PRELIMINARY UNDERGROUND STORAGE TANK (UST) INVESTIGATION AT THE SUTHERLAND AVENUE FACILITY

FINAL REPORT

Prepared for:

CENTRA GAS MANITOBA INC.

Prepared by:

CH2M HILL
ENGINEERING
LTD.

Waterloo, Ontario

January 1994

CH2M HILL ENGINEERING LTD.

January 12, 1994

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Centra Gas Manitoba Inc.
444 St. Mary Avenue
Winnipeg, Manitoba
R3C 3T7

Attention: Richard Perkins (Manager, Purchasing & Stores)

Subject: Preliminary Investigation of Underground Storage Tanks at the Sutherland Avenue Facility

CH2M HILL ENGINEERING LTD. (CH2M HILL) is pleased to submit three copies of this final report for the preliminary investigation of the underground storage tanks (USTs) at the Sutherland Avenue facility. The approach to decommissioning of the USTs will be addressed in a technical memorandum following discussions with Andy Galarnyk and you. It will be necessary to initiate the UST decommissioning with consideration of the critical path identified for the environmental, health and safety assessment in progress at the Sutherland Avenue facility. The timing for submission of the preliminary UST report to the Manitoba Environment and initiation of the UST decommissioning is critical to the successful completion of both projects onsite.

Further discussions concerning the implications of this report will be address during the week of January 24, 1993.

If you have any questions or concerns please do not hesitate to phone. I will be contacting you on January 13, 1993 to address any immediate requirements you may have.

CH2M HILL ENGINEERING LTD.

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Section 1
Introduction

In November 1992, Centra Gas Manitoba Inc. (Centra Gas) approved an Environmental Policy to address areas of possible environmental concern at Centra Gas sites.

CH2M HILL ENGINEERING LTD. (CH2M HILL) was invited by Centra Gas to submit a proposal to complete a preliminary underground storage tank (UST) investigation at the Sutherland Avenue Operations Facility. This investigation was completed as a preliminary investigation to provide information intended for planning the UST decommissioning. Because no previous subsurface information was available in the vicinity of the USTs, Centra Gas recognized that it would be prudent to complete some limited investigation in this area.

This report outlines the preliminary UST investigation and its results at the Sutherland Avenue facility. The location and site plan of the facility are shown in Figure 1-1.

Objectives

The main objectives of the preliminary investigation conducted at the Sutherland Avenue Facility were as follows:

- To provide a preliminary indication of the presence of petroleum contamination in the vicinity of the tank structures
- To determine compliance of chemical results obtained from the investigation with guidelines established by Manitoba Environment as well as other applicable jurisdictions
- To identify the nature of the geologic materials in the vicinity of the USTs
- To identify the presence of free product either by borehole observations or monitoring well installations
- To provide support for the necessary approvals (i.e. approval forms) required by Manitoba Environment to initiate the tank decommissioning
- To provide planning information to identify the need for soil or groundwater remediation activities associated with tank decommissioning
- To provide information suitable for discussions with Manitoba Environment to identify the remediation cleanup levels prior to decommissioning of the USTs
- To allow for budget planning by Centra Gas prior to decommissioning of the USTs

Scope of Work

To address the above-mentioned objectives, the preliminary investigation involved the following activities:

- Records review
- Site reconnaissance
- Physical subsurface characterization (advancement of three boreholes with one borehole completed as a monitoring well)
- Site sensitivity assessment
- Review of applicable guideline criteria used to assess the conditions at the site
- Analytical characterization and comparison of results to applicable guidelines for inorganic and organic constituents (characterized two soil samples and one leachate test including one groundwater sample)

The scope of the preliminary investigation for the physical subsurface characterization was limited to the immediate vicinity of the USTs.

Section 2
Site Information Assessment

The site information assessment was composed of two components:

- Records review
- Site reconnaissance

This section describes the sources of information that were used in the site information assessment. The information was used as a component of the site sensitivity assessment outlined in Section 6.

Records Review

A review of the following information concerning the USTs onsite as well as receptors that could be impacted by petroleum by-products or coal tar residuals potentially present in the soils in the vicinity of the USTs was conducted:

- Facility documents
- Product inventory records
- Drawings of the present day plant operation
- Maps of geology, topography, and physiography
- Photographs

A former coal gasification plant operated from 1873 until 1959. It produced coke oven gas which was used in a similar manner to present day natural gas. Demolition of this former plant was completed between 1967 and 1969 followed by construction of the present day Centra Gas Facility. Some of the by-products associated with the operation included coal tar.

The current facility consists of an operations building, a vehicle service building, a stores building, and a training complex building. The operations building is used for engineering, planning, customer service, construction, and maintenance activities. The vehicle service building is used for fleet maintenance. Two USTs used to contain leaded and unleaded petroleum products, an underground waste oil tank, and a natural gas compressor station are located in the immediate vicinity of the vehicle service building. These tanks were not associated with the earlier use of the site for coal gasification. The stores building is used to inventory parts associated with the natural gas industry. The training building is used for training and storage of construction and maintenance equipment. An overview of the site is provided in Figure 1-1.

Centra Gas is presently the sole natural gas distribution company in the Province of Manitoba. The company's gas supply is delivered through the TransCanada Pipelines

Limited. Centra Gas serves customers in approximately eighty-two locations and through subsidiaries is engaged in distribution to other customers in Ontario, Alberta, and British Columbia. Centra Gas Manitoba Inc. is owned by Westcoast Energy Inc. located in Vancouver, British Columbia.

From discussions with Centra Gas, it was indicated that the three USTs used onsite were installed around 1970 during the construction of the present day Centra Gas facility. The USTs have been used for more than 20 years. The two gasoline USTs have been used to supplement fuel requirements and have not been used for the storage of diesel fuel. Natural gas is used as the primary fuel for service vehicles onsite. The waste oil tank has been used to store oils collected during vehicle maintenance activities. The fill spouts of the three tanks are located below ground surface. The spouts are covered over with a protective cap along with a protective casing and surface cap. The USTs have the following volumes:

- East gasoline tank (13,500 litres)
- West gasoline tank (13,500 litres)
- Waste oil tank (2,700 litres)

In addition to the three USTs, vent pipes located to the south, two fuel filling pumps to the west, and associated underground piping comprise the UST facility. Figure 2-1 and Photographs 1 to 4 in Appendix A depict the UST facility.

In February 1993, Centra Gas registered the USTs with Manitoba Environment to address requirements established by Manitoba Environment and to address the newly established environmental policies within the Centra Gas organization.

From review of the gasoline fuel inventory records, the following points are worth noting:

- Following initiation of the newly defined environmental policy within the Centra Gas facility, the volume of fuel in the USTs was recorded on a daily basis beginning March 31, 1993.
- Prior to this period, a monthly inventory of fuel was completed. The litres of fuel issued to employees with service vehicles were recorded, where possible.
- From review of monthly gasoline reports from 1989 to 1993, significant fuel overages and shortages have been recorded throughout this time period; however, it is possible that fuels purchased offsite by employees have been combined into these monthly reports.
- Bulk purchases of gasoline have continued at the Sutherland Avenue Facility since March 31, 1993. Centra Gas has intentions to deplete these USTs of gasoline when the approach to the UST decommissioning has been identified.

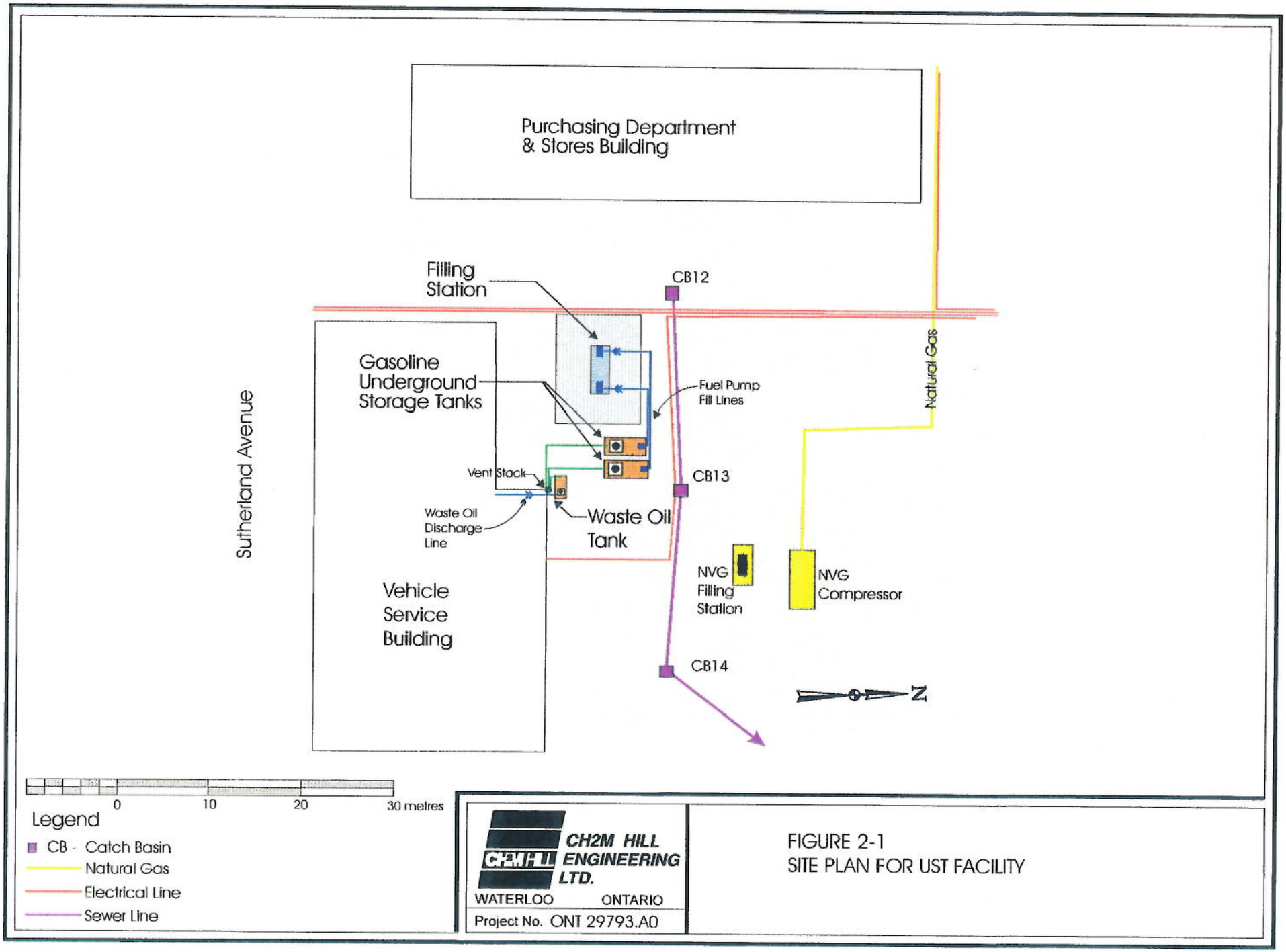


FIGURE 2-1
SITE PLAN FOR UST FACILITY

Because of the method of inventory used for the fuel located in these USTs, the records cannot be used to reliably determine if the USTs are leaking. Records of the inventory of oil in the waste oil UST were unavailable. However, it was mentioned by Centra Gas that the waste oil tank contents are frequently pumped by an oil recycling firm during the year.

Although the records were unavailable, it was indicated that the USTs were checked for leaks over the last several years. It was reported by Centra Gas that the USTs were found not to leak. No documentation of test results was available for review during this investigation.

An aerial photograph taken in 1978 was reviewed to identify the land use in the area surrounding the site. The aerial photograph is provided in Appendix A. Figure 1-1 also identifies the surrounding land use. The following points from this review are worth noting:

- The Red River is located approximately 400 metres north of the UST facility. Residential land use does not exist between the Centra Gas property and the Red River to the north.
- Centra Gas operates the property south of Sutherland Avenue under commercial/industrial land use zoning.
- The Simmons Mattress Factory is located approximately 90 metres southeast of the UST facility, south of Sutherland Avenue. It is zoned for commercial/industrial land use.
- A power substation, zoned commercial/industrial, is located east of the operations building, approximately 100 metres northeast of the USTs.
- An old housing development (zoned residential) is located south of the power substation and east of the Centra Gas property. Nine houses were identified adjacent to Annabella Street. The closest house is approximately 50 metres east of the UST facility.
- A second residential area is located west of the Centra Gas purchasing department and stores building. There are four to five houses in this area. The closest house is located approximately 60 metres from the UST facility.
- This Disraeli Freeway is located west of the operations building. Vegetated areas (i.e. boulevards) associated with the highway ramps exist in this area. Residential lands do not exist in this area.
- To the southeast of the UST facility on the east side of Annabella Street, the land use was identified as commercial/industrial.

From facility drawings, a storm sewer system was identified north of the gasoline USTs trending in a west to east direction. The storm sewer discharges to a combined sewer

(i.e. storm and sanitary) on Annabella Street, adjacent to the residential development as identified on Figure 1-1. Water discharged to the combined sewer is directed to the south where it intersects the sewer system on Sutherland Avenue.

An electrical cable was identified on the facility drawings which appears to be installed in the same trench as the storm sewer system located north of the USTs. A natural gas line is directed from the NVG compressor toward Gladstone Street, north of the purchasing department and stores building. These features are identified on Figure 2-1.

Site Reconnaissance

A thorough inspection of the Sutherland Avenue Facility was completed for the UST investigation. The inspections were conducted in September and October 1993 to identify receptors that may be impacted by petroleum by-products and/or coal gasification residues potentially present in the subsurface in the vicinity of the USTs. The depths of the USTs, including the spout lengths were measured to determine the dimensions of the USTs to support the subsurface investigation. As well, measurements of depth and elevation were addressed at the catchbasins associated with the storm sewer system in the vicinity of the USTs. Evidence of petroleum/oil spillage on the asphalt surface in the area of the pumps was inspected. Discussions with Centra Gas personnel were included in the site reconnaissance to identify other relevant information. Information obtained from the above-mentioned activities was used in the site sensitivity assessment presented in Section 6. A summary of the UST dimensions is provided in Table 2.1. Measurements completed at the catchbasins in the vicinity of the USTs are provided in Table 2.2. Photographs of the area completed during the inspections are provided in Appendix A.

Table 2.1
Summary of UST Specifications

Tank	Ground Elevation (metres)	Top of Fill Spout Elevation (metres)	Depth of Tank Relative to Top of Fill Spout (metres)	Diameter (metres)	Volume (litres)	Calculated Length (metres)
East Gasoline Tank	229.650	234.190	2.82	1.91	13500	4.73
West Gasoline Tank	229.750	229.614	2.93	1.95	13500	4.51
Waste Oil Tank	229.650	229.567	2.49	1.23	2700	2.26

Table 2.2 Summary of Catchbasin Inspection in Vicinity of USTs					
Storm Sewer Catchbasin	Surface Elevation (metres)	Catchbasin Bottom Elevation (metres)	Depth of Catchbasin (metres)	Thickness of Sediment in Bottom of Catchbasin (metres)	Comments
CB12	229.41	227.59	1.82	0.04	- Faint naphthalene odour identified - Very little water observed
CB13	229.25	227.33	1.92	0.1	- Faint naphthalene odour identified - Very little water observed
CB14	229.08	227.10	1.98	0.16	- No odour identified - Very little water observed

The observations made during these inspections are as follows:

- Results from review of the aerial photograph were confirmed during the inspection. The land use in the area is primarily commercial/industrial. A limited number of residential properties exist in the area.
- The Red River is located a significant distance from the USTs and likely will not be impacted by potential petroleum residuals in the subsurface in the vicinity of the USTs.
- The underground waste oil tank is located close to the vehicle service building. The proximity of this tank to the building should be considered in the decommissioning approach used.
- A small volume of waste oil was identified in the annulus space between the fill spout of the oil tank and the protective casing around the spout close to ground surface. The oil was observed following pumping of the contents by the recycling firm.
- Fuel staining was not observed in the vicinity of the gasoline USTs or around the pump island.
- Free product petroleum was not identified in the storm sewers, particularly CB13, north of the USTs. However, a faint naphthalene odour was identified at CB12 and CB13. CB12 and CB13 are identified on Figure 2-1.
- Very little sediment or water exists in the catchbasins close to the USTs. However, a faint naphthalene odour was detected at CB12 and CB13.
- The vehicle service and purchasing buildings were constructed on slab foundations, eliminating confined spaces where potential vapours in the subsurface in the vicinity of the USTs could accumulate. No basement

foundations were identified close to the UST facility. The closest basement foundation structure on Centra Gas property was the west side of the operations building, located approximately 100 metres north of the USTs. The closest offsite basement foundation structure was located approximately 50 metres east of the USTs in a residential development. It was assumed that some of the houses adjacent to Annabella Street were constructed with basement foundations, although this was not confirmed.

- An asphalt surface covers the area surrounding the USTs, minimizing the impact of potential vapours in the vicinity of the USTs.
- The topography in the vicinity of the USTs is generally flat; it is lower in the vicinity of the catchbasins north of the USTs.

Section 3

Field Investigation Methodology

Health and Safety Plan

CH2M HILL developed a Health and Safety Plan (HSP) specific to the Centra Gas Environmental, Health, and Safety Assessment (EHSA), the first investigation conducted at the Sutherland facility. This HSP was also implemented for the Sutherland UST preliminary investigation to address aspects such as hazardous definition, safety responsibility, personal protective equipment, onsite monitoring, emergency response, and safe operating procedures.

The HSP was primarily designed for the drilling task to ensure worker health and safety during periods of potential exposure. The real time air monitoring completed during these tasks with the Gastechtor analyzer indicated that only Level D worker protection was required and that respirators were unnecessary. The safety equipment used was composed of rubber/nitrile gloves, rubber boots, tyvek suits and safety hard hats. No incident of injury or significant exposure occurred onsite during the investigation.

Soil Gas Sampling

Soil gas sampling is typically used to map subsurface contamination due to the presence of volatile organic substances such as hydrocarbon-based fuels (i.e. gasoline, diesel, etc.).

In conducting soil gas surveys, shallow (i.e. <1 metre) small boreholes are advanced into the subsurface. A packer assembly is inflated inside the small borehole which isolates it from the atmosphere. Soil gases are withdrawn under vacuum conditions and analyzed onsite using portable gas analyzers (i.e. Gastechtor, HNu, OVA, etc.).

Soil gas surveys can be valuable in providing screening for areas of environmental concern; however, some limitations exist as identified below.

- Very limited where fine-grained soils such as silts and clays are present
- Difficult to map the extent of a plume where vapour concentrations are low
- Hot spots identified from the vapour survey do not always correlate with the location of an underlying petroleum spill. This is especially true in fine-grained deposits of silt and clay which are prevalent in the Winnipeg area.

CH2M HILL recommended that no soil gas sampling be completed in the preliminary investigation based on the following key points:

- Limited success in locating petroleum spills in fine-grained soils.
- A limited potential exists for vapours that may be present in the subsurface to migrate into adjacent buildings based on the proximity of the buildings and the absence of basement foundation structures. All buildings in the vicinity of the USTs have been constructed on slab foundations and are identified on Figure 1-1.

Air Monitoring

Air monitoring and sampling was not conducted in the buildings closest to the USTs. The purchasing department and stores building is approximately 20 metres from the USTs and was constructed on a slab foundation. The nature of the fill and geologic materials underlying the site and the distance the USTs are located from the purchasing department and stores building suggested that air monitoring was unnecessary in this area. The vehicle service building, closest to the USTs, is used for repair and maintenance of service vehicles. Residual odours associated with maintenance activities in the vehicle service building would cause interference with detection of petroleum vapours potentially associated with the USTs. Air monitoring was not completed in the vehicle service building.

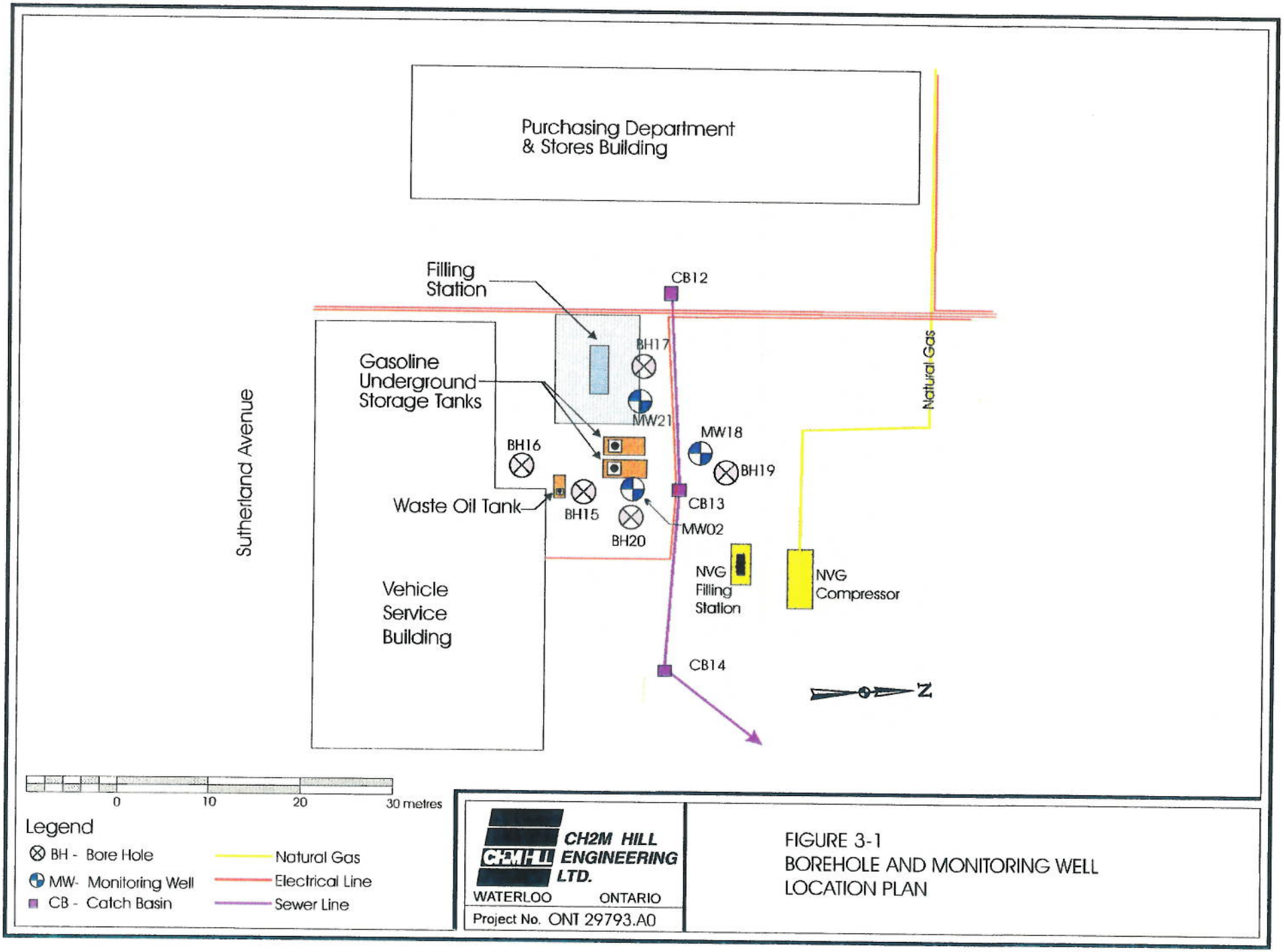
Borehole Advancement and Soil Sampling

Seven boreholes were advanced between September 29 and September 30, 1993 for the UST investigation. The locations of and rationale for boreholes/and monitoring wells are shown in Figure 3-1 and Table 3.1, respectively. BH02/MW02 completed for the EHSA investigation was included in Figure 3-1 and Table 3.1. The 8 boreholes were used in the subsurface characterization for the preliminary UST investigation.

The drilling program was developed to:

- Determine the presence or absence of petroleum contamination in the soils at strategic locations in the vicinity of the USTs
- Determine the presence or absence of free product petroleum on the surface of the perched water table
- Determine the presence or absence of coal gasification residues in the soils in the vicinity of the USTs

Paddock Drilling Ltd. was retained to advance and sample the boreholes on the site under the direct supervision of CH2M HILL. The boreholes were advanced with a


Purchasing Department
& Stores Building
Filling
Station
CB12
BH17
Gasoline
Underground
Storage Tanks
MW21
Natural Gas
Sutherland Avenue
MW18
BH16
BH19
Waste Oil Tank
BH15
CB13
MW02
BH20
NVG
Filling
Station
NVG
Compressor
Vehicle
Service
Building
CB14
N
0
10
20
30 metres
Legend
BH - Bore Hole
MW- Monitoring Well
CB - Catch Basin
Natural Gas
Electrical Line
Sewer Line
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WATERLOO
ONTARIO
Project No. ONT 29793.A0
FIGURE 3-1
BOREHOLE AND MONITORING WELL
LOCATION PLAN

Table 3.1
Rationale for Boreholes/Monitoring Well Locations

Location	Number of Boreholes	Number of Monitor Wells	Rationale
Underground Storage Tank (UST) Investigation			
BH15	1	0	- Assess the presence of oil and petroleum-based fuel residuals in the soils downgradient (north) of the waste oil tank - Confirm fill/geologic conditions - Assess the presence of gasification plant residuals
BH16	1	0	- Assess the presence of fuel and/or oil residuals upgradient (south) of the USTs - Confirm fill/geologic conditions in the vicinity of USTs - Assess the presence of gasification plant residuals
BH17	1	0	- Assess the presence of fuel residuals to the north of the filling station - Confirm fill/geologic conditions in the vicinity of the USTs - Assess the presence of gasification plant residuals
BH18 (MW18)	1	1	- Establish a monitoring point to identify if petroleum residuals exists in the groundwater north of the tanks in the vicinity of the storm sewer (i.e. a potential receptor) - Establish a monitoring point to determine the potential for groundwater to reach saturated sewer bedding and piping - Establish a point to identify the groundwater flow direction - Assess the presence of residual fuel in the soils north of the USTs - Confirm fill/geologic conditions - Assess presence of gasification plant residuals
BH19	1	0	- Shallow borehole completed to identify the extent of petroleum residuals north of the sewer - Confirm fill/geologic conditions - Assess the presence of gasification plant residuals
BH20	1	0	- Shallow borehole completed to assess the lateral extent of petroleum residuals and presence of gasification plant residuals - Confirm fill conditions
MW21	1	1	- Assess groundwater quality downgradient of the filling station - Assess the presence of petroleum residuals and/or gasification residuals - Confirm fill/geologic conditions - Establish a monitoring point to characterize the groundwater and identify the level of groundwater in this area
Component of EHSA Investigation			
BH2 (MW2)	1	1	**Old Retort House, Equipment Storage Facility and Existing Underground Storage Tanks** - Assess groundwater quality and presence of residuals in the vicinity of the Old Retort House and Equipment Storage Facility - Assess downgradient groundwater and soil quality in proximity to the present underground storage tanks - Confirm fill/geologic conditions - Establish a monitor point to support the determination of groundwater flow direction, if possible
Total Boreholes	8		
Total Monitoring Wells	3		

conventional truck-mounted Canterra CT250 drill equipped with hollow-stem augers, continuous samplers and split-spoon samplers.

To expedite the drilling process, hollow-stem augers with an inside diameter (I.D.) of 0.092 metres were used with a continuous sampler for all boreholes advanced. The outside diameter (O.D.) of the boreholes advanced with this method was 0.20 metres.

Grab samples (i.e soil cuttings brought to surface by the hollow-stem augers) were collected at BH19 and BH20 in order to expedite the drilling procedure for these extra boreholes.

Prior to the start of drilling, a central onsite equipment decontamination facility was established. The facility was composed of a trailer housing the supplies, pressure washer and containment equipment required for decontamination of the drilling equipment. The drill rig and equipment were brought to the site fully decontaminated.

All downhole equipment and above-ground hardware in contact with equipment advanced into the borehole was decontaminated between each location to eliminate cross-contamination. A containment tank with steel grates was used to lay out the downhole drill equipment during decontamination procedures. Vegetable oil was used as a lubricant during drilling activities when required. Petroleum-based oil and greases were not used making decontamination procedures much less difficult. Care was taken to prevent contamination of cleaned equipment prior to use.

All underground utilities in the vicinity of each borehole and monitoring location were verified prior to the start of drilling at each location. Utilities such as electrical cables, natural gas lines, water and sewer lines were identified.

Prior to drilling, site drawings were reviewed to determine the length and orientation of the USTs. However, it was indicated that the exact location of the USTs was not identified to scale on these drawings. As a component of the EHSA investigation, a geophysical survey was completed at the Sutherland Avenue facility which included the area in the vicinity of the USTs. The orientation of the USTs could not be identified by the geophysical survey due to interference with underground piping, cables and re-bar in the concrete comprising the pump island. As well, devices used by Centra Gas personnel could not locate the USTs prior to drilling. In order to avoid breaching of the USTs, a method similar to "well witching", using copper wires, was implemented. This method was successful in identifying the orientation of the USTs. The lengths of the tanks were calculated using the diameter and volume of the USTs. The boreholes were completed as close to the USTs as possible; however, underground piping and electrical cables, etc., forced the boreholes to be further from the USTs than originally anticipated. The USTs were not intercepted during drilling activities.

Site access was controlled at each location drilled by providing an area of limited access to prevent the public from potential exposure to coal gasification residuals during the subsurface investigation. A temporary barrier using "caution tape" was erected around

the drill site. When exiting the site work area, workers were required to wash their rubber boots in the two basins provided and remove heavily soiled tyvek suits, if required. This was supervised by CH2M HILL staff to ensure that tracking of soil outside the drill zone did not occur. All affected materials were placed in drums prior to the removal of the temporary barrier.

Borehole Abandonment

BH15 and BH17 were abandoned using bentonite grout pumped from the bottom of the borehole to 1.2 metres below ground surface. Hydrated bentonite chips were placed from 1.2 to 0.6 metres. A concrete mixture was placed from 0.6 to ground surface.

BH16 was abandoned with hydrated bentonite chips from 5.2 metres to 0.6 metres below ground surface. A concrete mixture was used from 0.6 to ground surface to complete the borehole abandonment.

BH19 and BH20 were backfilled with auger cuttings from 3.1 to 1.5 metres. Hydrated bentonite chips were placed from 1.52 to 0.6 metres below ground surface. Concrete was placed from 0.6 metres to ground surface to complete the backfilling at these locations.

Soil Observations and Classification

All soil samples collected during the investigation were inspected in detail for determination of the following key information:

- Presence or absence of petroleum by-products and coal gasification residuals with depth
- Type and depth of native geologic materials
- Presence, type and depth of fill materials

All samples inspected were grouped into categories based on the physical level of contamination observed. The following categories were used:

- NC = No contamination (background)
- TC = Trace contamination
- VC = Visual contamination
- C(noVC) = Contamination exists but no visual contamination evident

Most of the samples collected were further characterized with the use of headspace analyses. An HNu total organic vapour analyzer was used in a controlled test environment inside the operations facility to complete the characterization. The HNu was

calibrated prior to use with isobutylene calibration gas. The samples collected onsite were sealed after inspection and brought into the test area. Each sample was attached to the test apparatus and a directed reading of total organic vapour in ppm was recorded. The results of these analyses were used to support the characterization completed during the physical inspection of each sample.

Borehole logs were prepared for each location advanced. The logs identify the depth of each sample collected, the types of materials observed with depth, the TOV readings with depth, where possible, and the classification category for physical contamination with depth. The borehole logs are presented in Appendix B.

Monitoring Well Installation

Of the 7 boreholes advanced in the preliminary UST investigation, two boreholes were completed as monitoring wells. The monitoring well location and rationale for each monitor well is identified in Figure 3-1 and Table 3.1, respectively. BH02/MW02 completed in the EHSA was included in Figure 3-1 and Table 3.1. A total of 3 monitoring wells were used in the subsurface characterization in the vicinity of the USTs.

The monitoring well installations were completed as single wells screened across or close to the water table. Materials used for the well installations consisted of 0.05 metre I.D., Schedule 40 PVC riser-pipe with No. 10 slotted screens cleaned and bagged by the manufacturer. Well seals generally were completed using solid bentonite chips hydrated with water. The filter pack was completed with 65 grain clean silica sand. Expanding J-plug caps were used to protect the monitoring well from surface infiltration. Flush-mount, sealable, protective casings were used at ground surface at each monitoring well installation. A concrete mixture was used at surface to secure the flush-mount casing at surface. The details of the monitoring well installations are summarized in Appendix B.

Handling of Excess Liquids and Solids

Soil cuttings brought to the surface into the containment pit by the hollow-stem augers were stored in sealed drums, classified according to their physical level of contamination using the NC, TC and VC designation categories, labelled using an appropriate approach followed by placement in the pipe storage yard, south of Sutherland Avenue.

Soil and water generated during the investigation were retained in order to identify the appropriate method of disposal.

Surveying

A location and elevation survey was conducted at the Sutherland facility in order to correlate subsurface information collected at various monitoring points. A surveyed plan of the UST area was unavailable, so it was prudent to complete a limited survey to address the preliminary UST investigation onsite. Beattie and Associates Limited was retained to complete the survey under the direction of CH2M HILL. The survey was completed using a total station on October 10, 1993. The geodetic datum used for the survey was located south of the site and is designated as datum 26-008 by the City of Winnipeg. With the survey information referenced to a geodetic datum, a comparison to other subsurface information collected in the City of Winnipeg can be completed, if required.

Water Level Monitoring

Water level monitoring was completed by both CH2M HILL and Centra Gas during the UST investigation. Centra Gas provided support for monitoring because water levels in some of the monitoring wells did not stabilize during the period of monitoring when CH2M HILL was onsite. Water level monitoring was completed on the following dates:

- October 2, 1993 (CH2M HILL)
- October 3, 1993 (CH2M HILL)
- October 4, 1993 (CH2M HILL)
- October 23, 1993 (CH2M HILL)
- October 24, 1993 (CH2M HILL)
- November 12, 1993 (Centra Gas)
- November 16, 1993 (Centra Gas)

The procedure for completing water level measurements onsite was as follows:

- Protective casings were opened and the inner cap was loosened to allow the monitoring wells to be exposed to atmospheric pressure. The protective casing surface cap was replaced over the monitoring well and the bolts were fastened hand-tight. This was completed one day prior to monitoring, when possible. Care was taken not to expose the monitoring well to surface infiltration during the monitoring period.
- Water level monitoring was initiated the next day. The probe of the water level sounding device was sprayed with distilled water and wiped clean with a cloth prior to placement into the well.
- The probe was lowered slowly to the surface of the water. When a constant beeping sound was observed, the depth to water was recorded relative to the top of the monitoring well pipe on a data sheet prepared for these measurements.

- Care was taken when completing water level measurements to avoid brushing surface debris into the monitoring wells located below ground surface.
- After the water level was recorded at each well, the well cap was secured tightly to avoid leakage from surface into the well pipe. The sealable flush-mount protective cap was wiped clean and secured over the well pipe and well cap for additional protection against surface leakage.

The data obtained from water level monitoring activities was tabulated and is presented in Section 5.

Groundwater Development, Purging and Sampling

To collect representative groundwater samples from the monitoring wells onsite, it was necessary to develop and purge the wells prior to groundwater sampling. Groundwater development is a procedure that is used to remove fine sediments within the filter pack material induced during the drilling process. Groundwater purging involves the removal of potentially biased groundwater and waters induced during the drilling process so that representative groundwater from the monitoring well can be sampled. The methodology used for groundwater development and purging was as follows:

- Wattera pump systems were used in each well for purging and development activities except at MW21 which was not developed due to poor groundwater recoveries.
- Each pump was vigorously agitated in order to create a surging effect in and out of the well screen and filter pack to dislodge sediment. This was completed frequently during purging activities.
- Fine sediment brought into the well was removed by pumping the sediment-laden water to surface with the Wattera pump system. The purge waters were stored in drums on surface.
- Field parameters such as pH, temperature, electrical conductance, and redox potential were collected throughout these activities to determine when groundwater sampling could be completed. Generally, stable field parameters collected over time are indicative of representative groundwater.
- The wells were evacuated on at least three occasions prior to groundwater sampling, where possible.

The groundwater remained somewhat turbid during the purging and development procedures due to the very fine gradation of the native materials.

Results of these activities are presented in Section 8.

Groundwater samples were collected between October 4 and 5, 1993 and at MW02 on October 24, 1993 in the vicinity of the USTs. A description of the analyses conducted is summarized in Section 4. The following approach was adopted to preserve sample integrity:

- Minimized agitation in the wells when operating the Wattera pump system.
- Maintained saturation of the pump at the bottom of the well at all times.
- Used clean surgical gloves to avoid physical contact with sample.
- Minimized the headspace for all parameters (Note: A positive meniscus was formed before capping the BTXE samples).
- Collected BTXE and TPH samples first in order to minimize de-gassing of volatile organic compounds.
- Minimized contact with the plastic cap for samples analyzed for PAH by using teflon.
- Minimized contact with direct sunlight for all samples.
- Stored and transported samples in a cool, dark environment.
- Filtered the lead parameter using a 0.45μ in-line filter cartridge.
- Preserved the lead parameter with clean nitric acid.

Section 4

Analytical Methodology

Rationale for Selection of Analytical Parameters

BTXE (Benzene, Toluene, Xylenes and Ethylbenzene)

This group of parameters was used for detection of petroleum-based residuals but also as an indicator for the presence of coal gasification residuals in the vicinity of the USTs. Separation of petroleum-based contamination associated with USTs from contamination associated with coal gasification processes can be supported by a detailed physical examination of a soil sample. Light aromatics are moderately soluble and volatile and exhibit a slight tendency for adsorption, but to a much lesser extent than PAHs.

Phenolics

Phenols provide a good indication of the impact of petroleum by-products on the subsurface. Analysis conducted for phenols was also used as an indicator for coal gasification residuals. Phenols are highly soluble in water with low vapour pressures. These properties indicate little tendency for adsorption on soils or sediments. Phenols are particularly useful as an indicator for contamination in groundwater. This parameter is identified in the Alberta (MUST) criteria so it was used in order to provide a comparison against this criteria.

Total Hydrocarbons

Total volatile hydrocarbons and total semi-volatile hydrocarbons can be useful indicators for petroleum-based contamination associated with USTs. Guidelines exist that provide a useful comparison to identify the impact of petroleum contamination on the environment. Soils and groundwater were analyzed in support of this comparison.

Trace Metals

Trace metals (i.e. arsenic, barium, boron, cadmium, chromium, lead, selenium and silver) were analyzed in leachate extracted from soil in order to provide a comparison against leachate quality criteria. The leachate criteria is used to help determine if the soil is a hazardous material or not.

Trace metals are generally non-volatile and their fate depends largely on soil/water interaction. Most metals tend to adsorb in soils, especially in clays with a high cation exchange capacity.

The lead analysis is typically used as an indicator of leaded petroleum-based contamination associated with USTs. During the operation of the USTs, leaded gasoline may have been stored onsite, although it is no longer used. A comparison of the analytical results to guideline criteria can provide an indication of the severity of contamination in the vicinity of the USTs.

Free Cyanide

Free cyanide is grouped into the organic nitrogen compounds. It is identified in the Manitoba Leachate Quality Criteria used to determine if a soil/solid is a hazardous substance. The Manitoba Leachate Quality Criteria is discussed in Section 7. This parameter was completed for comparison to the above-mentioned criteria.

Mineral Oil and Grease

This parameter is a useful indicator for the determination of waste oil contamination in the soils in the vicinity of USTs. Guideline criteria exists for soils which can provide an assessment of the impact of contamination.

PAHs (Polynuclear Aromatic Hydrocarbons)

PAHs are the primary constituents of tar and sludges produced by gasification plants and may occur in the subsurface environment in the vicinity of the USTs. This group of parameters is used as a key indicator for the determination of the impact of gasification plant residuals on the environment. PAHs are very stable compounds and exhibit low volatility and aqueous solubility, but tend to exhibit a strong tendency to adsorb on soils and sediments.

Field Indicator Parameters

Field indicators such as electrical conductance, pH, and the redox potential are useful in identifying potential contamination in groundwater. Field monitoring often initiates consideration for additional chemical analysis if unexpected results are obtained.

Characterization Methods

A summary of the methods used to analyze specific parameter groups for groundwater and soils is identified in Table 4.1 for soil and Table 4.2 for groundwater. The method of analysis for the leaching test sample extracted on soil is identified in Table 4.2 with the analytical methods associated with groundwater chemical characterization. The specific analyses completed on samples from individual borehole locations and monitoring well locations for soil and groundwater along with the method detection limits are provided in Section 8. As well, laboratory reports are provided in Appendix C.

Table 4.1
Summary of Analytical Methods for Soil Analyses

Parameter Group	Method of Analysis
BTXE	GC/MS/EC (modified USEPA 601/602)
Trace Metals (i.e Lead)	ICP atomic emission spectrometry scan
Total Semi-volatile Hydrocarbon	Sonication liquid/liquid extraction, GC/MS
Total Volatile Hydrocarbon	GC/MS/EC (modified USEPA 601/602)
Mineral Oil & Grease	Infrared Spectrometry
PAHs	Sonication liquid/liquid extraction, GC/MS (USEPA SW846)

Notes: ICP - Inductive Coupled Plasma
4-AAP - Aminoantipyrine solution
GC/MS/EC - Gas Chromatography/Mass Spectrometry/Electron Capture
BTXE - Benzene, toluene, xylenes, ethylbenzene
PAHs - Polynuclear aromatic hydrocarbons
Specific parameters analyzed for PAHs are identified in Section 8 along with Method Detection Limits

Table 4.2
Summary of Analytical Methods for Groundwater and Leaching Test Analyses

Parameter Group	Sample Type	Method of Analysis
BTXE	groundwater	GC/MS/EC (modified USEPA 601/602)
Phenolics	groundwater	4-AAP - Chloroform Extractor (APHA-16th ed.)
Trace Metals and Cations	leachate	ICP atomic emission spectrometry scan
Trace Metals (i.e. Lead)	groundwater	ICP atomic emission spectrometry scan
Arsenic, Cadmium, Chromium Copper, Lead, Nickel Silver, Selenium	leachate	Graphite furnace Atomic Adsorption
Free Cyanide	leachate	ICP atomic emission spectrometry scan
Total Semi-volatile Hydrocarbon	groundwater	Liquid/liquid extraction, GC/MS (modified USEPA 625 method)
Total Volatile Hydrocarbon	groundwater	Purge and Trap GC/MS (modified USEPA 624 method)
PAHs	groundwater	GC/MS (modified USEPA 610 method)

ICP - Inductive Coupled Plasma
4-AAP - Aminoantipyrine solution
GC/MS/EC - Gas Chromatography/Mass Spectrometry/Electron Capture
BTXE - Benzene, toluene, xylenes, and ethylbenzene
Specific parameters analyzed for trace metals and PAHs are identified in Section 8 along with Method Detection Limits.

The soil, groundwater, and leachate test analyses were conducted by CANVIRO Analytical Laboratories Ltd. A quality assurance/quality control (QA/QC) program was implemented to ensure reliability of the data obtained. Discussion of the QA/QC procedures is provided in Section 8.

The leaching tests on the soil were completed in accordance with guidelines established by the Manitoba Dangerous Goods Handling and Transportation Act. The approach for the leachate extraction process adopted by the Manitoba government is a Canadian standard used in all provinces.

Section 5

Subsurface Characterization

Geology

Regional Geology

The City of Winnipeg lies within the Manitoba Lowlands Physiographic Region in the Red River Basin. Prior to glaciation, a karstic bedrock terrain developed in the centre of the Red River Basin. Glaciation removed the eroded surface of the bedrock leaving a deep depression in the area which was later filled with unconsolidated sediments from melt waters of the Late Wisconsin glacial stage. Distinct, fine-textured, deep water sediment accumulated in this basin and is characterized by thick deposits of clay and silt that exhibit little topographic relief. Typically, the deep basin deposits reflect the underlying topography of the older till deposits and bedrock surface. The stagnant waters of old Lake Agassiz played a primary role in the deposition of the fine-grained deposits.

The deposition and erosion of sandstone, shale, and limestone deposits over hundreds of millions of years, the placement of unconsolidated deposits during the advance and retreat of glaciers (ice sheets), and the more recent erosion of deposits by rivers such as the Red River and Assiniboine River have influenced the present stratigraphy and topography in the Winnipeg area.

The regional geology of the City of Winnipeg consists of varying thicknesses of pleistocene or glacial deposits (overburden) of quaternary age overlying consolidated bedrock deposits. These overburden deposits were mainly placed under great thicknesses of glaciers or in glacial rivers and lakes.

The quaternary glacial deposits in the area can be classified into two main groups:

- Those deposited by the glacial ice itself, forming glacial till that is mainly unsorted by water action
- Those formed by melt water associated with the glaciers, resulting in various types of stratified deposits

From a review of documentation compiled by the University of Manitoba, the primary deposits underlying the City of Winnipeg are described below.

Upper Complex Zone

This zone ranges in thickness from 1 metre to 4.5 metres and consists of stratified silty clay and silt, with varying amounts of organic soils, alluvial silts, and sands. The bottom of the silt generally suggests the bottom of the complex zone. Often, fill deposits derived from human activity and of varying composition comprise the upper section of this zone.

Glaciolacustrine Clay Deposit

This deposit generally underlies the Upper Complex Zone and ranges in thickness from 0 to 21 metres. The upper 1.5 to 4.5 metres is weathered to a brown or mottled grey-brown colour. The brown clay is highly plastic and has a laminated structure. Often, the upper weathered brown clay is highly fractured and the fractures are filled in with gypsum precipitates. Silt clasts and pockets are also commonly observed in the weathered zone.

The transition between the weathered oxidized brown clays and underlying unweathered clays occurs between 4.5 to 9.5 metres below ground surface. The unweathered portion of the clay deposit has a characteristic grey colour, ranges in plasticity, and becomes soft with depth as the till is approached. Silt clasts and pockets are common in this zone.

Till Deposit

Silty clay tills underlie the upper clay deposits and are generally composed of silt and clay with varying quantities of coarser materials such as boulders and gravel. The thickness of the till ranges substantially throughout the city but is typically between 3 to 6 metres. The depth to the till is variable and in areas close to the Red River can exceed 21 metres. The materials comprising the clay and till deposits alternate in the transition area between the two deposits. The till deposit is highly variable in density and consistency.

Bedrock

Underlying the quaternary deposits is consolidated bedrock. The upper bedrock in the Winnipeg area consists of Paleozoic sedimentary rocks of Ordovician age and are generally overlain with a till deposit. The influence of glaciation has left the surface of the bedrock very irregular. The Selkirk and Fort Garry members of the Red River Formation form the near surface bedrock. The Selkirk member is primarily a mottled tan-coloured dolomitic limestone and is generally 140 metres thick. The Fort Garry member consists of buff-coloured dolomite with thin limestone layers in the upper section and a bed of red argillaceous breccia. The Fort Garry member has an average thickness of 33 metres. The upper 0.3 to 0.9 metres of the bedrock are generally highly fractured and disturbed. The depth to the upper bedrock surface in the majority of the City of Winnipeg generally ranges from 15 to 21 metres.

Geology in UST Area

The main native overburden stratigraphic units identified in the vicinity of the USTs include:

- Weathered Glaciolacustrine Silty Clay/Clayey Silt Deposit
- Unweathered Glaciolacustrine Silty Clay/Clayey Silt Deposit
- Silty Clay Till

The locations of the geological cross sections of the Centra Gas facility is shown in Figure 5-1. Figures 5-2 and 5-3 provide subsurface information on the geological conditions in the vicinity of the underground storage tanks (USTs) located at the south end of the Centra Gas facility. Additional details are provided in the borehole/ monitoring well location plan presented in Section 3.

The geologic information obtained from the drilling program conducted by CH2M HILL in the vicinity of the USTs is consistent with findings obtained from the University of Manitoba in the City of Winnipeg. As well, the geology is consistent with reports completed in 1967 by Ripley, Klohn and Leonoff Ltd., a local geotechnical consulting firm, concerning site conditions at the Centra Gas facility.

Weathered Glaciolacustrine Silty Clay/Clayey Silt Deposit

This deposit underlies the surficial fill layers at shallow depth. The unit varies between a clayey silt and a silty clay. These materials have been grouped into one deposit because of their similar composition and structure. The deposit ranges in thickness from 2.0 to 4.0 metres and was intercepted at depths ranging from 1.5 to 3.4 metres. The deposit extends to approximately 5.5 metres below ground surface. The water table was not identified in the native material during drilling activities. A summary of the geology in the vicinity of the USTs is provided in Figures 5-2 to 5-3.

The silty clay has a moderate to high plasticity and moderate cohesion, is stiff in consistency, and is moist. The colour was generally a mottled grey-brown or olive-brown indicative of the effects of weathering processes (i.e. oxidation). White silt pockets and organics (i.e. shells and rootlets) were observed in this deposit. Occasional silt laminations were also observed. Fractures in this material were observed at MW02 but did not appear to be frequent. Only a trace of sand was identified.

The clayey silt has a moderate plasticity and moderate cohesion, is firm to stiff in consistency, and is moist. The colour is similar to the silty clay. White silt pockets and organics (i.e. shells and rootlets) were observed along with silt laminations. From comparison of materials identified at BH17 and MW02, the frequency of fractures was higher in the clayey silt than the silty clay in the weathered deposit. As well, trace sand was identified in this deposit.

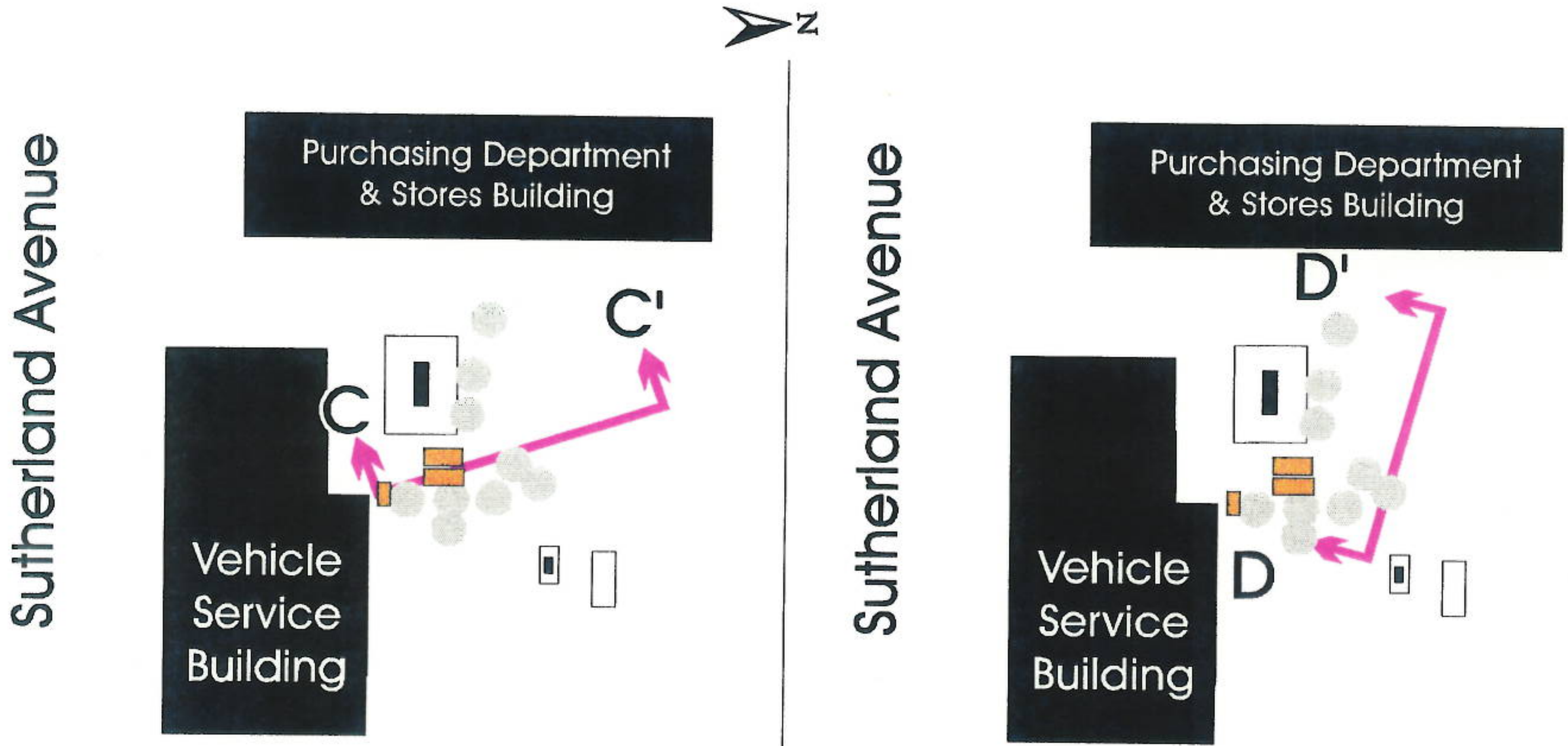

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FIGURE 5-1
PLOT PLANS SHOWING
GEOLOGIC SECTION LINES FOR
CROSS SECTIONS C-C' & D-D'

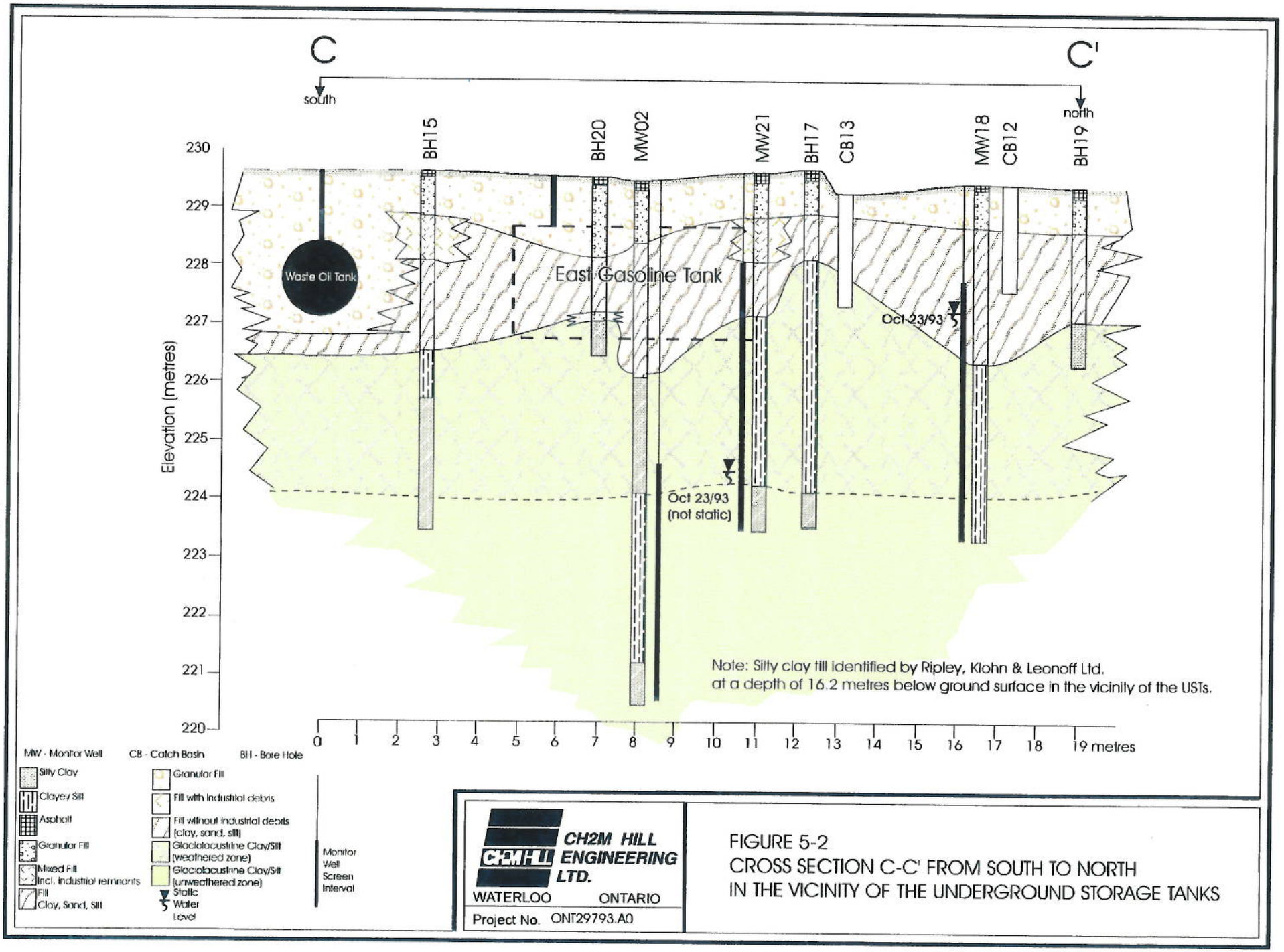

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FIGURE 5-2
CROSS SECTION C-C' FROM SOUTH TO NORTH
IN THE VICINITY OF THE UNDERGROUND STORAGE TANKS

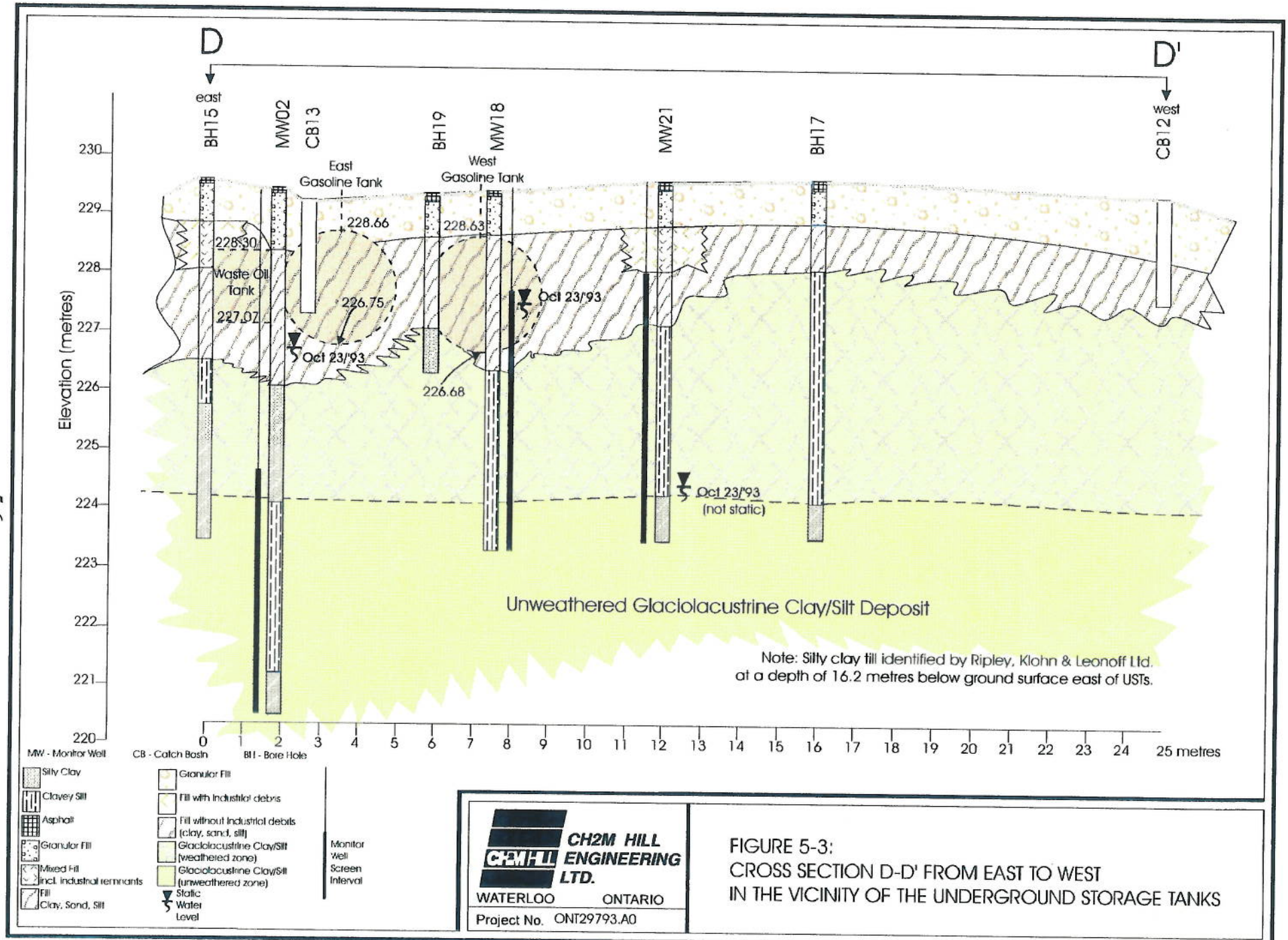

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FIGURE 5-3:
CROSS SECTION D-D' FROM EAST TO WEST
IN THE VICINITY OF THE UNDERGROUND STORAGE TANKS

Unweathered Glaciolacustrine Silty Clay/Clayey Silt Deposit

This deposit underlies the weathered glaciolacustrine silty clay/clayey silt deposit. As above, the silty clay and clayey silt zones have been grouped into one deposit because of their similar composition and structure. The primary difference between this deposit and the overlying zone is the general absence of weathering (i.e. oxidation, fractures, etc.). The water table was not readily observed during the drilling process. This deposit was encountered at a depth of approximately 5.5 metres; however, the thickness of this deposit was not determined because of the depth limitation of the drilling program. This zone is identified on Figures 5-2 to 5-3.

Silty clay was observed underlying the upper weathered deposit at all locations advanced into the subsurface, except at MW02 which was underlain with clayey silt. Some of the characteristics of silty clay material are as follows:

- High plasticity and cohesion
- No fracturing
- Little or no oxidation
- Higher moisture content
- Less mottled
- Darker grey in colour
- Occasional organic remnants (i.e. shells and vegetation debris)
- Fewer silt pockets
- Trace coarse sand and gravel
- Stiff in consistency

The clayey silt material extended to 8.2 metres at MW02 before the silty clay deposit was encountered. Generally, the characteristics of the clayey silt material were similar to those of the silty clay except that the plasticity and cohesion was lower and organic remnants such as shells were more evident. No fractures were identified in the unweathered, clayey silt zone at MW02.

Silt Clay Till Deposit

From geotechnical investigations conducted onsite by Ripley, Klohn and Leonoff Ltd. in 1967, it was reported that the till deposit was encountered at 53 feet (16.2 metres) below ground surface, east of the USTs. The geologic characterization completed in the EHSA investigation identified the silty clay till deposit at 13.49 metres below ground surface at the north end of the property. Some of the observations identified in this deposit include:

- Some coarse-grained sand and gravel
- Predominantly silty clay matrix
- Very dense/hard
- Grey and moist

Distribution of Fill Materials

Fill encountered during the subsurface investigation was delineated by physical observations and is presented on the borehole logs in Appendix B. Figures 5-2 to 5-3 provide an overview of the distribution of this material.

The thickness of the fill ranged between 1.4 to 3.2 metres. The greatest thickness of fill was observed at MW02 and BH15, close to the USTs and at MW18 close to the storm sewer system.

The fill material delineated onsite was categorized into three groups:

- Granular Fill
- Fill without Industrial Debris
- Fill with industrial debris (only observed at two locations in the vicinity of the USTs)

Granular Fill

The granular fill forms the subbase for the 0.15 metre thick asphalt surface in the vicinity of the UST facility. This material is a compact, tan-brown, dry sand and gravel with little cohesion. Some black staining was observed at MWO2 and BH17 at 0.6 metres below ground surface. The sand and gravel was moist at BH17 and was silty at BH20. The granular fill ranged in thickness from 0.6 to 1.2 metres. This material forms a continuous zone underlying the asphalt surface in the vicinity of the USTs.

Granular fill was also observed underlying the zone of fill (without industrial debris) at BH20. The layer was brown, moist and non-cohesive and appeared localized to this area.

Fill Without Industrial Debris

This material was variable in composition but was generally fine-grained. Typical materials observed included sandy silt, silty clay and clayey silt. These materials ranged in thickness from 0.3 to 2.3 metres. The observations identified from inspection of these materials include the following:

- At MW02 (close to the east gasoline UST) the silty clay material was soft and black with a high organics content, occasional white silt inclusions and trace sand.

- Sandy silt and clay silt were identified at MW18, slightly north of the storm sewer system. The materials were tan-brown, loose with occasional white silt inclusions. Black staining was not observed.

- Loose, black sandy silt fill was identified at MW21.

- The upper portion of the clayey silt fill (1.52 to 2.2 metres) at BH15 was black in colour. The lower portion (2.2 to 3.1 metres) was grey-brown, loose, and mottled with some oxidation.

- Cohesive, highly plastic, dark-grey, soft, silty clay fill was observed at BH16, located closest to the vehicle service building. Black staining was not observed.

- A black, loose, non-cohesive sandy silt fill was observed at BH17 from 0.76 to 1.52 metres below ground surface.

- Cohesive, soft silty clay was identified at BH19 from 0.76 to 2.29 metres below ground surface. The upper portion was olive-green. The bottom 0.3 metres appeared black in colour.

- Sandy silt and silty clay fill was identified at BH20. The sandy silt was brown, oxidized and non-cohesive. The silty clay was cohesive and olive-green in colour.

- The fill materials observed were all moist.

Fill With Industrial Debris

Concrete and rubble type material appeared to be localized between 0.76 to 1.52 metres below ground surface at MW21 and BH15. Black staining was observed at MW21 but not at BH15. At BH16, construction debris including wood chips and some black staining was observed between 0.76 and 1.22 metres below ground surface. Materials of this type were not observed at the other locations advanced in the vicinity of the USTs.

Distribution of Contamination in the Fill and Native Deposits

As discussed in Section 3, the distribution of physical contamination was determined during the drilling program from inspection of each soil sample. Characteristics such as odour, discoloration, and total organic vapour (TOV) readings were used to classify the materials into the following groups:

- NC - no contamination
- TC - trace contamination
- VC - visual contamination (black staining, coal tar residues or free product petroleum)
- C (no VC) - contaminated but no visual evidence

The NC designation was used where the TOV reading was low (i.e. <3 ppm), little or no odour was evident, and no presence of discoloration or coal tar remnants existed.

The TC classification was used where little or no visual evidence of contamination was observed; however, a faint odour and low to moderate TOV reading existed (i.e. 0.1 to 71 ppm).

The VC designation was used where a black discoloration of the soil material was observed or for the presence of free product petroleum, if identified. As well, it was used where coal tar was observed. Generally the odour was strong and a high TOV reading resulted (generally between 40 to 156 ppm). However, in some casings only a faint odour was observed and a low TOV reading was obtained.

The C (no VC) classification was used where no visual evidence existed; however, a strong odour associated with petroleum by-products or coal tar residues was still present. TOV readings were generally in the range of 40 to 156 ppm; however, much lower readings were obtained.

On occasion, the moisture content in the soils was high enough to cause interference with the TOV measurements. Often, these readings are biased lower when higher moisture contents are present. Where interference was observed, the physical characteristics of the sample from visual observations and smell were used to classify the soil.

The VC and C (no VC) classifications represent materials where the greatest impact has likely occurred from the former gasification facility and existing underground storage tanks (USTs). It is worth mentioning that soil classified as VC or C (no VC) when analyzed by a laboratory may indicate that significant contamination does not exist, although the physical characterization suggests that some degree of impact has occurred.

A summary of the results of this classification is identified in Figures 5-4a and 5-4b. The sample depth and qualitative classification are provided along with the TOV readings, if available. The classification for visual contamination and contamination with no visual evidence have been given the same weighting in these figures. As well, details concerning the classification of contamination with depth along with an indication of the geologic materials is provided in the borehole logs in Appendix B. An overview of the site geology has also been provided in the previous sections.

From review of this information, the following points are worth mentioning:

- An NC classification was identified at the termination depth in each borehole completed in the vicinity of the USTs with the exception of BH19, which was terminated at a shallower depth. However, a TC classification was identified at BH19 which suggests that little adverse impact has occurred in these materials. The unweathered glaciolacustrine silty clay/clayey silt deposit will impede migration of petroleum/coal tar residuals, if present, to greater depth.

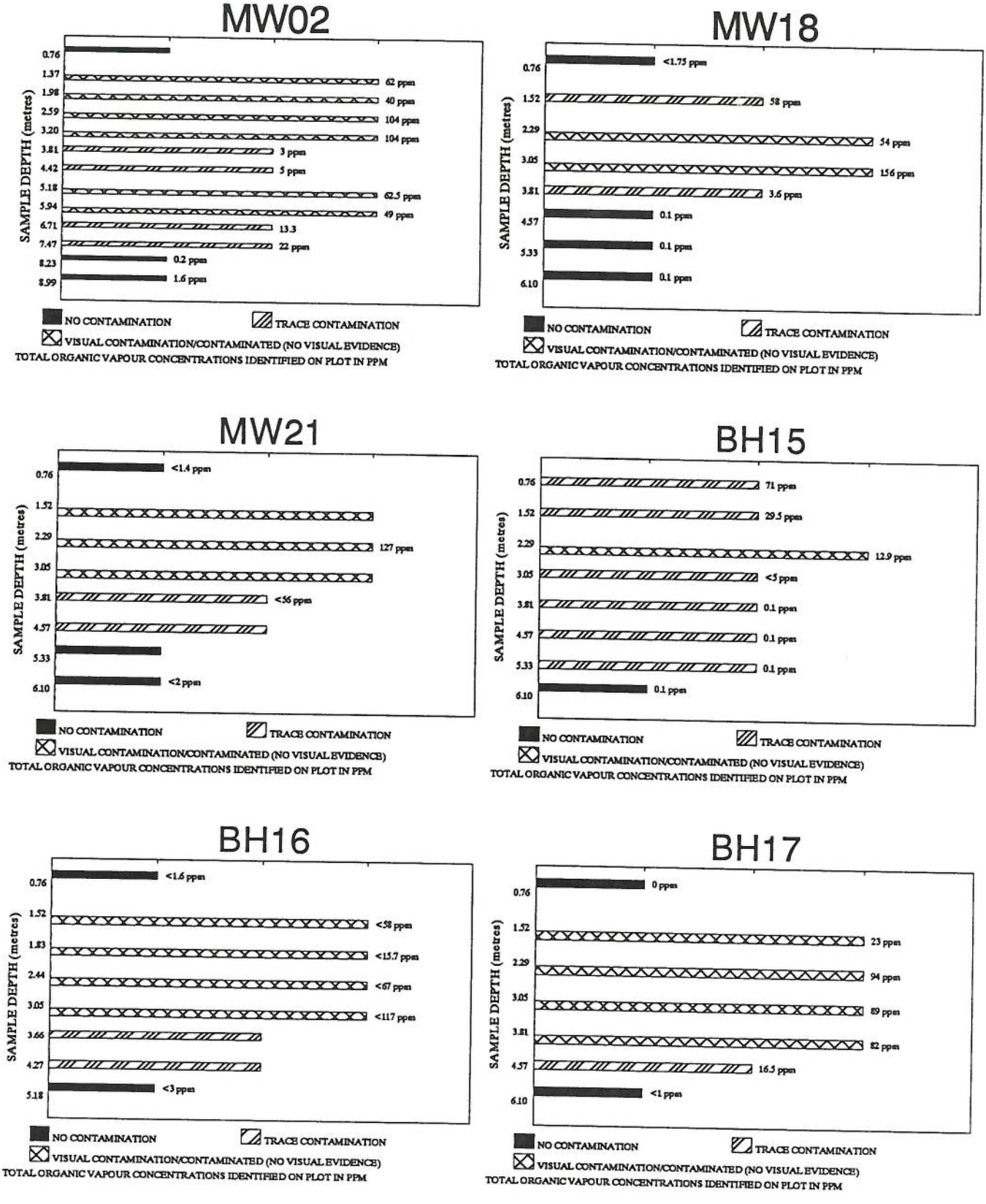
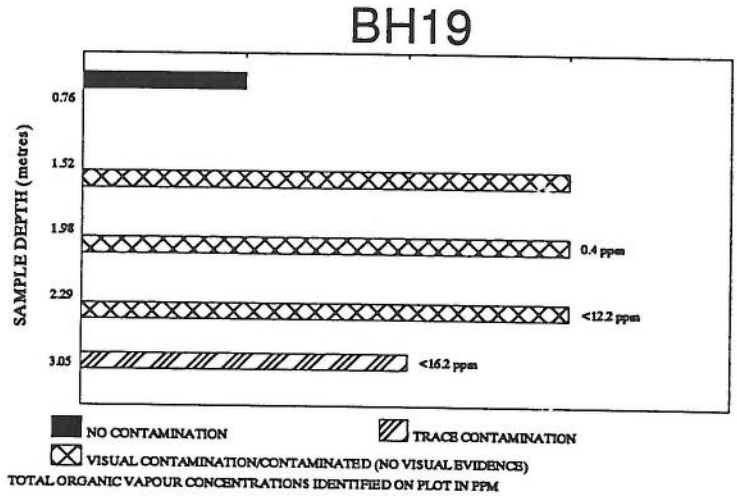


FIGURE 5.4a
PHYSICAL CHARACTERIZATION OF SOIL IN THE VICINITY OF USTs



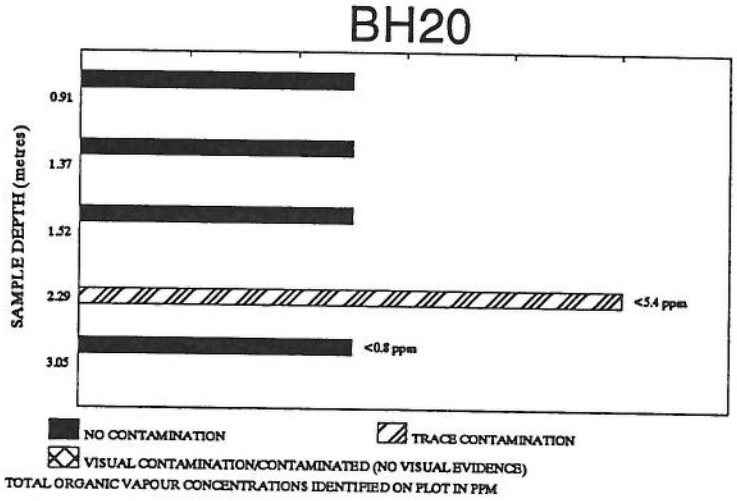


FIGURE 5.4b
PHYSICAL CHARACTERIZATION OF SOIL IN THE VICINITY OF USTs

- At MW02, fill materials from 0.76 to 3.1 metres below ground surface were identified primarily with a VC classification. Black staining was observed but no coal tar or free product petroleum was evident. Generally, petroleum odours were strongest between 2.0 and 3.1 metres. TOV readings were recorded between 40 and 104 ppm in this zone. No discoloration was observed from 3.1 metres to the termination depth of 9 metres. Petroleum odours dissipated between 3.1 and 4.4 metres as identified by low TOV readings. Elevated TOV readings were identified between 4.4 and 5.9 metres in the weathered glaciolacustrine silty clay deposit; however, free product petroleum or coal gasification residues were not observed. An NC classification was identified from 7.6 metres to the termination depth of 9 metres at MW02.

- Strong petroleum odours were identified in the fill materials at MW18 between 1.52 to 3.05 metres below ground surface. MW18 is located north of the storm sewer and the USTs. Black staining or free product petroleum was not observed. TOV readings of 54 and 156 ppm were recorded in the clay silt fill and was classified as C (no VC). Vapours associated with the USTs and the former coal gasification plant may be present at this location. Little or no evidence of impact was observed from 3.1 to 6.1 metres below ground surface at MW18.

- The upper surface of the weathered glaciolacustrine clayey silt deposit had a faint naphthalene odour (associated with coal gasification operations) and was black in colour at MW21. Black staining was observed between 0.8 and 3.1 metres in the fill material and was classified as VC, but no coal tar or free product petroleum was observed at MW21 within this depth range.

- BH15 (located close to the waste oil UST) had some localized discolouration in the fill materials between 1.5 and 2.1 metres. The old petroleum odour that was recorded between the above-mentioned depth range, dissipated in the native weathered deposits. Black staining was not evident from 2.1 metres to the termination depth of 6.1 metres. Some vapours exist in the granular fill at BH15 based on the elevated TOV reading of 71 ppm.

- The upper portion of the native weathered silty clay and the fill zone below the granular subbase were identified as VC at BH16. Some black staining was observed in the fill (with industrial debris). Black staining was also observed in laminated seams in the weathered silty clay deposit down to a depth of 3.7 metres. TOV readings ranged between 15.7 to 117 ppm in the above-mentioned materials. No contamination was observed from 4.6 metres to the termination depth of 5.2 metres.

- A VC classification was identified at BH17 (adjacent to the pump island) because of the presence of coal gasification residues in the subsurface materials. Coal tar residues were observed between 1.5 and 3.8 metres

below ground surface in the fractured portion of the weathered glaciolacustrine clayey silt deposit. Black staining was observed in the granular fill and sandy silt fill overlying the native deposits; however, coal tar residues were not observed. TOV readings ranged between 82 to 94 ppm in the fractured native deposits. A strong naphthalene odour was also observed between 1.5 and 3.8 metres. BH17 was the only location in the vicinity of the UST facility where coal tar residues were visually observed. Free product petroleum associated with the USTs was not observed during inspection of samples at BH17. As well, odours characteristic of petroleum contamination were not evident during inspection of the samples at BH17. At 3.8 metres below grade, a TC classification was identified based on no evidence of coal tar residues in these materials and only a faint naphthalene odour. The contamination level dissipated significantly in the unweathered silty clay deposit at 5.5 metres below ground surface. The TOV reading was <1 ppm, no black staining was observed and only a very faint naphthalene odour was recorded at 5.5 metres.

- Black staining was observed at BH19, but free product petroleum or coal gasification residues were not observed. Because of the black stained colour, the soil materials were classified as VC. Only a faint odour was identified at the termination depth of 3.1 metres and the soil was no longer discoloured. The material at 3.1 metres was classified as TC.

- Visual contamination, high TOV readings or strong odours were not identified at BH20, located east of the USTs beyond MW02. A faint old fuel odour was identified with generally low TOV readings which suggested that a significant impact has not occurred in this area. Most of the samples inspected were classified as NC.

In summary, no free product petroleum was observed during inspection. The only location where coal gasification residues were observed was at BH17. Significant UST leakage (i.e. soils saturated with petroleum product) was not identified during the drilling activities.

The black discoloured soils and petroleum/naphthalene odours were identified in this area suggesting that some impact has occurred from the former coal gasification plant and USTs. The black discolouration and petroleum/naphthalene odours were generally confined to shallow depth, above 3 metres in the fill material and weathered glaciolacustrine silty clay/clayey silt deposit. A number of chemical analyses were conducted to support the physical characterization.

Chemical characterization was completed at MW18, the location with the highest TOV reading. MW18 is also an important location for chemical characterization since contamination may be present north of the storm sewer system. Chemical characterization was conducted at MW02, the closest location to the east gasoline UST, to address

the elevated TOV readings between 4.6 and 5.9 metres. Physical characterization suggests that an adverse impact may have occurred to greater depth at this location. Subsurface materials at shallow depth were analyzed at MW21, where strong odours associated with the coal gasification plant were identified.

Hydrogeology

Regional Hydrogeology

Bedrock

The major aquifer underlying the Winnipeg area is located in the upper 15 to 30 metres of the fractured Paleozoic limestone and dolomite bedrock. This aquifer is generally referred to as the Upper Carbonate Aquifer. The aquifer is semi-confined by the overburden and the underlying lower permeability carbonate bedrock. The water yield for this aquifer is reportedly 250 to 1250 m^2/day.

This aquifer system is recharged from the following sources:

- Lateral recharge from the glacial till east of the glaciolacustrine clays
- Lateral recharge from the thin glacial till northwest of Winnipeg
- Lateral recharge from the thin veneer of glacial till and fluvial deposits on the west side of the Red River Basin
- Vertical movement from the overburden down to the bedrock aquifer, although it is expected to be very slow through the overburden deposits
- Vertical recharge from local rivers overlying the aquifer system, although it is very slow in some areas of the city

Prior to the development of the Lake of the Woods aqueduct, the groundwater of the Upper Carbonate Aquifer was an important source of water for both municipal and industrial use. Presently, the City of Winnipeg is supplied from the Lake of the Woods aqueduct for potable water. The Upper Carbonate Aquifer is used as a potable source of water in rural areas bordering the city and primarily for industrial use within the city.

Overburden

The overburden in the City of Winnipeg is not used as a potable source of water. Primarily low permeability tills and glaciolacustrine silt and clay deposits dominate the area with the exception of locations along the floodplain of the rivers where permeabilities may be slightly higher. Reportedly the hydraulic conductivity of these deposits ranges from 1.5×10^{-7} m/s to 2.06×10^{-9} m/s.

Fractured areas in the glaciolacustrine silts and clays as well as in the till deposit can be a source of secondary permeability. However, it is highly dependent on the fracture width and spacing within the deposit. Some recharge is expected to occur from the overburden to the underlying Upper Carbonate Aquifer but it is expected to be very slow. It is expected that the overburden also discharges to the rivers in the City of Winnipeg.

Onsite Hydrogeology

In the vicinity of the USTs, three (3) wells were installed as dictated by budget constraints. Information obtained during the EHSA was incorporated in order to provide additional insight into the site conditions. Water level measurements completed during the investigation are summarized in Table 5.1. Figures 5-2 and 5-3 indicate the location of the perched water in relation to the USTs and the catchbasins in the area. The following points were derived from review of information obtained for this site:

- A perched water table appears to exist in the vicinity of the USTs. The water level at MW02 fluctuated 0.18 metres between October 2 and November 16, 1993. The water level at MW18 fluctuated 0.12 metres from October 2 to November 16, 1993. On October 23, 1993, the water level at MW02 was 2.78 metres below ground surface and 1.94 metres below grade at MW18 in the fill materials. On October 23, 1993, the water level at MW18 was 0.83 metres higher than at MW02. A downward vertical gradient was observed from comparison of water levels at MW02 and MW18.
- Water levels at MW18, in the vicinity of CB13, suggest that water infiltration is likely occurring in the bedding materials around the storm sewer piping and to a lesser extent around the USTs.
- The elevation of the perched water at MW02, closest to the gasoline USTs, suggested that the perched water level is below the bottom of the three USTs.
- Flow direction of perched water identified at shallow depth is complicated by shallow utilities, trenches, USTs, buildings and the storm sewer system.
- The overall groundwater flow direction across the site is expected to be toward the Red River based on the EHSA investigation. The number of monitoring wells with static water levels was insufficient to confirm the groundwater flow direction in the vicinity of the USTs.
- From water level monitoring conducted after groundwater purging activities, slow groundwater recoveries were evident at MW21 and MW02. However at MW18, the groundwater recovered quickly; MW18 is located in the vicinity of the storm sewer system. The groundwater

Table 5.1
Water Level Elevations for Monitor Locations

Monitor Location	Ground Elevation (metres)	Top of Well Elevation (metres)	Date							
			Sept. 29/93		Sept. 30/93		Oct. 2/93		Oct. 3/93	
			Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water
MW02	229.45	229.336	NA	NA	NA	NA	226.486♦	2.85	224.286•	5.05
MW18	229.43	229.245	226.145♦	3.1	226.445♦	2.8	227.615♦	1.63	227.555•	1.69
MW21	229.6	229.498	NA	NA	NA	NA	dry♦	dry	dry	dry

Monitor Location	Ground Elevation (metres)	Top of Well Elevation (metres)	Date							
			Sept. 29/93		Sept. 30/93		Oct. 2/93		Oct. 3/93	
			Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water	Water Level Elevation	Depth to Water
MW02	229.45	229.336	224.226•	5.11	226.666♥	2.67	223.801♠	5.535	226.578♥	2.756	226.598♥	2.738
MW18	229.43	229.245	227.505•	1.74	227.495♥	1.75	227.470♠	1.775	227.413♥	1.832	227.379♥	1.866
MW21	229.6	229.498	dry•	dry	224.398♠	5.1	225.248♠	4.25	225.748♥	3.75	225.868♠	3.63

♦ = Following Drilling and prior to Purging
• = During Purging Activities
♥ = Static conditions
♠ = After Purging
♠ = Not Fully recovered to Static Condition
NA = Not analyzed

Note: No free product petroleum observed during monitoring activities.

recovery rate at MW21 was the slowest observed onsite. After almost two months of recovery time, the water level still had not risen to static conditions. For this reason, MW21 could not be used in the hydrogeologic interpretation. Hydraulic testing was not conducted at the monitoring wells to quantify the qualitative recovery rate information within the scope of the preliminary UST investigation.

- Downward migration of groundwater in the vicinity of the USTs is expected to be very slow based on the characteristics of the unweathered glaciolacustrine silty clay deposit and the general absence of fractures beyond approximately 4.0 metres below ground surface.

Offsite migration of the contaminants beneath the ground surface may occur when groundwater and surface water interacts with potentially contaminated materials in the subsurface. Preferential migration may also occur along sewer backfills and piping. This is of particular concern during periods of high precipitation where groundwater levels may intercept the bottom portion of the storm sewer catchbasin and piping. Groundwater levels at MW18 and MW02 may rise up into the storm sewer bedding materials during periods of high precipitation. Vertical and lateral migration of any contaminants in the vicinity of the USTs through the fill and native materials is expected to be slow, although this was not confirmed by hydraulic testing.

The storm sewer may also enhance migration of vapours identified in the subsurface.

Generally, there are no significant pathways that were identified onsite with a high risk of causing an adverse impact on human health or the environment.

Section 6
Site Sensitivity Assessment

The site sensitivity assessment is a means of ranking the site for the purpose of assigning appropriate remediation criteria. The assessment considers both the sensitivity of the potential human and environmental receptors and the likelihood of impact on those receptors for a number of exposure scenarios such as ingestion or inhalation. This approach is not considered to be a site risk assessment; however, it can provide suitable information to assign appropriate remediation criteria.

The site sensitivity assessment system classifies the site according to its sensitivity (low, moderate, or high) on the basis of site-specific factors governing the likelihood of impact and receptor sensitivity.

The site information assessment identified in Section 2 and the results from the subsurface drilling program identified in Section 5 were the information sources used to complete the site sensitivity assessment.

Ingestion Pathway of Water

The primary route of ingestion of petroleum by-products, coal tar residuals or oil residuals would be in contaminated groundwater or surface waters used as a potable water source. Ingestion of contaminated soils is unlikely as the site is either paved, built on or vegetated. Consideration of aesthetic qualities of the water and the potential effect on aquatic life associated with surface bodies should be assessed.

Based on a review of the information sources, information relevant to ingestion pathways is outlined below:

- Although not confirmed in the area of the USTs, the groundwater flow direction is expected to trend north toward the Red River at a very slow rate. Perched water in the vicinity of the storm sewer system is higher than the perched water in the vicinity of the USTs, suggesting that water levels may be significantly influenced by the storm sewer and on occasion the direction of groundwater flow may be indeterminate.
- The shallow groundwater underlying the Centra Gas facility is not used as a potable source of water. Groundwater in the upper Paleozoic sedimentary bedrock, referred to as the Upper Carbonate Aquifer, located between 15 and 21 metres below ground surface, is used for commercial/industrial applications. The Upper Carbonate Aquifer is not used as a drinking water source in the vicinity of the Centra Gas facility. Drinking water in the City of Winnipeg is derived from the Lake of the

Woods aqueduct. The shallow groundwater in the vicinity of the site is not used for irrigation purposes.

- The Red River is located approximately 400 metres north of the UST facility. The distance that the river is located from the USTs is significant suggesting that little risk of an adverse impact on surface water quality or aquatic life is likely to occur from the direct discharge of potentially contaminated groundwater in the vicinity of the UST facility. Other surface water bodies (i.e. ponds or lakes) do not exist in this area.

- The unweathered glaciolacustrine silty clay deposit and underlying silty clay till will act as a low permeability barrier to impede migration of petroleum by-products, coal tar residuals, and waste oil potentially present in the subsurface, to greater depths.

- The storm sewer located slightly north of the USTs may enhance the migration of potentially contaminated groundwater in this area. Groundwater migration could occur along sewer backfill materials and may infiltrate the storm sewer piping. The storm water collected in the vicinity of the USTs is directed to a combined sewer (i.e. storm and sanitary) on Annabella Street. The combined sewer in the area is used to direct surface waters from storm events and sewage generated in the area to the water pollution control plant. The water levels measured during the investigation were generally below the bottom elevation of the catchbasin close to USTs (i.e CB13), except at MW18 which was slightly above the bottom elevation of CB13. Although the storm sewer piping and backfill may enhance migration of potentially contaminated groundwater, and infiltration of potentially contaminated groundwater into the sewer may occur, it is expected that an adverse impact will not occur offsite on surface water quality in the Red River.

In summary, there are no significant ingestion receptors at this site. The potential for vertical migration of groundwater in the vicinity of the USTs to the deep bedrock aquifer is very low. Although the potential exists for groundwater to migrate along or into the sewer system, the risk of this pathway adversely impacting surface water quality from water discharge into the combined sewer and directed to the Red River is very low. The sensitivity ranking that addresses the conditions at this site based on ingestion pathways is low.

Inhalation Pathway of Vapours from Soil and Groundwater

The receptor sensitivity to vapour inhalation can be related to land use as identified below:

- Residential land use has a high sensitivity

- Commercial/industrial land use has a medium sensitivity
- Open lands have a low sensitivity

Confined spaces, buildings with basement foundations, etc. need to be considered in the assessment.

From review of the information sources identified in Section 2 and 5, the following points related to inhalation pathways are worth mentioning:

- The entire UST facility is covered over by an asphalt surface, minimizing the upward migration of vapours potentially present in the vicinity of the USTs.

- No basement foundation structures exist close to the UST facility at this site. Slab foundations have been used for the vehicle service and purchasing/stores buildings, closest to the USTs. Therefore confined spaces or migration of vapours through basement foundation cracks and the impact of these vapours on human health through these pathways is not considered an issue at this site.

- The operations building is the only building onsite that was constructed with a basement foundation. However, it is located approximately 100 metres north of the USTs and is considered a low risk for migration of vapours potentially present in the vicinity of the USTs.

- The closest residential property to the UST facility is located 50 metres east, adjacent to Annabella Street. It was not confirmed but some of the houses in this area may not have been constructed with basement foundations.

- Shallow utility trenches may enhance vapour migration in the vicinity of the USTs; however, significant receptors do not exist onsite.

- The storm sewer system located slightly north of the UST facility was identified as a potential pathway for migration of vapours potentially present in the subsurface. If present, cracks in the sewer piping may enhance the migration of vapours into the sewer system. The storm sewer discharges to an offsite combined sewer system (i.e. storm and sanitary) located on Annabella Street. The residential development adjacent to Annabella Street is connected to the combined sewer for discharge of sewage to the water pollution control plant. The shallow nature of the onsite storm sewer and the positioning of catchbasins in the area north and east of the USTs, will act to dissipate any accumulation of vapours potentially present in the subsurface. If contaminated groundwater entered the sewer system onsite in the area of the USTs, significant volatile contamination would have to be present to produce an adverse impact on air quality in the sewer system downgradient.

The sensitivity ranking that addresses the conditions at this site based on inhalation pathways is low.

Site Sensitivity Ranking

Based on the sensitivity rankings identified for the two pathways, the remediation criteria that should be used for comparison is the Level III criteria for both soil and groundwater. The Level III criteria is the least strict compared to Level I and II criteria. The Alberta (MUST) Level III criteria for groundwater and the Manitoba UST Level III for soil, which are discussed further in Section 7, were used for comparison to analytical results presented in Section 8.

Section 7
Overview of Environmental Regulations, Criteria, and Guidelines

Environmental regulations, criteria, and guidelines enforced in the Province of Manitoba are directly relevant to the interpretation of investigative results.

Two main provincial acts are relevant to this project:

- Environment Act
- Dangerous Goods Handling and Transportation Act

The Environment Act, dated July 17, 1987, was intended to ensure that the environment is maintained to sustain a high quality of life in Manitoba for present and future generations. The act is general in nature but provides broad powers to implement regulations or orders to protect the environment [Section 41(1)]. These powers can include setting of environmental quality criteria [Section 41(1)e]; design or operation of systems to abate or control pollution [Section 41(1)k]; collection, treatment, and disposal of pollutants [Section 41(1)l]; or responding to any product that pollutes or damages the environment [Section 41(1)o]. The act provides authority for broad powers of inspection to determine compliance and to order abatement where environmental damage has occurred. Under the Environmental Act there are regulations associated with individual environmental issues. The Storage and Handling of Gasoline and Associated Products Regulation has direct application to the Sutherland Avenue UST facility.

The Dangerous Goods Handling and Transportation Act (DGHTA), first passed in 1986, deals primarily with the requirements for the handling, transportation, and disposal of hazardous materials. This act also provides the Director with authority to issue Remedial Orders if dangerous goods or contaminants have caused or may cause an adverse impact on the environment. The DGHTA provides authority to implement regulations related to all aspects of dangerous goods including hazardous wastes. Manitoba Regulation 172/85, entitled *Federal Regulations Adoption Regulation*, adopts the portion of the federal legislation entitled *Regulation Respecting the Handling, Offering for Transport and Transportation of Dangerous Goods (TDG)* dealing with the definition and classification of substances affected by the regulation. Further definition is provided under Manitoba Regulation 282/87, entitled *Classification Criteria for Products, Substances and Organisms Regulation (CCPSOR)*.

To assist in the evaluation of analytical results for soil and groundwater the results were compared to environmental quality criteria which are identified below. The guidelines are referenced only as a benchmark to identify the potential for remediation activities onsite during UST removal and to identify the method of disposal for potential wastes

in the vicinity of the USTs. As well, the guidelines have been used to assess the severity of the environmental impact onsite.

The analytical results were compared to Manitoba guidelines, where available. If Manitoba guidelines were not in existence, guidelines were adopted from other provincial or federal jurisdictions. In many instances, Manitoba has adopted guidelines developed by the federal government. Since no changes in the Centra Gas site usage are anticipated, the commercial/industrial land use criteria were adopted for this evaluation.

The criteria and guidelines applicable to each media relevant to this project are outlined in the remainder of this section.

Soil Quality Guidelines

Hydrocarbons

Manitoba Environment has developed a guideline specific to petroleum contamination of the subsurface entitled *A Guideline for the Investigation and Remediation of Petroleum Sites in Manitoba*, dated July, 1993. Manitoba Environment prepared this document to support concerns over regulating contaminated soils associated with the increasing numbers of underground storage tanks requiring removal in Manitoba. The guideline was developed to identify the extent of the impact on the subsurface soils where a release of petroleum product had occurred and to select the appropriate remediation level at which disposal/treatment of contaminated soils is required. Although the investigation conducted in the vicinity of the USTs at the Sutherland Avenue facility was preliminary in nature, Centra Gas is using the guideline criteria for pre-planning purposes in order to assess the conditions at the site prior to removal of the USTs or in support of UST abandonment, if possible.

The Manitoba guideline is modelled after the Alberta MUST guideline. It involves conducting a qualitative risk assessment (i.e. site sensitivity assessment) to determine which remediation criteria (Level I, II, or III) should be applied to a given site, if required. Level I criteria is the most strict and Level III is the least strict. If the remediation levels are not considered feasible or appropriate, a provision exists to conduct a site-specific risk assessment to develop modified criteria. A detailed quantitative risk assessment was not conducted during this preliminary investigation.

In applying the results of the sensitivity assessment for the USTs on the Centra Gas site, it was determined that the site sensitivity was low for impact on receptors. Details of the sensitivity assessment are provided in Section 6. The site sensitivity ranking based on water use indicates that cleanup levels should be based on toxicity levels for specific receptors. The site sensitivity ranking indicates that Level III criteria for soil

should be adopted for the site. Soils not exceeding the Level III criteria would remain onsite in the original excavation pending review by the Manitoba Environment.

The above-mentioned Manitoba guideline is not in itself a legally enforceable standard; however, the guideline criteria can be referenced under control orders from the Manitoba Environment through enforcement of the DGHTA and Environmental Act.

In 1991, the Canadian Council of Ministers of the Environment (CCME) released the *Interim Canadian Environmental Quality Criteria for Contaminated Sites*. Many of the criteria in this document do not have complete supporting rationale and are considered to be interim. Two types of guidelines exist: assessment and remediation. Assessment guidelines are approximate background concentrations or approximate analytical detection limits. Remediation guidelines are generally considered protective of human and environmental health and are based on experience and professional judgement. The CCME remediation guidelines for commercial/industrial land use were referenced for comparison in this document. The CCME remediation guidelines for residential/ parkland land use are identified in support of the evaluation. If CCME remediation guidelines were unavailable, CCME interim assessment criteria were referenced. These criteria were used secondary to the Manitoba Environment guideline mentioned above.

Manufactured Gas Plant Residue Criteria

The two 13,500-litre USTs under investigation have always been used for the storage of hydrocarbons. The 2,700-litre waste oil UST has been used for the storage of waste oil only. However, the site itself was used for the manufacturing of coal gas during an earlier period, as identified in Section 2. The possible presence of manufactured gas plant residues may warrant management concurrent with the removal or abandonment of the USTs. Therefore, the presence of manufactured gas plant residues was assessed during this program.

In 1989, the Canadian Council of Ministers of the Environment (CCME) developed a document entitled *Interim Guidelines for PAH Contamination at Abandoned Coal Tar Sites* which includes criteria for soil and groundwater. These guidelines were developed for interim use while more definitive guidelines were developed but more definitive guidelines have not been published to date. The CCME guidelines were based on modifications to the Quebec ABC criteria to make them more consistent with the World Health Organization (WHO) drinking water guideline of 0.01 µg/L for Benzo(a)pyrene [B(a)P]. The Quebec criteria and the CCME criteria are based on limited toxicological data and not on risk assessment models.

The recommended application of this guideline by CCME is that Level B values be adopted as a trigger above which further detailed investigation is required on commercial or industrial sites. Level C criteria are values above which action is required to reduce exposure for humans or other biota. Possible actions listed in the guideline include cleanup, other mitigation, or change in land use. Manitoba Environment has

indicated that it would be appropriate to refer to the above-referenced CCME guideline to assess the results of the preliminary UST investigation at the Sutherland Avenue facility.

Water Quality Guidelines

Hydrocarbons

Manitoba Environment has not developed criteria for petroleum contamination in groundwater at this time. However, it was indicated that where groundwater is or may be used for domestic consumption, the levels of BTEX and lead should not exceed the Canadian Drinking Water Guideline (CDWG) criteria at the point of withdrawal. Although the groundwater in the vicinity of the site is not used as a potable source, the CDWG has been referenced in this document for comparison. Because the groundwater is not used as a potable source of groundwater, the Alberta MUST criteria (Alberta Environment, 1990) provide a more useful comparison in the vicinity of the USTs and have been referenced in this document. As mentioned above in the subsection concerning soil guidelines, a site sensitivity assessment was completed to support the level of remediation criteria selected at this site. Level III was identified as suitable remediation criteria based on the sensitivity assessment detailed in Section 6.

The document entitled *Interim Canadian Environmental Quality Criteria for Contaminated Sites* (CCME, 1991) has also been referenced for water quality criteria in this report. Although remediation criteria are provided in the report, they are based on other available criteria for various water uses. Remediation criteria for irrigation and livestock watering are derived from the Canadian Water Quality Guidelines (CCME, 1987). The drinking water criteria referenced in this report are from the Guidelines for Canadian Drinking Water Quality (Health and Welfare, 1989). Drinking water guidelines apply strictly where water is used as a source of potable drinking water; however, these values have received wider application as an overall indicator of groundwater quality and thus have been used for comparison in this document.

Manufactured Gas Plant Residues

CCME (1989) includes Level A, B and C criteria for PAHs in groundwater. The criteria are not rigorously developed and are based on multiples of the detection limit and the drinking water guideline of 10 ppt for B(a)P as well as their relative toxicity.

The Freshwater Aquatic Life criteria apply where surface water bodies are the receptors of pollutants. For instance, the quality of groundwater reaching the Red River would be judged based on these guidelines, as a minimum. Drinking Water Guidelines apply strictly where water is used as a source of potable drinking water but these values have received wider application as an overall indicator of groundwater quality.

Waste Soil Guidelines

Hydrocarbons

The process for classifying wastes is provided in the DGHTA and in part by the federal TDG legislation. The soils may fall into the Class 3 or 4 of the DGHTA based on their potential to ignite.

If the classification process for contaminated soils follows that for "not fully specified goods", these materials onsite may potentially fall into the miscellaneous products or substances group (Class 9). This requires that a leachate extraction be performed to assess waste classification. Unfortunately, the chemicals for which leachate quality criteria have been developed do not include many of the chemicals that are indicative of petroleum by-products (i.e. BTEX, TPH, etc.) due to their volatile nature. As a result, the waste could be classed as non-hazardous, but could still contain appreciable amounts of petroleum by-products.

Manitoba Environment prepared an information update, entitled *Classification and Regulation of Petroleum Contaminated Soil*, which identifies a specific policy on the handling of petroleum contaminated soils. In the vicinity of the USTs, those wastes identified above the Level III Manitoba UST criteria would be further classified under this policy. Heavily contaminated soils, those which exceed the hazardous waste criteria, will be regulated as hazardous wastes and controlled under the DGHTA. Medium and lightly contaminated soils will be managed as non-hazardous wastes and will be controlled under the Environmental Act.

From the above-mentioned information update, the soil may be categorized as a hazardous waste based on the presence of benzene, toluene, ethylbenzene, or xylene for individual components at concentrations greater than 100 ppm. Soils meeting or exceeding the hazardous waste criteria must be directed to a licenced hazardous waste disposal facility by a licenced haulage company, or treated onsite with approval by Manitoba Environment. At present, only one facility, the Manitoba Hazardous Waste Management Corporation (MHWMC), is licenced to accept soil contaminated to the hazardous waste levels in Manitoba. Table 7.1 identifies requirements that must be addressed by the generator and carrier of the contaminated soil. Also identified in Table 7.1 are the requirements for the treatment or disposal facility. Acceptance criteria at the MHWMC facility have been derived from the Manitoba leachate quality criteria provided in the DGHTA. A leachate extraction test may be required for a number of parameters in order to determine if acceptance of the hazardous waste will be approved. Analysis of a number of bulk parameters (i.e. PCBs, PAHs, and lead) may also be required by the MHWMC for comparison against its acceptance criteria.

Table 7.1
Requirements for Handling and Disposal of Petroleum Contaminated Soil

Soil Classification	Hazardous Waste	Non-hazardous (contaminated)	Non-hazardous (uncontaminated)
Generators (Typically the generator will be the owner of tanks and/or the affected property. This is the party who is normally responsible for ensuring that a proper environmental investigation of the site has been conducted and a report, with a remediation proposal, is submitted to Manitoba Environment.)	• Generator must be registered as a hazardous waste generator ("one time" numbers may be issued for individual projects).	• No registration required. • Generator (normally site owner) must notify Manitoba Environment of intent to remove soil from site or to implement in situ remediation.	• Generator must notify Manitoba Environment of soils removed from site as a result of petroleum tank removals or site decommissioning.
Carriers (All loads must be properly covered during transport and must proceed directly to the treatment/disposal site.)	• Hazardous waste carrier licence required to transport soils. • Waste manifest required. • Shipment must comply with Transportation of Dangerous Goods Regulations.	• No carrier licence required. • Carrier must maintain records of loads transported.	• No requirements.
Treatment/Disposal Facilities	• Onsite treatment requires Director's approval under DGH&T Act. • Other treatment/disposal facilities must be appropriately licenced under Section 8 of DGH&T Act.	• Onsite treatment requires approval by Director or Environment Officer. • Landfarming operations at existing municipal waste disposal grounds require an amendment to the operating permit under Manitoba Regulation 150/91. • Single use soil treatment sites require Director's approval. • Commercial soil treatment/disposal facilities must be licenced under The Environment Act.	• No requirements.

For soil that is identified as non-hazardous but is still considered contaminated based on levels exceeding the Level III remediation criteria selected for this site, the soil is not required to be disposed of at a hazardous waste facility. However, disposal of soils to a municipal landfill or treatment onsite must still be considered to address the problem. Remedial measures are more flexible and generally costs are lower for soils categorized into this group. Table 7.1 identifies the regulatory requirements that need to be considered under this classification.

Soil identified below the Level III remediation criteria selected for this site and categorized as non-hazardous may remain onsite. Table 7.1 identifies the regulatory requirements to be considered under this classification.

Manufactured Gas Plant By-products

Waste management guidelines have their most immediate application in the disposal of contaminated drill cuttings generated during the investigation. These guidelines also

provide some insight into the management requirements that would apply if coal gasification residues were managed by excavation and off-site disposal.

The process for classifying these residuals is provided in the DGHTA and in part by the federal TDG legislation. Manufactured gas plant residuals, specifically those containing coal tar, which is the main waste stream of environmental concern, are listed as dangerous goods in Class 3.2 and 3.3 (coal tar distillates, flammable) due to their flammability. However, residual by-products from manufactured gas plants are unlikely to be flammable as the volatile component would have largely dissipated since their placement several decades ago. Therefore they would not fall into the 3.2 or 3.3 classification. Coal tar (including creosote) is listed as a poisonous liquid under Class 6.1 and 9.2. This classification would apply to actual tar.

Materials containing coal tar mixed with some other substance such as soil are to be classified as above and the word "mixture" is to follow the shipping name (ie."coal tar"). This classification process is somewhat deficient in that it does not define a lower threshold below which the materials are no longer hazardous.

If the classification process for contaminated soils follows that for "not fully specified goods", these materials potentially fall into the miscellaneous products or substances group (Class 9). This requires that a leachate extraction be performed to assess waste classification. Unfortunately, the chemicals for which leachate quality criteria have been developed do not include any of the chemicals that are indicative of coal tar (ie. PAHs). As a result, the waste could be classed as non-hazardous but still contain appreciable amounts of PAHs, a number of which are carcinogenic.

This deficiency in the legislation was recognized in Ontario during a province-wide program to investigate former coal gasification plants. A policy document was developed, entitled *Interim Guideline on the Management of Coal Tar Wastes* dated June, 1989. Since Manitoba Environment has no specific policy dealing with these wastes, the Ontario policy was adopted for soils and sediments affected by manufactured gas plant wastes in this project. The Ontario policy is summarized as follows:

- **Coal Tar**

  These materials are chemically similar to decanter tank tar bottoms which in Ontario are a hazardous wastes. As such, coal tar is considered a hazardous waste. Any material which contains coal tar, defined to include visual evidence of coal tar in soil, should be treated as hazardous.

  NOTE: The classification of decanter tank tar sludge as a hazardous waste is compatible with the TDG legislation where it is in Class 6.1 (Waste Type 97), a Poisonous (Toxic) and Infectious Substance.

- **Contaminated Soils and Sediments**

  Contaminated soils and sediments not falling into the above category are to be subjected to the Leachate Extraction Procedure and the known carcinogenic PAH [B(a)P] is to be analyzed. The material is classified as follows:

B(a)P > 1.0 ppb:	hazardous
0.1 < B(a)P 1.0 ppb:	non-hazardous, registerable
0.01 < B(a)P < 0.1 ppb:	non-hazardous, non-registerable
B(a)P < 0.01 ppb:	material does not have to be removed from the site

It is the opinion of CH2M HILL that the adoption of the Ontario policy stated above will result in the appropriate and environmentally responsible management of wastes containing manufactured gas plant residues. This system is compatible with the DGHTA and TDG but provides better definition for lower levels of contamination. Concurrence of the regulatory agencies will be required prior to implementing this policy. Wastes would need to be registered and manifested according to the DGHTA requirements.

Wastewater

During removal of USTs onsite, some dewatering of the excavation may be required to allow for compaction of the native/imported materials placed back into the excavation after tank removal. If this approach is required, it would be best discharged directly to a water pollution control dump station. Contact with the City of Winnipeg has indicated that By-Law No. 5058/88 would apply to any groundwater extracted during the tank removal and proposed for discharge to the City sewers. Direct discharge of waters in the vicinity of USTs to a sanitary sewer is prohibited in most if not all cases based on discussion with the City of Winnipeg. However, the City of Winnipeg indicated that generally no action is taken at dump stations if the water meets the following criteria: the sum of BTXE is less than 100 ppm, benzene concentration is less than 5 ppm, and the flashpoint is greater than 61 degrees celsius. If free product petroleum is identified, it must be separated from the water extracted from the excavation prior to discharge to the dump station. As an additional precaution, an alarm set at 25% LEL is established at the dump stations to identify if potentially flammable liquids are present in the discharge waters. The City of Winnipeg indicated that approvals are necessary prior to discharge of the above-mentioned waters.

Section 8

Interpretation of Chemical and Field Monitoring Results

The results of chemical analyses of samples and of field indicator analyses are presented and discussed in this section. Laboratory reports are included in Appendix C. As discussed in Section 7, established criteria and guidelines have been referenced in interpreting the results. These criteria are not strictly applicable or enforceable. These criteria are referenced as benchmarks against which to analyze the results to plan the most appropriate approach to decommissioning of the USTs onsite and identify if remediation is required.

Soil Analysis

Quality Assurance/Quality Control (QA/QC)

The QA/QC program included the use of laboratory blanks, method spikes, and deuterated surrogates. The results of these analyses for soils are presented in Table 8.1. Duplicate samples were also collected as a component of the Sutherland Avenue UST investigation.

Laboratory blanks are used to identify the presence of contamination induced during preparation of the sample for analysis. A laboratory blank is spiked with chemicals of known concentration (i.e. method spike) and the analysis is completed to detect the percent recovery for each parameter. The method spikes are used to identify the performance of the sample extraction and analysis for a given parameter analyzed. Ideally, these values should be close to 100 percent. Low levels suggest that significant interference and losses may have occurred during the sample extraction and/or analysis. The method spikes were used for organic analysis only.

In addition, specific recovery surrogates of known concentration are added to individual soil samples and the sample is analyzed. The percent recovery of these surrogates is used to identify the performance of the extraction and analysis. Low levels suggest interference and losses may have occurred.

Organic Chemicals

The laboratory QA/QC results for organic analyses are summarized in Table 8.1.

The recovery surrogates for BTXE, TPH and PAH analysis at each location including the laboratory blanks and method spikes indicate an acceptable performance level. The d8-naphthalene recovery surrogate indicated lower levels than the other surrogates used in the TPH and PAH analysis; however, they are consistent with expected levels.

Table 8.1
Quality Assurance/Quality Control Data for Soil Samples (Organics)

					REPRODUCIBILITY OF ANALYSIS				
Sample Name	Lab Blank	Lab Blank	Method Spike	MW2	MW18	MW18 (Dup)	MW18	MW21	MDL
Sample Date	20-Sep-93	20-Sep-93	20-Sep-93	20-Sep-93	29-Sep-93	29-Sep-30	29-Sep-93	30-Sep-93	
Sample Depth				4.57-5.18	3.05-3.81	3.05-3.81	1.52-3.05	1.83-2.13	
Laboratory No.	9310227	9310227	9310227	10227-06	10227-02	10227-04	10227-03	10227-05	
PAH's (µg/kg)			%						
Naphthalene	NA	<	76	NA	NA	NA	NA	NA	0.88
Acenaphthylene	NA	<	75	NA	NA	NA	NA	NA	0.9
Acenaphthene	NA	<	76	NA	NA	NA	NA	NA	1.12
Fluorene	NA	<	77	NA	NA	NA	NA	NA	2.4
Phenanthrene	NA	<	81	NA	NA	NA	NA	NA	3.6
Anthracene	NA	<	78	NA	NA	NA	NA	NA	1.6
Fluoranthene	NA	<	82	NA	NA	NA	NA	NA	1.18
Pyrene	NA	<	83	NA	NA	NA	NA	NA	1.98
Benzo (a) anthracene	NA	<	84	NA	NA	NA	NA	NA	0.88
Chrysene	NA	<	84	NA	NA	NA	NA	NA	1
Benzo (b) fluoranthene	NA	<	82	NA	NA	NA	NA	NA	1.94
Benzo (k) fluoranthene	NA	<	87	NA	NA	NA	NA	NA	2.2
Benzo (a) pyrene	NA	<	86	NA	NA	NA	NA	NA	1.42
Indeno (1,2,3-cd) pyrene	NA	<	90	NA	NA	NA	NA	NA	1.42
Dibenzo (a,h) anthracene	NA	<	96	NA	NA	NA	NA	NA	1.86
Benzo (ghi) perylene	NA	<	90	NA	NA	NA	NA	NA	1.74
d8-Naphthalene (Recovery Surrogate for PAH) (%)	NA	79	72	32	46	NA	52	47	NA
d12-Chrysene (Recovery Surrogate for PAH) (%)	NA	87	91	97	82	NA	84	91	NA
BTXE (µg/kg)									
Benzene	<	NA	NA	NA	NA	NA	NA	NA	0.58
Toluene	<	NA	NA	NA	NA	NA	NA	NA	0.8
m & p Xylene	<	NA	NA	NA	NA	NA	NA	NA	0.59
Ethyl Benzene	<	NA	NA	NA	NA	NA	NA	NA	0.39
o-Xylene	<	NA	NA	NA	NA	NA	NA	NA	0.42
d6-Benzene (Recovery Surrogate for BTXE) (%)	94	NA	NA	87	95	NA	93	81	NA
d10-Ethylbenzene (Recovery Surrogate for BTXE) (%)	99	NA	NA	100	87	NA	115	96	NA
Phenolics	NA	NA	NA	NA	NA	NA	NA	NA	100
TPH (mg/kg)									
Total Volatile Hydrocarbon	<	NA	NA	NA	<	<	NA	NA	1
Total Semi-Volatile Hydrocarbon	<	NA	150	NA	15.7	18.2	NA	NA	1
Total Petroleum Hydrocarbon	<	NA	NA	NA	15.7	18.2	NA	NA	1
d8-Naphthalene (Recovery Surrogate for TPH)	64	NA	92	45	62	60	61	NA	NA
d10-Ethylbenzene (Recovery Surrogate for TPH) (%)	99	NA	NA	100	87	97	115	NA	NA
d12-Chrysene (Recovery Surrogate for TPH)	99	NA	132	104	86	89	103	NA	NA

Notes:
Dup - Duplicate sample
MDL - Method Detection Limit
NA - Not available
< - Less than MDL
Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

The laboratory blanks indicate that no contamination was induced during the sample extraction or analysis.

The reproducibility of the results at MW18 for TPH was at an acceptable level.

The results of the QA/QC program have provided a reasonable level of confidence for the results obtained for the soil samples.

Inorganic Chemicals

The results of lead analysis in duplicates (Table 8.2) indicates non-detectable concentrations in both samples.

Oil and grease analysis in the duplicate found non-detectable levels in one sample and 13 mg/kg in the other sample, marginally above the detection limit of 10 ppm. This result is not considered to affect the validity of the results.

Soil Results

Table 8.3 summarizes the results from the chemical analysis completed on the soils by CANVIRO Analytical Laboratories Ltd. Guideline criteria from applicable jurisdictions have been provided for comparison. An indication of the depth of each sample, field classification of contamination, and the soil deposit that the sample was collected from are identified.

Hydrocarbons

As discussed in Section 7, the Manitoba UST criteria have been used as the primary criteria for comparison. Levels I, II and III have all been provided; however, as summarized in Section 6 from the sensitivity assessment, Level III has been considered to be directly applicable to identify the potential for remediation if UST removal is undertaken. The CCME Interim Remediation Criteria (CCME remediation) for commercial/industrial and residential/parkland land use and the CCME Interim Assessment Criteria (CCME assessment) have also been presented in support of the comparison, where applicable. The CCME criteria for PAHs are provided as a basis for comparison in light of historical land use.

From review of Table 8.3, BTXE analyses performed on four soil samples (MW2, MW18 (2 samples), and MW21) did not exceed the Level III UST criteria, identified as the level at which remediation would be required in the vicinity of the USTs. Nor did the results of the BTXE analysis exceed the criteria for Level I or II site sensitivity or for Residential/Parkland or Commercial/Industrial land use.

Table 8.2
Quality Assurance/Quality Control Data for Soil Samples (Inorganics)

REPRODUCIBILITY OF ANALYSIS			
Sample Name	MW18	MW18 (Dup)	MDL
Sample Date	29-Sep-30	29-Sep-30	
Sample Depth	3.05-3.81	3.05-3.81	
Laboratory No.	10227-02	10227-04	
Metals (mg/kg)			
Lead	<	<	10
Mineral Oil and Grease	<	13.2	10

Notes:
Dup – Duplicate sample
MDL – Method Detection Limit
< – Less than MDL

Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

Table 8.3
Comparison of Chemical Analysis of Soil Samples to Available Criteria (Organics)

Sample Location	Located near underground storage tanks					MDL	CRITERIA								
							CCME "ABC" FOR COAL GASIFICATION SITES			CCME INTERIM REMEDIATION		MANITOBA UST			MANITOBA HAZARDOUS CLASSIFICATION FOR PETROLEUM SOILS
	MW2	MW18	MW18 (Dup)	MW18	MW21		A	B	C	Residential/ Parkland	Commercial/ Industrial	Level I	Level II	Level III	
Sample Depth (m)	4.57–5.18	3.05–3.81	3.05–3.81	1.52–3.05	1.83–2.13										
FIELD CLASSIFICATION	C(noVC)	TC	TC	C(noVC)	VC										
SOIL DEPOSIT	♠	♠	♠	▸◂	▸◂										
Sample Date	20–Sep–93	29–Sep–93	29–Sep–93	29–Sep–93	30–Sep–93										
Laboratory No.	10227–06	10227–02	10227–04	10227–03	10227–05										
PAH's (µg/kg)															
Naphthalene	7.74	8.29	NA	411	843	0.88	100	5,000	50,000	5,000	50,000	--	--	--	--
Acenaphthylene	<	<	NA	9.3	46.7	0.9	--	--	--	--	--	--	--	--	--
Acenaphthene	<	<	NA	3.14	63	1.12	--	--	--	--	--	--	--	--	--
Fluorene	<	<	NA	6.69	735	2.4	--	--	--	--	--	--	--	--	--
Phenanthrene	<	<	NA	16.9	2430	3.6	100	5,000	50,000	5,000	50,000	--	--	--	--
Anthracene	<	<	NA	5.47	183	1.6	--	--	--	--	--	--	--	--	--
Fluoranthene	1.85	<	NA	9.69	532	1.18	--	--	--	--	--	--	--	--	--
Pyrene	<	<	NA	7.76	363	1.98	100	10,000	100,000	10,000	100,000	--	--	--	--
Benzo (a) anthracene	1.86	<	NA	4.45	80	0.88	100	1,000	10,000	1,000	10,000	--	--	--	--
Chrysene	1.47	<	NA	3.2	64.6	1	--	--	--	--	--	--	--	--	--
Benzo (b) fluoranthene	<	<	NA	5.9[COM]	70.4[COM]	1.94	100	1,000	10,000	1,000	10,000	--	--	--	--
Benzo (k) fluoranthene	<	<	NA	COM	COM	2.2	100	1,000	10,000	1,000	10,000	--	--	--	--
Benzo (a) pyrene	2.09	<	NA	3.13	33	1.42	100	1,000	10,000	1,000	10,000	--	--	--	--
Indeno (1,2,3–cd) pyrene	<	<	NA	<	18.2	1.42	100	1,000	10,000	1,000	10,000	--	--	--	--
Dibenzo (a,h) anthracene	<	<	NA	<	2.05	1.86	100	1,000	10,000	1,000	10,000	--	--	--	--
Benzo (ghi) perylene	<	<	NA	<	13.1	1.74	--	--	--	--	--	--	--	--	--
BTEX (µg/kg)															
Benzene	<11[c]	<	NA	<11[c]	<	0.58	--	--	--	500	5,000	50	500	5,000	100,000
Toluene	121[c]	<	NA	104[c]	<	0.8	--	--	--	3,000	30,000	1000	3,000	30,000	100,000
m & p Xylene	61.6[c]	1.3	NA	186[c]	21.8	0.59	--	--	--	5,000	50,000	1000	5,000	50,000	100,000
Ethyl Benzene	13.1[c]	<	NA	18.4[c]	11.1	0.39	--	--	--	5,000	50,000	1000	5,000	50,000	100,000
o–Xylene	156[c]	1.25	NA	102[c]	<	0.42	--	--	--	5,000	50,000	1000	5,000	50,000	100,000
Phenolics (µg/kg)	NA	NA	NA	NA	NA	100	--	--	--	--	--	--	--	--	--
TPH (mg/kg)															
Total Volatile Hydrocarbon	1.95	<	<	12.9	NA	1	--	--	--	--	--	100	150	800	--
Total Semi–Volatile Hydrocarbon	72.9	15.7	18.2	108	NA	1	--	--	--	--	--	500	2000	2000	--
Total Petroleum Hydrocarbon	74.9	15.7	18.2	121	NA	1	--	--	--	--	--	--	--	--	--

Notes:

Dup – Duplicate sample
MDL – Method Detection Limit
NA – Not applicable
< – Less than MDL
– Samples reported on dry weight basis
Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

[a] – Due to dilution, MDL's are 5000 x those stated
[b] – Due to dilution, MDL's are 100 x those stated
[c] – Due to dilution, MDL's are 20 x those stated

CCME – Canadian Environmental Quality Criteria for Contaminated Sites
-- – Guideline not available
EXCEEDS AT LEAST ONE CRITERIA

FIELD CONTAMINATION CLASSIFICATION
NC – No contamination
TC – Trace contamination
VC – Visual contamination
C(noVC) – Contaminated but no visual evidence

SOIL DEPOSIT
▸◂ FILL WITHOUT INDUSTRIAL DEBRIS
♠ WEATHERED GLACIOLACUSTRINE SILTY CLAY/CLAYEY SILT DEPOSIT

Inorganics

From review of Table 8.4, the Manitoba UST criteria (Levels I to III) for oil and grease and lead have not been exceeded for soils at MW2 or MW18. The detected concentrations for oil and grease at MW18, with a concentration of 13.2 and 28.7 mg/kg, are considered to be low, as the levels are below even the most stringent criteria. No oil and grease was detected at MW2. The CCME assessment criteria, the lowest criteria available, was not exceeded.

Manufactured Gas Plant Residues

Comparison of the PAH results to the CCME criteria for soils at former manufactured gas plant sites found that the only criteria exceeded were the Level A criteria. Concentrations of PAHs in this range do not warrant further investigation or remediation. Recognizing that limited testing was performed, these results also suggest that any manufactured gas plant residues in this vicinity are of little or no consequence.

Waste Characterization

Hydrocarbons

A leachate extraction test was performed on the sample at MW18 representing the C (no VC) field classification. The sample analyzed represents a worst case for petroleum contamination in the vicinity of the USTs. Analysis was performed for a portion of the list of chemicals that have leachate quality criteria in Manitoba under the DGHTA. The chemicals selected were those considered most likely to be of concern to Manitoba Environment. It should be recognized that the chemicals with leachate quality criteria do not include those most characteristic of petroleum contamination such as BTEX and TPH. A summary of this analysis is presented in Table 8.5. Parameters associated with the Manitoba leachate quality criteria were not exceeded for the analysis at MW18.

As identified in Section 7, the criteria used to identify if the soil is a hazardous waste is 100 ppm (100,000 ppb = 100,000 µg/kg) for individual BTEX parameters. Soil concentrations below the hazardous waste criteria and below the Level III UST remediation criteria are identified as non-hazardous and do not require remediation.

Manufactured Gas Plant Residues

A leachate analysis was also performed for PAHs to determine how the soils would be classified based on the presence of former gasification plant residues. The results of B(a)P in the leachate are compared to the drinking water objective for this chemical. The results, documented in Table 8.6, show non-detectable levels for B(a)P, indicating that if the soil is not a waste it does not have to be removed from the site.

Table 8.4
Comparison of Chemical Analysis of Soil Samples to Available Criteria (Inorganics)

Sample Location	Located near underground storage tanks				MDL	CRITERIA					
						CCME INTERIM Remediation		MANITOBA UST			CCME Interim Assessment
						LAND USE		Level I	Level II	Level III	
						Residential/ Parkland	Commercial Industrial				
Sample Depth (m)	MW2 4.57–5.18	MW18 3.05–3.81	MW18 (Dup) 3.05–3.81	MW18 1.52–3.05							
FIELD CLASSIFICATION	C(noVC)	TC	TC	C(noVC)							
SOIL DEPOSIT	▲	▲	▲	▸◂							
Sample Date	20–Sep–93	29–Sep–93	29–Sep–93	29–Sep–93							
Laboratory No.	10227–06	10227–02	10227–04	10227–03							
Metals (mg/kg)											
Lead	<	<	<	<	10	500	1000	375	500	1000	25
Mineral Oil and Grease (mg/kg)	<	<	13.2	28.7	10	NA	NA	1000	5000	5000	NA

Notes:
Dup – Duplicate sample
MDL – Method Detection Limit
NA – Not available
< – Less than MDL

– Samples reported on dry weight basis
– Samples analyzed by Canviro Analytical Laboratories Ltd.

FIELD CONTAMINATION CLASSIFICATION
NC – No contamination
TC – Trace contamination
VC – Visual contamination
C(noVC) – Contaminated but no visual evidence

SOIL DEPOSIT
▸◂ FILL WITHOUT INDUSTRIAL DEBRIS
▲ WEATHERED GLACIOLACUSTRINE SILTY CLAY/CLAYEY SILT DEPOSIT

EXCEEDS AT LEAST ONE CRITERIA

Table 8.5
Comparison of Leach Test Results on Soils to Available Criteria (Inorganics)

Sample Location	MW18	MDL	MANITOBA LEACHATE QUALITY CRITERIA (*)	MANITOBA HAZARDOUS WASTE MANAGEMENT CORPORATION (ACCEPTANCE CRITERIA) (*)
Sample Depth (m)	1.52–3.05			
FIELD CLASSIFICATION	C(noVC)			
SOIL DEPOSIT	▸◂			
Sample Date	29–Sep–93			
Laboratory No.	10399–03			
Metals (mg/L)				
Aluminum	<	0.1	--	--
Boron	0.09	0.05	500	500
Barium	0.67	0.01	100	--
Beryllium	<	0.005	--	--
Cadmium	<	0.032	0.5	0.5
Calcium	800	0.05	--	--
Chromium	<	0.02	5	5
Cobalt	<	0.09	--	--
Copper	0.04	0.02	--	--
Iron	0.02	0.007	--	--
Lead	<	0.1	5	--
Magnesium	210	0.01	--	--
Manganese	5.77	0.01	--	--
Vanadium	<	0.01	--	--
Zinc	0.09	0.01	--	--
Nickel	0.09	0.03	--	--
Phosphorus	<	0.32	--	--
Silver	<	0.02	5	5
Strontium	1.37	0.01	--	--
Sodium	10	2	--	--
Molybdenum	<	0.04	--	--
Titanium	0.03	0.01	--	--
Zirconium	<	0.01	--	--
Arsenic	<	0.005	5	5
Selenium	<	0.005	1	1
Free cyanide	<	0.005	20	--

Notes:
MDL – Method Detection Limit
NA – Not applicable
< – Less than MDL
-- – Guideline not available
Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)
* ONLY SELECT PARAMETERS ANALYZED

FIELD CONTAMINATION CLASSIFICATION

NC – No contamination
TC – Trace contamination
VC – Visual contamination
C(noVC) – Contaminated but no visual evidence

SOIL DEPOSIT

▸◂ FILL WITHOUT INDUSTRIAL DEBRIS

Table 8.6
Comparison of Leach Test Results on Soils to Available Criteria (Organics)

Sample Location	MW18	MOEE WASTE HANDLING CLASSIFICATION	MDL
Sample Depth (m)	1.52		
FIELD CLASSIFICATION	C(noVC)		
SOIL DEPOSIT	▸◂		
Sample Date	29-Sep-93		
Laboratory No.	10399-03		
PAH's (µg/L)			
Naphthalene	10.5	NA	0.004
Acenaphthylene	0.19	NA	0.004
Acenaphthene	0.058	NA	0.008
Fluorene	0.067	NA	0.004
Phenanthrene	0.096	NA	0.007
Anthracene	0.017	NA	0.008
Fluoranthene	0.018	NA	0.006
Pyrene	0.011	NA	0.004
Benzo (a) anthracene	<	NA	0.005
Chrysene	<	NA	0.007
Benzo (b) fluoranthene	<	NA	0.007
Benzo (k) fluoranthene	<	NA	0.007
Benzo (a) pyrene	<	(4)	0.006
Indeno (1,2,3-cd) pyrene	<	NA	0.011
Dibenzo (a,h) anthracene	<	NA	0.008
Benzo (ghi) perylene	<	NA	0.009
Perylene	NA	NA	0.006
Benzo (j) fluoranthene	NA	NA	0.007
Benzo (e) pyrene	NA	NA	0.006

Notes:

MDL – Method Detection Limit
NA – Not applicable
< – Less than MDL
Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

MOEE Policy on Handling of Coal Gas Wastes:
(1) When Benzo (a) pyrene >1.0 ppb: (HAZARDOUS)
(2) When Benzo (a) pyrene is >0.1 and <1.0 ppb: (NON-HAZARDOUS, REGISTERABLE)
(3)When Benzo (a) pyrene is >0.01 and <0.1 ppb: (NON-HAZARDOUS, NON-REGISTERABLE)
(4)When Benzo (a) pyrene is <0.01 ppb: (MATERIAL DOES NOT HAVE TO BE REMOVED FROM THE SITE)

FIELD CONTAMINATION CLASSIFICATION
NC – No contamination
TC – Trace contamination
VC – Visual contamination
C(noVC) – Contaminated but no visual evidence

SOIL DEPOSIT

▸◂ FILL WITHOUT INDUSTRIAL DEBRIS

Groundwater Analyses

Quality Assurance/Quality Control

QA/QC results for groundwater for organic chemicals are presented in Table 8.7. The result of the laboratory blank analysis in Table 8.7 indicates that non-detectable levels were observed for all chemicals except total semi-volatile hydrocarbons, where low concentrations were identified. These results suggest that some laboratory induced contamination has likely occurred, although this has little impact on the quality of the results and the comparison to criteria completed below.

The recovery of the method spike would be 100 percent under ideal conditions but in reality it is frequently lower due to losses during analysis. Values much below 75 percent suggest that the results may be biased on the low side. All recoveries were above 75 percent in the samples analyzed.

Deuterated surrogate recoveries, for example d8-Naphthalene, should also be close to 100 percent under ideal conditions. Deuterated surrogate recoveries range from 61 to 100 percent. As with the method spike, any values significantly below 100 percent indicate that the reported concentrations may be below actual concentrations and that they are biased on the low side. Deuterated surrogate recoveries were in the range typically encountered for the types of analyses performed. Deuterated surrogate recoveries do not indicate any need for concern in interpreting the results.

Only one chemical, naphthalene, was detected in the trip blank. The concentration was at 0.036 µg/L; therefore, any sample showing similar levels may not be indicative of in situ conditions and should be interpreted with caution.

Groundwater Results

The results of the chemical analyses on the groundwater samples are presented in Table 8.8 for field indicators, Table 8.9 for organic chemicals, and in Table 8.10 for inorganic chemicals.

Indicator Analyses

Indicator analyses were performed in the field as indicators of overall groundwater quality and were used to determine the completion of groundwater purging and development activities prior to sampling. The analyses performed included electrical conductance, pH, temperature, and redox potential. The results of these analyses are provided in Table 8.8.

The electrical conductance (EC) measurements ranged from 1100 to >2000 µS/cm during development procedures. The conductivity value of >2000 µS/cm may be indicative of inorganic salt residues from coal gasification. The pH values were near

Table 8.7
Quality Assurance/Quality Control Data For Groundwater Samples (Organics)

Sample Name	Lab Blank	Lab Blank	Method Spike	Method Spike	MW2	MW18	Trip Blank	MDL
Sample Date	04-Oct-93	04-Oct-93	04-Oct-93	04-Oct-93	04-Oct-93	04-Oct-93	20-Sep-93	
Laboratory No.	9310224	9310226	9310224	9310226	10224-02	10226-01	10224-09	
PAH's (µg/L)								
Naphthalene	<	NA	83%	NA	NA	NA	0.036	0.004
Acenaphthylene	<	NA	86%	NA	NA	NA	<	0.004
Acenaphthene	<	NA	88%	NA	NA	NA	<	0.008
Fluorene	<	NA	86%	NA	NA	NA	<	0.004
Phenanthrene	<	NA	85%	NA	NA	NA	<	0.007
Anthracene	<	NA	85%	NA	NA	NA	<	0.008
Fluoranthene	<	NA	82%	NA	NA	NA	<	0.006
Pyrene	<	NA	83%	NA	NA	NA	<	0.004
Benzo (a) anthracene	<	NA	86%	NA	NA	NA	<	0.005
Chrysene	<	NA	86%	NA	NA	NA	<	0.007
Benzo (b) fluoranthene	<	NA	85%	NA	NA	NA	<	0.007
Benzo (k) fluoranthene	<	NA	91%	NA	NA	NA	<	0.007
Benzo (a) pyrene	<	NA	82%	NA	NA	NA	<	0.006
Indeno (1,2,3-cd) pyrene	<	NA	82%	NA	NA	NA	<	0.011
Dibenzo (a,h) anthracene	<	NA	83%	NA	NA	NA	<	0.008
Benzo (ghi) perylene	<	NA	82%	NA	NA	NA	<	0.009
Perylene	<	NA	NS	NA	NA	NA	ND/NS	0.006
Benzo (j) fluoranthene	<	NA	NS	NA	NA	NA	ND/NS	0.007
Benzo (e) pyrene	<	NA	NS	NA	NA	NA	ND/NS	0.006
d8-Naphthalene (Recovery Surrogate for PAH) (%)	77	NA	77%	NA	96	NA	61	NA
d12-Chrysene (Recovery Surrogate for PAH) (%)	78	NA	87%	NA	112	NA	87	NA
BTXE (µg/L)								
Benzene	<	<	NA	NA	NA	NA	<	0.11
Toluene	<	<	NA	NA	NA	NA	<	0.16
m & p Xylene	<	<	NA	NA	NA	NA	<	0.12
Ethyl Benzene	<	<	NA	NA	NA	NA	<	0.08
o-Xylene	<	<	NA	NA	NA	NA	<	0.08
d6-Benzene (Recovery Surrogate for BTXE) (%)	93	88	NA	NA	128	58	92	NA
d10-Ethylbenzene (Recovery Surrogate for BTXE) (%)	100	98	NA	NA	98	79	97	NA
TPH (mg/L)								
Total Volatile Hydrocarbon	NA	<	NA	NA	NA	NA	NA	0.01
Total Semi-Volatile Hydrocarbon	NA	0.06	NA	98%	NA	NA	NA	0.01
Total Petroleum Hydrocarbon	NA	0.06	NA	NA	NA	NA	NA	0.01
d10-Ethylbenzene (Recovery Surrogate for TPH) (%)	NA	98	NA	NA	NA	79	NA	NA
Phenolics (µg/L)	NA	NA	NA	NA	NA	NA	<	0.8

Notes:

MDL - Method Detection Limit
NA - Not available
NS - Not Spiked
< - Less than MDL
Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

Table 8.8
Summary of Groundwater Indicator Results From Field Monitoring

Location	Date	Time	Purge Volume	Conductivity (uS)	pH	Redox-Pot. (mvolts)	Temperature (C)	Comments
MW2	02-Oct-93	18:33	14	1102	7.2	64	9.3	Grey, very silty, strong old fuel odour
	03-Oct-93	11:31	22	1484	7.0	77	9.3	
	03-Oct-93	18:53	25	1553	7.0	72	7.5	
	04-Oct-93	09:28	32	1576	6.9	112	7.6	
MW18	02-Oct-93	18:11	52	1962	6.6	190	9.7	Old fuel odour, murky brown
	03-Oct-93	11:21	89	>2000	6.7	237	10.9	Faint odour, murky brown
	03-Oct-93	18:42	125	>2000	6.6	113	9.3	
	04-Oct-93	09:16	161	>2000	6.6	264	9.5	

Table 8.9
Comparison of Chemical Analysis of Groundwater Samples to Available Criteria (Organics)

	Located near the UST's											
Sample Name	MW2	MW18	MDL	CRITERIA								
Sample Date	Oct. 4/93 Oct. 24/93	Oct. 4/93		CCME "ABC" FOR COAL GASIFICATION SITES			CDWG	ALBERTA MUST			CCME REMEDIATION	
				A	B	C		Level I	Level II	Level III	Drinking Water	Aquatic Life
Laboratory No.	10224–02 10319–02	10226–01										
PAH's (ppb)												
Naphthalene	2.63	NA	0.004	0.2	2	20	--	--	--	--	--	--
Acenaphthylene	0.368	NA	0.004	--	--	--	--	--	--	--	--	--
Acenaphthene	0.086	NA	0.008	--	--	--	--	--	--	--	--	--
Fluorene	0.251	NA	0.004	--	--	--	--	--	--	--	--	--
Phenanthrene	0.251	NA	0.007	0.2	2	20	--	--	--	--	--	--
Anthracene	0.042	NA	0.008	--	--	--	--	--	--	--	--	--
Fluoranthene	0.072	NA	0.006	--	--	--	--	--	--	--	--	--
Pyrene	0.092	NA	0.004	0.2	2	20	--	--	--	--	--	--
Benzo (a) anthracene	<	NA	0.005	0.01	0.1	1	--	--	--	--	--	--
Chrysene	<	NA	0.007	--	--	--	--	--	--	--	--	--
Benzo (b) fluoranthene	<	NA	0.007	0.01	0.1	1	--	--	--	--	--	--
Benzo (k) fluoranthene	<	NA	0.007	0.01	0.1	1	--	--	--	--	--	--
Benzo (a) pyrene	<	NA	0.006	0.01	0.1	1	0.01	--	--	--	0.01	--
Indeno (1,2,3–cd) pyrene	<	NA	0.011	0.01	0.1	1	--	--	--	--	--	--
Dibenzo (a,h) anthracene	<	NA	0.008	0.01	0.1	1	--	--	--	--	--	--
Benzo (ghi) perylene	<	NA	0.009	--	--	--	--	--	--	--	--	--
Perylene	<	NA	0.006	--	--	--	--	--	--	--	--	--
Benzo (j) fluoranthene	<	NA	0.007	--	--	--	--	--	--	--	--	--
Benzo (e) pyrene	<	NA	0.006	--	--	--	--	--	--	--	--	--
BTXE (ppb)												
Benzene	14.3[a]	<11[b]	0.11	--	--	--	5	5	50	250	5	300
Toluene	<1.6[a]	<16[b]	0.16	--	--	--	24	24	40000	100000	24	300
m & p Xylene	<1.2[a]	<12[b]	0.12	--	--	--	300	300	5000	20000	300	--
Ethyl Benzene	<0.8[a]	<8[b]	0.08	--	--	--	2.4	2	10000	50000	2.4	700
o–Xylene	277[a]	<8[b]	0.08	--	--	--	300	300	5000	20000	300	--
Phenolics (µg/L)	51	5.8	0.8	--	--	--	--	2	--	--	--	1.0
TPH (ppm)												
Total Volatile Hydrocarbon	NA/0.27	0.86	0.01	--	--	--	--	--	--	--	--	--
Total Semi–Volatile Hydrocarbon	(0.04/0.06)	0.06	0.01	--	--	--	--	--	--	--	--	--
Total Petroleum Hydrocarbon	(0.04/0.33)	0.92	NA	--	--	--	--	0.2	50	200	--	--

Notes:

Dup – Duplicate sample
MDL – Method Detection Limit
NA – Not applicable
< – Less than MDL
UST – Underground Storage Tank
COM – combined result identified for benzo(b), (j) and (k) fluoranthene where coeluting peaks were identified

a – Due to dilution, MDL's are 10 x those stated
b – Due to dilution, MDL's are 100 x those stated
c – Due to dilution, MDL's are 1000 x those stated

(0.04/0.06) – No Sediment/With sediment

Guidelines:
CDWG – Canadian Drinking Water Guidelines
CCME – Canadian Environmental Quality Criteria for Contaminated Sites

-- – Guideline not available
Analysis exceeds at least one guideline value

Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

Table 8.10
Comparison of Chemical Analysis of Groundwater Samples to Available Criteria (Inorganics)

	Located near the UST's					
Sample Name	MW2	MW18	MDL	CRITERIA		
Sample Date	24-Oct-93	04-Oct-93				
				CDWG	CCME Remediation (Drinking Water)	CCME Remediation (Aquatic Life)
Laboratory No.	10319-02	10226-01				
Metals (mg/L)						
Lead	<	<	0.0006	0.01	0.01	0.001-0.007

Notes:
Dup – Duplicate sample
MDL – Method Detection Limit
< – Less than MDL
UST – Underground Storage Tank

Analyzed by CANVIRO Analytical Laboratories Ltd. (CALL)

Guidelines
CDWG – Canadian Drinking Water Guidelines
CCME – Canadian Environmental Quality Criteria for Contaminated Sites
– – – Guideline not available
Analyses exceeds at least one guideline value

neutral ranging from 6.6 to 7.0. Temperature values are relatively consistent given that measurements may be affected by variations in air temperature. Redox values ranged from 72 mV at MW2 to 264 mV indicating that some reduction of oxygen has probably occurred, particularly at greater depths, as the redox values in water exposed to air would be on the order of 750 mV.

Inorganic and Organic Chemicals

The results of organic analysis of groundwater are provided in Table 8.9. The Level III UST (MUST) criteria are not exceeded in either sample suggesting that remediation is not required based on BTEX and TPH levels. Benzene exceeds the Level I UST (MUST) criteria at MW2 but is less than the Level II criteria. TPH exceeds Level I UST (MUST) criteria at MW2 and MW18, but only marginally. No other BTEX chemicals exceed Level I through Level III criteria.

Phenols are present at levels which exceed the MUST Level I criteria and the CCME Remediation Criteria for protection of aquatic life. No Manitoba criteria exist for phenols and the MUST criteria only include Level I. Phenols are known to be indicative of manufactured gas plant residues, indicating possible groundwater quality impacts due to former site uses, given the absence or low levels of other petroleum related chemicals.

No PAHs were found above the Level C CCME criteria. One PAH, naphthalene, was detected above the CCME Level B "ABC" criteria but below Level C. Benzo(a)pyrene, identified as a carcinogen, did not exceed the CDWG and CCME remediation drinking water criteria at MW02, located close to the USTs. No other PAHs were found above any of the criteria considered.

The results for inorganic analyses (i.e. lead, and oil and grease) are provided in Table 8.10. Both samples, collected from MW2 and MW18 were below analytical detection limits and did not exceed any of the criteria provided.

Section 9
Summary of Findings

The findings of the preliminary UST investigation are as follows:

- The sensitivity of the site based on inhalation and ingestion pathways is low indicating that Manitoba Level III UST criteria for soils and Alberta (MUST) Level III UST criteria for groundwater is applicable for remediation during the UST decommissioning.

- Commercial/industrial zoned lands occupy the largest area bordering the Sutherland Avenue facility which generally indicates that less stringent regulatory criteria applies. Residential land use is limited in the area.

- The storm sewer located north of the USTs is unlikely to create a significant pathway for the migration of vapours and groundwater offsite. An adverse environmental or human health impact is unlikely to occur in association with the storm sewer.

- The Red River, located approximately 400 metres from the UST facility, will not be adversely affected by petroleum-based/coal tar residuals identified in the vicinity of the USTs.

- An asphalt surface covers the area surrounding the USTs, minimizing the impact of any vapours present in the subsurface in the vicinity of the USTs.

- The presence of a low permeability unweathered glaciolacustrine clay and silty clay till deposit below the USTs will impede the vertical migration of petroleum or coal tar residuals in the soils to depth. The risk of an adverse impact on the underlying bedrock aquifer is very low.

- Management of the waste oil tank by removal may not be feasible due its proximity to the vehicle service building because the foundation may be undermined during excavation. Decommissioning of this tank in-place may be the only feasible solution.

- Field observations completed at BH15 and BH16 in the vicinity of the waste oil tank identified black discoloured soils, and oil/petroleum odours at shallow depth. These observations may be associated with the USTs, but chemical analysis was not completed to confirm this.

- Free product petroleum was not observed in CB12, CB13 and CB14 located in the vicinity of the USTs.

- Soils in the vicinity of the USTs were identified as non-hazardous based on Manitoba hazardous waste criteria for petroleum-contaminated soils. As well, relevant PAH criteria from Ontario identified non-hazardous levels for PAHs based on benzo(a)pyrene concentrations in the leachate extracted from the soil at MW18.

- Soils in the vicinity of the USTs did not exceed Level III UST criteria for the samples analyzed, suggesting that the soils in the vicinity of the USTs do not require remediation.

- Petroleum odours and above-background TOV readings were observed in the fill in the vicinity of the USTs, but chemical analysis of the worst case sample (MW18: 1.52 to 3.05 m) found that levels were below the Level III UST criteria. These results, together with absence of free product, suggest that minor petroleum impacts have occurred in the areas tested. The possibility of higher petroleum levels beneath the USTs is not precluded, but these results suggest that any petroleum that may be present is localized in lateral extent and confined in its depth. Any soils requiring disposal at the MHWMC-approved treatment facility, will meet the MHWMC acceptance criteria.

- Generally, groundwater results indicate that remediation is not required in the vicinity of the USTs. Although the phenol results exceed the Level I (MUST) UST criteria, believed to be associated with the former coal gasification plant and not the USTs, remediation of groundwater will likely be deemed unnecessary based on land use, the low potential for offsite migration, the fact that perched water is not used as a potable water source, and the underlying bedrock aquifer is protected by overlying low permeable silty clay materials. Phenols also exceed the CCME remediation aquatic life criteria which is established for protection of aquatic life in surface water bodies. There is little risk of phenol contamination (in the vicinity of the USTs) causing an adverse impact on aquatic life in the Red River based on the distance the river is located from the UST facility.

- Some evidence of manufactured gas plant residues was observed during the investigation through visual evidence, odour, TOV readings or chemical analysis. Chemical analysis suggests that the levels detected are relatively low and of little significance. The levels detected do not warrant removal of this material. However, concurrence with the Manitoba Environment concerning the management of the black soils identified in the vicinity of the USTs is required if removal of the USTs is selected as the decommissioning option.

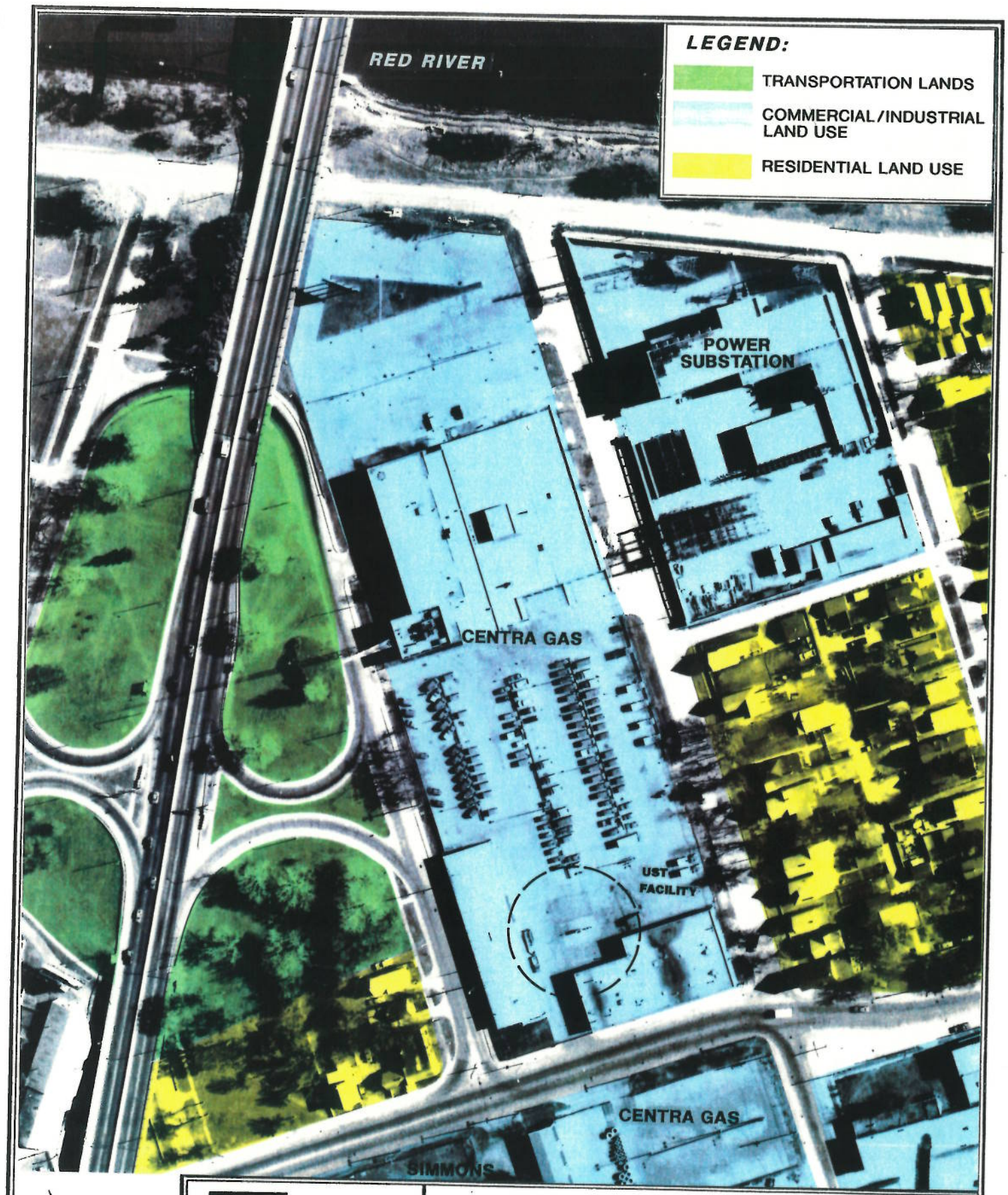
- Groundwater concentrations identified for BTEX do not exceed the interim guideline identified for discharge of waters to the water pollution

control plant dump station. All other parameters are at levels believed to be acceptable by the City of Winnipeg. PAHs in the groundwater for benzo(a)pyrene do not exceed the 1 ppb limit established by the City of Winnipeg for the discharge of water to the water pollution control dump station. If the UST removal option is selected to decommission the tanks and dewatering of the excavation is required, the City of Winnipeg will likely request confirmation analysis of BTEX, flash point and PAHs prior to discharge to the city treatment system.

The conclusions reached from the preliminary investigation suggest that a significant environmental impact has not occurred in association with the USTs. Any residuals associated with the USTs appear to be confined in vertical and lateral extent and do not pose a significant environmental concern. No receptors exist in the vicinity of the UST facility where an adverse environmental or human health impact could occur.

Appendix A

PHOTOGRAPHS



CH2M HILL ENGINEERING LTD.

WATERLOO ONTARIO

PROJECT No. ONT29793.AO

PHOTOGRAPH IDENTIFYING LAND USE IN AREA (PHOTOGRAPH TAKEN IN 1978)

PHOTOGRAPH 1: Identifies UST Facility, Catch Basin 13, Vehicle Service Building and Borehole/Monitoring Wells. (Photograph taken towards southwest.)

PHOTOGRAPH 2: Identifies UST Facility and other surrounding features. (Photograph taken to the south.)

PHOTOGRAPH 3: Identifies UST Facility with Purchasing and Stores building in background. (Photograph taken towards east.)

PHOTOGRAPH 4: Identifies the Gas Pump Fill Station. (Photograph taken to the northeast.)

Appendix B

SUBSURFACE LOGS

- Monitoring Well Logs
- Borehole Logs

Borehole Logs

CH2M HILL ENGINEERING LTD.

SUBSURFACE BOREHOLE LOG

BOREHOLE NO. : BH-15

PROJECT NO. : ONT29793.A0

CLIENT NAME : CENTRA GAS Manitoba Inc.

LOCATION : 35 Sutherland Ave. Winnipeg, Man.

DATE DRILLED : September 29, 1993

LOGGER : R. Stacey

DRILL COMPANY : Paddock Drilling Ltd.

DRILLING METHOD : CT250, Hollow-stem Augers

SURFACE ELEVATION (M) : 229.59

TOTAL DEPTH (M): 6.10

EASTING : 133.880

NORTHING : 230.310

LEGEND
NC - NO CONTAMINATION
TC - TRACE CONTAMINATION
C (noVC) - CONTAM./NO VISUAL EVIDENCE
VC - VISUAL CONTAMINATION
NA - NOT ANALYSED
G - GRAB SAMPLE
SS - SPLITSPOON SAMPLE
CS - CONTINUOUS SAMPLE

DEPTH BELOW SURFACE (metres)	SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESSMENT	SOIL DESCRIPTION
0				**ASPHALT** (15 cm)
	CS1	71	TC	**GRANULAR FILL** (0.15 m to 0.76 m) -tan brown, dry, compact, sand and gravel, old gasoline odour
1	CS2	29.5	TC	**MIXED FILL** (0.76 m to 1.52 m) -low sample recovery, construction debris, concrete chips, old gasoline odour
2	CS3	12.9	VC	**CLAYEY SILT FILL** (1.52 m to 3.05 m) -clayey silt, loose, black staining, old petroleum odour, moist
	CS4	<5	TC	-grey and brown, mottled, some oxidation, clayey silt, faint old fuel odour
3	CS5	0.1	TC	**CLAYEY SILT** (3.05 m to 3.81 m) -grey-brown, less mottling, some plasticity and cohesion, faint fuel odour
4	CS6	0.1	TC	**SILTY CLAY** (3.81 m to 6.10 m) -silty clay, moist, some oxidation, faint old fuel odour
5	CS7	0.1	TC	-olive-grey, silty clay, faint old fuel odour, moist, less oxidation
6	CS8	0.1	NC	-grey, moist, cohesive, high plasticity, no odour
7				**BOREHOLE TERMINATED AT 6.10 m**
8				
9				
10				

BACKFILL DETAILS

FILL MATERIAL
HOLE SEAL
SURFACE REPAIR

Borehole sealed with bentonite grout installed through tremie pipe from borehole termination depth to 1.2 m from surface

Hydrated bentonite chips placed from 1.2 m to 0.6 m

Concrete placed from 0.6 m to surface.

CH2M HILL ENGINEERING LTD.

SUBSURFACE BOREHOLE LOG

BOREHOLE NO. : BH-17 | PROJECT NO. : ONT29793.A0

CLIENT NAME : CENTRA GAS Manitoba Inc.	DRILLING METHOD : CT250, Hollow-stem Augers
LOCATION : 35 Sutherland Ave. Winnipeg, Man.	SURFACE ELEVATION (M) : 229.65
DATE DRILLED : September 29, 1993	TOTAL DEPTH (M): 6.10
LOGGER : R. Stacey	EASTING : 147.460
DRILL COMPANY : Paddock Drilling Ltd.	NORTHING : 259.580

SOIL SAMPLE DATA

DEPTH BELOW SURFACE (metres)	SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESSMENT	SAMPLE INTERVAL
0				
	CS1	0	NC	
	CS1	23	VC	
1	CS2	23	VC	
2	CS3	94	VC	
	CS4	89	VC	
3	CS5	82	VC	
4	CS6	16.5	TC	
5				
	CS7	<1	NC	
6				
7				
8				
9				
10				

SOIL DESCRIPTION

LEGEND
NC – NO CONTAMINATION
TC – TRACE CONTAMINATION
C (noVC) – CONTAM/NO VISUAL EVIDENCE
VC – VISUAL CONTAMINATION
NA – NOT ANALYSED
G – GRAB SAMPLE
SS – SPLITSPOON SAMPLE
CS – CONTINUOUS SAMPLE

ASPHALT (15 cm)

GRANULAR FILL (0.15 m to 0.76 m)
-tan brown, moist, compact sand and gravel

-at 0.6 m sand and gravel is stained black and has napthalene odour

SANDY SILT FILL (0.76 m to 1.52 m)
-black, moist, loose, non-cohesive sandy silt, faint napthalene odour

CLAYEY SILT (1.52 m to 5.49 m)
-olive-grey, moist, fractured clayey silt, moderate stiffness, some white silt pockets, visual tar in voids and fractures, strong napthalene odour

-olive-grey, moist, dense, fractured, oxidation on fracture surfaces, strong napthalene odour, some white silt pockets, tar in fractures and voids (less than above)

-light grey-brown, moist, stiff, fractured, oxidation in fractures, tarry substance in fractures and rootholes, strong napthalene odour

-grey-brown, moist, stiff, oxidation in fractures, clayey silt, some shells throughout, no visual contamination, faint napthalene odour

SILTY CLAY (5.49 m to 6.10 m)

-grey, oxidized silty clay, moist, some natural organics, very faint napthalene odour

BOREHOLE TERMINATED AT 6.10 m

BACKFILL DETAILS

FILL MATERIAL
HOLE SEAL
SURFACE REPAIR

Borehole sealed with bentonite grout installed through tremie pipe from borehole termination depth to 1.2 m from surface

Hydrated bentonite chips placed from 1.2 m to 0.6 m

Concrete placed from 0.6 m to surface.

CH2M HILL ENGINEERING LTD.

SUBSURFACE BOREHOLE LOG

BOREHOLE NO. : BH-19 | PROJECT NO. : ONT29793.A0

CLIENT NAME : CENTRA GAS Manitoba Inc.	DRILLING METHOD : CT250, Hollow-stem Augers
LOCATION : 35 Sutherland Ave. Winnipeg, Man.	SURFACE ELEVATION (M) : 229.380
DATE DRILLED : September 30, 1993	TOTAL DEPTH (M): 3.05
LOGGER : R. Stacey	EASTING : 166.910
DRILL COMPANY : Paddock Drilling Ltd.	NORTHING : 235.370

LEGEND
NC – NO CONTAMINATION
TC – TRACE CONTAMINATION
C (noVC) – CONTAM./NO VISUAL EVIDENCE
VC – VISUAL CONTAMINATION
NA – NOT ANALYSED
G – GRAB SAMPLE
SS – SPLITSPOON SAMPLE
CS – CONTINUOUS SAMPLE

DEPTH BELOW SURFACE (metres)	SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESSMENT	SAMPLE INTERVAL	SOIL DESCRIPTION	BACKFILL DETAILS
0	G1	NA	NC		ASPHALT (15 cm)	FILL MATERIAL HOLE SEAL SURFACE REPAIR
					GRANULAR FILL (0.15 m to 0.76m) –tan brown, dry, sand and gravel, no odour	
1	G2	NA	VC		SILTY CLAY FILL (0.76 m to 2.29 m) –olive green, moist, silty clay, faint fuel odour, some black staining	Borehole backfilled with auger cuttings from borehole termination depth to 1.52 m from surface Hydrated bentonite chips placed from 1.52 m below surface to 0.6 m Bentonite hydrated with distilled water. Concrete placed from 0.6 m to surface.
	G3	0.4	VC		–as above	
2	G4	<12.2	VC		–black, moist, cohesive, plastic, soft, strong napthalene odour	
	G5	<16.2	TC		SILTY CLAY (2.29 m to 3.05 m)	
3					–brown, moist, high plasticity, stiff, faint napthalene odour, oxidized (G5)	
					BOREHOLE TERMINATED AT 3.05 m	
4						
5						
6						
7						
8						
9						
10						

CH2M HILL ENGINEERING LTD.

SUBSURFACE BOREHOLE LOG

BOREHOLE NO. : BH-20 | PROJECT NO. : ONT29793.A0

CLIENT NAME : CENTRA GAS Manitoba Inc.	DRILLING METHOD : CT250, Hollow-stem Augers
LOCATION : 35 Sutherland Ave. Winnipeg, Man.	SURFACE ELEVATION (M) : 229.51
DATE DRILLED : September 30, 1993	TOTAL DEPTH (M): 3.05
LOGGER : R. Stacey	EASTING : 143.910
DRILL COMPANY : Paddock Drilling Ltd.	NORTHING : 226.060

LEGEND
NC – NO CONTAMINATION
TC – TRACE CONTAMINATION
C (noVC) – CONTAM./NO VISUAL EVIDENCE
VC – VISUAL CONTAMINATION
NA – NOT ANALYSED
G – GRAB SAMPLE
SS – SPLITSPOON SAMPLE
CS – CONTINUOUS SAMPLE

DEPTH BELOW SURFACE (metres)	SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESSMENT	SAMPLE INTERVAL	SOIL DESCRIPTION
0	G1	NA	NC		**ASPHALT** (15 cm)
					GRANULAR FILL (0.15 m to 1.37m) –tan brown, dry, silty sand and gravel, no odour non-cohesive
1	G2	NA	NC		
	G3	NA	NC		
	G4	<5.4	TC		**SANDY SILT FILL/SILTY CLAY FILL** (1.37 m to 2.29 m) –brown, moist, sandy silt fill, oxidized, no odour, non-cohesive –olive green, moist, silty clay fill, faint old fuel odour
2	G5	<0.8	NC		**GRANULAR FILL** (2.29 m to 2.44 m) –brown, moist, non-cohesive, faint old fuel odour
3					**SILTY CLAY** (2.44 m to 3.05 m) –olive green, silty clay, moist, faint old fuel odour
4					**BOREHOLE TERMINATED AT 3.05 m**
5					
6					
7					
8					
9					
10					

BACKFILL DETAILS

FILL MATERIAL
HOLE SEAL
SURFACE REPAIR

Borehole backfilled with auger cuttings from borehole termination depth to 1.52 m from surface
Hydrated bentonite chips placed from 1.52 m below surface to 0.6 m
bentonite hydrated with distilled water.
Concrete placed from 0.6 m to surface.

Monitoring Well Logs

CH2M HILL ENGINEERING LTD.

MONITORING WELL & CONSTRUCTION LOG

WELL NUMBER: MW-02

PROJECT NUMBER: ONT29776.A0

CLIENT NAME: CENTRA GAS Manitoba Inc.

LOCATION: 35 Sutherland Ave. Winnipeg, Man.

DATE DRILLED: September 20, 1993

LOGGER: R. Stacey

DRILL COMPANY: Paddock Drilling Ltd.

DRILLING METHOD: CT250, Hollow-stem Augers

ELEVATION: Surface Elevation: 229.450

(metres) Well Pipe Elevation: 229.336

TOTAL DEPTH (m): 8.99

EASTING: 144.780

NORTHING: 231.860

DEPTH BELOW SURFACE (metres)	SOIL SAMPLE DETAILS: SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESS.	SAMPLE INTERVAL	SOIL DESCRIPTION
					LEGEND NC – NO CONTAMINATION TC – TRACE CONTAMINATION VC – VISUAL CONTAMINATION C/noVC – CONTAM/NO VISUAL EVIDENCE SS – SPLIT-SPOON SAMPLE CS – CONTINUOUS SAMPLE S.P.T. – STANDARD PENETRATION TEST
0					**ASPHALT** (15 cm)
	SS1	NA	NC		**GRANULAR FILL** (0.15 m to 1.07 m) -grey, dry, crushed stone, compact, black staining at 0.6 m, faint petroleum odour (SS1) S.P.T. results = 10,10,13,11
1	SS2	62	C (noVC)		
	SS3	40	VC		**SILTY CLAY FILL** (1.07 m to 3.35 m) -black, moist, soft, high organics content, some rootlets, faint tar odour, silty clay (SS2) S.P.T. results = 4,5,8,12
2	SS4	104	VC		-black, moist, silty clay, some white silt pockets, strong petroleum odour (SS3) S.P.T. results = 2,4,5,7
	SS5	104	VC		-black, moist silty clay, strong petroleum odour, trace fine sand (SS4) S.P.T. results = 3,4,5,8
3	SS6	3	TC		-black, moist, some white silt pockets and infilling, trace fine sand (SS5) S.P.T. results = 3,5,6,8
	SS7	5	TC		**SILTY CLAY** (3.35 m to 5.33 m) -mottled brown and grey, moist, cohesive, highly plastic, slightly fractured, trace fine sand, some white silt pockets (SS6 & SS7) SS6 S.P.T. results = 6,8,9,11 SS7 S.P.T. results = 4,5,9,12
4	SS8	62.5	C (noVC)		-as above, fracture surfaces are oxidized, higher moisture content, some fine sand, faint odour (SS8) S.P.T. results = 4,5,6,8
	SS9	49	C (noVC)		**CLAYEY SILT** (5.33 m to 8.23 m) -dark grey, saturated, some organic fibres, faint odour (SS9) S.P.T results = 4,4,5,5
5	SS10	13.3	TC		-grey with some brown mottling, saturated, some shells and organic fibres, occasional medium sand grain (SS10) S.P.T. results = 4,5,6,8
	SS11	22	TC		-grey, saturated, some silt laminations, some shells (SS11) S.P.T. results = 2,3,4,5
6	SS12	0.2	NC		-as above with some organic fibres, shells and silt laminations, higher plasticity (SS12) S.P.T. results = 3,4,4,5
	SS13	1.6	NC		**SILTY CLAY** (8.23 m to 8.99 m) -grey, moist, high plasticity, cohesive, some organic fibres (SS13) S.P.T. results = 3,3,3,4
7					**BOREHOLE TERMINATED AT at 8.99 m**
8					
9					
10					

WELL CONSTRUCTION

CASING, SCREEN INTERVAL, FILTER PACK, WELL SEAL

FLUSH-MOUNT PROTECTIVE CASING
-cemented around well casing

LOCKABLE J-PLUG CAP

WELL SEAL
(0.3 m to 5.03 m)
-hydrated bentonoite holeplug

FILTER PACK
(5.03 m to 8.99 m)
-65 grain clean Silica Sand

WELL SCREEN
(5.64 m to 8.69 m)
10 slot, Schedule 40 P.V.C., 5 cm I.D.

BOREHOLE DIAMETER = 0.20 m

CH2M HILL ENGINEERING LTD.

MONITORING WELL & CONSTRUCTION LOG

WELL NUMBER: MW18

PROJECT NUMBER: ONT29793.A0

CLIENT NAME: CENTRA GAS Manitoba Inc.

LOCATION: 35 Sutherland Ave. Winnipeg, Man.

DATE DRILLED: September 29, 1993

LOGGER: R. Stacey

DRILL COMPANY: Paddock Drilling Ltd.

DRILLING METHOD: CT250, Hollow-stem Augers

ELEVATION: Surface Elevation: 229.430

(metres) Well Pipe Elevation: 229.245

TOTAL DEPTH (m): 6.10

EASTING: 160.730

NORTHING: 239.880

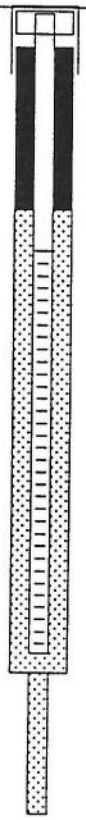
LEGEND
NC - NO CONTAMINATION
TC - TRACE CONTAMINATION
VC - VISUAL CONTAMINATION
C/noVC - CONTAM/NO VISUAL EVIDENCE

SS - SPLIT-SPOON SAMPLE
CS - CONTINUOUS SAMPLE
S.P.T. - STANDARD PENETRATION TEST

DEPTH BELOW SURFACE (metres)	SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESS.	SOIL DESCRIPTION
	CS1	<1.75	NC	**ASPHALT SURFACE** (10 cm) **GRANULAR FILL** (0.1 m to 0.76 m) -tan brown, dry, compact, sand and gravel, no odour
1	CS2	58	TC	**SANDY SILT FILL** (0.76 m to 1.52 m) -sandy silt, tan brown, loose, moist, sandy silt, highly organic, fuel odour
2	CS3	54	C (noVC)	**CLAY SILT FILL** (1.52 m to 3.05 m) -tan brown, moist, loose, clayey silt, some white silt pockets, strong gasoline odour
	CS4	156	C (noVC)	-as above, strong odour
3	CS5	3.6	TC	**CLAYEY SILT** (3.05 m to 6.10 m) -brown, weathered, oxidized, moist fractured, faint petroleum odour
4	CS6	0.1	NC	-as above, no odour
5	CS7	0.1	NC	-grey-brown, moist, less oxidation, fractured with silt in fractures, some organics near 5.2 m
	CS8	0.1	NC	-grey, moist, clayey silt, no oxidation, unfractured, some shells, no odour
6				**BOREHOLE TERMINATION AT 6.10 m**
7				
8				
9				
10				

WELL CONSTRUCTION

CASING, SCREEN INTERVAL, FILTER PACK, WELL SEAL



FLUSH-CASING
-cemented around well casing

LOCKABLE J-PLUG CAP

WELL SEAL
(0.3 m to 1.52 m)
-bentonite holeplug

FILTER PACK
(1.52 m to 6.10 m)
-#65 grain clean silica sand

WELL SCREEN
(1.83 m to 4.88 m)
-Schedule 40 P.V.C. #10 slot, 5 cm I.D.

BOREHOLE DIAMETER = 0.20 m

CH2M HILL ENGINEERING LTD.

MONITORING WELL & CONSTRUCTION LOG

Page

WELL NUMBER: MW-21

PROJECT NUMBER: ONT29793.A

CLIENT NAME: CENTRA GAS Manitoba Inc.

LOCATION: 35 Sutherland Ave. Winnipeg, Man.

DATE DRILLED: September 30, 1993

LOGGER: R. Stacey

DRILL COMPANY: Paddock Drilling Ltd.

DRILLING METHOD: CT250, Hollow-stem Augers

ELEVATION: Surface Elevation: 229.600 (metres)

Well Pipe Elevation: 229.498

TOTAL DEPTH (m): 6.10

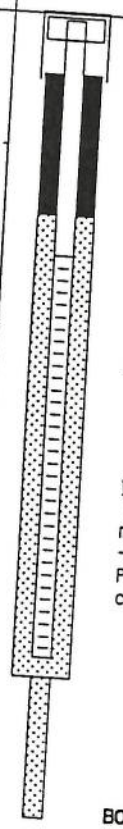
EASTING: 146.570

NORTHING: 251.780

DEPTH BELOW SURFACE (metres)	SOIL SAMPLE DETAILS: SAMPLE TYPE AND NUMBER	HNU ORGANIC VAPOUR CONC. (PPM)	VISUAL AND OLFACTORY ASSESS.	SAMPLE INTERVAL	SOIL DESCRIPTION
					LEGEND NC – NO CONTAMINATION TC – TRACE CONTAMINATION VC – VISUAL CONTAMINATION C/noVC – CONTAM/NO VISUAL EVIDENCE SS – SPLIT-SPOON SAMPLE CS – CONTINUOUS SAMPLE S.P.T. – STANDARD PENETRATION TEST
	CS1	1.4	NC		**ASPHALT** (15 cm)
1					**GRANULAR FILL** (0.15 m to 0.76 m) -sand and gravel, tan-brown, dry, compact, no odour
	CS2	NA	VC		**MIXED FILL** (0.76 m to 1.52 m) -low sample recovery, stone blocks sampler, some black staining and odour
2	CS3	127	VC		**SANDY SILT FILL** (1.52 m to 2.44 m) -black, sandy silt, moist, loose, strong napthalene odour
	CS4	NA	VC		-as above to 2.44 m
3					**CLAYEY SILT** (2.44 m to 5.33 m) -olive-grey, faint napthalene odour, trace to some black staining
	CS5	56	TC		-as above, faint napthalene odour, moist
4	CS6	NA	TC		-some shells and organic fibres, faint napthalene odour, (1) large shell observed
5	CS7	NA	NC		-light grey-brown, no odour, some white silt infilling, increasing clay content, mottled
	CS8	2	NC		**SILTY CLAY** (5.33 m to 6.10 m) -grey silty clay, less mottling, moist, no odour
6					**BOREHOLE TERMINATED AT 6.10 m**
7					
8					
9					
10					

WELL CONSTRUCTION

CASING, SCREEN INTERVAL, FILTER PACK, WELL SEAL



FLUSH-CASING
-cemented around well casing

LOCKABLE J-PLUG CAP

WELL SEAL (0.46 m to 1.52 m)
-bentonite holeplug

FILTER PACK (1.52 m to 6.10 m)
-#65 grain clean silica sand

WELL SCREEN (1.83 m to 4.88 m)
-Schedule 40 P.V.C. #10 slot, 5 cm I.D.

BOREHOLE DIAMETER = 0.20 m

Appendix C

CHEMICAL ANALYSIS

- **Soils Analysis**
- **Soils Leachate Analysis**
- **Groundwater Analysis**

Soils Analysis

CANVIRO
Analytical Laboratories Ltd.

R E P O R T O F A N A L Y S I S

CLIENT CH2M Hill Engineering Ltd.

ATTENTION Mr. Jeff Coyle

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8

CANVIRO PROJECT NO. 93-10227

SAMPLES RECEIVED Oct. 19, 1993

REPORTED Nov. 8, 1993

SAMPLE IDENTIFICATION			PARAMETERS FOR ANALYSIS
LAB NO.	SAMPLING DATE	DESCRIPTION	MINERAL OIL AND GREASE mg/kg
10227-02	09/29/93	BH18 (10-12.5') TTC	<10
10227-03	09/29/93	BH18 (5-10') HC	28.7
10227-04	09/29/93	RS-793-02 Sutherland Fac.	13.2
10227-06	09/20/93	BH2/MW2 (15'17')	<10

Results are reported on a Dry Weight Basis.

RESPECTFULLY YOURS

Brent Hodgson

BRENT HODGSON,
WET CHEMISTRY
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

R E P O R T O F A N A L Y S I S

CLIENT CH2M Hill Engineering Ltd.

ATTENTION Mr. Jeff Coyle

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8

CANVIRO PROJECT NO. 93-10227

SAMPLES RECEIVED Oct. 19, 1993

REPORTED Nov. 8, 1993

SAMPLE IDENTIFICATION			PARAMETERS FOR ANALYSIS
LAB NO.	SAMPLING DATE	DESCRIPTION	LEAD mg/kg
10227-02	09/29/93	BH18 (10-12.5') TTC	<10.0
10227-03	09/29/93	BH18 (5-10') HC	<10.0
10227-04	09/29/93	RS-793-02 Sutherland Fac.	<10.0
10227-06	09/20/93	BH2/MW2 (15'17')	<10.0

Results are reported on a Dry Weight Basis.

RESPECTFULLY YOURS

CLAUDE IRWIN,
TRACE INORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.

ATTENTION Mr. Jeff Coyle

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8

CANVIRO PROJECT NO. 93-10227

SAMPLES RECEIVED Oct. 19, 1993

REPORTED Nov. 8, 1993

BTXE ANALYSIS

IDENTIFICATION	LAB BLANK		BH18 (10 -12.5') TTC	BH18 (5-10) HC *	BH21/ MW21 (6-7')	BH2/ MW2 * (15-17')	MDL
SAMPLING DATE			09/29/93	09/29/93	09/20/93	09/20/93	
IDENTIFICATION NO.			10227-02	10227-03	10227-05	10227-06	
COMPOUND	ng/g		ng/g	ng/g	ng/g	ng/g	ng/g
Benzene	<		<	<11	<	<11	0.58
Toluene	<		<	104	<	121	0.80
m & p Xylene	<		1.30	186	21.8	61.6	0.59
Ethyl benzene	<		<	18.4	11.1	13.1	0.39
o-Xylene	<		1.25	102	<	156	0.42
% RECOVERY OF SURROGATES							
d6-Benzene	94		95	93	81	87	
d10-Ethylbenzene	99		87	115	96	100	

NOTE: Samples have been corrected for laboratory blank.
MDL = CANVIRO Method Detection Limit
< = Less than CANVIRO MDL
ng/g = nanograms per gram = ppb.
* = Sample required dilution, therefore, MDL's have been adjusted.

RESPECTFULLY YOURS,

JEANINE WAUGH,
TRACE ORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

TOTAL PETROLEUM HYDROCARBONS by "GC/MS" - RESULT DATA

IDENTIFICATION	LAB BLANK		BH18 (10-12.5') TTC	MDL
SAMPLING DATE			09/29/93	
IDENTIFICATION NO.			10227-02	
	ug/g		ug/g	ug/g
VOLATILE TPH	<		<	1.0
EXTRACTABLE TPH	<		15.7	1.0
TOTAL TPH	<		15.7	1.0
% RECOVERY OF SURROGATE				
d10-ethylbenzene	99		87	
d8-naphthalene	64		62	
d12 Chrysene	99		86	

TOTAL PETROLEUM HYDROCARBONS by "GC/MS" - RESULT DATA

IDENTIFICATION	BH18 (5-10) HC	RS-793-02 SUTHER-LAND FAC.	BH2/ MW2 (15-17')	METHOD SPIKE	MDL
SAMPLING DATE	09/29/93	09/29/93	09/20/93		
IDENTIFICATION NO.	10227-03	10227-04	10227-06		
	ug/g	ug/g	ug/g	%	ug/g
VOLATILE TPH	12.9	<	1.95	NA	1.0
EXTRACTABLE TPH	108	18.2	72.9	150	1.0
TOTAL TPH	121	18.2	74.9		1.0
% RECOVERY OF SURROGATE					
d8-naphthalene	115	97	100	NA	
d8-naphthalene	61	60	45	92	
d12 Chrysene	103	89	104	132	

NOTE: The purgeable and extractable fractions were analyzed by GC/MS.

Standards of gasoline, kerosene, diesel fuel and hydraulic oil were run as calibrants. Specific ions common to these hydrocarbon fractions were used to quantitate the sample(s).

Samples have been corrected for the laboratory blank.

NA = Not Analyzed

RESPECTFULLY YOURS

JEANINE WAUGH,
TRACE ORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

POLYNUCLEAR AROMATIC HYDROCARBONS BY "GC/MS"

IDENTIFICATION	LAB BLANK	BH18 (10-12.5') TTC	BH18 (5-10) HC	BH21/ MW21 (6-7')	BH2/ MW2 (15-17')	METHOD SPIKE	MDL
SAMPLING DATE		09/29/93	09/29/93	09/30/93	09/20/93		
IDENTIFICATION NO.		10227-02	10227-03	10227-05	10227-06		
	ng/g	ng/g	ng/g	ng/g	ng/g	%	ng/g
Naphthalene	0.005	8.29	411	843	7.74	76	0.88
Acenaphthylene	<	<	9.30	46.7	<	75	0.90
Acenaphthene	<	<	3.14	63.0	<	76	1.12
Fluorene	<	<	6.69	735	<	77	2.4
Phenanthrene	<	<	16.9	2,430	<	81	3.6
Anthracene	<	<	5.47	183	<	78	1.6
Fluoranthene	<	<	9.69	532	1.85	82	1.18
Pyrene	<	<	7.76	363	<	83	1.98
Benzo (a) anthracene	<	<	4.45	80.0	1.86	84	0.88
Chrysene	<	<	3.20	64.6	1.47	84	1.00
Benzo (b) fluoranthene	<	<	5.90	70.4	<	82	1.94
Benzo (k) fluoranthene	<	<	*	*	<	87	2.2
Benzo (a) pyrene	<	<	3.13	33.0	2.09	86	1.42
Indeno (1,2,3-cd) pyrene	<	<	<	18.2	<	90	1.42
Dibenzo (a,h) anthracene	<	<	<	2.05	<	96	1.86
Benzo (ghi) perylene	<	<	<	13.1	<	90	1.74
% RECOVERY OF SURROGATES							
D8-Naphthalene	79	46	52	47	32	72	
D12-Chrysene	87	82	84	91	97	91	

NOTE: MDL = CANVIRO Method Detection Limit
< = Less than CANVIRO MDL
ng/g = nanograms per gram = ppb.
* = benzo (b) and (k) fluoranthene coeluted, therefore, the results are reported as a total.

Results are reported on Dry Weight Basis.

Soils Leachate Analysis

CANVIRO
Analytical Laboratories Ltd.

ICAP SCAN

IDENTIFICATION	LEACHATE OF BH18(5-10)HC		MDL
IDENTIFICATION NO.	10399-03		
	CONCENTRATION		
	mg/L		mg/L
ALUMINUM	<		0.10
BORON	0.09		0.05
BARIUM	0.67		0.01
BERYLLIUM	<		0.005
CADMIUM	<		0.032
CALCIUM	>800		0.05
CHROMIUM	<		0.02
COBALT	<		0.09
COPPER	0.04		0.02
IRON	0.02		0.007
LEAD	<		0.10
MAGNESIUM	210		0.01
MANGANESE	5.77		0.01
VANADIUM	<		0.01
ZINC	0.09		0.01
NICKEL	0.09		0.03
PHOSPHORUS	<		0.32
SILVER	<		0.02
STRONTIUM	1.37		0.01
SODIUM	10.0		2.00
MOLYBDENUM	<		0.04
TITANIUM	0.03		0.01
ZIRCONIUM	<		0.01
ARSENIC	<		0.005
SELENIUM	<		0.005
FREE CYANIDE	<0.0048		0.0048

REPORTED BY: CLAUDE IRWIN, TRACE INORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

POLYNUCLEAR AROMATIC HYDROCARBONS BY "GC/MS"

IDENTIFICATION	LAB BLANK	LEACHATE OF BH18(5-10)HC	METHOD SPIKE	MDL
SAMPING DATE		09/29/93		
IDENTIFICATION NO.		10399-03		
	ppb	ppb	%	ppb
Naphthalene	0.005	10.5	89	0.004
Acenaphthylene	<	0.19	92	0.004
Acenaphthene	<	0.058	91	0.008
Fluorene	<	0.067	91	0.004
Phenanthrene	<	0.096	104	0.007
Anthracene	<	0.017	95	0.008
Fluoranthene	<	0.018	103	0.006
Pyrene	<	0.011	106	0.004
Benzo (a) anthracene	<	<	101	0.005
Chrysene	<	<	114	0.007
Benzo (b) fluoranthene	<	<	110	0.007
Benzo (k) fluoranthene	<	<	96	0.007
Benzo (a) pyrene	<	<	97	0.006
Indeno (1,2,3-cd) pyrene	<	<	72	0.011
Dibenzo (a,h) anthracene	<	<	97	0.008
Benzo (ghi) perylene	<	<	99	0.009
% RECOVERY OF SURROGATES				
D8-Naphthalene	67	53	67	
D12-Chrysene	95	85	86	

NOTE: MDL = CANVIRO Method Detection Limit
< = Less than CANVIRO MDL

Groundwater Analysis

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.
CANVIRO PROJECT NO. 93-10224

ATTENTION Mr. Jeff Coyle
SAMPLES RECEIVED Oct. 19, 1993

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8
REPORTED Nov. 8, 1993

SAMPLE IDENTIFICATION			PARAMETERS FOR ANALYSIS
LAB NO.	SAMPLING DATE	DESCRIPTION	PHENOLICS ug/L
10224-02	10/04/93	BH2/MW2	51

RESPECTFULLY YOURS

Brent Hodgson

BRENT HODGSON,
WET CHEMISTRY
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.
CANVIRO PROJECT NO 93-10319

ATTENTION Mr. Jeff Coyle
SAMPLES RECEIVED Oct. 25, 1993

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8
REPORTED Nov. 15, 1993

SAMPLE IDENTIFICATION			PARAMETERS FOR ANALYSIS
LAB NO.	SAMPLING DATE	DESCRIPTION	LEAD mg/L
10319-02	10/24/93	BH2/MW2	<0.0006

RESPECTFULLY YOURS

CLAUDE IRWIN,
TRACE INORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.
CANVIRO PROJECT NO 93-10319

ATTENTION Mr. Jeff Coyle
SAMPLES RECEIVED Oct. 25, 1993

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8
REPORTED Nov. 15, 1993

TOTAL PETROLEUM HYDROCARBONS by "GC/MS" - RESULT DATA

IDENTIFICATION	LAB BLANK	BH2/MW2 WITHOUT SEDIMENT	BH2/MW2 WITH SEDIMENT	MDL
SAMPLING DATE		10/24/93	10/24/93	
IDENTIFICATION NO.		10319-02A	10319-02B	
	ppm	ppm	ppm	ppm
VOLATILE TPH	<	NA	0.27	0.01
EXTRACTABLE TPH	0.06	0.04	0.06	0.01
TOTAL TPH	0.06	0.04	0.33	----

NOTE: The purgeable and extractable fractions were analyzed by GC/MS.

Standards of gasoline, kerosene, diesel fuel and hydraulic oil were run as calibrants. Specific ions common to these hydrocarbon fractions were used to quantitate the sample(s).

Samples have been corrected for the laboratory blank.

NA = not analyzed

RESPECTFULLY, YOURS

JEANINE WAUGH,
TRACE ORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.

ATTENTION Mr. Jeff Coyle

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8

CANVIRO PROJECT NO. 93-10224

SAMPLES RECEIVED Oct. 19, 1993

REPORTED Nov. 8, 1993

BTXE ANALYSIS

IDENTIFICATION	LAB BLANK	** BH2/MW2	MDL
SAMPLING DATE		10/04/93	
IDENTIFICATION NO.		10224-02	
COMPOUND	ppb	ppb	ppb
Benzene	<	14.3	0.11
Toluene	<	<1.6	0.16
m & p Xylene	<	<1.2	0.12
Ethyl benzene	<	<0.8	0.08
o-Xylene	<	277	0.08
% RECOVERY OF SURROGATES			
d6-Benzene	93	128	
d10-Ethylbenzene	100	98	

CONTINUES ON NEXT PAGE

CANVIRO
Analytical Laboratories Ltd.

POLYNUCLEAR AROMATIC HYDROCARBONS BY "GC/MS"

IDENTIFICATION	LAB BLANK	BH2/MW2	MDL
SAMPING DATE		10/04/93	
IDENTIFICATION NO.		10224-02	
	ppb	ppb	ppb
Naphthalene	<	2.63	0.004
Acenaphthylene	<	0.368	0.004
Acenaphthene	<	0.086	0.008
Fluorene	<	0.251	0.004
Phenanthrene	<	0.251	0.007
Anthracene	<	0.042	0.008
Fluoranthene	<	0.072	0.006
Pyrene	<	0.092	0.004
Benzo (a) anthracene	<	<	0.005
Chrysene	<	<	0.007
Benzo (b) fluoranthene	<	<	0.007
Benzo (k) fluoranthene	<	<	0.007
Benzo (a) pyrene	<	<	0.006
Indeno (1,2,3-cd) pyrene	<	<	0.011
Dibenzo (a,h) anthracene	<	<	0.008
Benzo (ghi) perylene	<	<	0.009
Perylene	<	<	
Benzo (j) fluoranthene	<	<	
Benzo (e) pyrene	<	<	
% RECOVERY OF SURROGATES			
D8-Naphthalene	77	96	
D12-Chrysene	78	112	

CONTINUES ON NEXT PAGE

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.
CANVIRO PROJECT NO. 93-10226

ATTENTION Mr. Jeff Coyle
SAMPLES RECEIVED Oct. 19, 1993

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8
REPORTED Nov. 8, 1993

SAMPLE IDENTIFICATION			PARAMETERS FOR ANALYSIS
LAB NO.	SAMPLING DATE	DESCRIPTION	PHENOLICS ug/L
10226-01	10/04/93	BH18/MW18	5.8

RESPECTFULLY YOURS

Brent Hodgson

BRENT HODGSON,
WET CHEMISTRY
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.

ATTENTION Mr. Jeff Coyle

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8

CANVIRO PROJECT NO. 93-10226

SAMPLES RECEIVED Oct. 19, 1993

REPORTED Nov. 8, 1993

SAMPLE IDENTIFICATION			PARAMETERS FOR ANALYSIS
LAB NO.	SAMPLING DATE	DESCRIPTION	LEAD mg/L
10226-01	10/04/93	BH18/MW18	<0.0006

RESPECTFULLY YOURS

CLAUDE IRWIN,
TRACE INORGANICS
LABORATORY SUPERVISOR

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT	CH2M Hill Engineering Ltd.	CANVIRO PROJECT NO.	93-10226
ATTENTION	Mr. Jeff Coyle	SAMPLES RECEIVED	Oct. 19, 1993
ADDRESS	180 King Street, Suite 600 Waterloo, Ontario N2P 1J8	REPORTED	Nov. 8, 1993

BTXE ANALYSIS

IDENTIFICATION	LAB BLANK	BH18/ MW18	MDL
SAMPLING DATE		10/04/93	
IDENTIFICATION NO.		10226-01*	
COMPOUND	ppb	ppb	ppb
Benzene	<	<11	0.11
Toluene	<	<16	0.16
m & p Xylene	<	<12	0.12
Ethyl benzene	<	<8.0	0.08
o-Xylene	<	136	0.08
% RECOVERY OF SURROGATES			
d6-Benz	88	58	
d10-Ethylbenzene	98	79	

NOTE: Samples have been corrected for laboratory blank.

MDL = CANVIRO's Method Detection Limit
< = Less than CANVIRO MDL
* = Samples required dilution, therefore, MDL's have been adjusted

RESPECTFULLY YOURS,

Gianna Rizzuti

for JEANINE WAUGH,
Trace Organics
Laboratory Supervisor

CANVIRO
Analytical Laboratories Ltd.

REPORT OF ANALYSIS

CLIENT CH2M Hill Engineering Ltd.

ATTENTION Mr. Jeff Coyle

ADDRESS 180 King Street, Suite 600
Waterloo, Ontario
N2P 1J8

CANVIRO PROJECT NO. 93-10226

SAMPLES RECEIVED Oct. 19, 1993

REPORTED Nov. 8, 1993

TOTAL PETROLEUM HYDROCARBONS by "GC/MS" - RESULT DATA

IDENTIFICATION	LAB BLANK	BH18/MW18			METHOD SPIKE	MDL
SAMPLING DATE		10/04/93				
IDENTIFICATION NO.		10226-01				
	ppm	ppm			%	ppm
VOLATILE TPH	<	0.86			NA	0.01
EXTRACTABLE TPH	0.06	0.06			98	0.01
TOTAL TPH	0.06	0.92				0.01
% RECOVERY OF SURROGATE						
d10-ethylbenzene	98	79			NA	

NOTE: The purgeable and extractable fractions were analyzed by GC/MS.

Standards of gasoline, kerosene, diesel fuel and hydraulic oil were run as calibrants. Specific ions common to these hydrocarbon fractions were used to quantitate the sample(s).

Sample has been corrected for the laboratory blank.

NA = not analyzed

RESPECTFULLY YOURS

for Glenna Reed

JEANINE WAUGH,
TRACE ORGANICS
LABORATORY SUPERVISOR

Appendix D

"A GUIDELINE FOR THE DISMANTLING AND REMOVAL OF UNDERGROUND, GRADE AND ABOVE GRADE LEVEL PETROLEUM STORAGE TANK SYSTEMS IN MANITOBA"

MANITOBA ENVIRONMENT

A GUIDELINE FOR THE DISMANTLING AND REMOVAL OF UNDERGROUND, GRADE AND ABOVE GRADE LEVEL PETROLEUM STORAGE TANK SYSTEMS IN MANITOBA

JUNE 1991

(addendum June, 1993)

This guideline outlines the procedures to be used for the dismantling, removal and disposal of underground, grade and above grade level storage tank systems and for the initial screening of the tank site for the presence of contamination.

Tank Removal Safety Precautions

When underground, grade and above grade level petroleum storage tank systems are removed, regardless of the reason for removal, precautions must be taken to ensure that the tank and piping are processed and disposed of properly and that any site contamination is identified.

Application for Permit to Construct or Modify

Contact your local Regional Environment Office to obtain an "Application for Permit to Construct or Modify." This form must be completed and sent to the regional office at least five (5) days prior to any removal work. You must receive written approval to remove from the regional office before work is to begin.

I. UNDERGROUND STORAGE TANKS

1. PREPARATION

a) All electric power connected to the tank or its associated equipment must be deactivated by dismantling the wire at the circuit breaker.

b) To avoid the risks of tank floatation, the procedures for flushing, cleaning, and removing the substances stored should be performed as close as possible to the time the actual excavation and removal will be initiated.

c) Barricades should be placed around all excavations, excavated soils, removed tanks, and equipment until completion of work.

d) Remove product with dispenser pump to the lowest draw-off point.

e) Drain and flush the piping into the tank with water.

f) Remove remaining product with a hand pump or vacuum pump.

g) Remove ancillary equipment, except a single vent line, which should remain connected until purging or inerting is completed. Alternatively, install a threaded 12-foot galvanized pipe in the access port opposite the one to be used for the purging or inerting process.

h) Temporarily plug remaining tanks openings.

2. TANK PURGING

a) Fill the tank with water and remove the floating product as the water level rises. Before selecting this method, make sure you have permission to dispose the contaminated water at a site approved by Manitoba Environment.

b) The tank can be ventilated with air, using a small gas exhauster operated with compressed air or by other suitable means. The flow of air shall be directed through the length of the tank. Vapour concentration in the tank shall be monitored with a combustible gas indicator, and the process shall continue until the tank is gas-free. During the purging process, all necessary precautions to prevent ignition in the entire area shall be taken (See Figure 1 and Figure 2).

c) Use steam to purge the tank of all petroleum vapours. At least one (1) storage tank volume is necessary. The use of steam to purge flammable vapours from the tanks is not recommended. Steam has a likelihood of producing static electricity, and this in turn may cause an explosion.

Note: **Use a Combustible Gas Meter to verify the tank is free of flammable vapours. Readings should be taken at each end of the tank and near the center of each of the following three levels a) bottom, b) middle, and c) upper levels of the tank. Always strive for a reading of 0% L.E.L., but never to exceed 10% L.E.L. at any depth within the tank.**

3. TANK INERTING

a) The tank can be purged with dry ice in the amount of 1.5 pounds to 2.0 pounds per 100 gallons (1 kg per 500 litres) of tank capacity. Dry ice shall be crushed and distributed evenly over the greatest possible area. During the purging process, all necessary precautions to prevent ignition in the entire area shall be taken.

Caution: ***Skin contact with dry ice will produce burns.***

b) Introduce N_2 (nitrogen) gas into the tank via the fill line. At least one (1) storage tank volume of nitrogen is necessary.

c) Introduce $C0_2$ (carbon dioxide) gas directly into the tank via the fill line. A minimum of one 75 lb (34 kg) cylinder of $C0_2$ gas is required per 2,000 gallons (9000 litres) of tank volume.

NOTE: **When inert gases such as $C0_2$ and N_2 are used, they should be introduced under low pressure to avoid the generation of static electricity. Pressure in the tank should not exceed 5 pounds per square inch gauge.**

Method 3b, nitrogen gas, method 3c, carbon dioxide gas, and method 2c, steam, can create an excessive build-up of static electricity which in turn may discharge and ignite the petroleum vapour/air mix in the tank. These are all more hazardous than the other methods and should be used with extreme care and being sure that the tank shell and injection equipment are bonded together adequately and grounded.

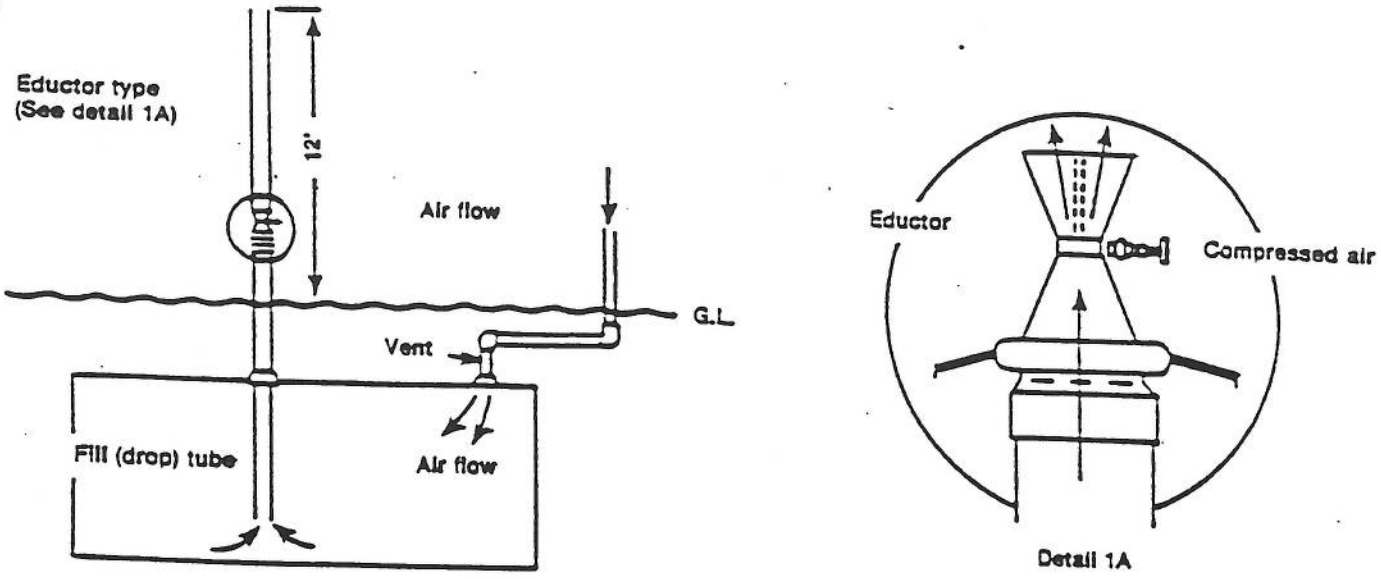
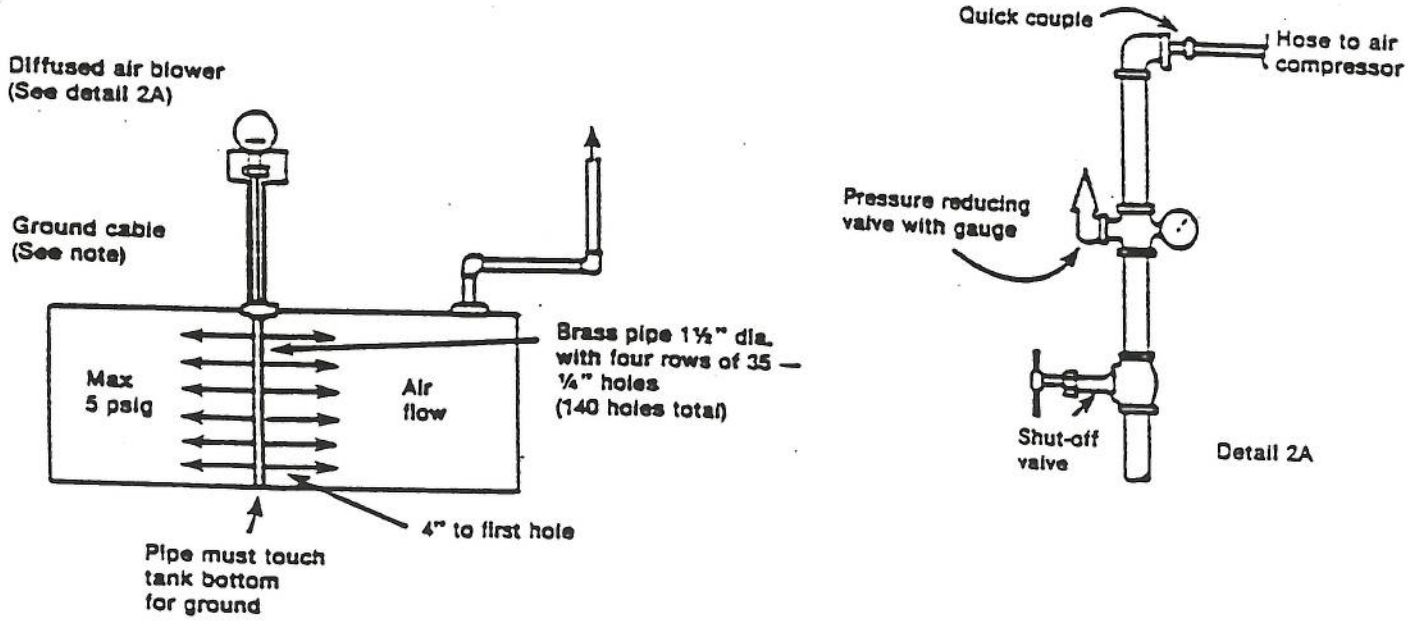


Figure 1—Eductor-Type Air Mover



Note: Ground cable brazed to pipe must be clamped to fill pipe. Use 12 gauge ground wire from fill pipe to water pipe or ground rod.

Figure 2—Diffused Air Blower

d) Do not use carbon dioxide fire extinguishers to inert a tank since static electricity may be created at the end of the tube applicator and an explosion may occur. The cone-shaped nozzle of a fire extinguisher enhances the potential for a static charge buildup creating the possibility for an explosion.

e) The use of Carbon Monoxide to inert a tank is not approved by Manitoba Environment.

f) Carbon dioxide will create more static electricity than nitrogen. Nitrogen is the gas of choice.

g) The correct instrument to use when inerting a tank is an oxygen indicator (01). Readings of less than 10% oxygen are considered safe, target readings should be 5% oxygen or less. Always strive to get as close to zero as possible.

CAUTION

On very hot days flammable vapours may reappear in less than one hour. Continuous monitoring is a must.

Removal, closure or cutting a tank may only begin when the atmosphere inside the tank reads 5% or less on an oxygen indicator.

4. TANK REMOVAL

a) After the tank has been purged or inerted, the excavation may be completed for removal of the tank and associated piping (Note comments on backfill material in "Soil Testing" section.)

b) The tank shall be examined for any evidence of perforations caused by corrosion or structural failure. The installer shall complete the Underground Petroleum Tank Removal Report, confirming the results of the tank examination. Copies of the report shall be sent to the owner and Manitoba Environment (See Appendix A).

c) Sufficient holes shall be cut in the tank to provide ventilation and to render it unfit for future use. The only exceptions are tanks which will be re-certified for re-installation at another location.

5. TANK DISPOSAL

a) Any tanks which are to be re-used for petroleum storage must be refurbished or recertified in accordance with ULC standards:

603A for steel tanks
615A for FRP tanks

b) Tanks which will not be refurbished or recertified must be transported directly to a scrap metal dealer.

c) The tank owner must obtain written confirmation from the scrap dealer that the tanks were received and will be processed or recycled for their metal content. A copy of the confirmation must be provided to Manitoba Environment by the tank owner.

6. WASTE DISPOSAL

The handling, transport and disposal of wastes associated with the tank removal must be performed in accordance with all relevant guidelines and regulations issued by Manitoba Environment.

- Liquid petroleum products and sludge's are usually regulated hazardous waste and must be handled in compliance with provisions of The Dangerous Goods Handling & Transportation Act.

- Petroleum contaminated water should be tested to determine suitable disposal options.

- Petroleum contaminated soil must be taken to a licensed treatment facility or to a site which complies with Manitoba Environment's "Classification and Regulation of Petroleum Contaminated Soil".

7. SOIL TESTING (Recommended Procedure)

During the removal of underground tanks, samples of excavated soils and the undisturbed soils at the perimeter of the excavation must be tested. This type of testing is required regardless of whether new tankage is to be installed on the site. Initial soil tests must be performed by either a licensed* tank removal contractor or a qualified consultant. The results must be reported on the tank closure report submitted to the department.

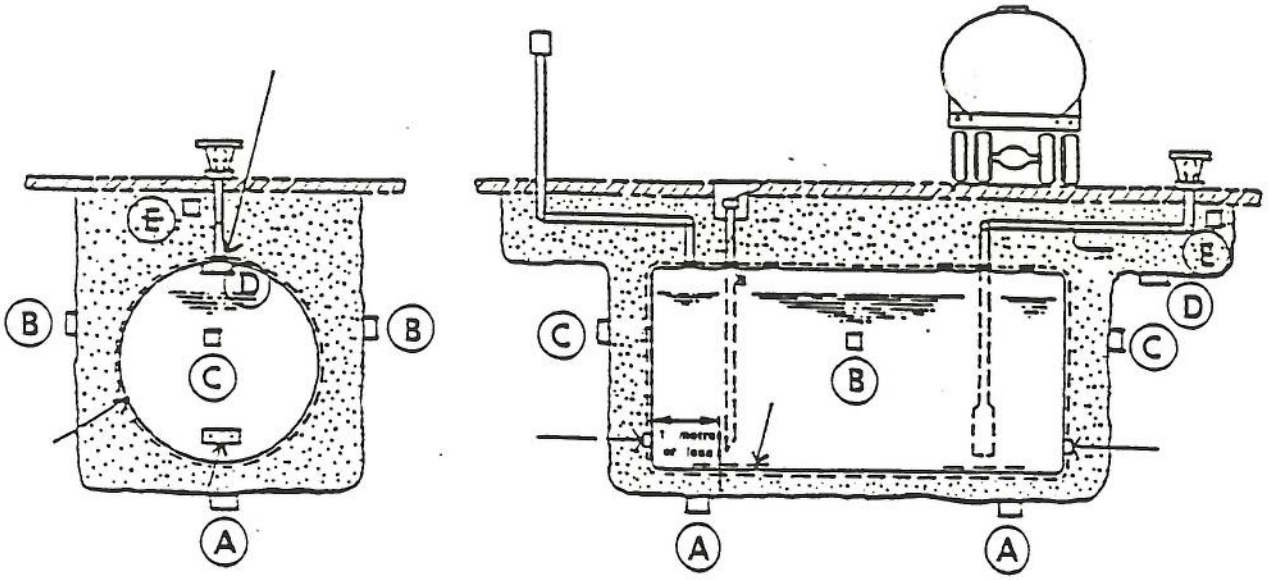
Representative samples must be taken from the bottom and sides of the tank excavation and from the pipe trench, if applicable. Recommended locations for sampling are shown on Figure 4. Additionally, samples must be taken from areas where staining, which may be indicative of soil contamination, is visible. Where the storage tanks contained a volatile product, such as gasoline, soil samples will be screened on site using the field test method described in Appendix B.

Where testing of soil excavated during the tank removal operation is not conducted, the excavated soil will be considered to be contaminated above hazardous waste criteria and appropriate treatment or disposal must be arranged.

Where field head space tests have been conducted, a minimum of two soil samples must be submitted for a confirmatory lab analysis (refer to Appendix C). Typically, these samples would be taken from the areas of the excavation which showed the highest volatile concentrations based on the field screening procedure (alternatively, the two samples could be selected to represent the "worst case" situation and the average or typical condition in the soil mass being examined). A sample should also be submitted from any visibly stained soil strata, even if field screening shows low vapour levels.

** Licensing provisions for petroleum contractors are included in proposed amendments to the petroleum storage & handling regulations (June/93).*

FIGURE 4 - LOCATION FOR SOIL SAMPLES



Bottom Samples

Obtain 2 soil samples per tank - take samples from locations "A" directly below the center line of the tank.

Side Wall Samples

Obtain one sample from each side wall at locations "B" - samples should be from approximately half way down the wall.

End Wall Samples

Obtain one sample from the wall adjacent to each end of each tank, at location "C" - samples should be taken approximately half way down the excavation wall.

Pump Island Sample

Obtain at least one sample adjacent to the pump island or between pump islands. Samples should be from approximately 1.0 m below original grade level, as per location "E".

All samples from the excavation should be taken from undisturbed soil after the backfill material has been removed. The sample should be taken approximately 15 cm in from the surface of the excavation wall to avoid sampling soil which has been directly exposed to the atmosphere. In some situations, additional samples should be taken where layers of porous soil (sand/gravel/silt) are noted in the soil formations exposed in the excavation.

NOTE: Where a site investigation is conducted by a qualified consultant, the complete soil testing procedure as outlined in this section is not required although some soil screening at a reduced sampling frequency is still recommended to augment the information in the site investigation. The results of the examination of the excavation must be described in the consultant's report on the investigation.

The soil screening procedure described in this section will not be considered to be a complete environmental investigation of the site.

8. PROJECT COMPLETION

A tank removal project will be considered complete when the tank registration information has been revised, the tank disposal confirmation has been provided to Manitoba Environment and a remediation program has been implemented for any contamination found to be above applicable standards.

II. GRADE AND ABOVE GRADE LEVEL STORAGE TANKS

Most of the above mentioned procedures for removal of underground storage tanks relate to the removal of grade and above grade level tanks.

Drilling and/or backhoe equipment would be used for site investigations (soil samples for analysis).

Appendix A

MANITOBA
ENVIRONMENT

UNDERGROUND PETROLEUM TANK REMOVAL REPORT

This form is to be completed by the petroleum installer and submitted to Manitoba Environment after completion of the project.

Site Information:

Business Name_____

Address:_____

Operating Permit Number:_____

Petroleum Tank Installer:_____

Tank Information: Include site plan using tank numbers listed in table.

Was Liquid Removed From Tanks: _____Yes _____No

Were Tanks Purged Prior To Removal: _____Yes _____No

Indicate Purging Procedure:_____

Tank #	Capacity	Perforations Found in Tank Shell		Other Visible Physical Damage		Product last Stored in Tank
		yes	no	yes	no	
1						
2						
3						
4						
5						

(For additional tank information see next page)

Product Piping Removed _____Yes _____No

Vent Piping Removed _____Yes _____No

TESTING

Was vapour concentration measured in each tank?_____ Yes _____No

Were field head space tests done on soils? _____Yes _____No

- instrument used_____
- calibrated on_____

Number of field tests:

Excavation walls	_____	highest reading _____
Excavation base	_____	highest reading _____
Excavated fill	_____	highest reading _____
Pipe trenches	_____	highest reading _____
Others _____		

Were soil samples submitted for lab analyses?

Name of Lab _____

Address _____

Number of samples _____

Type of analysis requested _____

Will any additional site investigations be done? _____Yes _____No

DISPOSAL

Tank disposal site _____

Date Shipped _____

Liquid disposal method _____

Disposal date _____

Was any excavated soil removed from site? _____Yes _____No

Volume removed _____

Disposal/treatment method _____

Disposal/treatment site _____

CERTIFICATION _____

Date _____ Signed _____

FOR ADDITIONAL TANK RECORD USE

Tank #	Capacity	Perforations Found in Tank Shell		Other Visible Physical Damage		Product last Stored in Tank
		yes	no	yes	no	
6						
7						
8						
9						
10						

Tank #	Capacity	Perforations Found in Tank Shell		Other Visible Physical Damage		Product last Stored in Tank
		yes	no	yes	no	
11						
12						
13						
14						
15						

Tank #	Capacity	Perforations Found in Tank Shell		Other Visible Physical Damage		Product last Stored in Tank
		yes	no	yes	no	
16						
17						
18						
19						
20						

APPENDIX B

FIELD SOIL SCREENING METHOD

The following procedure can be used as an initial indication of the presence of elevated levels of volatiles in soil samples. This method is most applicable to granular soils contaminated with a product such as gasoline which has a relatively high concentration of lighter end, volatile components. Use of the field head space test should be restricted to sites where contamination by volatile hydrocarbons is being investigated. The method should not be used for determining the presence of middle distillates or heavier products. Also, the effect of methane from soils with a high organic content must be considered.

The field screening method is used primarily as a comparative procedure to delineate areas with elevated levels of volatile vapours in the soil. It is not, in itself, a quantitative method which can be used as a final determination of site conditions.

The field screening method must be supported by confirmatory lab analyses of representative soil samples.

The recommended field screening method is as follows:

1. Soil samples collected from boreholes or excavations are placed in a clean 500 ml. glass container, such as a Mason jar. Where possible, samples of heavier consolidated soils should be broken up by hand before being placed in the container. The container is then sealed with one or more layers of aluminum foil and a screw-on lid. Other alternatives include using screw-on lids fitted with a probe hole or the use of sealable plastic bags equipped with a fitting for attachment to the vapour analyzer. Regardless of the method used, it is important that the soil sample be sealed in the container as quickly as possible to minimize the loss of volatile hydrocarbons. When glass containers are used they should be filled to 50% of the container volume.

2. Equipment used to obtain samples (trowels, split spoon samplers, etc.) must be properly cleaned after each sample to prevent cross contamination.

3. Sample containers are left in an ambient temperature of approximately 20 degrees Celsius for a period of 10 minutes. Some sources recommend agitating the sample for 10 to 15 seconds prior to allowing it to stand. This is an optional feature, however all samples from one site must be treated in the same manner.

4. After the 10 minute period, the probe of the vapour analyzer is inserted through the foil cap on the container or through the sampling orifice. The probe is inserted to half the depth of the head space in the container. The highest reading noted in the first 15 seconds after insertion is recorded. The vapour analyzer must be an instrument capable of detecting volatile hydrocarbons on a scale measured in parts per million. This would include instruments employing thermal conductivity, photo ionization or flame ionization detection principles. The use of detector tubes based on a colour change method is not recommended for this purpose. Calibration curves should be available for the instrument, and the instrument should be calibrated at least daily during a field investigation.

APPENDIX C

ANALYTICAL METHODS

"recommended procedure"

NOTE: The lab method designations indicated below are an interim list only. A revised section is under development.

Parameter	Lab Method
BTEX, Total Volatiles	EPA 5030/8015 EPA 5030/8020
Total Semi-Volatiles	EPA 3540/8015 EPA 3550/8015
Oil & Grease	Mineral Oil & Grease by IR

Selection of Test Methods

Where the specific petroleum product is known, the test methods for the parameters specified below can be used. Where the types of petroleum products handled at the site under investigation cannot be confirmed, a combination of the test methods specified below must be used.

Contaminant	Parameter
Gasoline	Total Volatiles plus BTEX
Diesel Fuel, Fuel Oil	Total Semi-Volatiles
Waste Oil, Bunker C	Oil & Grease plus Lead