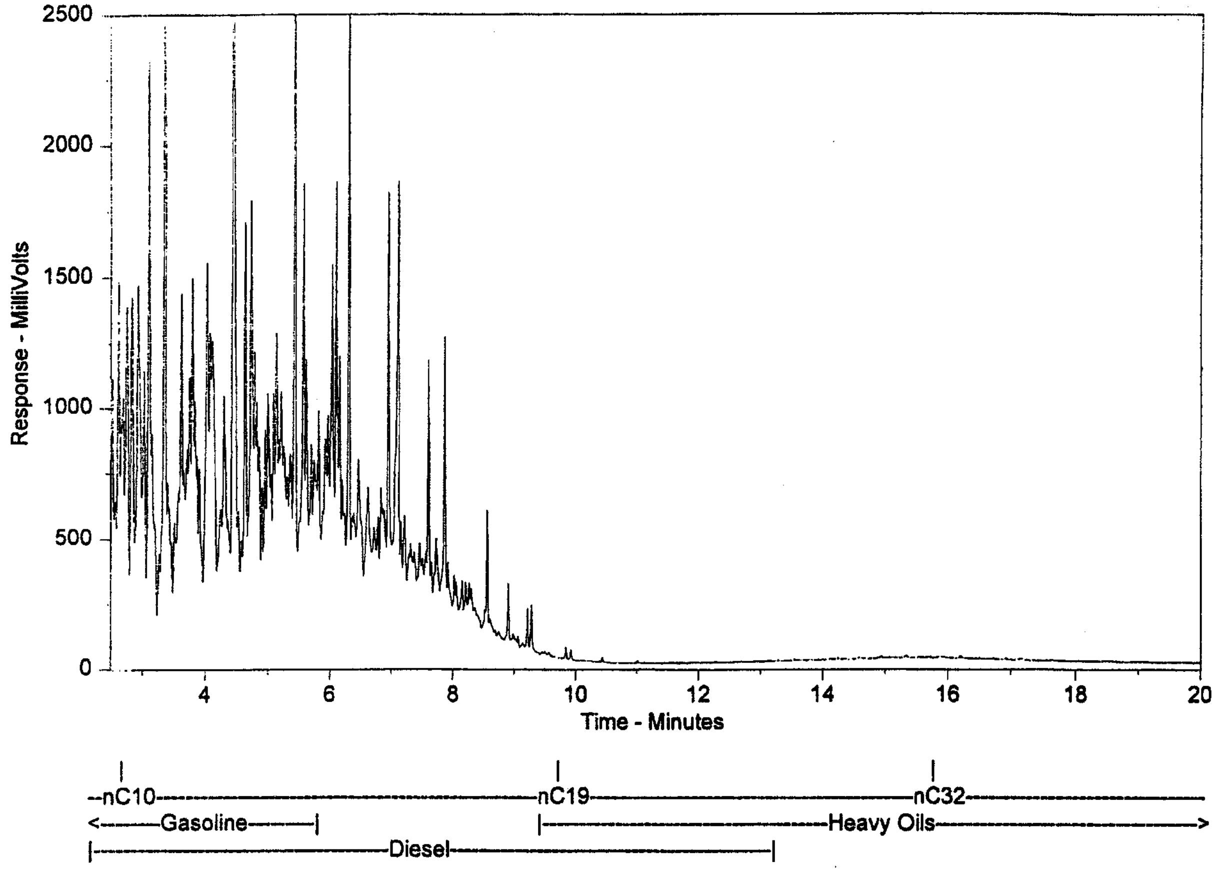
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-51
ASL Sample ID: **L1131-T--1**
File Name: c:\chrom\gc04\data\gc04_05octB.0027.RAW
Run Information: Acquired on GC04, 10/6/99 5:32:53 AM



Sample Amount = 9.2 (g or mL)

Dilution Factor = 8.0

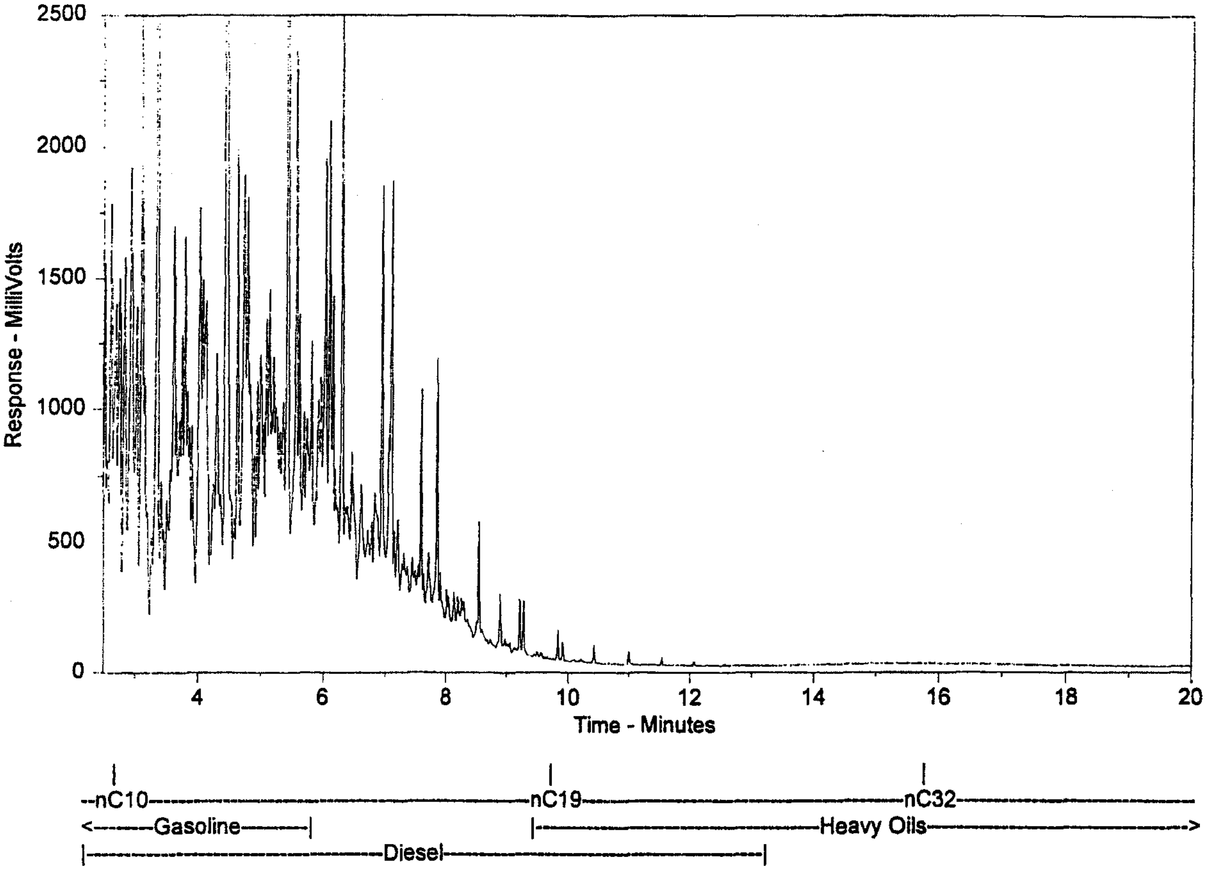
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-60
ASL Sample ID: L1131-T--7
File Name: c:\chrom\gc04\data\gc04_05octB.0035.RAW
Run Information: Acquired on GC04, 10/6/99 9:44:34 AM



Sample Amount = 11.3 (g or mL)

Dilution Factor = 8.0

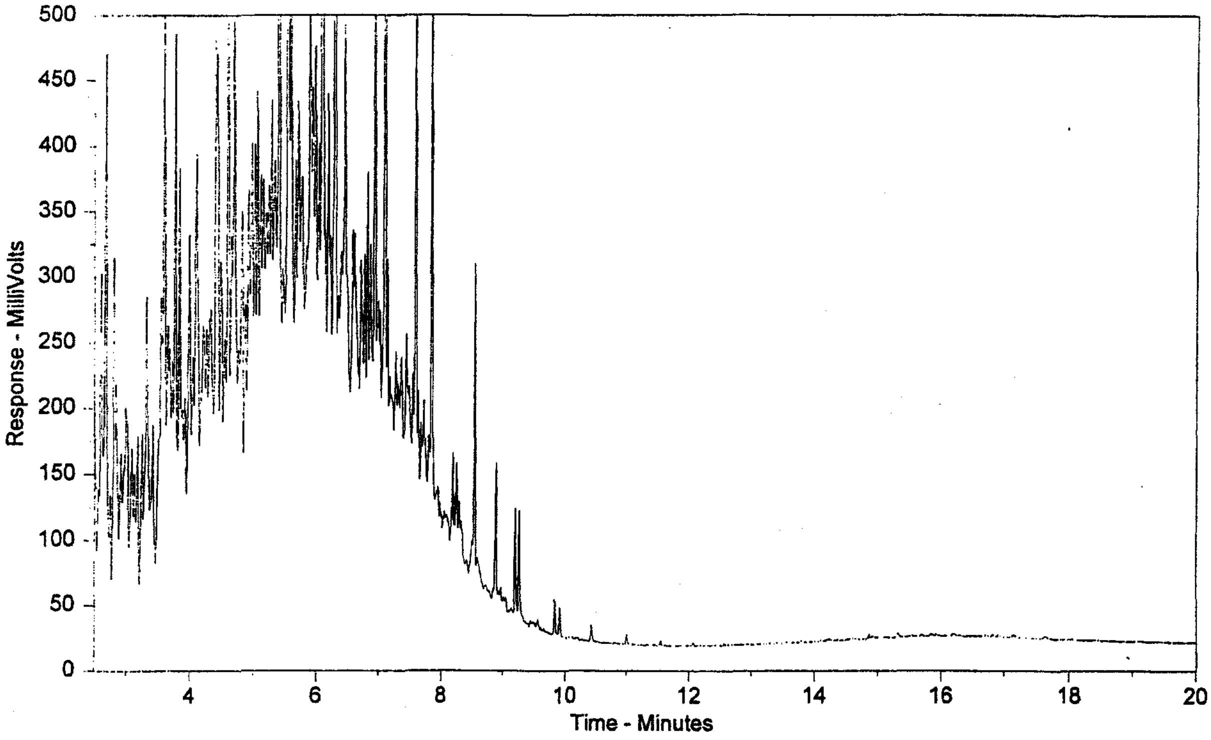
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	CS-63
ASL Sample ID:	**L1131-T--6**
File Name:	M:\Chrom\gc04\data\05oct\gc04_05octB.0034.RAW
Run Information:	Acquired on GC04, 10/6/99 9:13:03 AM



--nC10--nC19--------------------------------------nC32--------------------------
<---------Gasoline---------| |------------------------------------Heavy Oils------------------------------------>
|---------------------------------Diesel---------------------------------------|

Sample Amount = 12.2 (g or mL) Dilution Factor = 8.0

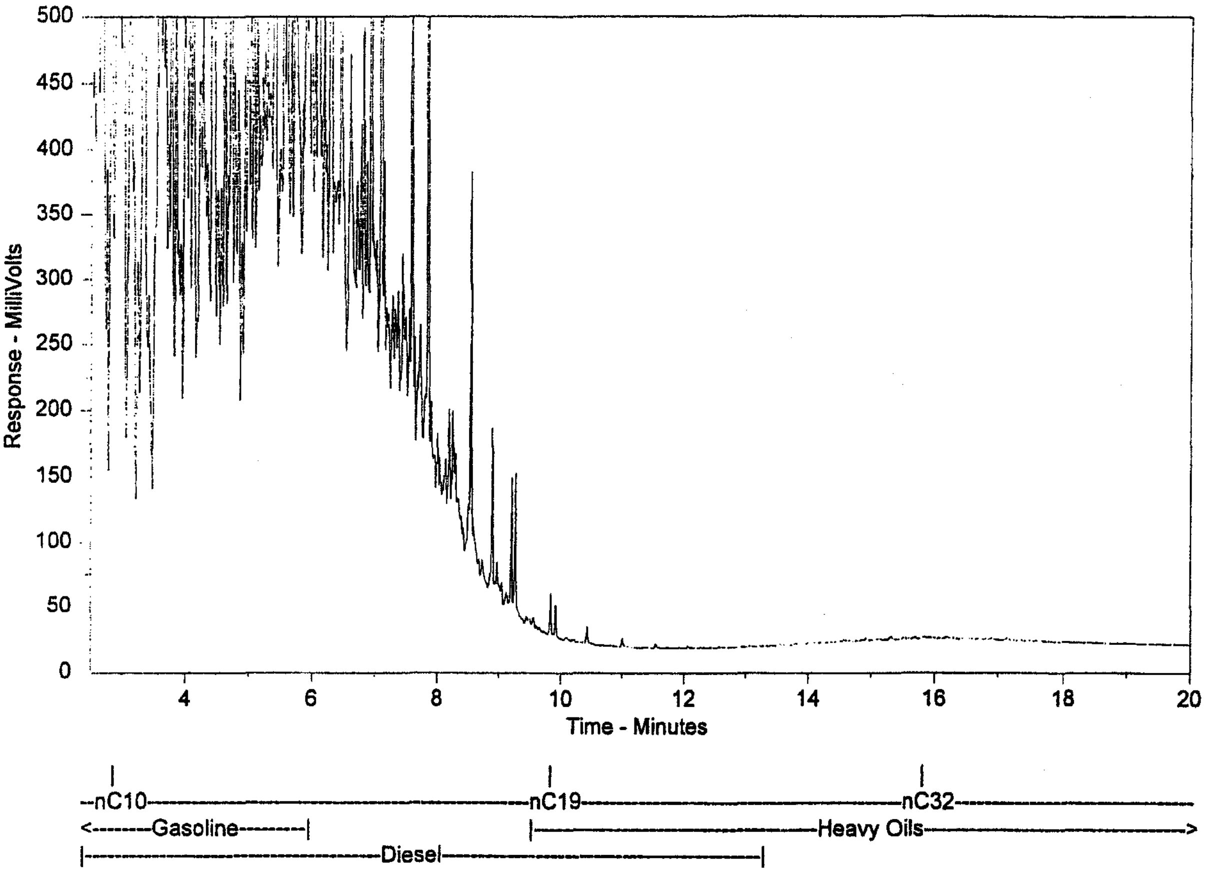
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: CS-68
ASL Sample ID: **L1131-T--11**
File Name: c:\chrom\gc04\data\gc04_05octB.0037.RAW
Run Information: Acquired on GC04, 10/6/99 10:47:41 AM



Sample Amount = 11.3 (g or mL)

Dilution Factor = 8.0

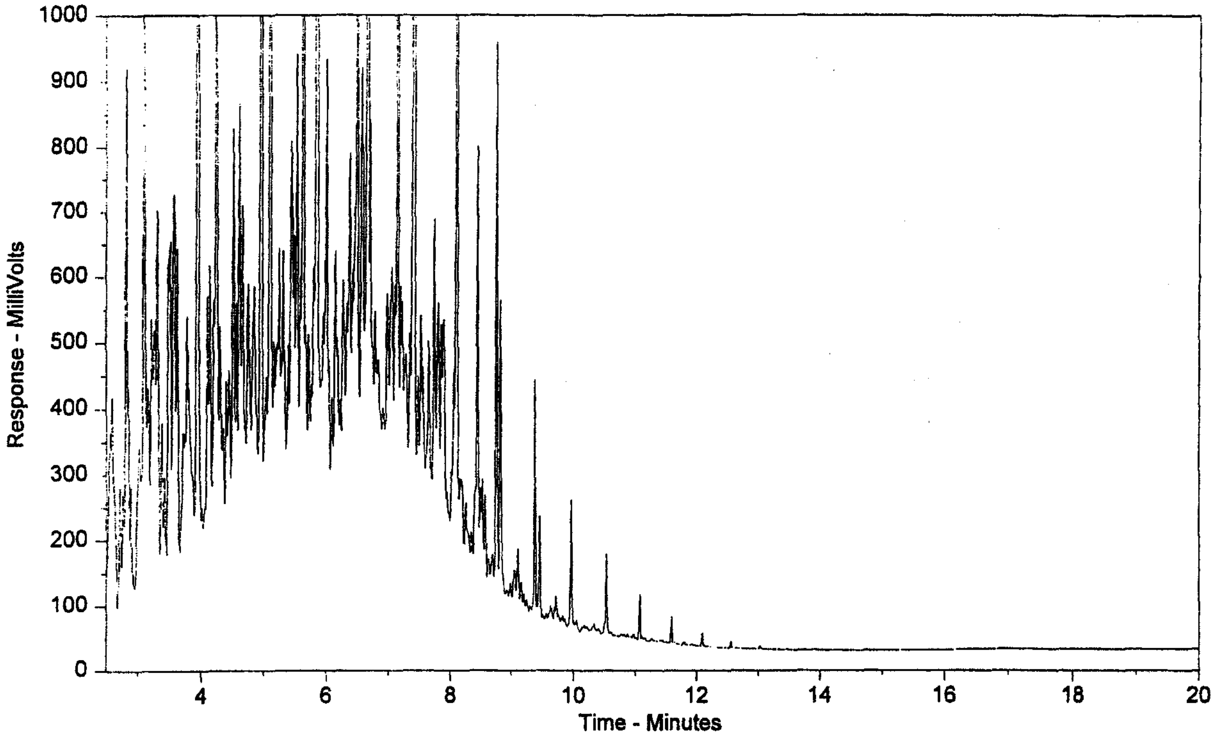
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: UST 2
ASL Sample ID: L1131-T--43
File Name: c:\chrom\gc12\data\gc12_06octA.0028.RAW
Run Information: Acquired on GC12, 10/7/99 6:20:09 AM



--nC10--nC19---------------------------nC32----------------
<-------Gasoline--------| |-----------------------------Heavy Oils------------------------->
|----------------------------Diesel-----------------------------------|

Sample Amount = 7.7 (g or mL) Dilution Factor = 8.0

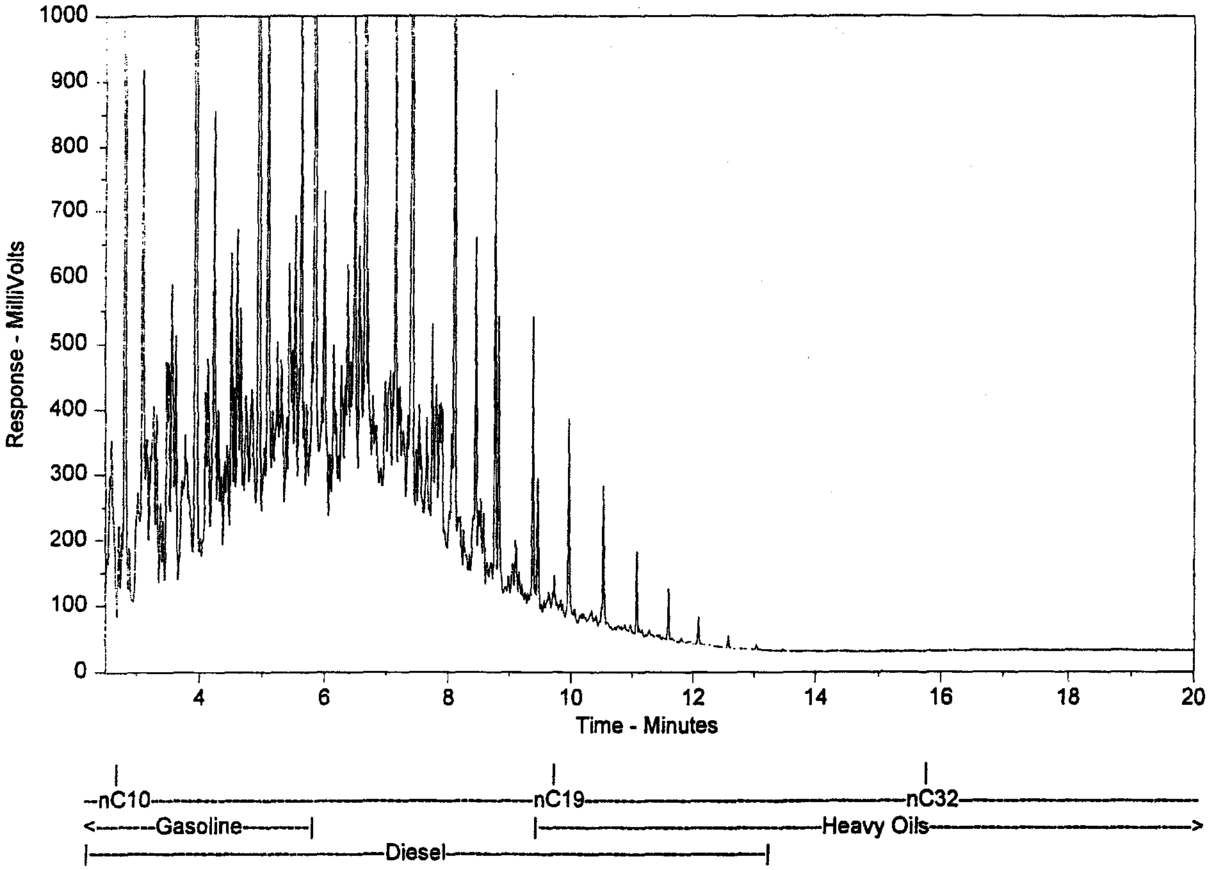
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: UST 11
ASL Sample ID: **L1131-T--45**
File Name: c:\chrom\gc12\data\gc12_06octA.0029.RAW
Run Information: Acquired on GC12, 10/7/99 6:51:36 AM



Sample Amount = 9.3 (g or mL) Dilution Factor = 8.0

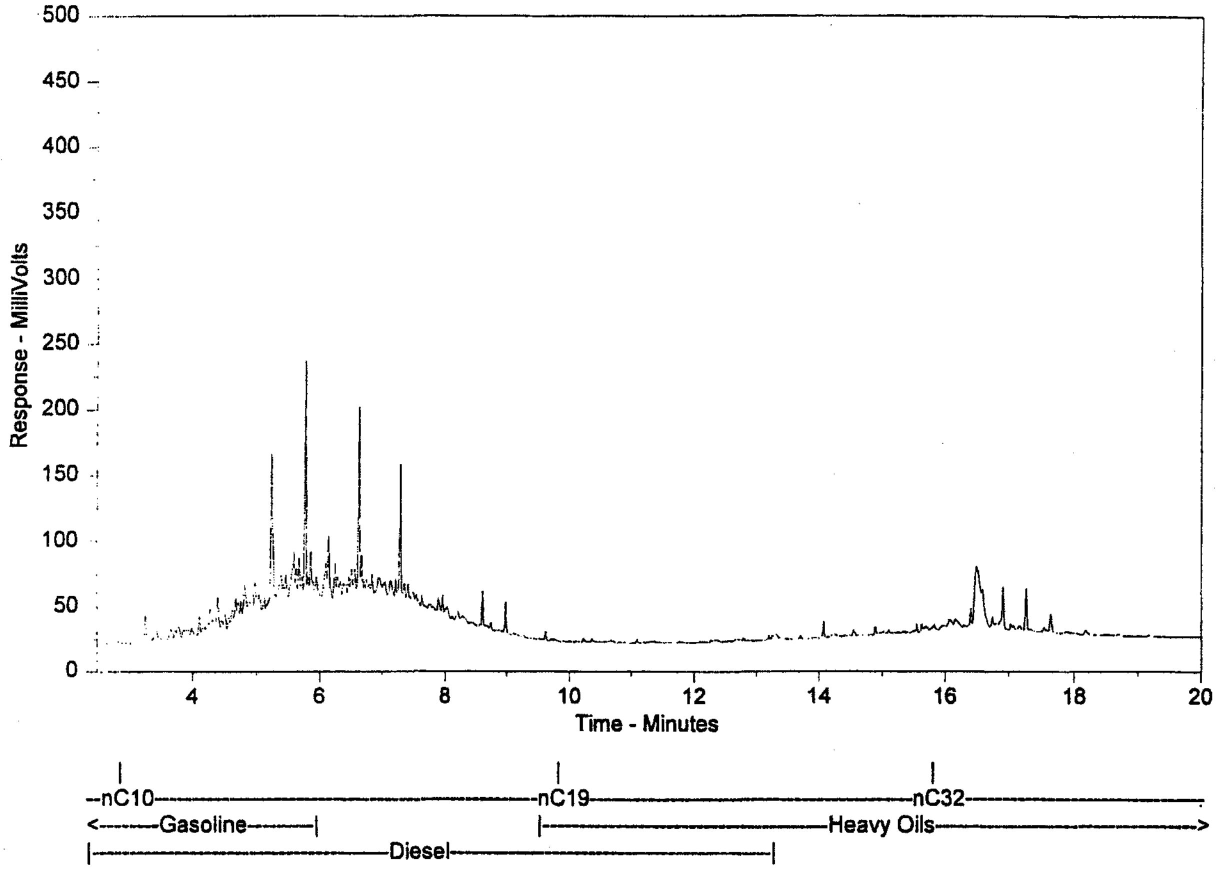
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: BLS-10
ASL Sample ID: **L1131-T--12**
File Name: c:\chrom\gc04\data\gc04_05octA.0038.RAW
Run Information: Acquired on GC04, 10/6/99 11:19:13 AM



Sample Amount = 5.6 (g or mL) Dilution Factor = 8.0

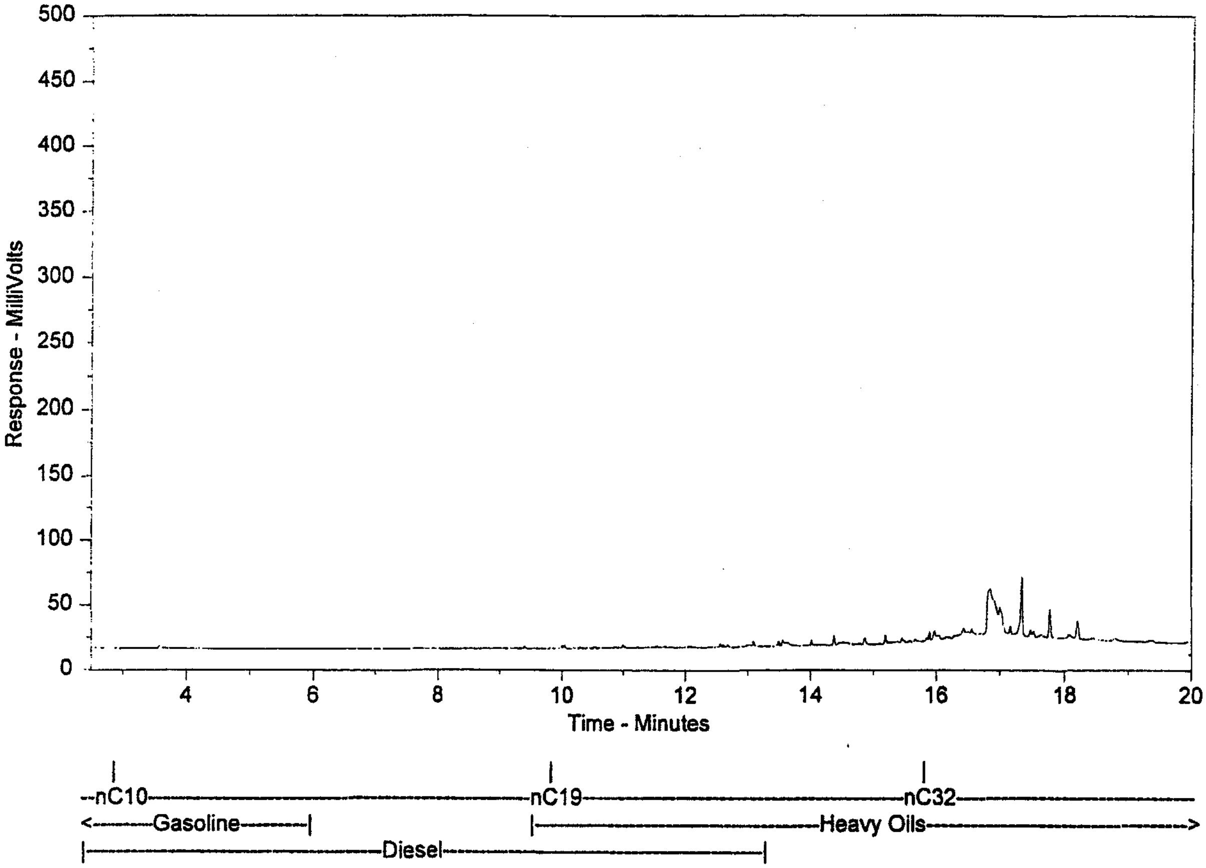
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: BLS-11
ASL Sample ID: L1131-T--13
File Name: c:\chrom\gc04\data\gc04_06octB.0004.RAW
Run Information: Acquired on GC04, 10/6/99 1:58:55 PM



Sample Amount = 7.7 (g or mL)

Dilution Factor = 8.0

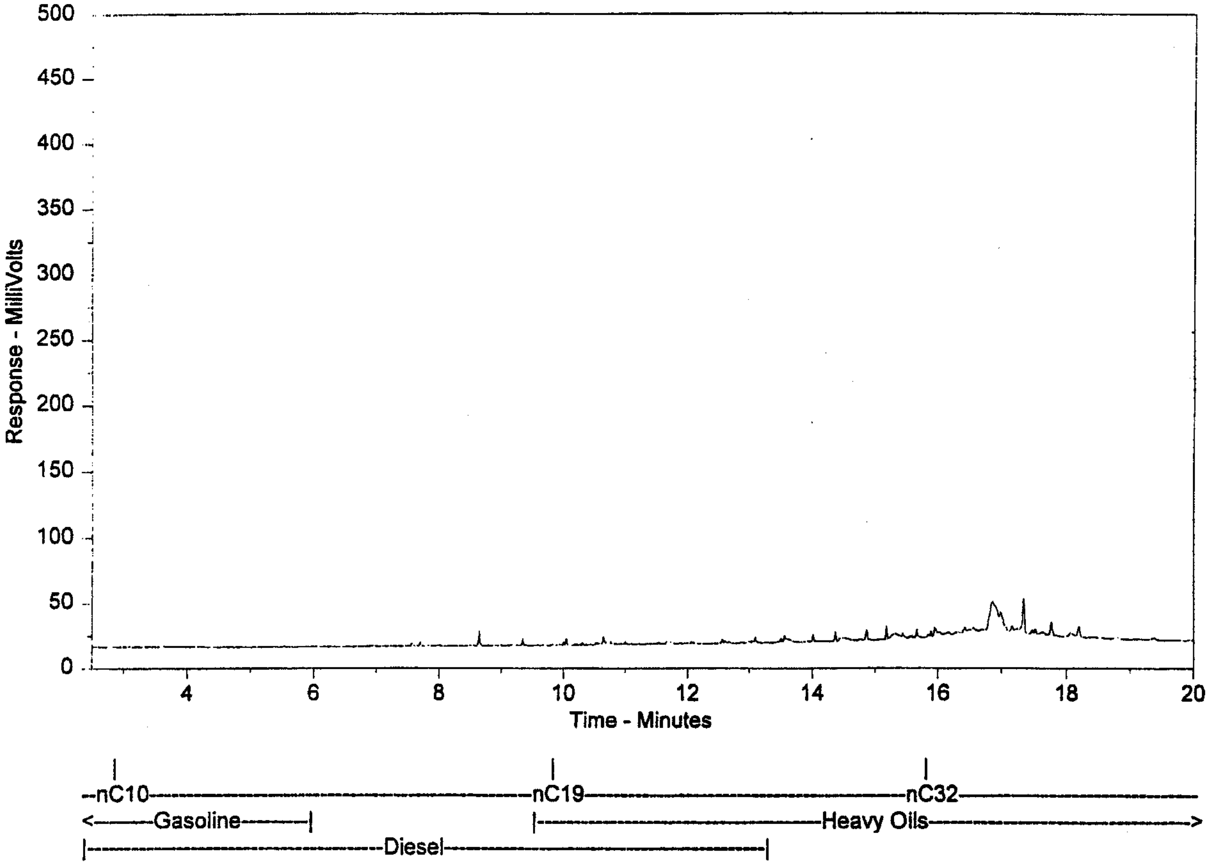
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: BLS-13
ASL Sample ID: **L1131-T--15**
File Name: c:\chrom\gc04\data\gc04_06octB.0005.RAW
Run Information: Acquired on GC04, 10/6/99 2:30:27 PM



Sample Amount = 7.9 (g or mL) Dilution Factor = 8.0

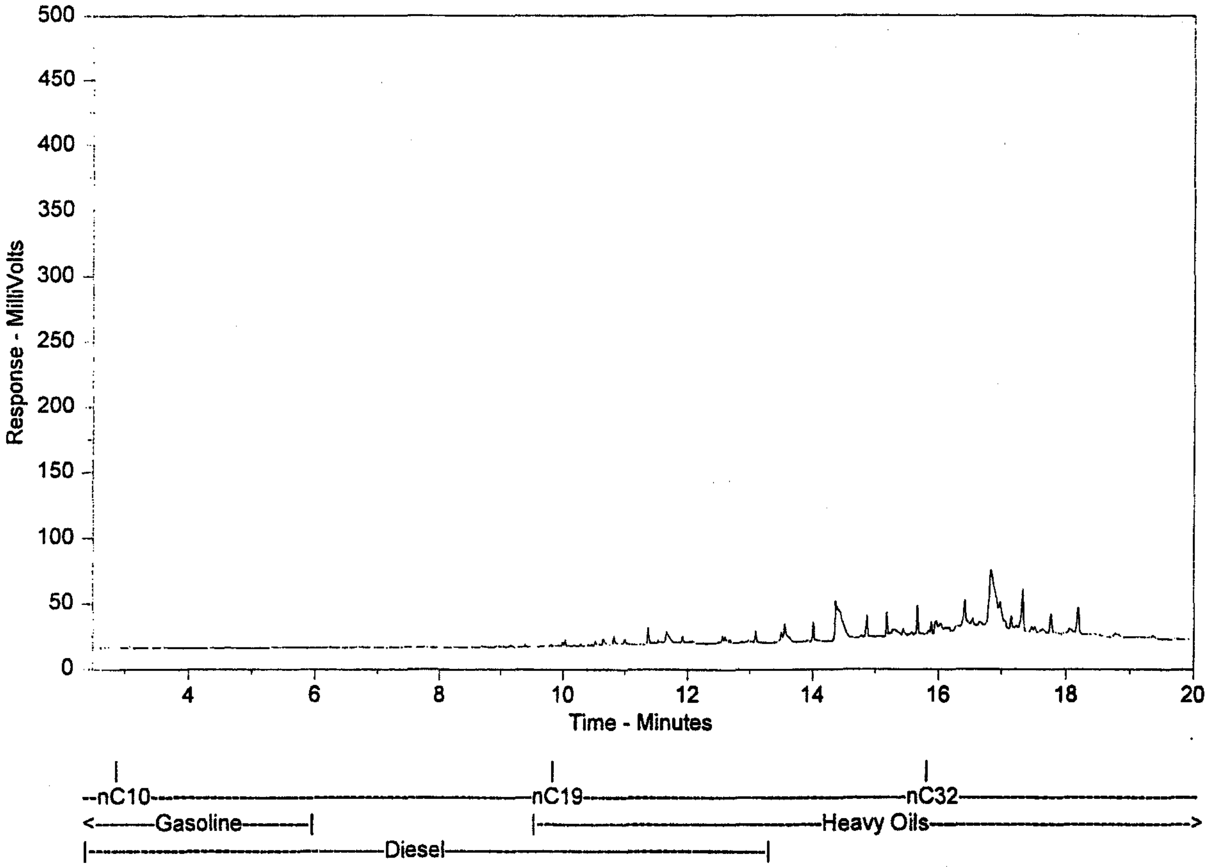
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: BLS-15
ASL Sample ID: L1131-T--17
File Name: c:\chrom\gc04\data\gc04_06octB.0006.RAW
Run Information: Acquired on GC04, 10/6/99 3:02:04 PM



Sample Amount = 7.6 (g or mL)

Dilution Factor = 8.0

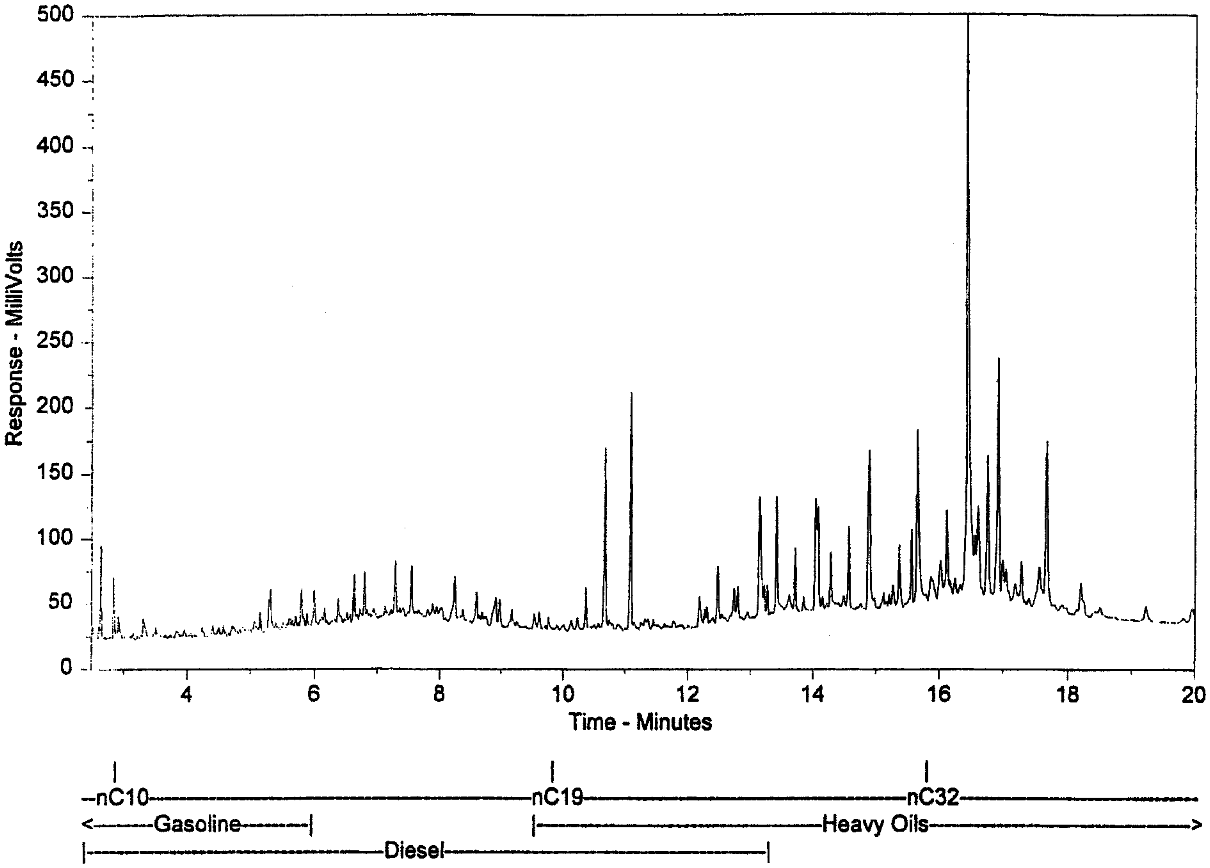
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: BLS-19
ASL Sample ID: **L1131-T--21**
File Name: c:\chrom\gc04\data\gc04_05octA.0026.RAW
Run Information: Acquired on GC04, 10/6/99 5:01:24 AM



Sample Amount = 4.0 (g or mL)

Dilution Factor = 10.0

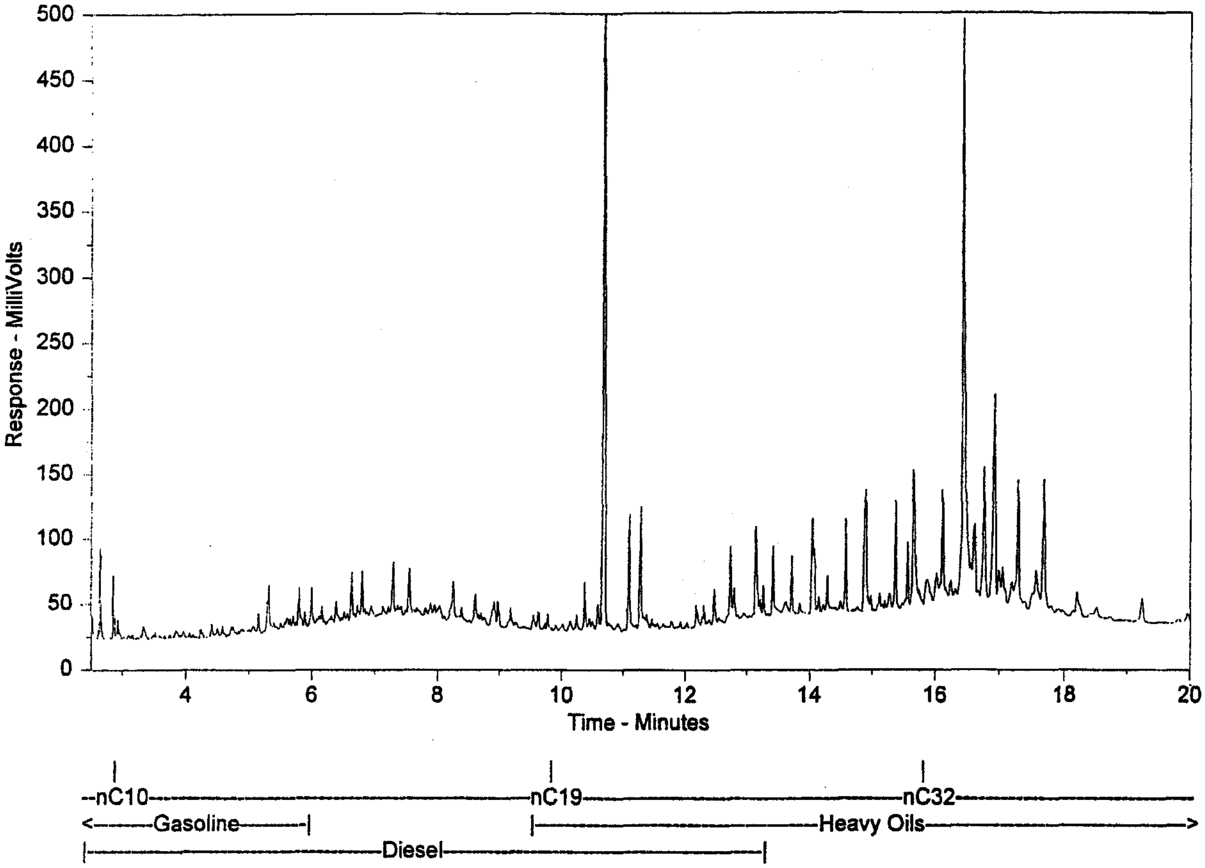
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	BLS-20
ASL Sample ID:	**L1131-T--22**
File Name:	c:\chrom\gc04\data\gc04_05octA.0027.RAW
Run Information:	Acquired on GC04, 10/6/99 5:32:53 AM



Sample Amount = 5.3 (g or mL)

Dilution Factor = 10.0

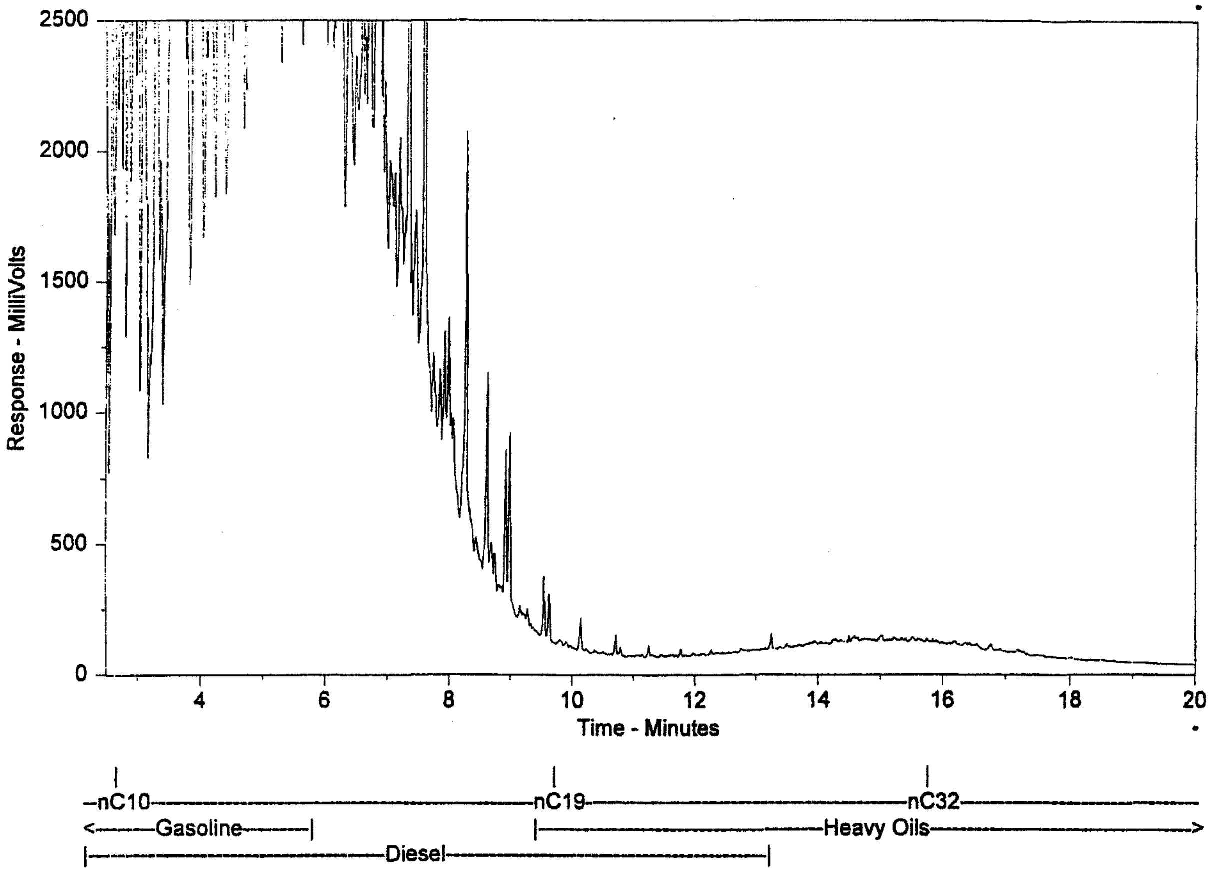
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID: Seep 1
ASL Sample ID: **L1131-T--10**
File Name: C:\chrom\gc04\data\gc04_03octA.0029.RAW
Run Information: Acquired on GC04, 10/4/99 7:26:41 AM



Sample Amount = 535.0 (g or mL)

Dilution Factor = 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.