



October 2015

REPORT ON

Landfill Environmental Risk Report for Closed Landfills Winnipeg, Manitoba

Submitted to:
City of Winnipeg
1120 Waverley Street
Winnipeg, MB
R3T 0P4

REPORT



Report Number: 1522283/2000

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder Associates) was retained by the City of Winnipeg (City), to provide professional consulting services relating to the City's Water and Waste Department closed landfills, as outlined under RFP No. 1199-2014. The study being completed, known as the Landfill Disposition Study, includes 33 landfill sites generally located within the City of Winnipeg, Manitoba (see Figure 1) and will be completed in a phased approach, consisting of the completion of a series of reports considering each site, including:

- Phase 1 – Landfill Status Report;
- Phase 2 – Landfill Environmental Risk Report;
- Phase 3 – Landfill Rehabilitation and Cost Estimate Report;
- Phase 4 – Landfill Land Use Potential Report; and,
- Phase 5 – Legal Risk and Responsibility Report.

The 33 landfills were operated from as early as 1875 to as late as 1998. Investigations undertaken by others in the area of the landfills have identified waste, and in some cases soil, groundwater, surface water, and landfill gas impacts, potentially associated with waste materials.

The potential impact that can occur from waste sites is influenced by factors such as the type and age of material deposited, depth of waste, cover material, and the local geology, hydrogeology and surface water bodies. As a result, investigations of areas where waste is known to have been deposited must assess and/or consider these factors in order to determine the potential for impact. Older waste fill areas containing little putrescible material and pre-dating use of industrial organics may be relatively innocuous, whereas those containing large amounts of organic material or liquid waste can continue to generate landfill gas or seepage even when a significant amount of time (like twenty-five years) has passed since closure of these sites.

This report fulfils Phase 2, the Landfill Environmental Risk Report. The Landfill Environmental Risk Report presents proposed changes to the current monitoring programs, data gaps of monitoring that should be considered and recommended improvements to the physical condition (proposed engineered control systems) of each of the 33 sites. A plan showing the extent of interpreted impact at each site and a discussion of the influence that proposed engineered control systems could have on that impact is provided.



The Landfill Environmental Risk Report is organized into the following sections:

- Methodology – outlines the steps utilized to complete this phase of the landfill disposition study;
- Program Recommendations – provides the proposed monitoring program changes, recommended improvements, data gap programs and extent of interpreted impact for each site;
- Findings – presents some overarching findings and comments that pertain to all of the closed landfill sites evaluated as part of this study; and,
- Closing – provides concluding statements for the Landfill Environmental Risk Report.



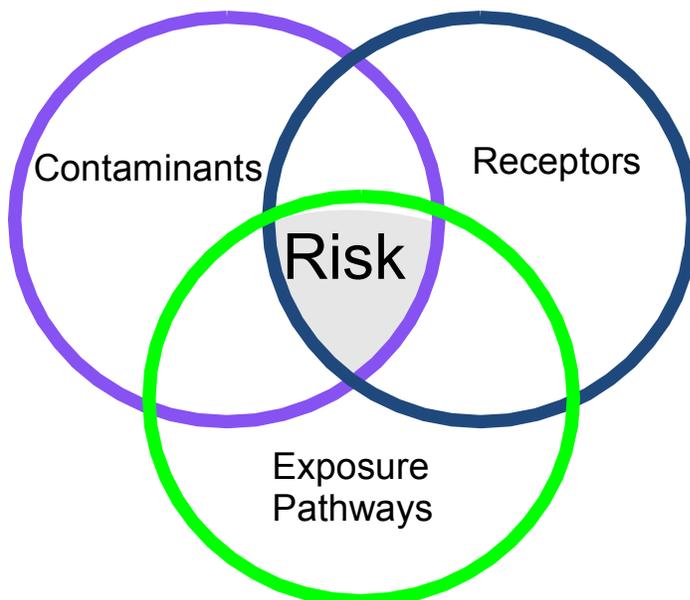
2.0 METHODOLOGY

Building on the data reviewed and results summarized within the Landfill Status Report, the Environmental Risk Report essentially visually presents areas of impact and proposes new investigations, modifications to monitoring and/or new or modified engineered control systems.

In the context of risk assessment and of management of potential impacts to human health and to the environment associated with a closed landfill site, there are three essential elements to consider. These three elements and their definitions are as follows:

- **Contaminant:** a substance in soil, sediment, groundwater, surface water, air, or another environmental medium that is present at a concentration above criteria and/or causes concern related to human health or safety, water resources or the wider environment. Examples of contaminants in the context of a closed landfill are: dissolved substances in groundwater, compounds of concern for human health found in the soil, methane gas produced by the decomposition of organic waste, etc.;
- **Pathway:** the means or route by which a receptor is exposed to a contaminant. Relevant to closed landfill sites, potential pathways could consist of consumption of water from a private water well tapping into an impacted aquifer, ingestion or dermal contact with impacted soil and/or waste, inhalation of contaminants that volatilize from soil or groundwater to indoor air, migration of potentially explosive landfill gases to basement of houses, surface run-off of landfill leachate or of leachate-impacted surface water to neighbouring water bodies, etc.; and,
- **Receptor:** someone or something which could be exposed to the contaminant, including humans, water resources, surface water courses or the wider environment. Examples of potential receptors include surrounding residents and private well users, users of recreational areas developed over a closed landfill site, ecosystems of surface water bodies located in the neighbourhood of a closed landfill site, etc.

The following diagram provides a definition of “risk” as the interaction between contaminant(s), pathway(s) and receptor(s):





While making decisions regarding data gap analysis, monitoring program changes and engineered control system changes the project team considered for each site and each potential impact the contaminant, pathway and receptor to assess if a risk was real. Further, data gaps considered issues like:

- Is the waste area adequately defined;
- Has groundwater sampling been completed or is it needed;
- Has surface water sampling been completed or is it needed; and,
- Has gas/methane sampling been completed or is it needed.

The data gap identification highlights information that would be required to allow for an evaluation of compliance to today's environmental criteria and/or to more accurately visually represent an area of impact.



3.0 PROGRAM RECOMMENDATIONS

A summary of the environmental risk of each landfill is provided in Appendices A through FF. The appendices include the following sections:

- Monitoring program changes – provides suggested monitoring program changes whether related to frequency, parameters or sampling locations and a brief rationale;
- Recommended improvements – presents recommendations to the implementation and/or modification for new and/or existing engineered control features and a brief rationale;
- Data gaps – offers recommendations related to new intrusive investigations to better delineate a site and/or understand potential impacts; and,
- Extent of impact – provides an interpretation of impact at each site on a plan and a second plan showing a revised interpretation of impact if proposed engineered control feature improvements are proposed.



4.0 FINDINGS

The following subsections outline the overarching findings from this Environmental Risk Report.

4.1 Control Zones

In general, most of the closed landfill sites have control zones that are beyond the interpreted extent of potential impact, indicating that the control zones at many sites can likely be reduced. It is recommended that additional groundwater monitoring wells and/or landfill gas wells are installed, where identified, to verify that this reduction can be made.

4.2 Landfill Gas

Many of the landfill gas probes installed at the closed landfill sites were installed in the 1980s. The borehole logs for these probes, when available electronically for review, often did not have information on the screen depths within the wells. The location of the screen is critical to understanding the reliability of non-detectable landfill gas readings. If the groundwater level is above the screen of the landfill gas probe then monitoring from that landfill gas probe will not provide tangible information about lateral landfill gas migration in that area. Landfill gas probes that consistently have water levels above the screen should not be included in the on-going monitoring program. Recommendations are made for additional landfill gas probes as required for each site.

It should be noted that the potentiometric surface of the groundwater in the bedrock has been rising since the 1970s (by up to approximately 15 metres) due to a decrease in consumptive groundwater use. This rise results in a lower hydraulic gradient from the shallow groundwater to the bedrock aquifer. As such, the shallow groundwater levels may also be affected (to a far lesser extent) by this change in the potentiometric surface of the groundwater in the bedrock. The potential for a rise in shallow groundwater may mean that well screens in landfill gas probes that were previously above the groundwater table in the 1980s and providing landfill gas results, may now be below the groundwater table.

4.3 Groundwater

Landfill gas has been the main focus of previous studies, but potential impact to groundwater is recommended to be investigated to assess any liabilities the City has in this area. While there is a clay deposit below most of the closed landfill sites, there is still the potential for landfill leachate to impact the underlying groundwater in the till or bedrock. It is recommended that when groundwater sampling is completed that the samples are analyzed for the parameter lists outlined in Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards). Schedule 5 of the Landfill Standards was developed by a team comprised of provincial regulators, academics and consultants who investigated numerous operational and closed landfill sites to identify relevant parameters that would be found in leachate. From that investigation a list of groundwater, surface water and leachate contaminants indicative of impact from municipal landfills were developed. Using this list of parameters when sampling groundwater, surface water or leachate will assist with the understanding of potential impact from landfill leachate.



4.4 Utility Trenches

It has been identified at some of the sites that utility trenches exist either within the landfill footprint or adjacent to the landfill. The bedding of these trenches is typically a granular material, which is a preferential pathway for landfill gas (if above the groundwater table) or landfill leachate (if below the groundwater table). Recommendations have been made at those sites with utility trenches within the landfill footprint or adjacent to the landfill footprint that probes be installed within the granular bedding to assess if landfill gas is migrating within this material. Sampling of the groundwater within these trenches has not been recommended at this time since the first step of understanding where the groundwater table is in comparison to the trench is required. If, during the installation of the landfill gas probe, it is determined that the granular material is fully saturated, then consideration can be given to sampling for groundwater instead of measuring landfill gas and/or future investigations will be recommended.

4.5 Data Organization

As a general observation the organization of monitoring data collected by the City can be improved so that future analysis can be done quickly and efficiently. Landfill gas results for each site can be compiled in a spreadsheet so that each year another column of data is added and the City can easily review changes to the gas composition at each probe over time. This same method of data organization should be used for any groundwater data (analytical and measured groundwater levels) or surface water data.

To understand groundwater flow and the relationship between the groundwater table and the potential leachate mound it is recommended that the top of the pipes for each probe or monitor be surveyed. Each site could then have a spreadsheet in which annual water levels can be entered and elevations automatically calculated for comparison.



5.0 IMPROVEMENT OR CHANGE SCHEDULE

Following further stages of this landfill disposition study, such as the Legal Risk and Responsibility Report, a schedule and/or ranking of the relative importance of action at each site will be provided. It should be noted that this ranking is not necessarily stagnant as future intrusive investigations at sites or receipt of additional monitoring data could change a perceived ranking. The Legal Risk and Responsibility Report will consider legal issues and apply a more rigorous system for evaluating priorities.



6.0 LIMITATIONS

This report was prepared for the exclusive use of the City of Winnipeg. The report, which specifically includes all tables, figures and attachments, is based on information provided by the City and is based solely on historical information and data obtained by Golder Associates during site visits. The City provided available electronic information for each site. Hard copies of additional historical documents for all of the landfill sites are stored at the City offices. Due to the quantity of these files, the review of these documents was out of the scope of this project, although they have been referenced on a limited basis. It has been assumed that the City has provided the relevant information required to complete this report. Reporting of results from the historical information provided does not allow for evaluation of the adequacy of the work completed.

Although comprehensive in nature, the data contained in this report should not be used in lieu of a more complete Phase II Environmental Site Assessment where such an assessment is required, for example, for a property transaction.

The information provided by the City has not been verified by any physical or intrusive methods other than visual inspection conducted during a visit of the sites. Consequently actual geographic limits of the footprint may extend beyond the boundaries shown on figures and the base of the waste may be different than what is reported.

The services performed, as described in this report, were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based on it, are the responsibilities of such third parties. Golder Associates accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The findings and conclusions of this report are valid only as of the date of this report. If new information is discovered in future work, including excavations, borings, or other studies, Golder Associates should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.



7.0 CLOSURE

There are 33 closed landfills generally within the City of Winnipeg. The landfills vary in cover material, waste type, height, depth, controls, on-site uses and adjacent uses. The monitoring program, data gaps and engineered control system of each landfill were evaluated in the attached appendices. Proposed changes at the sites related to monitoring or engineered features in many instances are considered iterative meaning a recommended change must be made and based on the results further changes may be required. The findings of this report will be used in writing the Landfill Rehabilitation and Cost Estimate Report.

We trust this report meets your current needs. If you have any further questions regarding this report, please contact the undersigned.

GOLDER ASSOCIATES LTD.

Patricia Edmond

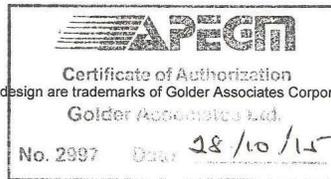
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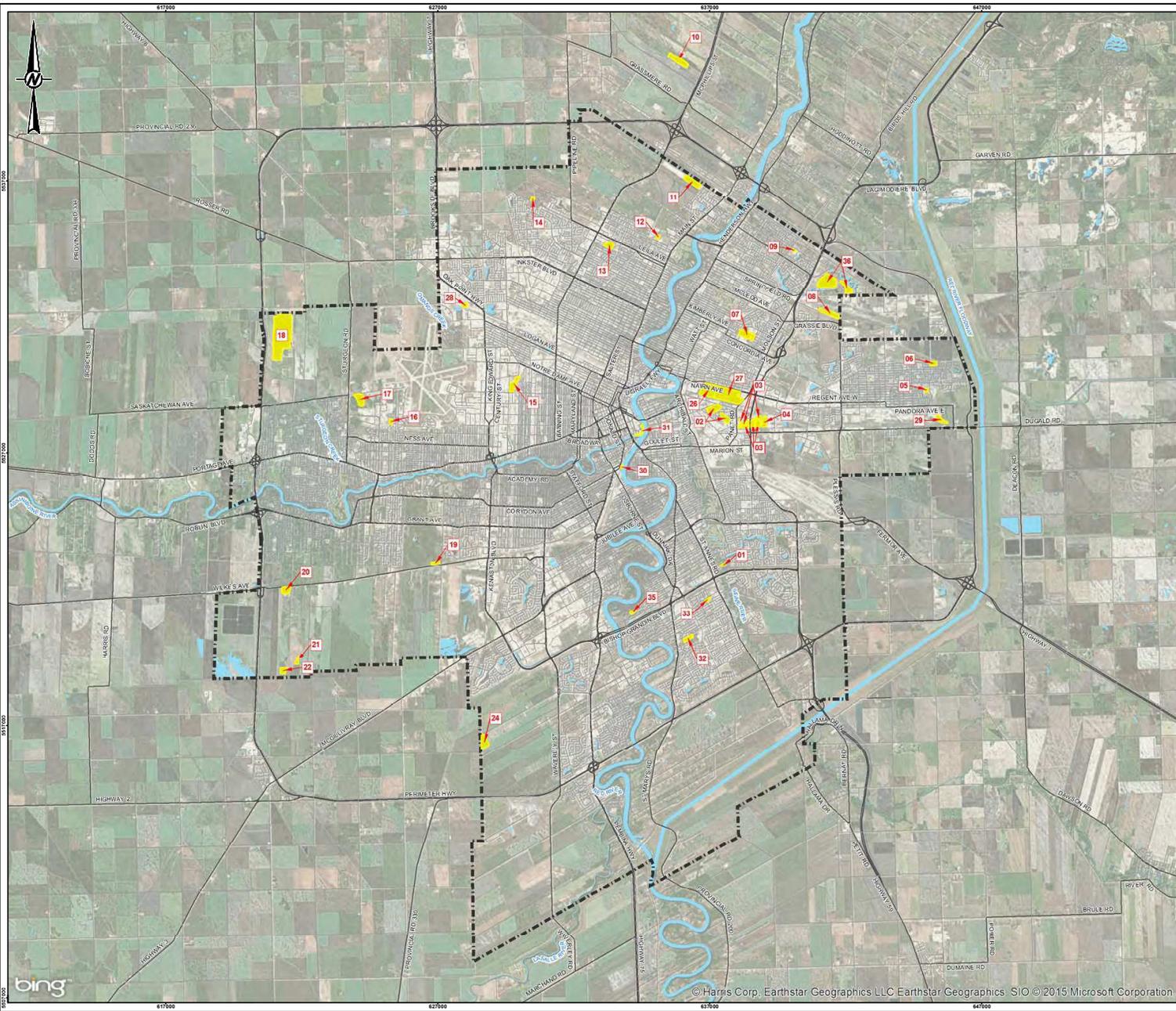




8.0 REFERENCES

Golder Associates Ltd. (Golder), 2015. *Landfill Status Report for Closed Landfills, Winnipeg, Manitoba*. Prepared for the City of Winnipeg.

Ontario Ministry of the Environment (MOE), 1998. *Ontario Regulation 232/98 (the Landfill Standards)* made under Part V of the *Environmental Protection Act*.



LEGEND

- MAJOR ROADWAY
- LOCAL ROADWAY
- WATERBODY
- CITY OF WINNIPEG CITY LIMIT
- LOCATION OF LANDFILL AND DUMP SITE

SITE 01: BELIVEAU ROAD DUMP SITE
 SITE 02: ST. BONIFACE DUMP SITE
 SITE 03: ST. BONIFACE LANDFILL SITE 1
 SITE 04: ST. BONIFACE LANDFILL SITE 2
 SITE 05: REDONDA DUMP SITE
 SITE 06: REDONDA LANDFILL SITE
 SITE 07: KIMBERLY LANDFILL SITE
 SITE 08: COROLITE LANDFILL SITE
 SITE 09: BONNER AVENUE LANDFILL SITE
 SITE 10: MCPHILLIPS STREET DUMP SITE (ASH DUMP)
 SITE 11: MCPHILLIPS STREET LANDFILL SITE
 SITE 12: MARGARET PARK LANDFILL SITE
 SITE 13: LEILA AVENUE LANDFILL SITE
 SITE 14: LEILA AVENUE (WEST) LANDFILL SITE
 SITE 15: SASKATCHEWAN AVENUE DUMP SITE
 SITE 16: BARRY AVENUE DUMP SITE
 SITE 17: HARCOURT STREET LANDFILL SITE
 SITE 18: SUMMIT ROAD LANDFILL SITE
 SITE 19: SHATESBURY BOULEVARD DUMP SITE
 SITE 20: CHARLESWOOD ROAD LANDFILL SITE
 SITE 21: CHARLESTON STREET (COMMUNITY ROW)
 SITE 22: CHARLESWOOD ROAD (SOUTH) LANDFILL SITE
 SITE 24: CABBORO ROAD (WEST) LANDFILL SITE
 SITE 26: ELMWOOD LANDFILL SITE
 SITE 27: NARN AVENUE LANDFILL SITE
 SITE 28: BROOKLANDS LANDFILL SITE
 SITE 29: CNR - DUGALD ROAD LANDFILL SITE
 SITE 30: CORYDON-OSBORNE DUMP SITE
 SITE 31: RED ASSINIBOINE RIVER JUNCTION DUMP SITE
 SITE 32: LOT 61, ST. MARY'S ROAD DUMP SITE
 SITE 33: RIEL DUMP SITE
 SITE 36: RIVER ROAD DUMP SITE
 SITE 36: KILCONA PARK LANDFILL SITE

0 2,000 4,000 8,000
 1:140,000 METRES

NOTE(S)
 1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1522283/2000.

REFERENCE(S)
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 3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
 COORDINATE SYSTEM: UTM ZONE 14 VERTICAL DATUM: CGVD28

CLIENT
 CITY OF WINNIPEG

PROJECT
 WINNIPEG LANDFILL RISK REPORT
 WINNIPEG, MANITOBA

TITLE
LOCATIONS OF CLOSED LANDFILL SITES

CONSULTANT	YYYY-MM-DD	2015-09-30
	DESIGNED	---
	PREPARED	BR
	REVIEWED	MKF
	APPROVED	PLE

PROJECT NO. 1522283 PHASE 2000 REV. 0 FIGURE 1

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APPENDIX A

1. Beliveau Road Dump Site



1.0 MONITORING PROGRAM CHANGES

Semi-annual surface water sampling should continue in the spring and fall of each year at an upstream and downstream location in the Seine River. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Landfill gas monitoring should continue annually at the Site, where possible, although it is understood that likely all probes have been significantly damaged or destroyed. As such, the landfill gas monitoring probes at this Site should be replaced as described in Section 3.0. Of particular importance is ensuring there is a landfill gas probe between the landfill and the residential properties located to the west of the Site. Groundwater levels should be obtained from the existing landfill gas probes. New landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect shallow groundwater samples, if required.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Deeper groundwater flow is reported to be to the north or northeast as such deeper monitoring wells should be installed to the south/southwest and north/northeast of the Site to evaluate background and downgradient groundwater quality, respectively. These deeper wells can include multi-level installations to also evaluate shallow groundwater quality. Shallow groundwater flow is likely towards the Seine River, which is expected to be a local discharge boundary. One of the nested monitoring wells located north/northeast of the Site can be used to assess direct discharge to the Seine River. It is recommended that the groundwater samples be collected annually and be analysed for the indicator list of groundwater parameters provided in Schedule 5 of the Landfill Standards. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Previous analytical results from five groundwater sampling events at L19 between 1981 and 1994 showed elevated levels of chloride and several metals above the CCME Water Quality Guidelines for the protection of aquatic life (used due to the proximity to the Seine River). When compared to the Health Canada Water Quality Guidelines, cadmium and chromium were elevated above their respective maximum allowable concentration guidelines. The remaining exceedances were of aesthetic guidelines only.

2.0 RECOMMENDED IMPROVEMENTS

Improvement of the on-going maintenance at the Site is recommended as the Site visit conducted on July 18, 2013 noted that the vegetation surrounding the gas probes was not trimmed. The Site visit also noted that three of the landfill gas probes were damaged at ground level, possibly from grass cutting machines. Any monitoring probe repairs required should be made.



Furthermore, the Site visit on June 17, 2015 noted and that there was some exposed debris in the southwest corner of the landfill that slopes towards the river. Due to the use of the Site for informal recreational purposes within a residential area, the gas probes must remain clearly visible to the public and maintenance crew to avoid further damage. No engineered control systems to mitigate the current or potential effects of leachate and/or landfill gas are recommended at this time as there is no current data to indicate that either are an issue at the Site.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

Health and safety protocols should be in place for utility maintenance work within the control zone and/or areas delineated as impacted by landfill gas.

3.0 DATA GAPS

Historical groundwater monitoring indicates that the shallow groundwater beneath the landfill may be impacted by landfill leachate. There is no current or deep groundwater quality information for the Site.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the north/northeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southwest end of the Site, and 2) at the northeast end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a landfill gas probe to be completed within the waste footprint should also be collected to understand the current quality of the landfill leachate. The two shallow monitoring wells installed in the nested wells located to the southwest and northeast of the Site should also be installed to be used as landfill gas probes (i.e., installed to straddle the water table).

In light of the poor repair of the three existing gas probes and their unknown well screen depths it is recommended that four new gas probes be installed at the Site. One gas probe should be located within the landfill footprint (also to be used as a leachate monitor described above) and three should be located outside the footprint to the northwest (between the landfill and the residential dwellings), southwest and north.

The two landfill gas probes to the northwest and southwest should be installed within the granular bedding for utilities located in this vicinity where the utilities continue to the west away from the control zone and interpreted extent of landfill gas impacts. Verification of utility trench depths and depth to groundwater are required to assess this migration potential.

If groundwater is found to be of poor quality during the recommended groundwater monitoring program, further drilling may be required along the perimeter of the control zone to determine if groundwater flowing off-Site is impacted.

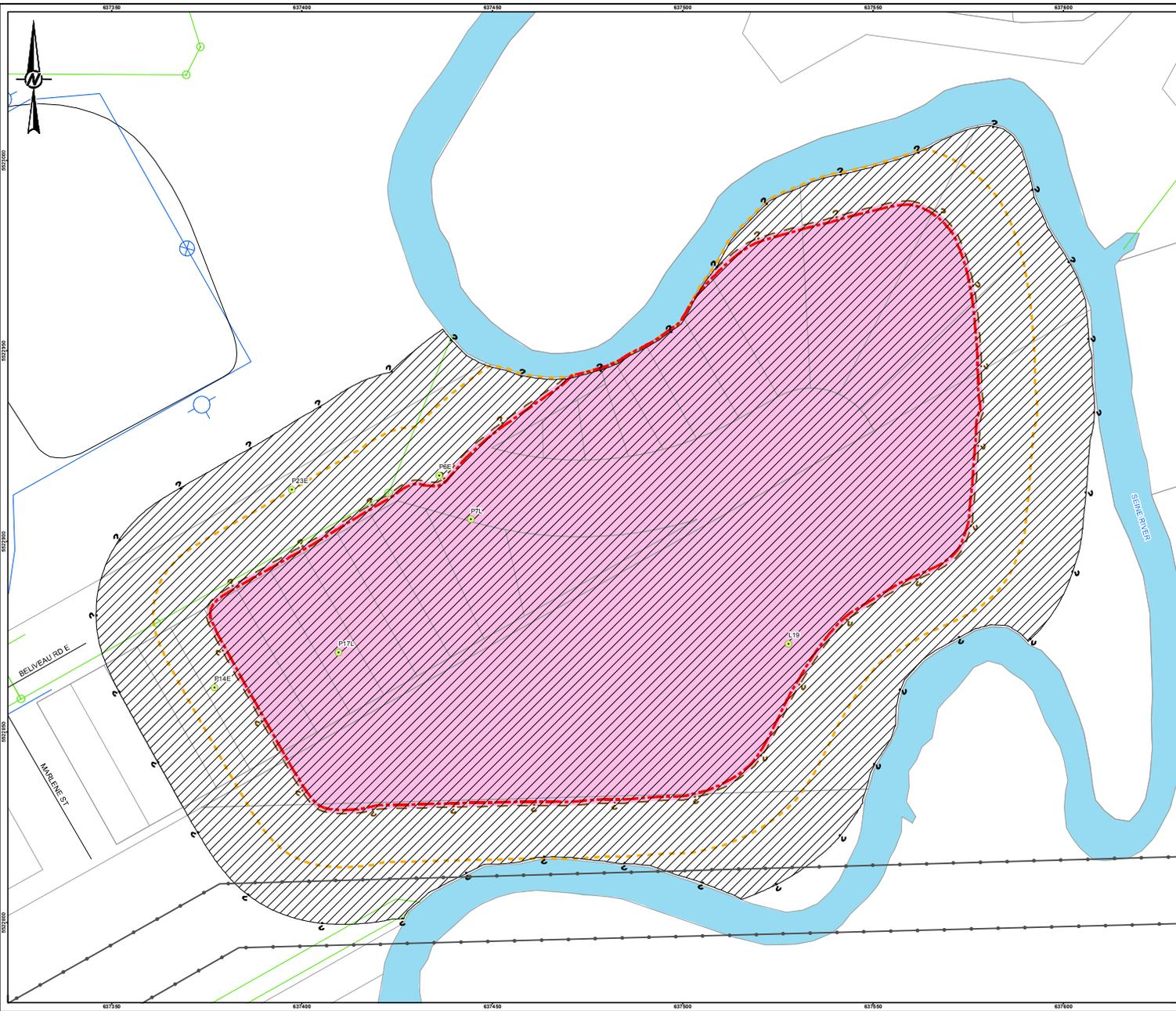


4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure A1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 3 metres (the distance of the waste below ground surface)) and D would therefore be 30 metres. With the presence of the Seine River, this distance would be reduced to the river itself on the north, east, and south sides of the Site. Note that although this is a fairly significant distance of potential impact the type of waste at this Site is not expected to generate significant concentrations of methane landfill gas. Monitoring data from landfill gas probes installed above the water table can potentially support this theory and possibly reduce the interpreted extent of landfill gas impact.

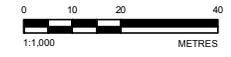
The extent of landfill leachate impact on groundwater is unknown at this time. Historical exceedances in the groundwater at L19 indicate that the groundwater is impacted within the waste fill area. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints, and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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LEGEND

- LANDFILL FOOTPRINT
- CONTROL ZONE AREA
- INTERPRETED EXTENT OF POTENTIAL LANDFILL GAS IMPACTS
- INTERPRETED EXTENT OF POTENTIAL GROUNDWATER IMPACTS
- GAS MONITORING PROBE
- PROPERTY PARCEL
- RIVER
- ROAD
- UTILITIES**
- SANITARY SEWER
- WATER MAIN
- POWER TRANSMISSION LINE (OVERHEAD)



NOTE(S)
 1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1522283/2000.

REFERENCE(S)
 1. BASE DATA PROVIDED BY CITY OF WINNIPEG.
 2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
 COORDINATE SYSTEM: UTM ZONE 14 VERTICAL DATUM: CGVD28

CLIENT
CITY OF WINNIPEG

PROJECT
WINNIPEG LANDFILL RISK REPORT
SITE 1: BELIVEAU ROAD DUMP SITE, WINNIPEG, MANITOBA

TITLE
INTERPRETED EXTENT OF IMPACT

CONSULTANT	YYYY-MM-DD	2015-09-30
	DESIGNED	---
	PREPARED	BR
	REVIEWED	MKF
	APPROVED	PLE
PROJECT NO. 1522283	PHASE 2000	REV. 0
		FIGURE A1

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APPENDIX B

2. St. Boniface Dump Site



1.0 MONITORING PROGRAM CHANGES

No monitoring is currently undertaken at the St. Boniface Dump Site. The historical landfill gas monitoring results indicate that the landfill was producing methane in the past but that by 1987 the production had slowed.

The Site is owned privately and as such, the Site is not easily accessible. There are three landfill gas probes located outside of the property (landfill gas probes P46E, P47E and P48E) on the northwest side of the Site near Plinguet Street. These monitoring wells never reported measureable landfill gas concentrations. Groundwater levels should be reviewed in these probes. If the groundwater level is above the screen then monitoring from the landfill gas probe will not provide tangible information about lateral landfill gas migration in that area. As such, since the spatial relationship between the well screens and the groundwater level is not known, it is recommended that one additional probe should be installed within the right-of-way of Plinguet Street. The newly installed probe should have a well screen that straddles the water table so that it can be used for groundwater sampling as well if required in the future.

It is recommended that methane gas and water levels be monitored semi-annually to determine if landfill gas is migrating off the Site. Continuation of landfill gas monitoring should be reassessed after two years.

The clay below the waste is reportedly 7.9 metres thick and the groundwater flow direction at the Site is to the south/southwest. It is expected that potential impacts to groundwater from landfill leachate would naturally attenuate before there would be available City-owned land to install groundwater monitoring wells. Therefore, bedrock groundwater monitoring is not recommended at this time. Shallow groundwater sampling is not recommended at this time due to current site ownership.

2.0 RECOMMENDED IMPROVEMENTS

There are no recommended improvements at this time pending continued monitoring.

3.0 DATA GAPS

Since non-detectable methane readings cannot be relied upon, one additional landfill gas probe is required at the site.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure B1. Based on the shallow groundwater table at the Site (1 metre below ground surface), the extent of lateral migration of landfill gas is interpreted to be limited. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 1 metre (assuming that is the distance to the water table) and D would therefore be 10 metres. The available historic landfill gas monitoring results indicate that



APPENDIX B

2. St. Boniface Dump Site – Winnipeg Landfill Environmental Risk Report

landfill gas was detected at landfill gas probes within 10 metres of the waste footprint. Monitoring probes P46E, P47E and P48E are located beyond 10 metres from the waste footprint and never had reported concentrations of methane, however, the screened interval of these monitoring probes cannot be confirmed at this time.

In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint.

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APPENDIX C

3. St. Boniface Landfill Site 1



1.0 MONITORING PROGRAM CHANGES

Landfill gas monitoring in the two buildings near the Site should continue. Since no methane has been detected to date, annual monitoring is satisfactory.

Landfill gas monitoring in existing and proposed (see Section 3.0) landfill gas probes should continue on an annual basis. Landfill gas monitoring should be followed by verification of water levels at each existing probe location. If the groundwater level is above the screen and/or the screen depth is unknown then monitoring from that landfill gas probe cannot provide tangible information about lateral landfill gas migration in that area. Landfill gas probes that consistently have water levels above the screen should not be included in the on-going landfill gas monitoring program.

Due to exceedances and the Guidelines for Canadian Drinking Water Quality noted in bedrock monitoring wells W1 and W2 in the early 2000s, it is recommended that groundwater samples be collected again from these monitors, as well as from water supply wells representative of background conditions, such as those previously sampled for Burns Meat Ltd. and at 663 Marion. If those water supply wells are not available for sampling, consideration should be given to installation of one representative background groundwater monitoring well. It is recommended that two groundwater monitors located at the south property boundary (and the southwest corner) should be installed in the bedrock to understand if impacted groundwater is migrating off-site. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from landfill gas probes P103E and P77E, which are located outside of the landfill footprints. A groundwater sample should also be collected from two of the newly installed landfill gas probes located within the waste footprint (north of Warman Road and southeast of Warman Road and Lagimodiere Boulevard (near the open-air building) as described in Section 3.0) to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Water levels should continue to be measured in any available monitoring wells.

It is known that groundwater has been impacted by petroleum hydrocarbons (although the source is not definitively known). It is recommended that the samples collected from the landfill gas probes P103E and P77E be analyzed for petroleum hydrocarbons to evaluate the extent of the impact.

2.0 RECOMMENDED IMPROVEMENTS

Ensure that the remaining on-Site building is kept open and limit future development on the Site while landfill gas is still being generated.

Health and safety protocols should be in place for any road work or utility maintenance work on the roads between landfill parcels.

Signs should be placed indicating that smoking or flames are not allowed at the Site.



3.0 DATA GAPS

Up to date bedrock groundwater monitoring is required to understand the potential impacts to the groundwater in the bedrock. Groundwater flows to the southwest. As such, two groundwater monitors should be installed in the bedrock at the following downgradient locations to understand potential for off-Site migration of landfill leachate-impacted groundwater: 1) the southern boundary, and 2) the southwest corner of the Site. One background monitor also completed within the bedrock is required for comparison. The background monitor may be a new installation north of the waste footprint or obtained from an existing neighbouring well if possible.

It is recommended that three landfill gas probes be installed within the waste footprint as follows: north of Warman Road, southeast of Warman Road and Lagimodiere Boulevard (near the open-air building) and at the thin landfill footprint southeast of Warman Road and Panet Road. These landfill gas probes will assist in understanding if those portions of the landfill are generating landfill gas. If the area is generating landfill gas, consideration can be given to adding additional landfill gas wells outside of the waste footprint to understand if landfill gas is migrating laterally. The landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect shallow groundwater samples, if required.

Landfill gas probes should be installed within the granular bedding for the sanitary sewers, watermains or road bedding that exist between parcels of the landfill to understand if landfill gas migration is occurring within this material. The focus of these monitors should be beyond the extents of the waste footprints to see if landfill gas migration may be occurring outside of the waste footprint. Specifically, five landfill gas probes should be installed in the the granular bedding material for the utilities on Softley Road, Fournier Street (north and west ends) and Warman Road (at the east end and near the intersection of Warman Road and Lagimodiere Boulevard) to assess whether landfill gas is migrating within these utility trenches. Depending on the results of the landfill gas monitoring, another landfill gas probe could be considered at the south end of Lagimodiere Boulevard. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure C1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, to be conservative, H would be 6 metres (this is the depth of the waste below ground surface and water levels measured outside of the landfill footprint have been lower than this in some instances) and D would therefore be 60 metres. While there are probes outside of the waste footprint that have recent methane readings of 0%, these wells have



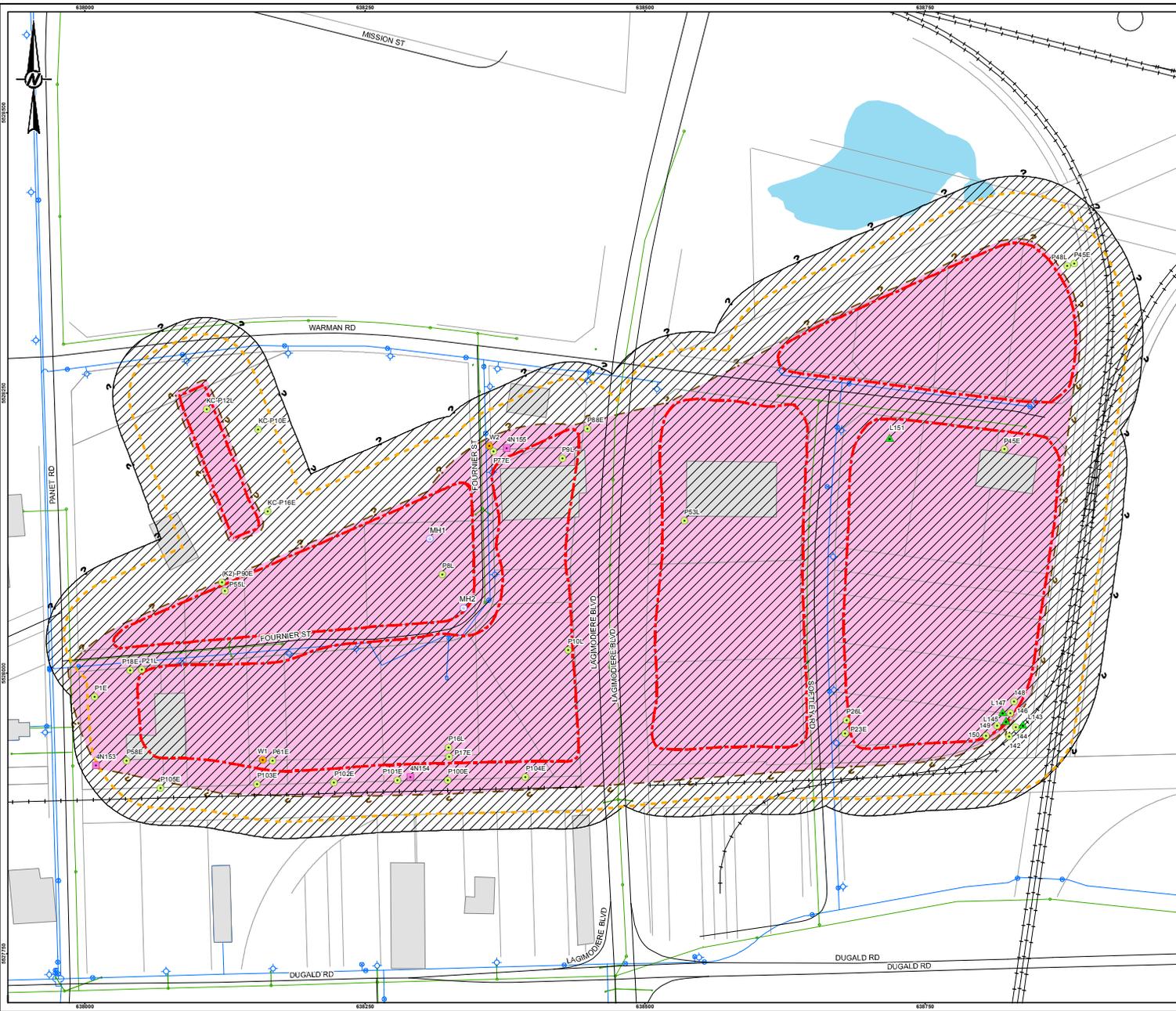
APPENDIX C

3. St. Boniface Landfill Site 1 – Winnipeg Landfill Environmental Risk Report

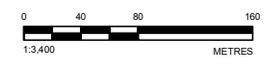
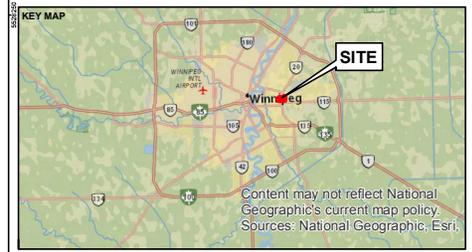
consistently had 0% readings (indicating that the water level is possibly above the well screen). Other landfill gas probes have some detections of methane between 2011 and 2014. Therefore, the 60 metre area around the waste footprint cannot be reduced based on monitoring results at this time and is interpreted as the extent of landfill gas impact.

The extent of landfill leachate impact on the deep groundwater is not known at this time. Groundwater flow is to the southwest and historic impacts have been noted at 4N153, 4N154 and P100E. As a starting point, it has been assumed that to the south and west of the landfill footprints that the interpreted impact of landfill leachate on groundwater is the farthest distance monitored with exceedance of the Guidelines for Canadian Drinking Water Quality. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts to the north and east are assumed to be the extents of the landfill footprint, but may be greater. Some parameters exceeded the Guidelines for Canadian Drinking Water Quality in groundwater from W2, so the interpreted extent of landfill leachate impact encompassed that location as well.

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- LEGEND**
- LANDFILL FOOTPRINT
 - CONTROL ZONE AREA
 - INTERPRETED EXTENT OF POTENTIAL LANDFILL GAS IMPACTS
 - INTERPRETED EXTENT OF POTENTIAL GROUNDWATER IMPACTS
 - GAS MONITORING PROBE
 - GROUNDWATER WELL
 - LEACHATE MAN-HOLE
 - LEACHATE PROBE
 - PIEZOMETER
 - PROPERTY PARCEL
 - ROAD
 - RAILWAY
 - WATERBODY
 - BUILDING FOOTPRINT
 - UTILITY
 - SANITARY SEWER
 - WATER MAIN



NOTE(S)
 1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1522283/2000.

REFERENCE(S)
 1. BASEDATA PROVIDED BY CITY OF WINNIPEG.
 2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
 COORDINATE SYSTEM: UTM ZONE 14 VERTICAL DATUM: CGVD28

CLIENT
 CITY OF WINNIPEG

PROJECT
 WINNIPEG LANDFILL RISK REPORT
 SITE 3: ST. BONIFACE LANDFILL SITE 1, WINNIPEG, MANITOBA

TITLE
 INTERPRETED EXTENT OF IMPACT

	CONSULTANT	YYYY-MM-DD	2015-09-30
	DESIGNED	---	---
	PREPARED	BR	---
	REVIEWED	MKF	---
	APPROVED	PLE	---
PROJECT NO.	PHASE	REV.	FIGURE
1522283	2000	0	C1

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 Plot User: jacob.mack
 Plot Printer: HP DesignJet T1100e

20mm
 IF THIS REQUIREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM



APPENDIX D

4. St. Boniface Landfill Site 2



1.0 MONITORING PROGRAM CHANGES

Waste is located above ground and there are ditches surrounding the waste footprint therefore annual surface water monitoring in the ditches surrounding the waste footprint is recommended at an upstream and downstream location. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Landfill gas monitoring should continue annually at the available probes P18L, P1L and P53E. Landfill gas monitoring should be followed by verification of water levels at each existing probe location. While it is expected that the screens at probes P18L and P1L are above the water table (based on historic methane measurements), methane has never been detected at P53E and it is therefore possible that this probe may not be providing accurate information on potential methane gas migration. The waste footprint is surrounded by a ditch that may act as a barrier to landfill gas migration. There is still a potential that landfill gas may migrate below the ditch, should there be space between the base of the ditch and the groundwater table. Migration of landfill gas is most important to understand on the east side of the Site where there are buildings. A survey should be undertaken to understand the elevation of the bottom of the east ditch and the elevation of the groundwater table (which could be acquired by measuring the elevation of top of pipe for probes P18L, P1L and P53E and then calculating the corresponding groundwater elevation). If the groundwater table elevation is below the elevation of the ditch then one landfill gas probe should be installed on the east side of the ditch between the landfill and the nearest off-Site building. This new probe should be added to the monitoring program.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow is to the south/southwest so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the northern end of the Site, and 2) at the south end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a landfill gas probe completed within the waste footprint should also be collected to understand the current quality of the landfill leachate. It is recommended that the groundwater samples be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Re-grading is required at this Site since the ground is uneven from previous dumping. Construction waste, such as rubble, fill and wood, has been placed at the site and should be appropriately covered after re-grading is complete.

Health and safety protocols should be in place for any utility maintenance work on sanitary sewer that extends into the east side of the Site.

Signs should be placed indicating that smoking or flames are not allowed at the Site.



APPENDIX D

4. St. Boniface Landfill Site 2 – Winnipeg Landfill Environmental Risk Report

3.0 DATA GAPS

There is currently limited groundwater quality information for the Site. It is recommended that two monitoring well nests (well screen completed in the shallow overburden and bedrock) be installed at the Site: one upgradient and one downgradient of the Site.

Following an investigation on the elevation of the groundwater and the bottom of the east ditch, a landfill gas probe may be required east of the east ditch and a probe within the bedding of the utility trench that extends into the east side of the Site is recommended.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure D1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, to be conservative, H would be 3 metres (this is the depth of the groundwater table below the surrounding ground surface) and D would therefore be 30 metres. Probe P53E is outside of the waste footprint and has recent and consistent methane readings of 0%. This may indicate that there is no methane gas migration in this area or that the probe screen depth is below the groundwater level. Therefore, the 30 metre landfill gas migration area around the waste footprint cannot be reduced based on monitoring results at this time.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of further data, due to low permeability soil surrounding the waste footprints, the downward hydraulic gradient and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the ditch network surrounding the waste footprint. Based on proposed monitoring the interpreted extent of potential groundwater impacts should be re-assessed following receipt of additional data.

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APPENDIX E

5. Redonda Dump Site



1.0 MONITORING PROGRAM CHANGES

Due to the surrounding mixed residential/institutional land use, an annual landfill gas monitoring program is recommended at the Site to obtain current data on potential methane concentrations. Historically, two of the four gas probes (P5L and P7L), sampled between 1982 and 1995, showed fluctuations in methane concentrations. The non-detectable methane concentrations reported at the other two gas probes (P3E and P8L) may be due to the screened interval being below the depth to groundwater. Therefore, current data is needed to confirm these reported conditions. Groundwater levels should be obtained from the existing landfill gas probes.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Local groundwater flow is to the west so monitoring well nests should be installed outside of the waste footprint at the east end of the Site and at the west end of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Signs should be placed indicating that smoking or flames are not allowed at the Site.

No improvements to the physical condition of the Site are recommended at this time as the most recent Site visit on June 16, 2015 reported no issues with slope, no exposed waste, and no signs of stressed vegetation. The 2014 Site visit reported that the Site was well maintained with no signs of illegal dumping, erosion, or leachate issues. On-going site maintenance should continue at the Site for its current use as a park with baseball diamonds and a skate park. No engineered control systems to mitigate the current or potential effects of leachate and/or landfill gas are recommended at this time as there is no current data to prove that either are an issue at the Site.

3.0 DATA GAPS

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the west so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the west end of the Site, and 2) at the east end of the Site, to obtain results on background and downgradient groundwater quality, respectively. An additional shallow monitoring well is recommended to be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.



4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure E1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 0.9 metres (the thickness of waste disposed above the water table) and D would therefore be 9 metres. Note that since landfill gas has historically been reported at landfill gas probe P7L located at the west edge of the control zone the interpreted extent of landfill gas impacts has been extended in this area.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX F

6. Redonda Landfill Site



1.0 MONITORING PROGRAM CHANGES

It is recommended that the landfill gas monitoring program remain the same for the inside of the building (Harold Hatcher School) on the Site and continue on an annual basis. Based on the most recent sampling event conducted in August 2014 no methane was detected from the methane probe, mid-air or near the two floor drains located inside the building. Groundwater levels should also be obtained from the existing landfill gas probes.

Due to the surrounding mixed residential/institutional land use, a semi-annual landfill gas monitoring program is recommended at the Site to obtain current data on potential methane concentrations. This program will require the installation of new landfill gas probes on the south and west sides of the landfill within the interpreted landfill gas impact extent as no probes remain. It is likely that two landfill gas probes on the west side and three landfill gas probes on the south side of the Site should be sufficient.

Landfill gas monitoring from the granular bedding material for the utilities along Redonda Street is required to understand if landfill gas migration is occurring within this material. It is recommended that one probe be installed at the end of the utility trench that lies within the landfill and/or control zone. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Local groundwater flow is west/southwest so monitoring well nests should be installed to the north east and southwest of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

There are no improvements recommended for the physical condition of the Site. It is recommended that the Site continue to be maintained as it has been in the past.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

Health and safety protocols should be in place for any road work or utility maintenance work on Redonda Street in areas beside or within the landfill and/or control zone. Further health and safety protocols should be shared with the owner of the fibre optic cable, gas line and hydro cable.

The waste boundary was not totally defined at the Site, although the drawings are reported to provide a reasonably accurate location of waste.



3.0 DATA GAPS

No historical or current groundwater quality has been established at the Site. Therefore, groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the northeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southwest end of the Site, and 2) at the northeast end of the Site, to obtain results on background and downgradient groundwater quality, respectively. An additional shallow monitoring well is recommended to be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Further drilling and groundwater sampling will allow for a greater understanding of the waste fill area and any potential groundwater impacts.

Additional gas probes (six total - two in the western portion of the Site, three in the southern portion of the Site and one within the utility trench) are required to ensure that landfill gas generation remains low within the Site. The landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required. One of these probes can also be used as the shallow groundwater monitoring well required in the southwest and one can be used in the utility trench, as noted above

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure F1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2 metres (the distance to the surrounding water table assumed to be at 236 to 237 metres above sea level from the surrounding ground surface of 234 to 235 metres above sea level) and D would therefore be 20 metres.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX G

7. Kimberly Landfill Site



1.0 MONITORING PROGRAM CHANGES

It is recommended that landfill gas monitoring should continue annually at the Site at existing probes and proposed landfill gas probes as described in Section 3.0. Landfill gas monitoring should be followed by verification of water levels at each existing probe location.

It is recommended that monitoring of the residential homes within the control zone be completed in the early evening hours so that more residents will be home and therefore, more homes will be monitored.

It is understood that the Terry Sawchuk Arena has a landfill gas detection alarm system. This system should be tested annually to ensure that it is still functioning properly. Landfill gas monitoring should continue within the arena.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater samples should be collected from two landfill gas probes located outside of the waste footprint to understand potential landfill leachate impact on shallow groundwater on adjacent sites and from one landfill gas probe located within the waste footprint to understand the current quality of the landfill leachate. Groundwater flow in the bedrock is to the south/southwest so monitoring wells should be installed in the bedrock outside of the waste footprint at the northern end of the Site and at the south end of the Site (on the south side of the Kimberly Avenue right-of-way) to obtain results on background and downgradient groundwater quality, respectively. It is recommended that the groundwater samples should be collected annually. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Due to the surrounding land uses, water levels should be measured in any available monitoring wells.

2.0 RECOMMENDED IMPROVEMENTS

Signs should be placed indicating that smoking or flames are not allowed at the Site, especially at the top of the waste mound where stressed vegetation was observed and may be indicative of methane venting from the waste. Continue re-seeding efforts and/or adding additional topsoil on an as needed basis.

Health and safety protocols should be in place for any road work or utility maintenance work on London Street, Kimberly Avenue, Rizer Crescent and Gibson Street in areas beside or within the control zone.

3.0 DATA GAPS

Landfill gas monitoring from the granular bedding material for the utilities along roads within the control zone is required to understand if landfill gas migration is occurring within this material. It is recommended that five probes be installed at the end of the utility trenches that lie within the control zone on the following roads: London Street (north and south ends), Blantyre Avenue, Kimberly Avenue and Rizer Crescent. If groundwater is encountered in the granular bedding material, then groundwater samples could be collected from these probes in lieu of samples collected from landfill gas probes located outside of the waste footprint as recommended in Section 1.0.



APPENDIX G

7. Kimberly Landfill Site – Winnipeg Landfill Environmental Risk Report

A landfill gas barrier surrounds the landfill. Methane was detected at the landfill gas probes located outside of the landfill gas barrier on each side of the landfill in 2011 (P51E, P55E, P117E, P119E and P47E), however, the detections returned to 0% methane in subsequent years. Even though no detections have been reported in more recent years, it is recommended that four new landfill gas probes be installed outside of the landfill gas barrier (one on each side of the landfill) since the well screen depths are not known for these locations and it is not possible to assess the reliability of a non-detectable methane reading. To assess the performance of the barrier system, four landfill gas probes should be installed on the inner edge of the landfill gas barrier on each side of the landfill, corresponding with the landfill gas probe outside of the landfill gas barrier.

Historic groundwater monitoring indicates that the shallow groundwater beneath the landfill may be impacted by landfill leachate. There is no current or deep groundwater quality information for the Site. Groundwater flows to the south/southwest. As such, one groundwater monitor should be installed in the bedrock at the southern boundary, outside of the waste footprint to understand potential for off-Site migration of landfill leachate impacted groundwater. One background monitor at the north end of the Site completed within the bedrock is required for comparison.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure G1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 4 metre (assuming that is the distance to the water table from the surrounding ground surface) and D would therefore be 40 metres. With the presence of the landfill gas barrier, this distance would be reduced to the landfill gas barrier itself. However, there are areas on all sides of the landfill that have waste beyond the landfill gas barrier. In these areas, the interpreted extent of landfill gas impact is 40 metres from the edge of the waste, unless there is evidence based on at least three years of 0% methane monitored in probes outside of the waste footprint. Methane was detected at P117E in the last three monitoring events and as such, while the waste in this area is within the landfill gas barrier, the interpreted extent of landfill gas impact was kept at 40 metres. With another year of landfill gas monitoring data, the interpreted extent of landfill gas impact could be reassessed. Review of Figure G1 indicates that the residential buildings on Green Valley Bay are outside of the interpreted extent of potential landfill gas impact, however, due to the proximity of the homes to the landfill it would be prudent to continue monitoring within the basements of these buildings.

It has been reported in the past the waste is deeper than the landfill gas barrier, however, the landfill gas barrier extends below the water table so the water itself will act as a barrier.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX H

8. Cordite Landfill Site



1.0 MONITORING PROGRAM CHANGES

Landfill gas monitoring should continue annually at the Site. Groundwater levels should be obtained from the existing landfill gas probes. If the water level is suspected to be above the screen then monitoring from that landfill gas probe will not provide tangible information about lateral landfill gas migration in that area. Based on the elevated landfill gas readings obtained in 2013 from the wells installed within the waste (as high as 71% of the lower explosive limit of hexane [LEL] at LD-49), it is suspected that the majority of these probes likely have well screens above the water table indicating representative data. Historically all probes at the Site have reported landfill gas concentrations on at least one occasion. The wells at the western limit of the Site, between the waste fill area and the adjacent industrial property (including P22E, P7E, and P25E) more recently have non-detectable readings and may be considered suspect. The well installed within the waste adjacent to these wells (P4L) had a methane concentration of 5% LEL.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Regional bedrock groundwater flow is reported to be to the southwest so monitoring wells nests should be installed outside of the waste footprint at the northeast corner of the Site and at the southwest end of the Site. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints. Also shallow groundwater samples are required from a well installed within the waste footprint to understand the quality of the leachate. It is recommended that the groundwater samples be collected annually and be analysed for the indicator list of groundwater parameters provided in Schedule 5 of the Landfill Standards. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Groundwater samples should also be collected annually from the adjacent industrial property.

2.0 RECOMMENDED IMPROVEMENTS

Several improvements are recommended at the Site to mitigate hazards. The Site is currently fenced to deter unauthorized use of the Site and should continue to be maintained in this manner. The improvements are related to evident slope failure on the east side of the Site and possible continued failure on the northeast end of the Site. Upon review of the KGS Group 2008 Cordite Road Remedial Works letter, notes and photos from the Golder 2015 field visit and the 2011 topographical information supplied by the City, it would appear that remedial works recommended for the north slope area located toward the east end of the landfill were not implemented as specified in the design. Further, based on the details of the KGS Group 2008 Cordite Road Remedial Works letter Golder is not certain that the mechanism of failure has been fully explained. As such, to mitigate failure on the east slope and determine whether further failure on the north slope is imminent, a geotechnical investigation is required. This investigation would also consider determining the leachate elevation within the eastern end of the landfill and reviewing as-builts and or design details of the leachate drain installed at the Site.

Areas of stressed vegetation should be covered with topsoil and re-seeded as needed.



3.0 DATA GAPS

Historical groundwater monitoring indicates that the shallow groundwater beneath the landfill may be impacted by landfill leachate. There is no current or deep groundwater quality information for the Site. Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the southwest so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southwest end of the Site, and 2) at the northeast end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. If possible, a sample should be collected from one of the existing leachate probes (LD-46, LD-48, LD-49 or LD-50). If it is not possible to obtain a sample from any of these probes then a new monitoring well should be installed within the waste footprint to understand the current quality of the landfill leachate. The two to three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Based on the unknown well screen depths in the wells exterior to the waste footprint, some additional new landfill gas probes are recommended. A total of three landfill gas probes should be installed at the Site: outside of the waste limits at the northwest corner; on the western site boundary (in the area of the off-Site building); and, on the southeast side of the Site. These three landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure H1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, to be conservative, H would be 2.1 metres and D would therefore be 21 metres.

The extent of landfill leachate impact on groundwater is unknown at this time. Historical exceedances were reported in the groundwater from on-Site groundwater monitoring wells although does not appear to be impacting adjacent properties. The interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX I

9. Bonner Avenue Landfill Site



1.0 MONITORING PROGRAM CHANGES

The Site consists of the Gateway Community Centre, and also includes a recreational area with play structures and a baseball diamond. Although historical records at the Site indicate no detectable methane at any of the previous gas probe locations, an annual landfill gas monitoring program at the Site is recommended to ensure reported conditions are representative and do not change followed by verification of water levels at each existing probe location. The relationship between the well screen depth and the water level of the historical probes is unknown. This information is important to obtain and understand as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area. Details of the proposed monitoring program are described in Section 3.0. Annual air samples from the crawl space in the community centre building should also continue to be collected at the Site.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Deep groundwater flow is to the south so monitoring well nests should be installed outside of the waste footprint at the north end of the Site and at the south end of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Polynuclear aromatic hydrocarbons ("PAHs") should also be analysed due to the presence of burned material.

2.0 RECOMMENDED IMPROVEMENTS

On-going site maintenance should continue at the Site. No improvements are recommended at this time as the Site visits on August 1, 2013 and June 16, 2015 reported a well maintained Site with no exposed debris, erosion, stressed vegetation, illegal dumping, or leachate issues. No additional engineered control systems to mitigate the current or potential effects of leachate and/or landfill gas are recommended at this time as there is no current data to indicate that either are an issue at the Site.

3.0 DATA GAPS

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the south so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the south end of the Site, and 2) at the north end of the Site, to obtain results on background and downgradient groundwater quality, respectively. An additional shallow monitoring well is recommended to be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.



APPENDIX I

9. Bonner Avenue Dump Site – Winnipeg Landfill Environmental Risk Report

One additional newly installed landfill gas probe (between the Site and the residential properties across Bonner Avenue) is recommended near or within the granular bedding of the watermain present on the north side of the Site near Bonner Avenue. A second probe near the sewer beside P98E could also be useful to assess if this utility has acted as a preferential pathway to landfill gas migration. These two landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure I1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.4 metres (the distance to the surrounding water table assumed to be at 228.6 metres above sea level from the surrounding ground surface of 231 metres above sea level) and D would therefore be 24 metres.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX J

10. McPhillips Street Dump Site (Ash Dump)



1.0 MONITORING PROGRAM CHANGES

An annual groundwater sampling program is recommended for the Site to determine any potential issues as there is no current data. Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality.

Due to the stressed vegetation along the eastern side of the slope it is recommended that a shallow groundwater sample be collected from a new monitoring well located near P3L, to determine whether there are impacts in the groundwater affecting nearby vegetation. The deep groundwater flow direction is east / southeast. New monitoring wells nests installed in the bedrock to the west / northwest and east / southeast should be installed to understand background water quality and downgradient water quality at the Site, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located both inside (i.e. at P3L) and outside of the landfill footprints. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Polycyclic aromatic hydrocarbons (PAHs) should also be analysed once as burned material is present on-Site and if not detected, can then be excluded from subsequent sampling events.

Landfill gas monitoring should continue annually at the Site followed by verification of water levels at each probe location. Monitor P7L had a reported methane gas concentration of 4% LEL in 2013. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area.

2.0 RECOMMENDED IMPROVEMENTS

As stressed vegetation has been noted in the past, this should be monitored closely for seeps and/or landfill gas migration.

Re-vegetation of the stressed areas is recommended although the Site is in a remote location and this would be considered a low priority.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

3.0 DATA GAPS

Due to the lack of groundwater and landfill gas data between 1992 and 2015 it is recommended that the monitoring well P3L and P9E on site be replaced to further investigate the stressed vegetation on the eastern side of the Site.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the east/southeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the east/southeast end of the Site, and 2) at the north/northwest end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. If possible, a sample should be collected from one of the existing or replaced leachate probes



APPENDIX J

10. McPhillips Ash Dump – Winnipeg Landfill Environmental Risk Report

(i.e. P3L, P7L, or P11L) located within the waste fill area. If it is not possible to obtain a sample from any of these probes then a new monitoring well should be installed within the waste footprint to understand the current quality of the landfill leachate. The two to three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings. Once wells are installed, it is recommended to include all new and remaining functioning wells in the annual gas sampling program.

To determine if non-detectable methane readings can be relied upon, information about the screened interval for the landfill gas probes and the water levels within those probes are required as they are currently unknown, although based on the reported detectable methane concentrations in some probes and the low water levels (and in some cases, dry conditions), it is assumed these probes will provide valid landfill gas information.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure J1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 0.5 metres (outside the waste footprint; however, within the waste the distance to the surrounding water table assumed to be at 230.5 metres above sea level from the surrounding ground surface of 230 metres above sea level) and conservatively D would therefore be 5 metres. With the presence of the ditches surrounding the Site and the high water table, the ditches would also provide a landfill gas migration barrier if landfill gas did migrate outside the 5 m anticipated zone of impact.

The extent of landfill leachate impact on groundwater is unknown at this time. Historical exceedances in the groundwater from groundwater monitoring wells P3L and P7L indicate that the interpreted extent of impact to groundwater should extend past these monitors. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater. There was an exceedance of lead at the residential property to the east, although it is unlikely related to the presence of the ash dump.

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APPENDIX K

11. McPhillips Street Landfill Site



1.0 MONITORING PROGRAM CHANGES

Annual groundwater monitoring should continue at the Site. Based on analytical results collected between 1986 and 1991 from all sampling locations, one or more of cadmium, chromium, copper and lead were elevated above the Health Canada Drinking Water Quality Guidelines. The groundwater flow direction is reported as south/southeast. Pending confirmation of the location of W1 and W2 it may be necessary to install one or more additional bedrock monitoring wells outside of the waste footprint to evaluate background and downgradient groundwater quality. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. It is recommended that the groundwater samples be collected annually and be analysed for the indicator list of groundwater parameters provided in Schedule 5 of the Landfill Standards. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters

Landfill gas monitoring should continue annually at the Site followed by verification of water levels at each existing probe location. Historically, landfill gas was present outside the waste fill area with reported concentrations greater than 20% of the lower exposure limit (LEL) while probes located inside the waste fill area had methane concentrations greater than 85% LEL. However, based on the most recent monitoring event results reviewed from 2013, non-detectable levels of methane were reported at all existing probes. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area. It is suspected that some monitoring wells may not have well screens above the water table. The annual landfill gas sampling program is also recommended to monitor and confirm that non-detectable levels of methane remain at the Site, especially on the southern border between the landfill and the residential development.

2.0 RECOMMENDED IMPROVEMENTS

There are no improvements recommended for the physical condition of the Site. It is recommended that the Site continue to be maintained as it has been in the past (i.e., as an open field) and to perform semi-annual maintenance at the Site for aesthetic purposes. Due to the evidence of minor illegal dumping at the Site, it is recommended that a barrier (fence, bollards or concrete blocks) be placed to limit public access onto the Site. As there are only shallow slopes present on-Site with no reported erosion or settling issues, there are no engineered control systems required.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

3.0 DATA GAPS

Further drilling should be considered pending information and location for monitoring wells W1 and W2. In the worst case, assuming information is not available, groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the south/southeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southeast end of the Site, and 2) at the northwest end of the Site, to obtain results on



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11. McPhillips Street Landfill – Winnipeg Landfill Environmental Risk Report

background and downgradient groundwater quality, respectively. An additional shallow monitoring well is recommended to be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Based on non-detectable readings along the east property line and the lack of installation details, two landfill gas probes should also be installed along the east property line. These two landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure K1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2 metres (the distance to the surrounding water table assumed to be at 228 metres above sea level from the surrounding ground surface of 230 metres above sea level) and D would therefore be 20 metres. Based on the historical presence of landfill gas at wells P6E, P7E, P17E, and P333E, the 20 m landfill gas impact zone has been extended past these locations. The existing ditch surrounding the landfill could also act as a barrier to landfill gas migration.

The extent of landfill leachate impact on groundwater is unknown at this time. Previous exceedances in the groundwater from groundwater monitoring wells W1 and W2 indicate that the interpreted extent of impact to groundwater should extend past these monitors, although their location is unknown but likely at the top of the waste fill area. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX L

12. Margaret Park Landfill Site



1.0 MONITORING PROGRAM CHANGES

Annual landfill gas monitoring should continue at the Vince Leah Community Centre. Annual landfill gas monitoring should occur at the remaining landfill gas probes and any new probes that are installed. Landfill gas monitoring should be followed by verification of water levels at each existing probe location. Methane has never been detected at P78E and P77E and it is possible that these probes may not be providing accurate information on potential methane gas migration. Landfill gas monitoring from the granular bedding material for the utilities where they meet Salter Street is required to understand if landfill gas migration is occurring within this material.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the bedrock is to the southeast so monitoring wells should be installed in the bedrock outside of the waste footprint at the northern end of the Site and at the south end of the Site to obtain results on background and downgradient groundwater quality, respectively. Groundwater samples should be collected from two landfill gas probes located outside of the waste footprint to understand potential landfill leachate impact on shallow groundwater on adjacent sites and from one landfill gas probe located within the waste footprint to understand the current quality of the landfill leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Signs should be placed indicating that smoking or flames are not allowed at the Site, especially at the top of the mound where potential stressed vegetation was observed and may be indicative of methane venting from the waste.

Previous Site inspections by the City indicated that landfill gas probes P78E and P77E are potential tripping hazards. Methane has never been detected at these locations. Landfill gas probe P77E has been recorded as "dry" on occasion, indicating that those non-detectable methane readings were accurate. Since well screen information is not available to confirm that the well screen at P78E is above the water table then the probe should be decommissioned as it is not providing relevant information on landfill gas migration.

Health and safety protocols should be in place for any utility maintenance work on the Site.

3.0 DATA GAPS

A landfill gas barrier surrounds the landfill. Three landfill gas probes on the outside of the landfill gas barrier on the north, south and west sides of the Site should be installed, with three corresponding landfill gas probes installed within the inner edge of the landfill gas barrier to understand if the landfill gas barrier is performing as expected. The landfill gas probes should be installed with well screens that straddle the water table so that they can be used for both landfill gas monitoring and groundwater/leachate monitoring. Repairs should be made to landfill gas probes P57B and P58B so that they can be opened. If repairs are not feasible then these probes



APPENDIX L

12. Margaret Park Landfill Site – Winnipeg Landfill Environmental Risk Report

should be decommissioned and replaced with new probes. One landfill gas probe should be installed on the inner edge of the landfill gas barrier, corresponding with landfill gas probe P58B (or the replacement probe), to understand if the landfill gas barrier is performing as expected in this area.

Landfill gas monitoring from the granular bedding material for the utilities where they meet Salter Street is required to understand if landfill gas migration is occurring within this material. It is recommended that one probe be installed at the end of the utility trench that lies within the control zone. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

There is no groundwater quality information for the Site. It is recommended that two bedrock monitoring wells be installed outside of the waste footprint at the Site: 1) at the northern end of the Site to obtain results on background groundwater quality, and 2) at the south end of the Site to obtain results on downgradient groundwater quality.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure L1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, to be conservative, H would be 3.5 metres (this is the depth of the groundwater table below the surrounding ground surface based on water level readings in flushmount probe P78E) and D would therefore be 35 metres. With the presence of the landfill gas barrier, this distance would be reduced to the landfill gas barrier itself, however, more data is required to confirm this in certain locations at the Site. The interpreted extent of landfill gas impact is 35 metres from the edge of the waste, unless there is evidence based on at least three years of 0% methane monitored in probes that are outside of the waste barrier or footprint and that are known to have screens above the water table. Non-detectable methane at the southwest edge of the landfill (at P77E) and at a portion of the southeast edge of the landfill (at P58B) allow the interpreted extent of landfill gas impact to be reduced to the landfill gas barrier at these locations. Waste may be beyond the extents of the landfill gas barrier at the southeast corner of the landfill. As such the interpreted extent of landfill gas impact is 35 metres from the edge of the waste at this location.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX M

13. Leila Avenue Landfill Site



1.0 MONITORING PROGRAM CHANGES

It is recommended that the annual landfill gas sampling program at the ten probe locations in the Garden City Shopping Centre continue, followed by verification of water levels at each existing probe location. It is also recommended that the back-up methane detectors located inside the cafeteria exhaust duct be inspected annually to ensure they are in good working order. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area.. New landfill gas probes installed within the landfill and to the east and south sides (see Section 3.0) of the landfill would assist in understanding if the waste is generating landfill gas and, if so, the extent of lateral migration.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. The groundwater flow is reported as southeast so nested monitoring wells should be installed outside of the waste footprint to the southeast and northeast to obtain results on background and downgradient groundwater quality. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

The Site is open to the public, Garden City Shopping Centre and as a recreational space (i.e. soccer pitches and baseball diamonds), and should continue to be maintained for these purposes. There were no illegal dumping, drainage, erosion, slope stability, or leachate issues reported during the 2013 site visit and therefore no further engineered control systems are recommended for the Site. Signs should be placed indicating that smoking or flames are not allowed at the Site.

Health and safety protocols should be in place for any utility maintenance work within the landfill and/or control zone. These health and safety protocols should be shared with the owner of the gas line.

3.0 DATA GAPS

There is no groundwater quality information for the Site. Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the southwest so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southwest end of the Site, and 2) at the northeast end of the Site, to obtain results on background and downgradient groundwater quality, respectively. An additional shallow monitoring well is recommended to be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.



APPENDIX M

13. Leila Avenue Landfill – Winnipeg Landfill Environmental Risk Report

It is recommended that one landfill gas probe be installed in the granular bedding material for the City utilities that extend beneath the waste at the northeast corner of the Site to understand if landfill gas migration is occurring within this material. It is recommended that two additional probes be installed at the end of the utility trench that extends beyond the control zone present along Kingsbury Avenue. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above. These three landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure M1.

Since waste was placed beneath ground surface, subsurface migration of landfill gas is possible. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.5 metres (the distance to the surrounding water table assumed to be at 229.5 metres above sea level from the surrounding ground surface of 232 metres above sea level) and D would therefore be 25 metres.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater, specifically within the utility corridors if they are found to be below the water table.

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APPENDIX N

14. Leila Avenue (West) Landfill Site



1.0 MONITORING PROGRAM CHANGES

Annual landfill gas monitoring should continue at the Site followed by verification of water levels at each existing probe location. Since waste is assumed to have been placed at the surface and possibly within trenches, the potential for migration of landfill gas in the subsurface is minimal. Historically, detectable concentrations of methane gas (up to 3% by volume) were detected along the northern limit of the Site, adjacent to the play area present in the northern control zone. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area. As well screen information is unknown at the Site, several new landfill gas probes are proposed in Section 3.0.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. The groundwater flow direction is southeast so nested monitoring wells should be installed outside of the waste footprint to the southeast and northwest of the Site to obtain results on background and downgradient groundwater quality. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Given that neighbouring developers have historically used the Site to get rid of unwanted material and waste type materials have been found to be sticking out of the cover, it is recommended that the Site be inspected semi-annually for seepage and/or runoff points as well as for exposed waste for the protection of the public. The City is reportedly contemplating turning the area into a micro-soccer field and fill will be brought to Site for this purpose. Depending on the amount of fill and how this effort goes it may be possible to reduce the frequency of Site inspections.

2.0 RECOMMENDED IMPROVEMENTS

Several improvements are recommended at the Site to mitigate hazards and deter illegal dumping. The Site is currently being used for recreational purposes; i.e. close-by park, toboggan hill, and a proposed micro-soccer field. The improvements include:

- Place topsoil material even to fill an irregular or particularly uneven surfaces to avoid tripping hazards;
- Place a minimum of 0.30 m of topsoil over the waste fill area to cover exposed waste (rebar and other waste noted sticking out on the 2015 site visit); and,
- Seed the topsoil to improve aesthetics and make the Site safer for public access.

If the above recommendations are not preferred, it is recommended to erect a gated fence surrounding the perimeter of the Site and to close off public access.

Signs should be placed indicating that smoking or flames are not allowed at the Site.



3.0 DATA GAPS

There is no historical or present information regarding groundwater quality. Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the southeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southeast end of the Site, and 2) at the northwest end of the Site, to obtain results on background and downgradient groundwater quality, respectively. An additional shallow monitoring well is recommended to be installed within the centre of the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

The existing landfill gas probes on Site are located on the north and south Site boundary. Two of these wells (one from the north side of the Site and one from the south side of the Site) should be included in the groundwater monitoring program. One additional landfill gas probe should be installed to the southwest of the waste fill area to obtain representative landfill gas data. This landfill gas probe should be constructed such that the well screen straddles the water table so that the probe could also be used to collect groundwater samples, if required.

All existing and new overburden well installations should be used for the annual landfill gas monitoring program.

Confirmation that waste does not extend below the surrounding ground surface elevation of 231 metres above sea level is required to support the interpretation that landfill gas is not migrating laterally. As such a day of test pitting (approximately 8 test pits) is proposed to verify the vertical extent of the waste. Given the land use of this Site as a recreation facility and park, test pitting may present a messier option for evaluation and borehole or augerhole drilling may be preferred. The advantage of test pitting is a larger area could be assessed more quickly.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure N1.

Waste at this Site was reportedly placed 4.6 metres below ground surface (mbgs) but it was not described in any of the borehole logs. This would indicate that waste was placed on the ground surface, and subsurface migration of landfill gas is not expected. The interpreted extent of potential landfill gas impacts is assumed to be the waste footprint. As noted above, the depth of waste should be verified and results updated if appropriate.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX O

15. Saskatchewan Avenue Dump Site



1.0 MONITORING PROGRAM CHANGES

Biannual surface water sampling should continue in the spring and fall of each year at an upstream and downstream location in Omand's Creek. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Landfill gas monitoring should continue annually at the Site. Groundwater levels should be measured in each landfill gas probe at the time of monitoring. If the groundwater level is above the screen then monitoring from that landfill gas probe will not provide tangible information about lateral landfill gas migration in that area. It is suspected that groundwater monitoring well W1 and MW-1 may not have well screens above the water table. Landfill gas monitoring should also occur near the building at the northeast corner as well as near the buildings to the northwest of the landfill.

Landfill gas monitoring from the granular bedding material for the utilities at the northeast corner of the Site is required to understand if landfill gas migration is occurring within this material. It is recommended that one probe be installed at the end of the utility trench that lies within the control zone. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

Leachate monitoring should continue. It is recommended that the samples from the leachate collection system (MH1) be collected annually and be analysed for the indicator list of leachate parameters provided in Schedule 5 of the Landfill Standards. Leachate samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater samples should be collected from two landfill gas probes located outside of the waste footprint (P7E and a newly installed landfill gas probe on the on the west side of the north portion of the site) to understand potential landfill leachate impact on shallow groundwater. Groundwater flow in the bedrock is to the southeast so monitoring wells should be installed in the bedrock outside of the waste footprint at the northern end of the Site and at the south end of the Site. It is recommended that the groundwater samples be collected annually and be analysed for the indicator list of groundwater parameters provided in Schedule 5 of the Landfill Standards. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Despite the fact that this is a steep Site it appeared stable from a waste exposure, erosion and slope stability perspective in a 2015 Site visit. Signs should be placed indicating that smoking or flames are not allowed at the Site.



APPENDIX O

15. Saskatchewan Ave Dump – Winnipeg Landfill Environmental Risk Report

Health and safety protocols should be in place for any utility maintenance work at the northeast corner of the Site. These health and safety protocols should be shared with Manitoba Telecom Services.

3.0 DATA GAPS

Historic groundwater monitoring indicates that the shallow groundwater beneath the landfill may be impacted by landfill leachate. There is no current or deep groundwater quality information for the Site. Groundwater flows to the southeast. As such, three groundwater monitors should be installed in the bedrock outside of the waste footprint: 1) at the southeast corner of the southern edge of the Site to understand potential for off-Site migration of landfill leachate impacted groundwater from the southern portion of the landfill, 2) mid-way along the east edge of the Site to understand potential for off-Site migration of landfill leachate impacted groundwater from the northern portion of the landfill, and 3) at the north end of the Site as a background monitor for comparison.

Two landfill gas probes should be installed outside of the waste limits: 1) at the northeast corner, to the north of the western portion (in the area of the off-Site building), and 2) on the west side of the north portion (in the area of the off-Site building). These wells should be installed with the well screens straddling the water table so that they can be used for both landfill gas monitoring and groundwater sampling. One landfill gas probe should be installed within the granular bedding material at the northeast corner of the site.

Well construction details are required for groundwater monitoring well W1 and piezometer IN75 to understand at what depth groundwater collected from these monitors is from. This can be verified in the field by measuring the depth of the monitor.

Additional subsurface investigation by way of test pits is recommended at the north portion of the east side of the landfill and the northern portion of the west side of the landfill to better define the waste limits in those area. Both of these areas have landfill gas probes (P1L and P11L) outside of the waste footprint that have “refuse” listed in the borehole log.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure O1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2 metres (the distance to the surrounding water table assumed to be at 231 metres above sea level from the surrounding ground surface of 233 metres above sea level) and D would therefore be 20 metres. Omand’s Creek is greater than 20 metres from the waste footprint so the presence of the creek does not reduce this distance.

The extent of landfill leachate impact on groundwater is unknown at this time. Historic exceedances in the groundwater from groundwater monitoring well W1 and piezometer IN75 indicate that the interpreted extent of impact to groundwater should extend past these monitors. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX P

16. Barry Avenue Dump Site



1.0 MONITORING PROGRAM CHANGES

Landfill gas monitoring should continue annually at the available probes and any newly installed probes as discussed in Section 3.0. Methane has never been detected at any of the landfill gas probes on-Site and could potentially be related to probe construction. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area.. As such, it is recommended additional probes should be installed within the landfill footprint and to the east of the landfill footprint but within the interpreted extent of potential impact from landfill gas as discussed in Section 4.0.

A landfill gas probe should be installed within the granular bedding for the utility at the southern end of the Site to assess whether landfill gas is migrating within this utility trench. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. This utility trench can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

It is recommended that methane gas and water levels be monitored annually to determine if landfill gas is migrating off the Site. Continuation of landfill gas monitoring should be reassessed after two years.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Groundwater flow is to the south/southeast so nested monitoring wells are recommended to be installed outside of the waste footprint at the northern end of the Site and at the south/southeast end of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints and within a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Polycyclic aromatic hydrocarbons (PAHs) should also be analysed once as burned material is present on-Site and if not detected, can then be excluded from subsequent sampling events.

2.0 RECOMMENDED IMPROVEMENTS

Depending on the outcome of recent landfill gas monitoring, signs should be placed indicating that smoking or flames are not allowed at the Site.

3.0 DATA GAPS

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the south/southeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southeast end of the Site, and 2) at the northwest end of the Site, to obtain results on background and downgradient groundwater



quality, respectively. An additional shallow monitoring well is recommended to be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Two additional gas probes should be installed to the east of the landfill footprint but within the interpreted extent of potential impact from landfill gas. A third landfill gas probe should be installed within the granular bedding for the utility at the southern end of the Site to assess whether landfill gas is migrating within this utility trench. These three landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure P1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, to be conservative, H would be 0.9 metres (this is the depth of the waste below the surrounding ground surface) and D would therefore be 9 metres. While methane has never been detected in any of the landfill gas probes this may indicate that the probe screen depth is below the groundwater level and/or that the waste material type is not generating methane. Therefore, the 9 metre landfill gas migration area around the waste footprint cannot be reduced based on monitoring results at this time.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of further data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the waste footprint. Based on proposed monitoring the interpreted extent of potential groundwater impacts should be re-assessed following receipt of additional data.

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APPENDIX Q

17. Harcourt Street Landfill Site



1.0 MONITORING PROGRAM CHANGES

Groundwater sampling should be completed on an annual basis at the thirteen gas probe locations. Water levels should continue to be measured in any available probes or monitoring wells.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the bedrock groundwater quality. Groundwater flow is to the south/southeast. Existing bedrock probes P40E and P41E represent background and downgradient groundwater quality, respectively. It is recommended that the groundwater samples should be collected annually. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters, recognizing that there may also be impacts from the recent use of the Site as a snow dump.

Annual landfill gas monitoring should continue at any available landfill gas probe and from the granular bedding material for the utilities along Saskatchewan Avenue. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

The utility trench through the south of the interpreted groundwater impacted area (see Section 4.0) could be a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following the results of the proposed groundwater and landfill gas monitoring program described above.

2.0 RECOMMENDED IMPROVEMENTS

Health and safety protocols should be in place for any road work or utility maintenance work on Saskatchewan Avenue, within the interpreted extent of potential impact from landfill gas as discussed in Section 4.0. Health and safety protocols should also be considered for any utility maintenance work to the south of the Site as a result of the interpreted extent of groundwater impacts advancing in this direction.

Signs should be placed indicating that smoking or flames are not allowed at the Site, especially in the area of probe P23L.

Steps should be taken to stop the illegal dumping of waste at the north end of the Site near Saskatchewan Avenue by means of signage and/or to fence the Site if this is not practical.

It is recommended that the stuck cap be repaired at probe P23L.

3.0 DATA GAPS

The extents of the waste footprint should be revisited by first reviewing borehole logs for the presence of waste. It would appear that the waste footprint goes beyond landfill gas probes P20E and P26E, however, review of the borehole log for these two probes indicate that waste is not present in these locations. The waste footprint does not extend to probe P4L, however, waste is present in this borehole log. A follow up subsurface investigation



APPENDIX Q

17. Harcourt Street Landfill – Winnipeg Landfill Environmental Risk Report

may be considered via test pitting, augerholes or boreholes. One day of test pitting (i.e. eight test pits) is proposed to verify the vertical extent of the waste. Given the land use of this Site (vacant), test pitting is a viable option for evaluation. The advantage of test pitting is a larger area could be assessed more quickly.

Landfill gas monitoring from the granular bedding material for the utilities along Saskatchewan Avenue within the landfill footprint is required to understand if landfill gas migration is occurring within this material. It is recommended that two landfill gas probes be installed (one at each end of the utility trench that lies within the waste footprint). These landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

The tops of the landfill gas probes and monitoring wells should be surveyed so that groundwater levels can be converted to elevations for comparison purposes.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure Q1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.1 metres (assuming that is the distance to the water table from the surrounding ground surface) and D would therefore be 21 metres. At least three consecutive monitoring events with no detection of methane at probes P15E and P5E allows for this distance to be reduced at these locations. Based on a historical 1989 report about the Site, there was concern that landfill gas may be migrating within the till below surface. Considering the shallow water table, it is not expected that landfill gas would be migrating in the till and this is confirmed by non-detectable methane readings between 2008 and present at monitor P35E, screened within the till.

The interpreted extent of landfill leachate impact on groundwater is unknown at this time since historical groundwater monitoring was confined to the waste footprint. Since the thickness of clay below the waste is minimal and even non-existent in some areas, there is the potential for impact to the underlying bedrock groundwater in the direction of groundwater flow (south and southeast). The interpreted extent of the landfill leachate impact on groundwater is unknown, but likely extends beyond the dead trees identified to the south of the Site. The interpreted extent of the landfill leachate impact on groundwater could be more definitive with additional groundwater monitoring.

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APPENDIX R

18. Summit Road Landfill Site



1.0 MONITORING PROGRAM CHANGES

Annual landfill gas monitoring from available landfill gas probes, leachate wells and piezometers should continue. Landfill gas monitoring should be followed by verification of water levels at each existing probe location.

Surface water samples should continue to be collected twice per year from an upstream location and a downstream location in Sturgeon Creek. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and petroleum hydrocarbons and polychlorinated biphenyls (PCBs). Petroleum hydrocarbons and PCBs have been detected in the landfill leachate previously. It can be reassessed after a year to determine if the analysis can be reduced from the comprehensive list to the indicator list of parameters.

Groundwater sampling should continue in the spring and fall at existing groundwater monitors W4, W5, W6, W7, W9, W10, W13 and IN232, and any new groundwater monitoring wells as discussed in Section 3.0. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards, petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs) and PCBs. It can be reassessed after a year to determine if the analysis can be reduced from the comprehensive list to the indicator list of parameters.

Leachate samples should continue to be collected annually from from the manholes MH3, MH6, MH8 and MH10. Leachate samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards, petroleum hydrocarbons, PAHs and PCBs. It can be reassessed after a year to determine if the analysis can be reduced from the comprehensive list to the indicator list of parameters.

Water levels should continue to be measured in any available piezometers, leachate risers or monitoring wells.

2.0 RECOMMENDED IMPROVEMENTS

Continued improvements to the final grading, top soil and seeding should be completed at the Site on an as needed basis.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

Addition of internal leachate sumps will help to reduce the mound within the landfill and decrease the number of landfill leachate seeps. It is not possible at this time to determine if reducing the leachate mound would also reduce the extent of the impact to the groundwater. The potential effect would need to be assessed using a groundwater model.

3.0 DATA GAPS

Four bedrock groundwater monitoring wells are recommended to be installed: one downgradient of the existing monitor W13, one southeast of the landfill (south of IN232) at the City-owned property boundary, one east of the landfill and one northwest of W13, closer to the Perimeter Highway to rule out potential impacts at monitoring well W13 from road salting activities.



APPENDIX R

18. Summit Road Landfill Site – Winnipeg Landfill Environmental Risk Report

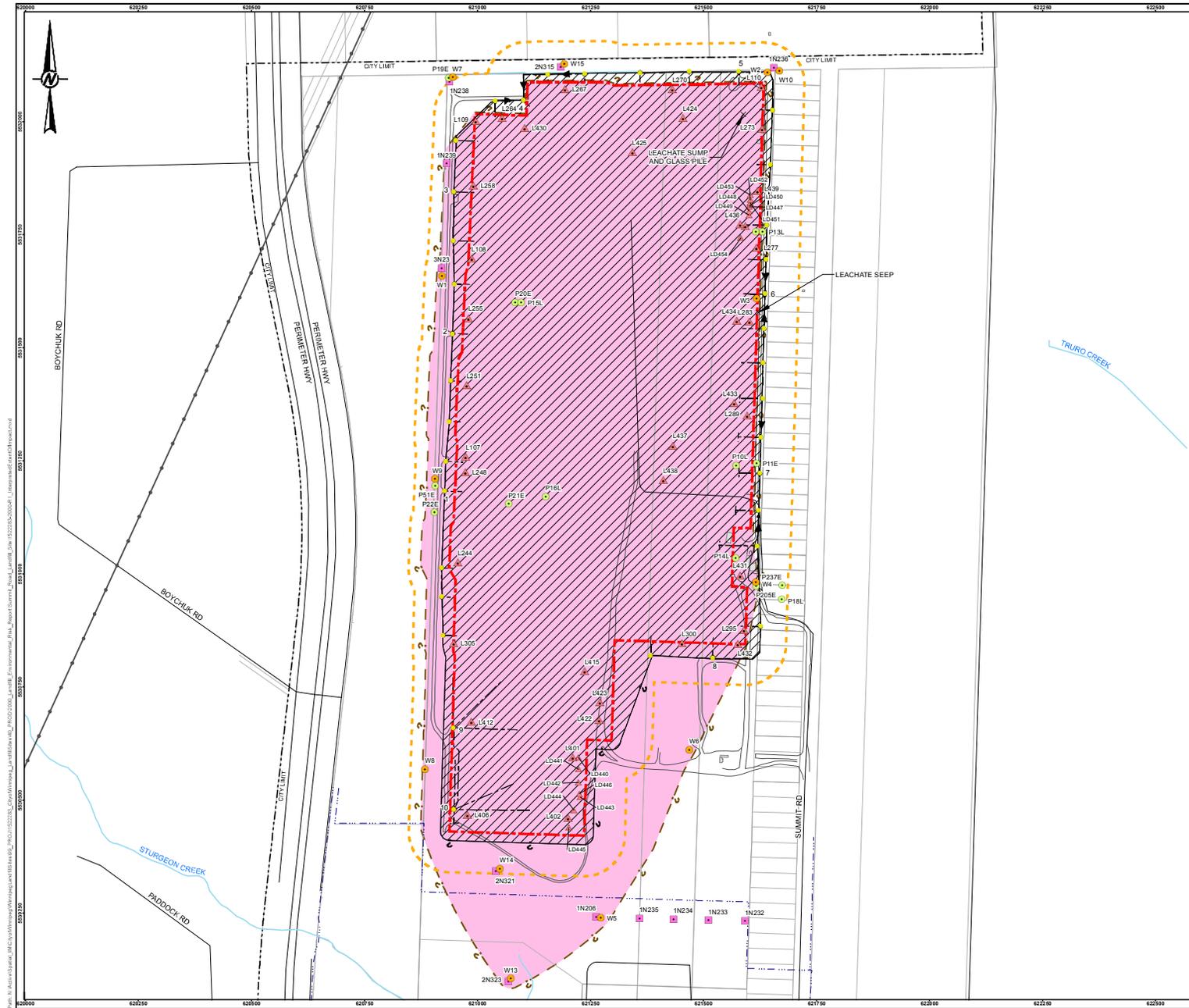
4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure RR1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.0 metres (the distance from the ground surface surrounding the waste mound to the water table within the overburden) and D would therefore be 20 metres. In the areas where the perimeter leachate collection system is present, the interpreted distance of potential impact from landfill gas is reduced to 0 metres.

The bedrock has been impacted by landfill leachate. The extent of impact is not known, but extends as far south as monitoring well W13.

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LEGEND

- LANDFILL FOOTPRINT
- CONTROL ZONE AREA
- INTERPRETED EXTENT OF POTENTIAL LANDFILL GAS IMPACTS
- INTERPRETED EXTENT OF POTENTIAL GROUNDWATER IMPACTS
- GAS MONITORING PROBE
- GROUNDWATER WELL
- PIEZOMETER NEST
- ▲ LEACHATE PROBE
- △ LEACHATE DRAIN
- LEACHATE MANHOLE
- LEACHATE COLLECTION SYSTEM
- CITY OF WINNIPEG LIMIT BOUNDARY
- BUILDING FOOTPRINT
- PROPERTY PARCEL
- ROAD
- POWER TRANSMISSION LINE (OVERHEAD)
- WATERCOURSE
- UTILITY
- BURIED CABLE



NOTE(S)
 1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1522283/2000.

REFERENCE(S)
 1. BASEDATA PROVIDED BY CITY OF WINNIPEG.
 2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
 COORDINATE SYSTEM: UTM ZONE 14 VERTICAL DATUM: CGVD28

CLIENT
CITY OF WINNIPEG

PROJECT
**WINNIPEG LANDFILL RISK REPORT
 SITE 18: SUMMIT ROAD LANDFILL, WINNIPEG, MANITOBA**

TITLE
INTERPRETED EXTENT OF IMPACT

CONSULTANT	YYYY-MM-DD	2015-09-30
	DESIGNED	---
	PREPARED	BR
	REVIEWED	MKF
	APPROVED	PLE
PROJECT NO. 1522283	PHASE 2000	REV. 0

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APPENDIX S

19. Shaftesbury Boulevard Dump Site



APPENDIX S

19. Shaftesbury Blvd Dump Site – Winnipeg Landfill Environmental Risk Report

1.0 MONITORING PROGRAM CHANGES

There is currently no monitoring program at the Site. It is recommended that landfill gas monitoring be undertaken annually at newly installed wells as described in Section 3.0. Water levels should also be measured annually in the probes to understand the potential leachate mound and the surrounding groundwater table.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Groundwater flow is to the east so monitoring wells nests are recommended to be installed outside of the waste footprint at the west end of the Site and at the east end of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints. Also shallow groundwater samples are required from a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

There are no recommended improvements at this time pending continued monitoring.

3.0 DATA GAPS

There is currently no groundwater quality information for the Site. Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the east so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the west end of the Site, and 2) at the east end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Landfill gas measurements should also be obtained from the two shallow groundwater wells located outside the waste, within the interpreted extent of landfill gas impact as shown on Figure S1, if possible.



APPENDIX S

19. Shaftesbury Blvd Dump Site – Winnipeg Landfill Environmental Risk Report

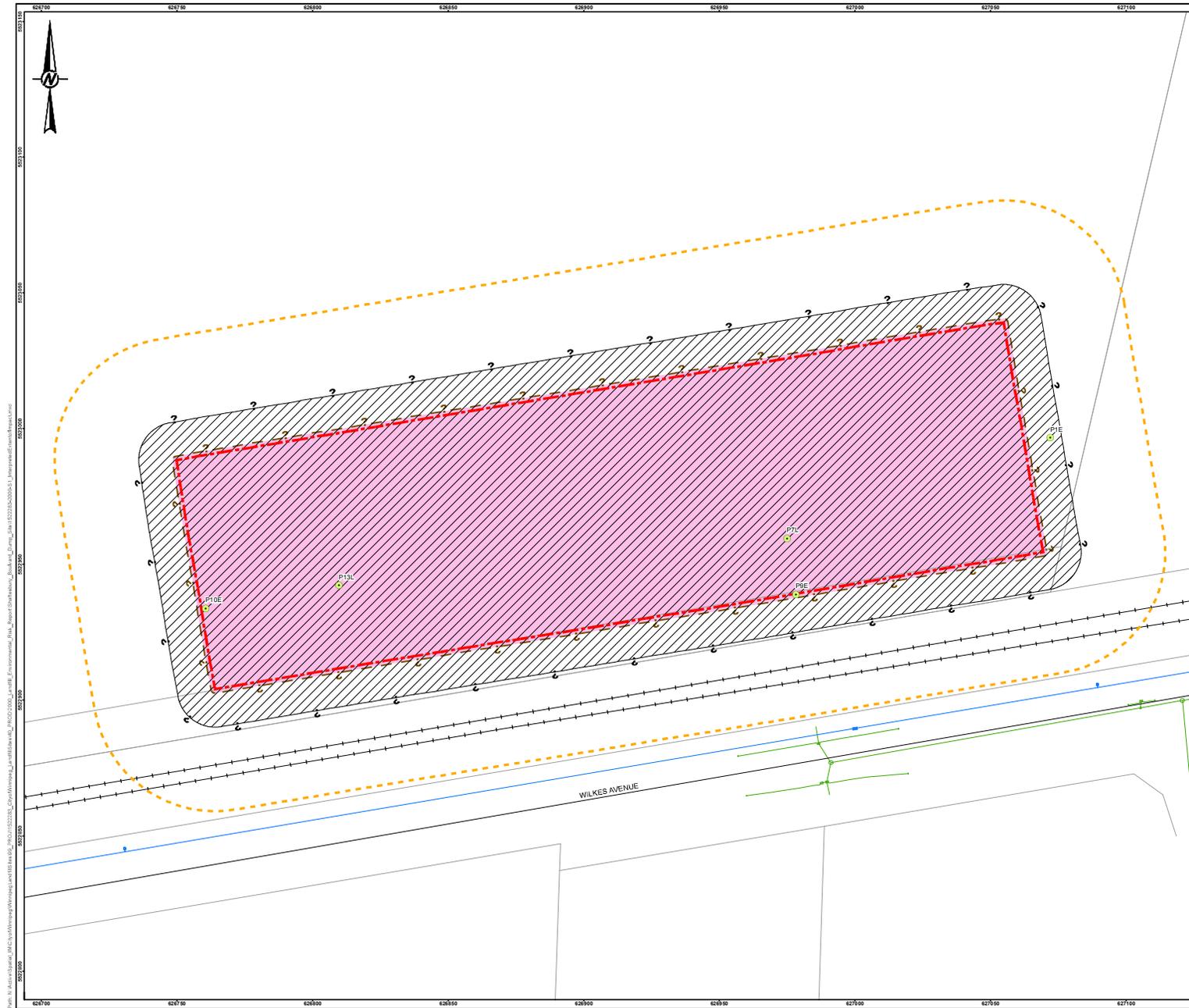
4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure S1.

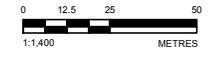
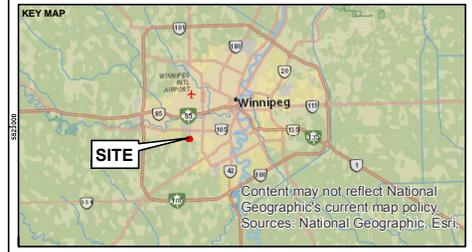
In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 1.4 metres (assuming that is the distance to the water table) and D would therefore be 14 metres. Historic monitoring at landfill gas probe, P1E, confirms that landfill gas migration did occur within this area.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the ditch network surrounding the waste footprint but may be greater.

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- LEGEND**
- LANDFILL FOOTPRINT
 - CONTROL ZONE AREA
 - INTERPRETED EXTENT OF POTENTIAL LANDFILL GAS IMPACTS
 - INTERPRETED EXTENT OF POTENTIAL GROUNDWATER IMPACTS
 - GAS MONITORING PROBE
 - ROAD
 - RAILWAY
 - PROPERTY PARCEL
 - UTILITY
 - SANITARY SEWER
 - WATER MAIN



NOTE(S)
1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1522283/2000.

REFERENCE(S)
1. BASEDATA PROVIDED BY CITY OF WINNIPEG.
2. PROJECTION: TRANSVERSE MERCATOR; DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 14 VERTICAL DATUM: CGVD28

CLIENT
CITY OF WINNIPEG

PROJECT
WINNIPEG LANDFILL RISK REPORT
SITE 19: SHAFTESBURY BOULEVARD DUMP SITE, WINNIPEG, MANITOBA
TITLE
INTERPRETED EXTENT OF IMPACT

CONSULTANT	YYYY-MM-DD	2015-09-30
	DESIGNED	---
	PREPARED	BR
	REVIEWED	MKF
	APPROVED	PLE

PROJECT NO. 1522283	PHASE 2000	REV. 0	FIGURE S1
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APPENDIX T

20. Charleswood Road Landfill Site



1.0 MONITORING PROGRAM CHANGES

It is recommended that landfill gas monitoring continue to be undertaken annually at existing landfill gas probes P5L, P25E and P6E followed by verification of water levels at each existing probe location. These landfill gas probes have not reported measurable landfill gas concentrations in recent years and it is unknown if they have reported measurable landfill gas concentrations in the past. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area.. As such, it is recommended an additional probe should be installed within the waste footprint and outside of the waste footprint. In addition, landfill gas monitoring should occur in a landfill gas probe installed within the granular material surrounding the water main within the waste footprint near the intersection of Wilkes Avenue and Charleswood Road. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described.

Water levels should also be measured annually in the probes to understand the potential leachate mound and the surrounding groundwater table.

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Groundwater flow is to the east/northeast so monitoring well nests are recommended to be installed outside of the waste footprint at the west or southwest end of the Site and at the east end or northeast corner of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints. Also shallow groundwater samples are required from a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Health and safety protocols should be in place for any water main maintenance work for the water main located within the waste footprint and/or control zone.

Continued annual inspection of the Site is recommended with emphasis on removing and/or covering any protruding waste which is observed.

Landfill gas probe P5L is recommended to be repaired (the casing cap needs to be replaced).

Signs should be placed indicating that smoking or flames are not allowed at the Site.

There are no other recommended improvements at this time pending continued monitoring.



3.0 DATA GAPS

The extents of the waste footprint should be revisited by first reviewing borehole logs for the presence of waste. It would appear that the waste footprint goes beyond landfill gas probe P6E, however, review of the borehole log for P6E indicates that waste is not present in that location. A follow up subsurface investigation may be required that could include test pits, augerholes and/or boreholes. As such a day of test pitting (approximately 8 test pits) is proposed to verify the extent of the waste. Given the land use of this Site as a recreation facility and park, test pitting may present a messier option for evaluation and borehole or augerhole drilling may be preferred. The advantage of test pitting is a larger area could be assessed more quickly.

Confirmation as to the location of landfill gas probe P25E is required. It may be one of the P16L locations shown on Figure T1.

The tops of the landfill gas probes should be surveyed so that groundwater levels can be converted to elevations for comparison purposes.

There is currently no groundwater quality information for the Site. Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the east/northeast so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the west or southwest end of the Site, and 2) at the east end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. If possible, a sample should be collected from one of the existing leachate probes (P5L or P25E, if located within the waste fill area). If it is not possible to obtain a sample from any of these probes then a new monitoring well should be installed within the waste footprint to understand the current quality of the landfill leachate. The two to three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Landfill gas measurements should also be obtained from the two shallow groundwater wells located outside the waste, within the interpreted extent of landfill gas impact as shown on Figure T1, if possible. An additional landfill gas probe should also be installed within the granular bedding material of the water main that exists within the landfill footprint. The landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure T1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.1 metres (assuming that is the distance to the water table) and D would therefore be 21 metres.

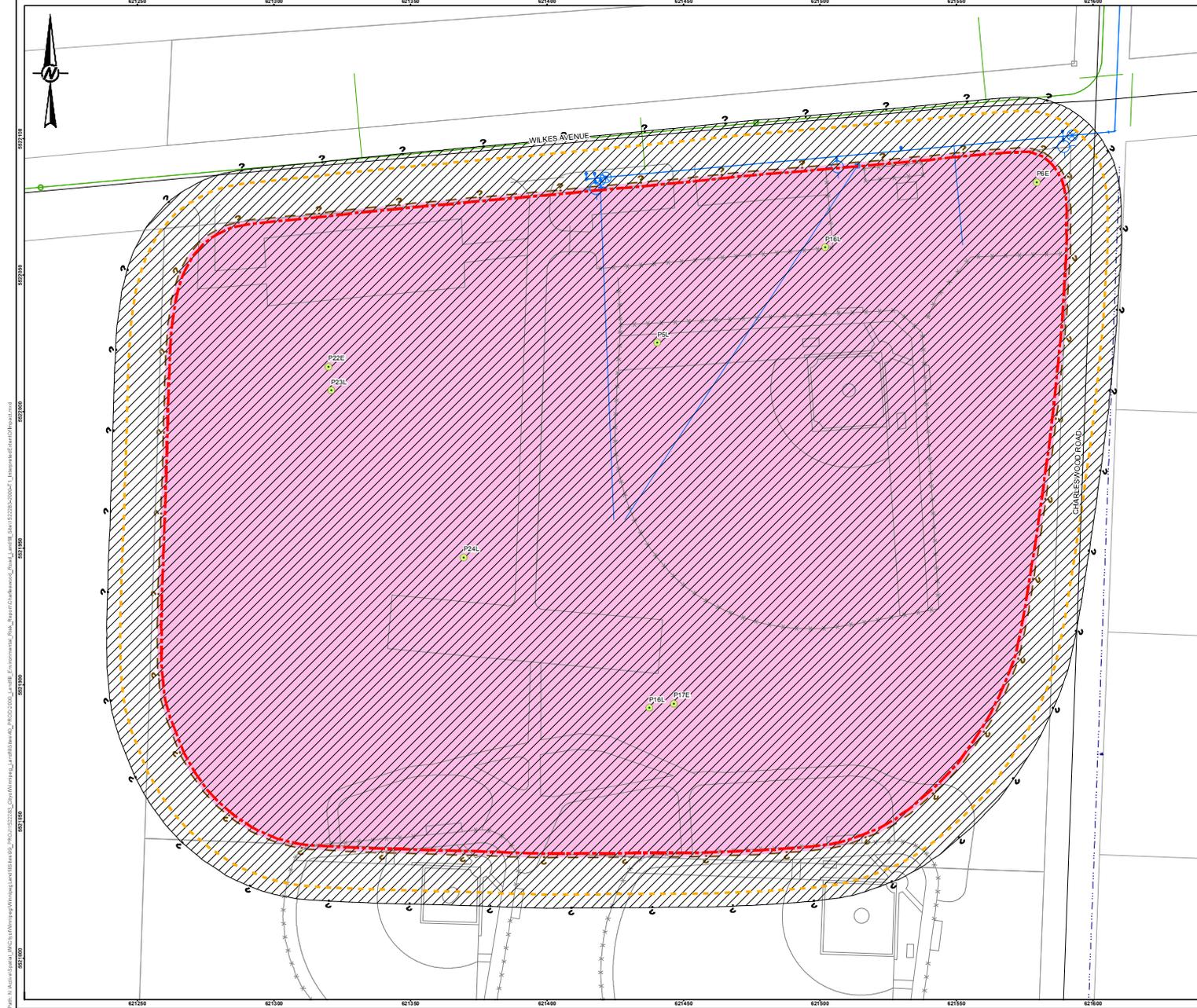


APPENDIX T

20. Charleswood Road Landfill – Winnipeg Landfill Environmental Risk Report

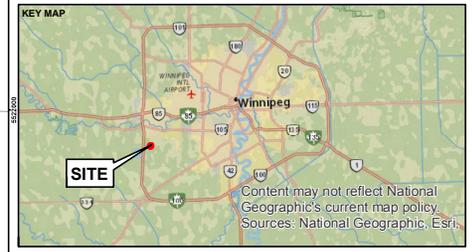
The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the waste footprint but may be greater.

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LEGEND

- LANDFILL FOOTPRINT
- CONTROL ZONE AREA
- INTERPRETED EXTENT OF POTENTIAL LANDFILL GAS IMPACTS
- INTERPRETED EXTENT OF POTENTIAL GROUNDWATER IMPACTS
- GAS MONITORING PROBE
- ROAD
- PROPERTY PARCEL
- UTILITY**
- MTS CABLE
- SANITARY SEWER
- WATER MAIN



NOTE(S)
 1. THIS FIGURE IS TO BE READ IN CONJUNCTION WITH THE ACCOMPANYING GOLDER ASSOCIATES LTD. REPORT NO. 1522283/2000.

REFERENCE(S)
 1. BASE DATA PROVIDED BY CITY OF WINNIPEG.
 2. PROJECTION: TRANSVERSE MERCATOR; DATUM: NAD 83
 COORDINATE SYSTEM: UTM ZONE 14 VERTICAL DATUM: CGVD28

CLIENT
CITY OF WINNIPEG

PROJECT
**WINNIPEG LANDFILL RISK REPORT
 SITE 20: CHARLESWOOD ROAD LANDFILL SITE, WINNIPEG, MANITOBA**

TITLE
INTERPRETED EXTENT OF IMPACT

CONSULTANT	YYYY-MM-DD	2015-09-30
	DESIGNED	---
	PREPARED	BR
	REVIEWED	MKF
	APPROVED	PLE
PROJECT NO. 1522283	PHASE 2000	REV. 0
		FIGURE T1

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APPENDIX U

21. Charleston Street (Community Row)



1.0 MONITORING PROGRAM CHANGES

If waste is found following recommended data gap analysis described in Section 3.0 the following monitoring actions should be considered.

Groundwater monitoring in the bedrock or till is recommended to understand potential landfill leachate impact on the groundwater quality. Shallow groundwater flow, if possible through the clay, is likely toward the on-Site drainage ditch. Deeper till and bedrock groundwater flow direction is noted as toward the east so monitoring well nests should be installed outside of the waste footprint at the eastern end of the Site and at the western end of the Site. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints. Also shallow groundwater samples are required from a well installed within the waste footprint to understand the quality of the leachate. It is recommended that the groundwater samples be collected annually and be analysed for the indicator list of groundwater parameters provided in Schedule 5 of the Landfill Standards. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Biannual surface water sampling is recommended in the spring and fall of each year at the wetland area north of the Site and within the drainage ditch flowing east-west through the southern portion of the Site. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Landfill gas monitoring should continue annually at the Site followed by verification of water levels at each existing probe location, although these wells could not be located in 2014. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area. It is suspected that monitoring probes P7E and P12E likely had well screens above the water table indicating that the non-detectable methane gas concentrations are representative of site conditions, although this needs to be verified.

2.0 RECOMMENDED IMPROVEMENTS

No improvements to the physical condition of the landfill are recommended as there were no signs of stressed vegetation in the 2015 site visit. No Site maintenance is required as no debris, illegal dumping, or erosion was reported during the 2014 or 2015 site visits.

3.0 DATA GAPS

Based on the data reviewed it is questionable that waste was ever received at this Site. An assessment of the Site using test pits, augerholes and/or boreholes is recommended to determine if waste is actually present. As such a day of test pitting (approximately 8 test pits) is proposed to verify the vertical extent of the waste. Given the land use of this Site (vacant), test pitting is a viable option for evaluation. The advantage of test pitting is a larger area could be assessed more quickly.



APPENDIX U

21. Charleston Street (Community Row) Dump – Winnipeg Landfill Environmental Risk Report

There is no groundwater quality information for the Site. If waste is confirmed to be present on-Site, groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the east so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the west end of the Site, and 2) at the east end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. If possible, a sample should be collected from one of the existing leachate probes (P7E or P12E, if located). If it is not possible to obtain a sample from these probes then a new monitoring well should be installed within the waste footprint to understand the current quality of the landfill leachate. The two to three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure U1.

As there is no reported waste below ground surface lateral migration of landfill gas at this Site is not considered to be an issue therefore the interpreted extent of landfill gas impacts are assumed to be the extents of the landfill footprint.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints, the downward hydraulic gradient and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but based on the waste type and the minimal volume reported, could be much less.

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APPENDIX V

22. Charleswood Road (South) Landfill Site



1.0 MONITORING PROGRAM CHANGES

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Groundwater flow is to the east so monitoring well nests should be installed outside of the waste footprint at the west end of the Site and at the east end of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints. Also shallow groundwater samples are required from a well installed within the waste footprint to understand the quality of the leachate. It is recommended that the groundwater samples be collected annually and be analysed for the indicator list of groundwater parameters provided in Schedule 5 of the Landfill Standards. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Landfill gas monitoring should continue annually at the Site followed by verification of water levels at each existing probe location, P10L and P21E. Re-drilling of wells P23L and P15E is recommended as historical data indicates high levels of landfill gas at these locations. The relationship between the well screen depth and the water level is currently unknown. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area.. It is anticipated that groundwater monitoring wells P10L and P21E may have well screens above the water table as historical landfill gas readings have been recorded and have been as high as 9% methane by volume at this P10L.

No surface water monitoring program is recommended as there is no surface water present on the Site (although a marshy area exists in the western portion of the Site).

2.0 RECOMMENDED IMPROVEMENTS

Signs should be placed indicating that smoking or flames are not allowed at the Site.

No improvements to the physical condition of the landfill are recommended as there were no signs of stressed vegetation or to the marshy area at the west side of the Site. No Site maintenance is required at the Site as it remains isolated with no debris, illegal dumping, or erosion reported in the 2013 and 2015 site visits. No engineered control systems to mitigate the potential effects of landfill gas are recommended for the Site at this time as there was no detectable landfill gas during the 2013 sampling event, no nearby receptors, and, based on the type waste reported, the potential for landfill gas generation is moderate. Furthermore, since there are no utilities through the waste fill area and coarse cover material is present and a marshy area present to the west, the potential for gas migration is expected to be limited.

3.0 DATA GAPS

Re-drilling of wells P23L and P15E is recommended as historical data indicates high levels of landfill gas at these locations. These wells could also be used as part of the recommended groundwater monitoring program described below

There is no current or deep groundwater quality information for the Site. Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the



deep bedrock aquifer is to the southwest so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the southwest end of the Site, and 2) at the northeast end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. If possible, a sample should be collected from one of the existing or replaced leachate probes (P10L, P23L and P15E). If it is not possible to obtain a sample from any of these probes then a new monitoring well should be installed within the waste footprint to understand the current quality of the landfill leachate. The two to three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.

Drilling two additional new gas probes within the southern portion of the waste area is also recommended at the Site. The new landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure V1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2 metres (the distance to the surrounding water table assumed to be at 236.2 metres above sea level from the surrounding ground surface of 238.4 metres above sea level) and D would therefore be 20 metres.

The extent of landfill leachate impact on groundwater is unknown at this time. Historical exceedances in the groundwater from groundwater monitoring wells P10L and P21E indicate that the interpreted extent of impact to groundwater should extend past these monitors. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint as P21E is located just outside the waste fill area, but may be greater.

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APPENDIX W

24. Cadboro Road (West) Landfill Site



1.0 MONITORING PROGRAM CHANGES

Landfill gas monitoring should continue annually at the Site at probes for which the screens are above the water table. Groundwater levels should be measured in each landfill gas probe at the time of monitoring. Several new landfill gas monitoring probes are recommended in Section 3.0.

Groundwater samples should be collected from GW13-06A, GW13-06B and P19E and analysed for petroleum hydrocarbons once to see if they have migrated beyond the waste footprint.

Biannual surface water sampling should be completed in the spring and fall of each year at an upstream and downstream location in the surface water ditches along Brady Road and Cadboro Road. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

MMM Group has investigated the groundwater surrounding the Site in recent years. Groundwater monitoring in the bedrock is recommended though to understand potential landfill leachate impact on the deep groundwater quality. The groundwater flow is to the northeast, so a deep monitor should be installed at the southwest and at the northeast of the waste footprint to capture upgradient and downgradient groundwater quality. It is recommended that the groundwater samples be collected annually. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Signs should be placed indicating that smoking or flames are not allowed at the Site, especially at the top of the waste mound where stressed vegetation was observed and may be indicative of methane venting from the waste. Continued inspection of the cover is recommended with addition of cover material and/or seeding as necessary.

3.0 DATA GAPS

With the residential developments to the east and south, a shallow landfill gas probe to the east and south of the waste footprint (with a screen above the water table), should be installed to monitoring landfill gas migration in those areas.

There is no deep groundwater quality information for the Site. Groundwater flows to the northeast. As such, two groundwater monitors should be installed in the bedrock outside of the waste footprint: 1) at the northeast corner of the Site to understand potential for off-Site migration of landfill leachate impacted groundwater, and 2) a background monitor completed within the bedrock at the southwest end of the Site for comparison.

Surveying the existing landfill gas probes and groundwater monitoring wells would be beneficial to understand the elevation of the groundwater table and the leachate mound within the waste.



4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure W1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2 metres (this is the greatest distance to the water table from the top of the pipe in probes outside of the waste footprint) and D would therefore be 20 metres. This distance could be reduced should there be evidence of non-detectable methane readings in landfill gas probes located outside of the waste footprint within the interpreted area of potential impact, however, it is not clear whether the well screens at the landfill gas probes in the control zone to the north and west of the landfill are above the water table or not.

The extent of landfill leachate impact on groundwater is not known at this time as the groundwater has not been analyzed for some parameters which may be indicative of landfill leachate impact. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX X

26. & 27. Elmwood and Nairn Avenue Landfill Sites



APPENDIX X

26. and 27. Elmwood and Nairn Avenue Landfill Sites – Winnipeg Landfill Environmental Risk Report

1.0 MONITORING PROGRAM CHANGES

Landfill gas monitoring should continue at all operational landfill gas probes and newly installed probes as described in Section 3.0. Landfill gas monitoring should be followed by verification of water levels at each existing probe location. Landfill gas monitoring should also be undertaken at every building within the landfill footprints twice a year. Occupants and/or owners of the buildings should be made aware of the potential risks due to methane gas if they are not already.

Landfill gas probes should be installed within the granular bedding for utilities leading away from the landfill. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

Annual surface water monitoring should occur in the stormwater management pond for the Public Works complex. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. The bedrock groundwater flow is to the south/southwest, so groundwater monitors installed in the bedrock southwest of the Nairn Avenue Landfill Site footprint and southwest of the Elmwood Landfill Site footprint (as described in Section 3.0) should be sampled to assess potential impacts to the downgradient groundwater quality. Two deep groundwater monitors installed in the bedrock north of each landfill footprint (as described in Section 3.0) should be sampled to capture the background groundwater quality. Groundwater samples collected from shallow wells installed at the same location as the bedrock wells should also be sampled. It is recommended that a groundwater sample be collected from a landfill gas probe located within the waste footprint of each landfill (P27L and P36L) to assess the quality of leachate. Groundwater samples should be collected annually and analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

The current use of a portion of the Elmwood Landfill Site as a potential dumping area for waste should be investigated.

Health and safety protocols should be in place for any road work or utility maintenance work on the roads or utilities within the waste footprints and/or control zone.

It is recommended that for the buildings for which there have been detections of methane during the past four years (481 Panet Road, 700 Mission Street, 650 Nairn Avenue, 980 Nairn Avenue, 730 Nairn Avenue, 1006 Nairn Avenue and 960 Thomas Avenue) that either a methane monitor and alarm be installed within the building or that measures be taken to vent the building.



Signs should be placed indicating that smoking or flames are not allowed at the Site.

3.0 DATA GAPS

Landfill gas monitoring from the granular bedding material for the sanitary sewers, watermains or road bedding that exist within the landfill footprint to understand if landfill gas migration is occurring within this material. The focus of these monitors should be at the extents of the Sites to see if landfill gas migration may be occurring outside of the waste footprint. Therefore, eight probes should be installed just outside of the waste footprint at the following roads: Cole Avenue, Tyne Avenue, Foster Street, Chester Street, Kent Street, Keenleyside Street, Thomas Avenue and the utility trench at Stapleton Street between Thomas Avenue and Nairn Avenue.

There is currently limited shallow groundwater quality outside of the waste footprint and deep groundwater quality information for the Site. It is recommended that four monitoring well nests (well screen completed in the shallow overburden and bedrock) be installed at the Site: one upgradient (north) of each landfill and one downgradient (south) of each landfill.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure X1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be the distance to the water table outside of the waste footprint to the surrounding ground surface. Water levels are available for landfill gas probes completed outside of the waste footprint in recent years. There is no information available about the stick-up of the probes, so it has been conservatively assumed that the water level measured is from the ground surface (i.e. the probes are flush mounts). Therefore, H would be 2.5 metres (the deepest water level measured) and D would therefore be 25 metres. Since there are no recent methane monitoring results for landfill gas probes located on the exterior of the landfill footprints, then the 25 metres cannot be reduced at this time based on monitoring results. However, where there are roadways within the 25 metres, then the interpreted extent of landfill gas impact will end at the roadway since it is expected that the roadway is constructed of material that would be a preferential pathway for landfill gas.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX Y

28. Brooklands Landfill Site



1.0 MONITORING PROGRAM CHANGES

Groundwater monitoring in the bedrock is recommended to understand potential landfill leachate impact on the groundwater quality. Groundwater flow is likely to the south so monitoring well nests should be installed outside of the waste footprint at the north end of the Site and at the south end of the Site to obtain results on background and downgradient groundwater quality, respectively. To understand potential landfill leachate impact on shallow groundwater, groundwater samples should be collected from the monitoring well nests, which are proposed to be located outside of the landfill footprints. Also shallow groundwater samples are required from a well installed within the waste footprint to understand the quality of the leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change’s report titled, “Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites” (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Landfill gas monitoring should continue annually at the Site at existing gas probe, P12L or a replacement, and additional wells (recommended to be installed on section 3.0) followed by verification of water levels at each existing probe location. This information is important to obtain as water levels above landfill gas probe screens will not provide tangible information about lateral landfill gas migration in that area..

2.0 RECOMMENDED IMPROVEMENTS

Signs should be placed indicating that smoking or flames are not allowed at the Site.

On-going Site maintenance of grass and vegetation is recommended to improve aesthetics and allow for easier access to the existing gas probes. Restricting access through the use of a gate or other barrier is recommended to prevent the illegal dumping of construction waste, such as concrete, metal, and yard trimmings, reported during the most recent site visit conducted on August 20, 2014. Grading of the uneven slopes should also be considered to improve stability and prevent further differential settling. Engineered controls to mitigate migration of landfill gas through the utility corridors may be suggested if the recommended investigations show deteriorating conditions at the Site or in areas where utilities are present and the risk for off-Site migration is high (i.e. to the northeast and southeast of the Site).

3.0 DATA GAPS

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the deep bedrock aquifer is to the south so two nested monitoring wells are recommended to be installed outside of the waste footprint: 1) at the north end of the Site, and 2) at the south end of the Site, to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a shallow monitoring well within the waste footprint is recommended. A new monitoring well should be installed within the waste footprint to understand the current quality of the landfill leachate. The three shallow monitoring wells should be constructed such that the well screen straddles the water table so that the wells can also be used to collect landfill gas readings.



APPENDIX Y

28. Brooklands Landfill– Winnipeg Landfill Environmental Risk Report

Re-drilling of gas probe P12L is recommended as the PVC inside the casing was reported as being “fully loose” during the most recent site visit on August 20, 2014. Re-drilling of the original gas probes, specifically P6E, P7E, and P16L where trace concentrations of methane were historically detected, is also recommended to further understand the conditions at the Site and off-Site. These three landfill gas probes should be constructed such that the well screen straddles the water table so that the probes could also be used to collect groundwater samples, if required.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure Y1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 1.5 metres (the distance to the surrounding water table assumed to be at 234 metres above sea level from the surrounding ground surface of 237 metres above sea level however waste was only disposed 1.5 metres below ground surface) and D would therefore be 15 metres. Since trace methane concentrations were reported at P6E and P7E, the landfill gas impact should extend past these locations. Due to the distance between the Site and P16E, additional investigations would be required to determine whether landfill gas continues to be present in this area as given the local geology and type of waste it seems unlikely the observed methane measurements were as a result of the waste disposed at this Site. However, buried utilities in the areas of P6E, P7E, and P16L could be acting as a migration pathway for landfill gas and investigations should be targeted to determine whether this is the reason for the previously detected concentrations of methane. To be conservative, the landfill gas impact area has been extended to surround this well until confirmation is received that landfill gas is no longer present this area.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX Z

29. CNR – Dugald Road Landfill Site



1.0 MONITORING PROGRAM CHANGES

In general this Site has been owned and operated by a party other than the City of Winnipeg. As such, and pending future reports as part of this landfill disposition study, the recommendations provided at this time for this Site may vary in the future depending on the legal liability this Site poses.

Since waste is assumed to have been placed at the surface, the potential for migration of landfill gas in the subsurface is minimal. Monitoring a landfill gas probe installed within the landfill would assist in understanding if the waste is generating landfill gas. Landfill gas monitoring should be followed by verification of water levels at each existing probe location.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the bedrock is to the west so monitoring wells should be installed outside of the waste footprint at the east end of the Site and at the west end of the Site to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a landfill gas probe completed within the waste footprint should also be collected to understand the current quality of the landfill leachate. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater samples be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Fill material with refuse should not be accepted at the Site. The Site needs to be evenly graded and capped to allow for proper Site drainage and mitigate tripping hazards. After grading, the area with fill should be covered with topsoil and seeded.

3.0 DATA GAPS

There is no groundwater quality information for the Site. It is recommended that two monitoring well nests (well screen completed in the shallow overburden and bedrock) be installed at the Site: one upgradient and one downgradient of the Site.

Since the only landfill gas probe located at the site cannot be opened and it is unknown whether the well screen is above the groundwater table, one additional probe should be installed within the waste footprint. The landfill gas probe should be installed such that the well screen straddles the water table, allowing for collection of groundwater samples.

Confirmation that waste does not extend below the surrounding ground surface elevation of 235 metres above sea level is required to support the interpretation that landfill gas is not migrating laterally. This can be accomplished by means of test pits, augerholes and/or boreholes. As such, a day of test pitting (approximately 8 test pits) is proposed to verify the vertical extent of the waste. The advantage of test pitting is a larger area could be assessed more quickly.



APPENDIX Z

29. CNR - Dugald Road Landfill – Winnipeg Landfill Environmental Risk Report

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure Z1.

Since waste was placed on the ground surface, subsurface migration of landfill gas is not expected. The interpreted extent of potential landfill gas impacts is assumed to be the waste footprint.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX AA

30. Corydon-Osborne Dump Site



1.0 MONITORING PROGRAM CHANGES

Since waste is assumed to have been placed at the surface, the potential for migration of landfill gas in the subsurface is minimal. Monitoring a landfill gas probe installed within the landfill would assist in understanding if the waste is generating landfill gas although given the type of waste disposed methane landfill gas generation is not expected. Any landfill gas monitoring should be followed by verification of water levels at that probe location.

The quality of the leachate, or leachate-impacted groundwater is not known. Potentially impacted groundwater would discharge to the Red River. As such, it is recommended that groundwater samples be collected from a shallow groundwater monitoring well once per year to understand the quality of the groundwater discharging to the surface water. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater sample be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Should the groundwater monitoring indicate that potentially impacted groundwater is discharging to the Red River then surface water samples should be collected upstream of the landfill and adjacent to the landfill. It is recommended that the surface water sample be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Health and safety protocols should be prepared and shared with Manitoba Telecom Services as they have utilities going through the Site.

3.0 DATA GAPS

There is uncertainty as to the exact location of the Site because the aerial photography does not match up with the observations from the Site visit. A subsurface investigation should be undertaken to confirm the exact location by means of test pits, augerholes and/or boreholes. As such a day of test pitting (approximately 8 test pits) is proposed to verify the vertical extent of the waste. Given the land use of this Site as a recreation area, test pitting may present a messier option for evaluation and borehole or augerhole drilling may be preferred. The advantage of test pitting is a larger area could be assessed more quickly.

If the Site is in the area of the two landfill gas probes observed during the Site visit then efforts should be made to open these probes and complete landfill gas monitoring at the probes and collect groundwater samples if available. If these landfill gas probes are not useable then another probe should be installed within the waste, screening the water table, so that both landfill gas monitoring and leachate quality monitoring can be completed.



4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure AA1.

Since waste was placed on the ground surface, subsurface migration of landfill gas is not expected. The interpreted extent of potential landfill gas impacts is assumed to be the waste footprint.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater and may extend into the Red River.

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APPENDIX BB

31. Red-Assiniboine River Junction Dump Site



1.0 MONITORING PROGRAM CHANGES

In general this Site has been owned and operated by a party other than the City of Winnipeg. As such, and pending future reports as part of this landfill disposition study, the recommendations provided at this time for this Site may vary in the future depending on the legal liability this Site poses.

Landfill gas probes should be installed and monitored on an annual basis until it can be confirmed that landfill gas is no longer being generated at this Site. Landfill gas monitoring should be followed by verification of water levels at each existing probe location.

The quality of the leachate, or leachate-impacted groundwater is not known. Potentially impacted groundwater would discharge to the Red River or the Assiniboine River. As such, it is recommended that groundwater samples be collected from shallow groundwater monitoring wells (one to the north and one to the south recommended) once per year to understand the quality of the groundwater discharging to the surface water. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. It is recommended that the groundwater sample be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Should the groundwater monitoring indicate that potentially impacted groundwater is discharging to the Red River or the Assiniboine River then surface water samples should be collected upstream of the landfill and adjacent to the landfill for whichever river is potentially being impacted. Note that there is a large volume of water within both of these rivers that would likely highly dilute potential impact from the landfill leachate, making it difficult to detect. It is recommended that the surface water sample be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

There are no recommended improvements at this time. Pending results of monitoring signage indicating no fires or open flames could be considered.

3.0 DATA GAPS

Two landfill gas probes should be installed: one at the northern portion and one at the southern portion. It would be ideal if the screen of the landfill gas probes straddled the water table so that the probe could be used for both landfill gas monitoring and shallow groundwater monitoring.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure BB1.

No information on landfill gas generation at the Site is available for review. The interpreted extent of potential landfill gas impacts is assumed to be the waste footprint, but could be more or less. There is conflicting information whether this waste was surface disposed or is below ground surface.



APPENDIX BB

31. Red-Assiniboine River Junction Dump Site – Winnipeg Landfill Environmental Risk Report

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater and may extend into the Red River or the Assiniboine River.

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APPENDIX CC

32. Lot 61, St. Mary's Road Dump Site



1.0 MONITORING PROGRAM CHANGES

Water levels should continue to be measured in any available probes.

Landfill gas monitoring in the retirement home should continue. It is recommended that monitoring occur twice per year. If access is not available one day then a second attempt should be made so that monitoring data is available.

Landfill gas monitoring in landfill gas probes should continue on an annual basis. Landfill gas monitoring should be followed by verification of water levels at each existing probe location. If the groundwater level is above the screen then monitoring from that landfill gas probe will not provide tangible information about lateral landfill gas migration in that area. Landfill gas probes that consistently have groundwater levels above the screen should not be included in the on-going monitoring program. New probes should be installed above the groundwater table as per the recommendations in Section 3.0.

In the absence of data that can confirm that landfill gas is not migrating beyond the interpreted potential impact area as noted in Section 4.0, then landfill gas monitoring should be undertaken twice per year in any structures (garages, sheds, homes) that fall within the interpreted potential impact area. It is recommended that monitoring of the residential homes/structures within the interpreted potential impact area be completed in the evening hours so that the maximum number of residents will be home.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the bedrock is to the northwest so monitoring wells should be installed in the bedrock outside of the waste footprint at the southeast end of the Site and at the northwest end of the Site to obtain results on background and downgradient groundwater quality, respectively. Groundwater samples should be collected from two landfill gas probes located outside of the waste footprint (such as P9E or P16E on the north and from the newly installed landfill gas probe to the south, as described in Section 3.0) to understand potential landfill leachate impact on shallow groundwater on adjacent sites and from one landfill gas probe located within the waste footprint (P25L) to understand the current quality of the landfill leachate. It is recommended that the groundwater samples should be collected annually. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analyzed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards with the addition of Petroleum Hydrocarbons (PHC) and benzene, toluene, ethylbenzene and toluene (BTEX) (based on anecdotal evidence of "oily waste") and then reassessed to determine if the analysis can be reduced to the indicator list of parameters and/or PHC or BTEX can be removed.

Landfill gas probes should be installed within the granular bedding for utilities extending beyond the control zone boundary to assess whether landfill gas is migrating within these utility trenches. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. Some of these utility trenches which extend into the landfill footprint area itself can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.



2.0 RECOMMENDED IMPROVEMENTS

Since landfill gas readings from probes P9E, P16E, P25L and P18L cannot be relied upon due to unknown screen elevations, these wells do not need to be repaired at this time. Repairs are required for the probes in the retirement home so that they can be opened.

Health and safety protocols should be in place for any road work or utility maintenance work in areas where these utilities exist within the landfill and/or control zone.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

3.0 DATA GAPS

During the past three years, methane was not detected at landfill gas probes except P6E and P35E in 2011. It is unknown whether the undetected methane is due to the lack of methane (primarily as a result of the type of waste disposed as this Site) or due to the water table being above the well screen. It is recommended that one new landfill gas probe completed within the waste be installed. Since P6E and P35E could not be located in the most recent monitoring event, it is recommended that new landfill gas probes be installed outside of the waste footprint as follows: one north of the waste footprint on the west end of the site, one north of the waste footprint on the east end of the site and one south of the waste footprint on the west end of the site. These landfill gas probes should be installed with a screen that straddles the water table so that shallow groundwater samples can be collected.

It is recommended that two landfill gas probes should be installed within the granular bedding for the utility trench on Sandrington Drive (one at either end of the extents of the control zone for the site).

Historic groundwater monitoring indicates that the leachate within the landfill exceeds the Guidelines for Canadian Drinking Water Quality. There is no current or deep groundwater quality information for the Site. Groundwater flows to the northwest. As such, one groundwater monitor should be installed in the bedrock at the northwestern boundary, outside of the waste footprint to understand potential for off-Site migration of landfill leachate-impacted groundwater. One background monitor at the southeast end of the Site completed within the bedrock is required for comparison.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure CC1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be the distance to the water table outside of the waste footprint to the surrounding ground surface. Water levels are available for landfill gas probes completed outside of the waste footprint in recent years. There is no information available about the stick-up of the probes, so it has been conservatively assumed that the water level measured is from the ground surface (i.e. the probes are flush mounts). Therefore, H would be 3.0 metres (the deepest water level measured in recent years) and D would therefore be 30 metres.



APPENDIX CC

32. Lot 61, St. Mary's Rd. Dump – Winnipeg Landfill Environmental Risk Report

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX DD

33. Riel Dump Site



1.0 MONITORING PROGRAM CHANGES

Since the residential homes are within the waste footprint, landfill gas monitoring should be completed semi-annually at the Site. It is recommended that monitoring of the residential homes within the control zone and/or landfill footprint be completed in the early evening hours so that more residents will be home and therefore, more homes will be monitored. Landfill gas monitoring should be performed at any operational probe as well as new probes as indicated in Section 3.0. Landfill gas monitoring should be followed by verification of water levels at each existing probe location.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact on shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater flow in the bedrock is to the northwest so monitoring wells should be installed outside of the waste footprint at the southeast end of the Site and northwest of the landfill to obtain results on background and downgradient groundwater quality, respectively. A groundwater sample from a landfill gas probe completed within the waste footprint should also be collected to understand the current quality of the landfill leachate. It is recommended that the groundwater samples should be collected annually. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Water levels should be measured in any available monitoring wells.

2.0 RECOMMENDED IMPROVEMENTS

Health and safety protocols should be in place for any road work or utility maintenance work on Ashworth Street between Meadowood Drive and Wales Avenue as well as the paved laneway off of Ashworth Street and parallel to Meadowood Drive. Manitoba Telecom Services also has utilities that occur within the waste footprint and it would be prudent to share the health and safety protocols with them for any work they complete in the area.

Signs should be placed indicating that smoking or flames are not allowed at the Site. A landfill gas barrier could be considered within the City owned sports field which could reduce lateral migration of landfill gas. However, waste is indicated to be present beyond the City owned property boundary. Further, although a clay barrier trench was noted as installed during the construction of homes on Ashworth Street, it is not apparent it has made measurable reductions in landfill gas concentrations in non-City owned property. Until additional monitoring results on landfill gas are obtained a barrier system is not recommended.

3.0 DATA GAPS

Additional landfill gas probes should be installed in, or as close as possible to the yards of homes within the landfill footprint and outside the waste footprint on each side of the landfill. Specifically at least three landfill gas probes along Ashworth Street and at least two landfill gas probes on the western half of the laneway off of Ashworth Street parallel to Meadowood Drive. Landfill gas probes should be installed such that the well screen straddles the water table, allowing for collection of groundwater samples if ever necessary.



Landfill gas monitoring from the granular bedding material for the utilities along Ashworth Street within the landfill footprint is required to understand if landfill gas migration is occurring within this material. It is recommended that one probe be installed at either end of the utility trench that lies within the waste footprint. If groundwater is encountered in these probes they should be sampled in lieu of installing the shallow groundwater monitoring wells noted below.

Historic groundwater monitoring indicates that the shallow groundwater beneath the landfill may be impacted by landfill leachate. There is no current or deep groundwater quality information for the Site. Groundwater flows to the northwest. As such, one groundwater monitoring well nest (well screen completed in the shallow overburden and bedrock) should be installed northwest of the waste footprint, to understand potential for off-Site migration of landfill leachate impacted groundwater. One background monitoring well nest (well screen completed in the shallow overburden and bedrock) southeast of the waste footprint, is required for comparison.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure DD1. In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.5 metres (assuming that is the distance to the water table from the surrounding ground surface) and D would therefore be 25 metres. While the recent landfill gas monitoring at P28E has had no detections of methane, the relationship between the well screen and the water table is not known and the results, therefore, cannot be relied upon. The interpreted extent of impacted area cannot be reduced near P28E without confirmation of well construction details.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX EE

35. River Road Dump Site



1.0 MONITORING PROGRAM CHANGES

Landfill gas monitoring should be undertaken twice per year at newly installed landfill gas probes as discussed in Section 3.0 and in the residential homes within the control zone (including those on Tracy Crescent that are currently not included in the monitoring program). Landfill gas monitoring should be followed by verification of water levels at each existing probe location. It is recommended that monitoring of the residential homes within the control zone be completed in the evening hours so that more residents will be home and therefore, more homes will be monitored.

Groundwater monitoring in the shallow overburden and the bedrock is recommended to understand potential landfill leachate impact shallow groundwater on adjacent sites and the groundwater quality in the bedrock, respectively. Groundwater samples should be collected from the two landfill gas probes to be installed outside of the waste footprint as discussed in Section 3.0 to understand potential landfill leachate impact on shallow groundwater on adjacent sites and from one of the landfill gas probes located within the waste footprint to understand the current quality of the landfill leachate.. Groundwater flow in the bedrock is to the northwest so monitoring wells should be installed outside of the waste footprint at the southeast end of the Site and at the northwest end of the Site to obtain results on background and downgradient groundwater quality, respectively. If groundwater is encountered in the landfill gas probe installed within the sanitary sewer bedding as discussed in Section 3.0, then groundwater samples should be collected from that location in lieu of one of the landfill gas probes located outside of the waste footprint. It is recommended that the groundwater samples should be collected annually. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters. Water levels should be measured in any available monitoring wells.

Landfill gas probes should be installed within the granular bedding for utilities in Kilmarnock Bay and crossing the northwest corner of the Site to assess whether landfill gas is migrating within these utility trenches. Verification of utility trench depths and depth to groundwater are required to assess this migration potential. These utility trenches on Kilmarnock Bay can also provide a pathway for leachate-impacted groundwater migration, however further investigation of this should be reassessed following results of the proposed groundwater and landfill gas monitoring program described above.

2.0 RECOMMENDED IMPROVEMENTS

Health and safety protocols should be in place for any road work or utility maintenance work on Kilmarnock Bay or other utilities within the control zone.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

No other improvements are recommended at this time.



3.0 DATA GAPS

Since none of the landfill gas probes can be found, it is recommended that additional probes be installed. The following landfill gas probes are recommended:

- Two within the waste footprint at the western edge of the residential properties on Kilmarnock Bay;
- Two outside of the waste footprint to the south of the waste (west end and east end); and,
- Two within the right-of-way of Kilmarnock Bay (in the area within the waste footprint), completed in the bedding material of the utility trench.

The landfill gas probes should be constructed such that the well screen straddles the water table so that the probes can be used for landfill gas monitoring as well as groundwater sampling.

Historic groundwater monitoring indicates that the leachate within the landfill exceeds the Guidelines for Canadian Drinking Water Quality. There is no current or deep groundwater quality information for the Site. Groundwater flow direction has been reported to be to the northwest. As such, one groundwater monitor should be installed in the bedrock at the northwestern boundary, outside of the waste footprint to understand potential for off-Site migration of landfill leachate impacted groundwater. One background monitor at the southeast end of the Site completed within the bedrock is required for comparison.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure EE1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be the distance to the water table outside of the waste footprint to the surrounding ground surface. Water levels are available for landfill gas probes P13 and P15 from the early 1980s. There is no information available about the stick-up of the probes, so it has been conservatively assumed that the water level measured is from the ground surface (i.e. the probes are flush mounts). Therefore, H would be 2.7 metres (the deepest water level measured) and D would therefore be 27 metres.

The extent of landfill leachate impact on groundwater is unknown at this time. In the absence of additional groundwater data, due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint, but may be greater.

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APPENDIX FF

36. Kilcona Park Landfill Site



1.0 MONITORING PROGRAM CHANGES

Water levels should continue to be measured in any available probes, piezometers, leachate risers or monitoring wells.

Landfill gas monitoring should continue to be undertaken within the maintenance building. Annual landfill gas monitoring from available landfill gas probes, leachate wells and piezometers should continue. Landfill gas monitoring should be followed by verification of water levels at each existing probe location. Landfill gas monitoring does not need to occur at bedrock groundwater monitoring wells as the well screen is expected to be below the water table.

Surface water samples should continue to be collected twice per year from an upstream location and a downstream location. It is understood that additional surface water sampling stations are sampled from the on-Site pond network, although their exact locations are not known. Sampling should include the ponds to the north and south of the west waste mound, and north of the east mound. Schedule 5 of the Ontario Ministry of Environment and Climate Change's report titled, "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (hereafter referred to as the Landfill Standards) provides recommended parameters for groundwater and surface water at and around landfill Sites. Surface water samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Groundwater monitoring should continue annually at W13 and W14 for background groundwater quality and from W8, W7 and W2 for downgradient water quality, as well as at water supply wells at the Kilcona Park Recreation Complex (WD25), the on-Site maintenance building (WD24) and at the picnic shelter to the west of the Site (WD26). Shallow overburden groundwater should be sampled from two landfill gas probes located outside of the waste footprint (P25E and P15E) to understand the potential for landfill leachate impact on the shallow groundwater on adjacent sites. Groundwater samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

Leachate samples should be collected from one location at each waste mound once per year. Leachate samples should be analysed once for the comprehensive list of parameters from Schedule 5 of the Landfill Standards and then reassessed to determine if the analysis can be reduced to the indicator list of parameters.

2.0 RECOMMENDED IMPROVEMENTS

Fill should continue to be brought to the Site for areas that have settled. Clay should be used to cover observed leachate seeps.

Observed leachate seeps are likely the result of a leachate mound within the waste. Mounded leachate decreases the stability of waste mound and also increases the potential for contaminants to impact the underlying bedrock aquifer. The perimeter leachate collection system was made with sand gravel that is more susceptible to clogging due to biological processes within the leachate collection system. While leachate is being collected, it has been observed to not be enough to decrease the mound within the waste. To reduce the mounding leachate, consideration should be given to adding a new perimeter leachate collection system with finger drains or purge wells within the waste mound. The implementation of this latter recommendation would be based on on-going monitoring results and is more of a long-term option for the Site.



3.0 DATA GAPS

It is recommended that a subsurface investigation be undertaken on the outer extents of the waste mounds to more clearly define the landfill footprints.

It is recommended the top of piezometers, monitoring wells and risers be surveyed so that the water and leachate levels measured can be converted to elevations for comparison purposes.

Signs should be placed indicating that smoking or flames are not allowed at the Site.

4.0 EXTENT OF IMPACT

A plan showing the features on the Site and the interpreted extent of impacted areas is illustrated in Figure FF1.

In the Guideline for Assessing Methane Hazards from Landfill Sites (MOE, 1987), it is stated that “a commonly applied rule of thumb is that significant methane migration may extend for a distance equal to 10 times the depth of landfill between the ground surface and the water table”, i.e., 10 times the effective thickness of refuse, H. Moreover, this Guideline goes on to say that “any proposed development may be approved if it can be shown that it is at a distance in excess of D in the relationship $D = 10H$.” In the case of this Site, H would be 2.0 metres (the distance from the ground surface surrounding the waste mound to the water table within the overburden) and D would therefore be 20 metres. The presence of the perimeter leachate collection system would be expected to reduce the interpreted distance of potential impact from landfill gas, however, review of the construction of the perimeter leachate collection system indicates that waste would be expected to extend beyond the perimeter leachate collection system, up the internal side slope of the waste below ground surface. A perimeter dyke was constructed to the west and south of the western mound, however, details of this construction are not known. Methane has been detected at landfill gas probes P15E, P33E and P38E, which are all beyond the expected extent of potential landfill gas impact, indicating that the extent of waste in the subsurface may not be accurate.

KGS Group indicated in 2014 that the bedrock groundwater was not impacted by landfill leachate. Due to low permeability soil surrounding the waste footprints and thickness of the clay beneath the waste, the interpreted extent of groundwater impacts are assumed to be the extents of the landfill footprint.

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