Manitoba Hydro

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Telephone / *N° de téléphone :* (204) 360-3314 • Fax / *N° de télécopieur :* (204) 360-6135
bgill@hydro.mb.ca

2012 07 11

Warren Rospad, B.Sc.
District Supervisor / Environment Officer
Environmental Compliance and Enforcement
Manitoba Conservation & Water Stewardship
Ste.160-123 Main Street
Winnipeg, MB R3C 1A5

Dear Mr. Rospad:

MANITOBA HYDRO SUTHERLAND AVENUE FACILITY: PARKING LOT SINK HOLE REMEDIATION

For your review, Manitoba Hydro is respectfully submitting three copies and an electronic version of our proposed remedial action plan (RAP) to remove a deposit of coal tar present within a limited area in the north parking lot at the Manitoba Hydro Sutherland Avenue Facility in Winnipeg. The RAP document is entitled "*Remedial Action Plan for the Parking Lot Sink Hole at the Former Sutherland Avenue Manufactured Gas Plant Site*".

A sink hole, measuring approximately 100 mm in diameter and coal tar residuals were identified in the Sutherland Avenue Facility north parking lot in July 2010. AECOM Canada Ltd. was retained by Manitoba Hydro to investigate the extent and source of the coal tar deposit, seal the affected area, and to develop a remedial action plan.

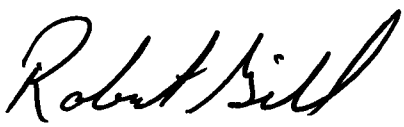
The results of the investigation were submitted to Manitoba Conservation on February 15, 2011. The investigation report is entitled "*Subsurface Investigation: Sink Hole Location in the Parking Lot of the Former Sutherland Avenue Manufactured Gas Plant Site*".

The RAP will involve removing approximately 50 m^3 of soil and coal tar for off-site disposal, and restoring the affected portion of the site.

The Sutherland Avenue Facility and adjacent area will continue to be monitored in accordance with Manitoba Hydro's Long Term Remedial Monitoring Program and with the Manitoba Conservation Director's Order D1-230.

Please contact me at 360-3314 if you would like to discuss this RAP further.

Yours truly,



Robert (Bob) Gill
Senior Environmental Specialist
Environmental Licensing & Protection Department
Power Planning Division
Power Supply

BG/20120711

Att.

Environment

Manitoba Hydro

Remedial Action Plan for the Parking Lot Sink Hole at the Former Sutherland Avenue Manufactured Gas Plant Site

Prepared by:

AECOM
99 Commerce Drive 204 477 5381 tel
Winnipeg, MB, Canada R3P 0Y7 204 284 2040 fax
www.aecom.com

Project Number:

60157798 (402.19.1)

Date:

December 2011

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- may be based on information provided to Consultant which has not been independently verified
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AECOM
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204 284 2040 fax

December 7, 2011

Mr. Bob Gill, M.N.R.M
Senior Environmental Specialist
Manitoba Hydro
360 Portage Avenue
Winnipeg, Manitoba R3C 0G8

Dear Bob:

Project No: **60157798 (402.19.1)**

Regarding: **Remedial Action Plan for the Parking Lot Sink Hole at the Former Sutherland Avenue Manufactured Gas Plant Site**

AECOM Canada Ltd. (AECOM) is pleased to submit the following Remedial Action Plan (RAP) to address the deposit of coal tar encountered in a sink hole present near the northeastern access to the employee parking lot at the former Sutherland Avenue Manufactured Gas Plant site in Winnipeg, Manitoba. The contents of this report are based on the findings of a subsurface investigation undertaken at the site by AECOM in August 2010 and detailed in the report entitled, "*Subsurface Investigation: Sink Hole Location in the Parking Lot of the Former Sutherland Avenue Manufactured Gas Plant Site*", dated January 26, 2011.

Should you have any questions in regards to the information contained within this report, please contact Ms. Andrea Hachkowski, P.Eng. at (780) 486-7060.

Sincerely,
AECOM Canada Ltd.

Tom Wingrove, P.Eng.
Executive Vice President
Deputy Operations Director
North America Environment

AH:dh
Encl.

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
6	2	Manitoba Hydro

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	A.Hachkowski	July 25/2011	Internal draft edits
2	A.Hachkowski	September 9/2011	Manitoba Hydro edits
3	A.Hachkowski	October 25/2011	Manitoba Hydro edits
4	A.Hachkowski	November 25/2011	Manitoba Hydro edits
5	A.Hachkowski	December 7, 2011	Final

AECOM Signatures

Report Prepared By:

Andrea Hachkowski, P.Eng.
Project Engineer
Environment

Report Reviewed By:

Tom Wingrove, P.Eng.
Executive Vice President
Deputy Operations Director
North America, Environment

APEGM
Certificate of Authorization
AECOM Canada Ltd. (MB)
No. 4671 Date: 2011/12/07

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1. Introduction

AECOM Canada Ltd. (AECOM) was retained by Manitoba Hydro to develop an environmental Remedial Action Plan (RAP) to address potential human and ecological health risks associated with a coal tar deposit encountered at 150 mm below the ground surface in an approximate 100 mm diameter sink hole near the Annabella Street (northeast) entrance to the employee parking lot at the former Sutherland Avenue Manufactured Gas Plant (MGP) site in Winnipeg, Manitoba. The location of the sink hole is shown in Figure 1-1.

A subsurface investigation was undertaken at the site in August 2010, with the intent of determining the potential source of the coal tar and delineating its extent. The results of this investigation were presented in an AECOM report entitled, "*Subsurface Investigation: Sink Hole Location in the Parking Lot of the Former Sutherland Avenue Manufactured Gas Plant Site*", and dated January 26, 2011. The findings of the investigation report are summarized in Section 1.1; however, in its entirety, it should be considered a companion to this document.

The purpose of this remedial action plan is to describe activities to be undertaken by Manitoba Hydro, with consultation, cooperation and assistance of Manitoba Conservation, to mitigate the potential environmental impacts associated with the sink hole and associated coal tar deposit. This includes potential human health exposures during remedial activities.

1.1 Background

1.1.1 Site History and Development of the Comprehensive Environmental Management Plan

The former Sutherland Avenue MGP is bordered by Gladstone and Annabella Streets to the west and east, respectively, and to north by Rover Avenue, as shown in Figure 1-1. The former MGP operated from 1883 to 1957, with the first phase of decommissioning beginning in 1959. Manitoba Hydro (and previously Centra Gas Manitoba Inc.) has been conducting environmental investigations at the site on an ongoing basis since 1993, with the intent of characterizing and determining the extent of residual hydrocarbon impacts related to historical coal gas production at the site. The various investigations have identified the presence of polycyclic aromatic hydrocarbons (PAHs), monocyclic aromatic hydrocarbons, such as benzene, toluene, ethylbenzene, and xylenes (BTEX) and petroleum hydrocarbons (PHCs) at concentrations greater than the relevant soil, groundwater, and sediment guidelines established by the Canadian Council of Ministers of the Environment (CCME). Manitoba Conservation formally designated the Sutherland site a "contaminated site" in 1997, emphasizing, in particular, the potential impact of contaminants on freshwater aquatic life in the Red River.

Upon request of Manitoba Conservation, and following extensive additional investigation of the on-site and off-site areas, including the Red River, Manitoba Hydro submitted a Comprehensive Environmental Management Plan (CEMP) for formal review in 2006. The CEMP outlines a scenario in which the contaminants are left in place and that rigorous monitoring is conducted to:

- Provide ongoing assurance that residual contaminants do not pose a threat to human health or the environment;
- Detect and measure any potential changes in conditions on or off site in a timely manner such that an appropriate response is given;
- Implement additional remedial actions if warranted; and
- Manage the site in an environmentally sound and socially responsible manner

Review of the 2006 CEMP was completed by a Technical Advisory Committee (TAC) led by Manitoba Conservation, and composed of representatives from all levels of government. After a series of meetings, which commenced in December 2006, supplemental information and clarifications on information provided in the CEMP was submitted to the TAC and Manitoba Conservation in February 2008.

Manitoba Hydro has been conducting a formal, rigorous monitoring program at the site since 2008, designed to assess contaminant concentrations along major pathways for coal tar constituents, as well as important potential exposure areas. As such, the monitoring program consists of quarterly groundwater monitoring, annual groundwater toxicity testing, annual soil vapour monitoring, and annual sediment and surface water monitoring. Ecological health risks are largely restricted to exposures in the riverine environment. In the context of human health exposures, the primary focus has been on vapour inhalation, based on the lack of usage of domestic groundwater in the vicinity of the site. Human health risks as a result of dermal contact or potential soil ingestion have also been precluded by the presence of asphalt pavement on the majority of the site. The sink hole represents a break in this barrier, however slight. Notwithstanding the shallowness of the coal tar deposit, the exposure potential is considered low. At present, the sink hole is sealed with granular bentonite and concrete.

1.1.2 Observations of Free Phase Product and Sink Hole Investigation

Prior to the observation of coal tar in the sink hole, free-phase product had previously been detected in the soil profile of various test holes/monitoring wells drilled in the western portion of the site, namely in MW-23C, MW-24D, MW-48, MW-51B, MW-62A, MW-63A, MW-64A, and MW-65A (Figure 1-1). The depth of the observed coal tar contamination in these test holes ranged from 2.3 m to 10.7 m below the existing ground surface, and was predominantly localized within the alluvial deposits of finely bedded mix of clay, silt, and sand that are prevalent on the north side of the site. The 2008 update of the CEMP hypothesized that these deposits (and occurrences of free product) may be connected to one another, based on the fact that: (i) the affected test holes were situated parallel to the known direction of groundwater flow; (ii) the more permeable layers were located at similar elevations in the soil profile; and (iii) no coal tar inclusions had been observed in the eastern portion of the site, towards Annabella Street, including MW-50A/B, situated approximately 6 m south of the sink hole location. The observations formed the basis of the work plan for the assessment of the sink hole and the assumption that the coal tar deposit was extremely localized.

Assessment of the sink hole location was completed between August 17 and 19, 2010, and included drilling fourteen (14) test holes, as shown on Figure 1-2, Figure 1-3, and Figure 1-4. Nine (9) soil samples were submitted for laboratory analysis of BTEX, PHC fractions F1 to F4, and PAHs. Soil samples with varied contaminant concentrations, based primarily on visual evidence of contamination, were chosen for analysis in light of the fact that choice of disposal facilities under the most likely remedial scenario (i.e. *ex-situ* remediation or excavation) would be dependent on the level and type of treatment required to sufficiently reduce contaminant concentrations to meet facility licensing requirements. It should be noted that soil headspace concentrations, both combustible, and ionizable were measured during the drilling activities. However, based on the general magnitude of contamination at the site, they are not considered to be as valuable of an assessment tool as visual indicators of anomalies in the soil profile. To this end, all combustible soil vapour concentrations measured in the field were in excess of 100 ppm, which is considered elevated based on the low volatility of coal tar.

As expected, every soil sample contained one (1) or more analytes at a concentration exceeding the applicable environmental and/or human health guideline values. The highest concentrations of contaminants were present in samples obtained from test holes TH-68(SH) and TH-76(SH), which contained visible quantities of coal tar. Soil samples were assessed against the following CCME guidelines:

- **BTEX** - Canadian Environmental Quality Guidelines (CEQG), Updated 2010.
- **PHC** - Canada-Wide Standards (CWS) for PHC in soil, January 2008.
- **PAHs** – Soil Quality Guidelines for the Protection of Environmental and Human Health, October 2008 (Revised 2010).

A full description of the rational for the use of these guidelines and the methodology employed for their implementation is provided in the investigation report. A summary of soil guideline exceedances is provided in Table 1-1, below, and in Figure 1-2, Figure 1-3, and Figure 1-4. The detailed laboratory results have been tabulated in Appendix A (Tables A1 to A5).

Table 1-1: Summary of Soil Guideline Exceedances - August 2010 Sink Hole Investigation

	Contaminant Category/Parameters Exceeding Guidelines			
Sample Identifier	**Volatile Hydrocarbons**	**Extractable Hydrocarbons**	**Carcinogenic PAHs[1]**	**Non-Carcinogenic PAHs**
TH68(SH) – 0.3 m	Benzene, PHC fraction F1	PHC fractions F2, F3, F4	Calculated Total Potency Equivalent (TPE) exceeds CCME guideline for 10^{-5} and 10^{-6} Incremental Lifetime Cancer Risk (ILCR)	Acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, phenanthrene
TH68(SH) - 1.5 m to 2.1 m	Benzene	PHC fractions F2, F3	Calculated TPE exceeds CCME guideline for 10^{-5} and 10^{-6} ILCR	Acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, phenanthrene
TH68(SH) – 5.8 m to 6.1 m	Benzene			Naphthalene, phenanthrene
TH69(SH) – 4.0 m to 4.1 m		PHC fraction F2		Naphthalene, phenanthrene
TH69(SH) – 5.9 m to 6.1 m				Naphthalene, phenanthrene
TH70(SH) – 0.8 m to 1.5 m			Calculated TPE exceeds CCME guideline 10^{-6} ILCR only	Naphthalene, phenanthrene
TH76(SH) – 0.6 m to 0.8 m	Benzene	PHC fractions F2, F3	Calculated TPE exceeds CCME guideline for 10^{-5} and 10^{-6} ILCR	Acenaphthene, acenaphthylene, anthracene, fluoranthene, fluorene, naphthalene, phenanthrene
TH77(SH) – 3.1 m to 3.8 m		PHC fraction F2		Naphthalene, phenanthrene, acenaphthene*, fluorene*
TH77(SH) – 4.4 m to 4.6 m		PHC fraction F2		Naphthalene, phenanthrene, acenaphthene*, fluorene*

Notes:

1. Benzo(a)pyrene TPE is the summation of the concentration of each potentially carcinogenic PAH analyte (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, benzo(g,h,i)perylene, dibenzo(ah)anthracene, and indeno(1,2,3-cd)pyrene) by their respective potency

equivalence factor (PEF). The calculated sum is then multiplied by three (3) to account for uncertainties related to carcinogenicity on coal tar sites. Further detail can be found in the January 26, 2011 investigation report.

As part of the investigation, AECOM also collected ambient air samples in the vicinity of the work area, with the goal of determining the actual airborne concentrations of volatile substances in coal tar and determining whether the odours observed in the parking lot during the investigation translated into a risk to human health. Simultaneous air samples, analysed for BTEX and PAHs, were collected on each of the first two (2) days of investigation. The sampling device was set up on the ledge of one (1) of the site building's windows, approximately 15 m to 20 m from the area of investigation, and 30 m from the staff entrance to the building (Figure 1-1). Meaningful real-time monitoring results could not be obtained (i.e. using a Photoionization detector (PID) or GasTech1238ME combustible vapour analyser) due to the influence of exhaust emissions from the drill rig and on-site generator powering the portable decontamination unit.

Ambient air concentrations were compared to the following guidance:

- Regulation 375/96 Environmental Management Act Contaminated Sites Regulation, British Columbia (BC) MOE, updated October 2010.
- Regulation 419/05 Standards and Point of Impingement Guidelines and Ambient Air Quality Criteria, Ontario Ministry of Environment (MOE), December 2005.
- Winnipeg Ambient Air Quality Data, Manitoba Conservation, 2005.
- Federal Contaminated Site Risk Assessment in Canada Part II: Health Canada Toxicological Reference Values (TRVs), Health Canada, 2004.
- Reference Concentrations from the United States Environmental Protection Agency (US EPA) Integrated Risk Information System (IRIS), 1996.

Concentrations of the majority of the analysed parameters were below the laboratory detection limits, with the following exceptions, shown in Table 1-2, below.

Table 1-2: Summary of Ambient Air Analysis

Sample Name	Run Time	Sample Volume	Detectable Analytes	Analytes in Excess of Guidelines
Ambient #1	366 minutes	3.66 L	Naphthalene Toluene Benzo(g,h,i)perylene Pyrene	Naphthalene
Ambient #2	468 minutes	4.68 L	Naphthalene Toluene	Naphthalene

Of the detected analytes, guidelines in the above list exist for naphthalene and toluene only. Toluene concentrations were well below the guideline values posted by the BC and Ontario MOEs, as well as the Health Canada TRVs. Breakthrough occurred during laboratory quantification of naphthalene; however, the data provided in the laboratory reports were sufficient to determine that the naphthalene concentrations measured on both the first and second days of drilling were in excess of the Ontario and BC guidelines and the US EPA IRIS reference values.

Based on the findings from the closely spaced pattern of test holes drilled at the site in August 2010, the coal tar deposit in the employee parking lot appeared to be localized and of minimal areal extent, estimated at 3 m^2. Its location proximate to the former MGP's rail loadout area indicated that it may be the result of localized spillage or waste disposal.

1.2 Remedial Guidelines

Notwithstanding the low potential for human and ecological exposures, the Sutherland site is significantly contaminated, both in terms of magnitude of contaminant concentrations present and the extent of contamination. Therefore, any expectation to remediate the vicinity of the sink hole to any set of numerical guidelines, risk-based or not, is simply not realistic. The goal of the ex-situ remedial actions described herein is to remove the entirety of the coal tar deposit investigated in 2010, such that upon completion, a new barrier of asphalt pavement can be constructed at the surface of the excavated area.

PLAN

0 25 50 m SCALE 1:2500

LEGEND

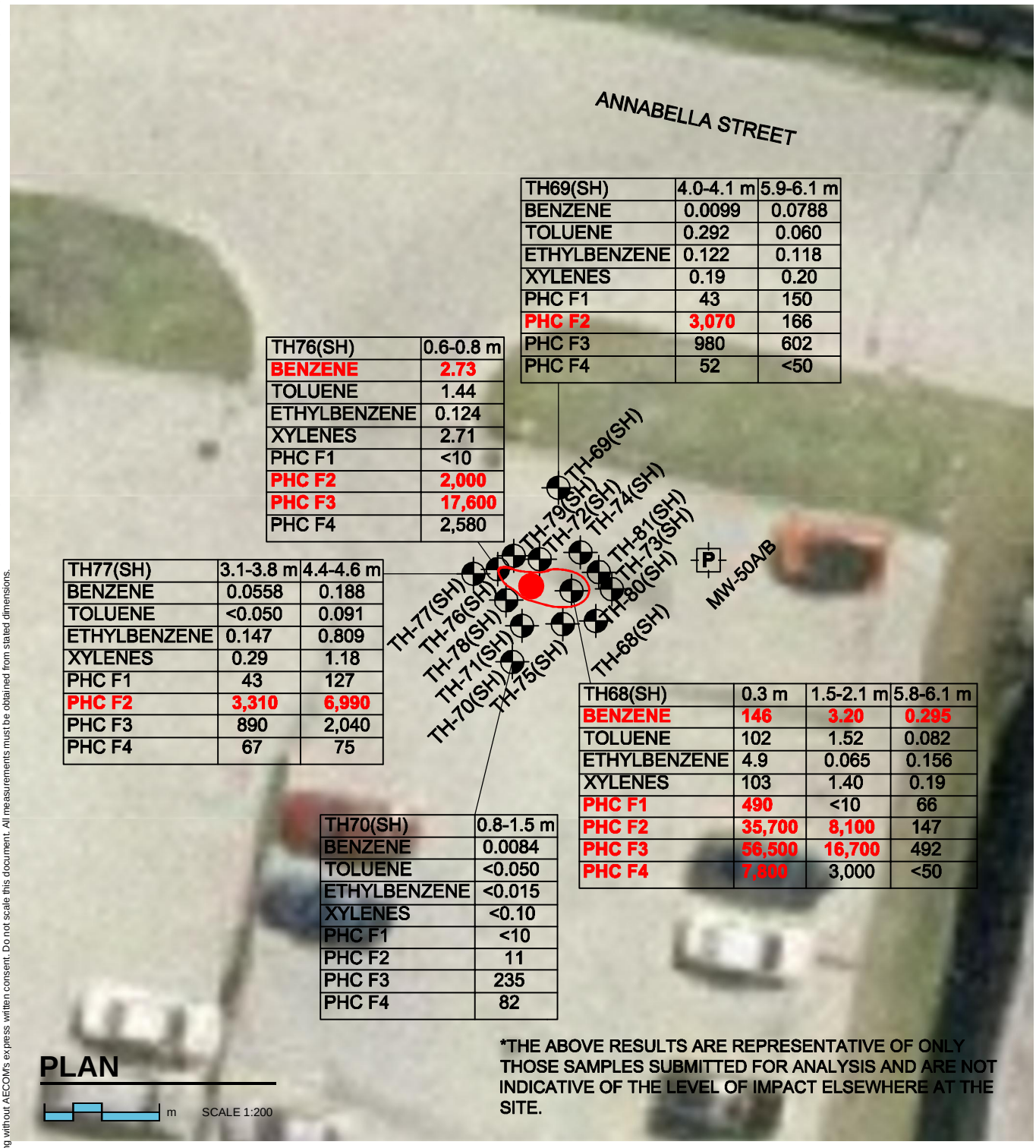
- VAPOUR PROBE LOCATION
- AMBIENT AIR SAMPLING LOCATION
- LOCATION OF GROUNDWATER WELL / NEST

AECOM

Manitoba Hydro
Remedial Action Plan for Parking Lot Sink Hole
Former Sutherland Avenue Manufactured Gas Plant Site

Site Plan

Figure 1-1



PLAN

m SCALE 1:200

*THE ABOVE RESULTS ARE REPRESENTATIVE OF ONLY THOSE SAMPLES SUBMITTED FOR ANALYSIS AND ARE NOT INDICATIVE OF THE LEVEL OF IMPACT ELSEWHERE AT THE SITE.

LEGEND

- P — VAPOUR PROBE LOCATION
- TEST HOLE LOCATION
- ESTIMATED EXTENT OF COAL TAR DEPOSIT
- SINK HOLE

CCME GUIDELINES COMMERCIAL LAND USE, FINE GRAINED SOIL

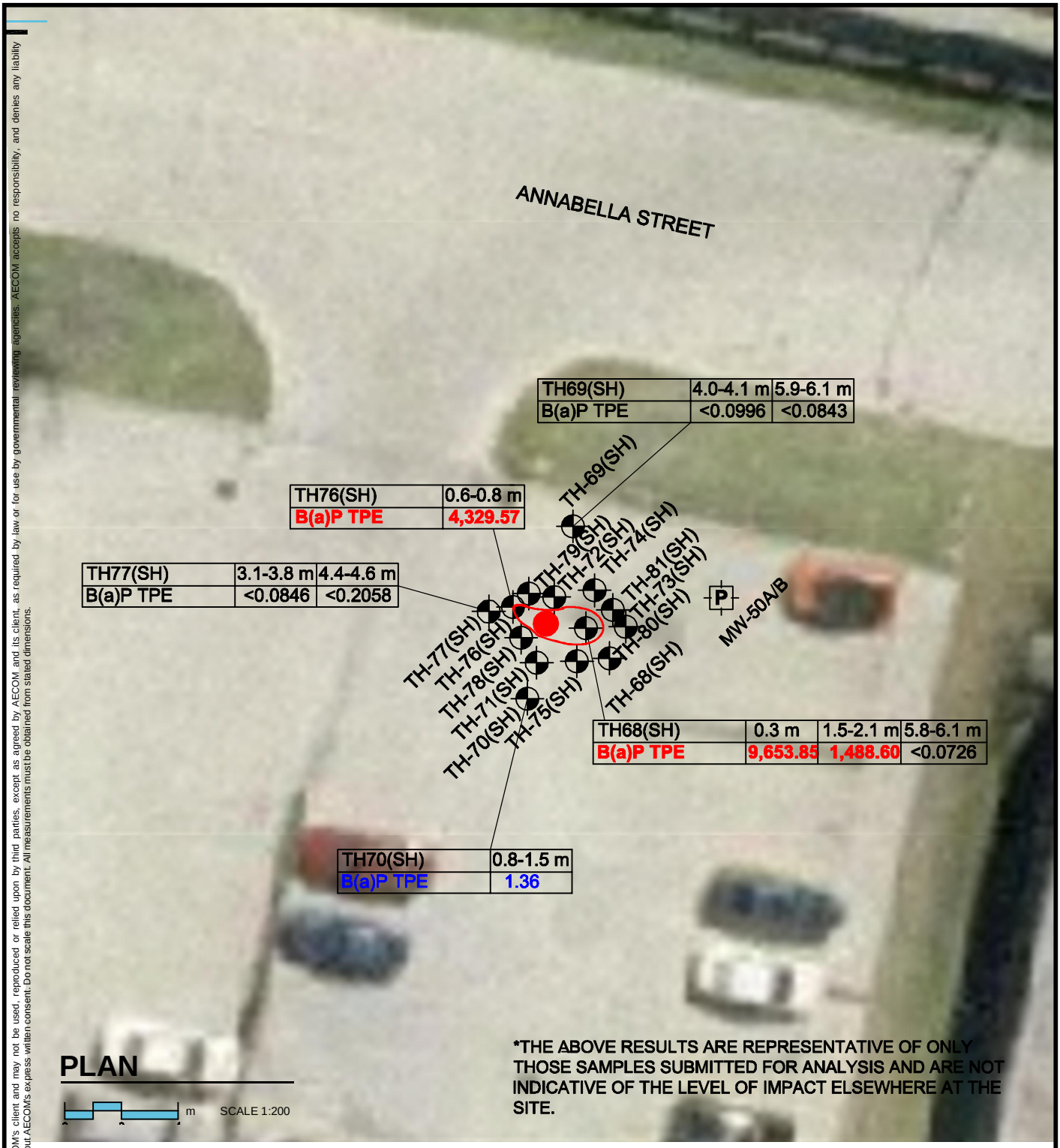
	B	T	E	X	F1	F2	F3	F4
SURFACE	0.28	330	430	230	320	260	2,500	6,600
SUBSURFACE	0.29	660	860	460	800	1,000	5,000	10,000

Manitoba Hydro
Remedial Action Plan for Parking Lot Sink Hole
Former Sutherland Avenue Manufactured Gas Plant Site

Concentrations of Petroleum Hydrocarbons in Soil

Figure 1-2

AECOM



PLAN

m SCALE 1:200

*THE ABOVE RESULTS ARE REPRESENTATIVE OF ONLY THOSE SAMPLES SUBMITTED FOR ANALYSIS AND ARE NOT INDICATIVE OF THE LEVEL OF IMPACT ELSEWHERE AT THE SITE.

LEGEND

- P — VAPOUR PROBE LOCATION
- TEST HOLE LOCATION
- SINK HOLE
- ESTIMATED EXTENT OF COAL TAR DEPOSIT

RESULTS SHOWN IN **BLUE** INDICATE A CALCULATED BENZO(A)PYRENE TOTAL POTENCY EQUIVALENT EXCEEDS GUIDELINE FOR AN ILCR OF 1E06 ONLY. THOSE SHOWN IN **RED** EXCEED THE ILCR OF 1E05 AND 1E06.

CCME GUIDELINES COMMERCIAL LAND USE
0.6 mg/kg - INCREMENTAL LIFETIME CANCER RISK = 1E06
5.3 mg/kg - INCREMENTAL LIFETIME CANCER RISK = 1E05

Manitoba Hydro
Remedial Action Plan for Parking Lot Sink Hole
Former Sutherland Avenue Manufactured Gas Plant Site

Concentrations of Potentially Carcinogenic PAHs in Soil

Figure 1-3

AECOM

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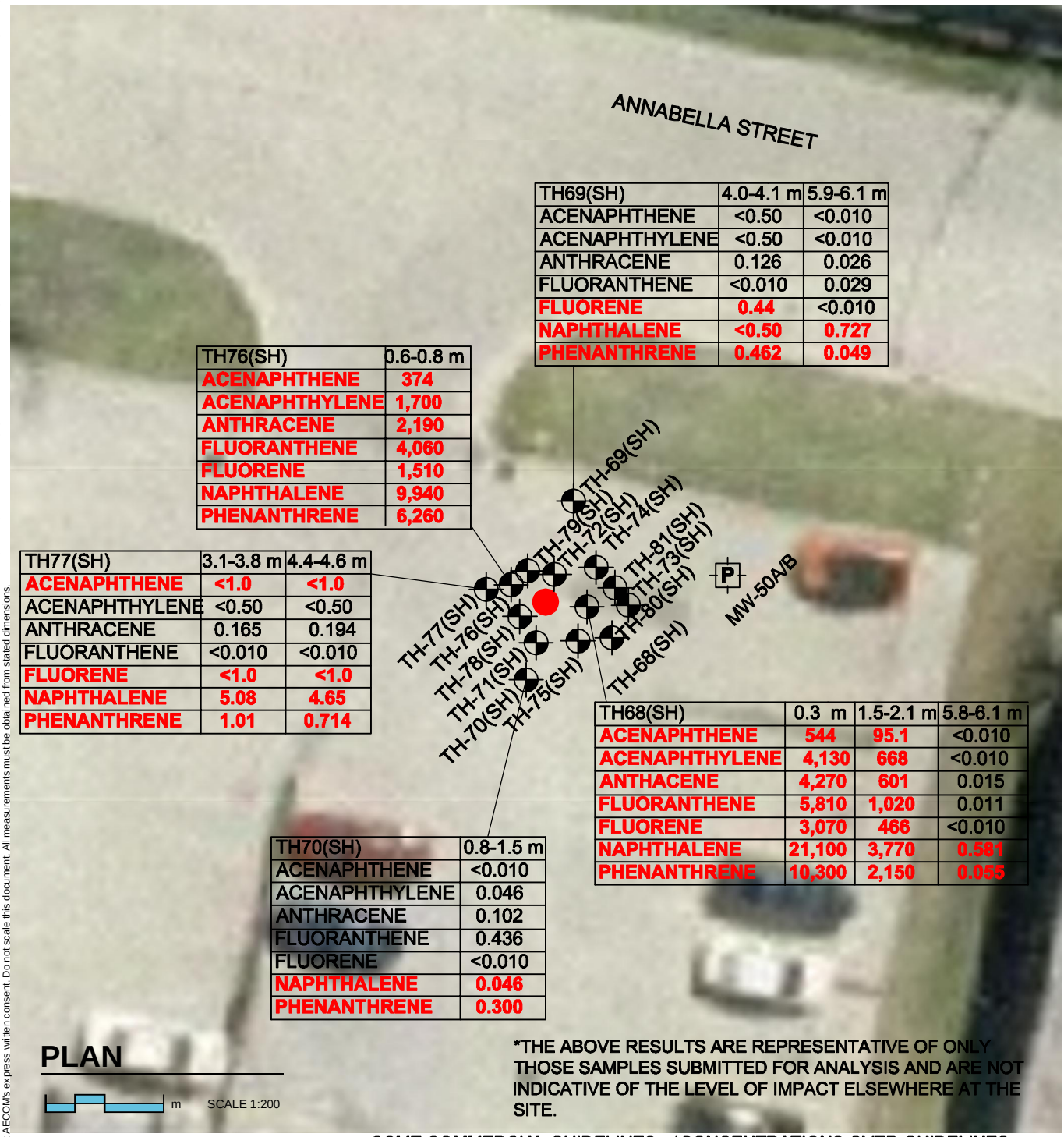
AECOM FILE NAME: 60157798-03-H-003-R0X.dwg Saved By: hachkowskia PLOT: 11/05/24 5:26:34 PM A SIZE 8.5" x 11" (215.9mm x 279.4mm)



TH69(SH)	4.0-4.1 m	5.9-6.1 m
ACENAPHTHENE	<0.50	<0.010
ACENAPHTHYLENE	<0.50	<0.010
ANTHRACENE	0.126	0.026
FLUORANTHENE	<0.010	0.029
FLUORENE	**0.44**	<0.010
NAPHTHALENE	**<0.50**	**0.727**
PHENANTHRENE	**0.462**	**0.049**

TH76(SH)	0.6-0.8 m
ACENAPHTHENE	**374**
ACENAPHTHYLENE	**1,700**
ANTHRACENE	**2,190**
FLUORANTHENE	**4,060**
FLUORENE	**1,510**
NAPHTHALENE	**9,940**
PHENANTHRENE	**6,260**

TH77(SH)	3.1-3.8 m	4.4-4.6 m
ACENAPHTHENE	**<1.0**	**<1.0**
ACENAPHTHYLENE	<0.50	<0.50
ANTHRACENE	0.165	0.194
FLUORANTHENE	<0.010	<0.010
FLUORENE	**<1.0**	**<1.0**
NAPHTHALENE	**5.08**	**4.65**
PHENANTHRENE	**1.01**	**0.714**

TH68(SH)	0.3 m	1.5-2.1 m	5.8-6.1 m
ACENAPHTHENE	**544**	**95.1**	<0.010
ACENAPHTHYLENE	**4,130**	**668**	<0.010
ANTHACENE	**4,270**	**601**	0.015
FLUORANTHENE	**5,810**	**1,020**	0.011
FLUORENE	**3,070**	**466**	<0.010
NAPHTHALENE	**21,100**	**3,770**	**0.581**
PHENANTHRENE	**10,300**	**2,150**	**0.055**

TH70(SH)	0.8-1.5 m
ACENAPHTHENE	<0.010
ACENAPHTHYLENE	0.046
ANTHRACENE	0.102
FLUORANTHENE	0.436
FLUORENE	<0.010
NAPHTHALENE	**0.046**
PHENANTHRENE	**0.300**

PLAN

m SCALE 1:200

*THE ABOVE RESULTS ARE REPRESENTATIVE OF ONLY THOSE SAMPLES SUBMITTED FOR ANALYSIS AND ARE NOT INDICATIVE OF THE LEVEL OF IMPACT ELSEWHERE AT THE SITE.

LEGEND

- P — VAPOUR PROBE LOCATION
- TEST HOLE LOCATION
- SINK HOLE
- ESTIMATED EXTENT OF COAL TAR DEPOSIT

CCME COMMERCIAL GUIDELINES

PARAMETER	GUIDELINE
ACENAPHTHENE	0.28
ACENAPHTHYLENE	320
ANTHRACENE	32
FLUORANTHENE	180
FLUORENE	0.25
NAPHTHALENE	0.013
PHENANTHRENE	0.046

*CONCENTRATIONS OVER GUIDELINES, OR WHOSE DETECTION LIMITS ARE OVER GUIDELINES ARE SHOWN IN **RED**.

Manitoba Hydro
Remedial Action Plan for Parking Lot Sink Hole
Former Sutherland Avenue Manufactured Gas Plant Site

Concentrations of Non-Carcinogenic PAHs in Soil

Figure 1-4

AECOM

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2. Site Information

2.1 Site Location and Surrounding Land Use

The subject site is located on the north side of Sutherland Avenue and is bordered by Gladstone Street to the west, Annabella Street to the east, and Rover Avenue to the north. The former MGP site, occupied by buildings addressed as 33, 35, and 37 Sutherland Avenue, encompasses an area of approximately 23,000 m^2. Manitoba Hydro also occupies the approximately 9,700 m^2 parcel of land at 38 Sutherland, which was a former coal storage area for the former MGP operations. The location of the site is shown in Figure 1-1.

Land use in the vicinity of the former Sutherland MGP site includes:

- North: Rover Avenue, followed by the Red River
- South: Sutherland Avenue, followed by the Manitoba Hydro Training Facility
- West: Gladstone Street, followed by green space, the Disraeli Freeway, and residential dwellings (from north to south)
- East: Annabella Street, followed by a Manitoba Hydro Substation and residential dwellings (from north to south).

The surface topography across the site is relatively flat, with the exception of minor grading in the vicinity of the site buildings and to direct surface runoff towards catchbasins located throughout the paved parking lots.

Based on the August 2010 test hole drilling program, the local soil profile in the vicinity of the sink hole is comprised of fill materials (a combination of clay, sand, and gravel), 1.2 m to 2.1 m thick and high plastic clay to a maximum drilling depth of 6.1 m. Coke residue was observed in eight (8) of the fourteen (14) test holes, either mixed in with the fill materials (TH74(SH), TH76(SH), and TH81(SH)) or as a distinct layer, as in test holes TH69(SH), TH70(SH), TH71(SH), TH77(SH), and TH80(SH). The thickness of the observed coke residue layers ranged from 0.2 m to 0.5 m. Distinct, interbedded layers of medium to high plastic clay, fine to medium grained sand, and silt were observed within the clay unit, which is consistent with observations made during previous investigations at the site.

2.2 Groundwater Conditions and Usage

Groundwater can be found throughout the overburden and bedrock profile beneath the City of Winnipeg. Within the upper clay soils, groundwater is present within the silt and fine sand lenses and layers in the upper 3 m to 5 m of the soil profile, as well as within the fractures in the clay mass below. Groundwater flow within the overburden sequence is vertically downward and laterally towards the topographic low occupied by the river. Locally, the river will also serve as a discharge boundary for flow in the underlying carbonate bedrock aquifer. The aquifer sees little domestic use in the downtown area, but is used for cooling and occasionally as industrial process water. According to the provincial groundwater well database maintained by Manitoba Water Stewardship, there is one (1) well within 500 m of the site. The well is located beneath the Disraeli Bridge, approximately 75 m from the site. Within the Provincial database, it is listed as a test well, with no defined purpose. Residents in the vicinity of the site are connected to the municipal water supply and there are no known domestic wells in the area.

As part of the CEMP for the site, groundwater flow and quality is monitored within the overburden on a quarterly basis. Based on calculations completed at the time of the supplemental CEMP report submission (February 2008), it is estimated that within the clay/silt subunit, groundwater flows at a rate of approximately 2 m/year to 5 m/year. Within the discrete sand layers encountered in the northern portion of the site, the approximate advective velocity ranges from 1 m/year to 7 m/year. The advective velocity within the till subunit is significantly lower than in the other two (2) subunits at 0.2 m/year to 0.4 m/year. All lateral groundwater flow is towards the Red River. The shallowest

observation of groundwater is most often at a depth between 2 m and 3 m below the surface of the site (in the upland area, away from the Red River).

2.3 Underground Structures and Utilities

Several utility providers have services running either directly beneath, or within close proximity of the Sutherland site. The following is a summary of the utilities and authorities that have been historically contacted to locate their services.

Table 2-1: Summary of Contacted Utility Providers

Utility	Appropriate Authority/Source of Information
Electricity/Natural Gas	Manitoba Hydro
Cable	Shaw Cable
Sewer/Water	City of Winnipeg
Telephone	Manitoba Telecom Services (MTS)
Private Electric	McCaine Electric

The only utility that has been identified in proximity to the proposed work area is a Manitoba Hydro primary electric line, which runs on the boulevard adjacent to the eastern boundary of the site, parallel to Annabella Street. The hydro line runs north to the southern boulevard off Rover Avenue and then runs west towards Gladstone Street. Shaw Cable and MTS fibre optic lines have previously been located near the western property boundary. A high pressure gas line runs south across the Sutherland site from beneath the Red River. Private electric lines have also been identified beneath the north parking lot of the site, primarily in proximity to the serviced parking spaces and the large lit sign in the west-central portion of the parking lot. Several catchbasins are also present in the parking lot, with combined sewer lines running between them.

All services will be located prior to proceeding with remedial activities.

3. Proposed Remedial Actions

3.1 Scope of Work

The RAP presented below addresses remediation of the coal tar deposit in the vicinity of the parking lot sink hole and the subsequent restoration of the area of remediation. The proposed plan addresses the management and disposal of contaminated material and free product encountered during remedial activities. As the remedial activities are expected to occur above the groundwater table, groundwater management is provided as a contingency measure only.

Due to the limited presence of active infrastructure at the site, and the relatively shallow depth and limited extent of the coal tar deposit, remediation of the site in the vicinity of the sink hole will be completed via excavation and off-site contaminant disposal.

3.1.1 Contaminants of Concern and Potential Risks During Remedial Activities

3.1.1.1 Contaminants of Concern

Typical contaminants found at former MGP sites include BTEX, volatile organic compounds (VOCs), PAHs, metals, and heavy metals. However, based on the results of the extensive historical and most recent site investigations, BTEX/PHCs and PAHs are considered to be the primary contaminants of concern with respect to human health and ecological risks at or around the former Sutherland Avenue MGP site. PAHs are a group of compounds formed during the incomplete burning of organic substances and are the primary constituents of the tar and sludges produced by gasification plants. PAHs tend to be very stable, exhibiting low volatility and aqueous solubility due to their pre-disposition to adsorb to soils and sediments, although lighter molecular weight PAHs (i.e. naphthalene) can be present in the air at low concentrations. Conversely, BTEX, as monocyclic aromatic hydrocarbons are moderately soluble and volatile and exhibit only a slight tendency for adsorption. The presence of BTEX on-site is a likely result of diffusion from coal tar sources and, to a lesser extent, the on-site storage of fuel during operations.

3.1.1.2 Exposure Routes and Potential Health Effects

Human Health

For acute exposure scenarios, incidents of PAH toxicity in humans are generally low. The most significant endpoint of chronic exposures is cancer. Benzo(a)pyrene was the first carcinogenic PAH to be discovered, with benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene also designated as probable human carcinogens by the United States Environmental Protection Agency (US EPA). Of the lower molecular weight/volatile contaminants present at the site, benzene is of particular interest due to its narcotic effect on the human body, through both acute and chronic exposures. Cancer is also a side-effect of long term exposures to benzene.

In terms of human health risks associated with residual coal tar and related products from the former MGP site, three (3) major exposure pathways merit evaluation:

- Direct exposures to PAH-contaminated soil/coal tar through dermal contact, incidental soil ingestion, and/or soil fine particle inhalation;
- Exposure to volatile components of subsurface coal tar contamination in the outdoor environment; and
- Exposure to volatile components of subsurface coal tar contamination in the indoor environment via soil vapour intrusion.

Under normal circumstances, dermal contact, soil ingestion/inhalation (i.e. direct exposures) of contaminated soils/coal tar at the Sutherland site is precluded as a result of the presence of hard surface pavement at the ground surface. However, because the remedial activities will involve excavating into the contaminated soils, unnecessary dermal exposures and ingestion will be avoided through (i) use of protective clothing, including gloves; and (ii) decontamination and thorough washing after working in or around the excavation, and especially prior to eating, drinking, smoking or any other activity that could promote contaminant ingestion. These exposures pertain to construction workers only, as neither the Manitoba Hydro employees working in the site buildings, nor the public at-large, will be exposed to soil, groundwater, and/or coal tar during the site work. Negligible to minimal dust is expected to be generated throughout the site activities, thus reducing the potential exposure to contaminants via dust/soil inhalation.

The monoaromatic hydrocarbons (BTEX) present in the coal tar and contaminated soil are sufficiently volatile that they can transfer from soils and groundwater into air at concentrations that can be detected by smell and, at higher concentrations, may be harmful depending on the conditions. With the exception of naphthalene, few of the PAH compounds are sufficiently volatile to become airborne contaminants of concern. Actual airborne concentrations of the volatile fraction of the coal tar and contaminated soil is dependent on:

- The amount of coal tar/contaminated soil exposed to the air;
- The specific composition of volatile hydrocarbons in the coal tar/contaminated soil;
- The gradation of the excavated soil and the degree of mixing with contaminants;
- Weather, specifically air temperature and relative humidity; and
- Degree of mixing of localized air containing volatilized hydrocarbons with the larger air mass. This is influenced by:
    - Height above the ground surface;
    - Wind speed and direction at the ground surface; and
    - Distance from the exposed coal tar to the person who may be exposed.

Due to the potential risks via inhalation of contaminants during the remediation, use of full facepiece respirators equipped with P100 or P95 filter/organic vapour cartridges will be mandated for workers proximate to the remedial area, with cartridges changed at the end of each work day. The north parking lot will be barricaded during remedial activities as a measure of limiting public access to the remedial area. In addition, Manitoba Hydro will adjust operation of their HVAC unit to minimize active intake of outdoor air into the site building (i.e. 35 Sutherland Avenue) during site activities. To reduce the presence of fugitive vapour emissions that pose a hazard to workers or create nuisance odours for nearby residents and employees at the Sutherland site, a vapour/odour suppressant, such as BioSolve®, will be used on the excavation sidewalls and base. Such products encapsulate hydrocarbon molecules, thus reducing their vapour pressure and are currently in use as part of the Sydney Tar Ponds remediation (similar contaminants). Liquid suppressants are considered advantageous over foam products as they can be applied in wet or windy conditions; can be applied on vertical surfaces; can be applied during ongoing excavation operations; and require no specialty equipment. BioSolve®, in particular, is biodegradable and is not expected to interfere with soil treatment.

Environmental Health

For living organisms other than humans, there are no viable exposure pathways for vegetation or wildlife, other than that entering the immediate area of the excavation during remedial activities. Barricades will be erected around the work area as a preventative measure.

3.1.2 Excavation of Contaminated Soil and Removal of Free Product

Following investigation and delineation of the coal tar deposit in the parking lot of the former Sutherland Avenue MGP site, all test holes, as well as the sink hole, were sealed to the surface by granular bentonite to remove any surficial exposure pathways. As such, the potential for human/ecological risk at the site as a result of this anomaly is relatively unchanged. Based on the commitment Manitoba Hydro made in the 2006 CEMP to maintain the site in a socially and environmentally responsible manner, even given the low potential for migration of the coal tar from the vicinity of the sink hole, remedial action is warranted.

Based on the findings from a closely spaced pattern of test holes drilled at the site in August 2010, the coal tar deposit appears to be of minimal areal extent, estimated at 3 m^2. Based on the depth to which the coal tar extends in the subsurface, the volume of the deposit is on the order of 5 m^3. Its location is consistent with the former MGP's rail loadout area, indicating that the coal tar may be present in the subsurface as a result of localized spillage, or waste disposal. Figure 1-2, Figure 1-3, and Figure 1-4 illustrate the estimated extent of the coal tar plume. Excavation of the coal tar deposit will also involve removal of a small portion of contaminated soils. It is estimated that the remedial activities will be confined to the upper 2 m of the soil profile. To achieve proper compaction for site restoration purposes (i.e. re-pavement of the excavation area), the excavated area will be on the order of 25 m^2. It should be re-iterated that the extent of contamination at the site precludes the possibility of excavating to limits at which non-impacted soil is encountered, either laterally or vertically. Rather, the intent of the excavation is to remove the coal tar from the subsurface and restore the site to a condition in which all pertinent exposure pathways (i.e. dermal contact, ingestion/inhalation) are no longer viable.

The coal tar will be excavated and transported off-site for treatment and/or disposal at the Clean Harbors facility near Sarnia, Ontario. Temporary stockpiling of soil will not be allowed during remedial activities. Excavated soil will be placed in roll-off containers to avoid double handling, with odour/vapour suppressant applied.

The limits of the excavation will be based on the observations made during the August 2010 sink hole investigation. Qualified personnel will be on-site to coordinate the excavation activities, segregate areas containing coal tar from otherwise contaminated soils, to collected samples from the margins of the excavation, and to document the contractor's daily activities.

To further document site conditions, representative samples will be collected at 0.3 m to 0.5 m depth intervals or at obvious stratigraphic boundaries around the excavation face and screened, with select samples submitted for laboratory analysis of BTEX and PAHs. Screening will be completed via measurement of organic and ionizable vapour readings, using a GasTech or Photoionization Detector (PID), respectively, or through visual indicators of impacts (i.e. staining).

The excavation is expected to be completed at a level above the water table and should not be adversely affected by water seepage into the excavation. Therefore, it should be feasible to excavate all coal tar and impacted soil with minimal, if any dewatering requirement.

3.1.3 Ex-Situ Soil Treatment and Disposal

Based on a preliminary analysis of the concentrations of PAHs and PHCs present in the coal tar by Clean Harbors, it is likely that the coal tar and soil can be treated via thermal desorption. To facilitate transportation and handling through the thermal desorption unit near Sarnia, Ontario, Clean Harbors has recommended that the coal tar be mixed with the surrounding contaminated soil such that it is no longer liquid and flowing. The applicability of thermal desorption will be confirmed via bench-scale treatability testing of the coal tar and soil approximately 72 hours prior to the onset of remedial activities. If the results of the bench testing prove negative, the coal tar/soil will be disposed of through incineration (also at Clean Harbors).

3.1.4 Installation of Hydrocarbon-Resistant Liner

Following excavation of the coal tar and surrounding contaminated soil, a 40 mil hydrocarbon-resistant High Density Polyethylene (HDPE) liner (i.e. Layfield Enviro Liner or equivalent). The liner will be placed along the perimeter and base of the excavated area to prevent the accumulation of contaminated soil vapours in that area of the site. This is considered appropriate based on the proximity of the remedial area to the site building.

3.1.5 Supply of Backfill Material

Material for backfilling the excavation will be obtained from a local supplier, chosen by the selected excavation contractor.

3.1.6 Site Restoration

Following removal of the coal tar and surrounding contaminated soil, the site will be restored, which will entail placement and compaction of granular backfill. Following compaction of the backfill material, asphalt pavement will be placed at the surface of the excavated area to eliminate surficial exposures to contaminated materials, as per the Sutherland site risk-based management plan.

4. Summary

The Remedial Action Plan presented herein has described the activities to be undertaken by Manitoba Hydro to remove a deposit of coal tar present within a limited area of the former Sutherland Avenue MGP site and subsequently restore the site to conditions at which risks to human health and the environment remain acceptably low. It is expected that approximately 50 m^3 of soil and coal tar will be removed from the subsurface and transported to the Clean Harbors facility near Sarnia, Ontario for treatment via thermal desorption, or disposal via incineration.

5. References

AECOM, 2011. Subsurface Investigation: Sink Hole Location in the Parking Lot of the Former Sutherland Avenue Manufactured Gas Plant Site.

AECOM, 2008. Manitoba Hydro Comprehensive Environmental Management Plan for Residuals from Historical Operations at the Sutherland Avenue Former Manufactured Gas Plant Updated Technical Information Prepared for the TAC, 121 pp.

AECOM, 2006. Manitoba Hydro Comprehensive Environmental Management Plan for Residuals from Historical Operations at the Sutherland Avenue Manufactured Gas Plant.

U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, 2010. Report on Carcinogens, Eleventh Edition.

Appendix A
Detailed Analytical Tables

Table A1: Organic Vapours in Soil
Former Sutherland Avenue Manufactured Gas Plant Site, Winnipeg, Manitoba

Test Hole	Date (yy/mm/dd)	Depth of Sample (m)																								
		0.2	0.3	0.4	0.6	0.7	1.2	1.4	1.8	1.9	2.6	2.7	2.9	3.0	3.4	3.8	4.0	4.1	4.4	4.5	4.7	5.0	5.3	5.7	5.9	6.0
TH68(SH)	10/08/17	--	268/510	--	--	--	--	--	330/190	--	--	220/320	--	--	200/200	200/200	--	--	220/82	--	170/65	--	350/138	310/119	250/95	--
TH69(SH)	10/08/18	--	--	160/16.4	--	--	--	250/106	--	100/70	205/150	--	--	100/92.3	140/183	--	--	130/96.7	385/340	--	260/132	370/135	--	275/105	--	227/87
TH70(SH)	10/08/18	40/4.3	--	--	110/33.1	--	120/364	--	--	100/27.3	--	--	220/200	100/34.3	120/143	--	--	560/127	--	--	--	240/81.3	--	550/152	--	--
TH71(SH)	10/08/18	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH72(SH)	10/08/18	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH73(SH)	10/08/18	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH74(SH)	10/08/19	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH75(SH)	10/08/19	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH76(SH)	10/08/19	--	--	--	--	275/500	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TH77(SH)	10/08/19	--	--	--	--	230/588	--	--	--	--	--	--	--	--	260/385	--	480/192	--	--	460/783	--	300/384	--	800/260	--	--
TH78(SH)	10/08/19	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH79(SH)	10/08/19	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH80(SH)	10/08/19	Vapour measurements not taken - test hole drilled for delineation purposes																								
TH81(SH)	10/08/19	Vapour measurements not taken - test hole drilled for delineation purposes																								

Notes:

Combustible vapour concentrations measured with an RKI Eagle Portable Gas Detector. Ionizable vapour concentrations measured with a Minirae 2000 Photoionization Detector. The above table presents the combustible vapours first, followed by the ionizable vapour concentrations.

--	Indicates no sample taken
	Indicates sample submitted for laboratory analysis of BTEX, PHC fractions F1 to F4, and PAHs

Table A2: Concentrations of Petroleum Hydrocarbons in Soil
Former Sutherland Avenue Manufactured Gas Plant Site, Winnipeg, Manitoba

Sample Identification	Date Sampled (yy/mm/dd)	Sample Depth (m, bgs)	Vapour Concentration (RKI Eagle) [1]	Vapour Concentration (PID) [2]	Soil Type	Benzene	Toluene	Ethylbenzene	Xylenes	F1 [3] (C6-C10)	F2 (C10-C16)	F3 (C16-C34)	F4 (C34-C50)
Base Method Detection Limit						0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
CCME Commercial Soil Quality Guideline (SQG_{EH}) (≤1.5 m)						**0.28**	**330**	**430**	**230**				
CCME Canada-Wide Standard (Eco Soil Contact PHC Fractions F1 to F4) (≤3.0 m)										**320**	**260**	**2,500**	**6,600**
TH68(SH) @ 1'	10/08/17	0.3	268 ppm	510 ppm	Sandy Clay Fill	**146** [5]	102 [5]	4.9 [5]	103 [5]	**490** [5]	**35,700** [5]	**56,500** [5]	**7,800** [5]
TH68(SH) @ 5'-7' [6]	10/08/17	1.5 - 2.1	330 ppm	190 ppm	Clay	--	--	--	--	<10	**8,100** [5]	**16,700** [5]	3,000 [5]
TH70(SH) @ 2.5'-5'	10/08/18	0.8 - 1.5	120 ppm	364 ppm	Coke Residue	0.0084	<0.050 [4]	<0.015	<0.10	<10	11	235	82
TH76(SH) @ 2'-2.5'	10/08/19	0.6 - 0.8	275 ppm	500 ppm	Clay Fill	**2.73**	1.44 [4]	0.124	2.71	<10	**2,000** [5]	**17,600** [5]	2,580 [5]
CCME Commercial Soil Quality Guideline (SQG_{EH}) (>1.5 m)						**0.29**	**660**	**860**	**460**				
CCME Canada-Wide Standard (Eco Soil Contact PHC Fractions F1 to F4) (>3.0 m)										**800**	**1,000**	**5,000**	**10,000**
TH68(SH) @ 5'-7' [6]	10/08/17	1.5 - 2.1	330 ppm	190 ppm	Clay	**3.20**	1.52 [4]	0.065	1.40	--	--	--	--
TH68(SH) @ 19'-20'	10/08/17	5.8 - 6.1	227 ppm	87 ppm	Clay	**0.295**	0.082 [4]	0.156	0.19	66	147	492	<50
TH69(SH) @ 13.25'-13.5'	10/08/18	4.0 - 4.1	130 ppm	96.7 ppm	Silty/Sandy Clay	0.0099	0.292	0.122	0.19	43	**3,070**	980	52
TH69(SH) @ 19.5'-20'	10/08/18	5.9 - 6.1	227 ppm	87 ppm	Clay	0.0788	0.060 [4]	0.118	0.20	150 [5]	166	602	<50
TH77(SH) @ 10'-12.5'	10/08/19	3.1 - 3.8	260 ppm	385 ppm	Clay	0.0558	<0.050 [4]	0.147	0.29	43	**3,310**	890	67
TH77(SH) @ 14.5'-15'	10/08/19	4.4 - 4.6	460 ppm	783 ppm	Sandy Clay	0.188	0.091 [4]	0.809	1.18	127	**6,990**	2,040	75

Notes:

All concentrations expressed in milligrams per kilogram (mg/kg), on a dry weight basis, unless otherwise indicated.

CCME SQG - Soil Quality Guideline for the Protection of Environmental Health, Canadian Environmental Quality Guidelines, Updated 2009. Fine grained soil, commercial land use.
Limiting exposure pathway for benzene is vapour inhalation (slab-on-grade) with an incremental risk of 10^{-6}.

Soil contact guidelines shown for toluene, ethylbenzene, and xylenes.

m, bgs - metres, below ground surface

1 - Combustible vapour concentrations measured with an RKI Eagle Portable Gas Detector

2 - Ionizable vapour concentrations measured with a Minirae 2000 Photoionization Detector

3 - F1 results have been adjusted for BTEX

4 - Result adjusted for method blank

5 - Detection limits adjusted for required dilution

6 - To be conservative, the CCME CWS for surface soils have been applied to all soils at or above 3.0 m, since the CCME has made no provision for soil between 1.5 m and 3.0 m below grade in the 2008 standards.

Sample parameter exceeds guideline value

Table A3: Concentrations of Potentially Carcinogenic Polycyclic Aromatic Hydrocarbons (PAH) in Soil
Former Sutherland Avenue Manufactured Gas Plant Site, Winnipeg, Manitoba

Sample Identification	Date Sampled (yy/mm/dd)	Sample Depth (m, bgs)	Vapour Concentration (RKI Eagle) [1]	Vapour Concentration (PID) [2]	Soil Type	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b) fluoranthene	Benzo(k) fluoranthene	Chrysene	Benzo(g,h,i) perylene	Dibenzo(ah) anthracene	Indeno(1,2,3-cd) pyrene	Calculated Benzo(a)pyrene TPE [3]
Base Method Detection Limit						0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	
Benzo(a)pyrene Potency Equivalence Factor (PEF)						0.1	1	0.1	0.1	0.01	0.01	1	0.1	
CCME Commercial Soil Quality Guideline (SQG_{HH}) - 10^{-6} ILCR						**0.6** [4]								
CCME Commercial Soil Quality Guideline (SQG_{HH}) - 10^{-5} ILCR						**5.3** [5]								
TH68(SH) @ 1'	10/08/17	0.3	268 ppm	510 ppm	Sandy Clay Fill	2940 [6]	2350 [6]	2560 [6]	87.5 [6]	2270 [6]	1250 [6]	161 [6]	1130 [6]	**9,653.85**
TH68(SH) @ 5'-7'	10/08/17	1.5 - 2.1	330 ppm	190 ppm	Clay	451 [6]	337 [6]	390 [6]	186 [6]	321 [6]	169 [6]	35.7 [6]	159 [6]	**1,488.60**
TH68(SH) @ 19'-20'	10/08/17	5.8 - 6.1	227 ppm	87 ppm	Clay	0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0726
TH69(SH) @ 13.25'-13.5'	10/08/18	4.0 - 4.1	130 ppm	96.7 ppm	Silty/Sandy Clay	<0.10 [6]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0996
TH69(SH) @ 19.5'-20'	10/08/18	5.9 - 6.1	227 ppm	87 ppm	Clay	0.039	0.011	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0843
TH70(SH) @ 2.5'-5'	10/08/18	0.8 - 1.5	120 ppm	364 ppm	Coke Residue	0.430	0.311	0.373	0.215	0.305	0.197	0.022	0.140	**1.36**
TH76(SH) @ 2'-2.5'	10/08/19	0.6 - 0.8	275 ppm	500 ppm	Clay Fill	1690 [6]	918 [6]	1380 [6]	610 [6]	1180 [6]	709 [6]	67 [6]	713 [6]	**4,329.57**
TH77(SH) @ 10'-12.5'	10/08/19	3.1 - 3.8	260 ppm	385 ppm	Clay	<0.05 [6]	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.0846
TH77(SH) @ 14.5'-15'	10/08/19	4.4 - 4.6	460 ppm	783 ppm	Sandy Clay	<0.050 [6]	<0.050 [6]	<0.010	<0.010	<0.050 [6]	<0.010	<0.010	<0.010	<0.2058

Notes:

All concentrations expressed in milligrams per kilogram (mg/kg), on a dry weight basis, unless otherwise indicated.

CCME SQG - Soil Quality Guideline for the Protection of Human Health - Direct Contact - Ingestion, Inhalation, and Dermal Exposures

m, bgs - metres, below ground surface

1 - Combustible vapour concentrations measured with an RKI Eagle Portable Gas Detector

2 - Ionizable vapour concentrations measured with a Minirae 2000 Photoionization Detector

3 - The Total Potency Equivalent (TPE) is equal to the summation of the concentration of each parameter, multiplied by the respective Potency Equivalence Factor (PEF). A three-fold factor of uncertainty has been incorporated given that there is uncertainty in the risks associated with coal tar contamination.

4 - Guideline given an Incremental Lifetime Cancer Risk (ILCR) of 1 in 1,000,000

5 - Guideline given an Incremental Lifetime Cancer Risk (ILCR) of 1 in 100,000

6 - Detection limits adjusted for required dilution

Sample TPE exceeds the SQG_{HH} for an ILCR of 1 in 1,000,000

Sample TPE exceeds the SQG_{HH} for an ILCR of 1 in 100,000 and 1 in 1,000,000

Table A4: Concentrations of Non-Carcinogenic Polycyclic Aromatic Hydrocarbons (PAH) in Soil
Former Sutherland Avenue Manufactured Gas Plant Site, Winnipeg, Manitoba

Sample Identification	Date Sampled (yy/mm/dd)	Sample Depth (m, bgs)	Vapour Concentration (RKI Eagle) [1]	Vapour Concentration (PID) [2]	Soil Type	Acenaphthene	Acenaphthylene	Anthracene	Benzo(b&j) fluoranthene	Fluoranthene	Fluorene	Naphthalene	1-Methyl Naphthalene	2-Methyl Naphthalene	Phenanthrene	Pyrene	Quinoline	Acridine
Base Method Detection Limit						0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.050	0.050
CCME Commercial Soil Quality Guideline (SQG_{EH})						**0.28** [3]	**320** [3]	**32** [4]	**NG** [5]	**180** [4]	**0.25** [3]	**0.013** [3]	**NG** [5]	**NG** [5]	**0.046** [3]	**NG** [5]	**NG** [5]	**NG** [5]
TH68(SH) @ 1'	10/08/17	0.3	268 ppm	510 ppm	Sandy Clay Fill	**544** [6]	**4,130** [6]	**4,270** [6]	2,560 [6]	**5,810** [6]	**3,070** [6]	**21,100** [6]	2,590 [6]	3,450 [6]	**10,300** [6]	6,140 [6]	<50 [7]	88 [7]
TH68(SH) @ 5'-7'	10/08/17	1.5 - 2.1	330 ppm	190 ppm	Clay	**95.1** [7]	**668** [6]	**601** [6]	390 [6]	**1,020** [6]	**466** [6]	**3,770** [6]	340 [6]	539 [6]	**2,150** [6]	1,120 [6]	109 [7]	22.7 [7]
TH68(SH) @ 19'-20'	10/08/17	5.8 - 6.1	227 ppm	87 ppm	Clay	<0.010	<0.010	0.015	<0.010	0.011	<0.010	**0.581**	0.168	0.142	**0.055**	0.012	<0.050	<0.050
TH69(SH) @ 13.25'-13.5'	10/08/18	4.0 - 4.1	130 ppm	96.7 ppm	Silty/Sandy Clay	<0.50 [7]	<0.50 [7]	0.126	<0.010	<0.010	**0.44** [7]	**<0.50** [7]	8.40	<0.010	**0.462**	<0.10 [7]	<0.50 [7]	<0.050
TH69(SH) @ 19.5'-20'	10/08/18	5.9 - 6.1	227 ppm	87 ppm	Clay	<0.010	<0.010	0.026	<0.010	0.029	<0.010	**0.727**	0.391	0.379	**0.049**	0.068	<0.050	<0.050
TH70(SH) @ 2.5'-5'	10/08/18	0.8 - 1.5	120 ppm	364 ppm	Coke Residue	<0.010	0.046	0.102	0.358	0.436	<0.010	**0.046**	0.046	0.034	**0.300**	0.536	<0.050	<0.050
TH76(SH) @ 2'-2.5'	10/08/19	0.6 - 0.8	275 ppm	500 ppm	Clay Fill	**374** [6]	**1,700** [6]	**2,190** [6]	1,370 [6]	**4,060** [6]	**1,510** [6]	**9,940** [6]	1,360 [6]	1,880 [6]	**6,260** [6]	3,470 [6]	<0.50 [7]	56 [7]
TH77(SH) @ 10'-12.5'	10/08/19	3.1 - 3.8	260 ppm	385 ppm	Clay	**<1.0** [7]	<0.50 [7]	0.165	<0.010	<0.010	**<1.0** [7]	**5.08** [7]	37.1 [6]	45.7 [6]	**1.01**	<0.050 [7]	<0.050	<0.050
TH77(SH) @ 14.5'-15'	10/08/19	4.4 - 4.6	460 ppm	783 ppm	Sandy Clay	**<1.0** [7]	<0.50 [7]	0.194	<0.010	<0.010	**<1.0** [7]	**4.65** [7]	28.1 [6]	39.9 [6]	**0.714**	<0.10 [7]	<0.050	<0.050

Notes:

All concentrations expressed in milligrams per kilogram (mg/kg), on a dry weight basis, unless otherwise indicated.

CCME SQG - Soil Quality Guideline for the Protection of Environmental Health

m, bgs - metres, below ground surface

1 - Combustible vapour concentrations measured with an RKI Eagle Portable Gas Detector

2 - Ionizable vapour concentrations measured with a Minirae 2000 Photoionization Detector

3 - Soil Quality Guideline (Environmental Health) for the Protection of Freshwater Life

4 - Soil Quality Guideline (Environmental) for Soil Contact

5 - No guideline has been developed

6 - Detection limits adjusted for required dilution

7 - Detection limits raised due to matrix interference

Sample parameter exceeds guideline value

Table A5: Summary of Ambient Vapour Results
Former Sutherland Avenue Manufactured Gas Plant Site, Winnipeg, Manitoba

Parameter (µg/m^3)	Laboratory Detection Limit (µg/m^3)	Ambient #1	Ambient #2	Guidelines					
				Winnipeg Ambient Air Quality [1]	Ontario Ministry of Environment		BC Ministry of Environment		
		17-Aug-10	18-Aug-10	Arithmetic Mean	Ontario Reg. 419/05	Quality Criteria	Generic Numerical Vapour Standards	Health Canada [2]	Reference Concentrations [3]
Benzene	2.7 [4]/2.1 [5]	<2.7	<2.1	0.78	--	--	4	3.03	--
Toluene	2.7 [4]/2.1 [5]	7.9	3.0	2.85	--	2,000	15,000	3,800	--
Ethylbenzene	2.7 [4]/2.1 [5]	<2.7	<2.1	0.43	1,000	--	3,000	--	--
Xylenes	8.2 [4]/6.4 [5]	<8.2	<6.4	1.74	730	--	300	--	100 [3]
Acenaphthene	14 [4]/11 [5]	<14	<11	1.2	--	--	--	--	--
Acenaphthylene	14 [4]/11 [5]	<14	<11	1.74	--	--	--	--	--
Anthracene	14 [4]/11 [5]	<14	<11	0.54	--	--	--	--	--
Benzo(a)anthracene	14 [4]/11 [5]	<14	<11	0.11	--	--	--	--	--
Benzo(a)pyrene	14 [4]/11 [5]	<14	<11	0.08	--	--	--	31	--
Benzo(b/k)fluoranthene	14 [4]/11 [5]	<14	<11	0.31	--	--	--	--	--
Benzo(g,h,i)perylene	14 [4]/11 [5]	71	<11	0.18	--	--	--	--	--
Chrysene	14 [4]/11 [5]	<14	<11	0.19	--	--	--	--	--
Dibenzo(a,h)anthracene	14 [4]/11 [5]	<14	<11	0.02	--	--	--	--	--
Fluoranthene	14 [4]/11 [5]	<14	<11	1.54	--	--	--	--	--
Fluorene	14 [4]/11 [5]	<14	<11	2.43	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	14 [4]/11 [5]	<14	<11	0.13	--	--	--	3.8	--
Naphthalene	14 [4]/11 [5]	**>38**	**>33**	0.11	--	22.5	9	--	3 [3]
Phenanthrene	14 [4]/11 [5]	<14.0	<11	6.49	--	--	--	--	--
Pyrene	14 [4]/11 [5]	45	<11	1.30	--	--	--	--	--

Notes:

All concentrations in µg/m^3 unless otherwise indicated

[1] Manitoba Conservation - Manitoba Ambient Air Quality 2005, based on 60 samples

[2] Health Canada Threshold Risk Value, 2004

[3] USEPA Integrated Risk Information System (IRIS), 1996

[4] Detection limit for Ambient #1, based on volume of air sampled

[5] Detection limit for Ambient #2, based on volume of air sampled

-- indicates no criteria

and bold indicates parameter exceeded one or more guideline value