Geokwan Engineering Ltd
ENVIRONMENTAL, GEOTECHNICAL & MATERIALS ENGINEERS

Manitoba Environment Department
Building No. 2, 139 Tuxedo Avenue
Winnipeg, Manitoba
R3N 0H6

November 1, 1990

DELIVERED

RECEIVED
NOV 1 1990
ENVIRONMENTAL OPERATIONS DIVISION

ATTENTION: Mr. Brian Durupt
Environmental Officer

Dear Sir:

RE: Canadian Tire Property
18th Street & Aberdeen Avenue
Brandon, Manitoba
Our Project No. 454

Further to our meeting on October 31, 1990, please find enclosed a copy of our environmental assessment report dated June 18, 1990 for the above noted project.

In the meeting, we have discussed a staged clean up program and the use of a vapour extraction system as a site remediation alternative to firstly remove the subsurface volatile vapours around the Canadian Tire store and secondly, the vapours and product in the south parking lot. You have indicated that the vapour extraction system is acceptable to the Manitoba Environment Department (MED) as a site remediation measure at the site and that clean up around the store and the south parking lot should be undertaken simultaneously. Will you please send us a letter to the above effect.

We are planning to install the wells early next week, followed by trenching for the header pipes and installation of the vapour extraction units. It is also planned that a large diameter recovery well will be installed near MW2, to recover the liquid gasoline by a septic truck for disposal at a site approved by MED. In this regard, please inform us of the disposal site and the name of a septic contractor who is approved by MED for handling hydrocarbon disposal in Brandon.

GE

103A SCURFIELD BLVD. WINNIPEG, MB. CANADA R3Y 1M6

TELEPHONE (204) 488-8103 FAX (204) 488-8102

If you have any questions in our report or our proposed site remediation strategies, please call the writer at your convenience.

Yours truly,

GEOKWAN ENGINEERING LTD.
Per:

Walter Kwan, M. Eng., P. Eng.

WK:ew

Enclosure

c.c. Hugh Law, Canadian Tire Corporation, Toronto

Don Arthurs, Cassels Brock & Blackwell

Geokwan Engineering Ltd
CONSULTING GEOTECHNICAL ENGINEERS

June 25, 1990

FAXED

Canadian Tire Corporation Ltd.
P O Box 770, Station K
Toronto, Ontario M4P 2V8

ATTENTION: Mr. Hugh Law, Real Estate Manager

Dear Hugh:

RE: Environmental Site Assessment, Stage 2 to 4
Report On Field Investigation & Lab Testing Results
Commercial Development, 14th Street & Aberdeen Ave.
Brandon, Manitoba Our Project No. 389

We are forwarding, by FAX, revised page 8 & 9, and new page 10 to 24 and Plate 1C of our environmental investigation report for the above noted project. Please discard page 8 & 9 of our report which were faxed to you, on Friday, June 22, 1990.

Two bound copies of the complete report have been shipped to-day to your Toronto office via Air Canada express (Waybill # 01450481012), and should be in your hands to-morrow, June 27, 1990.

We wish to express our sincere appreciation for your assistance, patience and understanding that you have shown during the various stages of our field investigations and preparation of this report. Please accept our apology for any inconvenience that may have caused you in this late submission.

You will note that 3 parcels of land (A, B & C shown on Plate 1C) have been identified by our firm as potentially suitable to commercial development at this site, and that a Stage 5 study has been recommended in our report. We expect that this study will be implemented, as soon as the present report is reviewed by the Canadian Tire Corporation Ltd. and after a brief meeting between yourself, the writer and the representatives of the Manitoba Environment Department. To ensure safety and health, the free phase gasoline and flammable vapours presently surrounding the CTC store in Brandon should be properly collected and disposed as soon as possible.

We trust that our report is adequate for your present purpose. If you, however, have any questions, please advise.

Yours truly,

GEOKWAN ENGINEERING LTD.
Per:

~~Walter Kwan, M. Eng., P. Eng.~~

WK:ss

Encl.

GE
110—1294 BORDER STREET WINNIPEG CANADA R3H 0M7
TELEPHONE (204) 694-4835 TELEX 07-587873

Geokwan Engineering Ltd

CONSULTING GEOTECHNICAL ENGINEERS

FAXED

Canadian Tire Corporation Ltd.
P O Box 770, Station K
Toronto, Ontario
M4P 2V8

ATTENTION: Mr. Hugh Law, Real Estate Manager

Dear Hugh:

RE: Environmental Site Assessment, Stage 2 to 4
Report On Field Investigation & Lab Testing Results
Commercial Development, 14th St. & Aberdeen Ave.
Brandon, Manitoba Our Project No. 389

In order not to rush the report and without our own satisfaction, we request that the submission of the above report to your office in Toronto be extended to Monday, June 25, 1990. We hope that this will meet with your approval.

For your immediate information, we are forwarding, by FAX, the first 10 pages of our report, Plate 64 & 65 showing the gasoline vapour plume and the flammable soil vapour distribution, respectively, plus 6 pages of the chemical testing results (dated February 28, 1990, February 23, 1990 & February 21, 1990) received from the Manitoba Research Council. To reduce the number of pages transmitted, we have elected not to send the graphs of the GC analyses at this time.

On the basis of our study to-date, it is our professional opinion that the prime suspect for the presence of free gasoline product in MW 13 & 2 in the parking lot is the existing Canadian Tire gas bar located to the southwest of the store. The free phase gasoline appears to have been weathered and as such, it may be related to the reported old leak in the tankage area. However, Plate 64 indicates that the highest gasoline vapour concentration (more than 12,000 ppm of gasoline vapour or greater than 100% LEL) exists adjacent to the pump island and not the tankage area, inferring that there might have been newer hydrocarbon leakage or spill. We recommend that the inventory of the product at the gas bar for the past 12 months be audited immediately, and that pressure tests be performed on all buried piping and the tanks as soon as possible. Clean up of the free phase gasoline and flammable vapours in the parking lot and around the Canadian Tire Store are strongly recommended.

Note

Yours truly,
GEOKWAN ENGINEERING LTD.
Per:

Walter Kwan, M. Eng., P. Eng.

Encl.

WK:tbs

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Geokwan Engineering Ltd
CONSULTING GEOTECHNICAL ENGINEERS

REPORT TO

CANADIAN TIRE CORPORATION LIMITED

ENVIRONMENTAL SITE ASSESSMENT - STAGE 2 - 4

FIELD INVESTIGATION & LABORATORY TESTING RESULTS

PROPOSED COMMERCIAL DEVELOPMENT

NORTH OF ABERDEEN AVENUE BETWEEN 14TH & 18TH STREETS

BRANDON MANITOBA

Distribution:

2 Copies - Canadian Tire Corporation Ltd.

1 Copy - Geokwan Engineering Ltd.

389

June 18, 1990

GE
110 — 1294 BORDER STREET WINNIPEG CANADA R3H 0M7
TELEPHONE (204) 694-4835 TELEX 07-587873

June 18, 1990

1.0 INTRODUCTION

As authorized by Mr. Hugh Law, Real Estate Manager of Canadian Tire Corporation Ltd., Geokwan Engineering Ltd. conducted the environmental site assessment of Stage 2 to 4, at the site of a proposed commercial development located between Aberdeen Avenue and the existing Petro-Canada Bulk Storage & Tank Farm, east and south of the existing Canadian Tire Store in Brandon, Manitoba. This work is a continuation of our Stage 1 study undertaken in November 1989.

The primary objective of this investigation was to put down additional monitoring wells, testholes and testpits at specific locations, perform chemical testing of typical soil, water and soil vapour samples and, based on these, comment on the nature and distribution of potential contamination to the subsoils and ground water at this site. For the Stage 4 study, air quality monitoring inside the Canadian Tire Store (especially within the auto service area) was also undertaken, to detect for the possible presence of flammable hydrocarbon vapour.

The detailed terms of reference for the work of Stage 2 to 4, can be found on page 6 & 7 of our earlier report dated November 15, 1989, our letter dated February 14, 1990 and Canadian Tire Corporation Ltd. Purchase Order No. R286 - 280926, dated May 7, 1990.

In the course of the Stage 2 - 4 studies between January and May 1990, numerous letter reports covering our findings and interim recommendations, a historical aerial photo showing the old refinery and one set of site photos and preliminary drawings indicating the testhole, monitoring well and testpit locations, direction of ground water flow and soil vapour distribution, had been submitted to Mr. H. Law of Canadian Tire Corporation Ltd.

2.0 PROCEDURES

The procedures engaged in the Stage 2 to 4 studies include interpretation of relevant historical aerial photos, personal communications with old residents in Brandon and others having knowledge of the site history, search and review of existing water well, soil and ground water information as well as geological evidence, a site reconnaissance, a field exploration & sampling program and chemical analysis of soil, water and soil vapour samples.

June 18, 1990

2.1 Fieldwork

2.1a Stage 2 & 3

During the Stage 2 & 3 studies, sixteen monitoring wells (i.e. #13, 15, 17, 18, 19, 20, 21, 22, 23, 25, 27, 29, 32, 38, 41 & 44), 19 testholes (#14, 16, 17A, 24, 27A, 27B, 28, 29A, 30, 31, 33, 34, 35, 36, 37, 39 40, 42 & 43) and 6 testpits (#26 or TP5, 45 or TP 1, 46 or TP2, 47 or TP3, 48 or TP4, 49 or TP6) were put down between January 17 & 19, 1990. These were deemed required to better assess the geology, hydrogeology and contaminant distribution across the site. The monitoring wells and testholes were drilled using a combination of a 5" diameter continuous flight auger and a 8" diameter hollow stem auger. The testpits were dug by a large tractor mounted backhoe. Locations of the monitoring wells, testholes and testpits are shown on the site plan, Plate 1 appended.

The subsoils encountered were visually classified to the full depth of each testhole or testpit. Soil samples were obtained from each testhole in regular intervals and checked for <u>soil vapour concentration (GV)</u> using our hydrocarbon surveyor. In addition, the undrained shear strengths of the cohesive soils were assessed with a steel penetrometer. All testholes, monitoring wells and testpits were terminated at or within a few feet of the relatively impermeable clay till surface, except TH 17A, MW 27 & TH 27B.

TH 17A & MW 27 were advanced to about 40' from grade, to obtain additional soil and ground water information at depths. Standard penetration tests and split spoon sampling were undertaken in the clay till and the interbedded sand layers at MW 27. TH 27B was terminated at the 2 foot depth due to the presence of suspected concrete rubble. Typical soil samples from the most contaminated areas were retained in glass jars for subsequent chemical analysis by the Manitoba Research Council.

Protective metal service boxes were constructed over the monitoring wells. A typical construction detail of the monitoring well is shown on Plate 1B. Upon completion of the drilling and well installation, the ground surface elevations of the testholes, testpits and monitoring wells including the top of pipe elevations, were determined by our survey crew, in relation to a geodetic benchmark.

On January 19, 1990, all monitoring wells were checked for the ground water elevations, immiscible fluid (free phase hydrocarbon or NAPL - Non Aqueous Phase Liquid) thicknesses and total soil vapour concentrations. In addition, ground water samples were obtained from the monitoring wells for visual quality assessment in terms of colour, turbidity, odour (see Table C), and for detection of the possible presence of immiscible fluids. Immiscible fluids were encountered at MW 13 (about 3" above the ground water table) and MW 22 (about 3/4").

During our subsequent field trip on February 8, 1990, the thickness of the immiscible fluid at MW 22 had increased from 3/4" to 4". On this date, water samples at MW 21, 44 & 20, a sample of the immiscible fluid (L-NAPL) and water (APL) in MW 22, a sample each of the diesel fuel and leaded gasoline from the adjacent Petro-Canada gas station, were obtained, and submitted to the Manitoba Research Council on February 9, 1990, for gas chromatography (GC) analyses.

Due to the very high flammable soil vapour concentrations (more than 11,000 ppm) measured at MW3, 4, 13, 20, 21, 29, 38, 41 & 44 and the presence of a natural gas line along the north property line, air samples using the gas collection bulbs and charcoal air monitoring tubes in conjunction with the sampling pumps, were obtained from the most critical wells and an existing pipe (put down previously by others and identified as CP on Plate 1) near our testhole 42. The bulb samples were analyzed for methane and ethane content, whereas the charcoal tubes were checked for the volatile components of gasoline, by the Manitoba Research Council.

The existing land and water usage in the vicinity of the site was visually evaluated by our senior engineer during a site reconnaissance trip. Existing water well records of the general site areas were obtained from the Water Resources Branch of the Manitoba Department of Natural Resources.

2.1b Stage 4

The Stage 4 work was conducted during the period between May 7 and 8 1990. This work was initiated due to a complaint of bad odour in the reception area of the service centre, inside the Canadian Tire Store in Brandon. A walk through inspection and monitoring of flammable hydrocarbon vapours, using a vapour detector, inside the store was performed by our emergency response team, at 11 p.m. on May 7, 1990 and 6 a.m. on May 8, 1990. The entire auto service centre and its reception area, and the remainder of the store were carefully checked. Vapour readings were taken in all critical areas such as the floor drains, floor cracks, sump pits/troughs, electrical and mechanical rooms, washrooms, any openings in the existing main floor slab and the entry points of buried utilities into the store.

Apart from the indoor vapour monitoring, 5 extra monitoring wells (MW 50 to 54) and two testholes (TH 55 & 56) were put down to the south, west, north, northwest and northeast of the existing store. These were needed to supplement our environmental assessment of the <u>on site</u> contaminant distribution (i.e. contaminants located within the Canadian Tire property).

Soil logging, sampling and soil vapour measurements were in accordance with those adopted in Stage 2 & 3. The ground water elevations, immiscible fluid thicknesses and soil vapour concentrations inside MW 50 to 54 were measured on May 8, 1990. During the 2nd field trip on May 18, 1990, MW 50 to 54 and most of the wells installed in Stage 1 to 3, were rechecked for the parameters noted above. In addition, ground water samples were extracted from MW 50 - 54, MW 20 - 22 & 44, in conformity with the procedures generally accepted by the petroleum industry. One water and 3 soil samples from the most contaminated areas were selected and submitted to the laboratory for chemical analysis.

2.2 <u>Laboratory Work</u>

In our laboratory, the testing included sample reclassification, determination of soil water contents, gradation of typical cohesionless samples, liquid and plastic limits of selected cohesive soil units. Results of the gradation (sieve) analysis and the liquid and plastic limit testing are in Appendix B, which can be used to estimate the hydraulic conductivities of the subsoils.

As discussed above, typical samples of soil, water and soil vapour were collected in the field and submitted to the chemical laboratory for detailed analyses.

3.0 SITE CONDITIONS

3.1 Site History

A detailed description of the site history can be found in Appendix A. Generally, the Canadian Tire property is located approximately in the southerly one half of an old refinery, which was operated by various companies to refine crude oil from 1937 to 1969. The last owner of the refinery was Gulf Canada who shut down the operation in 1969, followed by the complete removal of all storage tanks and associated facilities in 1970.

On the basis of our interpretation of historical aerial photos, site observations, communications with old residents in Brandon and existing soil/ground water information, the locations of the old tanks, a ring dyke, a bunker oil storage lagoon (i.e. the area bordered by an existing dyke to the north, Aberdeen Avenue to the south, TH 6 (MW 6) to the west and 14th Street to the east), shed, buildings and a gasoline/diesel fuel retail outlet (now known as the Petro-Canada Gas Station & tank farm) have been determined and plotted on Plate A1 & A2, in Appendix A.

Our aerial photo study suggests that the Petro-Canada (previously known as Gulf Canada) gas station and the associated pumps & pump islands located to the south and west of the gas station, the truck loading racks and some of the tanks in the tank farm (Plate A2) have been in existence since 1977.

The Canadian Tire Store was built in the early seventies, with a subsequent building addition added to the north of the store in 1988. The Canadian Tire gasoline retail outlet located to the southwest of the store, was reported to be about 2 years old (i.e. constructed approximately in 1988).

3.2 Existing Land & Well Use

The present land use adjacent to the site is indicated on Plate 1A. The Canadian Tire property is bordered by the Petro-Canada tank farm to the north, the Burger King restaurant and the Petro-Canada gasoline and diesel fuel retail outlet to the northwest, a lumber yard and light industrial development to the east, the City of Brandon cemetery to the southwest, a vacant, low-lying and swampy parcel of land to the southeast, and a commercial development (shopping mall and food store) to the west. Imported fill materials have been used to raise the surface elevation of the cemetery, some 10' to 15' higher than the subject site.

Residential houses are located at least 1000' or more away from the site. The closest residential neighborhood is to the east of the site, and located further east of the said lumber yard and light industrial developments.

Our site observations and existing information suggest that drinking water within a radius of at least 2000' of the site, is obtained through the municipal service, and that all wells in the immediate vicinity of the subject property are mainly used for irrigation purposes.

4.0 INVESTIGATION RESULTS

4.1 Subsoil Stratigraphy

A detailed description of the soil profile can be found in the testhole logs, Plate 2 to 61 inclusive. The subsoil stratigraphy encountered is quite variable across the site, especially near the upper 10 to 15' of the soil profile. In general, the soil sequence consisted of a layer of heterogeneous fill materials (sand, clay, organics, concrete rubble, construction debris, etc.) or topsoil, underlain by glaciolacustrine sand, clay and silt deposits overlying a clay till.

The worse fill area in terms of quality, composition and thickness (as much as 10' thick) was located in the southeast quadrant of the site. This area was used as a bunker oil storage lagoon, during the age of the old refinery. In addition, extensive sandy fill coated with dark brown to black oil existed to the northwest of the said bunker oil storage lagoon. The approximate extent of the visible surface fill is shown on Plate 1.

The subsoil stratigraphy and the significant variation in the soil profile across the site are illustrated in the geotechnical profiles, A-A to M-M, on Plate 71 & 72. The surface of the relatively impermeable clay till is extremely undulating, with high points and depressions. As can be seen from the clay till surface contour map on Plate 70, three high till ridges exist near MW 5, MW 7 & MW 44, at elevation 1281', 1282' & 1282', respectively, and thus forming a control channel for ground water movements through the overlying permeable sand and silts, in approximately a northwest - southeast direction. There are also two till depressions (elevation 1277' and 1275', respectively) at MW 1 - 2 and TH 37. Along the north property line, the clay till surface generally slopes downward from west to east. Near the northeast corner of the property, the till surface starts to slope downward to the northeast, with its lowest point located at MW 23 (till elevation 1273').

The elevation and gradient of the relatively impermeable clay till surface at this site, play a major role in limiting the migration of contaminants such as the APL (aqueous phase liquid), L-NAPL (light non aqueous phase liquid) and D-NAPL (dense non aqueous phase liquid).

Four phases of hydrocarbon contamination were identified in this study, namely free, absorbed, dissolved and vapour phases, as explained below.

4.2 Free Phase Hydrocarbons

Free phase hydrocarbons (L-NAPL) were encountered at the following locations:

Location	Free Product Thickness Above The Water Table			
	Jan 19/90	Feb 8/90	Feb 20/90	May 16/90
MW 2	0	-	-	3"
MW 13	3"	-	12"	0.12"
MW 22	3/4"	4"	4"	0
TP 2 (#46)	1"	-	-	-
TP 4 (48)	1/4"	-	-	-

On January 19, 1990, free phase, weathered, dark brown gasoline was detected in MW 13, and diesel fuel-like substance discovered in MW 22. Following the direction of the ground water flow, the gasoline plume had spread from MW 13 to MW 2, approximately over a 4 month period. Diesel fuel-like substance was no longer detected in MW 22, on May 16, 1990 and in this regard, it is our view that the free product had migrated northward into the neighboring properties, due to a change in the direction of the ground water flow induced by the spring flooding of the area (Plate 68).

Apart from the foregoing, black colour, dense hydrocarbons (DNAPL, heavier than the diesel fuel) were encountered in the subsoils above the clay till surface in TP 1 and MW 4. No significant separable hydrocarbons were experienced in the remainder of the monitoring wells as of May 16, 1990.

The free phase hydrocarbons obtained from TP 2(#46), MW 13 and MW 22 were analyzed by gas chromatography (GC). These GC results were compared with those of the commercial diesel fuel and leaded gasoline samples which were taken from the Petro-Canada Service Station to the northwest. In addition, the free phase hydrocarbon sample of MW 13 was further checked for its density and viscosity at 40 degrees C. All pertinent results of the hydrocarbon chemistry are described in MRC letter dated February 21, 1990, in Appendix C.

The MRC results suggest that the free phase hydrocarbons of TP 2 are predominately in the C14 to C22 range, with higher range of hydrocarbons, higher boiling points and heavier molecular weight as compared to the diesel fuel. A mixture of gasoline and diesel fuel is confirmed by MRC for the free phase hydrocarbon samples of MW 13 and MW 22. However, on the basis of the GC analysis, the water sample testing results and our soil vapour measurements in the field, it is our opinion that gasoline is the major component of the free phase liquid at MW 13, while diesel fuel is dominant at MW 22.

The MRC results also suggest that the light yellow liquid samples recovered from MW 21, 44 & 20 on February 8, 1990 do not contain free phase hydrocarbons (page 3, MRC letter dated February 21, 1990).

4.3 Absorbed Phase Hydrocarbons

Absorbed phase hydrocarbons (i.e. black and dark brown to black oily substances) trapped in the soil pores were visible at MW 44, 20, TP1 (45), MW22, TH 55, MW 3, TP 3 (#47), MW 8, TH 36, 24, MW 41, TP 2 (#46), MW 4, TH 37, MW 7, MW 38, 25, TH 42, MW 6, 11, 27, TH 39, MW 12, TH 28, 33, 31, MW 32, 30, 29 and TP 4 (#48) and TH 56. These oily substances were generally encountered in the surficial fill, the underlying saturated sands, silts and silty clays, and limited to the upper 11' or so of the soil profile, with the exception of TH 37 where the black oily soils were detected to 14.5' from grade.

Besides the oily substances, sand saturated with flammable gasoline was encountered in MW 2, 13, 50 & 53.

4.4 Vapour Phase Hydrocarbons (Soil Vapours)

Flammable vapour concentrations measured in the soil samples from the testholes and monitoring wells are given in the testhole logs, Plate 2 to 61, and in Table B appended. Flammable soil vapours of significance were detected at MW 2, 3, 4, 13, 17, 19, 20, 21, 22, 29, 38, 41, 44, 50, 51, 51, 53, 54, TH 37, 39, 42, 43 & 56, and the "CP" pipe (Plate 1) put down by others. These elevated flammable soil vapours were originated from either the free phase or absorbed phase hydrocarbons, and were identified mainly within the surficial fill and the underlying glaciolacustrine sands, silts and silty clays.

The vapour concentrations in the clay till were usually low and near the background levels. A plot of the flammable soil vapour concentrations versus geodetic elevations is shown on Plate B4-Table B. From this plot, soil vapours of 1000 ppm or greater are generally located between elevation 1278 & 1290'. Comparing this lower elevation of 1278' with the clay till surface contour map on Plate 70, it is evident that soil vapours of significance are primarily located above the clay till surface, in the surficial fill, sand, silt and clay deposits.

The highest vapour levels (i.e. 100% LEL - Lower Explosive Limit, or 11,000 ppm) in the soil samples were identified in MW 13, 50, 52 & 53 (i.e. areas immediately north of the Canadian Tire store, the parking lot and the gasoline retail outlet) & TH 39 (near the southerly end of the tankage area of the old refinery). The 2nd highest vapour levels (5000 - 8000 ppm) in the soil samples were detected at MW 22, 38, TH 42 & 56.

The flammable vapour concentrations (expressed as % LEL or gasoline vapour in ppm) measured inside the monitoring wells, during the period between October 21, 1989 and May 16, 1990 are illustrated on Plate 62 to 67.

It should be noted that the flammable vapours presented on Plate 62 to 64 are related to gasoline. These flammable vapours had been qualitatively and quantitatively confirmed using the Gastec gasoline detection tubes and sampling pump. As shown on Plate 64, there is a distinct gasoline vapour plume well defined by MW 53, 50, 13 & 2. Plate 64 also shows that the gasoline vapours in MW 51 & 21 in the westerly portion of the north property line are relatively high (4000 to 6250 ppm), revealing the possible migration of a different gasoline vapour plume into the Canadian Tire property from the north.

Plate 65 to 67 present the total concentrations of flammable soil vapours determined by our hydrocarbon surveyor. The surveyor will not differentiate the type of vapour being measured. Therefore, the measured flammable vapour concentrations may be related to varying types of hydrocarbons present in the subsoils. For an example, the vapour measurements from May 8 to 16, 1990 in MW 51 were 11,000 ppm by the hydrocarbon surveyor, and only 4000 ppm by the gasoline detection tube. This implies that there are other types of hydrocarbon vapours inside MW 51. On the basis of vapour analysis conducted by the Manitoba Research Council as explained later, methane gas is a major component of the measured flammable vapours inside the monitoring wells, where the % LEL reading is not consistent with the gasoline vapour concentration determined by a gasoline detection tube.

It should be appreciated that a high ground water table in a monitoring well will prevent an accurate measurement of the soil vapours at depth, as the water will act as a barrier preventing the flammable vapours of the submerged portion of the contaminated soils from entering the monitoring well. Consequently, only a low vapour reading may be recorded inside the monitoring well, when the heavily contaminated subsoils are submerged below the high ground water table. Therefore, the total vapour concentrations measured inside a given monitoring well, have to be compared with those of the soil samples obtained at varying depths from the same well, to determine the source and vertical extent of the soil vapour pollution.

Because of the high ground water tables measured on May 16, 1990, the east limit of the 1000 ppm gasoline contour on Plate 64, and the flammable vapour contours in terms of % LEL on Plate 67 are not considered representative of the actual soil vapour distribution in the easterly one half of the site.

In our opinion, Plate 64 (except the east portion of the 1000 ppm contour), 65 and 67 (except the easterly portion of the %LEL contours, east of MW 19, 41 & 3) are more representative of the distribution of flammable vapours (i.e. gasoline, methane, ethane, etc.) at this site. Please note that MW 3 is no longer useful for contaminant monitoring, as it had been damaged by the snow clearing crew for the CTC store since February 22, 1990.

Significant findings from Plate 62 to 67 relative to the flammable soil vapours are summarized below:

4.4a The entire Canadian Tire Store is presently surrounded by flammable soil vapours well in excess of the lower explosive limit (greater than 100% LEL).

4.4b On the south side of the store and in the south paved parking lot, the soil vapours are mainly volatile gasoline which has migrated to MW 2. On May 16, 1990, readings of 100% LEL were recorded by the hydrocarbon surveyor at MW 13, 50, 53 & 2, which were consistent with the gasoline vapour readings of more than 12,000 ppm determined by the Gastec gasoline detection tubes inside the same monitoring wells.

4.4c On the west side (TH 56), north side (MW 52, 51, 21, 44 & 20) and east side (MW 4 & 41) of the store, all soil vapours measured by the hydrocarbon surveyor exceeded 100% LEL, but they ranged only from approximately 1000 (MW 4) to 6250 ppm (MW 21) in terms of gasoline vapour in air, as detected by the Gastec gasoline detection tubes. This implies that there are other types of flammable soil vapours inside the monitoring wells in question. It can be inferred from the soil vapour analysis by the Manitoba Research Council that flammable methane gas is the major component of the soil vapours detected on the west, north and east sides of the Canadian Tire Store. An exception to this appears to be located at MW 21 and 51 where the gasoline vapour concentrations were relatively high (4000 to 6250 ppm).

4.4d There is a distinct stream of hydrocarbon vapour (greater than 100% LEL) migrating across the Canadian Tire property in a northwest - southeast direction, towards the marsh (Plate 65). Apart from the monitoring wells noted in item 4.4c above, 100% LEL flammable soil vapours were detected at MW 38, the CP pipe, TH 39 & MW 29 (near the southeast corner of the property). These soil vapours are mainly methane gas (especially at MW 29), with nominal concentrations of gasoline vapour.

4.4e As of May 16, 1990, low flammable soil vapours (less than 1000 ppm of gasoline vapour, or not more than 10% LEL) were identified in the area approximately south of MW 1, 5, 6 and west of MW 30, and a polygon bordered by TH 55, MW 8, MW 7, MW 12 to the west, TH 23 to the north, TH 28 to the south and 14th Street to the east.

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4.5 Dissolved Phase Hydrocarbons

The results of hydrochemical analyses performed on the ground water samples obtained from MW 1, 2, 4, 9, 13, 22, 29 & TP 2(#46) are in Appendix C. These water samples were taken from the most contaminated areas, except MW 9 where it appeared relatively clean, on a visual basis. As per our terms of reference for the studies to-date, only 5 mayor ground water contamination indicators were selected for the analyses. The ranges of measured concentrations are tabulated in Table 4.5 below, in conjunction with the Canadian Drinking Water and Province of Quebec Guidelines. The Manitoba Environment Department (MED) does not have specific guidelines for contaminated sites and at present, generally follows the Quebec and British Columbia guidelines.

TABLE
HYDROCHEMICAL DATA SUMMARY

Indicators	Measured Concentrations Upper Bound	Lower Bound	Contamination Guideline Canadian D.W.	Quebec
Phenol	.54 mg/l	<.1 mg/l	.002 mg/l	.003-.02 mg/l
Benzene	.11	<.1	-	.001-.005
Toluene	.32	<.1	-	.05 -.1
Xylene	.74	<.1	-	.02-.06
Petroleum Hydrocarbon (as oil & grease)	177,600 ppm	3.3 ppm	-	1 - 5 ppm

The following findings are considered significant, as may be inferred from the hydrochemical analyses summarized in Table 4.5 above and our observations from the test drilling in the field:

4.5a The measured phenol concentrations in all 8 sampling locations exceeded both the Canadian Drinking Water and Province of Quebec Guidelines. The most significant phenol concentrations were detected at MW 4 (0.4 mg/l - east of the CTC store), MW 13 (0.48 mg/l - south of the CTC store in the parking lot) and MW 22 (0.54 mg/l - at the north property line and to the northeast of the CTC store). However, the measured phenol concentrations did not exceed the health criterion of 3.5 mg/l set out by the U.S. Environmental Protection Agency (EPA).

4.5b Although dissolved petroleum hydrocarbons were encountered in all 8 water samples, detectable concentrations (i.e. >0.1 mg/l) were only encountered at MW 13 for benzene (.11 mg/l), toluene (.32 mg/l) and xylene (.74 mg/l), at TP 2(#46) for xylene (.68 mg/l), at MW 4 for toluene (.1 mg/l) and xylene (.4 mg/l).

4.5c At MW 22, very high concentrations of extractable petroleum hydrocarbon (22,000 ppm), phenol (0.54 ppm), and low concentrations of benzene, toluene and xylene were detected. These and the results of the GC (gas chromatography) analyses (MRC letter dated February 21, 1990 - Appendix C) would tend to show that the ground water contamination at MW 22 is mainly related to diesel fuel.

4.5d The APL (aqueous phase liquid) had migrated beyond the Canadian Tire property, through the existing swamp (area H-Plate 1A) and into the vacant swampy land (i.e. area G - Plate 1A), and the southwest corner of the lumber yard and light industrial development (area E - Plate 1A). In addition, the APL could have also migrated seasonally toward the north and northwest, beyond the north property line in the Spring months. Without extra boreholes being drilled off site and the hydrochemical analyses of additional water samples, the aerial extent of the dissolved phase of the hydrocarbon plume cannot be accurately defined.

4.6 Direction of Ground Water Flow

Contours of the ground water surface elevations (i.e. the piezometric surface elevations of the shallow, unconfined aquifer of the surficial, glaciolacustrine sands, silts and silty clays located above the clay till) measured on January 19, 1990, and May 16, 1990 are indicated on Plate 69 & 68, respectively.

4.6a Fall & Winter Months

It can be inferred from Plate 69 that in the Fall and Winter months, the principal direction of ground water flow runs from northwest to southeast, with the southeast corner (i.e. near MW 29) of the property being the outlet of the water flow. Existing information tends to suggest that as the ground water passes through the southeast corner of the CTC property, the flow direction changes from southeast to east.

Locally, there are minor directions of ground water flows. These include a flow from north to south, through the CTC store to the south parking lot, a flow from the CTC gas bar in a southwest - northeast or east direction, etc. (Plate 69).

4.6b <u>Spring Months</u>

Plate 68 presents the contours of ground water elevations of the site in the spring months. Due to a sharp rise in the ground water tables at MW 4 and 19 (probably resulting from the "snowmelt" runoff of the CTC parking lot and the surface water infiltration in the recharge areas situated north of the north property limit), the ground water flow changes its course into three directions as follows:

- From the high point of MW 4 & 19, the first flow direction goes southeast toward the marsh.

- The second flow direction runs approximately in a northwest-southeast direction, from MW 13 toward MW 2.

- A fairly steep hydraulic gradient exists at MW 3 & MW 8, which creates a third flow direction, from MW 3 & MW 8 toward MW 22 and varying from northeast to north.

4.6c <u>Contaminant Migration</u>

The migration of contaminants is largely governed by the hydraulic gradient, rate and direction of ground water flow. In this regard, it can be readily seen from Plate 68 that the <u>change</u> in the ground water flow direction is responsible for the disappearance of the diesel fuel in MW 22, on May 16, 1990. As discussed earlier, the diesel fuel in MW 22 had been pushed back into the Petro-Canada property or the car dealership site to the north, by the <u>reverse</u> ground water flow created in the early spring.

In addition, the steep hydraulic gradient of the second ground water flow described in 4.6b above had moved the free phase gasoline liquid from MW 13 to MW 2. The fact that the free phase gasoline (measured on May 16, 1990) was of a film thickness at MW 13 and only 3" at MW 2, would indicate that a majority of the liquid gasoline had degradated or vaporized into the subsoils, as it migrated from northwest to southeast.

It is of interest to note on Plate 64 that the transport of the gasoline plume is mainly in the form of <u>advection</u>, although some from of dispersion from MW 53 toward MW 50 is evident. A review of the as-built drawings show that an old sewer, running roughly south - north, enters the CTC store near MW 50, and that the CTC store and gas bar are connected with several buried utility lines. The trenches of these buried utilities will act as the preferential paths for contaminant movements, and thus lead to a dispersion of the gasoline plume, toward the northeast and into the CTC store.

4.7 Soil Vapour Chemistry

Air samples obtained from MW 44, 20 & 29 were analyzed to determine the types of flammable vapours present inside the pipes. In addition, extra air samples using charcoal tubes were recovered from MW 21, 44, 20, 22, 38 and the CP pipe. Among these charcoal samples, MW 20, 29 and the CP pipe were selected and analyzed for the presence of volatile gasoline vapour.

All relevant vapour chemistry results are given in the Manitoba Research Council (MRC) letters dated February 23 and 28, 1990, in Appendix C. The following can be inferred from the MRC analyses:

4.7a Analyses of the air bulb samples from MW 44, 20 & 29 show that the flammable soil vapours in MW 20 & 44 mainly consist of methane (14,000 and 4300 ppm respectively) and ethane (41 and 14.4 ppm respectively), and that only methane gas (2300 ppm) was detected in MW 29.

The foregoing test results indicate that the source of methane is not related to the nearby commercial natural gas line which runs parallel to the north property line. This statement is further substantiated by the verbal results of additional air sampling, testing and test pit digging, from Mr. Andrew Chizick of the gas company (ICG). Mr. Chizick verbally confirmed to the writer that no leak was found in the ICG gas line, and that during the testpit digging on the north side of MW 44 (Plate D8, Appendix D) and at the junction of the gas line and the lateral to the CTC store (Plate D9, Appendix D), soils saturated with hydrocarbons and strong petroleum odour were encountered.

4.7b The charcoal tube samples of MW 20, 29 and the CP pipe, analyzed by gas chromatography, show hydrocarbons primarily in the C5 - C6 ranges, which are consistent with the volatile components of a gasoline.

4.8 Indoor Hydrocarbon Vapour Monitoring

The areas of complaint for bad odour are shown on Plate D1 to D4, Appendix D. In discussion with Mr. Cruse, the Assistant Manager of the store and the night cleaner, we were advised that the bad odour mainly came from the lady washroom located on the main floor, and the vestibule at the auto centre entrance, and that bad odour sometimes occurred at the east stairwell and the general office area located outside the computer room on the mezzanine floor.

Our "walk through" inspection and indoor vapour monitoring of the complaint areas, show minor flammable hydrocarbon vapours (25 to 50 ppm from the floor drains in the man and lady washrooms on the main floor). Bad odour was only detected inside the vestibule located at the auto centre entrance. The "sewage-like" odour came from a metal grille mounted on the floor. Inside the auto service bays, more significant flammable soil vapours (100 to 200 ppm) were detected at a number of locations near the east and north walls where annular spaces existed between the existing vertical pipes and openings in the concrete floor. The flammable soil vapours entered the service bays from these annular spaces. Unless otherwise stated above, flammable hydrocarbon vapours of any significance were not encountered in the remainder of the store.

On the basis of the inspection and air monitoring results, we are of the opinion that the bad odour in the areas of complaint was mainly related to poor ventilation, and the occurrence of sulphate and sulfide substances which are normally expected in sanitary sewer pipes.

Considering the history of the site and the presence of very high concentrations of flammable hydrocarbon vapours outside the store, the bad odour may have been produced by degradation of residual hydrocarbons trapped in the subsoils. This smelly odour could simply follow the sewer trench and enter the washrooms at locations of floor drains. As a precaution, provisions had been recommended on May 8, 1990, to the management of the CTC store in Brandon, which should be maintained on an ongoing basis:

4.8a The floor drains of the man and lady washrooms on the main floor should be thoroughly flushed and cleaned out on a regular basis. The pit and pipe clean out under the metal grille of the vestibule at the Auto centre entrance, should be thoroughly cleaned and maintained frequently, as well.

4.8b To prevent any flammable or health threatening soil gases from entering the store, the floor drains in both the man & lady washrooms on the main floor should be kept full of water by the night cleaner daily. Alternatively, these two floor drains should be kept <u>air tight by some means</u>, when they are not in use. In addition, <u>a positive pressure must be maintained inside the areas of complaint</u>, by keeping open the doors of the said washrooms and the inner door of the vestibule after store hours at night, and blowing air continuously into the problem areas with 2 to 3 powerful fans for at least 8 hours very night. This procedure will, on a temporary basis, effectively push any undesirable soil gases back into the subsoils and away from the complaint area.

4.8c The existing annular spaces between the vertical pipes and openings in the concrete floor of the auto service bays should be properly sealed, to prevent further infiltration of flammable soil vapours into the store. Apart from the auto service centre, regular inspection of the concrete floor, the joints along the perimeter walls of the remainder of the store and all service entry points into the building should be undertaken. Any obvious cracks or unnecessary openings in the concrete floor should be properly grouted and sealed immediately.

4.9 Soil Chemistry

Soil samples taken from MW 4, 6, 8, 12, TP1 (#45), TP2(#46), MW 22 & M 29 were analyzed for 3 indicators (i.e. PH, Lead, Petroleum Hydrocarbons as Oil & Grease) of the soil clean up criteria for <u>commercial and industrial land use</u>, which are applicable in the Province of Quebec, Province of Ontario, and to refineries in Canada. For immediate reference, the analytical data from MRC (Letter dated February 21, 1990, Appendix C) are tabulated against the soil clean up criteria, in Table 4.9 below:

TABLE 4.9
SOIL CHEMISTRY DATA

Indicators	Concentrations Upper	Lower	Soil Clean Up Criteria Quebec	Ontario	Can. Refineries
PH	8.91	6.57	-	6 - 8	6 - 8
Lead	10	3ppm	200-600	750-1000	1000ppm
Petroleum Hydrocarbon	21.5%	0.017%	0.1-0.5%	1-2%	2%

Based on Table 4.9 and the soil chemistry data determined by MRC, the following findings are considered significant:

4.9a The PH values of all the tested soil samples were within the clean up criteria, except the sample of MW 29 (between 8-10') of which the PH has exceeded the upper criterion of 8 by 0.91 or 11%.

4.9b For the total extractable petroleum hydrocarbons as oil and grease, the soil samples of MW 6, MW 8, TP 1, MW 22 & 29 did not exceed the comparable clean up criteria. However, the soil samples at MW 4(4' - 98.2%) and MW 12 (0' - 21.5%) had exceeded all the three comparable clean up criteria. The soil sample of TP 2 (7' - 1.47%) also exceeded the Quebec criteria.

4.9c The soil sample of MW 12 (0') shows hydrocarbons in the C14 to 30 range, whereas the sample of MW 4 (4') indicates lighter hydrocarbons, from C10 to C22.

4.9d The soil samples of TP 1 (black oily soil at 9.7') and TP 2 (black oily soil at 7') show significant amounts of hydrocarbons, in a higher boiling point range/molecular weight than would be typical of a diesel fuel. Relatively, the sample of TP 2 is heavier and has higher molecular weight components than those of TP 1. Our visual observations suggest that these black hydrocarbons at TP 1 & 2 are DNAPLs (dense non aqueous phase liquids). The verification of the exact types of these DNAPLs will require more sophisticate chemical analysis.

5.0 DISCUSSION & CONCLUSIONS

Based on the results of the Stage 1 to 4 studies, the following conclusions may be drawn:

5.1 There is a serious problem of hydrocarbon contamination in the subsoils and groundwater at the Canadian Tire property in Brandon. The contamination problem is wide spread and laterally involves almost 95% of the entire site, including the existing Canadian Tire Store and gas bar. Only a limited number of monitoring wells and testholes do not contain visible black oily soils nor significant levels of flammable vapours (i.e. MW 9, 10, 15 & 18, TH 14, MW 15, TH 16, 34 & 35).

Vertically, the contaminants are mainly located in the surficial fill, sand, silt and silty clay, some 11 to 14.5' (TH 37 only) from grade. The vertical contamination is considerably deeper than that estimated in Stage 1.

Laterally, the heavily contaminated areas in terms of APL, LNAPL, DNAPL and flammable soil vapours are defined by the two 10% LEL contour lines, the north and west property lines as shown on Plate 65. These [illegible] large diameter hydrocarbon storage tanks, during the operational period of the old refinery (Plate A1, Appendix A).

The moderately to heavily contaminated areas are located to the west of the existing marsh, between MW6, MW 32 and MW 30, and between MW 12, TH 28, MW 27, MW 25 and MW 11 to the northeast of the marsh. These areas do not contain significantly high concentrations of flammable soil vapours, and are known to have been used as a bunker oil storage lagoon in the past. The petroleum hydrocarbons (black and dark brown to black colour oil and fuel) trapped in the subsoils are quite high. The exact types of hydrocarbons present in the subsoils are not well understood at present, but they can be determined by performing more advanced chemical analysis. The site history is such that bunker oil, light aliphatic hydrocarbons and PAH (polycyclic aromatic hydrocarbons) would be present in the contaminated subsoils.

Two areas are slightly contaminated. The first area is located south of the southerly 10% LEL contour line (Plate 65), between MW 1, 15, 18 & 32. The second area is bordered by MW 23, TH 55 to the north, MW 25 to the south, MW 7 & 8 to the west and the east property line (Plate 65).

5.2 The ground water under the entire site has been contaminated with various hydrocarbons (free or dissolved phase) and phenolic compounds. The dissolved constituents with concentrations exceeding the Canadian Drinking Water Guidelines, have already migrated off site, primarily to the southeast and east.

Due to the fact that municipal services are available within at least 1000' of the CTC site and that the water wells in the immediate vicinity of the site are mainly utilized for irrigation purpose, the contaminants in the ground water of the CTC site are not expected, on a short term basis, to adversely affect the intended use and quality of the nearby wells. However, existing information shows that drinking water wells are situated within about 1500' from the site, and as such, unless the polluted aquifer is rehabilitated, long term off-site migration of the contaminants to these drinking wells cannot be ruled out.

5.3 Of greatest concern at present, is the very high concentrations of flammable soil vapours (i.e. gasoline and methane) detected in the immediate vicinity of the Canadian Tire Store, and the presence of volatile liquid gasoline at MW 13 & 2 in the south parking lot and the proposed development area further to the south. To avoid a fire hazard and for safety and health reasons, we strongly recommend that recovery wells be immediately installed to capture the liquid gasoline plume, and that an active vapour extraction system be immediately installed in the vicinity of the Canadian Tire Store and gas bar, to properly control the subsurface flammable vapours. We can provide design details and implement the installation of the vapour management system, based on an additional study.

5.4 The prime suspect for the liquid gasoline contamination at MW 13 & 2 is the existing Canadian Tire gas bar, where leakage from the tankage area during construction has been reported.

5.5 Judging the subsoil stratigraphy and the ground water flow, the mixture of diesel fuel and gasoline liquid identified at MW 22 in the Canadian Tire property is considered to have been originated from the Petro-Canada tank farm situated immediately to the north. It is known that the Petro-Canada tank farm is a major retail outlet for diesel fuel, leaded and unleaded gasoline. The disappearance of this mixed liquid on May 16, 1990 is mainly due to the change in the direction of the ground water flow, which has probably pushed the free phase hydrocarbons back into the Petro-Canada property or the Car Dealership site.

5.6 The very high concentrations of <u>methane gas (100% LEL)</u> present to the north and east of the Canadian Tire Store, including the fairly narrow vapour stream (Plate 65) through MW 41, MW 4, MW 38, the CP pipe and MW 29, are considered to have been caused by the <u>long term degradation of hydrocarbons</u> (especially gasoline). Recent environmental research has shown that under certain bacteria actions, petroleum hydrocarbons trapped in the soil pores can degrade into methane and carbon dioxide, with time. The occurrence of methane gas may also related to natural cause (i.e. decomposition of natural organic materials). However, the amount of organic materials identified in the monitoring wells, testholes and testpits are such that the very high concentrations of methane gas detected at this site are <u>not</u> associated with natural causes but petroleum hydrocarbons.

The most logical source of the hydrocarbons would be the past spills from the old refinery storage tanks located within the Canadian Tire property. However, considering the soil and ground water conditions, the presence of significant residual hydrocarbons at the <u>most northwesterly portion of the CTC site</u> (i.e. area of MW 44, 21 & 51), may have been caused by past or present surface spills or leakage of buried pipes and tanks from the Petro-Canada property to the north. The existence of subsoils heavily saturated with hydrocarbons along the north property line between MW 22 and MW 21, the relatively high gasoline vapours (4000 to 6250 ppm) detected at MW 21 & 51, and the presence of free phase hydrocarbons (i.e. a mixture of diesel fuel and gasoline) at MW 22 are indicators of probable hydrocarbon migration into the subject site from the Petro-Canada property.

It should be noted that the ground surface in the areas of the Petro-Canada tank farm and loading racks are not paved (Plate D8 & D9, Appendix D) and as such, any daily minor surface spill can eventually accumulate a large quantity of subsurface hydrocarbons which will follow the direction of the ground water flow and migrate into the CTC property.

To confirm this thought, test drilling will have to be undertaken in the Petro-Canada property. The Manitoba Environment Department may be approached for assistance in this regard.

5.7 Unless a proper <u>containment</u> system can be installed along the north property line, there will always be a serious threat on any development in the CTC property, due to the migration of hydrocarbon and flammable vapours associated with probable new leak from the north. For this reason, any new buildings should be located away from the preferential paths (i.e. area located east of the CTC store and west of MW 8, 7, 12 & 29) of the soil vapours shown on Plate 65. In our opinion, the area of the preferential paths (i.e. area inside the two 10% LEL contour lines - Plate 65) for hydrocarbon migration should be developed as a parking lot or a park only.

5.8 Three parcels of land (Plate 1C) have been identified by us within the CTC property, where there are less environmental impact and are considered suitable for commercial building development, subject to proper foundation design, site drainage, and environmental control such as soil vapour and pungent odour management.

Parcel A (TH 55, MW 23, TH 24, MW 25, TH 34, MW 7 & 8) is slightly contaminated. With the exception of the ground water contaminants and their long term impact on nearby water wells, major site remediation at this location is not expected.

Parcel B (TH 14, MW 5, MW 32, 18 & 15) presently contains a narrow gasoline plume at and north of MW 2, and some oily soils between 7 and 9.5' at MW 32. It is rated as lightly to moderately contaminated.

The implementation of a subsurface vapour management system is regarded essential in this land. Once the subsurface gasoline vapour and liquid are under proper control using our vapour extraction system, this land is considered suitable for commercial development.

Parcel C (MW 25, 27, TH 28, MW 12, 11 & TH 34) is moderately to heavily contaminated with black oily soils (probably related to bunker oil) but it is not subject to any significant concentrations of flammable soil vapours. The significant environmental impact to the new development will be the post construction pungent odour related to the black oily soils. Some form of site remediation (say, excavation and disposal, pump & treat, bio-remediation, hot steam extraction, etc.) may be required. However, it is also possible to install a permanent odour and vapour management system below the building floor and strengthen the building ventilation system, in order to eliminate the potential odour problem. The final remediation alternative may require input from the Manitoba Environment Department.

5.9 A deep foundation system was previously suggested in our stage 1 report, for moderately to heavily loaded buildings. Due to the discovery of extensive hydrocarbons (APL, LNAPL & DNAPL) in the surficial fills, sands, silts and silty clays situated above the relatively impermeable clay till, deep foundation units should not be used at this location, to avoid possible cross contamination of the deeper aquifers interbedded with or below the clay till.

Lightly loaded, single storey, basementless, buildings supported on shallow raft foundations bearing on engineered fill would be suitable to Parcel A, B & C at this site. Site stripping requirements and the selection of final finished grade of the site should recognize the spring flood level and the need to minimize subsoil consolidation settlements induced by the new fill surcharge.

5.10 The dense black hydrocarbon encountered at TP 2 is located in close proximity of the CTC buried waste oil tanks, which were replaced approximately in 1988 . The fairly high xylene concentration of this dense black hydrocarbon would tend to suggest that it is an organic solvent.

5.11 A Stage 5 study should be implemented as soon as possible for the following environmental and geotechnical issues:

5.11a Meetings and liaison with representatives of the Manitoba Environment Department to:

- obtain approval for cleaning up the gasoline liquid and vapour surrounding the CTC store, gas bar and parcel B.

- define the need for further field drilling in the Petro-Canada property.

- discuss the site remediation requirements and options for Parcel A, B, C and the need for cleaning up the most contaminated areas which in this report, have been proposed to be used as a parking lot or park.

- the implication of long term off site migration of contaminants upon existing and future ground water users in the general site area.

- identify the location of disposal site for the contaminated soils and water, and the additional parameters/indicators which may have to be tested for the soil and ground water samples.

5.11b Evaluate site remediation alternatives and the associated costs.

5.11c Design, supply and installation of a vapour extraction system at the site to remove flammable vapours around the CTC store, gas bar and parcel B. Provide system monitoring and maintenance on a monthly basis.

5.11d Provide a final geotechnical and environmental report covering the design of foundations, floor slabs, pavements, site drainage, details on the under floor liner and collection system for disposing soil vapours, as well as other pertinent geotechnical and environmental related matters.

6.0 FINAL REMARKS

This report has been prepared for the exclusive use of Canadian Tire Corporation Limited, and any copying and reproduction of this report without the consent of Geokwan Engineering Ltd. is strictly prohibited.

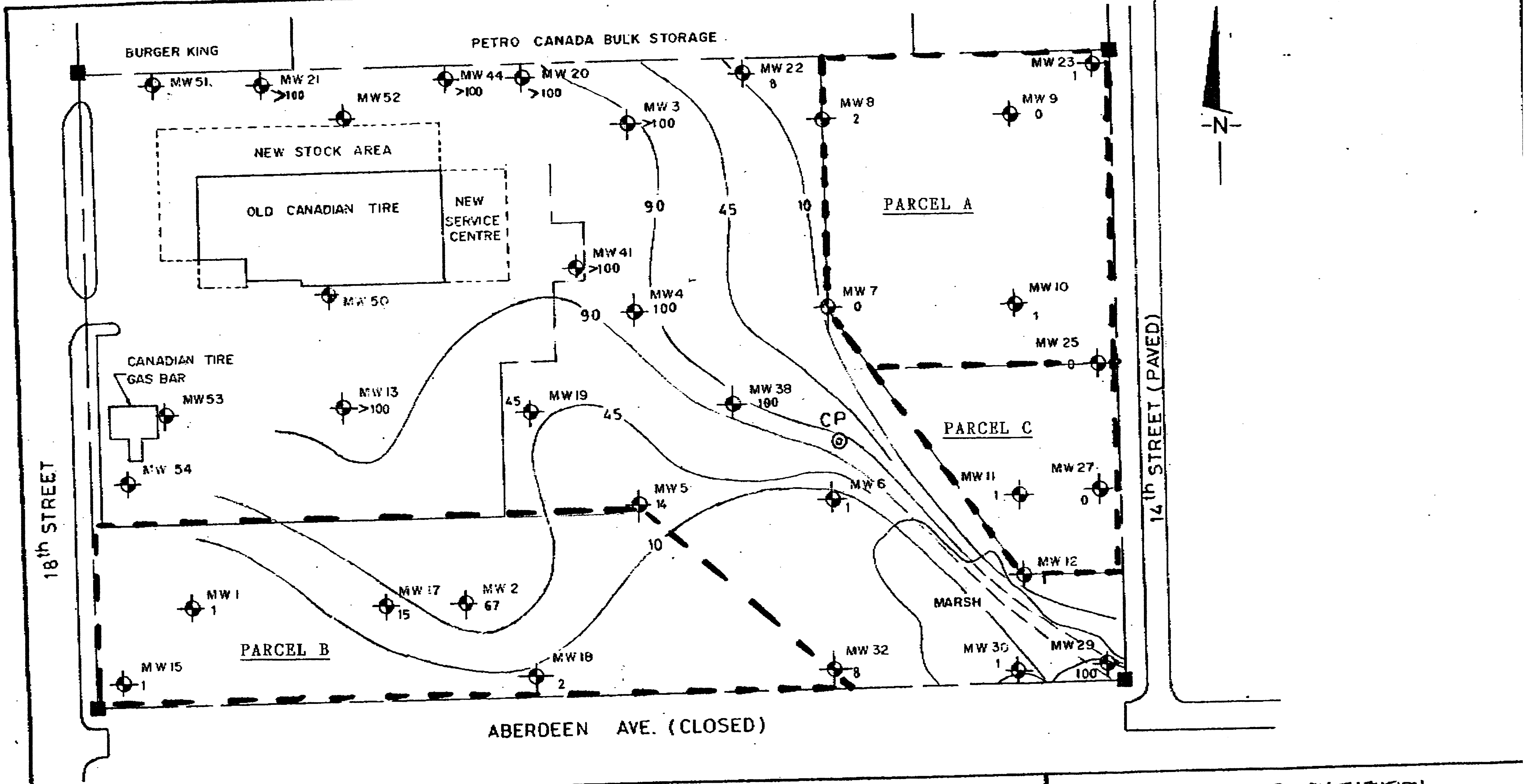
The information contained in this report is considered representative of the general environmental conditions at the site. Should there be any queries, please contact the writer.

Respectfully submitted,

GEOKWAN ENGINEERING LTD.
Per:

Walter Kwan, M. Eng., P. Eng.

WK:ss Encl.



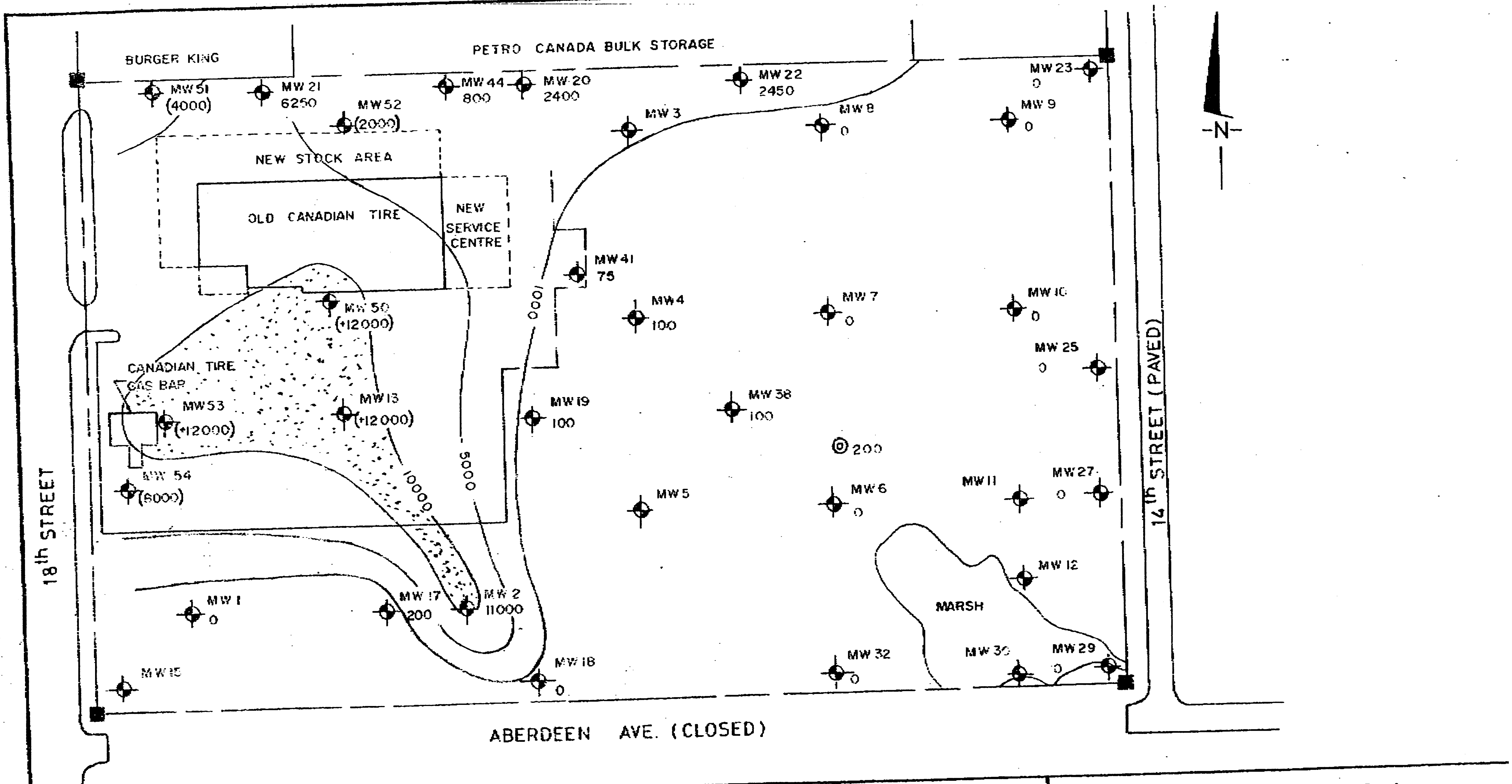
⊚ VAPOUR PIPE DONE BY OTHERS
>100 = FLAMMABLE SOIL VAPOUR CONCENTRATION MEASURED INSIDE THE MONITORING WELL GREATER THAN 100% L.E.L.

Geokwan Engineering Ltd

CONSULTING GEOTECHNICAL ENGINEERS

FLAMMABLE SOIL VAPOUR DISTRIBUTION
% L.E.L. - JANUARY 19, 1990
14TH ST. & ABERDEEN AVE, BRANDON

SCALE: 1"=120'	DATE: 22/05/90	MADE: RK	CHKD.: W K	JOB: 389	PLATE: 1C



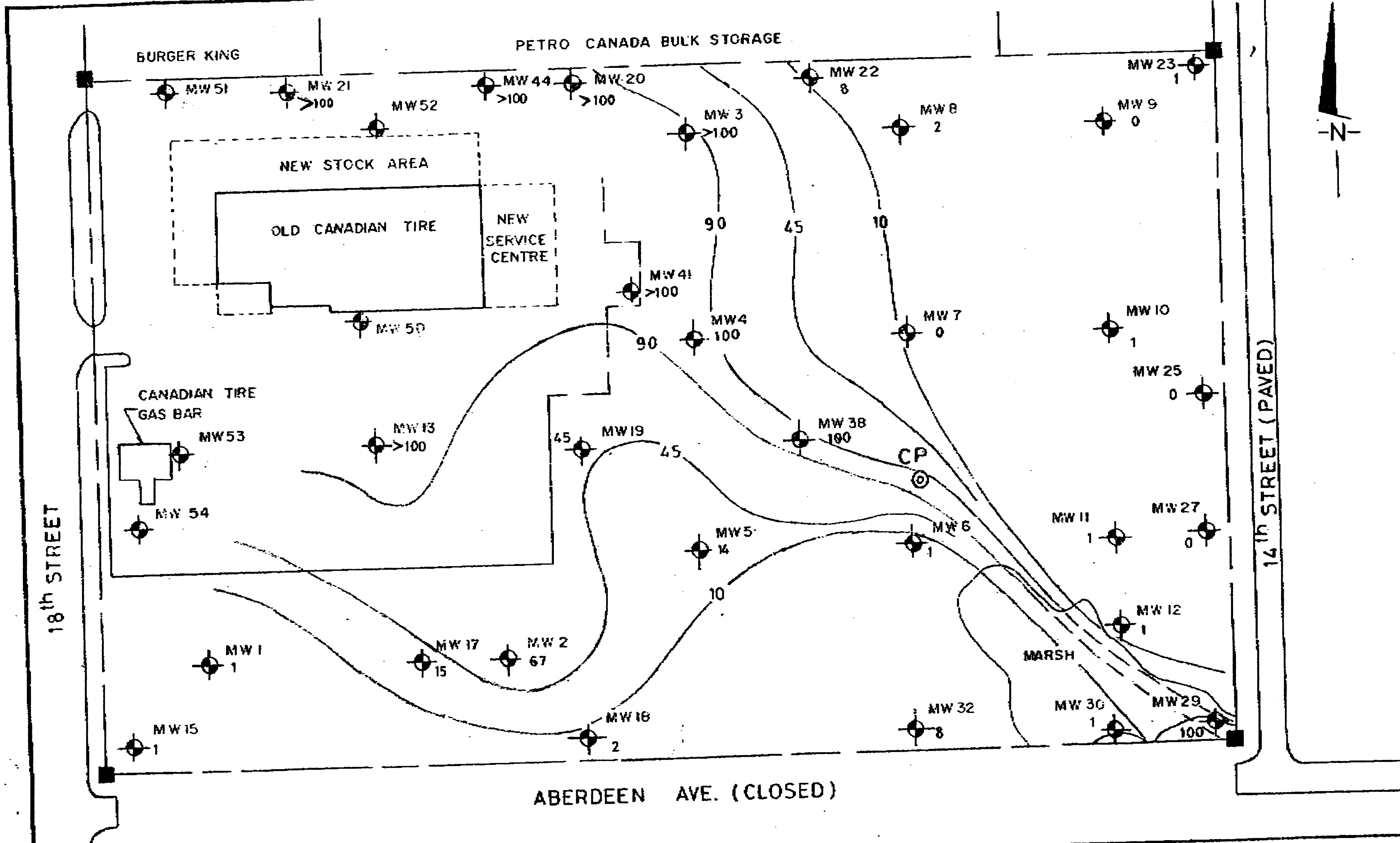
⊚ VAPOUR PIPE DONE BY OTHERS
100 - MAY 8/90 READING (PPM)
(2000) - MAY 16/90 READING (PPM)

Geokwan Engineering Ltd
CONSULTING GEOTECHNICAL ENGINEERS

GASOLINE VAPOUR DISTRIBUTION
MAY 8 & MAY 16, 1990
14TH ST. & ABERDEEN AVE., BRANDON

SCALE: 1"=120' | DATE: 22/05/90 | MADE: RK | CHKD.: W K | JOB: 389 | PLATE: 64

1990-06-22 18:54 001 P08



◎ VAPOUR PIPE DONE BY OTHERS
>100 = FLAMMABLE SOIL VAPOUR CONCENTRATION MEASURED INSIDE THE MONITORING WELL GREATER THAN 100% L.E.L.

Geokwan Engineering Ltd
CONSULTING GEOTECHNICAL ENGINEERS

FLAMMABLE SOIL VAPOUR DISTRIBUTION
% L.E.L. - JANUARY 19, 1990
14TH ST. & ABERDEEN AVE, BRANDON

SCALE: 1"=120'	DATE: 22/05/90	MADE: RK	CHKD.: W K	JOB: 389	PLATE: 65

RECEIVED MAR 1 2 1990

MANITOBA RESEARCH COUNCIL
1329 NIAKWA ROAD EAST
WINNIPEG, MANITOBA R2J 3T4
TEL: (204) 945-6000 FAX (204) 945-1784

RECEIVED MAR 1 2 1990

February 28, 1990

Mr. Walter Kwan
Geokwan Engineering Ltd.
110-1294 Border Street
Winnipeg, Manitoba
R3H 0M7

RE: Hydrocarbon Testing of Soil and Water Samples
Your Project # 389 - Stage 2

Results of tests performed on samples collected February 21, 1990 were given in our report of Feb. 23, 1990. An additional sample was submitted to the laboratory at that time, to be analyzed on request. Results of the sample MW 44 Feb 20, (MRC # 00306), collected in a gas collection bulb, are:

Methane	Ethane
4300 ppm	14.4 ppm

The expected ratio of ethane:methane if the gases were due entirely to commercial natural gas would be in the ratio of 1-4%. The ratio for this sample is 0.33%.

These results indicate that the sole source of methane is not commercial natural gas. However, the methane:ethane ratio could be influenced by the presence of naturally occurring methane, which would reduce this ratio.

G. Lypka
Manager, Environmental and
Analytical Chemistry Services

GL:gb

Project #02482

RECEIVED FEB 2 7 1990

MANITOBA RESEARCH COUNCIL
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February 23, 1990

Mr. Walter Kwan
Geokwan Engineering Ltd.
110-1294 Border Street
Winnipeg, Manitoba
R3H 0M7

RE: <u>Hydrocarbon Testing of Air Samples</u>
<u>Project # 389 - Stage 2</u>

Two air samples in gas collection bulbs and three charcoal air monitoring tubes were received for analysis by MRC on February 21, 1990. The air samples were analyzed for methane and ethane content, with the following results:

MRC #	Sample Description	Methane (ppm)	Ethane (ppm)
00305	MW 20 Feb 20	14,000	41
00306	MW 29 Feb 20	2,300	not detected

The normal ratio for methane:ethane in commercial natural gas is in the range of 1-4%. The results for these samples indicate that the methane is not from a commercial natural gas product. No propane was found in either of the samples.

The compounds collected on the charcoal air monitoring tubes were desorbed by carbon disulfide, with the resulting solutions analyzed by gas chromatography. Results are shown in Figures 1 - 3. These chromatograms all show components corresponding to the more volatile components of gasoline. A sample chromatogram of a liquid gasoline sample (Figure 4) is included for comparison. Figure 5 is a standard mixture of C_5 to C_8 hydrocarbons.

The sampling strategy for collection of organic vapours by charcoal tube was not designed to be quantitative.

RECEIVED FEB 2 7 1990

However, the amounts collected on each of the tubes are relative, as the sampling procedure and systems were similar. Figure 6-8 are chromatograms of the samples run at the same sensitivity. These chromatograms show that the sample with the most hydrocarbon vapour is 00298 (CP), and the sample with the least vapour is 00300 (MW 29), and sample 00299 (MW 20) having an intermediate amount.

The components found in sample 00298 (CP) were further analyzed by a gas chromatography/ mass selective detection. Compounds identified were primarily hydrocarbons in the C_5 - C_6 range, which would be consistent with the volatile components of a gasoline.

G. Lypka
Manager, Environmental and
Analytical Chemistry Services

M. Velpel
Lab Manager, Environmental and
Analytical Chemistry Services

GL:gb

Project #02482

RECEIVED FEB 2 6 1990

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TEL: (204) 945-6000 FAX (204) 945-1784

February 21, 1990

Mr. Walter Kwan
Geokwan Engineering Ltd.
110-1294 Border Street
Winnipeg, Manitoba
R3H 0M7

RE: Hydrocarbon Testing of Soil and Water Samples
Your Project # 389 - Stage 2

Four liquid and four soil samples were received at the Manitoba Research Council January 23, 1990, followed by four liquid samples and two fuel samples on February 9, 1990.

Analysis of the water samples gave the following results.

MRC #	Sample Description	Oil & Grease (ppm)	Phenol (ppm)	Benzene (ppm)	Toluene (ppm)	Xylene (ppm)
00127	TP 2 - 7'	21,500	0.17	< 0.1	< 0.1	0.68
00128	TH 13 - 10'	177,600	0.48	0.11	0.32	0.74
00129	TH 22 - 9'	22,000	0.54	< 0.1	< 0.1	< 0.1
00130	TH 29 - 7'	9	0.17	< 0.1	< 0.1	< 0.1

Samples 00127, 00128, and 00129 consisted of two phases, a bottom water phase and a top hydrocarbon phase. Oil and grease values are for the complete sample, including both phases. Phenol and BTX values are for the aqueous phase only. The top phase from sample 00128 (TH 13 - 10') had a density of 0.802 g/ml, and a viscosity at 40°C of 0.41 cSt. The corresponding values of several common hydrocarbon fuels, as found in Canadian General Standards Board (CGSB) specifications are:

Fuel	Density (g/ml)	Viscosity (cSt at 40°C)
regular gasoline	0.715 - 0.755	-----
premium gasoline	0.730 - 0.780	-----
diesel fuel	0.815 - 0.855	1.3 - 2.4
fuel oil	0.85 - 0.9	1.2 - 5.5

RECEIVED FEB 2 6 1990

The density of the top phase of sample 00128 (TH 13 - 10′) is slightly lower than would be expected for a diesel fuel, but is slightly greater than that of a gasoline. The viscosity is much less than that of diesel fuel.

The hydrocarbon layers of these three samples were analyzed by gas chromatography, with the chromatograms shown in figures 1 - 3. Chromatograms 4 and 5 are of samples of diesel fuel and leaded gasoline, as supplied by Geokwan.

Sample 00127 (TP 2 - 7′) contains hydrocarbons predominately in the C_{14} to C_{22} range, which is a somewhat higher range of hydrocarbons than would be found in diesel fuel.

Sample 00128 (TH 13 - 10′) and 00129 (TH 22 - 9′) show hydrocarbons in the boiling point range for both gasoline and diesel fuel, suggesting a mixture of the two. Sample 00128 (TH 13 - 10′) appears to have a greater proportion of the light end gasoline type hydrocarbons than sample 00129 (TH 22 - 9′).

Comparison of these chromatograms with the chromatograms of the supplied samples of diesel and gasoline show differences in the hydrocarbon distribution patterns. This may be due to aging of the fuels, which will alter the hydrocarbon composition, or may be due to slightly different hydrocarbon compositions of the original fuels.

Comparison of the sample chromatograms with that of a heating fuel oil (figure 6) shows differences in the hydrocarbon profile, with sample 00127 (TP2 - 7′) being a heavier oil, and the sample 00128 and 00129 (TH13 - 10′ and TH22 - 9′) having a much broader range of hydrocarbons than was found for the heating oil.

The freon extracts of the water samples are shown in figures 7 - 10. The hydrocarbon distribution pattern resembles that of the top layer, though has been altered due to solubility characteristics in water. Sample 00130, (TH 29 - 7′) shows no hydrocarbon peaks. This is consistent with the low findings for total oil and grease.

Analysis of the soil samples gave the following results:

MRC #	Sample Description	Oil & Grease (ppm)	pH (1:1 slurry)	Lead (ppm)
00123	TP 1 - 9.7′	1,600	6.57	3
00124	TP 2 - 7′	14,700	6.92	3
00125	TH 22 - 10.8′	710	7.91	3
00136	TH 29 8 - 10′	170	8.91	3

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Values for oil and grease and lead are based on the sample as received, and are not corrected to dry weight.

Figures 11 - 14 are the chromatograms of freon extracts of the soil samples. Samples 00123 and 00124 (TP 1 - 9.7′ and TP 2 - 7′) show significant amounts of hydrocarbons, in a higher boiling point range/ molecular weight than would be typical of diesel fuel. There was also a difference between these two samples, with sample 00124 (TP 2 - 7′) having heavier, or higher molecular weight components that 00123 (TP 1 - 9.7′).

Figures 15 - 17 are chromatograms of the freon extracts of water samples 00254 (TH 20), 00255 (TH 21) and 00257 (TH 44). No hydrocarbons were detected in these samples. Sample 00256 (TH 22) had two distinct phases - a top hydrocarbon layer, comprising approximately one-third of the sample, and a bottom aqueous layer.

The chromatogram of the hydrocarbon layer is shown in Figure 18. The hydrocarbon distribution profile indicates the presence of hydrocarbons in both the diesel and gasoline volatility range, suggesting a mixture of the two.

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