

March 2021

Volume IV

Environmental Assessment of the Proposed W12A Landfill Expansion, City of London



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Volume IV – Existing Conditions and Impact Assessment Reports

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- D.02 Noise Existing Conditions and Impact Assessment Report; completed by Golder Associates Ltd.
- D.03 Groundwater Existing Conditions and Impact Assessment Report; completed by Dillon Consulting Limited and Golder Associates Ltd., respectively
- D.04 Surface Water Existing Conditions and Impact Assessment Report; completed by Dillon Consulting Limited and Golder Associates Ltd., respectively
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D.01 Air Quality Existing Conditions and
Impact Assessment Report; completed by
Golder Associates Ltd.

REPORT**Air Quality Existing Conditions and Impact Assessment***W12A Landfill Expansion EA, City of London, Ontario*

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November 2020

Distribution List

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APPENDICES**APPENDIX A**

Background Air Quality

APPENDIX B

Emission Calculations

APPENDIX C

Dispersion Modelling

Acronyms and Glossary of Terms

Term / Acronym	Definition
AAQC	Ambient Air Quality Criteria
CAAQC	Canadian Ambient Air Quality Criteria (Federal)
CCME	Canadian Council of Ministers of the Environment
CEPA	<i>Canadian Environmental Protection Act</i>
C ₂ H ₃ Cl	Vinyl Chloride
CH ₄	methane
CO	Carbon monoxide
CO ₂	Carbon dioxide
CO ₂ e	Carbon dioxide equivalent
D/T	Dilution Threshold
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
ECCC	Environment and Climate Change Canada
EPA	<i>Environmental Protection Act</i>
ESDM	Emission Summary & Dispersion Modelling
GHG	Greenhouse gas
GHGRP	Greenhouse Gas Emissions Reporting Program
H ₂ S	Hydrogen Sulphide
HSW	Household Special Waste
LFG	Landfill gas
LGCCS	Landfill gas collection & control system
MECP	Ministry of the Environment, Conservation and Parks
MRF	Material Recovery Facility
NAAQOs	National Ambient Air Quality Objectives
NAPS	National Air Pollution Surveillance Network
NO ₂	Nitrogen dioxide
NO _x	Oxides of nitrogen
N ₂ O	Nitrous Oxide
O. Reg.	Ontario Regulation
O ₃	Ozone

Term / Acronym	Definition
PM ₁₀	Particles nominally smaller than 10 µm in aerodynamic diameter
PM _{2.5}	Particles nominally smaller than 2.5 µm in aerodynamic diameter
POI	Point-of-Impingement
SO ₂	Sulphur dioxide
SPM	Suspended particulate matter (also Total Suspended Particulate or TSP)
ToR	Terms of Reference
TSD	Technical Support Document
US EPA	United States Environmental Protection Agency
VOC	Volatile Organic Compounds

UNITS

Unit	Definition
Am ³ /hr	Actual cubic metre per hour
g/s	Grams per second
km	kilometre
Kt/yr	Kilotonnes per year
m	Metres
masl	Metres above sea level
OU/m ³	Odour units per cubic metre
OU/s	Odour units per second
µg/m ³	Micrograms per cubic metre
µm	Micrometres (also microns), one-millionth of a metre
scfm	Standard cubic feet per minute
Tonnes/yr	Tonnes per year

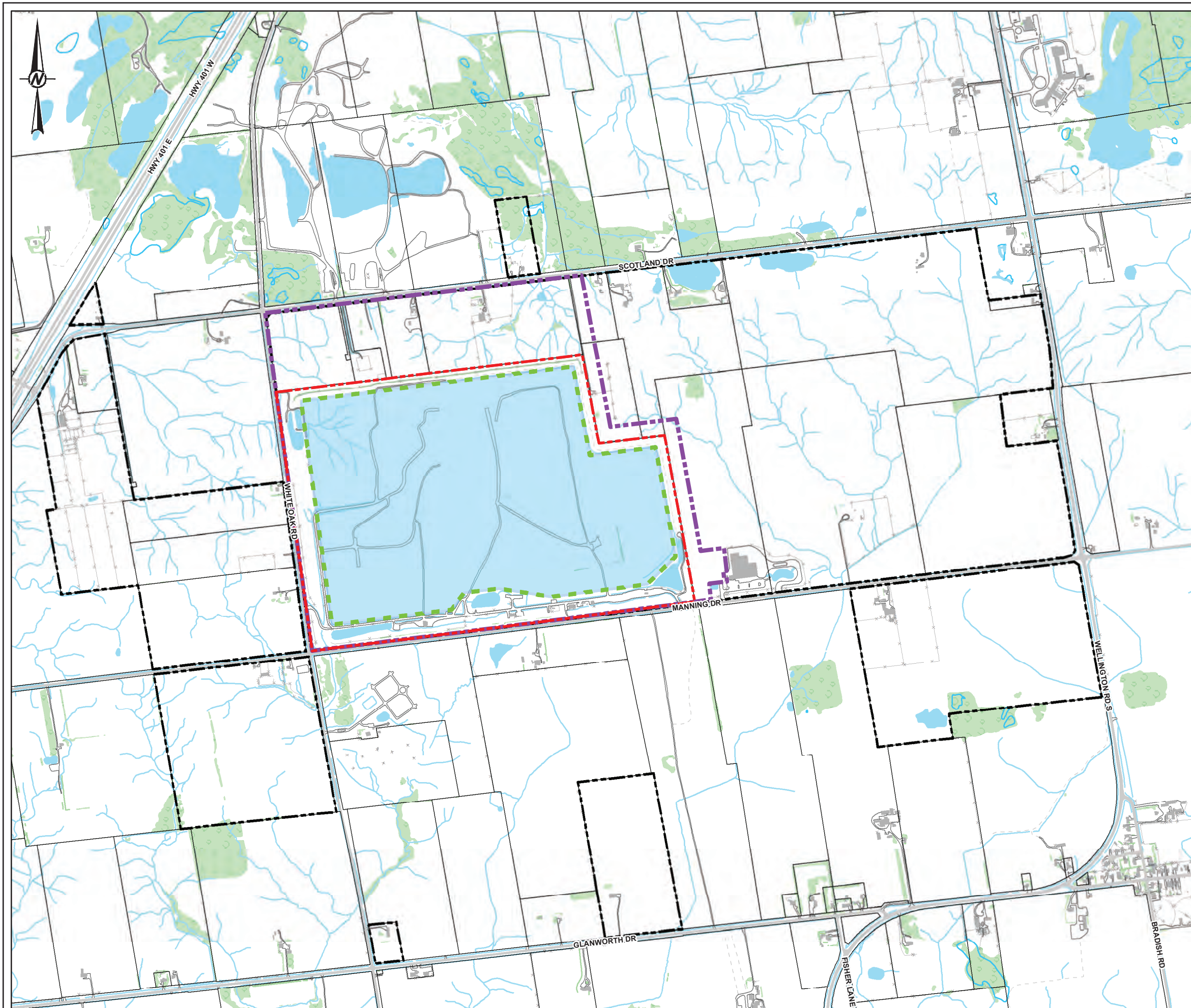
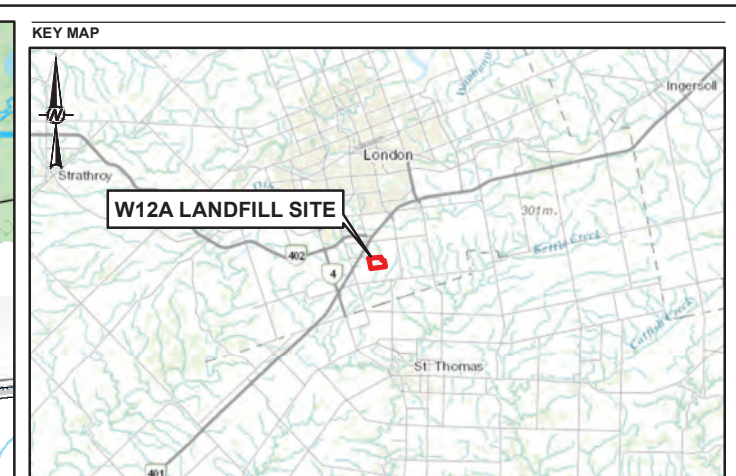
1.0 INTRODUCTION

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London, Ontario.

Figure 1 presents the Project site location. The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the air quality component (a sub-component of Atmosphere) existing conditions and impact assessment for the Environment Assessment (EA) of the proposed W12A Landfill expansion. This work has been conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR), dated February 2019 and the work plan, dated December 2019 prepared following commencement of the EA and circulated to the Ministry of the Environment, Conservation and Parks (MECP).

This report is a supporting document to the Environmental Assessment Study Report (EASR).

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- LEGEND**

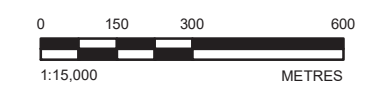
 -  WATERCOURSE
 -  DRIVEWAY
 -  FENCELINE
 -  TRAIL
 -  BUILDING FOOTPRINT
 -  WOODED AREA
 -  WATERBODY
 -  CITY OWNED PROPERTY
 -  EXISTING PROPERTY BOUNDARY
 -  PROPOSED PROPERTY BOUNDARY
 -  EXISTING APPROVED LIMIT OF WASTE
 -  PROPOSED LIMIT OF WASTE

REFERENCE(S)

1. DATA PROVIDED BY THE CITY OF LONDON.

2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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CLIENT
CORPORATION OF THE CITY OF LONDON

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A
LANDFILL EXPANSION: AIR QUALITY AND ODOUR

TITLE
SITE LOCATION PLAN

CONSULTANT	YYYY-MM-DD	2020-08-19
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PROJECT NO.	PHASE	REV.	FIGURE
1648176	0020	A	1

2.0 METHODOLOGY

The general approach used for assessing the atmospheric effects of the proposed undertaking, and documented in this assessment, supports the philosophy of the EA as a planning and decision-making process and conforms to the general methodology presented in the approved Amended ToR. The specific study methods used in the assessment are described in the following sections.

2.1 Study Area

For the purposes of the air quality and odour assessment, there are two study areas, as follows:

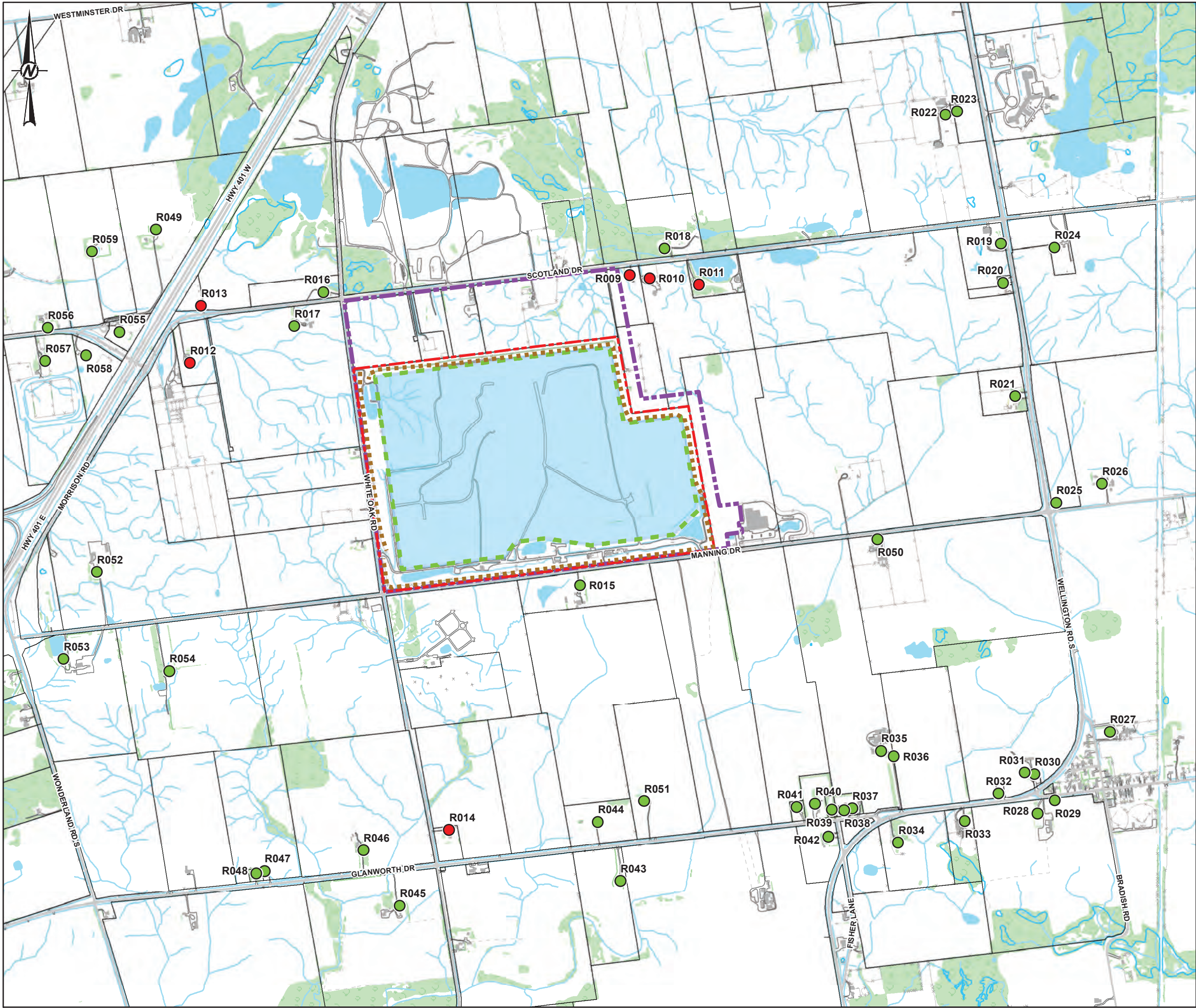
Site Area – The existing W12A Landfill Site, located at 3502 Manning Drive and adjacent lands where landfill expansion will occur.

Site-vicinity Study Area – The lands in the area immediately adjacent to the Site Area that have the potential to be directly affected by the landfill expansion and activities with the Site Area. The extent of the Site-vicinity Study Area will be determined for each of the environmental components. For most environmental components, a Site-vicinity Study Area of 500 metres (m) from the Site Area is appropriate. Air (health-related compounds) and dust emissions are required to meet provincial requirements at and beyond the landfill site boundary. Air dispersion modelling to demonstrate compliance with provincial requirements has been carried out in accordance with the MECP modelling guidelines (MECP, 2017), which includes the use of a receptor grid that meets the requirements of s.14 of Ontario Regulation (O. Reg.) 419/05. Odour emissions are required to meet provincial requirements at off-site sensitive receptors. Odour emissions may travel further than 500 m but any effects are expected to be within 1.5 kilometres (km) of the Site Area.

The locations of the closest sensitive receptors in all wind directions have been identified and reviewed for inclusion in the air dispersion model. Sensitive receptor locations were identified using the MECP definition in section 30(8) of O. Reg. 419/05 and the definition of “human receptors” in MECP guidance document “Methodology for Modeling Assessments of Contaminants with 10 Minute Average Standards and Guidelines under O. Reg. 419/05” (MECP, 2016). Specifically, locations where “human activities regularly occur” or that meet any of the following definitions:

- a health care facility
- a senior citizens’ residence or long-term care facility
- a child care facility
- an educational facility
- a dwelling
- a place where discharges of a contaminant may cause a risk to human health

Consideration was given to receptors that are greater than 1.5 km from the Study Area but limited to the closest sensitive receptors for a given wind direction. Sensitive receptors included in the air quality and odour assessment are illustrated on Figure 2. The majority of the sensitive receptors identified were dwellings. Several of these receptors are owned by the City but have been included in the assessment if they are still occupied.

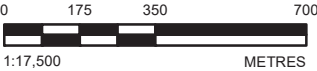


LEGEND

- CITY OWNED PROPERTY - EXISTING
- NON-CITY OWNED PROPERTY - EXISTING
- WATERCOURSE
- DRIVEWAY
- FENCELINE
- TRAIL
- APPROXIMATE BERM LOCATION
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- EXISTING PROPERTY BOUNDARY
- PROPOSED PROPERTY BOUNDARY
- EXISTING APPROVED LIMIT OF WASTE
- PROPOSED LIMIT OF WASTE

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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CLIENT CORPORATION OF THE CITY OF LONDON			
PROJECT ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION: AIR QUALITY AND ODOUR			
TITLE SENSITIVE RECEPTOR LOCATIONS			
CONSULTANT 	YYYY-MM-DD	2020-08-19	
	DESIGNED	---	
	PREPARED	JEM	
	REVIEWED	---	
	APPROVED	---	
PROJECT NO. 1648176	PHASE 0020	REV. A	FIGURE 2

2.2 Timeframe

The air quality and odour assessments focus on the operations phase of the project. During the post-closure phase, the only anticipated activities potentially related to emissions to the air are ongoing leachate collection and treatment, landfill gas (LFG) management, site performance monitoring, and maintenance. Once, the landfill operational activities have ceased, a final landfill cover will be in place and the LFG management system will be operating over the whole landfill; therefore, the overall emissions from the Project during the post-closure phase will be less than during the operational phase.

2.3 Indicator Compounds

The assessment of air quality focuses on predicting changes in the concentrations of indicator compounds. These indicator compounds represent compounds that are typically emitted from landfills, have the highest potential to cause adverse and/or non-mitigatable effects, and for which air quality criteria exist:

- **Particulate matter:** suspended particulate matter (SPM), particles nominally smaller than 10 µm in diameter (PM₁₀), and particles nominally smaller than 2.5 µm in diameter (PM_{2.5})
- **Combustion gases:** Nitrogen oxides (NO_x) represented by nitrogen dioxide (NO₂), sulphur dioxide (SO₂), and carbon monoxide (CO)
- **Other Indicator Compounds:** hydrogen sulphide (H₂S), vinyl chloride (C₂H₃Cl), odour (expressed as whole odour (OU/m³))

These compounds are associated with various landfill operations. Particulate matter is typically associated with airborne dust from vehicles travelling on on-Site paved roads and unpaved roads/haul routes, as well as material loading and unloading activities. Products of combustion (NO₂, SO₂ and CO) are associated with the exhaust from on-Site vehicles. Emissions of hydrogen sulphide and vinyl chloride are the result of breakdown of waste material within the landfill. To determine air quality impacts, the air quality predicted to result from the emissions from the proposed undertaking will be compared to existing ambient air quality objectives and criteria limits for the above compounds.

Ozone (O₃) has been identified as an indicator for the project because although it will not be directly emitted as a result of the project works and activities, it will be used to calculate NO₂ in the effects assessment. Ozone is not emitted directly into atmosphere but is associated with the reaction of NO_x and Volatile Organic Compounds (VOCs) (MECP 2018).

Odour represented as an odour threshold value (OTV) and described as “odour units” (OU/m³), is the primary method used in Ontario to quantify the presence of odorous compounds in air. The concentration of whole odour can be measured at a facility and evaluated through the use of an odour panel. The panel is exposed to the odorant at various dilution thresholds (D/T). Due to the variability in human perception of odour, the point at which 50 percent of the panel can detect the odour is used as the threshold odour concentration. An odour unit (OU) is the number of dilutions required to reduce the odour to its detection threshold and is the emission variable used in dispersion modelling.

An odour concentration (as an OU) is not an indicator of the offensiveness of a particular odour. Offensiveness is a subjective factor that varies by individual, thus has not been considered in this analysis.

2.4 Applicable Guidelines

The relevant air quality criteria used for screening the air quality effects of the Project include the Ontario criteria and federal standards and objectives where provincial guidelines are not available. The MECP has set guidelines related to ambient air concentrations that are summarized in *Ontario's Ambient Air Quality Criteria* (AAQC) document (MECP 2018). The Ontario AAQCs are characterized as desirable ambient air concentrations, they are an indicator of the air quality in an area. They are not regulatory limits and therefore can be exceeded. The Ontario AAQCs are used for screening the air quality effects in environmental assessments, for studies using ambient air monitoring data, and for assessment of general air quality in a community or across the province (MECP 2018).

There are two sets of federal objectives and criteria: the National Ambient Air Quality Objectives (NAAQOs) and the Canadian Ambient Air Quality Standards (CAAQs) (formerly National Ambient Air Quality Standards (NAAQS)). Similar to the Ontario AAQCs, the NAAQOs are benchmarks that can be used to facilitate air quality management on a regional scale and provide goals for outdoor air quality that protect public health, the environment, or aesthetic properties of the environment (CCME 1999). The federal government has established the following levels of NAAQOs (Health Canada 1994):

- The maximum **Desirable** level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted parts of the country and for the continuing development of control technology.
- The maximum **Acceptable** level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being.

The CAAQs have been developed under the *Canadian Environmental Protection Act, 1999*, and include standards for PM_{2.5}, NO₂, SO₂ and ozone that must be achieved by 2020. In 2015 the standard was phased in, with the final standard phase-in date in 2020 (Government of Canada 2013). Like the Ontario AAQCs, the CAAQs are not regulatory limits and are used as national targets for PM_{2.5}, NO₂, SO₂ and ozone, excluding Quebec (CCME 2014). These more stringent standards were adopted because, as stated by the CCME (emphasis added):

Canadians living in heavily populated and industrialized areas of the country may be exposed to potentially harmful levels of outdoor air pollutants, at concentrations that exceeded established standards. (CCME 2014)

However, the key aspect of “CAAQ Achievement” (i.e., compliance), as stated by the CCME, is (emphasis added):

Achievement of the CAAQ means that the measured air pollutant concentration in an air zone does not exceed the CAAQ numerical value. (CCME 2014)

These values are reported based on a series of monitoring stations located in airsheds across Canada and, in this context, an “air zone” refers to a local or regional sub-region of the established provincial or territorial airsheds. Currently, Southern Ontario and Southern Quebec are treated as a single Airshed (East Central) and Southern Ontario, excluding Hamilton and Sarnia, is designated as a single air zone.

For conservatism in this assessment, the lower of the Ontario AAQCs and the CAAQS, where applicable, were used for comparison to the maximum modelled concentrations. However, comparing the maximum predicted concentrations to the CAAQS standards is not appropriate for the following reasons:

- Neither the Site Area nor the Site-vicinity Study Area represent an “air zone”, the region over which the CCME states that achievement of the CAAQS is to be evaluated/compared.
- There are not heavily populated or industrialized areas located within the Site-vicinity Study Area. Therefore, there is no exposure pathway by which:
 - *Canadians living in heavily populated and industrialized areas of the country may be exposed to potentially harmful levels of outdoor air pollutants, at concentrations that exceeded established standards.* (CCME 2014)

A summary of the applicable Ontario and federal objectives and criteria are listed in Table 1.

For Odour, the MECP uses a guideline of 1 odour unit (OU/m³) based on the 99.5 percentile on a 10-minute time averaging period to assess the potential for nuisance. 1 OU/m³ is the concentration at which 50% of the population can perceive an odour, therefore 1 OU/m³ is typically used as an indicator for the likelihood of nuisance.

3.0 EXISTING CONDITIONS

The environment potentially affected by the Project can be delineated as the combination of the existing background air quality and the contribution from the approved activities at the W12A Landfill. The background air quality represents the existing conditions of air quality before the Project. Sources include industrial facilities, roadways, long range transboundary air pollution, small regional sources and large industrial sources.

Available data can be used to characterize the background air quality within the Site-vicinity Study Area; however, it cannot accurately describe the variations in concentrations that will result from emissions from existing sources at the Site (i.e., existing conditions). The approach used to describe the existing sources is described below.

- The existing air quality was characterized using a combination of existing information and dispersion models.
- Field studies were not undertaken to characterize the existing air quality. Adequate data was available from existing sources to characterize regional air quality and was used to describe background air quality within the Site-vicinity Study Area.
- The existing air quality described in Section 3.1 considers the combination of the background air quality from regional ambient monitoring stations with the modelled existing air quality from the approved sources at the W12A Landfill.

Table 1: Relevant Ambient Air Quality Criteria for Indicator Compounds

Substance	Averaging Period	Ontario Ambient Air Quality Guidelines ^(a) (µg/m ³)	Canadian Ambient Air Quality Standards ^(b) (µg/m ³)	National Ambient Air Quality Standards and Objectives ^(c) (µg/m ³)	
				Desirable	Acceptable
SPM^(d)	24-Hour	120	—	—	120
	Annual	60^(e)	—	60	70
PM₁₀	24-Hour	50^(f)	—	—	—
PM_{2.5}	24-Hour	30 ^(g)	27^(g)	—	—
	Annual	—	8.8	—	—
NO₂	1-Hour	400^(h)	79⁽ⁱ⁾	—	400
	24-Hour	200^(h)	—	—	200
	Annual	—	22.5⁽ⁱ⁾	60	100
SO₂	10 Minute	180	—	—	—
	1-Hour	100	170.34 ^(j)	450	900
	24-Hour	—	—	150	300
	Annual	10	10.5 ^(j)	30	60
CO	1-Hour	36,200	—	15,000	35,000
	8-Hour	15,700	—	6,000	15,000
O₃	1-Hour	165	—	100	160
	8-Hour	—	123.6	—	—
H₂S	10 Minute	13	—	—	—
	24-Hour	7	—	—	—
Vinyl Chloride	24-Hour	1	—	—	—
	Annual	0.2	—	—	—

Notes:

(a) MECP (2018)

(b) CAAQS published in the Canada Gazette Volume 147, No. 21 - May 25, 2013. Final standard phase in date of 2020 used (CCME 2014).

(c) CCME (1999)

(d) SPM in Ontario is defined as Suspended Particulate Matter (<44 µm diameter)

(e) Geometric mean

(f) Interim AAQC and is provided as a guide for decision making (MECP 2018)

(g) Compliance is based on the 98th percentile of the annual monitored data averaged over three years of measurements.(h) Standard is for nitrogen oxides (NO_x) but is based on the health effects of NO₂.(i) Canadian ambient air quality standard for NO₂ is effective from 2025. The 1-hour standard is based on the three-year average of the 98th percentile of the daily maximum 1-hour average concentration.(j) Canadian ambient air quality standard for SO₂ is effective from 2025. The 1-hour standard is based on the three-year average of the 98th percentile of the daily maximum 1-hour average concentration.**Bolded** values represent the criteria used in the assessment.

3.1 Air Quality Monitoring Data

Background air quality was characterised using observations from the Environment and Climate Change Canada (ECCC) National Air Pollution Surveillance Network (NAPS) air quality monitoring stations (ECCC 2019). The closest air quality monitoring station is located at 42 St. Julien Street in London (London Station). Two other NAPS air quality monitoring stations were selected, West Avenue and Homewood in Kitchener (Kitchener Station), and Beasley Park Hamilton Downtown in Hamilton (Hamilton Station). The location of these air monitoring stations is shown on Figure 3.

The Project is located in a rural location; however, it is located adjacent to Highway 401. A wind-rose for the area is provided in Appendix A and indicates that the predominant wind direction is from the south-west. The London Station (NAPS ID 60904) is the closest NAPS station to the Project (approximately 12 km north-east), so it is expected that the Project will experience similar wind patterns and impacts from regional transport of compounds as this station. It is similarly situated near residential areas. All indicator compounds with the exception of CO and SO₂ are monitored at this station.

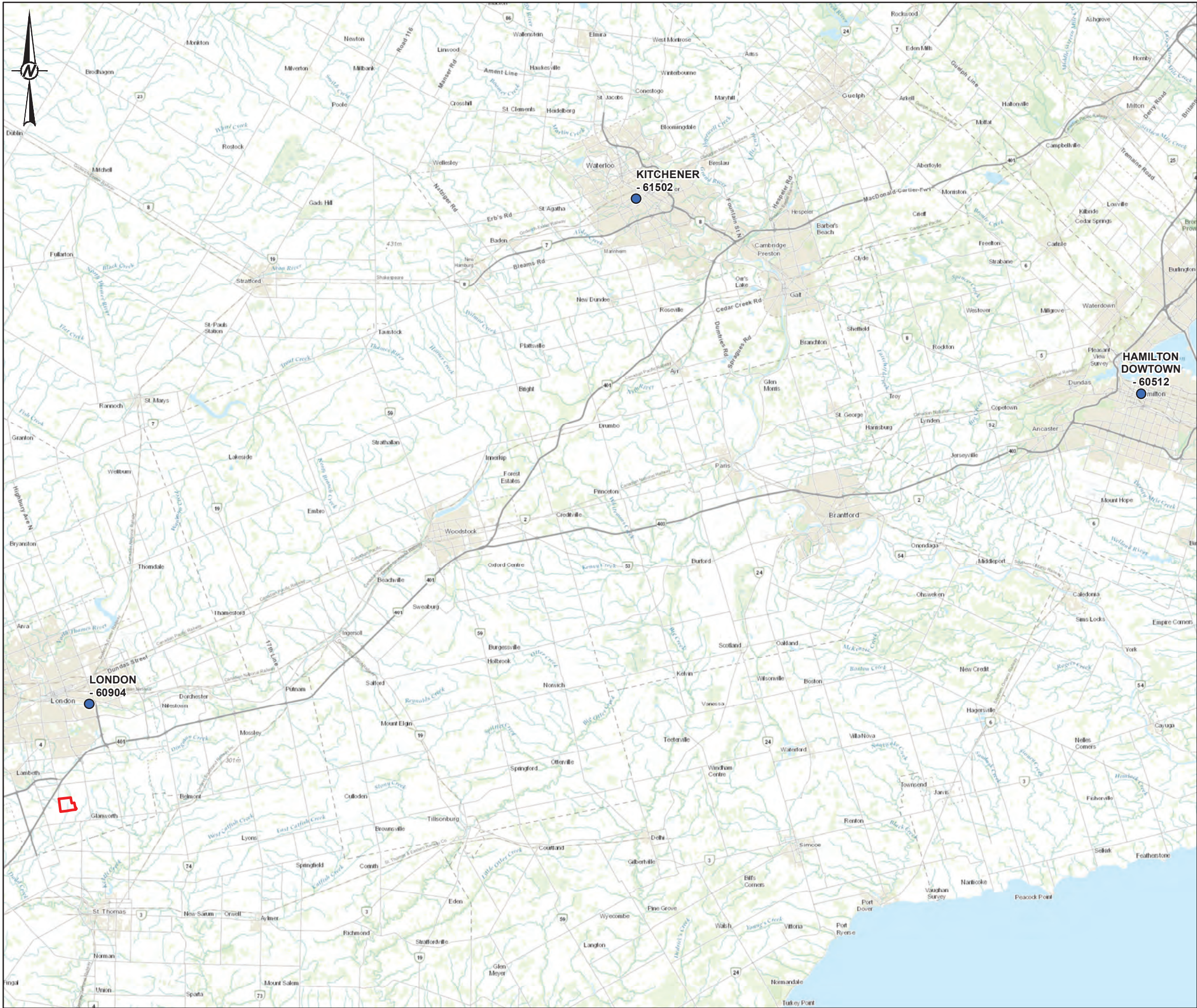
The Kitchener NAPS station (61502) located approximately 87 km away was selected due to Kitchener's similar size, industry and proximity to Highway 401 as London. All indicator compounds with the exception of CO and SO₂ are monitored at this station. The Hamilton station was selected for the CO and SO₂ data as it was the most representative station that monitors these compounds.

There is no monitoring data available for SPM and PM₁₀, however, the background SPM and PM₁₀ concentrations can be estimated from the available PM_{2.5} monitoring results. PM_{2.5} is a subset of PM₁₀, and PM₁₀ is a subset of SPM. Therefore, it is reasonable to assume that the ambient concentrations of SPM will be greater than corresponding PM₁₀ levels, and PM₁₀ concentrations will be greater than the corresponding levels of PM_{2.5}. The mean levels of PM_{2.5} in Canadian locations are found to be about 54% of the PM₁₀ concentrations and about 30% of the SPM concentrations (Lall et al. 2004). By applying this ratio, it is possible to estimate the background SPM and PM₁₀ concentrations for the study area.

Hydrogen sulphide is not measured at any of the above three stations, therefore the 1-hour background concentration was taken from the ECCC's draft screening Assessment for H₂S (ECCC, 2017) and converted to the relevant averaging periods using MECP recommended methodologies in the *Air Dispersion Modelling Guideline for Ontario* (MECP, 2017)

Background air quality data was primarily taken from the London Station as this is the closest site to the Study Area. A copy of the full Background air quality study is included as Appendix A.

The background air quality is provided in Table 2 and compared to the air quality criteria identified in Section 2.4. All background concentrations used in the assessment are below the relevant air quality criteria.



LEGEND

- AMBIENT AIR MONITORING STATION
- W12A LANDFILL SITE

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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0 3,900 7,800 15,600
1:400,000 METRES

CLIENT
CORPORATION OF THE CITY OF LONDON

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A
LANDFILL EXPANSION: AIR QUALITY AND ODOUR

TITLE
AIR QUALITY MONITORING STATIONS

CONSULTANT	YYYY-MM-DD	2020-08-19
	DESIGNED	---
	PREPARED	JEM
	REVIEWED	---
	APPROVED	---

GOLDER

PROJECT NO. 1648176	PHASE 0020	REV. A	FIGURE 3
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Table 2: Background Air Quality

Indicator	Averaging Period	Air Quality Criteria ($\mu\text{g}/\text{m}^3$)	Background Concentrations ($\mu\text{g}/\text{m}^3$)	Percentage of Air Quality Criteria (%)
SPM	24-hour	120	45.83	38.2%
	Annual	60	26.85	44.8%
PM ₁₀	24-hour	50	25.46	50.9%
PM _{2.5}	24-hour	27	13.75	50.9%
	Annual	8.8	8.06	91.6%
NO ₂	1-Hour	400/ 79	22.57	5.6%/28.6%
	24-Hour	200	19.87	9.9%
	Annual	32	11.70	52.0%
SO ₂	10-min	180	56.19	31.2%
	1-Hour	100	34.05	34.1%
	24-Hour	150	32.36	21.6%
	Annual	10	9.08	90.8%
CO	1-Hour	15,000	458.10	3.1%
	8-Hour	6,000	572.62	9.5%
O ₃	1-Hour	165	88.31	53.5%
	8-Hour	123.6	105.43	85.3%
H ₂ S	10-min	13	0.84	6.5%
	24-hour	7	0.21	3.0%
Vinyl Chloride	24-Hour	1	0.00382	0.4%
	Annual	0.2	0.00147	0.7%

3.2 Review of Existing Odour Complaints Data

In 2019, a total of 58 odour complaints were received by the City in relation to W12A Landfill. This value is similar to the number of complaints received in 2018 (62 complaints) but higher than in previous years (19 in 2014, 21 in 2015, 17 in 2016, 34 in 2017).

A review of the odour complaint records for the landfill in 2019 was conducted to identify the likelihood that the landfill may have contributed to each odour complaint. This was undertaken through a review of the location from which the complaint was made and corresponding wind direction at the time the complaint was logged. If the area of the complaint did not appear to be reasonably downwind of the W12A Landfill at the time the complaint was logged, it was deemed unlikely that W12A Landfill was a significant contributor to the complaint and thus the corresponding data was not used for further analysis.

Of the 58 odour complaints received in 2019, eight complaints were excluded based on wind direction, leaving 50 complaints that may reasonably be attributed, in whole or in part, to the W12A Landfill. These 50 complaints were received from 30 different reported addresses surrounding the Site with the majority recorded at addresses along the western end of Manning Drive.

Figure 4, below shows the frequency of complaints received for each wind direction. The majority of odour complaints have historically been recorded during times when winds are blowing from the east.

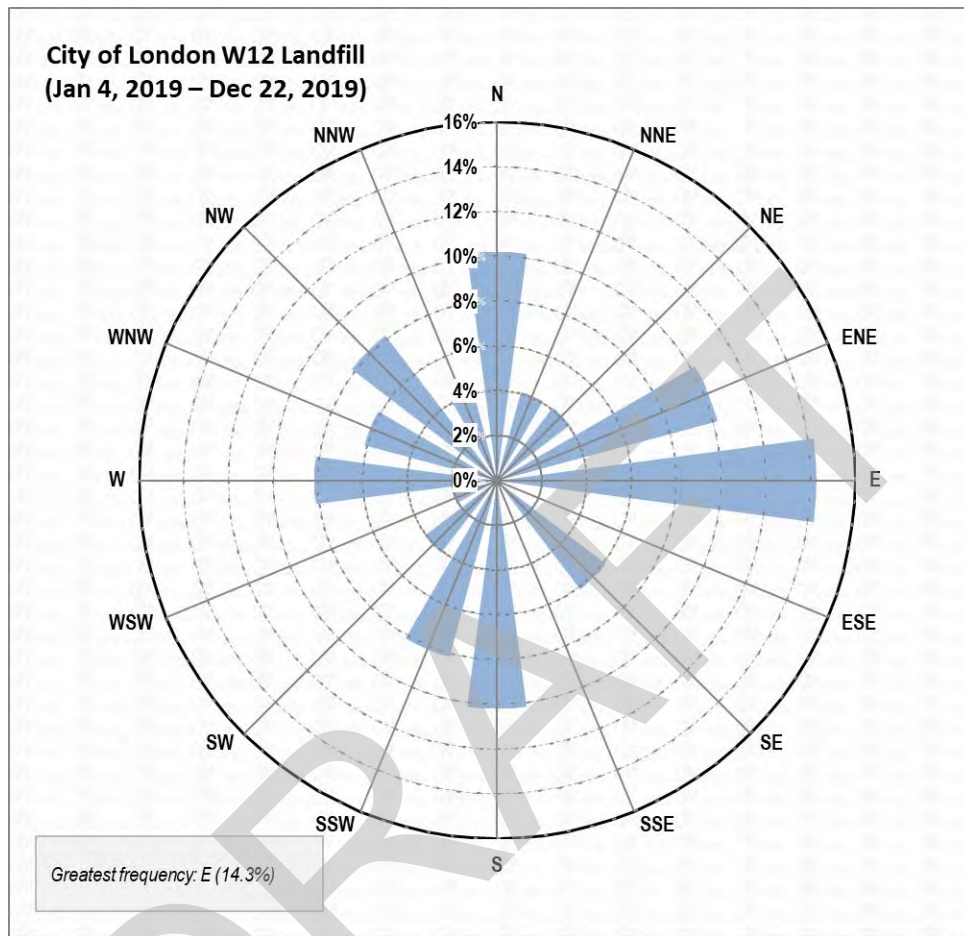


Figure 4: Odour Rose for 2019 Odour Complaints Potentially Attributed to W12A Landfill

3.3 Modelled Air Quality from Existing Sources

As described in Section 3.0, the existing air quality in the Site-vicinity Study Area was described using a combination of background air quality for the region and the modelled air quality resulting from the emissions of approved sources at the existing Site. Existing approved on-Site sources of air emissions include:

- landfill gas generated from waste decomposition
- by-products from combustion of landfill gas in the flare
- traffic, loading and unloading
- on-Site vehicle emissions
- landfill waste receipt activities
- landfill daily and final cover activities

The AERMOD model (Version 19191) was used to predict concentrations at a series of off-Site locations, referred to as receptors. These off-Site receptors included a series of receptors placed at nearby residences (referred to as sensitive receptors and illustrated on Figure 2). Model predictions for most of the indicator compounds are presented as the highest value from any modelled receptor.

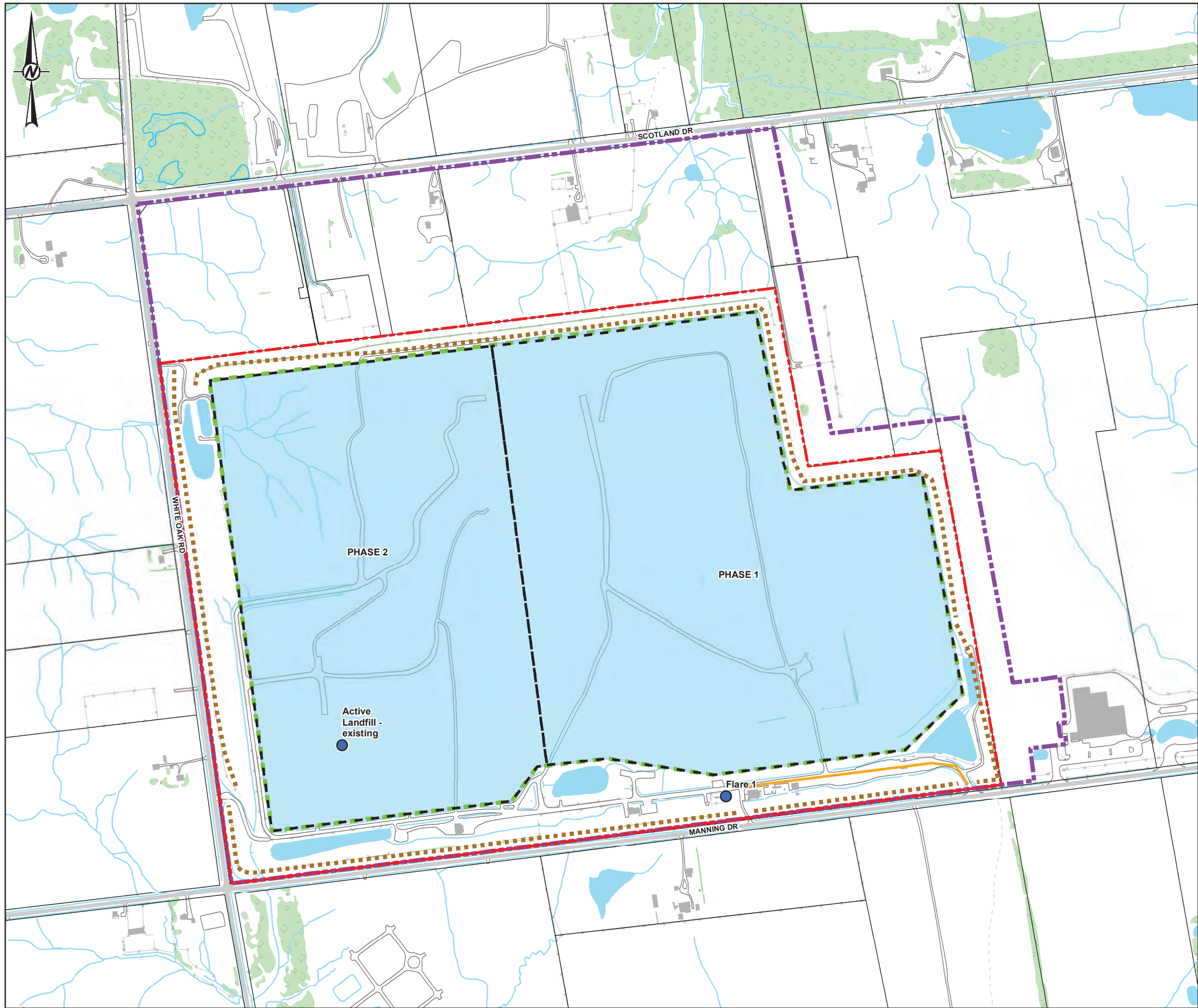
More details regarding the development of emission calculations are provided in Appendix B and additional details regarding the dispersion modelling set-up are provided in Attachment C. The locations of existing Emission Sources are illustrated on Figure 5.

Table 3 lists the emission rates from the W12A Landfill that were used to characterize the air quality in the Site-vicinity Study Area from currently approved sources, based on the emission rate calculations described in Appendix B.

Table 3: Existing Emissions from W12A Landfill

Compound	Units	Emission Rate
SPM	g/s	1.828
PM ₁₀	g/s	0.494
PM _{2.5}	g/s	0.198
NO _x	g/s	0.959
SO ₂	g/s	0.078
CO	g/s	1.612
H ₂ S	g/s	0.020
C ₂ H ₃ Cl	g/s	0.002
Odour	OU/s	5779.04

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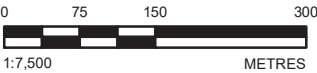


LEGEND

- AIR EMISSION SOURCE
- WATERCOURSE
- DRIVEWAY
- FENCELINE
- TRAIL
- APPROXIMATE BERM LOCATION
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- EXISTING PROPERTY BOUNDARY
- PROPOSED PROPERTY BOUNDARY
- EXISTING APPROVED LIMIT OF WASTE
- PROPOSED LIMIT OF WASTE
- ROADWAY TYPE**
- DECOMPOSABLE WASTE

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

DRAFT



CLIENT CORPORATION OF THE CITY OF LONDON			
PROJECT ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION: AIR QUALITY AND ODOUR			
TITLE SITE LAYOUT AND EMISSION SOURCE LOCATION: EXISTING			
	CONSULTANT	YYYY-MM-DD	2020-08-19
	DESIGNED	---	---
	PREPARED	JEM	---
	REVIEWED	---	---
	APPROVED	---	---
PROJECT NO. 1648176	PHASE 0020	REV. A	FIGURE 5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 28mm

The predicted model concentrations as a result of the existing approved activities at the W12A Landfill are summarized in Table 4. These numbers represent the maximum predicted concentrations at sensitive receptors.

Table 4: Maximum Predicted Air Quality Concentrations from Existing Approved Activities

Indicator	Averaging Period	Maximum Predicted Concentration - Existing Approved Activities ($\mu\text{g}/\text{m}^3$)
SPM	24-hour	12.01
	Annual	2.15
PM ₁₀	24-hour	5.35
PM _{2.5}	24-hour	1.57
	Annual	0.23
NO ₂ ^(a)	1-hour	119.32
	24-hour	84.60
	Annual	2.87
SO ₂	10-min	0.39
	1-hour	0.24
	24-hour	0.07
	Annual	0.004
CO	½-hour	789.52
	1-hour	657.93
	8-hour	97.09
H ₂ S	10-min	2.58
	24-hour	0.41
C ₂ H ₃ Cl	24-hour	0.034
	Annual	0.006
Odour ^(b)	10-min	0.55

Notes:

(a) NO₂ concentrations are calculated from the predicted NO_x concentrations as described in Attachment C.

(b) Values are in OU/m³ and presented at the 99.5 percentile

(c) In accordance with Ontario guidance (MECP, 2017), meteorological anomalies have been removed when calculating the maximum predicted concentrations.

3.4 Existing Air Quality

The existing air quality conditions against which the Project will be evaluated are a combination of background air quality for the region and the modelled air quality resulting from the emissions of currently approved sources at the existing Site. Table 5 provides a summary of the existing conditions for each of the indicator compounds.

Table 5: Existing Air Quality (background plus currently approved activities)

Indicator	Averaging Period	Background Air Quality ($\mu\text{g}/\text{m}^3$) ⁽¹⁾	Maximum Predicted Concentration – Currently Approved Activities ⁽²⁾ ($\mu\text{g}/\text{m}^3$)	Existing Air Quality ($\mu\text{g}/\text{m}^3$)
SPM	24-hour	45.83	12.01	57.84
	Annual	26.85	2.15	29.00
PM ₁₀	24-hour	25.46	5.35	30.81
PM _{2.5}	24-hour	13.75	1.57	15.32
	Annual	8.06	0.23	8.29
NO _x	1-hour	22.57	119.32	141.89
	24-hour	19.87	84.60	104.47
	Annual	11.70	2.87	14.57
SO ₂	10-minute	56.19	0.39	56.58
	1-hour	34.05	0.24	34.29
	24-hour	32.36	0.07	32.43
	Annual	9.08	0.0035	9.08
CO	½-hour	549.72	789.52	1,339.24
	1-hour	458.10	657.93	1,116.03
	8-hour	572.62	97.09	669.71
H ₂ S	10-min	0.84	2.58	3.42
	24-hour	0.21	0.41	0.62
C ₂ H ₃ Cl	24-hour	0.00382	0.0335	0.037
	Annual	0.00147	0.0057	0.007
Odour ⁽³⁾	10-min	—	0.55	0.55

Notes:

(1) Data from Table 2

(2) Data from Table 4

(3) Values are in OU/m³ and presented at the 99.5%ile

4.0 PROJECT DESCRIPTION

The landfill expansion consists of a vertical expansion over the existing landfill footprint to provide 13.8 million m³ of airspace for waste and daily cover. To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be adjacent to Scotland Drive and a 100 m buffer width will be provided on the east side of the landfill footprint and some additional area in the southeast corner to tie into the adjacent MRF property line. This results in a 106.3 ha landfill footprint within a 192.4 ha landfill property, with a highest ridge elevation of waste of 318.43 metres above sea level (masl).

The landfill expansion will be developed sequentially in eight Phases, 1E through 8E. The expansion will commence in Phase 1E in the southwest and in the non-decomposable cell in the southeast, which will involve progressive stripping of the existing cover material from the active area and the placement and compaction of waste and spreading of daily cover soil, compaction and daily covering of the waste. The daily cover will be mostly suitable types of materials incoming to the site on an ongoing basis, supplemented as needed by material from on-Site soil stockpiles. To reduce air emissions (for odour control purposes during landfilling operations and to increase the overall collection of landfill gases), it is proposed that a number of horizontal landfill gas collection pipes will also be installed progressively as waste is placed.

After completion of a cell and moving to the next disposal area (as per the phasing plan), final cover soil will be placed over the waste and revegetated and the vertical landfill gas collection system progressively installed with the final cover. During operations, vehicles will travel on the on-Site perimeter roads and on the haul roads located on the landfill, as well as to and from the soil stockpiles in the north buffer area. There will be ongoing maintenance and monitoring activities. The operations activities during the expansion will basically be a continuation of current site activities both on and adjacent to the existing landfill footprint, with raising of the landfill to reach the design configuration.

It is estimated that the total expanded landfill will theoretically generate a maximum of 4,395 standard cubic feet per minute (scfm) of LFG in 2049 (the year following completion of filling of the expansion), of which typically 50% is methane as noted in the main EA. LFG is collected from completed areas of the landfill using a vertical well system that is connected to an enclosed flare; the existing flare is sized to combust a maximum of approximately 1,700 scfm of LFG. Since September 2020, approximately 1,700 scfm of LFG has been captured and flared as a result of the LFG collection system expansion including horizontal collection pipes as well as vertical collection wells installed in the spring of 2020. Based on the 2019 data and pre LFG collection system expansion, it is reasonable to conclude a collection efficiency of around 60% is what was occurring for landfill design and existing conditions on the currently approved landfill; using this collection efficiency, the analysis indicates that the capacity of the flare would be exceeded around year 2027.

The timing for installation of additional flare capacity will depend on the actual operation of the existing flare and its ability to handle the collected gas flow rate. As mentioned in late 2020 the flare was operating at capacity (1,700 scfm) and the City has commenced appropriate approvals action for enlarging the flaring station. It is proposed to utilize vertical LFG extraction wells with a collection efficiency of 85% to be progressively installed with the construction of final cover following placement of waste to final contours in each Phase.

5.0 IMPACT ASSESSMENT

The effects of the Project on air quality were identified for different phases of the expansion and involved the following three steps:

- Calculating representative emissions rates for each of the significant sources (detailed in Appendix B).
- Carrying out atmospheric dispersion modelling to predict off-Site concentrations of the indicator compounds (detailed in Appendix C).
- Comparison of predicted concentrations to existing conditions and the Applicable Guidelines (Section 2.4).

5.1 Emission Estimation

The method used for calculating and quantifying air emissions resulting from the proposed project involved the following steps:

- **Identifying emissions sources:** Emission sources were identified based on detailed project information provided by the City of London.
- **Calculating emission rates:** Air emission rates were calculated using accepted methods, such as published emission factors, and were based on design activity data provided by the engineering team. Emission rates were conservatively calculated to estimate the release rates into the atmosphere.

The emission estimation methods followed accepted MECP practices including, where applicable, guidance in the Ontario MECP document *Procedure for Preparing an Emission Summary and Dispersion Modelling Report Version 4.1* (MECP, 2018b).

In calculating these emissions, all potential sources for the proposed project were considered; however, only significant sources (i.e., existing daily cover stockpiles) were carried through to Step 2. Sources with emissions rates that were less than 1% of the site-wide emissions were considered insignificant. Additionally, infrequent operations were also considered insignificant (i.e., testing of standby power generators). Details of the specific emissions calculation methods and resulting emissions are provided in Appendix B.

5.2 Identification of Emission Sources

Table 6 outlines the activities (i.e., sources of emissions) that have been assessed as part of the air quality assessment for both the existing scenario and the expansion phases. For sources that were identified and not included in the assessment, the rationale has been presented in the table.

Emissions during normal operations and after expansion are expected to be greater than during the post-operation phase (i.e., closure) because the level of on-Site activities will be greater during the operational phase; therefore, the air emissions and associated effects during the project operational phase represent the greatest potential impacts.

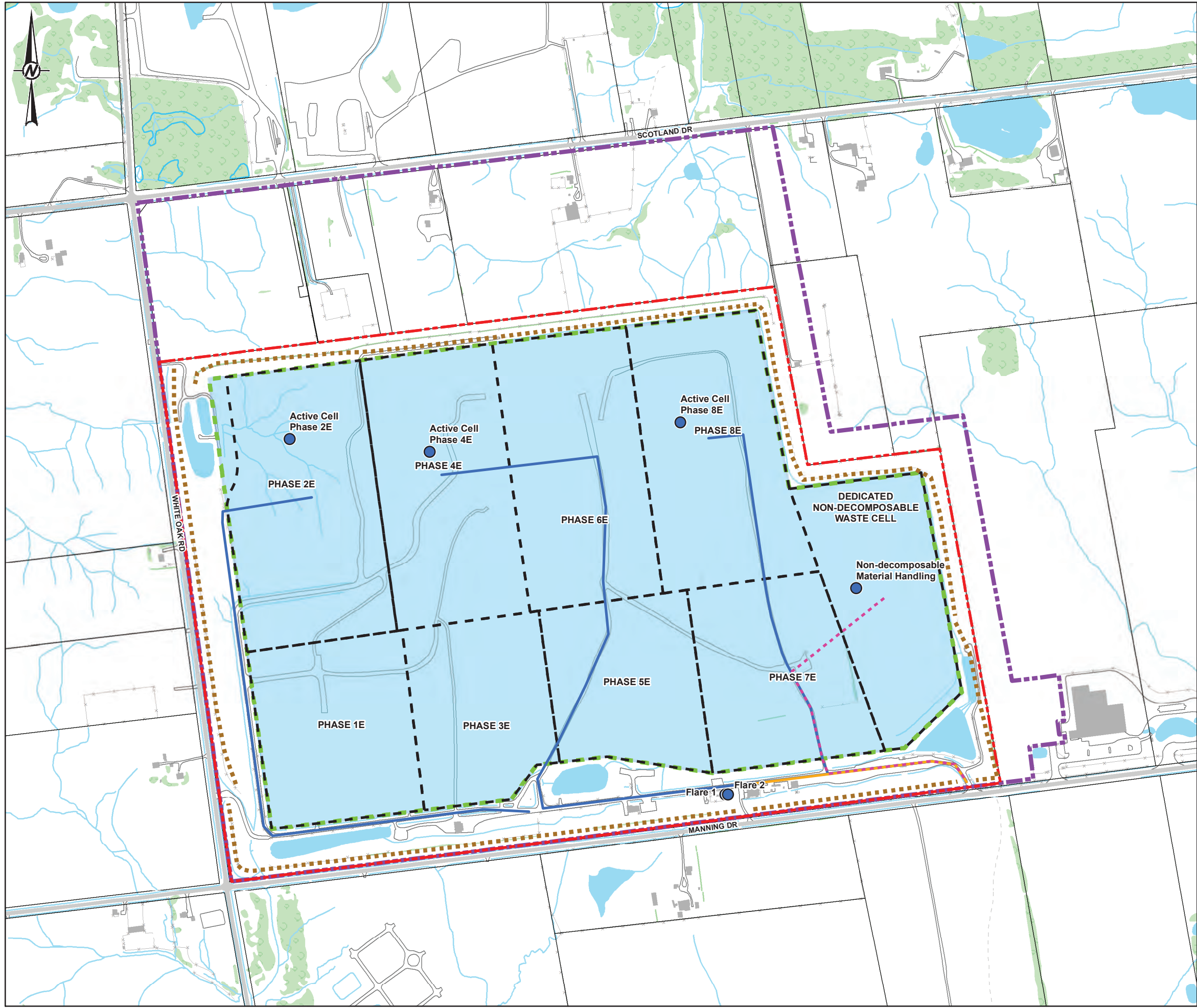
As the project will be conducted in eight phases, consideration was given to identifying the operational phase that results in the “worst case” emissions scenario. Three different phases were considered for this purpose:

- Phase 2E
- Phase 4E
- Phase 8E

These phases were selected as they have the longest on-Site vehicle access routes (i.e., result in largest fugitive dust and vehicle exhaust emissions). The location of Project Emission Sources is illustrated on Figure 6.

For odour, the main sources of emission are the active filling areas. As a result, all eight phases of the site were modelled and the active filling area for each respective phase was placed in the location closest to sensitive receptors, typically close to the site boundary. Emissions from the capped areas of the landfill were also modelled, using the existing landfill footprint. The location of the modelled odour sources is illustrated on Figure 7.

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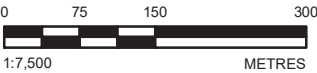
- AIR EMISSION SOURCE
- WATERCOURSE
- DRIVEWAY
- FENCELINE
- TRAIL
- APPROXIMATE BERM LOCATION
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- EXISTING PROPERTY BOUNDARY
- PROPOSED PROPERTY BOUNDARY
- EXISTING APPROVED LIMIT OF WASTE
- PROPOSED LIMIT OF WASTE

ROADWAY TYPE

- DECOMPOSABLE WASTE
- NON-DECOMPOSABLE
- PHASE 2E, 4E, 8E

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

DRAFT



CLIENT CORPORATION OF THE CITY OF LONDON			
PROJECT ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION: AIR QUALITY AND ODOUR			
TITLE SITE LAYOUT AND EMISSION SOURCE LOCATION: EXPANSION			
	CONSULTANT	YYYY-MM-DD	2020-08-19
	DESIGNED	---	---
	PREPARED	JEM	---
	REVIEWED	---	---
	APPROVED	---	---
PROJECT NO. 1648176	PHASE 0020	REV. A	FIGURE 6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 28mm

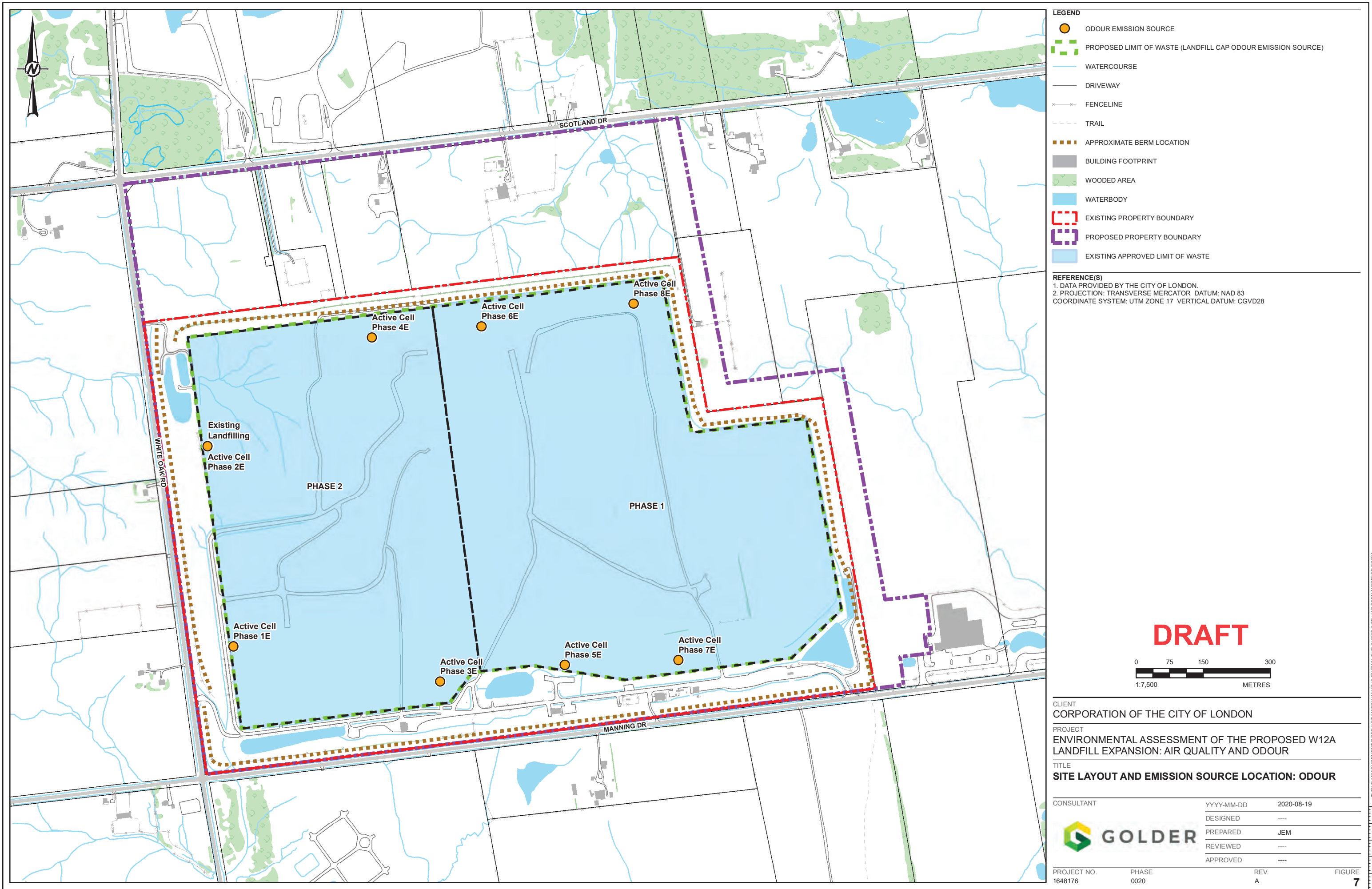


Table 6: Project Emission Sources

Source Information		Significant	Modelled	Rationale
General Location	Source	(Yes or No)?	(Yes or No)?	
Landfill	Landfill cap	Yes	Yes	—
	Landfill operations (material handling & vehicle exhaust)	Yes	Yes	—
Landfill gas collection & control system (LGCCS)	Enclosed LFG flare (existing)	Yes	Yes	—
	Enclosed LFG flare (proposed)	Yes	Yes	—
	Propane combustion equipment	No	No	Propane is used to ignite the pilot flame on the flare. The pilot flame is not ignited at the same time as the flare is operated with LFG, therefore combustion associated with the pilot flame is not included in the model as it does not represent the worst-case scenario.
Paved & unpaved roads	Vehicle exhaust and fugitive road dust	Yes	Yes	—
Storage piles	On-Site storage piles wind erosion	No	No	Emissions from wind erosion for the piles were calculated but are considered to be negligible in comparison to the other activities occurring on-Site.
Non-decomposable Area	Non-decomposable Area	Yes	Yes	—
Public Drop Off Area	Public Drop Off Area	No	No	These activities are considered to be negligible in comparison to the other activities occurring on-Site.
HSW building	HSW building	No	No	These activities are considered to be negligible in comparison to the other activities occurring on-Site.

Source Information		Significant	Modelled	Rationale
General Location	Source	(Yes or No)?	(Yes or No)?	
Leachate collection system	Leachate collection and treatment	No	No	The leachate is treated off-Site and therefore there are no emissions from on-Site leachate treatment. The Facility does have a capacity for below-grade temporary leachate storage, but it is not anticipated more than a few times per year.
Support activities	Emergency power generator(s)	No	No	The emergency power equipment only operates periodically (rather than continuously) and therefore produces emissions that are negligible relative to the overall emissions from the Site.
	Comfort Heating	No	No	These activities are considered to be negligible in comparison to the other activities occurring on-Site.
	Operational support activities, such as maintenance activities & stormwater ponds	No	No	These activities are considered to be negligible in comparison to the other activities occurring on-Site.

5.3 Emission Summary

Table 7 below summarizes the estimated emission rates for each indicator compound from the Project operations as identified in the previous sections. More details and the emissions per source are provided in Appendix B.

Table 7: Summary of Emission Rates from Project During Operation

Compound	Units	Operational Phase		
		Phase 2E	Phase 4E	Phase 8E
SPM	g/s	2.933	5.062	4.106
PM ₁₀	g/s	0.820	1.643	1.242
PM _{2.5}	g/s	0.311	0.411	0.379
NO _x	g/s	1.287	1.286	1.278
SO ₂	g/s	0.188	0.188	0.188
CO	g/s	1.988	1.988	1.985
H ₂ S	g/s	0.015	0.015	0.015
C ₂ H ₃ Cl	g/s	0.001	0.001	0.001
Odour	OU/s	4458.667	4458.667	4458.667

5.4 Dispersion Modelling

Atmospheric dispersion models were used to predict ground-level concentrations of indicator compounds. The models incorporate the emission rates for each scenario and local atmospheric conditions and terrain.

The AERMOD-PRIME (AERMOD) dispersion model (Version 19191) was used to predict ground-level concentrations for the indicator compounds. The AERMOD modelling system was developed by the United States Environmental Protection Agency (U.S. EPA) and has been adopted in Ontario as the regulatory model recommended by the MECP.

The AERMOD system consists of the dispersion model itself and two pre-processors; the AERMET meteorological pre-processor and the AERMAP terrain pre-processor. The following approved dispersion model and pre-processors were used in the assessment:

- AERMOD dispersion model (v.19191)
- AERMAP surface pre-processor (v.18081)

AERMET was not required since MECP provided a 5-year site-specific pre-processed meteorological dataset (2013-2017).

Results were predicted at the sensitive receptors, identified on Figure 2.

Additional details regarding the dispersion modelling inputs and source characterization are provided in Appendix C.

5.5 Effects Prediction

To determine potential effects of the proposed project on air quality and odour, the predicted concentrations of indicator contaminants were compared to the applicable guidelines identified in Section 2.4.

Background air quality conditions (i.e., the concentrations without any landfill activities) are also presented in Table 8, which are added to the predicted concentrations from the Project to provide the cumulative concentration for each indicator compound.

Maximum predicted concentrations for the expansion scenario (that presents the maximum predicted concentration from Phase 2E, 4E or 8E) at the sensitive receptors are presented in Table 8.

The maximum cumulative concentrations of all indicator compounds are below the relevant guidelines for all indicator compounds, with the exception of NO₂ on a 1-hour basis.

For NO₂, the maximum predicted 1-hour NO₂ concentration is greater than the CAAQS of 79 µg/m³; however, comparison to the CAAQS is not appropriate and the maximum predicted 1-hour NO₂ concentrations above the CAAQS standard is not significant because neither the Site Area nor the Site-vicinity Study Area represent an “air zone”, the region over which the CCME states that achievement of the CAAQS is to be evaluated/compared (Section 2.4).

The predicted 1-hr CAAQS for NO₂ can be calculated within the Site-vicinity Study Area using the model output; however, such a comparison is inherently biased by model input assumptions and is not suitable for comparison to monitoring based values such as the CAAQS that use a 3-year averaging period. The NO₂ emissions inventory for the Project are designed to be conservative and represent a ‘worst-case’ scenario. Project emissions assume all combustion sources (including the flare and heavy-duty truck traffic) operate at their peak intensity/load/capacity for each hour for 1-hr simulations. In reality, individual equipment will be idling or off for varying parts of the workday, which cannot be predicted but will result in lower emissions than currently estimated. The likelihood that all equipment operates simultaneously for an hour or more along with unfavourable weather conditions to produce the maximum concentrations modelled is very low. A less conservative but more appropriate comparison to the Ontario AAQC of 400 µg/m³ for 1-hr NO₂ would result in a maximum predicted concentration that is only about 32% of the relevant criteria.

As such, the predicted compound concentrations associated with the expansion are predicted to meet the relevant air quality criteria.

Table 8: Maximum Predicted Concentrations at the Sensitive Receptors for Proposed Project

Indicator	Averaging Period	Air Quality Criteria ($\mu\text{g}/\text{m}^3$)	Background Conditions ⁽¹⁾ ($\mu\text{g}/\text{m}^3$)	Maximum Predicted Concentration - Proposed Landfill Expansion ($\mu\text{g}/\text{m}^3$)	Cumulative Effect - Proposed Landfill Expansion ($\mu\text{g}/\text{m}^3$)	Percentage of Air Quality Criteria (%)
SPM	24-hour	120	45.83	23.26	69.09	57.6%
	Annual	60	26.85	3.11	29.96	49.9%
PM ₁₀	24-hour	50	25.46	9.36	34.82	69.6%
PM _{2.5}	24-hour	27	13.75	1.14	14.89	55.2%
	Annual	8.8	8.06	0.21	8.27	94.0%
NO ₂	1-hour	400/ 79	22.57	103.63	126.20	31.6%/159.8%
	24-hour	200	19.87	29.52	49.39	24.7%
	Annual	32	11.70	2.48	14.18	63.0%
SO ₂	10-min	180	56.19	1.22	57.41	31.9%
	1-hour	100	34.05	0.74	34.79	34.8%
	24-hour	150	32.36	0.17	32.53	21.7%
	Annual	10	9.08	0.01	9.09	90.9%
CO	1-hour	15,000	458.10	406.73	864.83	5.8%
	8-hour	6,000	572.62	72.16	644.78	10.7%
H ₂ S	10-min	13	0.50	0.52	1.36	10.5%
	24-hour	7	0.50	0.07	0.28	4.0%
C ₂ H ₃ Cl	24-hour	1	0.00334	0.006	0.0094	0.9%
C ₂ H ₃ Cl	Annual	0.2	0.00147	0.0011	0.0025	1.3%
Odour ⁽²⁾	10-min	1	—	0.69	0.69	Below 1 OU/m3

Notes:

(1) Existing conditions as described in Section 3.1

(2) Values for odour are in odour units per cubic metre (OU/m³) and presented at the 99.5 percentile

“—” indicates that there is no data available for existing conditions.

5.6 Compliance With Ontario Regulation 419/05

In addition to the assessment of the effects of the Project on ambient air quality and odour, consideration was given to an evaluation of compliance by determining whether an Environmental Compliance Approval (ECA) for air and noise under Section 9 of the Environmental Protection Act could be obtained based on whether the facility is in compliance for those sources regulated under O. Reg. 419/05. At the landfill, this would include landfill gases and materials handling emissions only. All mobile equipment is exempt from compliance requirements under O. Reg. 419/05. In addition, assessment of compliance with O. Reg. 419/05 would not include any consideration of the background air quality. The table below summarizes the estimated emission rates for each indicator compound from the Project operations as identified in the previous sections suitable for assessment against O. Reg. 419/05. More details and the emissions per source are provided in Appendix B.

A modelling grid that satisfies s. 14 O. Reg. 419/05 assessment was used in modelling the indicator compounds. Emissions from tailpipe, bulldozing and road dust were not considered in O. Reg. 419/05 assessment as they can be excluded from modelling as per O. Reg. 524/98 and the ESDM Procedure Document.

Table 9: Summary of O. Reg. 419/05 Emission Rates

Compound	Units	Emission Rates from O. Reg. 419/05 Sources
SPM	g/s	0.307
NO _x	g/s	0.555
SO ₂	g/s	0.188
CO	g/s	0.657
H ₂ S	g/s	0.015
C ₂ H ₃ Cl	g/s	0.001
Odour	OU/s	4458.667

Maximum concentrations at the property boundary and the gridded receptors as per section 14 of O. Reg. 419/05 are presented in Table 10 and were predicted with the AERMOD dispersion model (as described in Section 5.4).

Table 10: Predicted Air Quality Compliance with O. Reg. 419/05

Indicator	Averaging Period	Air Quality Criteria ($\mu\text{g}/\text{m}^3$)	Maximum Predicted POI Concentration ($\mu\text{g}/\text{m}^3$)	Percentage of Air Quality Criteria (%)
SPM	24-hour	120	20.90	17.4%
NO _x	1-hour	400	9.28	2.3%
NO _x	24-hour	200	2.64	1.3%
SO ₂	1-hour	690	3.23	<1%%
SO ₂	24-hour	275	0.93	<1%%
CO	½-hour	6000	13.54	<1%%
H ₂ S	10-min	13	0.5398	4.2%
H ₂ S	24-hour	7	0.0912	1.3%
C ₂ H ₃ Cl	24-hour	1	0.0074	<1%
Odour ⁽¹⁾	10-min	1	0.69	Below 1 OU/m3

Notes: ⁽¹⁾ Values for odour are in odour units per cubic metre (OU/m³) and presented at the 99.5 percentile at sensitive receptors.

The assessment indicates that the proposed facility will be in compliance with Schedule 3 of O. Reg. 419/05.

6.0 CONSIDERATION OF CLIMATE CHANGE

The potential effects of climate change on infrastructure associated with the Project have been included in this report in an effort to qualitatively assess potential climate change effects. Ways that the project could reduce greenhouse gas (GHG) emissions or remove GHGs from the atmosphere have also been considered.

The activities at the Project that will produce GHGs include the following:

- landfill gas
- stationary combustion emissions from the flare(s)
- on-site transportation fuel combustion emissions
- stationary combustion emissions from natural gas used for comfort heating in the buildings

The GHG emission estimates, where applicable, have followed quantification guidelines for both provincial and federal reporting:

- Federal reporting under Section 46 of the *Canadian Environmental Protection Act*, (CEPA), SC 1999: Greenhouse Gas Emissions Reporting Program (GHGRP).
- Provincial reporting under Ontario's Greenhouse Gas Emissions: Quantification, Reporting, and Verification Regulation, Ontario Regulation 390/18 (O. Reg. 390/18).

6.1 Project Greenhouse Gas Emissions

The following table presents the sources of emissions from the Project, the GHGs emitted, and the corresponding methodology used to estimate emissions.

GHG emissions from on-Site transportation have been estimated using emission factors from Tables 2-2 and 2-6 of Canada's ECCC Document "2019 Canada's Greenhouse Gas Quantification Requirements" dated December 2019 (GHGRP Guidance Document) (ECCC, 2019b). Fuel consumption for the on-Site transportation equipment was estimated using methods in the document titled 'Exhaust and Crankcase Emission Factors for Nonroad Engine Modelling – Compression Ignition NR-009d' dated July 2010 (Crankcase Document) (US EPA, 2010). Stationary combustion emissions from natural gas used for comfort heating were estimated using Equation 2-19 and emission factors from Table 2-4 of the GHGRP Guidance Document. Emissions from the fugitive release and combustion of landfill gas are categorized as "Waste Emissions" under the 2019 GHGRP Guidance Document. There is no prescribed method in the 2019 GHGRP Guidance Document for estimating fugitive methane emitted through the landfill cap or emissions from biomass combustion through the flare and therefore GHG emissions from these sources were estimated using engineering calculations. Fugitive methane that is oxidized in the atmosphere once emitted through the cap has not been taken into consideration for this assessment; however, it is commonly assumed that approximately 10% of the methane from landfill gas oxidizes.

The methods used to estimate GHG emissions from each source are summarized in Table 11 below.

Table 11: GHG Emissions Sources and Methods

Source Category	Emission Sources	Emissions Methodology	GHG
Stationary Combustion	<ul style="list-style-type: none"> Natural Gas 	<ul style="list-style-type: none"> 2019 GHGRP Guidance Document s.2.A.2.c Equation 2-9 2019 GHGRP Guidance Document s.2.B Equation 2-13 	<ul style="list-style-type: none"> Carbon Dioxide (CO₂) Methane (CH₄) Nitrous Oxide (N₂O)
On-site Transportation	<ul style="list-style-type: none"> Diesel Gasoline 	<ul style="list-style-type: none"> 2019 GHGRP Guidance Document s.2.A.1 Equation 2-2 Crankcase Document (Fuel Consumption) 2019 GHGRP Guidance Document s.2.B Equation 2-13 	<ul style="list-style-type: none"> CO₂ CH₄ N₂O
Waste (Landfill Gas)	<ul style="list-style-type: none"> Fugitive LFG 	<ul style="list-style-type: none"> Not prescribed in 2019 GHGRP Guidance Document Engineering Estimate (EE) – Carbon Dioxide/Methane composition of LFG and the amount of LFG lost fugitively 	<ul style="list-style-type: none"> CO₂ CH₄
Waste (Landfill Gas Flare)	<ul style="list-style-type: none"> LFG Combustion 	<ul style="list-style-type: none"> Not prescribed in 2019 GHGRP Guidance Document Engineering Estimate (EE) – Methane composition of LFG, Flare destruction efficiency, conversion of methane to carbon dioxide. N₂O estimated from Western Climate Initiative (WCI) method for LFG Flares 	<ul style="list-style-type: none"> CO₂ CH₄ N₂O

Table 12 and Table 13 summarize the estimated annual GHG emission rates in tonnes per year for each activity at the Project for the existing landfill and the proposed expanded landfill, respectively.

Table 12: Summary of Estimated GHG Annual Emissions from the Existing (early 2020) W12A Landfill

Source	Estimated Annual Emissions [tonnes/yr]			Annual Total [tonnes/yr]
	CO ₂	CH ₄	N ₂ O	CO ₂ e
Landfill Gas	12,635	4,584	0	127,245
LFG Flare	20,346	151	0.039	24,141
Mobile Combustion Emissions (road & non-road vehicles)	8,310	0.240	0.697	8,523
Comfort Heating	169	0.003	0.003	170

Note: CO₂e equals carbon dioxide equivalence, which is the summation of multiplying the emissions of CO₂, CH₄, N₂O by their respective global warming potential of 1, 25, and 298, respectively (IPCC, 2012)

The existing annual emissions were estimated to represent the 2020 year.

Table 13: Summary of Estimated GHG Annual Emissions from the Proposed Expansion of the W12A Landfill in Year 2049

Source	Estimated Annual Emissions [tonnes/yr]			Annual Total [tonnes/yr]
	CO ₂	CH ₄	N ₂ O	CO ₂ e
Landfill	8,870	3,219	0	89,337
LFG Flare	49,043	365	0.095	58,191
Mobile Combustion Emissions (road & non-road vehicles)	10,032	0.290	0.840	10,291
Comfort Heating	169	0.003	0.003	170

The peak annual GHG emissions were predicted to occur in 2049.

6.2 Reportable Greenhouse Gas Emissions

The tables below summarize the reportable GHG emissions under the GHGRP and O. Reg. 390/18. Table 14 and Table 15 present the annual GHG emission rates in tonnes per year for each activity at the Project for the existing landfill and the proposed expanded landfill, respectively. Carbon dioxide from the combustion of biomass is excluded from GHGRP per Schedule 3 s.2(b) of the Notice with respect to reporting of greenhouse gases for 2019 and it is not included in the Reporting Amount per s.6(2) of O. Reg. 390/18. Carbon dioxide from the decomposition of biomass is excluded from GHGRP per Schedule 3 s.2(c) of the Notice with respect to reporting of greenhouse gases for 2019 and from O. Reg. 390/18 per ON.191 of the MECP Guideline for QRV of GHG Emissions, Feb 2020.

Table 14: Summary of Reportable Annual GHG Emissions from the Existing (early 2020) W12A Landfill

Source	Estimated Annual Emissions [tonnes/yr]			Annual Total [tonnes/yr]
	CO ₂	CH ₄	N ₂ O	CO ₂ e
Landfill	—	4,584	0	114,610
LFG Flare	—	151	0.039	3,795
Mobile Combustion Emissions (road & non-road vehicles)	8,310	0.240	0.697	8,523
Comfort Heating	169	0.003	0.003	170

The existing annual emissions were estimated to represent the 2020 year.

Table 15: Summary of Reportable Annual GHG Emissions from the Proposed Expansion of the W12A Landfill in Year 2049

Source	Estimated Annual Emissions [tonnes/yr]			Annual Total [tonnes/yr]
	CO ₂	CH ₄	N ₂ O	CO ₂ e
Landfill	—	3,219	0	80,466
LFG Flare	—	365	0.095	9,148
Mobile Combustion Emissions (road & non-road vehicles)	10,032	0.290	0.840	10,291
Comfort Heating	169	0.003	0.003	170

The peak annual GHG emissions were predicted to occur in 2049.

6.3 Comparison to Provincial and Canadian Totals

Table 16 presents a comparison of the W12A Landfill's existing and proposed expansion GHG emissions to the provincial and Canadian totals. As indicated, the increase in emissions from the existing case to the proposed expansion would have a negligible contribution of less than 0.04% to the Ontario emissions and less than 0.01% to the Canadian emissions; therefore, the Project will have a negligible effect on climate change.

Table 16: Comparison of GHG Emissions from the Project to Ontario and Canadian Emission Totals

Source	Existing Emissions [kt/year CO ₂ e]	Expansion Emissions [kt/year CO ₂ e]	Increase in Emissions [kt/year CO ₂ e]
Project GHG Emissions	160	158	-2
Comparison to Ontario Total	0.10%	0.10%	-0.0013%
Comparison to Canada-wide Total	0.02%	0.02%	-0.0003%
Ontario GHG Emissions (2018)	165,000		
Canada-wide GHG Emissions (2018)	729,000		

7.0 BEST MANAGEMENT PRACTICES AND ADDITIONAL MITIGATION

In determining the air emissions associated with the Project works and activities, consideration was given to those mitigation measures that were considered to be integral to the design and implementation of the works and activities. These mitigation measures, which are considered to be typical and consistent with best practices, were incorporated into the emission estimates presented in Section 5.3, and therefore were incorporated in the effects predictions presented in Section 5.5. The in-design mitigation measures that were included in the air quality and odour assessment are summarized in Table 17.

Table 17: Summary of In-Design Mitigation Incorporated into the Air Quality and Odour Assessment

Mitigation Measure	Mitigation Specifics	Works and Activities Affected	Compound Affected by Mitigation Measure	Project Phase where Mitigation is being Considered
Dust suppressant on paved and unpaved roadways	Application of dust suppressant on unpaved roads on a routine basis	<ul style="list-style-type: none"> Vehicle movements related to initial construction, waste placement and cover placement 	<ul style="list-style-type: none"> SPM PM₁₀ PM_{2.5} 	<ul style="list-style-type: none"> Construction Operation
Paved road entrance and access road	Sweep/clean the roads as required to prevent mud track out on vehicles	<ul style="list-style-type: none"> Vehicle movements 	<ul style="list-style-type: none"> SPM PM₁₀ PM_{2.5} 	<ul style="list-style-type: none"> Construction Operation
Maintenance of on-Site vehicles and equipment	On-Site vehicles and equipment engines will meet Tier 3 emission standards and be maintained in good working order	<ul style="list-style-type: none"> On-Site Vehicles 	<ul style="list-style-type: none"> NO₂ CO SO₂ SPM PM₁₀ PM_{2.5} 	<ul style="list-style-type: none"> Construction Operation
Minimize idling of vehicles on-Site	Minimize idling of vehicles on-Site	<ul style="list-style-type: none"> On-Site vehicles 	<ul style="list-style-type: none"> NO₂ CO SO₂ SPM PM₁₀ PM_{2.5} 	<ul style="list-style-type: none"> Construction Operation
Minimize working face/daily cover	Site will operate with approx. 1500 m ² maximum working face, daily cover of waste is required	<ul style="list-style-type: none"> Landfill 	<ul style="list-style-type: none"> H₂S C₂H₃Cl Odour 	<ul style="list-style-type: none"> Operation
Capping of Landfill	Landfill will be capped and LFG collection system installed and put into operations progressively as Phases of landfilling are completed	<ul style="list-style-type: none"> Landfill 	<ul style="list-style-type: none"> H₂S C₂H₃Cl Odour 	<ul style="list-style-type: none"> Operation Post-closure

8.0 MONITORING

The conceptual air quality monitoring activities for the Project are described below. It is recognized that monitoring will be relevant at all stages of the Project (e.g., operation and post-closure). Moreover, it is recognized that monitoring will likely be a condition of environmental approvals and/or permits, and the final details will be confirmed in the ECA(s) for the Project. The follow-up air quality verification program provided in the following sub-sections contains sufficient detail to allow independent judgment to:

- Verify emission rates, to allow a comparison of actual with predicted effects;
- Confirm effectiveness of mitigation measures, and in doing so determine if alternate mitigation strategies are required; and
- Provide information for use in adaptive management to address potential unforeseen effects.

A follow-up air quality program will assist in determining if the environmental effects of the Project are consistent with predictions reported in this assessment. It can also be used to verify that mitigation measures are effective once implemented and determine whether there is a need for additional mitigation measures. A preliminary follow-up air quality program is provided below. The follow-up air quality verification program is designed to be appropriate to the scale of the Project and the potential effects identified through the EA process.

8.1.1 Initial Scope of the Follow-up Air Quality Activities

Table 18 summarizes the conceptual follow-up air quality verification program for the air quality and odour components. The recommendations identify the general timeframe for follow-up (operations or post-closure phase).

Table 18: Proposed Follow-Up Activities for Air Quality and Odour

Component	Project Phase	Objective	Suggested Program Activity
Air Quality (including odour)	Operations Phase	<ul style="list-style-type: none"> To verify the predicted concentrations of SPM, PM₁₀ and PM_{2.5}. To verify that the mitigation measures considered integral to the Project are being incorporated as planned and are effective. 	<ul style="list-style-type: none"> One time only sampling of unpaved and paved road silt loadings to confirm emission estimates. Review and update of existing fugitive dust management plan and complaints response protocol
		<ul style="list-style-type: none"> To verify that the Odour emission rates used in the assessment were reasonable, but conservative To verify the predicted concentrations of Odour To verify that the mitigation measures considered integral to the Project are being incorporated as planned, and are effective 	<ul style="list-style-type: none"> One time landfill gas sampling early in the expansion to determine actual emission rates from the site of indicator compounds Sampling analysis to include odourous compounds, Vinyl Chloride and Hydrogen sulphide Review and update the odour management plan and complaints response protocol

9.0 OTHER APPROVALS

The Project will require an application for an amendment of the ECA for air and noise under Section 9 of the *Environmental Protection Act*. An application for an ECA for air and noise must include a demonstration that a facility can document compliance with O. Reg. 419/05.

The assessment described in Section 5.6 of this report demonstrates that the W12A Landfill is expected to continue to be able to document compliance with O. Reg. 419/05 following the commencement of the Project.

10.0 CONCLUSION

This report evaluated the potential effects of the proposed Project on air quality and odour. The conclusions of the assessment are highlighted below. Emissions estimates and dispersion modelling were carried out to predict concentrations from all emission sources of the indicator compounds. Anticipated measurable air emissions were identified and evaluated to determine effects. The residual effects were evaluated and it is concluded that they do not result in adverse effects in terms of air quality or odour, as they are all below the relevant guidelines with the exception of NO₂. The maximum predicted concentration of NO₂ is greater than the 2025 1-hour CAAQS. However, as described in Section 5.5, the maximum predicted concentration is significantly less than the less conservative, but still applicable Ontario AAQC for 1-hour NO₂.

A follow-up air quality monitoring program is recommended in accordance with Section 8.0, and subject to the ECA for the W12A Landfill, to:

- Verify the emission rates for air quality indicator compounds.
- Verify that the mitigation measures considered integral to the W12A Landfill are being incorporated as planned, and are effective.

Specifically, one-time sampling for road silt loadings, as well as landfill gas sampling are proposed. In addition, the dust and odour management plans and complaints protocol for the site will be updated and included in the ECA amendment application.

An assessment to demonstrate that the Project can achieve compliance with O. Reg. 419/05 was also completed. Air modelling guidance for the Province of Ontario was followed where appropriate. This assessment demonstrates that the Project can be expected to operate in compliance with s. 20 of O. Reg. 419/05.

11.0 IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied, is made.

This report has been prepared for the specific site, design objective, developments and purpose described to Golder by City of London (the City). The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location.

The information, recommendations and opinions expressed in this report are for the sole benefit of the City. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the City, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the City and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The City and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The City acknowledges the electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the City cannot rely upon the electronic media versions of Golder's report or other work products.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the City in the design of the specific project.

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, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report, and to provide amendments as required.

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APPENDIX A

Background Air Quality

DRAFT

APPENDIX A**Background Air Quality***W12A Landfill Expansion EA, City of London, Ontario*

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November 2020

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1.0 INTRODUCTION

This appendix is part of the Air Quality assessment for the proposed expansion of the W12A Landfill by the City of London. This work has been conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR), dated February 2019 and the work plan December 2019 prepared following commencement of the EA and circulated to the Ministry of the Environment, Conservation and Parks (MECP).

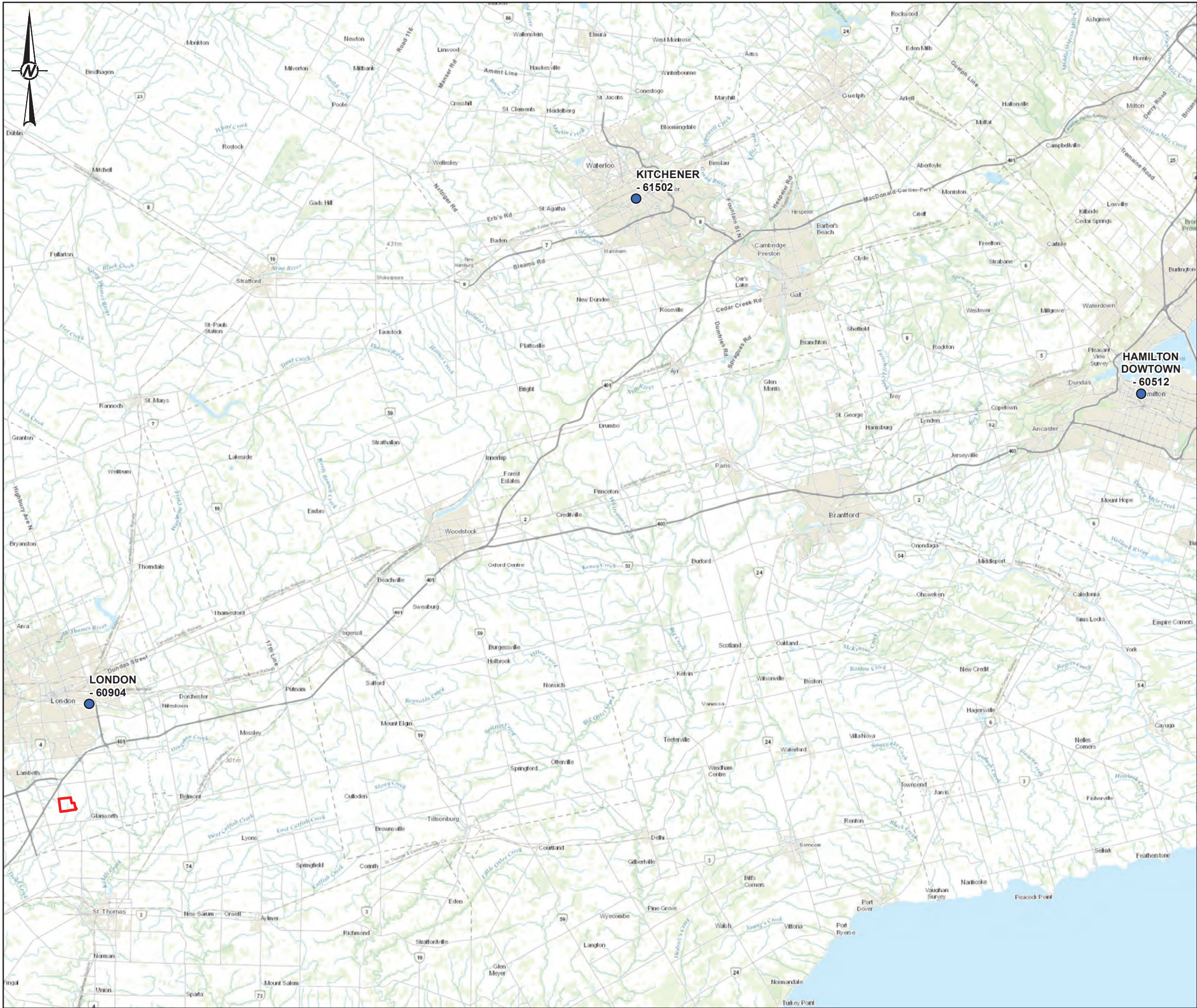
1.1 Purpose

This appendix documents the methods, inputs and assumptions that were used to calculate background air quality concentrations for the Site-vicinity Study Area.

2.0 AIR QUALITY MONITORING DATA

Background air quality was characterised using observations from the Environment and Climate Change Canada (ECCC) National Air Pollution Surveillance Network (NAPS) air quality monitoring stations (ECCC 2019). The closest air quality monitoring station is located at 42 St. Julien Street in London (London Station). Two other NAPS air quality monitoring stations were selected, West Avenue and Homewood in Kitchener (Kitchener Station), and Beasley Park Hamilton Downtown in Hamilton (Hamilton Station).

The Project is located in a rural location; however, it is located adjacent to Highway 401. A wind-rose for the area is provided in Appendix A and indicates that the predominant wind direction is from the southwest. The London Station (NAPS ID 60904) is the closest NAPS station to the Project (approximately 12 km northeast), so it is expected that the Project will experience similar wind patterns and impacts from regional transport of compounds as this station. It is similarly situated near residential areas. All air quality indicator compounds with the exception of CO and SO₂ are monitored at this station.



LEGEND

 AMBIENT AIR MONITORING STATION

 W12A LANDFILL SITE

REFERENCE(S)

1. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

DRAFT

0 3,900 7,800 15,600
1:400,000 METRES

CLIENT
CORPORATION OF THE CITY OF LONDON

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A
LANDFILL EXPANSION: AIR QUALITY AND ODOUR

TITLE
AIR QUALITY MONITORING STATIONS

CONSULTANT	YYYY-MM-DD	2020-08-19
	DESIGNED	---
	PREPARED	JEM
	REVIEWED	---
	APPROVED	---

 **GOLDER**

PROJECT NO. 1648176	PHASE 0020	REV. A	FIGURE A1
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The Kitchener NAPS station (61502) located approximately 87 km away was selected due to Kitchener's similar size, industry, and proximity to Highway 401 as London. All air quality indicator compounds with the exception of CO and SO₂ are monitored at this station. The Hamilton station was selected for the CO and SO₂ data as it was the most representative station that monitors these compounds.

The relative locations of the air quality monitoring stations selected to describe the background air quality are summarized in Table A-1 and presented on Figure A-1.

Table A-1: Location of Air Monitoring Stations

Station	Address	NAPS Station ID	Latitude and Longitude	Distance to the Project (km)	Direction
London	42 St. Julien St.	60904	42.97446, -81.20086	12	North-Northeast
Kitchener	West Avenue and Homewood	61502	43.44383, -80.50381	87	North-Northeast
Hamilton	Elgin & Kelly	60512	43.25778, -79.86167	119	East-Northeast

As shown on the wind rose for London (Figure A-2), the air flow into the London area is predominantly from the southwest.

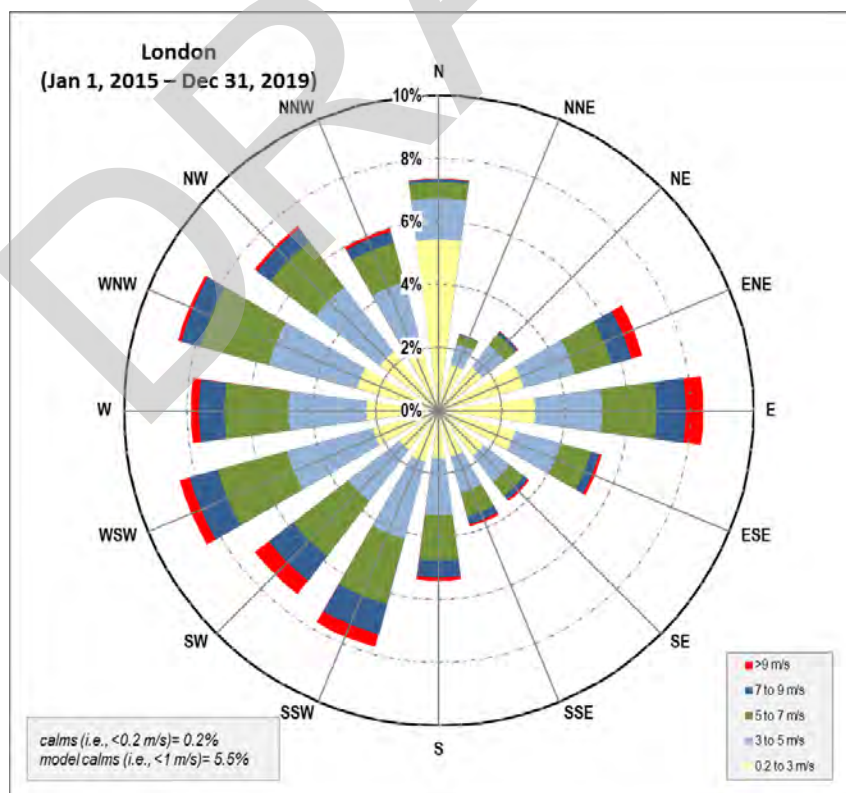


Figure A-2: Five-year Wind Rose for London Ontario

Table A-2 provides a summary of the monitoring data available from the London, Kitchener and Hamilton stations for the period from 2013 through 2017. The London and Kitchener data is used for PM_{2.5}, NO₂, O₃, and Vinyl Chloride while the Hamilton data is used for SO₂ and CO.

There is no monitoring data available for SPM and PM₁₀; however, the background SPM and PM₁₀ concentrations can be estimated from the available PM_{2.5} monitoring results. PM_{2.5} is a subset of PM₁₀, and PM₁₀ is a subset of SPM. Therefore, it is reasonable to assume that the ambient concentrations of SPM will be greater than corresponding PM₁₀ levels, and PM₁₀ concentrations will be greater than the corresponding levels of PM_{2.5}. The mean levels of PM_{2.5} in Canadian locations are found to be about 54% of the PM₁₀ concentrations and about 30% of the TSP concentrations (Lall et al. 2004). By applying this ratio, it is possible to estimate the background SPM and PM₁₀ concentrations for the Site-vicinity Study Area. Hydrogen sulphide is not measured at any of the above three stations, therefore the 1-hour background concentration was taken from the ECCC's draft screening Assessment for H₂S (ECCC, 2017) and converted to the relevant averaging periods using MECP recommended methodologies in the *Air Dispersion Modelling Guideline for Ontario* (MECP, 2017)

Table A-2: Availability of Ambient Air Quality Data

Compound	London Station	Kitchener Station	Hamilton Station
SPM	—	—	—
PM ₁₀	—	—	—
PM _{2.5}	2013-2017	2013-2017	2013-2017
NO ₂	2013-2017	2013-2017	2013-2017
SO ₂	—	—	2013-2017
CO	—	—	2013-2017
O ₃	2013-2017	2013-2017	2013-2017
H ₂ S	—	—	—
C ₂ H ₃ Cl	2014-2017	2013-2017	—

Notes:

"—" indicates that data for the parameter were not available.

Bolded years indicates which station was used for the compound.

2.1 Assessment of Background Air Quality

The continuous monitoring stations listed in Table A-1 were used to reflect the existing conditions in the Site-vicinity Study Area. The existing air quality levels, based on background air concentrations from available monitoring stations, are summarized in the following sections. The available air monitoring data represents the combined effect of emissions from sources near to each of the monitoring stations, as well as the effect of the emissions transported into the region. The emissions transported into the region could be considered to be the 'background air quality', which would be added to dispersion modelling results as part of the impact assessment for the proposed expansion of the W12A Landfill.

Although gaseous monitoring equipment records concentrations in units of parts per million parts (ppm) or parts per billion parts (ppb), regulatory criteria are established on the basis of micrograms per cubic metre ($\mu\text{g}/\text{m}^3$). In this section, monitoring results for gaseous compounds are presented in the units of $\mu\text{g}/\text{m}^3$, to facilitate the comparison of monitoring to criteria. The conversion from ppm to $\mu\text{g}/\text{m}^3$ is unique to each compound, based on the molecular weight of the compound and standard atmospheric conditions (1 atmosphere of pressure and 25°C). In contrast, particulate and metals monitoring equipment records concentrations in units of $\mu\text{g}/\text{m}^3$, allowing for direct comparison to the regulatory criteria.

2.2 Comparison of Monitored Data by Indicator Compound

The 90th percentile of the 1-hour, 8-hour, and 24-hour measurements are typically used to represent the background air quality value when conducting an impact assessment, as this value is exceeded only 10% of the time. The annual average concentration is used for annual background levels (Alberta Environment 2013) and based on the limited measurement data. The average concentration for the shorter time periods provides an indication of what air quality would typically be at the location. The 75th percentile provides an indication of the concentration below which the vast majority of the existing air quality readings occurred. Significant differences between the average and 75th percentile readings provide an indication that the background air quality is dominated by infrequent, but extreme events.

2.2.1 Fine Particulate Matter ($\text{PM}_{2.5}$)

Particulate emissions occur due to anthropogenic activities (such as industrial, transportation, and residential sources) and natural sources. Suspended particulate matter is classified based on its aerodynamic particle size, primarily due to the different health effects that can be associated with particles of different diameters. In Ontario, $\text{PM}_{2.5}$ emissions have been demonstrating a steady decline over time, decreasing by approximately 16% from 2008 to 2017 (MECP 2019).

The 24-hour standard for $\text{PM}_{2.5}$, the Canadian Ambient Air Quality Standard (CAAQS), is calculated as the three year average of the annual 98th percentile of the daily 24-hour average concentrations. The annual CAAQS is based on the annual average concentration averaged over three years of measurements. Table A-3 lists the 24-Hour and Annual $\text{PM}_{2.5}$ ambient monitoring results calculated according to these methodologies.

Table A-3: Summary of 24-Hour and Annual PM_{2.5} Monitoring Results for Comparison to the Canadian Ambient Air Quality Standard

Years	PM _{2.5} Concentration [µg/m³]			
	London		Kitchener	
	24-Hour (CAAQS = 27 µg/m³)	Annual (CAAQS = 8.8 µg/m³)	24-Hour (CAAQS = 27 µg/m³)	Annual (CAAQS = 8.8 µg/m³)
2013–2015	22.01	8.72	23.64	8.91
2014–2016	20.21	8.05	22.53	8.55
2015–2017	17.96	7.47	19.54	7.78

The 24-hour CAAQS has not been exceeded at either station. The Annual CAAQS was exceeded at the Kitchener station over the 2013-2015 period but the measurements for the subsequent three year periods have decreased to below the corresponding CAAQS.

2.2.2 Nitrogen Dioxide (NO₂)

NO_x is emitted in two primary forms: nitric oxide (NO) and nitrogen dioxide (NO₂). NO reacts with ozone in the atmosphere to create NO₂. The primary source of oxides of nitrogen (NO_x) in the region is the combustion of fossil fuels. Emissions of NO_x result from the operation of stationary sources such as incinerators, boilers, and generators, as well as the operation of mobile sources such as vehicles, haul trucks, and other equipment.

The annual mean concentrations of NO₂ in Ontario have decreased by 25% from 2008 to 2017 (MECP 2019). None of the monitored values for NO₂ were above the 1-hour or 24-hour Ontario AAQC for NO₂.

Tables A-4 and A-5 below present the 90th percentile and maximum monitored concentrations compared to the 1-hour and 24-hour AAQC.

Table A-4: Summary of the 90th Percentile and Maximum 1-Hour NO₂ Monitoring Results for Comparison to the Ontario AAQC

Station	NO ₂ 1-hour Criteria [µg/m³]	90 th percentile concentration [µg/m³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m³]	Maximum as a % of the Criteria
London	400	22.57	6%	99.69	25%
Kitchener	400	26.33	7%	114.74	29%

Table A-5: Summary of the 90th Percentile and Maximum 24-Hour NO₂ Monitoring Results for Comparison to the Ontario AAQC

Station	NO ₂ 24-hour Criteria [µg/m ³]	90 th percentile concentration [µg/m ³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m ³]	Maximum as a % of the Criteria
London	200	19.87	10%	57.76	29%
Kitchener	200	22.57	11%	67.09	34%

The 1-hour CAAQS standards for NO₂ are calculated as the 98th percentile of the daily maximum 1-hour concentrations, averaged over three years of measurements. Table A-6 lists the 1-Hour ambient monitoring results calculated according to this methodology.

Table A-6: Summary of 1-Hour NO₂ Monitoring Results for Comparison to the Canadian Ambient Air Quality Standard

Years	1-Hour NO ₂ [µg/m ³] (CAAQS 1-Hour = 79 µg/m ³)	
	London	Kitchener
2013–2015	70.95	80.98
2014–2016	70.76	75.52
2015–2017	64.84	69.42

The 1-hour CAAQS was exceeded at the Kitchener station over the 2013-2015 period but the measurements for the subsequent three year periods have decreased to below the corresponding CAAQS.

2.2.3 Sulphur Dioxide (SO₂)

The primary source of SO₂ in Ontario is the combustion of fossil fuels in the electricity and smelter sectors. Emissions have decreased significantly due to the phase out of coal-fired generating stations in the province.

The annual mean concentrations of SO₂ in Ontario have decreased by 46% from 2008 to 2017 (MECP 2019).

Tables A-7 through A-9 below present the 90th percentile and maximum monitored concentrations compared to the 10-Minute, 1-hour and Annual AAQC. Out of the chosen stations, SO₂ data is only available at the Hamilton station. SO₂ data for the Hamilton Station is collected on a 1-hour basis, therefore the 1-hour data was converted to a 10-minute basis using MECP conversion factors (MECP, 2017).

Table A-7: Summary of the 90th Percentile and Maximum 10-minute SO₂ Monitoring Results for Comparison to the Ontario AAQC

Station	SO ₂ 10-minute Criteria [µg/m ³]	90 th percentile concentration [µg/m ³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m ³]	Maximum as a % of the Criteria
Hamilton Downtown	180	56.19 ^(a)	31%	527.28 ^(a)	293%

Notes:

^(a) 10-minute SO₂ concentrations were converted from the corresponding 1-hour SO₂ monitoring results using MECP conversion factors (MECP, 2017)

Table A-8: Summary of the 90th Percentile and Maximum 1-Hour SO₂ Monitoring Results for Comparison to the Ontario AAQC

Station	SO ₂ 1-hour Criteria [µg/m ³]	90 th percentile concentration [µg/m ³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m ³]	Maximum as a % of the Criteria
Hamilton Downtown	100	34.05	34%	319.56	320%

Table A-9: Summary of the 90th Percentile and Maximum 24-hour SO₂ Monitoring Results for Comparison to the AAQC

Station	SO ₂ 24-hour Criteria [µg/m ³]	90 th percentile concentration [µg/m ³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m ³]	Maximum as a % of the Criteria
Hamilton Downtown	150	32.36	22%	112.41	75%

The monitored 1 hour and 10-minute measured SO₂ concentrations have been periodically above the Ontario AAQC at the Hamilton Station over the 5 year monitoring period but the 90th percentile of all monitoring data is below the corresponding Ontario AAQCs.

2.2.4 Carbon Monoxide (CO)

Carbon Monoxide is a colourless, odourless, tasteless, and, at high concentrations, toxic gas. It is produced primarily from the incomplete combustion of fossil fuels, as well as natural sources, with approximately 71% of emissions arising from the transportation sector in Ontario (MECP 2019).

Tables A-10 and A-11 below present the 90th percentile and maximum monitored concentrations compared to the 1-hour and 8-hour National Ambient Air Quality Standards and Objectives. Out of the chosen stations, CO data is only available at the Hamilton station. No exceedances of the 1-hour or 8-hour National Ambient Air Quality Standards and Objectives criteria for CO were recorded at the station from 2013 to 2018.

Table A-10: Summary of the 90th Percentile and Maximum 1-Hour CO Monitoring Results for Comparison to the National Ambient Air Quality Standards and Objectives

Station	CO 1-hour Criteria [µg/m ³]	90 th percentile concentration [µg/m ³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m ³]	Maximum as a % of the Criteria
Hamilton Downtown	15,000	458.10	3%	3321.20	22%

Table A-11: Summary of the 90th Percentile and Maximum 8-Hour CO Monitoring Results for Comparison to the National Ambient Air Quality Standards and Objectives

Station	CO 8-hour Criteria [µg/m ³]	90 th percentile concentration [µg/m ³]	90 th percentile as a % of the Criteria	Maximum concentration [µg/m ³]	Maximum as a % of the Criteria
Hamilton Downtown	6,000	317.41	5%	1188.19	20%

2.2.5 Ozone (O₃)

Ground-level ozone is formed when NO_x and VOCs react in the presence of sunlight. Monitored ground-level ozone records were well below the Ontario 1-hour AAQC at both the London station and the Kitchener station in 2017. Between 2013 - 2018 the maximum 1-hour concentration of O₃ at the London station reached the Ontario AAQC concentration limit of 160 µg/m³; however, the 90th percentile at the London station was well below the Ontario AAQC. At the Kitchener station, between years 2013-2018, the maximum 1-hour concentration of O₃ and 90th percentile was also below the Ontario AAQC.

Currently there is no 8-hour Ontario AAQC for O₃, but there is a Canadian Ambient Air Quality Standard that has been used for comparison to the data. While the maximum 8-hour concentration of O₃ exceeds the standard at the London and Kitchener stations, compliance with the Canadian Ambient Air Quality Standard is based on the fourth highest 8-hour value annually, averaged over a 3-year period. Table A-12 presents a summary of the three year averaging methodology using 8-hour O₃ ambient monitoring results. The Canadian Ambient Air Quality Standard has been exceeded at both the London and Kitchener stations.

Table A-12: Summary of 3-year average for 4th Highest 8-Hour O₃ Value Monitoring Results for Comparison to the CAAQS

Years	8-Hour Ozone [$\mu\text{g}/\text{m}^3$] (CAAQS = 123.6 $\mu\text{g}/\text{m}^3$)	8-Hour Ozone [$\mu\text{g}/\text{m}^3$] (CAAQS = 123.6 $\mu\text{g}/\text{m}^3$)
	London Downtown	Kitchener Downtown
2013 - 2015	131.98	127.96
2014 - 2016	132.96	130.33
2015 - 2017	132.79	129.28

2.2.6 Vinyl Chloride (C₂H₃Cl)

Vinyl Chloride is a volatile organic compound (VOC) and one of the common constituents in landfill gas (LFG). It is formed in the environment when soil organisms break down chlorinated solvents.

Table A-13 below presents the 90th percentile and maximum monitored concentrations compared to the 24-hour and Vinyl Chloride AAQC. No exceedances of the 24-hour or annual AAQC for Vinyl Chloride were recorded at either station from 2013 to 2018.

Table A-13: Summary of the 90th Percentile and Maximum 24-Hour Vinyl Chloride Monitoring Results for Comparison to the Ontario AAQC

Station	Vinyl Chloride 24-hour Criteria [$\mu\text{g}/\text{m}^3$]	90 th percentile concentration [$\mu\text{g}/\text{m}^3$]	90 th percentile as a % of the Criteria	Maximum concentration [$\mu\text{g}/\text{m}^3$]	Maximum as a % of the Criteria
London	1	0.008	<1%	0.016	1.6%
Kitchener	1	0.010	1%	0.015	1.5%

2.2.7 Hydrogen Sulphide (H₂S)

Hydrogen Sulphide is a major odorous component in landfill gas (LFG). LFG and Hydrogen Sulphide is formed from the biodegradation of the municipal solid waste material within the landfill.

Hydrogen sulphide is not measured at any of the three NAPS stations used for background air quality, therefore the 1-hour background concentration was taken from the ECCC's Draft Screening Assessment for H₂S (ECCC, 2017) and converted to the relevant averaging periods using MECP recommended methodologies (MECP, 2017). Table A-14 below summarises the 10-minute and 24-hour average background concentrations used in the assessment.

Table A-14: Summary of Hydrogen Sulphide Concentrations for Comparison to the Ontario AAQC

Indicator Compound	Averaging Period	AAQC Criteria [$\mu\text{g}/\text{m}^3$]	Background Concentration [$\mu\text{g}/\text{m}^3$]	Percentage of Air Quality Criteria
Hydrogen Sulphide	10-minute	13	0.84	6.5%
	24-Hour	7	0.21	3.0%

2.2.8 Summary of Monitored Data by Station

For the London and Kitchener stations, monitoring data for the years 2013 through 2017 (where available) were summarized by indicator compounds for the averaging period relevant to the AAQC. CO and SO₂ data were summarized for the years 2013 through 2017 from the Hamilton Downtown station. To provide an understanding of the variability of the monitoring data, the average, 75th percentile, 90th percentile, and maximum values are summarized in Tables A-15 to A-17. As discussed in the previous sections, the 90th percentile of the 1-hour, 8-hour, and 24-hour measurements is typically used to represent the background air quality value when conducting an impact assessment and the annual average concentration is used for annual background levels (Alberta Environment 2013). The average concentration for the shorter time periods provides an indication of what air quality would typically be at the location. The 75th percentile provides an indication of the concentration below which the vast majority of the existing air quality readings occurred.

Table A-15: Summary of Background Air Quality at London Station (2013 – 2017)^(a) in $\mu\text{g}/\text{m}^3$

Indicator	Averaging Period	Average	75th	90th	Max
SPM ^(b)	24-Hour	26.82	34.11	45.83	99.44
	Annual	26.85	—	—	30.43
PM ₁₀ ^(b)	24-Hour	14.90	18.95	25.46	55.25
	Annual	8.05	10.23	13.75	29.83
PM _{2.5} ^(a)	24-Hour	8.05	10.23	13.75	29.83
	Annual	8.06	—	—	9.13
NO ₂ ^(a)	1-Hour	11.71	15.05	22.57	99.69
	24-Hour	11.70	13.95	19.87	57.76
	Annual	11.70	—	—	13.06
O ₃ ^(a)	1-Hour	55.23	72.61	88.31	160.92
	8-Hour	74.41	87.33	105.43	151.85
C ₂ H ₃ Cl ^(c)	24-Hour	0.00340	0.00477	0.00853	0.0161
	Annual	0.00340	—	—	0.00406

Notes:

"—" indicates that data for the parameter were not available at that station.

(a) Data measured in parts per billion (ppb) or parts per million (ppm), were converted to $\mu\text{g}/\text{m}^3$ assuming standard temperature and pressure (25°C and one atmosphere of pressure).

(b) Data converted from PM_{2.5}.

(c) Data from years 2014-2017

Table A-16: Summary of Background Air Quality at Kitchener Station (2013 – 2017)^(a) in $\mu\text{g}/\text{m}^3$

Indicator	Averaging Period	Average	75th	90th	Max
SPM ^(b)	24-Hour	27.01	35.00	48.75	124.03
	Annual	26.91	—	—	30.92
PM ₁₀ ^(b)	24-Hour	15.01	19.44	27.08	68.90
PM _{2.5} ^(a)	24-Hour	8.10	10.50	14.63	37.21
	Annual	8.07	—	—	9.28
NO ₂ ^(a)	1-Hour	13.07	16.93	28.21	114.74
	24-Hour	13.06	16.62	24.45	67.09
	Annual	13.07	—	—	14.44
O ₃ ^(a)	1-Hour	54.76	70.65	88.31	174.66
	8-Hour	71.95	86.10	102.29	160.68
C ₂ H ₃ Cl ^(c)	24-Hour	0.00376	0.00511	0.00977	0.0153
	Annual	0.00376	—	—	0.00441

“—” indicates that data for the parameter were not available at that station.

(a) Data measured in parts per billion (ppb) or parts per million (ppm), were converted to $\mu\text{g}/\text{m}^3$ assuming standard temperature and pressure (25°C and one atmosphere of pressure).

(b) Data converted from PM_{2.5}.

(c) Data from years 2014-2017

Table A-17: Summary of Background Air Quality at the Hamilton Downtown Station (2013-2017)^(a) in $\mu\text{g}/\text{m}^3$

Indicator	Averaging Period	Average	70th	90th	Max
SO ₂ ^(a)	10-minute ^(b)	14.98	12.97	56.19	164.23
	1-Hour	9.08	7.86	34.05	319.56
	24-hour	9.08	13.79	32.36	60.90
	Annual	9.08	—	—	13.22
CO ^(a)	1-Hour	244.50	343.57	458.10	3321.20
	8-Hour	317.41	415.15	572.62	1188.19

Notes:

“—” indicates that data for the parameter were not available at that station.

(a) Data measured in parts per billion (ppb) or parts per million (ppm), were converted to $\mu\text{g}/\text{m}^3$ assuming standard temperature and pressure (25°C and one atmosphere of pressure).

(b) Data converted from 1-hour average concentrations using MECP methodologies (MECP, 2017)

2.3 Summary of Background Air Quality

This section presents the existing air quality for the Site-vicinity Study Area to be added as background to the dispersion modelling results as part of the impact assessment for the W12A Landfill expansion. The London station is the closest station to the W12A Landfill (approx. 12 km), so it is expected to experience similar wind patterns and impacts from transport of compounds into the city as the Project location.

Due to proximity to the Site-vicinity Study Area, and the fact the Site-vicinity Study Area is similarly located close to urban areas adjacent to residential areas, the London station is considered to be the most representative station of the Site-vicinity Study Area, and therefore represents the background for indicator compounds monitored at that station. Table A-18 provides the background air quality values.

Table A-18: Background Air Quality Values (90th Percentile, Average for Annual Only)

Indicator	Averaging Period	Background ($\mu\text{g}/\text{m}^3$)
SPM	24-hour	45.83
	Annual	26.85
PM ₁₀	24-hour	25.46
PM _{2.5}	24-hour	13.75
	Annual	8.06
NO ₂	1-Hour	22.57
	24-Hour	19.87
	Annual	11.70
SO ₂	10-minute	56.19
	1-Hour	34.05
	24-hour	32.36
	Annual	9.08
CO	1-Hour	458.10
	8-Hour	572.62
O ₃	1-Hour	88.31
	8-Hour	105.43
H ₂ S	10-minute	0.84
	24-Hour	0.21
C ₂ H ₃ Cl	24-Hour	0.00853
	Annual	0.00340

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APPENDIX B

Emission Calculations

DRAFT

APPENDIX B**Emission Calculations**

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1.0 INTRODUCTION

This appendix is part of the Air Quality Impact Assessment for the proposed expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London, Ontario.

1.1 Purpose

This appendix documents the methods, input parameters and assumptions that were used to estimate the air emission rates for the Project activities at the landfill. The change associated with the proposed Project is an increase of the permitted volume for disposal at the landfill (landfill airspace) through reconfiguration and vertical expansion. Emission rates of indicator compounds for the existing landfill and the proposed landfill were calculated.

The calculated emission rates were used as inputs for dispersion modelling to predict the indicator compound concentrations resulting from the existing and proposed expanded landfill. The emission estimation methods described within this appendix follow generally accepted practices for conducting Environmental Assessments (EAs) and, where appropriate, guidance in the Ministry of the Environment, Conservation and Parks ESDM Procedure Document (MECP 2018).

2.0 ASSESSMENT OF COMPOUNDS AND ACTIVITIES

Emissions were assessed for activities described in the approved Amended Terms of Reference for Environmental Assessment of the Proposed W12A Landfill Expansion, City of London (Golder February 2019), based on process descriptions and equipment/vehicle specifications provided by the City of London and the Golder design team. Scientifically accepted and well documented emission factors, most notably U.S. AP-42 (U.S. EPA 1995), were also used.

Compounds that will be discharged from the landfill in negligible amounts and/or activities that discharge a compound in a negligible amount were excluded from further analysis.

All potential sources of emissions for the proposed project were identified; however, only significant sources (e.g., emissions from the landfill cap) were carried through to the dispersion modelling assessment. Sources with emissions rates that were less than 1% of the site-wide emissions were considered insignificant. Additionally, infrequent operations were also considered insignificant (e.g., testing of standby power generators). Details of the specific emissions calculation methods and resulting emissions are provided in the following sections.

Table B-1 below provides a summary of the activities for which emissions were calculated in the air quality assessment, as well as a summary of the compounds expected to be released.

Table B-1: Significant Activities at the Proposed W12A Landfill Expansion

Source Information		Significant (Yes or No)?	Modelled (Yes or No)?	Rationale
General Location	Source			
Landfill	Landfill cap	Yes	Yes	—
	Landfill operations – main area (material handling & vehicle exhaust)	Yes	Yes	—
	Landfill operations – Non-decomposable Area (material handling & vehicle exhaust)	Yes	Yes	—
Landfill gas collection & control system (LGCCS)	Enclosed LFG flare (existing)	Yes	Yes	—
	Enclosed LFG flare (proposed)	Yes	Yes	—
	Propane combustion equipment	No	No	Propane is used to ignite the pilot flame on the flare. The pilot flame is not ignited at the same time as the flare is operated with LFG, therefore combustion associated with the pilot flame is not included in the model as it does not represent the worst-case scenario.
Paved & unpaved roads	Vehicle exhaust and fugitive road dust	Yes	Yes	—
Storage piles	On-site storage piles wind erosion	No	No	Emissions from wind erosion for the piles were estimated but are considered to be insignificant in comparison to the other activities occurring on-site as they are less than 1% of the site wide emissions. The daily cover material is received daily and applied directly to the active filling area.

Source Information		Significant (Yes or No)?	Modelled (Yes or No)?	Rationale
General Location	Source			
Public Drop Off Area	Public Drop Off Area	No	No	These activities are considered to be insignificant in comparison to the other activities occurring on-site.
HHW building	HHW building	No	No	These activities are considered to be insignificant in comparison to the other activities occurring on-site.
Leachate collection system	Leachate collection and treatment	No	No	The leachate is treated off-site and therefore there are no emissions from on-site leachate treatment. The Project will have capacity for temporary leachate storage, but it is not anticipated more than a few times per year.
Support activities	Emergency power generator(s)	No	No	The emergency power equipment only operates periodically (rather than continuously) and therefore produces infrequent emissions.
	Comfort Heating	No	No	These activities are considered to be negligible in comparison to the other activities occurring on-site. as they are less than 1% of the site wide emissions.
	Operational support activities, such as maintenance activities & stormwater ponds	No	No	These activities are considered to be insignificant in comparison to the other activities occurring on-site.

2.1 Activities Not Included in Assessment

There are many activities associated with the Project that produce emissions; however, not all activities produce emissions for any or all compounds that are relevant to the overall emissions assessment. All activities that potentially produce emissions were evaluated to determine their relevance; however, only activities that were assessed as relevant were included in the assessment. The following rationale describes why certain activities and/or emissions of certain compounds can be excluded from the assessment, as per the MECP ESDM Procedure Document (MECP 2018):

- The emission rates of certain compounds are very small relative to the overall emissions at the proposed W12A landfill expansion; and
- The emissions of certain sources are known to not be relevant due to the type of operations in the assessment (i.e., activities that are carried out by subcontractors).

Table B-2 lists the activities that were not assessed and the accompanying rationale.

Table B-2: Emissions Not Included in the Assessment

Activity/Compound	Rationale for Excluding from the Assessment
Vehicles on-site used by subcontractors (excluding landfill/earth moving equipment)	This activity is known to not be relevant to the type of operations in this assessment.
Construction and post closure phases for landfill expansion	These activities are considered to be insignificant in comparison to the operational phase of the landfill.
Propane combustion equipment	Propane is used to ignite the pilot flame on the flare. The pilot flame is not ignited at the same time as the flare is operated with LFG, therefore combustion associated with the pilot flame is not included in the model as it does not represent the worst-case scenario.
On-site storage piles	Emissions from wind erosion for the piles were estimated but are considered to be insignificant in comparison to the other activities occurring on-site as they are less than 1% of the site wide emissions. The daily cover material is received daily and applied directly to the active filling area.
Leachate collection	The leachate is treated off-site and therefore there are no emissions from on-site leachate treatment. The Project will have capacity for temporary leachate storage but it is not anticipated more than a few times per year.
Emergency power generator	The emergency power equipment only operates periodically (rather than continuously) and therefore produces infrequent emissions.

Activity/Compound	Rationale for Excluding from the Assessment
Operational support activities, such as maintenance activities & stormwater ponds	The leachate is treated off-site and therefore there are no emissions from leachate treatment on-site. These activities are considered to be negligible in comparison to the other activities occurring on-site.
Comfort Heating	These activities are considered to be negligible in comparison to the other activities occurring on-site. as they are less than 1% of the site wide emissions.
Public Drop Off Area	These activities are considered to be insignificant in comparison to the other activities occurring on-site.
HHW building	These activities are considered to be insignificant in comparison to the other activities occurring on-site.

3.0 DATA SOURCES AND ASSUMPTIONS

Table B-3 to B-4, below, document the assumptions made as part of the estimation of emission rates for Current Operations (Table B-3) and Proposed Expansion Operations (Tables B-4)

Table B-3: Data Sources and Assumptions – Current Conditions

Activity	Parameter	Value	Unit	Notes
Landfill Operations	Landfill area	1,070,000	m ²	Terms of Reference for the Environmental Assessment
	LFG Emissions	3.70x10 ⁷	m ³ /yr	Calculated using the LandGEM model.
	LFG Emissions	4229 (2489)	m ³ /hr (CFM)	
	Collection efficiency	62	%	Estimated to the total LFG LandGEM model for 2020
	Odour concentration	10,000	OU/m ³	Upper range estimate of odour concentration from the MECP's Interim Guide to Estimate and Assess Landfill Air Impacts
	Surface area of daily tipping face	1,500	m ²	Estimate provided by the City of London
	Average daily waste receipt	1,667	Mg/day	Conservatively estimated to 500,000 tonnes/year (approximately 50% more than current average daily rate)
	Depth of daily cover applied	0.15	m	Estimate provided by the City of London
	Density of daily cover	0.80	m	Estimated based on similar landfills

Activity	Parameter	Value	Unit	Notes
	Moisture content of waste	11	%	Misc. fill materials, US EPA AP-42 Section 13.2.4
	Moisture content of daily cover	12	%	Cover, US EPA AP-42 Section 13.2.4
Flare	LFG flow rate to flare	2633 (1550)	m ³ /hr (CFM)	Estimate provided by the City of London
	Methane in landfill gas	50	%	LandGEM
	Operating period	365	days/yr	Number of days in a year
	Inner diameter	2.7	m	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare height above grade	12.2	m	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare exit temperature	871	°C	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare exit flow rate	47	m ³ /s	Information from Comcor
Paved Roads	Average vehicle height	2.98	m	Estimated based on similar landfills
	Average lane width	3.75	m	Estimated based on similar landfills
	Silt loading	7.4	g/m ²	US EPA AP-42 Section 13.2.1, mean silt loading for MSW landfills
	Dust suppressant control efficiency	85	%	Estimated based on dust suppression activities (WGA, 2006)
Unpaved Roads	Average vehicle height	3.5	m	Height of waste hauling trucks
	Average lane width	3.8	m	Estimated based on similar landfills
	Vehicle weights	Various	tonnes	Provided by City of London
	Silt Content	6.4	%	US EPA AP-42 Section 13.2.2, mean silt loading for MSW landfills
	Dust suppressant control efficiency	85	%	Estimated based on dust suppression activities

Table B-4: Data Sources and Assumptions – Expansion

Activity	Parameter	Value	Unit	Notes
Landfill Operations	Landfill area	1,070,000	m ²	Terms of Reference for the Environmental Assessment
	LFG Emissions	6.54E+07	m ³ /yr	Calculated using the LandGEM model
	Collection efficiency	85	%	MECP recommendation
	Odour concentration	10,000	OU/m ³	Upper range estimate of odour concentration from the MECP's Interim Guide to Estimate and Assess Landfill Air Impacts
	Surface area of daily tipping face	1,500	m ²	Estimate provided by the City of London
	Average daily waste receipt	1,667	Mg/day	Conservatively estimated to 500,000 tonnes/year (approximately 50% than current average daily rate)
	Depth of daily cover applied	0.15	m	Estimate provided by the City of London
	Density of daily cover	0.80	m	Estimated based on similar landfills
	Moisture content of waste	11	%	Misc. fill materials, US EPA AP-42 Section 13.2.4
	Moisture content of daily cover	12	%	Cover, US EPA AP-42 Section 13.2.4
Flare 1	LFG flow rate to flare	3744 (2204)	m ³ /hr (CFM)	LandGEM
	Methane in landfill gas	50	%	LandGEM
	Operating period	365	days/yr	Number of days in a year
	Inner diameter	2.7	m	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare height above grade	12.2	m	Amended Certificate of Approval Air - No. 4183-78XHLX

Activity	Parameter	Value	Unit	Notes
	Flare exit temperature	871	°C	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare exit flow rate	47	m ³ /s	Information from Comcor
Flare 2	LFG flow rate to flare	2592(1526)	m ³ /hr (CFM)	LandGEM
	Methane in landfill gas	50	%	LandGEM
	Operating period	365	days/yr	Number of days in a year
	Inner diameter	2.7	m	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare height above grade	12.2	m	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare exit temperature	871	°C	Amended Certificate of Approval Air - No. 4183-78XHLX
	Flare exit flow rate	33	m ³ /s	Information from Comcor
Paved Roads	Average vehicle height	2.98	m	Estimated based on similar landfills
	Average lane width	3.75	m	Estimated based on similar landfills
	Silt loading	7.4	g/m ²	US EPA AP-42 Section 13.2.1, mean silt loading for MSW landfills
	Dust suppressant control efficiency	85	%	Estimated based on dust suppression activities (WGA, 2006)
Unpaved Roads	Average vehicle height	3.5	m	Height of waste hauling trucks
	Average lane width	3.8	m	Estimated based on similar landfills
	Vehicle weights	Various	tonnes	Provided by City of London
	Silt Content	6.4	%	US EPA AP-42 Section 13.2.2, mean silt loading for MSW landfills
	Dust suppressant control efficiency	85	%	Estimated based on dust suppression activities

4.0 EMISSION CALCULATION METHODOLOGIES

The following sections detail the emission calculation methodology for each source included in the assessment. The emission rates are all in units of grams (g) per second (g/s), with the exception of odour that is in odour units (OU) per second (OU/s), which is required for the dispersion models. The dispersion model assumes the emission rate is constant over an hourly period, which is the smallest time-step within the models used for predictions.

4.1 Landfill Cap

LFG not collected and distributed to the flare may result in fugitive LFG emissions through the landfill cap. LFG constituents and their estimated respective concentrations in the LFG were obtained from the U.S. EPA AP 42 Chapter 2.4 (US. EPA, 2008). Average fugitive LFG emissions per year were estimated using results from the LandGEM model and an 85% capture efficiency by the LGCCS.

The following is a sample calculation for the emission rate of vinyl chloride from the landfill cap for the proposed expansion conditions:

$$ER = \text{conc.} \frac{\mu\text{g}}{\text{m}^3} \times \text{LGF} \frac{\text{m}^3}{\text{yr}} \times \frac{1 \text{ yr}}{365 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hrs}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1 \text{ g}}{1,000,000 \mu\text{g}} \times (1 - \text{collection efficiency (\%)})$$

Where:

ER = emission rate (m³/s),

conc. = concentration of the contaminant in the landfill gas (g/m³) obtained from US EPA AP 42 Chapter 2.4 (draft, October 2008),

LFG = average landfill gas emissions per yr. (m³/yr.) (obtained from LandGEM), and
collection efficiency = efficiency of landfill gas collection system (85%)

$$ER = 3627 \frac{\mu\text{g}}{\text{m}^3} \times 65,419,680 \frac{\text{m}^3}{\text{yr}} \times \frac{1 \text{ yr}}{365 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hrs}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1 \text{ g}}{1,000,000 \mu\text{g}} \times (1 - 85\%)$$

$$ER = 0.00113 \frac{\text{g}}{\text{s}}$$

Emissions of the remaining indicator compounds were calculated in the same manner presented above.

The odour emissions from the landfill cap were also calculated in the same manner but using an odour emission concentration of 10,000 OU/m³ (MECP, 1992).

The following is a sample calculation for the emission rate of odour from the landfill cap for the proposed expansion conditions:

$$ER = \text{conc.} \frac{\text{OU}}{\text{m}^3} \times \text{LGF} \frac{\text{m}^3}{\text{yr}} \times \frac{1 \text{ year}}{365 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hrs}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times (1 - \text{collection efficiency (\%)})$$

Where:

ER = emission rate (m³/s),

OU = Odour Units

conc. = concentration of the odour in the landfill gas (OU/m³) (MECP, 1992).

LFG = average landfill gas emissions per yr. (m³/yr.) (obtained from LandGEM), and
collection efficiency = efficiency of landfill gas collection system (85%)

$$ER = 10000 \frac{\text{OU}}{\text{m}^3} \times 65,419,680 \frac{\text{m}^3}{\text{yr}} \times \frac{1 \text{ yr}}{365 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hrs}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1 \text{ g}}{1,000,000 \text{ } \mu\text{g}} \times (1 - 85\%)$$

$$ER = 3110 \frac{\text{OU}}{\text{s}}$$

4.2 Material Transfer at the Active Area

U.S. EPA AP-42 emission factors were used to calculate the fugitive dust emissions associated with material transfer activities that will occur at the landfill active area, including depositing of waste and application of daily cover (US EPA 2006 and 1998). Odour emissions were estimated based on the working face of other representative landfills in Ontario (City of London, 2018)

The following predictive emissions equation was used in determining the emission factors for material handling:

Fugitive from depositing of waste:

$$EF = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

EF = particulate emission factor (kg/Mg),

k = particle size multiplier for particle size range (see Table B-5),

U = mean wind speed (m/s), and

M = moisture content of material (percent) (%).

Table B-5: Particle Size Assumptions Material Transfer (US EPA, 2006)

Size Range	k
PM _{2.5}	0.053
PM ₁₀	0.35
SPM	0.74

The following is a sample calculation for the SPM emission factor for the depositing of waste in the active area. A mean wind speed of 4.14 m/s was obtained from the pre-processed meteorological data (2013-2018) used in the modelling assessment, along with a moisture content of 12% for municipal solid waste landfill cover soil

$$EF = 0.74 \times 0.0016 \times \frac{\left(\frac{4.14 \text{ m/s}}{2.2}\right)^{1.3}}{\left(\frac{12}{2}\right)^{1.4}}$$

$$EF = 0.000247 \text{ kg/Mg}$$

The following is a sample calculation for the SPM emission rate per drop for a handling rate of 1667 Mg/day.

$$ER = EF \frac{\text{kg}}{\text{Mg}} \times \text{Operation Max Capacity} \frac{\text{Mg}}{\text{day}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ day}}{\text{hours of operations}}$$

$$ER = \frac{0.000247 \text{ kg}}{\text{Mg}} \times \frac{1667 \text{ Mg}}{\text{day}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ day}}{12 \text{ hr}}$$

$$ER = 0.00954 \text{ g/s}$$

The emission rates of PM₁₀ and PM_{2.5} were calculated in the same manner as above.

Fugitive Dust from Material Movement (Bulldozing):

SPM

$$EF = \frac{2.6(s)^{1.2}}{(M)^{1.3}}$$

SPM ≤ 10 μm

$$EF = \frac{0.45(s)^{1.5}}{(M)^{1.4}} \times 0.75$$

SPM ≤ 2.5 μm

$$EF = \frac{2.6(s)^{1.2}}{(M)^{1.3}} \times 0.105$$

Where:

EF = particulate emission factor (kg/hr),

s = material silt content (%), and

M = moisture content of material (%).

Table B-6: Assumptions Material Movement (Bulldozing)

Parameter	Value	Reference
Moisture Content (M)	12	US EPA, 2006 – municipal solid waste landfill cover
Silt Content (s)	9	US EPA, 2006– municipal solid waste landfill cover

$$EF(\text{SPM}) = \frac{2.6 (9)^{1.2}}{(12)^{1.3}}$$

$$EF = 1.44 \text{ kg/hr}$$

The following is a sample calculation for the SPM emission rate for material movement.

$$ER = EF \frac{\text{kg}}{\text{hr}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{12 \text{ hours of operations}}{24 \text{ hours}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$ER = 1.44 \frac{\text{kg}}{\text{hr}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{12 \text{ hours of operations}}{24 \text{ hours}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$ER = 0.199 \text{ g/s}$$

The emission rates of PM₁₀ and PM_{2.5} were calculated in the same manner as above with the exception of using the specific particle size emission factor equation.

The odour from the material handling operations was determined based on an odour emission rate of 0.898 OU/m²/s based on the working face of other representative landfills in Ontario (City of London, 2018). This emission rate was multiplied by the size of the active area, which was estimated to be 1500 m² (City of London, 2018) The resulting emission rate for odour is 1,347 OU/s.

The following is a sample calculation for the emission rate of odour from the working face for the proposed expansion conditions:

$$ER = \text{conc.} \frac{\text{OU}}{\text{m}^2/\text{s}} \times \text{Area } \text{m}^2$$

Where:

ER = emission rate (m^3/s),

OU = Odour Units

conc. = concentration of the odour in the landfill gas ($\text{OU}/\text{m}^2/\text{s}$) working face of other representative landfills in Ontario

Area = Surface area of daily working face (m^2)

$$ER = 0.898 \frac{\text{OU}}{\text{m}^2/\text{s}} \times 1500 \text{ m}^2$$

$$ER = 1347 \text{ OU/s}$$

4.3 Material Handling – Non-Decomposable Waste

The fugitive dust emissions associated with the activity of depositing non-decomposable waste material into a specific area other than the tipping face were calculated using published emission factors. The operation of depositing non-decomposable waste material in a specific area does not occur in the current existing landfill operations but will occur in the expansion phases.

Fugitive dust emissions from non-decomposable waste activities were calculated with the same method as presented in Section 4.1 of this appendix and AP-42 emission factors (US EPA 2006 and 1998) were used to calculate the fugitive dust emissions. The following predictive emissions equation was used in determining the emission factors for material handling:

Fugitive dust from depositing of waste:

$$EF = k \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

EF = particulate emission factor (kg/Mg),

k = particle size multiplier for particle size range,

U = mean wind speed (m/s), and

M = moisture content of material (percent) (%).

Table B-7: Particle Size Assumptions Material Transfer (US EPA, 2006)

Size Range	k
PM _{2.5}	0.053
PM ₁₀	0.35
SPM	0.74

The following is a sample calculation for the SPM emission factor for the depositing of waste in the proposed non-decomposable area. A mean wind speed of 4.14 m/s was obtained from the meteorological data used in the dispersion modelling. A moisture content of 7.4% for non-decomposable waste was used (US EPA, 2006)

$$EF = 0.74 \times 0.0016 \times \frac{\left(\frac{4.14 \text{ m/s}}{2.2}\right)^{1.3}}{\left(\frac{7.4}{2}\right)^{1.4}}$$

$$EF = 0.000431 \text{ kg/Mg}$$

The following is a sample calculation for the SPM emission rate per drop for a handling rate of 150 Mg/hr.

$$ER = EF \frac{\text{kg}}{\text{Mg}} \times \text{Material Handled per day} \frac{\text{Mg}}{\text{day}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ day}}{\text{hours of operations}}$$

$$ER = \frac{0.000431 \text{ kg}}{\text{Mg}} \times \frac{150 \text{ Mg}}{\text{day}} \times \frac{1 \text{ hr}}{3,600 \text{ s}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{1 \text{ day}}{12 \text{ hr}}$$

$$ER = 0.00150 \text{ g/s}$$

The emission rates of PM₁₀ and PM_{2.5} were calculated in the same manner as above.

Fugitive Dust from Material Movement (Bulldozing):

$$\begin{array}{lll}
 \text{SPM} & \text{SPM} \leq 10 \mu\text{m} & \text{SPM} \leq 2.5 \mu\text{m} \\
 EF = \frac{2.6(s)^{1.2}}{(M)^{1.3}} & EF = \frac{0.45(s)^{1.5}}{(M)^{1.4}} \times 0.75 & EF = \frac{2.6(s)^{1.2}}{(M)^{1.3}} \times 0.105
 \end{array}$$

Where:

EF = particulate emission factor (kg/hr),

s = material silt content (%), and

M = moisture content of material (%).

Table B-8: Assumptions Material Movement (Bulldozing)

Parameter	Value	Reference
Moisture Content (M)	7.4	US EPA 2006 municipal solid waste landfill - Sand
Silt Content (s)	2.6	US EPA 2006 municipal solid waste landfill - Sand

$$EF(\text{SPM}) = \frac{2.6 (2.6)^{1.2}}{(7.4)^{1.3}}$$

$$EF = 0.61 \text{ kg/hr}$$

The following is a sample calculation for the SPM emission rate for the non-decomposable waste material movement.

$$ER = EF \frac{\text{kg}}{\text{hr}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{12 \text{ hours of operations}}{24 \text{ hours}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$ER = 0.61 \frac{\text{kg}}{\text{hr}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \times \frac{12 \text{ hours of operations}}{24 \text{ hours}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$ER = 0.0843 \text{ g/s}$$

The emission rates of PM₁₀ and PM_{2.5} were calculated in the same manner as above with the exception of using the specific particle size emission factor equation.

4.4 Enclosed Flare

The LGCCS was estimated to collect 85% of the LFG produced by the landfill, with the remaining fugitively emitted through the cap. For the existing scenario, the gas collected is combusted using an enclosed flare. Based on an 85% collection efficiency and the outputs from LandGEM, there is approximately 50% methane in the LFG and the flow rate of LFG to the existing flare is 0.99 m³/s. The estimated concentrations of indicator compounds in the LFG were obtained from the U.S. EPA AP 42 Chapter 2.4 (Table 2.4-1) (Draft, October 2008).

The following is a sample calculation for the emission rate of vinyl chloride from the existing flare (Flare 1) for the existing scenario:

$$ER = \text{Landfill Gas flow rate} \frac{\text{m}^3}{\text{s}} \times \text{conc.} \frac{\mu\text{g}}{\text{m}^3} \times \frac{1 \text{ g}}{1,000,000 \mu\text{g}} \times (1 - \text{destruction efficiency (\%)})$$

Where:

ER = emission rate (g/s),

Landfill Gas Flow rate = flow rate of landfill gas to the flare (m³/s),

conc. = concentration of the indicator compound in the landfill gas (μg/m³)

destruction efficiency = amount of the indicator compound that is destroyed during combustion (%) Estimated to be 98% (US EPA, 2008)

$$ER_{\text{vinyl chloride}} = 0.99 \frac{\text{m}^3}{\text{s}} \times 3627 \frac{\mu\text{g}}{\text{m}^3} \times \frac{1 \text{ g}}{1,000,000 \mu\text{g}} \times (1 - 98 \%)$$

$$ER_{\text{vinyl chloride}} = 0.0000531 \frac{\text{g}}{\text{s}}$$

The emission rate for sulphur dioxide was estimated based on the concentration of compounds containing sulphur (based on the draft US EPA AP 42 Chapter 2.4) multiplied by the number of moles of sulphur in each compound. The following is a sample calculation for the emission rate of reduced sulphur from the Existing Flare (Flare 1) during the existing scenario.

$$ER = \text{conc. of sulphur in the LFG} \frac{\text{m}^3 \text{ S}}{\text{m}^3 \text{ LFG}} \times \text{flow rate} \frac{\text{m}^3 \text{ LFG}}{\text{sec}} \times \frac{1 \text{ mol. K}}{8.3145 \text{ m}^3 \text{ S. PA}} \times \frac{101325 \text{ Pa}}{298.15 \text{ K}} \\ \times \frac{32.1 \text{ gS}}{\text{mol}}$$

$$ER = 40.66 \frac{\text{m}^3 \text{ S}}{1,000,000 \text{ m}^3 \text{ LFG}} \times 0.73 \frac{\text{m}^3 \text{ LFG}}{\text{sec}} \times \frac{1 \text{ mol. K}}{8.3145 \text{ m}^3 \text{ S. PA}} \times \frac{101325 \text{ Pa}}{298.15 \text{ K}} \times \frac{32.1 \text{ g}_s}{\text{mol}}$$

$$ER = 0.039 \frac{\text{g}}{\text{s}}$$

The sulphur dioxide emission rate from the flare was calculated as follows¹:

$$ER = \text{reduced sulphur compounds emission rate} \times \frac{MW_{SO_2}}{MW_S}$$

$$ER = 0.039 \frac{g_s}{s} \times \frac{64.0}{32.1}$$

$$ER = 0.08 \frac{g}{s}$$

Where:

ER = emission rate (g/s)

MW = Molar weight

The following is a sample calculation for the emission rate of combustion by-products (in this case nitrogen oxides) from the flare:

$$ER = \text{flow rate (dscm)} \times \text{percent of methane in LFG(\%)} \times \text{NOx emission factor} \times \text{conversion factors}$$

$$ER = 0.73 \frac{m^3}{s} \times 50\% \text{ CH}_4 \times \frac{631 \text{ kg}}{1,000,000 \text{ dscm of CH}_4} \times 1000 \frac{g}{kg}$$

$$ER = 0.231 \frac{g}{s}$$

4.5 Non-Road Vehicles – Exhaust Emissions

Emission Rates for tailpipe emissions from non-road equipment were calculated using emission factors (US EPA, 2018). Load factors for the non-road equipment were estimated for each piece of equipment based on assumptions for similar equipment. (US EPA, 2002)

Table B-9: Non-Road Equipment

Equipment	Horsepower	# of units
Active Area		
Compactor - Caterpillar 836K	555	1
Compactor - Bomag BC772R10-4	450	1
Crawler Dozer - Caterpillar D8T	310	1
Crawler Dozer - Caterpillar D6R WDA LGP	175	1
Tracked Excavator - Caterpillar 336D	260	1
Rock Truck - Caterpillar 730	365	1
Front End Loader -	178	1

¹ S= sulphur

The following predictive emissions equation was used to determine the combustion emission rates for SPM, CO, and NO_x for the on-site vehicles:

$$ER = EF \times \text{engine horsepower rating} \times \text{load factor} \times \frac{1 \text{ hr}}{3,600 \text{ s}}$$

Where:

ER = emission rate (g/s), and

EF = emission factor (g/hp-hr).

Load factor = utilization factor for the equipment

The following is a sample calculation for the NO_x emissions for the Caterpillar 836K Compactor located at the active area:

$$ER = \frac{0.30 \text{ g}}{\text{hp} - \text{hr}} \times 555 \text{ hp} \times 0.43 \times \frac{1 \text{ hr}}{3,600 \text{ s}}$$

$$ER = 0.0199 \frac{\text{g}}{\text{s}}$$

The emission rates for PM₁₀ and PM_{2.5} were calculated by multiplying SPM emission rate by estimated particle size fraction (US EPA, 1990). The following is a sample calculation for PM₁₀ emissions for Caterpillar 836K Compactor:

$$ER \text{ for SPM} = 0.000663 \frac{\text{g}}{\text{s}}$$

$$ER \text{ for PM}_{10} = 0.000663 \frac{\text{g}}{\text{s}} \times 0.96$$

$$ER \text{ for PM}_{10} = 0.000636 \frac{\text{g}}{\text{s}}$$

The following emissions equation was used to determine the combustion emission factor for SO₂ in grams per horsepower hour (US EPA, 2018):

$$SO_2 = (\text{BSFC} \times 453.6 \times (1 - \text{SO}_{\text{xcnv}}) - \text{HC}) \times 0.01 \times \text{SO}_{\text{xdsl}} \times 2$$

Where:

SO₂ is in g/hp-hr

BSFC = is the in-use adjusted fuel consumption in the lb/hp-hr

453.6 = conversion factor from weight percent to weight fraction

SO_{xcnv} = fraction of fuel sulfur converted to direct PM

HC = the in-use adjusted hydrocarbon emissions in g/hp-hr

0.01 = the conversion factor from weight percent to weight fraction

SO_{xdsl} = the episodic weight percent to weight fraction

2 = the grams of SO₂ formed from a gram of sulfur

The following is a sample calculation for the SO_2 emissions factor for the Caterpillar 836K Compactor located at the active area:

$$SO_2 = \left(0.367 \frac{lb}{hp-hr} \times 453.6 \times (1 - 0.02247) - 0.0080 \right) \times 0.01 \times 0.0015\% \times 2$$

$$\text{Emission Factor for } SO_2 = 0.0000488 \frac{g}{hp-hr}$$

Emission rate sample calculation for SO_2 :

$$ER = \frac{0.0000488 g}{hp-hr} \times 555 hp \times 0.43 \times \frac{1 hr}{3,600 s}$$

$$ER = 3.23 \times 10^{-6} \frac{g}{s}$$

Emission rates for non-road vehicles were calculated for each of the active areas where non-road equipment operate. The emission rates from each of the vehicles was summed to give the total emission rate for each contaminant in the active area.

4.6 On-Road Vehicles – Exhaust Emissions

Emission factors for the on-site vehicle exhaust for on-road vehicles were obtained using the U.S. EPA MOVES 2014a emission model.

For roads located on the W12A landfill property, the location, type and length of the road segments was provided by the City of London and is summarized in Table B-10.

Table B-10: W12A Landfill Road Segment Summary

Segment ID	Phase	Road Type	Lanes	Length [m]
B-R1	Current	Paved	2	1577
B-R2	Current	Unpaved	2	155
2-R1	Phase 2	Paved	2	2018
2-R2	Phase 2	Unpaved	2	173
4-R1	Phase 4	Paved	2	847
4-R2	Phase 4	Unpaved	2	1023
8-R1	Phase 8	Paved	2	287
8-R2	Phase 8	Unpaved	2	752
ND-R1	All	Paved	2	288
ND-R2	All	Unpaved	2	442
HHW	All	Paved	2	461

Type, description, and volume of on-road vehicles travelling on the W12A Landfill road segments was provided by the City of London and is summarized in Table B-11:

Table B-11: W12A Landfill On-road Vehicles – Type and Volume of Vehicles

Vehicle Type Description	Average Vehicle Weight (tonnes)	Average Trips per day	Average Trips per hour	Current Maximum Trips per Hour ^(a)	Proposed Maximum Trips per Hour ^(b)
Short Haul Truck	16.23	4.47	0.32	0.56	0.74
Truck Tandem (Triaxle, Dump)	16.23	166.67	11.91	20.71	27.62
Passenger Vehicle (Car or Minivan or pick-up truck)	2.32	74.82	5.34	9.30	12.40

Notes:

^(a) Based on current receipts

^(b) Based on forecasted data

The emission factors developed for the on-road vehicles operated at the facility are provided in the Tables below:

Table B-12: Emission Factors for Waste Trucks Calculated Using MOVES Model

Compound	Emission Factor (g/VKT) ^(a)
SPM	0.0122
PM ₁₀	0.0122
PM _{2.5}	0.0117
NO _x	0.268
SO ₂	0.000583
CO	0.0752

Notes: ^{a)} VKT =vehicle kilometres travelled

TableB-13: Emission Factors for Short Haul Trucks Calculated Using MOVES Model

Compound	Emission Factor (g/VKT) ^(a)
SPM	0.0379
PM ₁₀	0.0379
PM _{2.5}	0.0379
NO _x	0.788
SO ₂	0.000
CO	0.250

Table B-14: Emission Factors for Passenger Vehicles (Gasoline) Calculated Using MOVES Model

Compound	Emission Factor (g/VKT)
SPM	0.000
PM ₁₀	0.000
PM _{2.5}	0.000
NO _x	0.0203
SO ₂	0.000
CO	0.159

The following equation was used to determine the vehicle kilometres travelled per hour (VKT/hr):

$$\frac{\text{VKT}}{\text{hr}} = \frac{\# \text{ of Trucks}}{\text{Hour}} \times \text{Road Length Travelled (km)}$$

The following is a sample calculation for VKT/hr on one segment (BR-1) of the paved roads for the current operations:

$$\frac{\text{VKT}}{\text{hr}} = \frac{21 \text{ Waste Trucks}}{\text{Hour}} \times 1.58 \text{ km}$$

$$\text{VKT/hr} = 65$$

The VKT for each of the road segments was calculated using the equation above. The maximum number of vehicle trips per hour for current existing and proposed phases for each road segment was used in the calculation. Tables B-15 to B-17 list the road segments and VKT/hr for each of the three vehicle types travelling on the roads.

Table B-15: Waste Truck – Road Segment Maximum VKT/hr

Road ID	Description	Vehicles on Segment	Maximum Trips per hour	Segment Length [one way, m]	Maximum VKT/hr
B-R1	Current Paved	Waste Truck	21	1577	65
B-R2	Current Unpaved	Waste Truck	21	155	6
2-R1	Phase 2 Paved	Waste Truck	28	2018	111
2-R2	Phase 2 Unpaved	Waste Truck	28	173	10
4-R1	Phase 4 Paved	Waste Truck	28	847	47
4-R2	Phase 4 Unpaved	Waste Truck	28	1023	57
8-R1	Phase 8 Paved	Waste Truck	28	287	16
8-R2	Phase 8 Unpaved	Waste Truck	28	752	42

Table B-16: Short Haul Truck – Road Segment Maximum VKT/hr

Road ID	Description	Vehicles on Segment	Maximum Trips per hour	Segment Length [one way, m]	Maximum VKT/hr
ND-R1	All Phases Paved	Short Haul	1	288	0.4
ND-R2	All Phases Unpaved	Short Haul	1	442	0.7

Table B-17: Passenger Vehicle (Gasoline) – Road Segment Maximum VKT/hr

Road ID	Description	Vehicles on Segment	Maximum Trips per hour	Segment Length [one way, m]	Maximum VKT/hr
HHW	All Phases Paved	Passenger	12	461	11.4

The following predictive emissions equation was used to determine the exhaust emission rates for on-site vehicles travelling on paved and un-paved roads:

$$ER = EF \times \frac{VKT}{hr} \times \frac{1 \text{ hr}}{3,600 \text{ s}}$$

Where:

ER = emission rate (g/s),

EF = emission factor (g/VKT)

The following is a sample calculation for the total NO_x emissions for Waste Truck exhaust emissions on B-R1 paved road segment for the current phase.

$$ER = \frac{0.268 \text{ g}}{\text{VKT}} \times \frac{65 \text{ VKT}}{\text{hr}} \times \frac{1 \text{ hr}}{3,600 \text{ s}}$$

$$ER = 0.00486 \text{ g/s}$$

Additionally, SPM, PM₁₀ and PM_{2.5}, SO₂, and CO were calculated using the same equation. The exhaust emission rates for unpaved road segments were calculated using the same emissions factor and the same approach to determine the VKT.

4.7 Unpaved Road Dust

The predictive equation referenced in AP42 emission methodologies for unpaved roads (US EPA, 2006b) was used to calculate the fugitive dust emissions from unpaved roadways. The equation accounts for the application of dust suppressant control efficiency. The equation is as follows:

$$EF = \left(k \left(\frac{s}{12} \right)^a \times \left(\frac{W}{3} \right)^b \times 281.9 \right) (1 - \text{control efficiency})$$

Where:

EF = particulate emission factor (g/VKT),

k = empirical constant for particle size range (pounds (lbs) per vehicle mile travelled (VMT)) (see Table B-18),

s = road surface silt content (%) assumed to be 6.4% (as per US EPA AP-42 Section 13.2.2 for MSW landfills),

W = average weight (tons) of the vehicles traveling the road,

a = empirical constant for particle size range (dimensionless) (see Table B-18),

b = empirical constant for particle size range (dimensionless) (see Table B-18),

281.9 = conversion from pounds per vehicle miles travelled to grams per vehicle kilometres travelled, and

control efficiency = reduction of fugitive dust emissions due to dust suppressant use.

Table B-18: Particle Size Assumptions for Unpaved Road Dust

Size Range	k (lb/VMT)	a	b
SPM	4.9	0.7	0.45
PM ₁₀	1.5	0.9	0.45
PM _{2.5}	0.15	0.9	0.45

The following is a sample calculation for SPM for the emission factor for a Waste Truck that will travel road segment BR-2 in the current phase (unpaved road to active area of landfill).

A Waste Truck travelling on this segment will have an average weight of 15.97 tons; vehicle weights were provided by the City of London and are presented in Table B-19.

Table B-19: Road Vehicle Weights

Vehicle Type Description	Average Vehicle Weight (tonnes)	Average Vehicle Weight (tons)
Short Haul Truck	16.23	15.97
Truck Tandem (Triaxle, Dump)	16.23	15.97
Passenger Vehicle (Car or Minivan or pick-up truck)	2.32	2.28

A control efficiency of 85% was selected for unpaved roads to represent the use of dust suppressants.

$$EF = \left(4.9 \left(\frac{6.4}{12} \right)^{0.7} \times \left(\frac{15.97}{3} \right)^{0.45} \times 281.9 \right) (1 - 85\%)$$

$$EF = 238.2 \text{ g/VKT}$$

The following is a sample calculation for the SPM emission rate for vehicles travelling along the BR-2 unpaved road segment in current phase:

$$ER = \frac{238.2 \text{ g}}{\text{VKT}} \times \frac{6 \text{ VKT}}{\text{hr}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$ER = 0.503 \text{ g/s}$$

The emission rates of PM₁₀ and PM_{2.5} were calculated as presented above.

4.8 Paved Road Dust

Published emission factors were used to calculate the fugitive dust emissions from paved roadways (US EPA, 2011). The following predictive emissions equation was used to determine the fugitive dust emission factor for paved roads:

$$EF = (k(sL)^{0.91} \times (W)^{1.02}) (1 - \text{control efficiency})$$

Where:

EF = particulate emission factor (having units matching the units of k),

k = particle size multiplier for particle size range and units of interest (see Table B-20),

sL = road surface silt loading (g/m²) assumed to be 7.4 (as per US EPA AP-42

Section 13.2.1-3, silt loading for MSW landfills),

W = average weight (tons) of the vehicles traveling the road, and

control efficiency = reduction of fugitive dust emissions due to dust suppression activities.

TableB-20: Particle Size Assumptions for Paved Road Dust (US EPA, 2006)

Size Range	k (g/VKT)
SPM	3.23
PM ₁₀	0.62
PM _{2.5}	0.15

The following is a sample calculation for SPM for the predictive emission factor for a Short Haul Truck that will travel along the road segment ND-R1. The Short Haul Truck will have an average weight of 15.97 tons. A control efficiency of 85% was selected to represent the dust suppression activities at the facility.

$$EF = (3.23 \times (7.4)^{0.91} \times (15.97)^{1.02})(1 - 85\%)$$

$$EF = 283.2 \text{ g/VKT}$$

The following is a sample calculation for the SPM emission rate for vehicles travelling along the same paved road segment:

$$ER = \frac{238.2 \text{ g}}{\text{VKT}} \times \frac{1 \text{ VKT}}{\text{hr}} \times \frac{1 \text{ hr}}{3600 \text{ s}}$$

$$ER = 0.0515 \text{ g/s}$$

The emission rates of PM₁₀ and PM_{2.5} were calculated as presented above.

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APPENDIX C

Dispersion Modelling

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APPENDIX C**Dispersion Modelling***W12A Landfill Expansion EA, City of London, Ontario*

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November 2020

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1.0 INTRODUCTION

This appendix is part of the Air Quality assessment for the proposed expansion of the W12A Landfill by the City of London. This work has been conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR), dated February 2019 and the Work Plan, dated December 2019 prepared following commencement of the EA and circulated to the Ministry of the Environment, Conservation and Parks (MECP).

1.1 Purpose

This appendix documents the methods, inputs and assumptions that were used to carry out the dispersion modelling to predict ground-level concentrations of indicator contaminants resulting from the operations of the existing landfill and the proposed landfill expansion (the Project).

The modelling approach described within this appendix follows generally accepted practices for conducting EAs and, where appropriate, follows MECP guidance (MECP, 2017).

2.0 AIR DISPERSION MODEL

Potential effects to air quality were evaluated with the aid of the latest version of the AERMOD dispersion model (Version 19191). AERMOD was selected for the project since:

- it is recognized by provincial regulators as one which is suitable for this application
- it can evaluate various source configurations and compounds
- it has a technical basis that is scientifically sound, and is in keeping with the current understanding of dispersion in the atmosphere
- it makes predictions that are consistent with observations

AERMOD was developed by the U.S. EPA and consists of the model and two pre-processors: the AERMET meteorological pre-processor and the AERMAP terrain pre-processor. The following approved dispersion model and pre-processors were used in the assessment:

- AERMOD dispersion model (v. 19191)
- AERMAP surface pre-processor (v. 18081)

AERMET was not required since an MECP 5-year pre-processed meteorological dataset (2013-2017) was used.

2.1 Model Inputs

To predict ambient air concentrations with the aid of AERMOD, a series of inputs are required. These inputs can be grouped into categories:

- dispersion meteorological data
- terrain and receptors
- emissions and source configurations

Each of these input categories are discussed separately in the following sections.

2.1.1 Meteorological Data

The MECP, as well as other agencies, recommends that five years of hourly data be used in the model to cover a wide range of potential meteorological conditions. A site-specific MECP pre-processed meteorological dataset for the site was obtained directly from MECP on February 20, 2020. The dataset covers the period of January 1, 2013 to December 31, 2017.

The AERMET pre-processor produced two meteorological data files. The first file contains boundary layer scaling parameters (e.g., surface friction velocity, mixing height, and Monin-Obukhov length) as well as wind speeds, wind directions and temperature at a reference-height (i.e., 10 m). The second file contains one or more levels (a profile) of winds, temperature, and the standard deviation of the fluctuating components of the wind. These files were used directly as inputs to AERMOD.

2.1.2 Terrain

Terrain elevations have the potential to influence air quality concentrations at individual receptors, therefore surrounding terrain data is required when using regulatory dispersion models in both simple and complex terrain situations. Digital terrain data is used in the AERMAP pre-processor to determine the base elevations of receptors, sources and buildings. AERMAP then searches the terrain height and location that has the greatest influence on dispersion for each receptor (U.S. EPA, 2004). This is referred to as the hill height scale. The base elevation and hill height scale produced by AERMAP are directly inserted into the AERMOD input file.

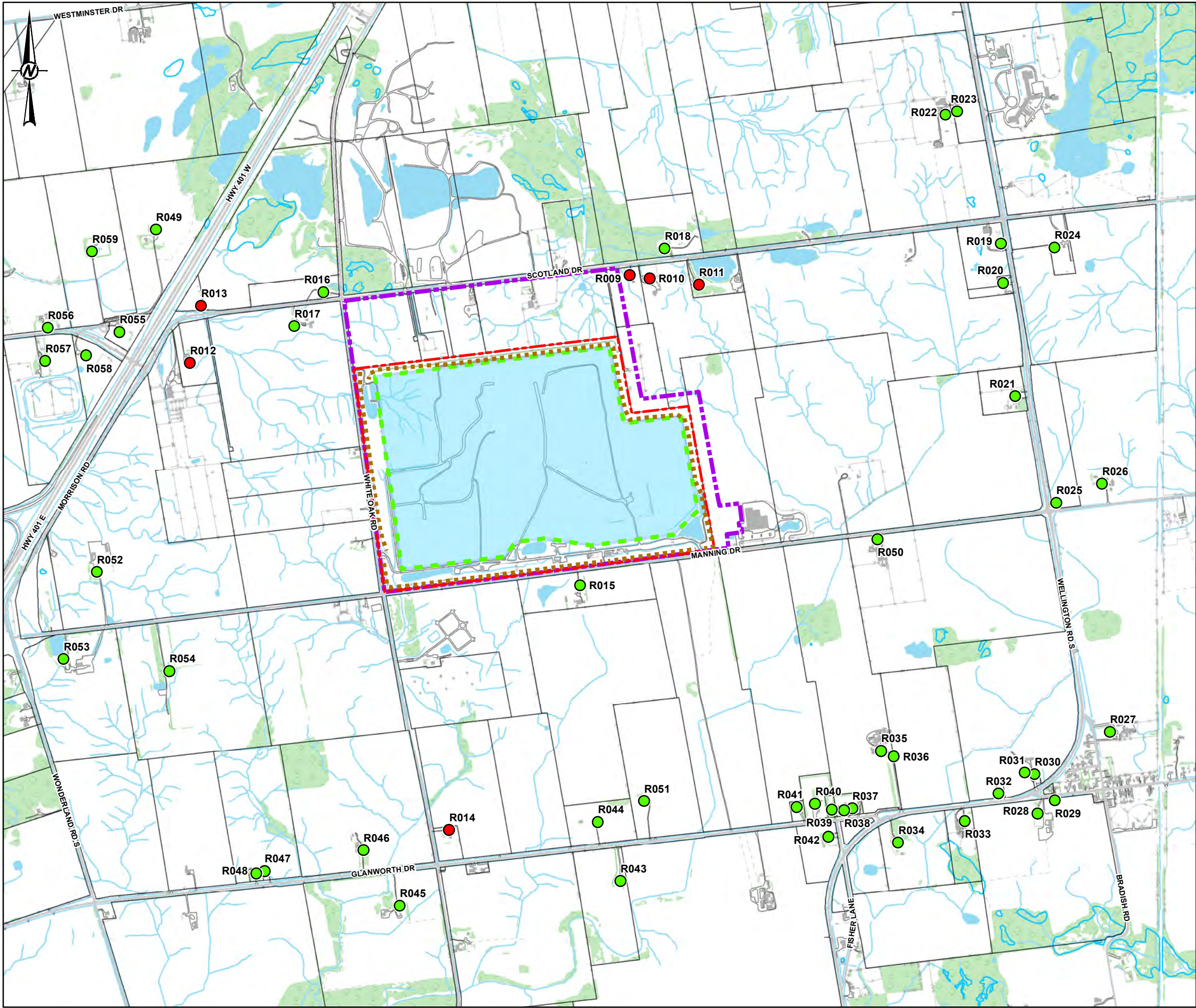
Digital terrain data for the site was obtained from the MECP (GeoTIFF Format) (MECP, 2019). The digital elevation model (CDEM) file used in the modelling was CDEM_DEM_040I.

2.1.3 Receptors

Discrete receptors located off-site at nearby residences (referred to as sensitive receptors) were used for the indicator compounds, illustrated on Figure C-1.

For the assessment of compliance with O. Reg. 419/05, a nested grid of receptors was used for the assessment based on the MECP Dispersion Modelling Guideline (MECP, 2017). Receptors were centered on the sources and placed as follows:

- 20 m spacing within 200 m of all sources of emissions
- 50 m spacing within 300 m of all sources of emissions
- 100 m spacing within 800 m of all sources of emissions
- 200 m spacing within 1,800 m of all sources of emissions
- 500 m spacing within 5,000 m of all sources of emissions.



LEGEND

- CITY OWNED PROPERTY - EXISTING
- NON-CITY OWNED PROPERTY - EXISTING
- WATERCOURSE
- DRIVEWAY
- FENCELINE
- TRAIL
- APPROXIMATE BERM LOCATION
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- EXISTING PROPERTY BOUNDARY
- PROPOSED PROPERTY BOUNDARY
- EXISTING APPROVED LIMIT OF WASTE
- PROPOSED LIMIT OF WASTE

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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CLIENT CORPORATION OF THE CITY OF LONDON			
PROJECT ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION: AIR QUALITY AND ODOUR			
TITLE SENSITIVE RECEPTOR LOCATIONS			
	CONSULTANT	YYYY-MM-DD	2020-08-19
		DESIGNED	---
		PREPARED	JEM
		REVIEWED	---
		APPROVED	---
PROJECT NO. 1648176	PHASE 0020	REV. A	FIGURE C1

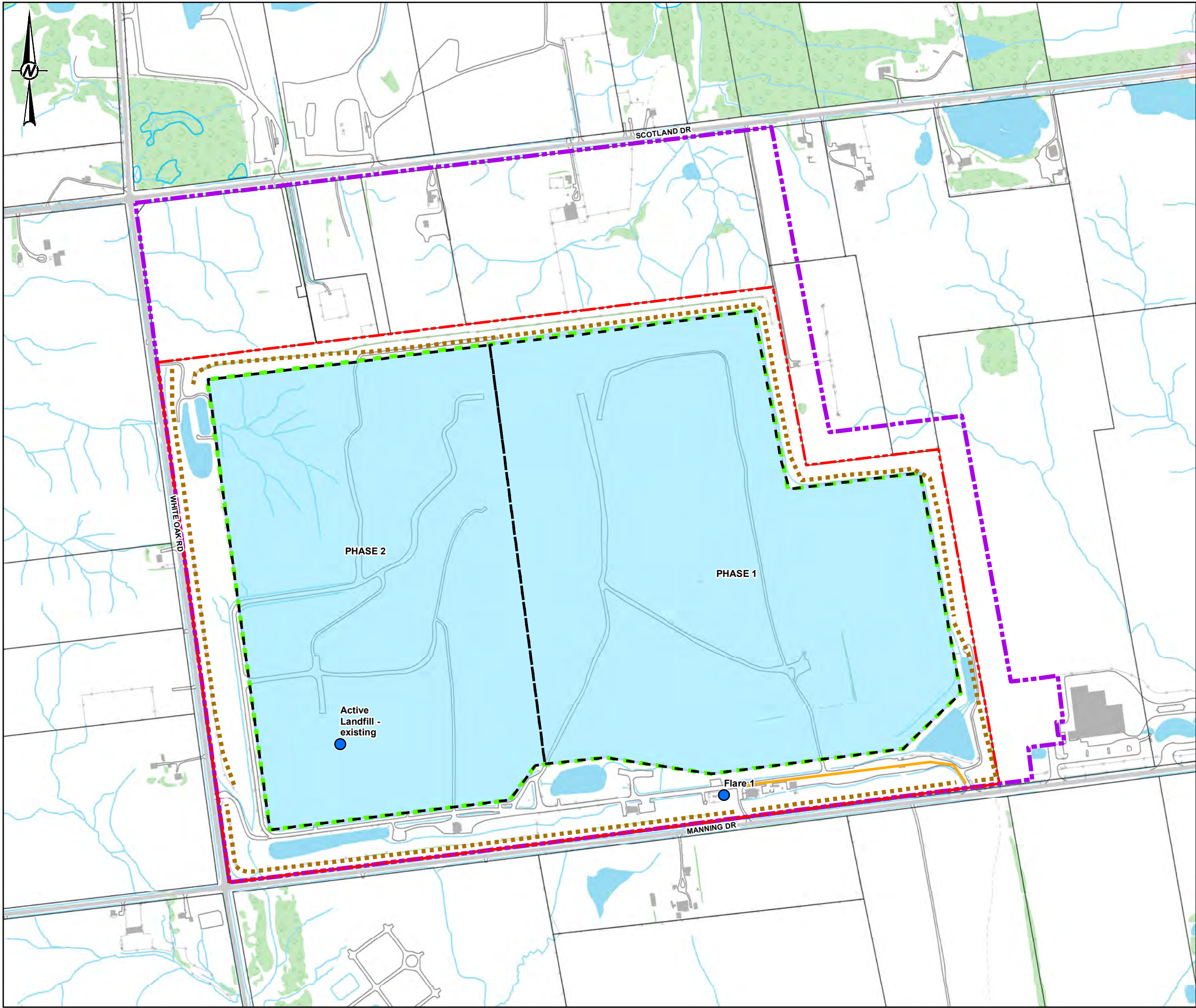
2.1.4 Emission Rates

Hourly emission rates were estimated for the indicator compounds for the W12A Landfill expansion activities (including existing activities) as inputs for the dispersion model. A detailed description of the methodology and sample calculations for determining the emission rates is provided in Appendix B.

2.2 Model Source Configurations

Emission sources that were parameterized in the modelling include the landfill cap, material handling operations in the active area and non-decomposable area, flares, fugitive road dust, and exhaust emissions from road and non-road vehicles for the existing operations and proposed expansion operations.

The model source types that were used in this assessment include: point, area, and volume sources, as described below. Site layout and emission source location figures showing the location of the emission sources for the existing landfill are presented on Figure C-2 and the proposed expansion phases are illustrated on Figure C-3.



LEGEND

- AIR EMISSION SOURCE
- WATERCOURSE
- DRIVEWAY
- - - FENCELINE
- - - TRAIL
- - - APPROXIMATE BERM LOCATION
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- - - EXISTING PROPERTY BOUNDARY
- - - PROPOSED PROPERTY BOUNDARY
- EXISTING APPROVED LIMIT OF WASTE
- - - PROPOSED LIMIT OF WASTE

ROADWAY TYPE

- DECOMPOSABLE WASTE

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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CLIENT CORPORATION OF THE CITY OF LONDON		
PROJECT ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A LANDFILL EXPANSION: AIR QUALITY AND ODOUR		
TITLE SITE LAYOUT AND EMISSION SOURCE LOCATION: EXISTING		
CONSULTANT	YYYY-MM-DD	2020-08-19
	DESIGNED	---
	PREPARED	JEM
	REVIEWED	---
	APPROVED	---
PROJECT NO. 1648176	PHASE 0020	REV. A
		FIGURE C2

2.2.1 Point Sources

Point sources are typically used to represent elevated stacks or vents as well as enclosed flares. The existing and proposed second flare are enclosed flares and best represented as a point source (MECP, 2017).

The input parameters for the point sources are provided in Tables C-1 and C-2. The input parameters for the existing flare were obtained from the Environmental Compliance Approval (Air) for the flare (ECA reference 4183-78XHLX, dated December 24, 2007.) and supporting documents from the flare manufacturer. These same input parameters were used for the proposed second flare for the landfill expansion.

Table C-1: Point Source Summary – Existing

Source Description (and ID #)	Stack Height Above Grade [m]	Stack Gas Exhaust Rate (Am ³ /s)	Stack Exit Gas Temp. (°C)	Stack Inner Diameter (m)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operation (g/s)
Enclosed LFG Flare 1 (F1)	12.2	47	871	2.7	481615.8	4747069.9	SPM	8.71E-02
							PM10	8.71E-02
							PM2.5	8.71E-02
							H ₂ S	6.52E-04
							C ₂ H ₃ Cl	5.31E-05
							CO	2.70E-01
							NO _x	2.31E-01
							SO ₂	7.81E-02

Table C-2: Point Source Summary – Expansion

Source Description (and ID #)	Stack Height Above Grade [m]	Stack Gas Exhaust Rate (Am ³ /s)	Stack Exit Gas Temp. (°C)	Stack Inner Diameter (m)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operation (g/s)
Enclosed LFG Flare 1 (F1)	12.2	47	871	2.7	481621	4747069.9	SPM	1.24E-01
							PM10	1.24E-01
							PM2.5	1.24E-01
							H ₂ S	9.27E-04
							C ₂ H ₃ Cl	7.54E-05
							CO	3.83E-01
							NO _x	3.28E-01
							SO ₂	1.11E-01

Source Description (and ID #)	Stack Height Above Grade [m]	Stack Gas Exhaust Rate (Am ³ /s)	Stack Exit Gas Temp. (°C)	Stack Inner Diameter (m)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operation (g/s)
Enclosed LFG Flare 2 (F2)	12.2	32.54	871	2.7	481621	4747069.9	SPM	8.57E-02
							PM10	8.57E-02
							PM2.5	8.57E-02
							H ₂ S	6.42E-04
							C ₂ H ₃ Cl	5.22E-05
							CO	2.65E-01
							NO _x	2.27E-01
							SO ₂	7.68E-02

2.2.2 Area Sources

Area sources are used to model low elevation or ground releases. The landfill cap, operations at the active area; and operations at the non-decomposable waste area were modelled as area sources.

The landfill expansion will be conducted in eight phases. As discussed in Section 5.2 of the main EASR, consideration was given to identifying the operational phase that results in the “worst case” emissions scenario. Three different phases were considered for this purpose:

- Phase 2E
- Phase 4E
- Phase 8E

These phases were selected as they have the longest on-Site vehicle access routes (i.e., result in largest fugitive dust and vehicle exhaust emissions).

For the assessment of the current scenario, the active filling source (FILL) was located within the phase 2 of the current landfill design and it is intended to represent an approximate location of current filling, but closer to the fence line and nearby sensitive receptors for conservatism.

The input parameters for the area sources are provided in Table C-3. The release heights were estimated to be the difference between the Base Elevation in AERMAP and the final (target) elevations.

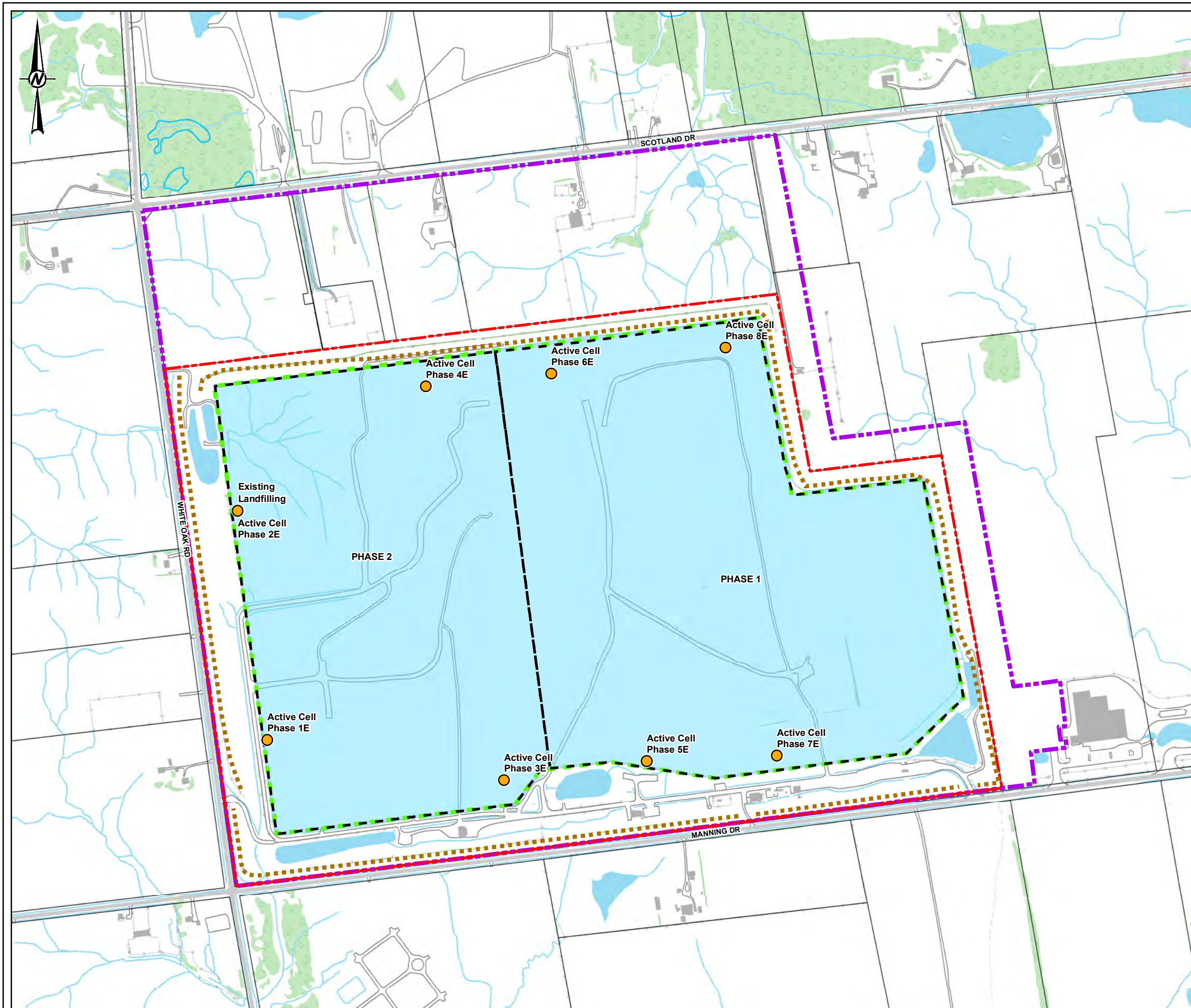
Table C-3: Area Source Summary

Source Description (and ID #)	Release Height Above Grade [m]	Area (m ²)	UTM Northing (m)	UTM Easting (m)	Indicator Compound	Emission Rate During Operation (g/s-m ²)
Existing Landfill Cap (CAP_E)	3	1070000	480734.28	4747009.64	CO	1.16E-08
					H ₂ S	1.85E-08
					C ₂ H ₃ Cl	1.50E-09
Existing Landfill Operations (FILL)	0	1500	480872	4747169	SPM	1.62E-04
					PM ₁₀	5.00E-05
					PM _{2.5}	3.43E-05
					CO	8.85E-04
					NO _x	4.82E-04
Landfill Active Area -Phase 2E (FILL Phase 2E)	13	1500	480770.36	4747760.38	SO ₂	1.26E-08
					SPM	2.42E-01
					PM ₁₀	7.51E-02
					PM _{2.5}	5.15E-02
					CO	1.33E+00
					NO _x	7.22E-01
Landfill Active Area -Phase 4E (FILL Phase 4E)	10	1500	481041.85	4747735.7	SO ₂	1.90E-05
					SPM	2.42E-01
					PM ₁₀	7.51E-02
					PM _{2.5}	5.15E-02
					CO	1.33E+00
					NO _x	7.22E-01
Landfill Active Area -Phase 8E (FILL Phase 8E)	10	1500	481528.99	4747792.86	SO ₂	1.90E-05
					SPM	2.42E-01
					PM ₁₀	7.51E-02
					PM _{2.5}	5.15E-02
					CO	1.33E+00
					NO _x	7.22E-01
Landfill Operations – Non-Decomposable Waste (ND_MH)	3	1000	481869.8	4747470.6	SO ₂	1.90E-05
					SPM	8.58E-02
					PM ₁₀	1.26E-02
					PM _{2.5}	8.95E-03

2.2.2.1 *Area Odour Sources*

The main sources of odour emission from the Project are the active filling areas. Therefore, in order to identify the maximum emission scenario, all eight phases of the site expansion were modelled, in conjunction with the corresponding active filling area that is located closest to sensitive receptors for each phase (typically closest to the site boundary). Emissions from the capped areas of the landfill were also modelled, using the existing landfill footprint. The location of the modelled odour sources is presented on Figure C-4.

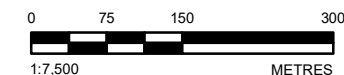
DRAFT



- LEGEND**
-  ODOUR EMISSION SOURCE
 -  PROPOSED LIMIT OF WASTE (LANDFILL CAP ODOUR EMISSION SOURCE)
 -  WATERCOURSE
 -  DRIVEWAY
 -  FENCELINE
 -  TRAIL
 -  APPROXIMATE BERM LOCATION
 -  BUILDING FOOTPRINT
 -  WOODED AREA
 -  WATERBODY
 -  EXISTING PROPERTY BOUNDARY
 -  PROPOSED PROPERTY BOUNDARY
 -  EXISTING APPROVED LIMIT OF WASTE

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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CLIENT
CORPORATION OF THE CITY OF LONDON

PROJECT
ENVIRONMENTAL ASSESSMENT OF THE PROPOSED W12A
LANDFILL EXPANSION: AIR QUALITY AND ODOUR

TITLE
SITE LAYOUT AND EMISSION SOURCE LOCATION: ODOUR

CONSULTANT	YYYY-MM-DD	2020-08-19
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GOLDER

YYYY-MM-DD	2020-08-19
DESIGNED	---
PREPARED	JEM
REVIEWED	---
APPROVED	---

PROJECT NO.	PHASE	REV.	FIGURE
1648176	0020	A	2

The modelling heights for each source are presented in Table C-4. The release heights were estimated to be the difference between the Base Elevation in AERMAP and the final (target) elevations.

Table C-4: Odour Sources Modelling Heights

Source Description (and ID #)	Base Elevation in AERMAP [masl]	Target Elevation [masl]	Release Height [m]
CAP_E (Cap Existing)	273.0	276	3.0
CAP_EX (Cap Expansion)	273.0	296	23.0
ACT_FILL (active filling)	275.7	280	4.3
Landfill Active Area -Phase 1E ACT_1E	275.7	283	7.3
Landfill Active Area -Phase 2E ACT_2E	278.0	283	5.0
Landfill Active Area -Phase 3E ACT_3E	276.0	286	10.0
Landfill Active Area -Phase 4E ACT_4E	280.9	288	7.1
Landfill Active Area -Phase 5E ACT_5E	275.0	287	12.0
Landfill Active Area -Phase 6E ACT_6E	281.0	290	9.0
Landfill Active Area -Phase 7E ACT_7E	279.1	284	4.9
Landfill Active Area -Phase 8E ACT_8E	280.0	288	8.0

The input parameters for the area sources are provided in Table C-5.

Table C-5: Odour Area Source Summary

Source Description (and ID #)	Release Height Above Grade [m]	Area (m ²)	UTM Northing (m)	UTM Easting (m)	Emission Rate During Operation (g/s-m ²)
Existing Landfill Cap (CAP_E)	3	1070000	480734.28	4747009.64	4.14E-03
CAP_EX (Cap Expansion)	23	1070000	480734.28	4747009.64	2.89E-03
ACT_FILL (active filling)	4	1500	480660.13	4747633.95	8.98E-01
Landfill Active Area -Phase 1E ACT_1E	7	1500	480717.21	4747186.09	8.98E-01
Landfill Active Area -Phase 2E ACT_2E	5	1500	480659.63	4747633.23	8.98E-01
Landfill Active Area -Phase 3E ACT_3E	10	1500	481179.10	4747107.14	8.98E-01
Landfill Active Area -Phase 4E ACT_4E	7	1500	481026.66	4747875.67	8.98E-01
Landfill Active Area -Phase 5E ACT_5E	12	1500	481457.08	4747145.07	8.98E-01
Landfill Active Area -Phase 6E ACT_6E	9	1500	481271.00	4747900.44	8.98E-01
Landfill Active Area -Phase 7E ACT_7E	5	1500	481711.46	4747155.67	8.98E-01
Landfill Active Area -Phase 8E ACT_8E	8	1500	481610.69	4747951.45	8.98E-01

2.2.3 Volume Sources

Volume sources are used to model releases from a variety of industrial sources that cannot be classified as a point or area source. The roads at the W12A Landfill have been modelled following the line volume source approach (MECP, 2017). This includes modelling the roads as a series of individual volume sources creating a line that follows the road (US EPA, 2012).

The roads were divided into separated contiguous volume sources with a release height of 2.98 m, which was calculated by multiplying the assumed height of the vehicles (3.5 m) by 1.7 and dividing by 2 as per the MECP and USEPA Guidance (MECP, 2017, USEPA, 2012). The roads are assumed to be 7.6 m wide (for 2 lanes). The emission rate for the entire road segment was divided between the volume sources for the entire segment including both lanes. The roads were modelled using this approach for both the existing and proposed landfill scenarios. The road segments are depicted on Figure C-2 (Existing Scenario) and C-3 (Expansion Scenario). The parameters used in the modelling are identified in Table C-6.

Table C-6: Volume Source Summary

Source Description (and ID #)	Release Height Above Grade [m]	Plume Height [m]	Plume Width [m]	Indicator Compound	Emission Rate per Road Segment (g/s)	# of AERMOD Sources in Road Segment	Emission Rate Per Model Source (g/s)
Paved Road Segment – Current (BR-1)	2.98	5.95	13.6	SPM	0.9175	59	1.56E-02
				PM ₁₀	0.1763		2.99E-03
				PM _{2.5}	0.0428		7.26E-04
				SO ₂	1.06E-05		1.79E-07
				CO	1.36E-03		2.31E-05
				NO _x	0.0049		8.24E-05
Unpaved Road Segment – Current (BR-2)	2.98	5.95	13.6	SPM	0.5035	7	7.19E-02
				PM ₁₀	0.1359		1.94E-02
				PM _{2.5}	0.0136		1.94E-03
				SO ₂	1.04E-06		1.48E-07
				CO	1.34E-04		1.91E-05
				NO _x	0.0005		6.81E-05
Paved Road Segment – Phase 2E (2R-1)	2.98	5.95	13.6	SPM	1.5657	75	2.09E-02
				PM ₁₀	0.3008		4.01E-03
				PM _{2.5}	0.0184		2.45E-04
				SO ₂	1.80E-05		2.41E-07
				CO	2.33E-03		3.10E-05
				NO _x	0.0083		1.11E-04
Unpaved Road Segment – Phase 2E (2R-2)	2.98	5.95	13.6	SPM	0.7522	7	1.07E-01
				PM ₁₀	0.2031		2.90E-02
				PM _{2.5}	0.0203		2.90E-03
				SO ₂	1.55E-06		2.21E-07
				CO	2.00E-04		2.85E-05
				NO _x	0.0007		1.02E-04
Paved Road Segment – Phase 4E (4R-1)	2.98	5.95	13.6	SPM	0.6567	32	2.05E-02
				PM ₁₀	0.1262		3.94E-03
				PM _{2.5}	0.0182		5.68E-04
				SO ₂	7.57E-06		2.37E-07
				CO	9.76E-04		3.05E-05
				NO _x	0.0035		1.09E-04
Unpaved Road	2.98	5.95	13.6	SPM	4.4470	39	1.14E-01
				PM ₁₀	1.2006		3.08E-02
				PM _{2.5}	0.1202		3.08E-03

Source Description (and ID #)	Release Height Above Grade [m]	Plume Height [m]	Plume Width [m]	Indicator Compound	Emission Rate per Road Segment (g/s)	# of AERMOD Sources in Road Segment	Emission Rate Per Model Source (g/s)
Segment – Phase 4E (4R-2)				SO ₂	9.15E-06		2.35E-07
				CO	1.18E-03		3.03E-05
				NO _x	0.0042		1.08E-04
Paved Road Segment – Phase 8E (8R-1)	2.98	5.95	13.6	SPM	0.2228	12	1.86E-02
				PM ₁₀	0.0428		3.57E-03
				PM _{2.5}	0.0181		1.51E-03
				SO ₂	2.57E-06		2.14E-07
				CO	3.31E-04		2.76E-05
				NO _x	0.0012		9.84E-05
Unpaved Road Segment – Phase 8E (8R-2)	2.98	5.95	13.6	SPM	3.2687	29	1.13E-01
				PM ₁₀	0.8825		3.04E-02
				PM _{2.5}	0.0884		3.05E-03
				SO ₂	6.73E-06		2.32E-07
				CO	8.68E-04		2.99E-05
				NO _x	0.0031		1.07E-04
Paved Road Segment – All Phases (ND-R1)	2.98	5.95	13.6	SPM	0.0027	12	2.27E-04
				PM ₁₀	0.0005		4.39E-05
				PM _{2.5}	0.0002		1.87E-05
				SO ₂	0.00E+00		0.00E+00
				CO	2.96E-05		2.47E-06
				NO _x	0.0001		7.77E-06
Unpaved Road Segment – All Phases (ND-R2)	2.98	5.95	13.6	SPM	0.0515	17	3.03E-03
				PM ₁₀	0.0139		8.19E-04
				PM _{2.5}	0.0014		8.22E-05
				SO ₂	0.00E+00		0.00E+00
				CO	4.55E-05		2.68E-06
				NO _x	0.0001		8.43E-06
Paved Road Segment – All Phases (HHW)	2.98	3.4	13.6	SPM	0.0220	18	1.22E-03
				PM ₁₀	0.0042		2.35E-04
				PM _{2.5}	0.0011		6.17E-05
				SO ₂	0.00E+00		0.00E+00
				CO	5.06E-04		2.81E-05
				NO _x	0.0001		3.58E-06

2.3 Options to be used in the AERMOD Model

The options that were used in the AERMOD model are summarized in Table C-7 below.

Table C-7: Options Used in the AERMOD Model

Modelling Parameter	Description	Used in the Assessment?
DFAULT	Specifies that regulatory default options will be used.	Yes
CONC	Specifies that concentration values will be calculated.	Yes
EMISFACT HROFDY	Specifies that variable emissions are in use for variable emissions type "Hour-of-day"	Yes (see table C-8)
OLM	Specifies that the non-default Ozone Limiting Method for NO ₂ conversion will be used.	No
DDPLETE	Specifies that dry deposition will be calculated.	Yes
WDPLETE	Specifies that wet deposition will be calculated.	Yes
FLAT	Specifies that the non-default option of assuming flat terrain will be used.	No, the model will use elevated terrain as detailed in the AERMAP output.
NOSTD	Specifies that the non-default option of no stack-tip downwash will be used.	No
AVERTIME	Time averaging periods calculated.	1-hr, 8-hr, 24-hr, Annual
URBANOPT	Allows the model to incorporate the effects of increased surface heating from an urban area on pollutant dispersion under stable atmospheric conditions.	No
URBANROUGHNESS	Specifies the urban roughness length (m).	No, site specific urban roughness values were incorporated into the AERMET processing.

The variable emissions by hour of day option in AERMOD was applied for road segments where the volume of vehicle traffic on road segments varies significantly over the course of the day. Table C-8 lists the road segments and scaling factor applied to emissions.

Table C-8: Road Segments Variable Emissions Scaling Factors

Roads	Hour of Day	Scaling Factor
BR-1 BR-2 2R-1 2R-2 4R-1 4R-2 8R-1 8R-2	6:00-7:00	0.0005
	7:00-8:00	0.35
	8:00-9:00	0.63
	9:00-10:00	0.78
	10:00-11:00	1.00
	11:00-12:00	0.95
	12:00-13:00	0.75
	13:00-14:00	0.71
	14:00-15:00	0.59
	15:00-16:00	0.24
	16:00-17:00	0.005
	17:00-18:00	0.004
	18:00-19:00	0.002
	19:00-6:00	0.000

AERMOD has the ability to model both wet and dry deposition; however, modelling deposition results in plume depletion, which reduces predicted ground level concentrations. The required inputs are particle diameter, mass fraction and particle density. The following table presents particle data from the Existing Landfill Operations source.

Table C-9: Source Parameters for Gas and Particle Deposition

Sources	Particle Diameter [microns]	Mass Fraction [0 to 1]	Particle Density [g/cm ³]
FILL FILL_2E FILL_4E FILL_8E MH_ND	0.50	0.10	2.65
	5.00	0.10	2.65
	20.00	0.80	2.65
HHW 2_R1 4_R1 8_R1 ND_R1 BR_1	0.50	0.03	2.65
	5.00	0.16	2.65
	20.00	0.81	2.65
2_R2 4_R2 8_R2 ND_R2 BR_R2	0.50	0.03	2.65
	5.00	0.24	2.65
	20.00	0.73	2.65
F1 F2	0.50	1.00	1.00
	5.00	0.00	1.00
	20.00	0.00	1.00

2.4 Time Average Conversions

The smallest time scale that AERMOD predicts is a 1-hour average value. There are instances when criteria are based on shorter averaging times, and in these cases a conversion factor, recommended by the MECP, for conversion from a 1-hour averaging period to the applicable averaging period less than 1-hour was used (MECP, 2017).

An example is given below for converting from a 1-hour averaging period to a 10-minute averaging period, which is required for odour modelling:

$$\begin{aligned} F &= \left(\frac{t_1}{t_0} \right)^n \\ &= \left(\frac{60}{10} \right)^{0.28} \\ &= 1.65 \end{aligned}$$

Where:

F = the factor to convert from the averaging period t_1 output from the model (MECP assumes AERMOD predicts true 60 minute averages) to the desired averaging period t_0 (assumed to be 10-minutes in the example above), and

n = the exponent variable; in this case the MECP value of $n = 0.28$ is used for conversion.

For averaging periods greater than 1-hour, the AERMOD output was used directly.

3.0 REFERENCES

- MECP (Ministry of the Environment, Conservation and Parks). 2017. *Air Dispersion Modelling Guideline for Ontario, Version 3.0*. PIBS: 5165e03, Toronto, Ontario
- MECP (Ministry of the Environment, Conservation and Parks) . 2016. *Methodology for Modelling Assessments of Contaminants with 10-Minute Average Standards and Guidelines under O.Reg. 419/05*. Technical Bulletin.
- United States Environmental Protection Agency (U.S. EPA). 2004. *Users Guide for the AERMOD Terrain Preprocessor (AERMAP)*. EPA-454/B-03-003. Office of Air Quality Planning and Standards. Emissions, Monitoring, and Analysis Division. Research Triangle Park, North Carolina.
- United States Environmental Protection Agency (U.S. EPA). 2012. *Haul Road Workgroup Final Report*. Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

DRAFT

D.02 Noise Existing Conditions and
Impact Assessment Report; completed by
Golder Associates Ltd.



DRAFT REPORT

Noise Existing Conditions and Impact Assessment

W12A Landfill Expansion EA, City of London, Ontario

Submitted to:

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October 2020

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FIGURES

Figure 1: Noise Study Areas and Points of Reception

Figure 2: Mitigation at Existing Point of Reception R15

Acronyms and Glossary of Terms

Term / Acronym	Definition
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
dB	decibels
dBA	A-weighted decibels
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
HVAC	heating, ventilation and air conditioning
ISO	International Organization for Standardization
LCS	leachate collection system
LFG	landfill gas
Leq	equivalent noise level
LLM	Logarithmic Mean Impulse Sound Level
MECP	Ministry of Environment, Conservation and Parks
MRF	Material Recovery Facility
MTO	Ontario Ministry of Transportation
ORNAMENT	Ontario Road Noise Analysis Method for Environment and Transportation
POR	Point of Reception
POW	Plane of Window
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London, Ontario.

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the noise component existing conditions and impact assessment for the Environment Assessment (EA) of the proposed W12A Landfill expansion. In particular, this report describes and summarizes a noise assessment that considers the existing conditions and potential effects of the Project on the outdoor acoustic environment. Specifically, environmental effects relevant to human noise receptors are assessed. This work has been conducted in accordance with the requirements set out in the approved Terms of Reference (ToR), dated February 2019 and the work plan dated November 2019 prepared following commencement of the EA in September 2019 and circulated to the Ontario Ministry of Environment, Conservation and Parks (MECP).

This report is a supporting document to the Environmental Assessment Study Report (EASR).

2.0 PROJECT DESCRIPTION

The following describes the Project components considered relevant for the purposes of this noise assessment.

General Description: The landfill expansion consists of a vertical expansion over the existing landfill footprint to provide 13.8 million m³ of airspace for waste and daily cover. To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be adjacent to Scotland Drive and a 100 m buffer width will be provided on the east side of the landfill footprint and some additional area in the southeast corner to tie into the adjacent Material Recovery Facility (MRF) property line. This results in a 106.3 ha landfill footprint within a 192.4 ha landfill property, with a highest ridge elevation of waste of 318.43 masl.

Landfill Phasing and Development: The landfill expansion will be developed sequentially in eight Phases, 1E through 8E, progressing from the west side of the landfill towards the east. Landfilling in each Phase will be approximately 2.5 to 3.5 years based on an expected typical annual air space consumption of 500,000 m³ per year, which corresponds to an average annual waste receipt of 370,000 tonnes per year over the 25 year planning period. A separate cell dedicated for disposal of the non-decomposable portion of the waste stream will be provided in the southeastern area of the landfill expansion. Filling in this non-decomposable waste cell will take place in lifts over the 25 year expansion period, and will be blended in to meet the temporary sideslopes in the adjacent Phases 7E and 8E as they are developed. Because this waste is non-decomposable, it would not receive daily cover; however, if it is observed that specific materials are generating odours or are otherwise of concern if left uncovered, daily cover material would be placed. This fill area would receive final cover consistent with that on the remainder of the landfill, but it is not proposed to install a landfill gas collection system in this area as part of the final cover construction.

To commence filling in each Phase, the existing cover material would be progressively stripped from an area large enough to accommodate the year's disposal, which is estimated to average

approximately 4 ha. The area of exposed waste would be limited to that needed to spread, compact and cover the waste received on a daily basis, and will range from about 40 m by 25 m typically (1,000 m²) to 50 m by 30 m (1,500 m²). The waste will be spread and compacted in lifts of about 0.6 m to a height of approximately 3 m. All waste will be covered daily.

For the southern Phases 1E, 3E, 5E and 7E the waste would be placed initially to build a berm along the south side of the Phase and will be covered with final cover soil and seeded to establish vegetation; the berm will screen the view of subsequent filling operations north of the berm from off-Site vantage points to the south. The south side perimeter waste berm would be raised sequentially and filled in behind until the peak elevation is reached. The Phase boundaries have been designed (offset) such that the completed southern Phases (1E, 3E, 5E, 7E) will effectively screen the view of landfilling operations in the northern Phases (2E, 4E, 6E, 8E) from off-Site vantage points to the south.

Temporary soil berms, and if necessary shallow swales, would be provided to direct surface water runoff from existing covered upslope areas around the active fill areas / Phases to the stormwater management system since this runoff has not been in contact with waste.

On an annual or biannual basis, final cover would then be constructed over areas reaching final grade and permanent vertical landfill gas (LFG) wells will be installed and connected to the LFG collection system

For the portion of the proposed vertical expansion that will involve placement of additional waste above the Phase 2 area, the existing leachate collection system (LCS) will continue to be used to collect and remove leachate from the area.

Leachate Control and Management: Phase 2 utilizes the clay till as a natural low permeability liner, and has a continuous granular drainage blanket and piping system over a shaped subgrade to collect leachate and direct it by gravity to the north end of the Phase 2 area where the collected leachate is removed for subsequent off-site treatment. The waste in the Phase 1 area rests directly on the underlying low permeability clay till and has a perimeter LCS around the north, east and south sides to intercept leachate seepage at the base of the waste. Collected leachate either drains into the Phase 2 collection system or into a separate storage tank from where it is removed for subsequent off-site treatment.

For the portion of the proposed vertical expansion that will involve placement of additional waste above the Phase 2 area, the existing LCS will continue to be used to collect and remove leachate from the area. For the vertical expansion above the Phase 1 area, it is proposed to replace the existing perimeter LCS with a new perimeter LCS that will more effectively serve the same functions as the existing system. To control the potential for leachate seeps along the perimeter sideslopes that could occur as a result of leachate mounding and/or perched leachate in Phase 1, it is proposed to construct granular finger drains around the north, east and south sides of the exterior perimeter of the Phase 1 area and connect them into the replacement Phase 1 perimeter LCS.

The leachate collected from the Phase 1 and Phase 2 LCS will continue to be routed through on-Site piping to the main leachate pumping station located at the southeast corner of the Site. From here, the leachate will be pumped off-Site through a leachate forcemain to the Dingman Road pump station, where combined with municipal sewage it will enter the municipal sanitary sewer system to treatment at the Greenway Wastewater Treatment Plant (WWTP).

Landfill Gas Generation and Control: It is estimated that the total expanded landfill will theoretically generate a maximum of approximately 4,000 standard cubic feet per minute (scfm) of LFG in 2049 (the year following completion of filling of the expansion), of which typically 50% is methane. LFG is collected from completed areas of the landfill using a vertical well system that is connected to an enclosed flare; the existing flare is sized to combust a maximum of approximately 1,700 scfm of LFG. Considering the actual extent of the LFG well extraction system and its collection efficiency, analysis indicates that the capacity of the existing flare may be exceeded around year 2027. The timing for installation of additional flare capacity will depend on the actual operation of the existing flare and its ability to handle the collected gas flow rate. It is proposed to utilize vertical LFG extraction wells to be progressively installed with the construction of final cover following placement of waste to final contours in each Phase. To reduce air emissions (for odour control purposes during landfilling operations and to increase the overall collection of landfill gases), it is proposed that a number of horizontal landfill gas collection pipes will also be installed progressively as waste is placed.

Site Operations and Ancillary Components: The expanded landfill will operate, at the maximum, from 7 a.m. to 5 p.m., Monday through Saturday plus one hour before, i.e., 6 a.m. to 7 a.m., for site preparations and one hour after, i.e., 5 p.m. to 6 p.m. to complete placement of daily cover. The Site will be closed on Sundays; on statutory holidays site operations will be as required to accommodate hauling contracts.

It is proposed that the maximum annual receipt of waste for the expanded landfill will be 500,000 tonnes per year, reduced from the 650,000 tonnes per year allowed for the existing landfill.

The expanded landfill will also need to continue to occasionally operate 24 hours per day, 7 days per week when lime stabilized dewatered biosolids (dewatered sewage sludge) from the Greenway WWTP are being received and disposed at the landfill. This is typically required for three weeks per year; however, some years this period could be extended. In addition, re-builds or major equipment repairs typically occur approximately every five years or longer and can take up to two to three months to complete. The landfill may receive a load of biosolids (approximately 15 tonnes) every 75 to 90 minutes. Disposal of the biosolids involves excavating a hole in the existing waste in the active area (when practical) prior to the load arriving and covering the biosolids with daily cover soil as soon as the load has been dumped.

The main site access for the expansion will be at the same location as for the existing site, off Manning Drive at the southeast corner of the Site. The main ancillary facilities are located along the perimeter road across the south side of the Site. It is proposed that many of the existing ancillary facilities at the site will be progressively upgraded or replaced during the expansion at or close to their existing location, except for a new site office / administration building to be located close to the site entrance. These facilities consist of the contractor's office and garage; administration building; flare and control system; weigh scales and scale house and leachate pump station; and small vehicle waste drop-off. A new enclosed night

waste storage facility for receipt and temporary storage of three to five loads of waste may also be constructed; access to the landfill at night will be done using card key access and automatic gates. In addition, in the vacant southeast corner area between the landfill and the MRF there will be a new scale and scalehouse, a grade-separated small vehicle drop-off for waste, a grade-separated small vehicle drop-off for recyclable materials, an area for drop-off of brush, tires and large items, and a new Household Special Waste depot.

The source of heating for all site buildings will be natural gas.

The existing roads on the south and west sides of the landfill are paved and will remain paved for the expansion. It is proposed that the perimeter access road around the north and east sides of the landfill will also be paved, as will the vehicle access roads for the proposed recycling drop-off facilities in the southeast corner between the landfill facilities and the MRF. Access for collection vehicles to the expansion Phases will be mainly from the south side perimeter road, and for Phases 1E and 2E from the west side perimeter road. From the south side, it is anticipated that the two existing granular surfaced haul roads will continue to be utilized.

A secondary site access off Scotland Drive will be used as a service road for operations and maintenance vehicles to the north part of the landfill property and as an emergency access/exit. The secondary access will have a locked gate to prevent unauthorized usage and will be gravel surfaced.

Off-Site Haul Routes: The current designated haul route consists of two options: Manning Drive via Wonderland Road to the west and Manning Drive via Wellington Road South to the east (Haul Routes).

Closure and Post-closure: The landfill Phases will be progressively closed after the final waste contours have been reached in a Phase and landfill operations have proceeded into the next Phase(s). The final cover on the landfill will consist of a permeable cover design, comprised of 600 mm of soil topped with 150 mm of topsoil or similar and vegetated. The vertical LFG extraction wells will be installed to collect gas from within the expanded waste mass as part of the progressive construction of the final cover system.

Post-closure activities will involve continued operation and maintenance of the leachate collection and removal system, the LFG control system and the stormwater management system. In addition to general inspection of the site, there will be inspection of the landfill cover for evidence of erosion, leachate seeps or instability, and maintenance / repair as required.

3.0 KEY NOISE CONCEPTS

Acoustic values can be described in terms of noise or sound. While noise is defined as unwanted sound, the terms noise and sound are often used interchangeably. An introduction to key concepts used in the assessment of outdoor acoustics is provided below:

- “Noise” or “noise levels” refers to the levels that can be heard or measured at a Point of Reception (POR).
- A noise “receptor” or “POR” is any location on a noise sensitive land use where noise is received.
- The “level” of a noise is expressed on a logarithmic scale, in units called decibels (dB). Since the scale is logarithmic, a noise that is twice the noise level as another will be three decibels (3 dB) higher. “Sound pressure level” is the physical quantity that is measured in the environment that describes sound waves quantitatively. It is a ratio of the absolute pressure relative to a reference (i.e., 20 micropascals [μPa]). This ratio of pressures is converted to a decibel scale (dB).
- Noise emissions and noise levels have an associated frequency. The human ear does not respond to all frequencies in the same way. Mid-range frequencies are most readily detected by the human ear, while the human ear is generally less sensitive to low and high frequencies. Environmental noise levels used in this assessment are presented as “A-weighted decibels” (or dBA), which incorporates the frequency response of the human ear.
- Outdoor noise is usually expressed as an “equivalent noise level” ($L_{eq, T}$), which is a logarithmic average (i.e., energy average) of the measured or predicted noise levels over a given period of time (T). An equivalent noise level measured or predicted over the nighttime period would be referred to as $L_{eq, \text{night}}$.
- The “percentile noise level”, designated L_n , is the noise level exceeded “n” percent of a specified time period and is measured in dBA. The L_{90} , for instance, is the noise level exceeded 90% of the time. It is a noise level index that commonly refers to the baseline noise level and is most often referenced in a rural setting.
- Environmental noise levels vary throughout the day and it is therefore important to distinguish between the time of day (i.e., daytime / evening / nighttime). For the purposes of this assessment, in general the day is divided into two periods for which noise is evaluated: daytime from 07:00 to 23:00 and nighttime from 23:00 to 07:00. However, applicable guidance documents for this assessment provide other definitions of daytime and nighttime, or define three periods (i.e., daytime, evening, and nighttime), which were also considered depending on the assessment criteria being evaluated.

4.0 METHODOLOGY

The following methodology was carried out to establish existing noise levels and assess the potential impacts due to the Project:

- identification of Study Areas including noise sensitive receptors;
- determination of applicable noise criteria;

- determination of existing ambient noise levels without the Project;
- determination of future noise levels with the Project;
- determination of potential noise impact; and
- assessment of noise mitigation.

4.1 Study Areas

The EA study areas are the areas within which activities associated with the Project will occur and where potential environmental effects will be studied. The following study areas have been defined for the noise assessment as follows and presented in Figure 1:

- **Site Area** – The lands for the preferred landfill expansion (existing W12A Landfill Site, located at 3502 Manning Drive plus the additional on-site buffer).
- **Site-vicinity Study Area** – The lands in the area within 1500 m of the Site Area boundary and within 500 m of the road centrelines of the two designated Haul Routes. This area has the potential to be directly affected by the landfill expansion activities associated with the Project.

A desktop review was completed using orthoimagery and information provided by the City to identify potential PORs in the vicinity of the Project where human activity is expected to occur. PORs were identified in general accordance with *“Environmental Noise Guideline Stationary and Transportation Sources – Approval and Planning Publication NPC-300”* (NPC-300) (MECP 2013). NPC-300 defines PORs as sensitive land uses with human activity, including dwellings, campsites or campgrounds, sensitive institutional uses (e.g., educational, nursery, hospital, healthcare, community centre, place of worship, or detention centre), or sensitive commercial uses (e.g., hotel or motel).

Much of the lands within the Site-vicinity Study Area, near the Site Area, are owned by the City, as shown in Figure 1, and do not contain any existing noise-sensitive buildings or are scheduled to be demolished in the near future (i.e., vacant lands). According to the City of London Zoning By-law Z.-1 Section 45, the Agricultural AG2 zoning designation permits the use of the land for farm dwellings (in most cases) amongst a list of other types of uses. As presented in NPC-300, this type of land use is considered to be noise sensitive and, therefore, PORs representing these vacant lands were assessed as vacant lots following the methodology described in NPC-300. Note, according to NPC-300, vacant lands must be accessible in order to be assessed. Part of the vacant land directly east of the Project (i.e., south of R09) is within the Project boundary and was considered inaccessible, as the existing road that appeared to previously provide access is now within the Project boundary. Therefore, the vacant lands directly east of the Project were not assessed. In addition, as noted by the MECP, if noise mitigation for vacant land receptors is required for the Project to meet applicable sound level limits (discussed in Section 4.2), installation of these mitigation measures will be deferred to future dates following the development and occupation of sensitive-use buildings on these vacant lands. The City does not plan on building sensitive-use buildings on these vacant lands and therefore it is expected that mitigation measures will not be required.

Figure 1 presents all of the PORs that were identified within the Site-vicinity Study Area. A total of 11 of the identified PORs were selected as being representative of the most sensitive PORs in the Site-vicinity Study Area with respect to the Project for further assessment, which are summarized in Table 1.

Table 1: Summary of Representative Points of Reception Locations

Point of Reception ID	Description	UTM Coordinates (NAD83, Zone 17T)
R01	City-owned vacant lot directly west of the Site Area	480497 mE 4747525 mN
R02	City-owned vacant lot directly west of the Site Area	480554 mE 4747106 mN
R04	City-owned vacant lot 300 m east of the Site Area	482626 mE 4747261 mN
R06	Non-City owned vacant lot directly south of the Site Area	481951 mE 4746989 mN
R10	City-owned two storey residence 120 m northeast of the Site Area	481841 mE 4748321 mN
R15	Non-City owned two storey residence directly south of the Site Area	481544 mE 4746930 mN
R16	Non-City owned two storey residence 100 m northwest of the Site Area	480383 mE 4748259 mN
R19	Non-City owned two storey residence 1500 m east of the Site Area and 20 m from the Haul Route	483447 mE 4748476 mN
R23	Non-City owned one storey residence 1700 m east of the Site Area and 100 m from the Haul Route	483248 mE 4749075 mN
R25	Non-City owned one storey residence 1400 m east of the Site Area and 40 m from the Haul Route	483698 mE 4747304 mN
R50	City owned two storey residence 600 m east of the Site Area and 20 m from the Haul Route	482888 mE 4747138 mN

4.2 Noise Criteria

The methodology used for the noise assessment was based on the MECP publications “*Noise Guidelines for Landfill Sites*” (Landfill Guidelines) (MECP 1998) and NPC-300 (MECP 2013). These guidelines outline the sound level limit criteria for evaluating landfilling operations and ancillary facilities (i.e., stationary noise sources).

The noise assessment was carried out at the representative PORs identified within the Site-vicinity Study Area, as discussed in Section 4.1. All representative PORs identified in this noise assessment are conservatively described as being located in a Class 3 area, as defined

in NPC-300 as a rural area with an acoustical environment that is dominated by natural sounds.

The sound level limits for the Project landfilling operations are established in the Landfill Guidelines as 55 dBA and 45 dBA during the daytime period (i.e., 07:00 to 19:00) and nighttime period (i.e., 19:00 to 07:00) respectively.

The Landfill Guidelines also outline the protocol for evaluating off-site vehicle traffic for which there are no specific sound level limits. In accordance with the Landfill Guidelines, the potential noise impact of off-site vehicles on the existing noise environment is described qualitatively based on a quantitative assessment of the potential increase to the one hour equivalent sound level ($L_{eq,1hr}$), as described in Table 2.

Table 2: Landfill Guidelines Qualitative Noise Impact Ratings for Off-site Vehicles

Sound Level Increase (dB)	Qualitative Rating
1 to 3 inclusive	Insignificant
3 to 5 inclusive	Noticeable
5 to 10 inclusive	Significant
10 and over	Very significant

The sound level limits for the Project ancillary facilities are established in accordance with NPC-300 for the daytime (07:00 to 19:00), evening (19:00 to 23:00), and nighttime (23:00 to 07:00) periods. In assessing steady sounds from stationary noise sources, the MECP has established exclusionary Plane of Window (POW) and outdoor sound level limits for Class 3 areas. The POW is typically assessed at the center of a window (i.e., for a two-storey home, typically it would be at a height of 4.5 m above grade). An outdoor location is assessed at a location within 30 m of a dwelling façade at a height of 1.5 m above grade. The POW sound level limit for the noise sensitive receptors in a Class 3 area is described as follows:

The sound level limit at a POW POR is set as the higher of either the applicable exclusionary limit of 45 dBA in the daytime period of 07:00-19:00, 40 dBA in the evening period of 19:00-23:00 and 40 dBA in the night-time period of 23:00-07:00, or the minimum background sound level that occurs or is likely to occur during the time period corresponding to the operation of the stationary source under impact assessment.

The outdoor sound level limit for the noise sensitive receptors in a Class 3 area is described as follows:

The sound level limit at an outdoor POR is set as the higher of either the applicable exclusionary limit of 45 dBA in the daytime period of 07:00-19:00 and 40 dBA in the evening period of 19:00-23:00, or the minimum background sound level that occurs or is likely to occur during the time period corresponding to the operation of the stationary source under impact assessment. In general, the outdoor POR will be protected during the night-time as a consequence of meeting the sound level limit at the adjacent POW.

Note that for vacant lands, the location of the POR was assessed in accordance with NPC-300; either at the centre of the vacant lot, or within a 1 hectare portion of the vacant lot

located in a manner consistent with the existing zoning by-law and the typical building pattern in the area, at a height of 4.5 m above grade.

The one hour equivalent sound level ($L_{eq,1hr}$) MECP exclusionary sound level limits for steady sounds from stationary noise sources at a POR in a Class 3 area are summarized in Table 3, and used to assess compliance of the Project. The potential Project noise levels at each of the existing residences were predicted at both the POW and outdoor POR, but only the results from the location with the highest levels (i.e., POW or outdoor) are shown.

Table 3: Sound Level Limits for Class 3 Area – Steady Stationary Sources

Time Period	POW MECP Exclusionary Sound Level Limit (dBA)	Outdoor MECP Exclusionary Sound Level Limit (dBA)
	Class 3	Class 3
Daytime (07:00 – 19:00)	45	45
Evening (19:00 – 23:00)	40	40
Nighttime (23:00 – 07:00)	40	not applicable

As the testing of emergency equipment is limited to a periodic basis, the MECP allows for an increase to the exclusionary sound level limit. NPC-300 outlines the emergency equipment sound level limits as follows:

The sound level limits for noise produced by emergency equipment operating in non-emergency situations, such as testing or maintenance of such equipment, are 5 dB greater than the sound level limits otherwise applicable to stationary sources.

The noise produced by emergency equipment operating in non-emergency situations should be assessed independently of all other stationary sources of noise. Specifically, the emissions are not required to be included with the overall noise assessment of a stationary source facility.

Therefore, the stationary sources sound level limits presented in Table 3 above were increased by 5 dB when assessing the testing of emergency equipment.

For impulsive sounds from a stationary source, the sound level limit at a POR expressed in terms of the Logarithmic Mean Impulse Sound Level (L_{LM}) is the higher of: the applicable exclusionary level limit given in Tables 4 and 5 for the POW and outdoor POR, or the background sound level for that POR.

Table 4: Stationary Sources (Impulsive Sounds) - Exclusionary Sound Level Limit Values of Logarithmic Mean Impulse Sound Level (L_{LM} , dBA) POW of Noise Sensitive Spaces

Actual Number of Impulses in Period of One-Hour	Class 1 Area (07:00-23:00)/ (23:00-07:00)	Class 2 Area (07:00-23:00)/ (23:00-07:00)	Class 3 Area (07:00-19:00)/ (19:00-07:00)	Class 4 Area (07:00-23:00)/ (23:00-07:00)
9 or more	50/45	50/45	45/40	60/55

Actual Number of Impulses in Period of One-Hour	Class 1 Area (07:00-23:00)/ (23:00-07:00)	Class 2 Area (07:00-23:00)/ (23:00-07:00)	Class 3 Area (07:00-19:00)/ (19:00-07:00)	Class 4 Area (07:00-23:00)/ (23:00-07:00)
7 to 8	55/50	55/50	50/45	65/60
5 to 6	60/55	60/55	55/50	70/65
4	65/60	65/60	60/55	75/70
3	70/65	70/65	65/60	80/75
2	75/70	75/70	70/65	85/80
1	80/75	80/75	75/70	90/85

Table 5: Stationary Sources (Impulsive Sounds) - Exclusionary Sound Level Limit Values of Logarithmic Mean Impulse Sound Level (L_{LM}, dBAI) Outdoor POR

Time of Day	Actual Number of Impulses in Period of One-Hour	Class 1 Area	Class 2 Area	Class 3 Area	Class 4 Area
07:00 - 23:00	9 or more	50	50	45	60
	7 to 8	55	55	50	65
	5 to 6	60	60	55	70
	4	65	65	60	75
	3	70	70	65	80
	2	75	75	70	85
	1	80	80	75	90

Impulsive sounds from stationary noise sources are currently not expected. Administrative controls as part of the normal landfill site operations are expected to minimize any potential impulsive sounds (i.e., tailgate slamming, equipment driving over the weigh scale or ruts in on site roadways, movement of waste containers). Therefore, due to the inherent administrative controls, it is expected that impulsive noise will not be a substantial noise source on-site and, accordingly, was not further assessed.

4.3 Existing Conditions and Impact Assessment

A desktop assessment was completed to establish the existing conditions in the acoustic environment Site-vicinity Study Area and assess the potential impacts due to the Project. Existing noise levels in the Site-vicinity Study Area are influenced by vehicle traffic, existing landfill operations and operations of other facilities within the Site-vicinity Study Area, such as the aggregate pits to the north and the MRF to the east of the Project.

Based on Section 2.0 and information provided by the City, noise levels from the following activities were assessed to determine existing conditions and potential impacts due to the Project:

- landfilling operations, which are comprised of the following scenarios:
 - normal operations (07:00 to 17:00);
 - site preparation (06:00 to 07:00);
 - building a berm (daytime only);
 - placement of daily cover (17:00 to 18:00); and
 - disposal of dewatered biosolids (24-hour operations).
- landfill ancillary equipment, including emergency diesel generator testing; and
- landfill traffic along off-site Haul Routes.

It was assumed that the landfilling operations scenarios do not occur concurrently. Other activities associated with the landfill may occur but are expected to result in lower noise impacts when compared with the activities listed above and therefore were not further assessed. The landfill does not use pest control devices and there are no plans to use them in the future; therefore no assessment was carried out.

To establish existing conditions, the assessment of existing landfill operations considered daily landfilling operations (normal operations, site preparation, and placement of daily cover), landfill ancillary equipment, and existing landfill traffic along the off-site Haul Routes. It was assumed that daily landfilling operations occurred in the western portion of the landfill (i.e., Phase 2 of landfill area).

Project-specific on-site and off-site noise measurements were completed to support with the noise assessment. The following sections outline the noise measurements conducted to characterize the primary noise sources associated with existing and Project activities, and the modelling completed to establish existing and Project noise levels.

4.3.1 Short-term Monitoring

A noise field study was carried out to characterize existing noise levels in the Site-vicinity Study Area. This noise field study was completed on 15 July 2020 and involved short-term noise monitoring at ten off-site locations shown in Figure 1 to collect existing noise levels during the daytime period. The noise field study focused on understanding how the vehicle traffic, existing landfill operations and operations of other facilities within the Site-vicinity Study Area, such as the aggregate pits to the north and the MRF to the east of the Project, influenced the existing acoustic environment.

The short-term noise monitoring was carried out using a Larson Davis 831 sound level meter for monitoring periods ranging from 5 to 10 minutes in duration. The short-term monitoring locations were carried out on readily accessible public areas near the identified representative receptors, which were generally along the edge of the roads. The calibration of the instrumentation was verified before and after the measurements with the use of a hand-held calibrator. All measuring equipment used in this study meets the MECP requirements.

4.3.2 Landfill Equipment Sound Level Measurements

Source sound level measurements were carried out at the existing landfill to establish noise emissions of the existing sources of noise to support the characterization of existing noise

levels and assessment for potential Project noise impacts in the Site-vicinity Study Area. Measurements were conducted with a Larson Davis Model 831 sound level meter/realtime analyzer on 24 August 2020. This instrument provides the spectral (i.e., frequency) characteristics of the sound sources under review and is a valuable tool for identifying, quantifying and ranking noise source emissions from equipment at a given POR. The calibration of the instrumentation was verified before and after the measurements with the use of a hand-held calibrator. All measuring equipment used in this study meets the MECP requirements.

4.3.3 Noise Prediction Modelling

Noise predictions were carried out using the Computer Aided Noise Attenuation (CadnaA) noise modelling software to establish the existing conditions, and support the assessment of potential Project noise impacts within the Site-vicinity Study Area. The CadnaA noise modelling software (version 2020 MR 1), developed by DataKustik GmbH, is widely accepted for evaluating environmental noise. Numerous algorithms are made available for use within CadnaA but, for the purposes of the EA, the model algorithm International Organization for Standardization (ISO) 9613 Acoustics: Attenuation of Sound during Propagation Outdoors (ISO 1993 and 1996) was considered for the landfill noise sources and RLS-90 was considered for the road traffic sources. A summary of CadnaA model input parameters is presented in Table 6.

Table 6: CadnaA Model Input Parameters

Parameter	Model Setting	Notes
Software	CadnaA Version 2020 MR 1	CadnaA is a widely used environmental noise monitoring software package developed by DataKustik GmbH
Standards	ISO 9613-2 (landfill equipment) RLS-90 (road traffic)	All sources and attenuation effects were treated as required by this standard
Ground effect	G = 0 (paved roads) G = 1 (rest of site and Site-vicinity Study Area)	
Temperature/ humidity	10°C / 70% relative humidity	
Other meteorological conditions	Wind: 1 to 5 m/s; all receivers downwind from all sources; or Temperature Inversion: Moderate temperature inversion	Consistent with standard ISO 9613-2
Receptor height	1.5 m (outdoor PORs, POW one-storey homes) 4.5 m (vacant lots, POW two-storey homes)	
Terrain	Contour lines (254 to 316 masl)	Terrain has been accounted for in the model within the Site-vicinity Study Area.

4.3.3.1 Landfill Equipment

The noise predictions for landfill equipment were carried out using CadnaA using the ISO 9613 modelling algorithm. The ISO 9613 prediction method is conservative as it assumes that all PORs are downwind from the noise source or that a moderate ground-based temperature inversion exists. In addition, ground cover and physical barriers, either natural (terrain-based) or constructed and atmospheric absorption are included as they relate specifically to the Project. Noise sources for the landfill equipment were characterized by entering the sound power and/or sound pressure octave band spectrum associated with each source. Other parameters including building dimensions, frequency of use, hours of operation, and enclosure attenuation ratings also define the nature of sound emissions.

The landfill expansion will be developed sequentially in eight Phases, 1E through 8E, progressing from the west side of the landfill towards the east. All landfill operation sources operating within the active area of a phase were modelled as a 25 m by 40 m area source, based on the active area of exposed waste discussed in Section 2.0. For all landfill operations except for building a berm, it was assumed the active area will be located a minimum of 20 m from the edge of the area of new waste placement to allow for the building of a working berm. Source operations, locations and elevations for each of the modelling scenarios were selected such that the predicted Site-vicinity Study Area noise levels were expected to result in the worst-case noise predictions at all representative PORs.

4.3.3.2 Road Traffic

The noise predictions for road traffic were carried out using CadnaA with the RLS-90 modelling algorithm to characterize existing noise levels and assessment of potential Project noise impacts within the Site-vicinity Study Area. Based on past experience, using RLS-90 for the road traffic sources provide prediction results consistent with actual noise levels and those predicted using the MECP's Ontario Road Noise Analysis Method for Environment and Transportation (ORNAMENT), which is the basis of the DOS-based STAMSON modelling software provided by the MECP. The MECP's ORNAMENT was used to verify the CadnaA noise predictions with respect to the road traffic in the Site-vicinity Study Area. Road traffic was assessed over a 16-hour daytime period (07:00 to 23:00) and an 8-hour nighttime period (23:00 to 07:00).

Existing and anticipated Project noise levels due to road traffic were established using Annual Average Daily Traffic (AADT) provided by the City or, for Highway 401 and Highway 402, from published data from the Ontario Ministry of Transportation (MTO) (MTO 2016). The daytime and nighttime period percentages and total truck percentages for local roadways were provided by the City. The total truck percentage was divided into medium and heavy trucks based on either the "Adaptation and Verification of AASHTO Pavement Design Guide for Ontario Conditions – Final Report" (ERES Consultants 2008), which provides medium and heavy truck percentages based on road classification for local roadways, and on the MTO Environmental Guide for Noise (MTO 2006) for Highway 401 and Highway 402. Speed limits were provided by the City/MTO or determined from readily available public imagery.

A summary of the road traffic data is provided in Table 7.

Table 7: Summary of Existing and Project Road Traffic Data

Road Segment	Speed Limit (km/hr)	Existing Traffic				Traffic – With Project			
		AADT	Daytime / Nighttime Breakdown	% Car / Medium Truck / Heavy Truck		AADT	Daytime / Nighttime Breakdown	% Car / Medium Truck / Heavy Truck	
				Day	Night			Day	Night
Wonderland Road north of Manning Drive	80	9100	90 / 10	97 / 1 / 2	97 / 1 / 2	9133	90 / 10	96 / 1 / 3	97 / 1 / 2
Wonderland Road south of Manning Drive	80	9100	90 / 10	97 / 1 / 2	97 / 1 / 2	9100	90 / 10	97 / 1 / 2	97 / 1 / 2
Manning Drive west of White Oak Road	70	345	94 / 6	63 / 1 / 36	94 / 0 / 6	378	95 / 5	61 / 1 / 38	94 / 0 / 6
Manning Drive between White Oak Road and landfill entrance	70	355	94 / 6	61 / 1 / 38	93 / 0 / 7	390	95 / 5	60 / 1 / 39	93 / 0 / 7
Manning Drive between landfill entrance and Wellington Road	80	562	96 / 4	45 / 1 / 54	85 / 0 / 15	644	97 / 3	44 / 1 / 55	85 / 0 / 15
Manning Drive east of Wellington Road	80	210	90 / 10	96 / 0 / 4	100 / 0 / 0	213	91 / 9	95 / 0 / 5	100 / 0 / 0
Wellington Road north of Scotland Drive	70	14200	90 / 10	96 / 1 / 3	96 / 1 / 3	14279	90 / 10	96 / 1 / 3	96 / 1 / 3
Wellington Road between Scotland Drive and Manning Drive	80	14200	90 / 10	96 / 1 / 3	96 / 1 / 3	14279	90 / 10	96 / 1 / 3	96 / 1 / 3
Wellington Road south of Manning Drive	80	14200	90 / 10	96 / 1 / 3	96 / 1 / 3	14200	90 / 10	96 / 1 / 3	96 / 1 / 3
Dingman Drive	60	4000	90 / 10	93 / 3 / 4	93 / 3 / 4	4000	90 / 10	93 / 3 / 4	93 / 3 / 4
Westminster Drive	80	1000	90 / 10	98 / 2 / 0	98 / 2 / 0	1000	90 / 10	98 / 2 / 0	98 / 2 / 0
Scotland Drive	80	280	Cars – 90 / 10 Trucks – 97 / 3	85 / 13 / 2	85 / 13 / 2	280	Cars – 90 / 10 Trucks – 97 / 3	85 / 13 / 2	85 / 13 / 2
Decker Drive	60	900	90 / 10	98 / 2 / 0	98 / 2 / 0	900	90 / 10	98 / 2 / 0	98 / 2 / 0
Morrison Road	80	180	90 / 10	63 / 33 / 4	63 / 33 / 4	180	90 / 10	63 / 33 / 4	63 / 33 / 4
White Oak Road south of Manning Drive	60	1350	90 / 10	93 / 6 / 1	93 / 6 / 1	1350	90 / 10	93 / 6 / 1	93 / 6 / 1
White Oak Road north of Manning Drive	80	1350	90 / 10	93 / 6 / 1	93 / 6 / 1	1352	90 / 10	93 / 6 / 1	93 / 6 / 1
Highway 401	100	28500	90 / 10	80 / 5 / 15	80 / 5 / 15	28500	90 / 10	80 / 5 / 15	97 / 2 / 0
Highway 402	110	28500	90 / 10	80 / 5 / 15	80 / 5 / 15	28500	90 / 10	80 / 5 / 15	80 / 5 / 15

Notes: Daytime (07:00 – 23:00), Nighttime (23:00 – 07:00)

4.4 Effects Characterization

To determine potential adverse effects from the Project, two criteria were used. The first was a comparison against applicable noise limits, and the second was an assessment of changes to noise levels relative to existing noise levels at the most sensitive PORs within the Site-vicinity Study Area. These changes were assessed against the magnitude ratings identified in Table 8.

A change in level of 3 dB is generally accepted as the smallest change detectable by the human auditory system in the environment (MECP 1998). Changes in noise levels for the period L_{eq} (A-weighted energy equivalent sound level) that would be hardly perceptible (i.e., less than or equal to 3 dB) were assigned a negligible magnitude. A noticeable change in the period L_{eq} (i.e., greater than 3 dB, but less than or equal to a 5 dB change, based on Table 2) was classified as having a low magnitude. Clearly noticeable changes in the period L_{eq} , perceived as less than twice as loud (i.e., greater than 5 dB, but less than or equal to 10 dB), were considered of moderate magnitude. Very significant changes in the noise levels for the period L_{eq} that are perceived as more than twice as loud (i.e., greater than 10 dB) were classified as having a high magnitude.

A potential adverse effect is expected when a magnitude rating of moderate or high is predicted.

Table 8: Magnitude Ratings For Potential Noise Effects

Magnitude	Criteria
Negligible	<ul style="list-style-type: none"> Project related noise levels do not exceed MECP sound level limits; and Project related change relative to existing noise levels in daytime and nighttime equivalent noise level is ≤ 3 dB.
Low	<ul style="list-style-type: none"> Project related noise levels do not exceed MECP sound level limits; and Project related change relative to existing noise levels in daytime and nighttime equivalent noise level is > 3 dB and ≤ 5 dB.
Moderate	<ul style="list-style-type: none"> Project related noise levels do not exceed MECP sound level limits; and Project related change relative to existing noise levels in daytime and nighttime equivalent noise level is > 5 dB and ≤ 10 dB.
High	<ul style="list-style-type: none"> Project related noise levels exceed MECP sound level limits; or Project related change relative to existing noise levels in daytime and nighttime equivalent noise level is > 10 dB.

5.0 NOISE EMISSIONS

Noise emissions from the existing landfill operations were used as inputs for the noise prediction model to establish existing noise levels and for the assessment of potential Project noise impacts in the Site-vicinity Study Area at identified PORs.

5.1 Landfill Operations Noise Emissions

The assessment considered the noise emissions associated with the landfilling operations for both the existing landfill and the Project. Table 9 provides a summary of: the overall sound power data for each noise source considered in the assessment of landfilling operations; during which scenarios each piece of equipment is expected to operate and; the expected quantity. This landfill equipment was considered for both existing and Project landfill operations. Noise emissions (i.e., sound power levels) were established using the Project information, Golder's database of similar noise sources, manufacturers' specifications, and on-site noise measurements discussed in Section 4.3.2.

It was conservatively assumed that when a piece of equipment was operating during a certain scenario, it would operate continuously for any one-hour period when assessing compliance with MECP sound level limits.

Table 9: Sound Power Data for Landfilling Operations Noise Sources

Source	Quantity					Overall Sound Power Level (dBA)
	Normal Operations (07:00 to 17:00)	Site Preparation (06:00 to 07:00)	Building a Berm (Daytime)	Placement of Daily Cover (17:00 to 18:00)	Disposal of Biosolids (24 hours)	
Compactor	2	1	0	2	0	111
Large Crawler Dozer	1	0	0	0	0	113
Medium Crawler Dozer	1	0	1	0	0	110
Tracked Excavator	1	0	1	0	1	105
Rock Truck	1	0	1	0	0	108
Front End Loader	1	0	0	0	0	108
Flusher Truck	1	0	0	0	0	107
Generator for lights	0	0	0	0	1	96
Existing Waste Truck ¹	22	0	0	0	1	102
Project Waste Truck ¹	28	0	0	0	1	102

Notes:

¹ 22 (existing) or 28 (Project) waste trucks per hour are expected to arrive to the landfill during the maximum worst case predictable hour, travelling along main haul roads on-site

dBA = A-weighted decibels

5.2 Ancillary Equipment Noise Emissions

The existing landfill includes a landfill gas collection system including a blower building and flare stack, exhaust fans on the Household Special Waste building, two pumping stations, heating, ventilation and air conditioning (HVAC) units on several on-site buildings, and two emergency diesel generators. The Project will include expanding the flare capacity with a second flare, and the installation of HVAC units on the new on-site buildings. Table 10 provides a summary of the overall sound power data for each noise source considered in the assessment of ancillary equipment for existing and Project landfill operations. Noise emissions (i.e., sound power levels) were established using the Project information, manufacturers' specifications, and on-site noise measurements.

The periodic testing of the emergency diesel generators will be limited to daytime periods, each tested concurrently for 20 minutes three times per year. As a conservative assessment, this has been included in the EA but as per NPC-300 it may be considered an infrequent event and would typically not need to be considered.

Table 10: Sound Power Data for Ancillary Facilities Noise Sources

Source	Quantity	Overall Sound Power Level (dBA) ²
Emergency Diesel Generator ¹	2	100
Existing Flare Station	1	94
Future Flare Station	1	94
Household Special Waste Fumehood Exhaust Fan (West)	1	90
Household Special Waste Fumehood Exhaust Fan (South)	1	86
Existing Flare Stack	1	Insignificant noise source
Future Flare Stack	1	Insignificant noise source
Existing HVAC	1	Insignificant noise source
Project HVAC	8	Insignificant noise source
Pumping Station	2	Insignificant noise source

Notes:

¹ The periodic testing of the emergency diesel generators will be limited to daytime periods, each tested concurrently for 20 minutes up to three times a year.

² Noise sources identified as insignificant are not substantial noise sources relative to the other equipment and are not expected to significantly contribute to noise levels at a representative POR. This determination is based on information provided and/or site observations.

6.0 EXISTING CONDITIONS

6.1 Short-term Monitoring Results

The existing acoustic environment in the Site-vicinity Study Area is dominated primarily by road traffic along the local roads and, at certain PORs, existing landfill operations and other facilities in the Site-vicinity Study Area. Table 11 summarizes the locations (shown in Figure 1) and measured noise levels at each of the 10 monitoring locations. Note that the short-term monitoring locations were on readily accessible public areas near the identified representative receptors, which were generally along the edge of the roads.

Table 11: Summary of Short-term Noise Monitoring Results

Noise Measurement ID	Noise Monitoring Location	UTM Coordinates (NAD83 17T)	Measured L_{eq} (dBA) ¹	Measured L_{90} (dBA) ²
M01	Scotland Drive east of R11	482081 mE 4748407 mN	64	37
M02	Scotland Drive west of R09	481151 mE 4748286 mN	68	42
M03	White Oak Road adjacent to R02	480603 mE 4747115 mN	55	49
M04	Manning Drive between R06 and R07	482168 mE 4747050 mN	66	43
M05	Wellington Road north of R25	483644 mE 4747509 mN	75	55
M06	Wellington Road across from R20	483510 mE 4748342 mN	75	59
M07	Scotland Drive between R12 and R17	480016 mE 4748166 mN	67	48
M08	Manning Drive west of R03	480171 mE 4746808 mN	55	36
M09	Manning Drive between R08 and R50	482690 mE 4747110 mN	60	40
M10	Glanworth Drive between R42 and R43	482097 mE 4745785 mN	75	45

Notes:

¹ L_{eq} – Equivalent (average) sound pressure level

² L_{90} – Average sound pressure level exceeded 90% of the time

6.2 Modelling Results

As discussed in Section 4.3, existing noise levels in the Site-vicinity Study Area are influenced by vehicle traffic, existing landfill operations and operations of other facilities within the Site-vicinity Study Area. In completing a conservative assessment, these other facilities were not assessed in quantifying existing noise levels. Existing noise levels were evaluated as an average over the daytime (07:00 to 23:00) and nighttime (23:00 to 07:00) periods.

Noise levels due to existing traffic were predicted using RLS-90 in CadnaA, and calibrated to ORNAMENT as discussed in Section 4.3.3.2. Predicted road traffic noise levels are presented in Table 12.

Existing landfill operations were predicted over the entire daytime and nighttime periods, considering Normal Operations, Site Preparation, Placement of Daily Cover, and ancillary equipment, as described in Section 4.3. These landfill operating scenarios were time-weighted accordingly, based on the operating hours specified in Section 4.3. Predicted existing landfill operations noise levels at representative PORs are presented in Table 12.

The overall existing noise levels, shown in Table 12, were calculated by combining the existing road traffic noise levels and the existing landfill operations noise levels.

Table 12: Predicted Existing Noise Levels

Receptor	Existing Average Road Traffic Noise Level (dBA)		Existing Average Landfill Operations Noise Level (dBA)		Existing Overall Average Noise Level (dBA)	
	Day	Night	Day	Night	Day	Night
R01	52	45	50	34	54	46
R02	52	45	50	35	54	45
R04	50	36	35	20	50	36
R06	50	36	46	30	51	37
R10	46	37	43	27	48	37
R15	49	35	51	37	53	39
R16	58	49	40	25	58	49
R19	65	59	30	14	65	59
R23	55	48	31	15	55	48
R25	62	56	31	14	62	56
R50	60	44	36	20	60	44

In general, the noise levels from the short-term monitoring illustrated in Table 11 exceeded the predicted overall existing noise levels shown in Table 12, by an average of 5 dB and up to 14 dB. The largest differences were observed when measurements were taken near other facilities in the Site-vicinity Study Area (i.e., the aggregate pits north of the landfill and the MRF to the east). Site observations indicated these other facilities were major sources of noise for some receptors. Therefore, it is expected that the predicted overall existing noise levels shown in Table 12 are generally underestimated, resulting in a conservative assessment for Project related change relative to existing noise levels.

Note that when establishing the applicable sound level limits to assess compliance of the landfill with MECP guidelines, the noise emissions associated with the existing landfill were not considered and therefore the MECP's most restrictive (i.e., Class 3) exclusionary sound level limits were conservatively considered in this assessment. It is also noted that Highway 401 is expected to influence the acoustical environment in parts of the Site-vicinity Study Area, but was conservatively not considered in establishing the background noise levels.

7.0 IMPACT ASSESSMENT

7.1 Potential Noise Effects

The following presents the noise prediction results of: Project landfilling operations, ancillary equipment, and traffic on the off-site Haul Routes, which were considered in both the assessment of compliance with MECP guidelines (if applicable) and the change due to the Project relative to existing noise levels. Therefore, noise predictions of landfilling operations, ancillary equipment, and off-site Haul Routes were each assessed independently against the MECP guidelines (where applicable), and then combined to assess change relative to existing noise levels.

7.1.1 Compliance with MECP Guidelines

7.1.1.1 Landfilling Operations

Table 13 and Table 14 provide a summary of the predictable worst case hour predicted noise levels for the landfill operation scenarios described in Section 4.3 during the daytime (07:00 to 19:00) and nighttime (19:00 to 07:00) periods, respectively. Noise levels were predicted at the identified representative PORs within 500 m of the Site Area.

Noise predictions were carried out for the five scenarios representing the landfill operations of the Project. Normal Operations, Placement of Daily Cover, and Building a Berm are expected to occur during the daytime only and therefore are compared to the Landfill Guidelines daytime sound level limit of 55 dBA. Site Preparation and Disposal of Dewatered Biosolids may occur during the nighttime and therefore are compared to the Landfill Guidelines nighttime sound level limit of 45 dBA. The following tables also include the applicable Landfill Guidelines sound level limit; bold values indicate predicted noise levels that exceed the sound level limit.

Table 13: Daytime Landfilling Operations Predictable Worst Case Noise Predictions

Receptor	Normal Operations Noise Level (dBA)	Placement of Daily Cover Noise Level (dBA)	Berm Building Noise Level (dBA)	Landfill Guidelines Daytime Sound Level Limit (dBA)
R01	58	53	53	55
R02	58	53	53	55
R04	48	42	42	55
R06	57	52	52	55
R10	51	46	46	55
R15	55	50	49	55
R16	49	44	44	55

Note: **Bold** indicates predicted noise levels that exceed Landfill Guidelines sound level limits

Table 14: Nighttime Landfilling Operations Predictable Worst Case Noise Predictions

Receptor	Site Preparation Noise Level (dBA)	Disposal of Dewatered Biosolids Noise Level (dBA)	Landfill Guidelines Nighttime Sound Level Limit (dBA)
R01	50	44	45
R02	49	44	45
R04	39	34	45
R06	49	44	45
R10	43	38	45
R15	47	41	45
R16	41	36	45

Note: **Bold** indicates predicted noise levels that exceed Landfill Guidelines sound level limits

The results presented in Table 13 and Table 14 indicate that mitigation is required for Normal Operations (at R01, R02 and R06) and Site Preparation (at R01, R02, R06 and R15) scenarios to meet the Landfill Guidelines sound level limits. Mitigation is further discussed in Section 7.2.

7.1.1.2 Ancillary Equipment

Table 15 provides a summary of the predictable worst case hour predicted noise levels due to ancillary equipment and testing of emergency diesel generators at the identified representative PORs within 500 m of the Site Area. The predicted noise levels from the ancillary equipment are compared to the nighttime NPC-300 stationary source sound level limits, as it is expected the equipment will operate continuously for 24 hours per day and the nighttime limits are more stringent. Testing of the emergency diesel generators will be limited to the daytime period, as per the operating conditions in Section 5.2, and therefore the results are compared to the daytime NPC-300 sound level limits for emergency equipment.

As shown in Table 15, the ancillary equipment and emergency diesel generators are expected to operate below the NPC-300 sound level limits at the representative PORs.

Table 15: Ancillary Equipment / Emergency Generator Predictable Worst Case Noise Predictions

Receptor	Ancillary Equipment Noise Level (dBA)	NPC-300 Nighttime Stationary Source Sound Level Limit (dBA)	Emergency Diesel Generator Noise Level (dBA)	NPC-300 Daytime Emergency Equipment Sound Level Limit (dBA)
R01	10	40	7	50
R02	15	40	23	50
R04	16	40	18	50
R06	26	40	38	50
R10	7	40	7	50
R15	34	40	31	50
R16	9	40	5	50

7.1.1.3 Off-Site Haul Route

As discussed in Section 4.2, the Landfill Guidelines outline the protocol for evaluating the noise impact due to off-site haul road vehicles. The Haul Routes consist of Manning Drive via Wonderland Road to the west and Manning Drive via Wellington Road South to the east. It is expected that in the future there will be a 25% increase in landfill heavy truck traffic and a 20% increase in other landfill vehicle traffic over the existing landfill traffic.

Predicted noise levels due to the daytime average existing landfill traffic were compared to noise levels due to future expected traffic (i.e., existing plus the Project) during the predictable worst case hour. Table 16 summarizes the expected change between future and existing noise levels at representative PORs along the Haul Routes as well as the associated qualitative rankings (as summarized in Table 2 in Section 4.2). Results are shown for all representative PORs in Table 1 that are located within 500 m of the Haul Routes.

Table 16: Predicted Change in Noise Levels along Haul Routes

Receptor	Existing Traffic Average Noise Level (dBA)	Project Traffic Worst Case Hour Noise Level (dBA)	Change in Noise Level (dB)	Qualitative Rating ¹
R02	52	52	0	Insignificant
R04	50	53	3	Insignificant
R06	50	54	4	Noticeable
R15	49	53	4	Noticeable
R19	65	67	2	Insignificant
R23	55	56	1	Insignificant
R25	62	64	2	Insignificant
R50	60	64	4	Noticeable

Note: 1. See Table 2 for details of qualitative ranking system

The results in Table 16 indicate that during the Project predictable worst case hour, the change in noise levels ranges from insignificant to noticeable. The noticeable changes occur on Manning Drive, where the landfill contributes a large portion of the traffic.

If it was assumed that the future maximum Project traffic occurs during the same hour as the current maximum landfill traffic along the local roadways, the predicted change due to the Project would be insignificant at all PORs, as a 20% to 25% increase in traffic would be expected to increase noise levels by less than 3 dB. As it is unknown if the existing and Project peak hours will align, the existing average daytime traffic was conservatively considered.

7.1.2 Change from Existing Noise Levels

In addition to meeting compliance with MECP guidelines, the change relative to existing noise levels within the Site-vicinity Study Area was evaluated. The combined noise levels from all significant noise sources during the predictable worst case daytime and nighttime periods were calculated, based on the operating hours of each scenario presented in Section 4.3.

Noise levels were evaluated as an average over the daytime (07:00 to 23:00) and nighttime (23:00 to 07:00) periods. Table 17 summarizes: the existing noise levels, the predictable worst case Project noise levels, and the corresponding change and magnitude rating, as defined in Table 8, at the identified representative PORs.

Table 17: Predicted Daytime and Nighttime Noise Levels and Change from Baseline due to the Project

Receptor	Existing Noise Level (dBA)		Project Average Noise Level (dBA)		Change in Noise Level (dB)		Meets Applicable MECP Sound Level Limit ¹ (Yes/No)		Magnitude Rating ²	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R01	54	46	57	48	3	2	No	No	High	High
R02	54	45	57	48	3	3	No	No	High	High
R04	50	36	51	38	1	2	Yes	Yes	Negligible	Negligible
R06	51	37	57	45	6	8	No	No	High	High
R10	48	37	51	41	3	4	Yes	Yes	Negligible	Low
R15	53	39	55	44	2	5	Yes	No	Negligible	High
R16	58	49	58	49	0	0	Yes	Yes	Negligible	Negligible
R19	65	59	66	59	1	0	n/a	n/a	Negligible	Negligible
R23	55	48	55	48	0	0	n/a	n/a	Negligible	Negligible
R25	62	56	62	56	0	0	n/a	n/a	Negligible	Negligible
R50	60	44	60	45	0	1	n/a	n/a	Negligible	Negligible

Note: ¹ See Tables 13, 14 and 15 for assessment of compliance with MECP sound level limits.

² See Table 8 for details of qualitative ranking system.

The results in Table 17 and the assessment in Section 7.1.1 indicate that mitigation measures are required so that the Project does not result in an adverse effect on noise (i.e., a moderate or high magnitude rating) at specific receptors.

7.2 Mitigation Measures

The noise prediction results presented in Section 7.1 indicate that noise mitigation is required for the Project to meet the applicable MECP sound level limits at specific receptors. The following mitigation has been designed such that the landfilling operations satisfy the MECP sound level limits:

- When in the western section of Phase 1E or Phase 2E:
 - For all landfill operating scenarios, except for the Building a Berm scenario, working equipment within the active area must be behind a 5 m high berm when operating within 330 m of a POR to the west.
 - Note that the PORs to the west (i.e., R01 and R02) are all currently vacant and therefore implementation of this mitigation is not required unless a noise-sensitive building is constructed.

- When in the southern section of Phase 5E, Phase 7E, or the dedicated non-decomposable waste cell:
 - For all landfill operating scenarios, except for the Building a Berm scenario, working equipment must be behind a 5 m high berm when operating within 330 m of a POR to the south.
 - Site Preparation must not start before 07:00 when operating between 330 m and 380 m of a POR to the south.
 - Note that a POR does exist at 3691 Manning Drive (i.e., R15), but is located approximately 310 m from the edge of the area of new waste placement. As discussed in Section 4.3.3.1, the active area was located 20 m from the edge of the area of new waste placement and therefore a 5 m berm is not expected to be required. All other PORs to the south (i.e., R06) are all currently vacant and therefore implementation of this mitigation is not required for these PORs unless a noise-sensitive building is constructed.

Figure 2 shows the areas where mitigation is required based on the current existing receptor (i.e., R15).

As discussed in Section 2.0, in the southern phases the waste will initially be used to build a working berm along the south side of the phase. This working berm can act as the 5 m high berm described above in the areas where a berm is required; however, the height of the berm must be maintained 5 m above the working grade of the equipment, or an acoustically equivalent control will need to be implemented. In addition, when there is a requirement for the equipment to operate behind a berm, all equipment working in the active area must be within 50 m of the top of the berm.

The mitigation measures were developed such that the Normal Landfill Operations during the daytime period and the Site Preparation during the nighttime period would comply with the Landfill Guidelines. It was assumed that all other landfilling operation scenarios except for Building a Berm (i.e., Placement of Daily Cover and Disposal of Dewatered Biosolids) would occur behind the berm when operating under the conditions listed above.

7.3 Potential Mitigated Noise Effects

The following describes the mitigated noise prediction results of the landfilling operations with the noise controls described in Section 7.2 and the resulting change from existing noise levels.

7.3.1 Compliance with MECP Guidelines

Table 18 and Table 19 provide a summary of the mitigated predictable worst case hour predicted noise levels, with the noise controls described in Section 7.2, for the scenarios described in Section 4.3 at the identified representative PORs during the daytime and nighttime, respectively. The mitigated predicted noise levels at all of the identified representative PORs meet the Landfill Guidelines sound level limits.

Table 18: Mitigated Daytime Landfilling Operations Predictable Worst Case Noise Predictions

Receptor	Normal Operations Noise Level (dBA)	Daily Cover Noise Level (dBA)	Landfill Guidelines Daytime Sound Level Limit (dBA)
R01	55	49	55
R02	55	50	55
R04	48	40	55
R06	55	47	55
R10	51	46	55
R15	55	50	55
R16	49	44	55

Table 19: Mitigated Nighttime Landfilling Operations Predictable Worst Case Noise Predictions

Receptor	Site Preparation Noise Level (dBA)	Disposal of Dewatered Biosolids Noise Level (dBA)	Landfill Guidelines Nighttime Sound Level Limit (dBA)
R01	45	41	45
R02	45	41	45
R04	39	31	45
R06	45	38	45
R10	43	38	45
R15	45	41	45
R16	41	36	45

7.3.2 Change from Existing Noise Levels

The mitigated combined noise levels from all significant noise sources during the predictable worst case daytime and nighttime periods were calculated. Table 20 summarizes the: existing noise levels, the mitigated predictable worst case Project noise levels, and the corresponding change and magnitude rating, as defined in Table 8, at the identified representative PORs.

Table 20: Mitigated Predicted Daytime and Nighttime Noise Levels and Change from Baseline due to the Project

Receptor	Predicted Existing Noise Level (dBA)		Mitigated Predicted Project Noise Level (dBA)		Change in Noise Level (dB)		Meets Applicable MECP Sound Level Limit (Yes/No)		Magnitude Rating	
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
R01	54	46	56	47	2	1	Yes	Yes	Negligible	Negligible
R02	54	45	55	47	1	2	Yes	Yes	Negligible	Negligible
R04	50	36	51	38	1	2	Yes	Yes	Negligible	Negligible
R06	51	37	55	41	4	4	Yes	Yes	Low	Low
R10	48	37	51	41	3	4	Yes	Yes	Negligible	Low
R15	53	39	55	43	2	4	Yes	Yes	Negligible	Low
R16	58	49	58	49	0	0	Yes	Yes	Negligible	Negligible
R19	65	59	66	59	1	0	n/a	n/a	Negligible	Negligible
R23	55	48	55	48	0	0	n/a	n/a	Negligible	Negligible
R25	62	56	62	56	0	0	n/a	n/a	Negligible	Negligible
R50	60	44	60	45	0	1	n/a	n/a	Negligible	Negligible

Table 20 indicates that, with the implementation of the mitigation presented in Section 7.2, the Project is predicted to have a 'negligible' to 'low' magnitude impact on existing noise levels and therefore there are no likely adverse effects.

Note that the short-term monitoring indicated other sources of noise from facilities in the Site-vicinity Study Area (i.e., the aggregate pits north of the landfill and the MRF to the east) that were not considered in the existing noise level predictions could impact the acoustic environment in the Site-vicinity Study Area. As discussed in Section 6.2, measured daytime noise levels were higher by an average of 5 dB than predicted, which would reduce all mitigated magnitude impacts to 'negligible'.

7.4 Assessment of Potential Noise Effects

The noise modelling indicates that, with the implementation of noise mitigation: 1) the Project is expected to operate in compliance with MECP noise guidelines as specified in the Landfill Guidelines and NPC-300, and 2) the Project-related change in noise level is predicted to be between 0 and 5 dB, which results in a 'negligible' to 'low' magnitude at the identified representative PORs. Therefore, there are no likely adverse noise effects due to the Project.

Note that the impact assessment noise predictions considered when landfilling operations are expected to be predictable worst case and/or maximum noise levels (i.e., near the edges of the Project limit of waste). Ambient noise levels can be expected to increase by a noticeable

amount, on occasion, due to the landfilling operations at the identified representative PORs, but will be short-term relative to the life of the Project, occurring when the active area of the landfill approaches the identified representative PORs. The range in increased noise levels will depend primarily on the number, type and operating time of noise sources and their proximity to the PORs when operating within the active area. Based on the attenuation of sound due to distance and a lack of a direct line-of-sight between equipment and the receptors when the equipment is further set back, noise levels are expected to decrease when operating away from the edges of the Project limit of waste and the distance increases. Therefore, any noticeable increases in noise levels due to the Project are expected to be short-term in duration and become negligible as the Project progresses.

8.0 BEST MANAGEMENT PRACTICES

The following best management practices should be considered to help minimize potential noise effects due to the Project and should be implemented by the Project:

- Employ noise mitigation identified for the acoustic environment in Section 7.2.
- Limit landfill activities to the hours described in Section 4.3 to reduce the potential effect of noise on nearby PORs.
- All mobile equipment should be properly maintained according to manufacturers' recommendations and be in accordance with the noise emissions specified in Section 5.0 and MECP NPC-115 – Construction Equipment.
- When possible, maintain an acceptable setback distance from the identified PORs.
- Maintain on-site roadways to minimize vehicles travelling over ruts.
- Address noise concerns if they arise through a compliant resolution mechanism whereby persons can contact the landfill if there are perceived noise issues.
- Design on-site access roads to minimize reversing, which is expected to minimize use of backup warning devices where possible.
- Operate vehicles and equipment such that impulsive noise is minimized (i.e., truck tailgate closing), where possible.
- Where reasonable and practical, turn off vehicles and equipment when not in use, unless weather and/or safety conditions dictate the need for them to remain idling and in a safe operating condition.

9.0 MONITORING

A follow-up noise monitoring program is recommended for the Project when landfill operations are within 330 m of the existing residence to the south (i.e., R15) and if the residence is present when landfilling operations occur in the southern areas of Phase 5E and Phase 7E. Since the other identified representative PORs that are within the distances that trigger the requirement for noise mitigation specified in Section 7.2 are currently vacant, any noise mitigation at these locations is deferred until occupied with a noise sensitive use.

This noise monitoring program is recommended to verify the results of the noise prediction modelling carried out in this EA, to confirm the following: that the Project is operating in compliance with the applicable MECP guidelines, the effectiveness of the noise mitigation measures and to evaluate whether the Project is operating in accordance with the best management practices outlined in Section 8.0.

It is recommended the methodology of the noise monitoring program, including the frequency, timing, duration and selection of noise data to be collected, be determined prior to landfilling operations occurring in the southern areas of Phase 5E and Phase 7E, as it is expected there may be updated Project information at that time or a noise sensitive use will no longer be present at R15.

10.0 OTHER APPROVALS

The Project will require an application for an amendment of the Environmental Compliance Approval (ECA) for air and noise under Section 9 of the *Environmental Protection Act*. An application for an ECA for air and noise must demonstrate that a facility can operate in compliance with the MECP's Landfill Guidelines and NPC-300.

With the implementation of the mitigation measures and best management practices described in this report, the Project is expected to operate in compliance with MECP noise guidelines as specified in the Landfill Guidelines and NPC-300. The proposed expansion and subsequent permitting requirements are expected to be achievable from a noise perspective, subject to MECP approval.

11.0 CONCLUSION

This noise assessment evaluated the potential effects of the Project on noise levels based on two criteria. The first was a comparison against applicable noise limits, and the second was an assessment of changes to noise levels relative to existing noise levels at the most sensitive PORs within the Site-vicinity Study Area. Predictive noise modelling indicated that landfilling operations would result in noise levels that exceed relevant MECP sound level limits at some identified representative PORs, which resulted in a 'high' magnitude rating. The predicted change in noise levels resulted in a 'moderate' magnitude rating at some of the other identified representative PORs.

Noise mitigation measures were developed for the identified representative PORs, but are only required when landfilling operations are close to noise sensitive uses. Therefore, at the time of this noise assessment, the landfill will need to implement noise mitigation measures when operating within 330 m of the existing residence R15; but, for the locations that are vacant, noise mitigation can be deferred until occupied with a noise sensitive use.

These noise mitigation measures could include working behind a 5 m high berm and not beginning Site Preparation until 7 am (i.e., the daytime period), or acoustically equivalent. With these mitigation measures in place, the potential effects of the Project on noise levels are expected to have a 'negligible' or 'low' magnitude rating, and therefore no adverse noise effects are expected.

12.0 IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care

Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practicing under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied, is made.

Basis and Use of the Report

This report was prepared for the exclusive use of the City of London (the Client) and, once finalised, are intended to fulfil Ontario Ministry of the Environment, Conservation and Parks (MECP) data requirements in support of an Environmental Assessment Study Report. The report is based on review of the project design (the Project), discussions with the Client, review of documentation provided by Client and calculations made to identify potential noise impacts due to the Project. The reports cannot account for changes to the Project after it has been finalised and submitted by Client to the MECP.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client and the applicable regulatory authorities that are authorized to rely on the report as Authorized Users, subject to the limitations and purposes described herein. No other party may use or rely on this report or any portion thereof without Golder's express written consent. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client and any Authorized Users can not rely upon the electronic media versions of Golder's report or other work products unless it was directly provided by Golder.

When evaluating the Project and developing this report, Golder has relied on information provided by Client, the regulatory authorities, and others. Golder has acted in good faith and accepts no responsibility for any deficiencies, misstatements, or inaccuracies contained in this report resulting from omissions, misinterpretations or falsifications by those who provided Golder with information.

13.0 REFERENCES

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Signature Page

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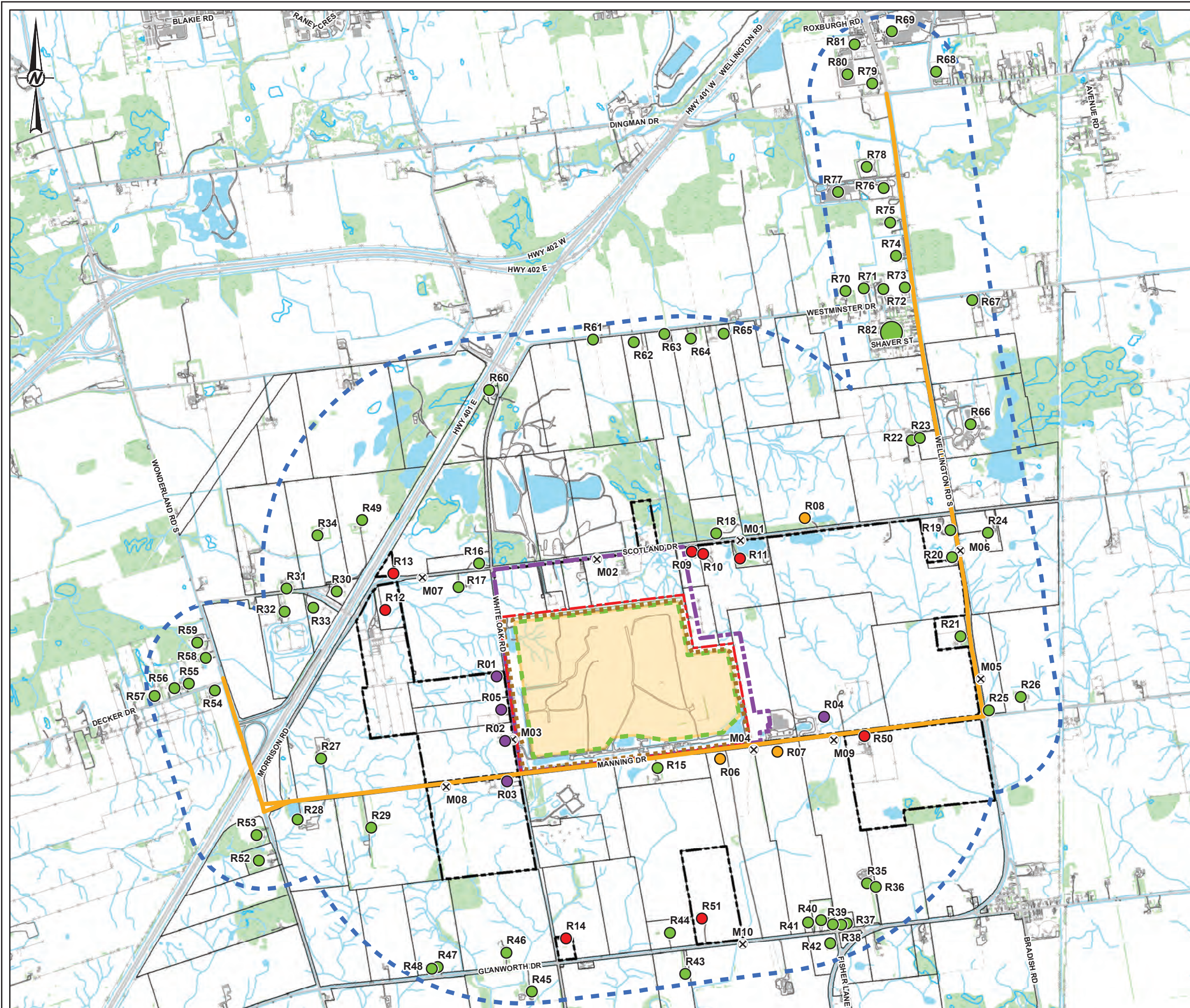
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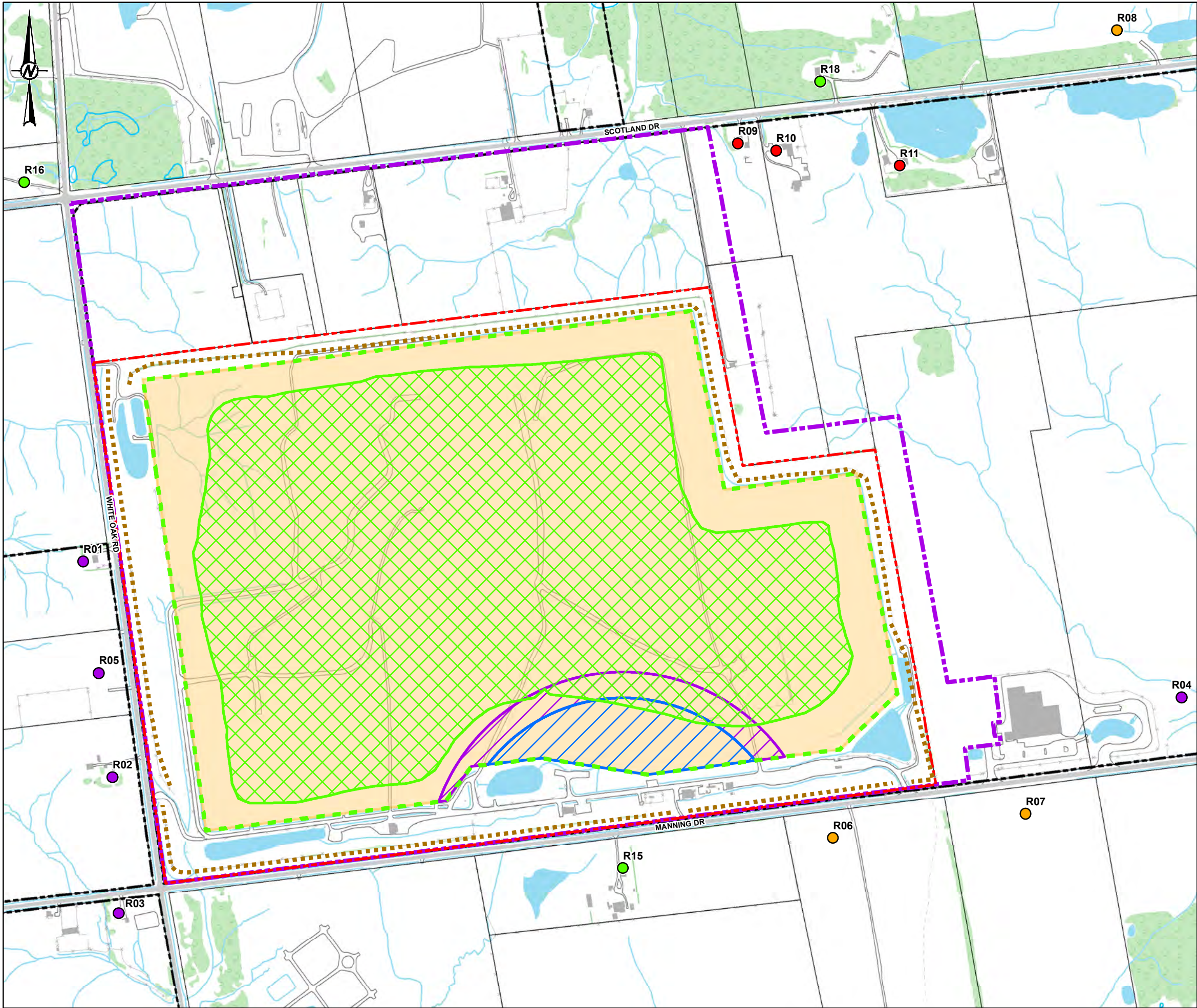
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LEGEND

- CITY OWNED PROPERTY - EXISTING
- CITY OWNED PROPERTY - VACANT
- NON-CITY OWNED PROPERTY - EXISTING
- NON-CITY OWNED PROPERTY - VACANT
- WATERCOURSE
- DRIVEWAY
- FENCELINE
- TRAIL
- APPROXIMATE BERM LOCATION
- BUILDING FOOTPRINT
- WOODED AREA
- WATERBODY
- CITY OWNED PROPERTY
- EXISTING PROPERTY BOUNDARY
- PROPOSED PROPERTY
- EXISTING APPROVED LIMIT OF WASTE
- PROPOSED LIMIT OF WASTE
- AREA OF NEW WASTE PLACEMENT
- NO SITE PREPARATION BEFORE 7 am
- MUST WORK BEHIND A 5 m HIGH BERM

REFERENCE(S)
1. DATA PROVIDED BY THE CITY OF LONDON.
2. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83
COORDINATE SYSTEM: UTM ZONE 17 VERTICAL DATUM: CGVD28

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CLIENT CORPORATION OF THE CITY OF LONDON			
PROJECT AIR AND NOISE ASSESSMENT - W12A LANDFILL EXPANSION			
TITLE MITIGATION AT EXISTING POINT OF RECEPTION R15			
	CONSULTANT	YYYY-MM-DD	2020-09-18
	DESIGNED	---	---
	PREPARED	JEM	---
	REVIEWED	---	---
	APPROVED	---	---
PROJECT NO. 1648176	PHASE 0012	REV. A	FIGURE 2

D.03 Groundwater Existing Conditions and
Impact Assessment Report; completed by
Dillon Consulting Limited and
Golder Associates Ltd., respectively

REPORT

Groundwater Existing Conditions and Impact Assessment

W12A Landfill Expansion EA, City of London, Ontario

Submitted to:

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1648176

November 2020

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ATTACHMENTS

ATTACHMENT A

Existing Groundwater Conditions – Dillon Consulting Limited

ATTACHMENT B

Groundwater Impact Assessment – Golder Associates Ltd.

Acronyms and Glossary of Terms

Term / Acronym	Definition
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
ECA	Environmental Compliance Approval
EPA	<i>Environmental Protection Act</i>
HELP	Hydrologic Evaluation of Landfill Performance
m	metres
m ³	cubic metres
masl	Metres Above Sea Level
MECP	Ministry of Environment, Conservation and Parks
MRF	Material Recovery Facility
POLLUTE	contaminant transport model
ToR	Terms of Reference

1.0 INTRODUCTION

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located at 3502 Manning Drive, part of Lots 18, 19 and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London Ontario.

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the details of the existing conditions and impact assessment related to groundwater for the Environment Assessment (EA) of the proposed W12A Landfill expansion. This work has been completed in two parts; Dillon Consulting Limited (Dillon) completed the existing conditions in Attachment A and Golder Associates Ltd. (Golder) completed the impact assessment in Attachment B.

All work was conducted in accordance with the requirements set out in the approved Amended Terms of Reference (ToR) dated February 2019 and the Work Plan dated November 2019 that was developed with input from First Nation Communities (Aamjiwnaang First Nation, Chippewas of the Thames First Nation, Munsee-Delaware First Nation, Oneida First Nation) and their consultant (Dragun Corporation) and circulated to the Ministry of the Environment, Conservation and Parks (MECP). In addition, the work also included additional contaminant transport modelling as a result of feedback from a First Nation Communities workshop held in August 2020.

This report is a supporting document to the Environmental Assessment Study Report (EASR).

2.0 PROJECT DESCRIPTION

The following describes the Project components considered relevant for the purposes of this groundwater assessment.

The landfill expansion consists of a vertical expansion over the existing landfill footprint to provide 13.8 million cubic metres (m^3) of airspace for waste and daily cover. To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be adjacent to Scotland Drive and a 100 metre (m) buffer width will be provided on the east side of the landfill footprint and some additional area in the southeast corner to tie into the adjacent Material Recovery Facility (MRF) property line. This results in a 106.3 hectare (ha) landfill footprint within a 192.4 ha landfill property, with a highest ridge elevation of waste of 318.43 metres above sea level (masl).

Additional details of the project pertinent to the groundwater impact assessment are described in Attachment B, Section 2.

3.0 EXISTING CONDITIONS

The details and discussion of existing conditions is provided in Attachment A by Dillon. Dillon first reviewed previous hydrogeological investigations of the landfill and then completed supplementary hydrogeological investigations in 2019 and 2020 to provide additional information on previously less investigated parts of the Site Study Area including information required to assess impacts associated with landfill expansion. The supplementary hydrogeological investigations included evaluating hydrogeological conditions to the north of

the existing landfill, hydrogeological conditions to the east of the existing landfill, and supplementary subsurface investigations including test pitting and borehole drilling with monitoring well installations. Upon completion of these investigations, Dillon prepared a summary of the existing hydrogeological conditions.

4.0 IMPACT ASSESSMENT

The completion of the impact assessment is provided in Attachment B by Golder. Golder prepared an assessment of long-term groundwater quality impacts by using the HELP model to estimate leachate generation rates and the POLLUTE model to assess possible impacts from the expanded landfill on the groundwater quality off-Site. The parameters evaluated included those required by the Landfill Standards and Ontario Regulation 232/98. The results identified that additional mitigation beyond the original project description would be required for long term protection of off-Site groundwater and compliance with Ontario Regulation 232/98.

Within the impact assessment the potential effects of the expansion on groundwater quantity was also evaluated. The analysis indicates the expansion is not expected to affect: the groundwater supply available to water supply wells in the area; groundwater baseflow to off-Site watercourses or other natural environment features in the area of the landfill; or, off-Site groundwater levels that support vegetation.

5.0 MITIGATION

Additional mitigation is required to meet groundwater quality objectives at the landfill site property boundary. It is proposed to incorporate leachate collection into the design of a first tier of horizontal landfill gas collector trenches to be installed in the older part of the landfill known as Phase 1 (see Attachment B, Appendix A). This will control the height of the leachate mound. With this additional mitigation, all groundwater quality requirements for the landfill expansion are predicted to be met.

6.0 GROUNDWATER AND LEACHATE MONITORING PROGRAM

The City of London has an existing comprehensive groundwater monitoring program for the existing landfill that has been updated to reflect current existing conditions and the proposed landfill expansion. A summary of the proposed groundwater monitoring program for the landfill expansion, leachate and neighbouring water wells is provided in Attachment B Table 12, Table 13 and Table 14, respectively. Attachment B Section 6 also provides details regarding a leachate mound monitoring component for the Phase 1 area of the landfill.

7.0 OTHER APPROVALS

The groundwater component of this EA will also require approval under the *Environmental Protection Act* (EPA) as part of an amended Environmental Compliance Approval (ECA) for waste disposal.

ATTACHMENT A

**Existing Groundwater Conditions –
Dillon Consulting Limited**

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CITY OF LONDON

Existing Groundwater Conditions

Environmental Assessment of the Proposed W12A Landfill
Expansion

July 2020 – 19-1230

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- B Test Pit Summary
- C Soil Analysis Results
- D Hydraulic Conductivity Tests
- E Water Levels and Hydrographs
- F Groundwater Quality
- G Isotope Analysis

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1.0 Introduction

This document presents the existing hydrogeological conditions as part of the groundwater component of the Environmental Assessment (EA) of the proposed W12A Landfill expansion (project). The Existing Groundwater Conditions documentation forms part of the overall groundwater assessment developed for the Environmental Assessment and documented in the report, titled “Groundwater Work Plan”, dated August 2019.

1.1 Overall Assessment Framework

The Environmental Assessment is completed in a series of nine steps as follows:

- Step 1 – Characterize existing environmental conditions
- Step 2 – Identify the ‘Alternative Methods’ of landfill expansion
- Step 3 – Qualitative evaluation of ‘Alternative Methods’
- Step 4 – Compare the ‘Alternative Methods’ for landfill expansion and identify the preferred alternative
- Step 5 – Refine the mitigation measures and determine the net effects of the preferred alternative
- Step 6 – Describe the preferred ‘Alternative Method’
- Step 7 – Consideration of climate change
- Step 8 – Cumulative impact assessment
- Step 9 – Preparation of the EA Study Report

The report documents Step 1 for the Groundwater Discipline.

1.2 Report Format

This report presents an overview of existing environmental conditions for the groundwater component on and in the area of the W12A Landfill. The existing conditions described in this report are based on existing documentation which consist of numerous previous hydrogeological investigations completed for the W12A Landfill area and a supplemental investigation completed in 2019 and 2020 that focused on obtaining additional hydrogeological information related to the expansion alternatives for the W12A landfill. The work plan for the supplemental investigations is detailed in the Groundwater Work Plan, dated August 2019.

2.0 Overview of Hydrogeological Conditions

Previous investigations over the last 40 years have resulted in a thorough understanding of the hydrogeological setting of the existing landfill. In terms of geological setting, the landfill is located on part of the Westminster moraine, which consists of low permeability till soils identified as the Port Stanley Till. Immediately north of the landfill site, gravel and gravelly sand were formed from the older Catfish Creek drift (located under the Port Stanley Till) or were deposited underneath the Port Stanley Till by subglacial streams.

Major hydrostratigraphic units are divided into aquitards and aquifers. An aquitard consists of low permeability soils that inhibit groundwater flow. An aquifer consists of permeable soils that can transmit large enough quantities of water such that when water wells are installed they produce usable quantities of water.

In terms of the hydrogeological setting, the site is underlain by low permeability Port Stanley Till, which comprises most of the Westminster Moraine. The next major regional hydrogeological feature is an aquifer found beneath the Port Stanley Till, consisting of stratified sand and gravel soils, most likely part of the Catfish Creek Drift. These soil deposits comprise the White Oak Aquifer. The White Oak Aquifer extends as far north as Lambeth and extends southeast to Kettle Creek. The aquifer has an irregular vertical distribution with a maximum thickness of approximately 45 m just north of the landfill along Scotland Drive. Groundwater flow in the White Oak Aquifer in the area of the landfill is in a general north to south/southeast direction.

Some local aquifers consisting of sand and gravel soil layers occur in the Port Stanley Till and were probably formed by subglacial processes at the time that the till soils were deposited. These local aquifers are not regionally extensive and generally thinner than the White Oak Aquifer. One such local aquifer is present underneath the landfill (referred to as the Upper Aquifer) and separates the Port Stanley Till into the Surficial Aquitard and a Lower Aquitard, both of which are above the White Oak Aquifer. The Upper Aquifer has not been identified north of Scotland Drive, but extends south of Manning Drive; groundwater flow in the Upper Aquifer is towards the southwest.

The thickness of the Surficial Aquitard varies from as much as 20 m at the northwest corner of the existing W12A Landfill site, to 15 m or greater below much of the existing landfill, and to about 8 m at the southeast corner of the site along Manning Drive. Groundwater moves downward at an estimated velocity of 1 to 2 centimetres (cm) per year in the Surficial Aquitard. The upper portion of the Surficial Aquitard is weathered and fractured. The degree of significant fracturing decreases with depth such that the shallower fractured till zone is more hydraulically active than the lower less fractured till soil. Generally, regional studies have indicated that the tills are highly fractured to a depth of 3-4 m, a transitional zone occurs beneath the highly weathered and fractured soil with isolated vertical fractures occurring to depths of approximately 6 m. Studies completed by the University of Western Ontario and Dillon in 2000 on Phase 1 of the landfill (where excavation depths of landfill cells were less than those in Phase 2) indicated that the depth of active fractures beneath the waste fill is less than 2 m and that desiccation fractures in till soils occurring during landfill cell construction are “self-healing” (this study is subsequently described in more detail in this report)

Limestone bedrock is found approximately 80 to 90 m below the landfill and slopes downwards from north-northeast.

Municipal water is available to residences near the landfill on Manning Drive, White Oak Road, Scotland Drive and Wellington Road South; however, some of the homeowners have not connected to the available municipal services. These residences, as well as residences and farms further away from the landfill area, rely on individual water supply wells, installed in either the Upper Aquifer or the White Oak Aquifer for their water supply. Individual water supply wells in the vicinity of the landfill are monitored annually.

Source water protection studies were carried out for the watersheds in which the City of London is located. The resulting Source Water Protection Plans delineate source protection areas with respect to municipal drinking water supplies (Wellhead Protection Areas – WHPAs and Intake Protection Zones – IPZs) as well as groundwater recharge areas, assign vulnerability to these source protection areas and describe appropriate land use planning for their protection. There are two Source Protection Regions in the area of and surrounding the W12A Landfill; the Thames-Sydenham & Region (the Upper Thames River Source Protection Area) and the Lake Erie Region Drinking Water Source Protection Region (Kettle Creek Source Protection Area). The primary source of drinking water for the City is surface water from Lake Huron and Lake Erie, with a stand-by backup supply from groundwater from the Hyde Park and Fanshawe well fields located in the northeast and west parts of the City.

All of these sources are distant from the W12A Landfill. The closest municipal well field to the W12A Landfill is the Belmont well field (Kettle Creek Source Protection Area) located 10 km east of the landfill. The capture area for the Belmont well field extends to the north of Belmont and not in the direction of the landfill. There are no source water protection areas identified on or in the area of the W12A Landfill. As such, neither the existing landfill nor the proposed expansion are influenced by planning considerations or requirements related to source water protection.

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3.0 Previous Hydrogeological Assessments

There have been numerous hydrogeological investigations completed at the landfill over the past 40 years. A listing of these reports are contained in the References section of this report. Numerous boreholes have been drilled and monitoring wells installed. Two hydrogeological assessments were completed that have particular relevance to this assessment and are discussed in detail below.

3.1 2000 W12A Hydrogeological Investigation, University of Western Ontario and Dillon

The objective of this hydrogeological investigation was to determine if the leachate collection system used in Phase 1 of the existing landfill provided sufficient protection to groundwater resources and to make recommendations for potential modifications to the leachate collection system design for Phase 2 of the landfill (Dillon, 2000). The Phase 1 leachate collection system is a perimeter collection system and leachate will mound between the perimeter drains. The 2000 hydrogeological investigation was targeted on defining the hydraulic characteristics of the Surficial Aquitard and using contaminant transport modelling to predict potential impacts to groundwater resources and consisted of the following tasks:

1. Borehole drilling, soil sampling and monitoring well installation below and beside Phase 1 of the landfill.
2. Contaminant profiling underneath the Phase 1 fill area by extracting porewater from discrete sections of soil cores taken beneath the waste, analyzing for chloride concentrations and then using computer models to back-calculate contaminant transport parameters.
3. Laboratory testing of soil samples to estimate properties such as vertical hydraulic conductivity, the fraction of organic carbon and cation exchange capacity.
4. Leachate sampling to determine leachate quality.
5. Contaminant transport modelling to predict groundwater impacts from Phase 1 of the landfill and the new landfill area (Phase 2).

Tasks 3 and 4 were completed by the Geotechnical Research Centre of the University of Western Ontario and the results are summarized below:

- The hydraulic conductivity as determined by flexible wall hydraulic conductivity testing on two soil cores were 1.3×10^{-10} m/s and 1.4×10^{-10} m/s.
- The chloride diffusion coefficient obtained by a diffusion test was estimated to be 6.5×10^{-10} m²/s (0.02 m/a) which is typical for chloride diffusion rates measured in clayey soils.
- The cation exchange capacity from two soil cores was 15.2 meq/100 g and 14.2 meq/ 100 g. Cation exchange capacities of this amount indicates significant adsorption potential for heavy metals.

The fraction of organic carbon was 0.4% of one soil core. The greater the fraction of organic carbon the more adsorption potential there is for organic parameters. Computer modelling was completed to simulate the migration of chloride due to advection and diffusion and estimated the advective flux at 0.005-0.010 m/year. For the measured porosity of 0.35, this flux would result in a downward groundwater velocity of 0.014 to 0.028 m/year. For a Surficial Till thickness of 14 m, this would translate to a travel time of about 700 years. This is consistent with a hydraulic conductivity of the Surficial Aquitard of 1×10^{-10} m/s.

Contaminant transport modelling was completed for a number of different scenarios of leachate collection systems design configurations. Modelled parameters consisted of those listed in Schedule 4 of O.Reg. 232/98: namely, chloride, dichloromethane, benzene, vinyl chloride, cadmium and lead. Of these parameters, chloride is an aesthetic related parameter and the other parameters are health-related parameters. For the health related parameters, modelling results for Phase 1 of the landfill indicated that concentrations decrease to negligible values within 2 metres of the base of the landfill though a combination of adsorption and biodegradation. The heavy metals were significantly adsorbed onto the soil resulting in extremely long travel times in the Surficial Aquitard. Chloride concentrations were predicted to increase to maximum concentrations in the Upper Aquifer at about the advective travel time of 700 years. The modelling indicated that a full leachate underdrain resulted in less predicted chloride concentration increases and a full underdrain leachate collection system design was adopted for Phase 2 of the landfill.

3.2 W12A Landfill Area Plan Study, Hydrogeological Background Study (2005)

The Hydrogeological Background Study, was one of six background studies prepared in support of the W12A Landfill Area Plan Study as part of the City of London Official Plan Secondary Planning process (Dillon, 2005). The purpose of the assessment was to assemble and analyze the hydrogeological conditions within the Study Area (defined as an area of 1.5 km buffer around the Core Area). The Core Area was defined as the area of land confined by White Oak Road to the west, Manning Drive to the south, Wellington Road to the east and Scotland Drive to the north. The study assessed the continuity of the major hydrostratigraphic units beneath and adjacent to the landfill site. A Surficial Aquitard Thickness Map was produced that illustrated the thickness of the Surficial Aquitard and areas where the aquitard does not exist.

The study concluded that generally, the White Oak Aquifer Complex is protected by the overlying Surficial Aquitard and Lower Aquitard hydrostratigraphic units south of Scotland Drive. The amount of recharge through the overlying aquitard units is limited by the low permeability of the aquitards. The White Oak Aquifer occurs at surface at the gravel pits north of Scotland Drive and the ponds located along Highway 401, west of White Oak Road. It was concluded that this area is a significant recharge area for the White Oak Aquifer. The groundwater flow direction in the White Oak Aquifer Complex is to the south / southeast.

The study also concluded that significant groundwater protection is provided by the Surficial Aquitard to the underlying aquifers. The Surficial Aquitard is thickest (15 to 20 m thick) in the western part of the Core Area. In the southeastern portion of the Core Area the Surficial Aquitard varies in thickness from 6 m to 15 m. Groundwater movement is extremely slow (a few centimetres per year) in the Surficial Aquitard and it was concluded that the aquitard provides groundwater protection for most potential land uses within the Core Area. The study also recommended that the integrity of the Surficial Aquitard be retained. Any penetration of the Surficial Aquitard should be completed with this in mind (e.g., all wells should be fully grouted, and if not used, decommissioned, and any foundation piles or deep excavations should be completed using methods ensuring that the natural protection provided by the aquitard is retained).

4.0 Supplemental Hydrogeologic Investigation 2019-2020

In addition to reviewing the data sources described in **Section 3** and despite the thorough understanding of the hydrogeology setting of the existing landfill, there remains some potential areas for further field investigations to the north and east of the existing landfill, related to existing conditions but also landfill expansion

4.1 Hydrogeologic Issues North of Existing Landfill

The main issue at this location is the nature of the hydrogeological connection between the local Upper Aquifer and the regional White Oak Aquifer especially to the north of the existing landfill. Integral to the connection is the presence and hydraulic conductivity of the till layer (aquitard) separating the aquifer hydrostratigraphic units.

An evaluation of this issue consisted of using a “multiple lines of evidence” approach where borehole data was used to develop physical localized hydrostratigraphic limits coupled with groundwater level data and hydrogeochemistry data. In addition, hydrogeological data that has been obtained over the operating period of the landfill obtained from hydrogeological studies completed on aggregate pits north of the landfill site (north of Scotland Drive) has been used to supplement the hydrogeological understanding of this area. Overall, these sources of information were used to further define aquifer units and identify data gaps that could be addressed by additional investigation. The need for additional hydrostratigraphic information in the area immediately south of Scotland Drive was identified. New boreholes / monitoring wells in this area would further define lithology and groundwater levels and enable a better understanding of existing conditions and aid in the evaluation of proposed expansion alternatives (i.e., lateral landfill expansion to the north of the existing landfill).

4.2 Hydrogeologic Issues East of Existing Landfill

One of the proposed landfill development alternatives is possible expansion to the east of the present fill site. The hydrogeology east of the landfill is well understood but additional information in this area would allow better evaluation of expansion alternatives in this area.

4.3 Supplemental Subsurface Investigation Methodology

To address the issues requiring additional hydrogeological information identified above, a subsurface investigation was completed in the fall of 2019. This investigation consisted of the following components:

- Borehole drilling / monitoring well installations at seven locations: three east of the existing landfill and four north of the existing landfill. Monitoring wells were installed in different hydrostratigraphic units (“nested” monitoring wells) mainly in the Upper Aquifer and the White Oak Aquifer
- Testing of soil cores obtained in the drilling program
- Groundwater sampling and analysis from the new monitoring wells
- Groundwater level monitoring including the installation of dataloggers in select monitoring wells (completed in January/February 2020)
- The completion of a large test pit immediately east of the landfill to assess the degree of weathering and fracturing of the upper portion of the Surficial Aquitard

4.3.1 Borehole Drilling

The drilling locations are shown on **Figure 1**. The deepest borehole (White Oak Aquifer) at each location was drilled using a PQ coring using drilling mud as the drilling fluid by Aardvark Drilling. This system provided relatively good quality continuous soil cores. The soil cores were logged for soil type, structure, colour, and moisture using ASTM Standard D2488 for Visual-Manual Description and Identification of Soils. Borehole logs are contained in **Appendix A** and include soil descriptions, soil core retrieval information (intervals and recovery). If a monitoring well was required in the Upper Aquifer (no Upper Aquifer monitoring wells were installed at locations BH19-1 and BH19-3 since Upper Aquifer monitoring wells already existed near these locations), soil sampling was completed at select intervals using standard splitspoons to obtain standard penetration test data (“blow counts”) and to obtain Shelby tubes for subsequent soil testing.

4.3.2 Monitoring Well Installation

Monitoring wells were installed in each borehole. The monitoring well constructions details are shown on the borehole logs (**Appendix A**) and generally consisted of nominal 50 mm diameter PVC monitoring pipe connected to a 1.5 m long PVC No. 10 slot screen. Silica sand was placed around the screen annulus and extended at least 0.5 m above the top of screen, bentonite chips were then placed above the silica sand and the remaining borehole annulus was filled with bentonite grout to ground surface. The monitoring wells were developed by removing a relatively large quantity of water using a submersible pump.

The nomenclature used to name boreholes and monitoring wells is summarized in **Table 1**, which also contains the hydrostratigraphic units in which the wells were installed.



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SITE PLAN

Figure 1

LEGEND

- 2019 Drilling Location
- Historical Borehole Location
- ▢ Test Pit Location

Note: See Figure 8 for Geologic Sections



MAP CREATED BY : LOM
MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO



PROJECT: 19-1230

STATUS: FINAL

DATE: AUGUST 2020

Table 1: Borehole and Monitoring Well Designations

Borehole Number	Monitoring Well Designation	Hydrostratigraphic Unit
BH19-1	19-1	White Oak Aquifer
BH19-2	19-2	Upper Aquifer
BH19-2-2	92-7a	Upper Aquifer (a replacement monitoring well for existing monitoring well 92-7, which was decommissioned in 2019 due to integrity concerns)
BH19-3	19-3	White Oak Aquifer
BH19-4	19-4a	White Oak Aquifer
BH19-4-2	19-4b	Upper Aquifer
BH19-5	19-5a	White Oak Aquifer
BH19-5-2	19-5b	Upper Aquifer
BH19-6	19-6a	White Oak Aquifer
BH19-6-2	19-6b	Upper Aquifer
BH19-7	19-7a	Lower White Oak Aquifer
BH19-7-2	19-7b	Upper White Oak Aquifer
BH19-7-3	19-7c	Surficial Aquitard
BH19-9	92-10a	White Oak Aquifer (a replacement monitoring well for existing monitoring well 92A-10a which was decommissioned in 2019 due to integrity concerns)

4.3.3 Soil and Hydrogeological Testing

Soil samples from the Surficial Aquitard, Upper Aquifer, Lower Aquitard and White Oak Aquifer were collected and tested for various parameters as listed in **Table 2**. In addition, groundwater samples were taken from the new monitoring wells and analyzed for conventional water quality analysis.

Number and Type of Soil and Hydrogeological Tests

Test	Hydrostratigraphic Unit			
	Surficial Aquitard	Upper Aquifer	Lower Aquitard	White Oak Aquifer
Grain Size Analysis, Moisture Content	13	4	4	4
Fraction of Organic Carbon, Cation Exchange Capacity	6	1		
Flexible Wall Permeability Tests	6			
Conventional Water Quality Analysis		5		4
Isotope Analysis (porewater extracted from aquitard soil cores)	8			

4.3.4 Water Level Monitoring

Water levels in the new monitoring wells were taken using a manual water level tape several times in 2019 and 2020. In addition, dataloggers were installed in select monitoring wells to continuously record water levels with time. The dataloggers were installed in early January 2020 and were downloaded in late February 2020. The dataloggers remain in the monitoring wells and continue to continuously record water levels. The “top of pipe” elevation of the monitoring wells were surveyed by the City of London and this data was used to convert water level depth measurements to geodetic elevations (i.e., metres above sea level – masl).

4.3.5 Test Pit Excavation - Surficial Aquitard Fracture Assessment

The presence of fractures within the upper portion of the Surficial Aquitard is a well-known phenomenon. To evaluate the nature of the fractures and their potential to create a preferred pathway for leachate migration from the landfill expansion, a benched test pit measuring approximately 12 m x 12 m in plan and 5.4 m in depth was completed. The test pit was located between the landfill and the Material Recovery Facility (shown on **Figure 1**). The test pit allowed the fracture characteristics and fracture frequency to be assessed with depth.

The fracture network was logged and photographs taken. **Appendix B** contains a summary of the observations from the test pit as well as photographs.

DRAFT

4.4 Results of Laboratory Analysis of Soil Samples

The results of the grain size analysis is presented as a ternary diagram (see **Figure 2**). The results of the soil tests are summarized in **Table 3** and **Table 4**. Detailed test results are in **Appendix C**.

Table 3: Summary of Grain Size Analysis

Borehole No.	Sample No.	Depth		Layer	Grain Size Analysis (%)				Water Content %
		mbgs	masl		Clay	Silt	Sand	Gravel	
BH19-1	2	3	270.7	SA	46	44	7	3	15.2
	4	10.3	263.4	UA	5	9	86	0	20.4
	5	13.1	260.6	UA	5	23	72	0	20.3
	9	24.2	249.5	LA	48	43	9	0	18.3
	12	40.6	233.1	WOA	26	24	47	3	13.1
BH19-2	1	3.6	269.4	SA	42	52	6	0	18.6
	2	9.3	263.7	SA	39	41	10	10	20
	3	13.2	259.8	UA	5	25	70	0	18.4
	4	24.9	248.1	LA	41	44	14	1	16.4
	5	30.6	242.4	LA	22	60	18	0	11
	6	46.9	226.1	WOA	10	36	53	1	9
BH19-3	2	4.7	270.5	SA	46	46	8	0	23.5
	5	9.2	266	SA	45	49	6	0	20.2
	8	14.4	260.8	UA	1	97	2	0	19.1
BH19-4	1	4.4	276.7	SA	42	48	9	1	20.5
	2	9.2	271.9	SA	43	48	9	0	21.2
BH19-5	1	4.4	278.3	SA	41	49	10	0	20.9
	4	9.2	273.5	SA	43	47	9	1	20.1
	7	13.7	269	SA	44	46	10	0	20.4
	10	17	265.7	SA	48	45	7	0	20.3
	13	24.5	258.2	LA	44	43	12	1	16.9
	14	31.2	251.5	WOA	7	21	72	0	18.4
BH19-6	1	4.6	276.3	SA	49	43	8	0	21.1
	2	9.3	271.6	SA	45	43	9	3	20.1
	8	26.1	254.8	WOA	16	30	54	0	16.7

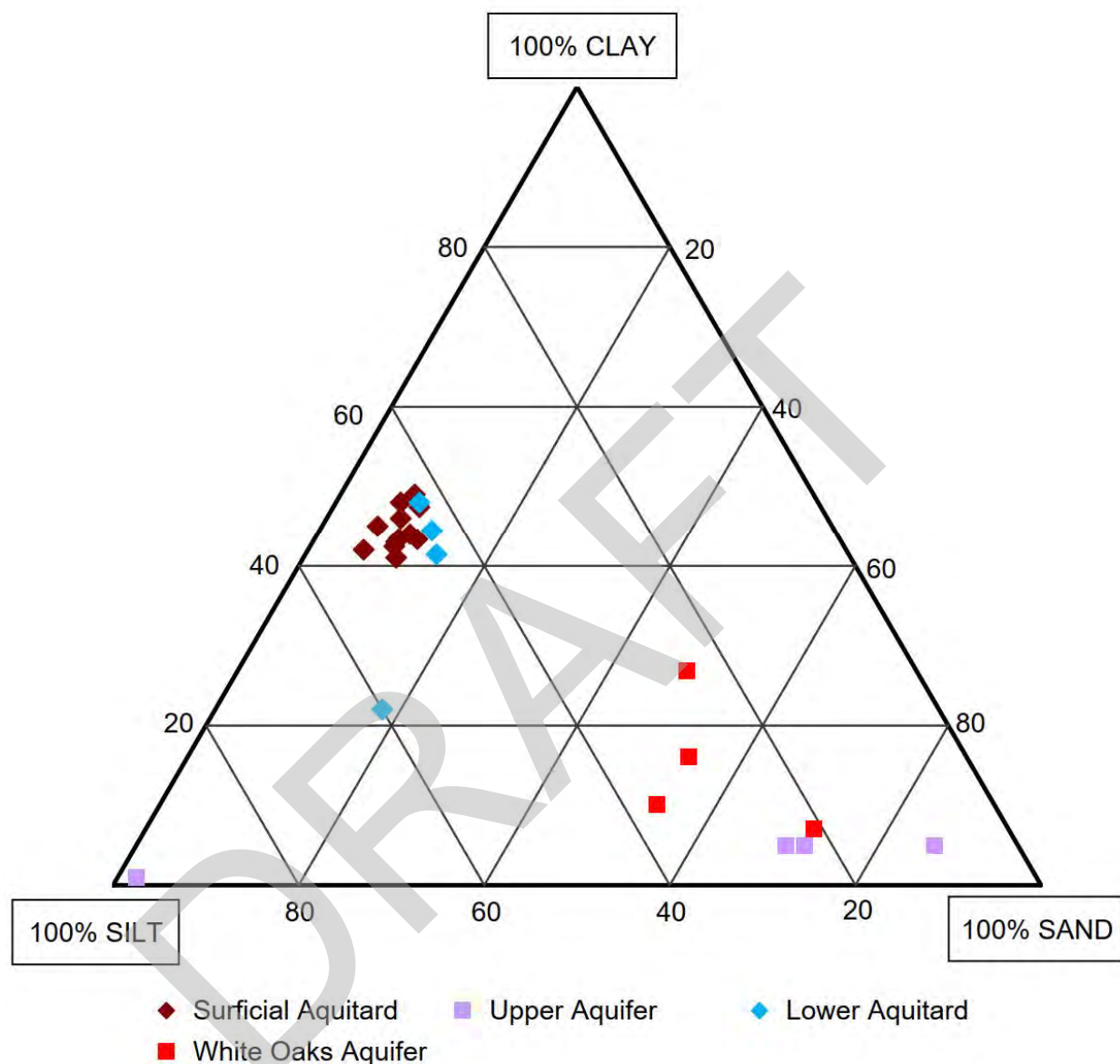
SA = Surficial Aquitard; UA= Upper Aquifer; LA = Lower Aquitard; WOA = White Oak Aquifer

Table 4: Summary of Fraction of Organic Carbon and Cation Exchange Capacity Tests

Borehole No.	Sample No.	Depth		Layer	Cation Exchange Capacity (meq/100 g)	Total Organic Carbon (%)	
		mbgs	masl			<0.6mm	Whole Soil
BH19-3	2	4.7	270.5	SA	118.3	0.28	0.27
	5	9.2	266.0	SA	112.4	0.19	0.18
	8	14.4	260.8	UA	16.5	0.08	0.08
BH19-5	1	4.4	278.3	SA	112.8	0.16	0.15
	4	9.2	273.5	SA	100.8	0.19	0.19
	7	13.7	269.0	SA	108.0	0.23	0.21
	10	17.0	265.7	SA	107.2	0.23	0.22

SA = Surficial Aquitard; UA= Upper Aquifer

As **Figure 2** illustrates, soil samples from the different hydrostratigraphic units plot in similar areas on the Ternary Diagram. In particular, soil samples taken from the Surficial Aquitard all plot very closely together on the diagram which is consistent with the field observations that the composition of the Surficial Aquitard is very consistent both by depth and location.

Figure 2: Grain Size Data

4.5 Hydraulic Conductivity Tests

Hydraulic conductivity testing was completed on soil cores taken at three drilling locations: BH19-2, BH19-5 and BH19-6. The purpose of these tests was to take soil cores at approximately the same depth those taken in 2000 and tested by the University of Western Ontario in 2000. At the new locations, flexible wall permeameter tests (ASTM D5084 – Method A; Constant Head) were completed on soil core obtained by taking Shelby tubes (thin walled steel sample tubes that minimize the disturbance of the soil structure) at a depth equivalent to being below the landfill base. The test results are found in **Appendix D** and are summarized in **Table 5**. The intent was to also complete in situ hydraulic conductivity tests in Upper Aquifer wells. There was insufficient water in these monitoring wells to complete these tests (water levels are documented in Section 4.6)

Table 5: Summary of Hydraulic Conductivity Test Results

Borehole No.	Sample No.	Depth		Layer	Hydraulic Conductivity (m/s)
		mbgs	masl		
BH19-2-2	SS1	5	268	SA	1.0×10^{-10}
BH19-2-2	SS2	6.4	266.6	SA	1.0×10^{-10}
BH19-5-2	SS1	4.8	277.9	SA	9.0×10^{-11}
BH19-5-2	SS2	6.4	276.3	SA	1.0×10^{-10}
BH19-6-2	SS1	4.8	276.1	SA	1.0×10^{-10}
BH19-6-2	SS2	6.2	274.7	SA	1.0×10^{-10}
BH00-5a*	1	1.9**	267.2	SA	1.3×10^{-10}
BH00-7a*	1	1.3**	271.5	SA	1.4×10^{-10}

Notes - *sample tested by UWO in 2000; **depth below waste interface (Phase 1)

SA – Surficial Aquitard

4.6 Groundwater Level Monitoring

Water levels from monitoring wells were used to identify groundwater flow directions and to calculate hydraulic gradients. Hydrographs are found in **Appendix E**.

4.6.1 Groundwater Flow Directions

4.6.1.1 Surficial Aquitard

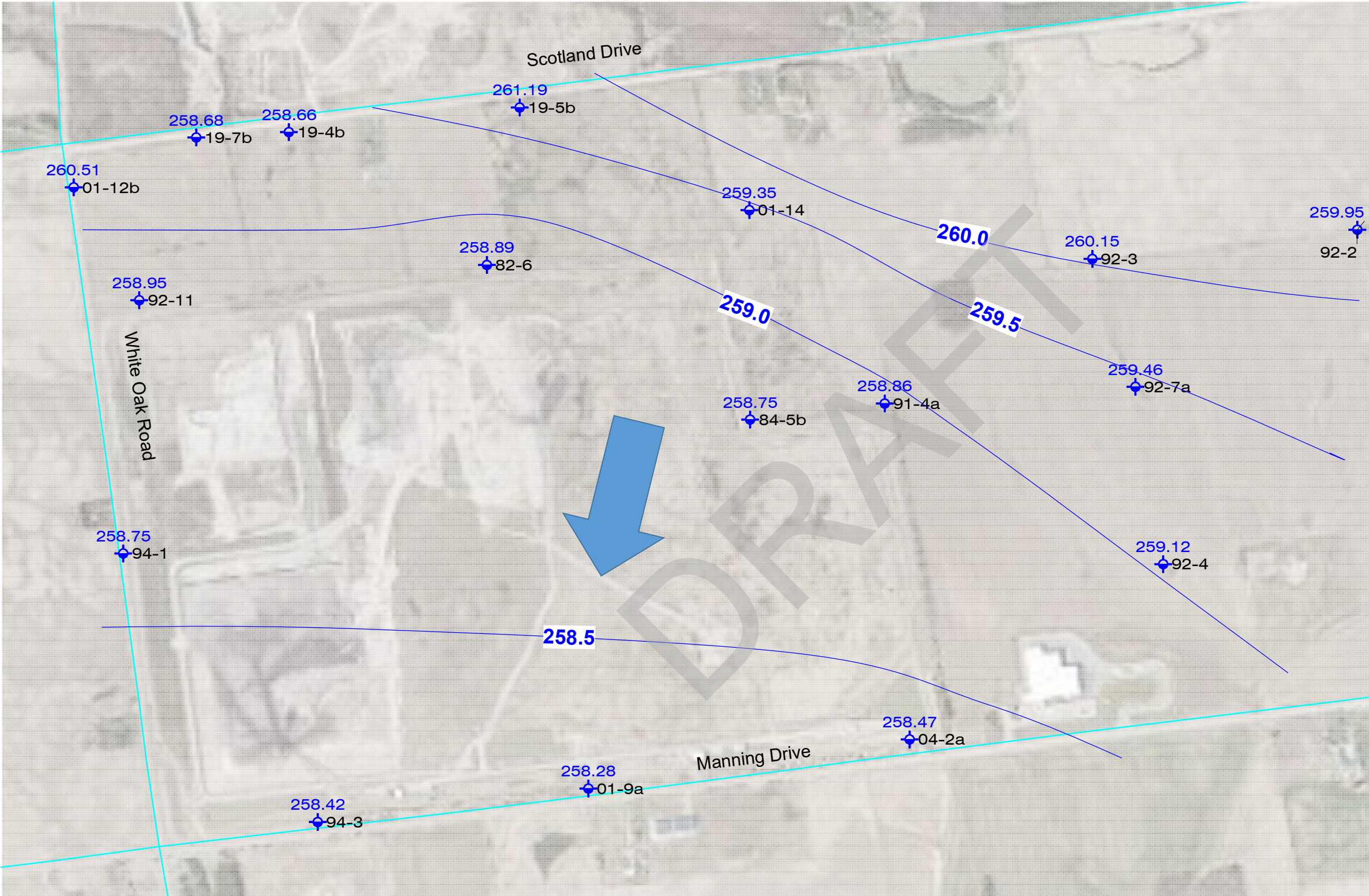
Groundwater flow in the Surficial Aquitard is principally vertical under a high vertical hydraulic gradient. The water level in the underlying Upper Aquifer is below the surface of the aquifer which results in the high vertical gradient. The significantly weathered and fractured clay that occurs at surface and extends within the first 5 m will have a horizontal component of groundwater flow. However most of the active highly fractured zone will be removed by horizontal expansion landfill cell construction and the remaining fractures are spaced sufficiently far apart to significantly reduce the horizontal groundwater flow component. In addition, the self-healing properties of the clay as documented in the University of Western Ontario study indicate that the effect of these fractures will be reduced with the addition of effective stress (weight) induced by the overlying waste fill.

4.6.1.2 Upper Aquifer

Groundwater flow in the Upper Aquifer is shown on **Figure 3**. As indicated on the figure, groundwater flows from the northeast to the southwest. The groundwater elevation in the new monitoring well 19-6b was installed in an aquifer encountered at a higher elevation than the Upper Aquifer at nearby monitoring wells 19-4b and 19-5b. This aquifer is probably related to a localized sand layer located within the Surficial Aquitard and is not hydraulically related to the Upper Aquifer system.

4.6.1.3 White Oak Aquifer

Figure 4 illustrates the water level in the White Oak Aquifer. Groundwater elevations are highest in the northwest near Scotland Drive and White Oak Road and decrease to the southeast. Based on previous assessments (Dillon, 2015), the ponds in the gravel pits north of Scotland Drive are directly hydraulically connected to the White Oak Aquifer and cause an elevated groundwater elevation in this area. Groundwater elevations decrease to the southeast. Three new monitoring wells were installed in the White Oak Aquifer (19-1, 19-2a and 19-3) and groundwater elevations at 19-2a, 19-1 and historic monitoring well 92-8 are very similar in elevation (~253.5 masl). The reason for the lack of hydraulic gradient in this area is not known but may be related to a decrease in recharge from surface and /or less influence from the recharge zone north of Scotland Drive (the gravel pit ponds) due to a greater distance from the recharge zone.



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**GROUNDWATER ELEVATION
IN UPPER AQUIFER**

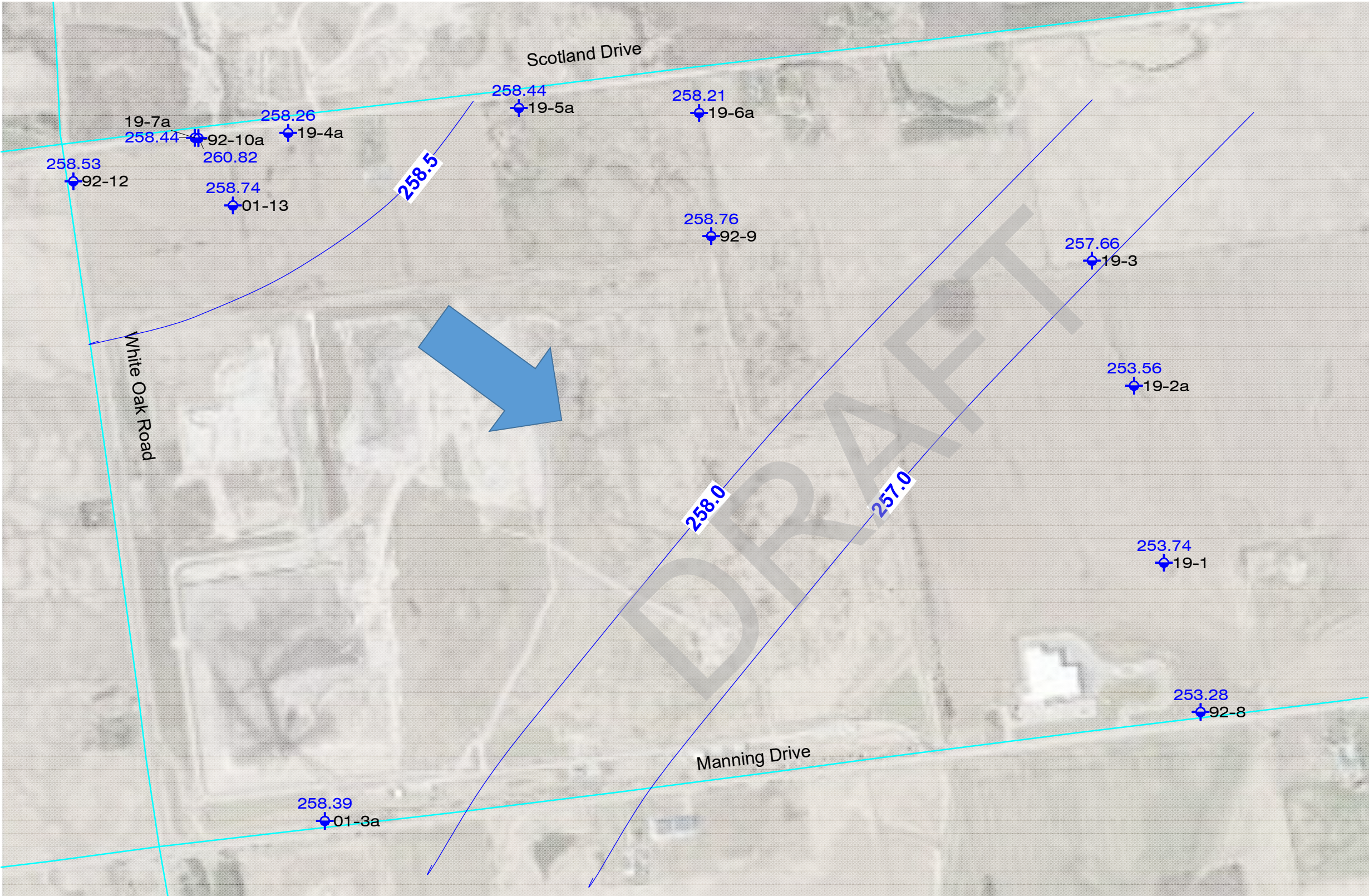
Figure 3

LEGEND

- 259.46 Fall 2019 Upper Aquifer Groundwater Elevation (masl)
- Groundwater Flow Direction



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MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO



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GROUNDWATER ELEVATION
IN WHITE OAK AQUIFER

Figure 4

LEGEND

- 257.66
Fall 2019 White Oak Aquifer
Groundwater Elevation (masl)
- Groundwater
Flow Direction



MAP CREATED BY : LOM
MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO



4.7 Groundwater Chemistry

Groundwater samples were collected from the new monitoring wells installed in the proposed expansion areas. The target parameter list was similar to the current groundwater monitoring program. A summary of the laboratory results is found in **Appendix F** which also contains the laboratory Certificates of Analysis. Samples were not obtained in the newly installed Upper Aquifer wells since these wells had insufficient water column in the well to be sampled. The exception to this was monitoring well 19 to 6b.

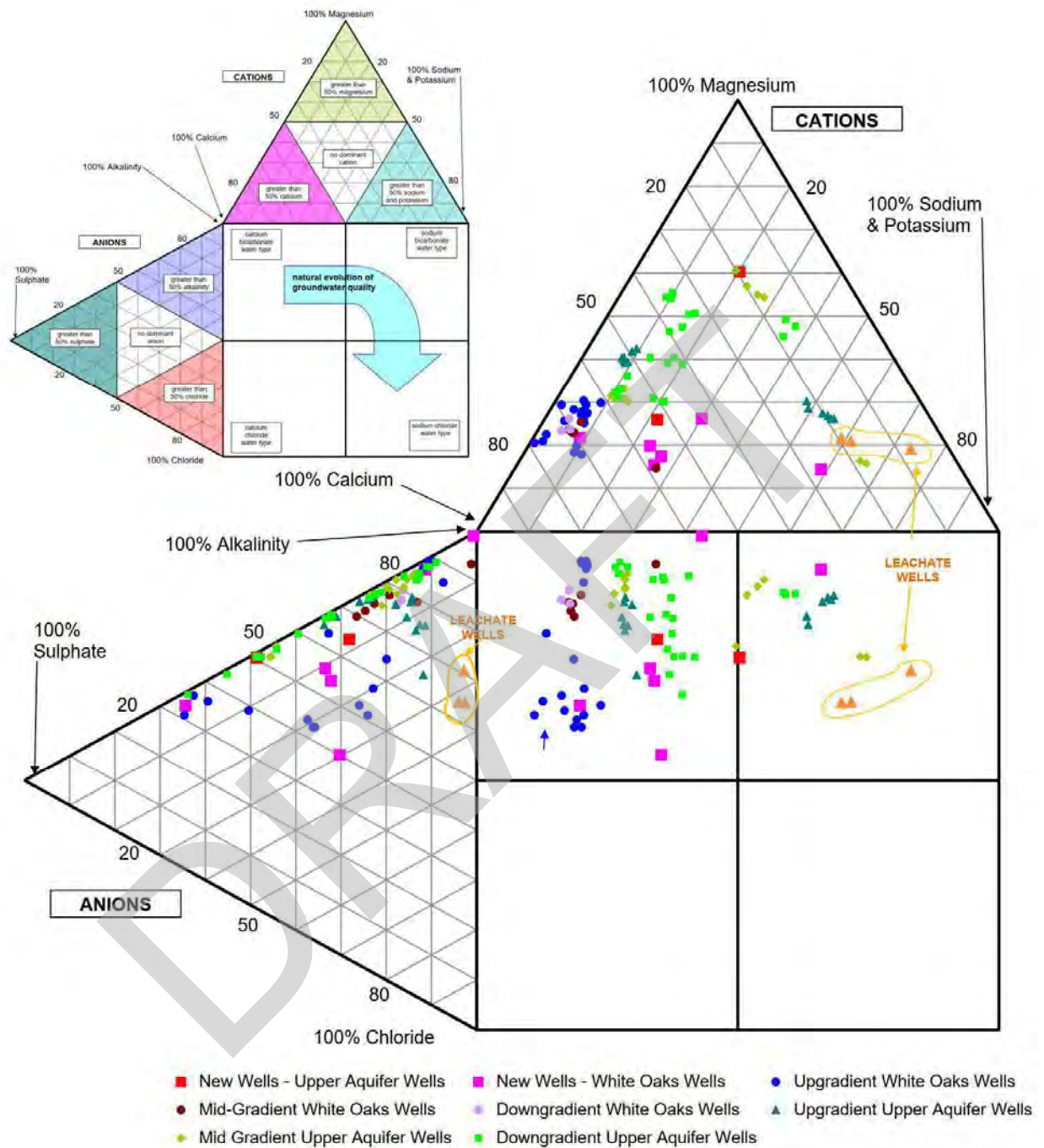
In addition, the isotopes of oxygen and hydrogen were quantified in porewater extracted from soil cores. Water samples from Upper Aquifer monitoring wells were also planned to be submitted for isotopic analysis but could not, since these wells could not be sampled.

The chemistry of groundwater changes as it moves through soils and rock and can be used to assess the relative residence time in the subsurface. From this perspective, groundwater chemistry “ages” in the subsurface. For instance, relatively fresh groundwater recently recharged from surface infiltration is dominated by a calcium/magnesium cation and bicarbonate (alkalinity) as the dominant anion. As the residence time in the subsurface increases, groundwater chemistry slowly changes so that sodium is the dominant cation and chloride is the dominant anion.

Major ion data from the laboratory analysis of groundwater samples were used to generate Durov diagrams that utilize trilinear diagrams to differentiate groundwater chemical characteristics for different hydrostratigraphic units and locations within the groundwater environment. A Durov diagram plots major cations and anions in trilinear plots and then transfers their location in a general rectangular plot. **Figure 5** has an explanatory Durov diagram and illustrates the various “types” of groundwater and the general evolution of groundwater quality from “fresh” calcium bicarbonate type water to “old” sodium chloride type water.

Figure 5 includes the data collected for the monitoring wells previously installed in the area of the landfill as well as the samples taken from the new monitoring wells. Data from the historic monitoring wells is from 2010 to 2019. As shown on the figure, the dominant water type is a calcium-bicarbonate water type with the Upper Aquifer exhibiting both calcium-bicarbonate and sodium bicarbonate type waters. Overall, it can be concluded that the new wells are consistent with the laboratory analytical data from the existing wells included in the monitoring program.

Figure 5: Durov Diagram



4.8 Isotope Chemistry

Stable isotopes of oxygen and hydrogen are other indicators of groundwater movement. They are particularly useful because they are part of the ions that constitute water and are not subject to attenuation processes that can change concentrations of dissolved constituents and have been used to date the age of groundwater.

The depletion of oxygen-18 ($\delta^{18}\text{O}$) and deuterium ($\delta^2\text{H}$) with respect to Vienna Mean Standard Ocean Water (VMSOW) is an age indicator when data are compared to similar data in areas where the relationship between oxygen-18 depletion and groundwater age has been established. Desaulniers, et al, 1981 established that greater depletion indicates greater age. However, Edwards and Fritz, 1987 describes a possible exception to this where groundwater recharged during the Hypsithermal era (between approximately 4,000 and 7,000 years ago) could be less depleted than modern recharge waters. Cross-plots of depletion of Oxygen-18 against deuterium (hydrogen-2) provide insight into groundwater movement and age. Isotopic data is reported as a difference between the sampled water and VMSOW and is reported in per thousand (‰). For instance, a value of Oxygen-18 of -10‰ means that the water sample has 10‰ less (i.e., is depleted) Oxygen-18 than the standard. Interpretation of stable isotope data is commonly referenced to the Meteoric Water Line (MWL), representative of these isotopes in global precipitation (Dansgaard, 1964). A more local meteoric water line has been established and is referred to as the Great Lakes Meteoric Water line and it is shown on **Figure 6**.

The results of the laboratory analysis of porewater extracted from soil cores is found in **Appendix G**. **Figure 6** cross-plots the results of the analysis of oxygen-18 and deuterium in porewater from soil core samples collected during the drilling of BH19-3 and BH19-5. This figure shows that Oxygen-18 and deuterium becomes more depleted, with respect to VMSOW and at depth. Porewater collected from less depth had Oxygen-18 values of greater than -10‰. Oxygen-18 and deuterium become increasingly depleted with depth (**Figure 7**).

The results of the analysis of stable isotopes indicate that the porewater in the deeper soil cores is representative of water recharged during progressively colder/older paleoclimates which occurred more than 8,000 years before present. The estimated travel time through the Surficial Aquitard has been estimated to be in the order of 700 years (Dillon, 2000). The results of the stable isotope assessment indicates that the travel time may be significantly longer than that estimated.

Figure 6: Porewater Isotope Chemistry

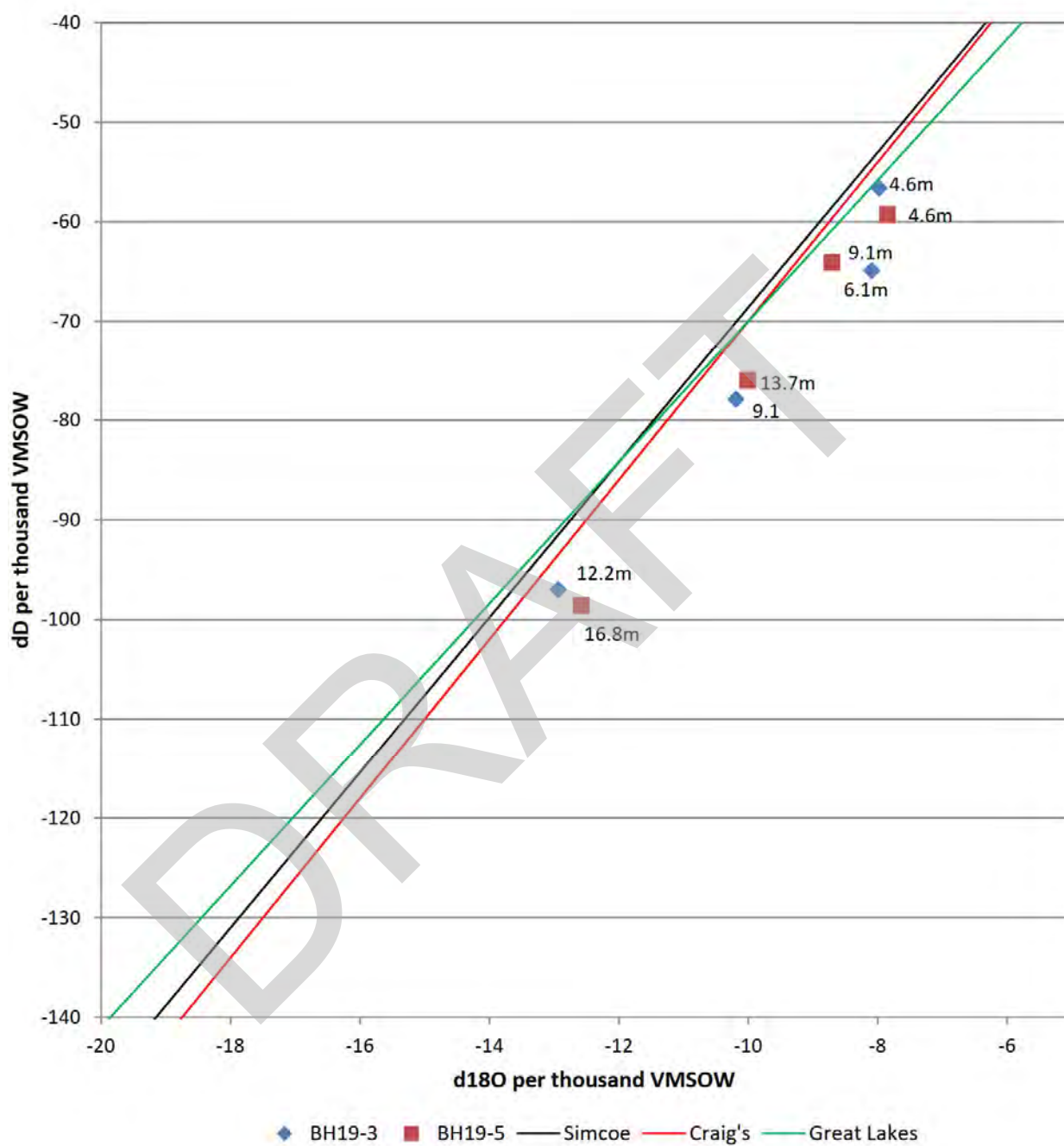
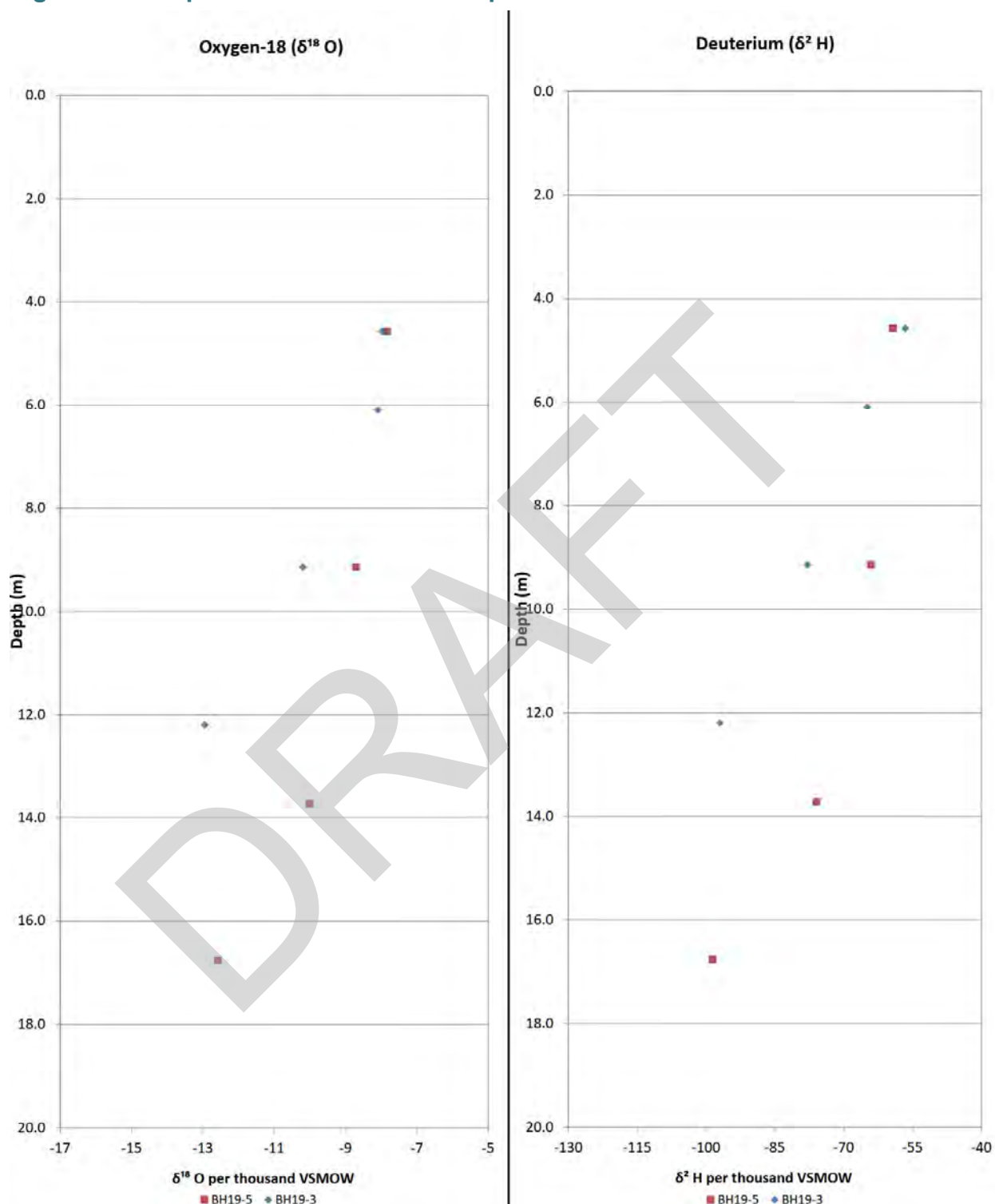


Figure 7: Isotopes in Porewater with Depth

Tritium concentrations in porewater also serve as an indicator of groundwater age. Tritium levels in global precipitation increased significantly between the years 1952 and 1963 as a result of atmospheric thermonuclear bomb testing. Given that tritium has a half life of 12.3 years, tritium concentrations in groundwater recharged prior to bomb testing should be generally less than 1 tritium unit (TU). The enriched tritium results are summarized in **Table 6** for soil core samples taken at various depths at BH19-3 and BH19-5. Overall, tritium concentrations are quite low, which makes definitive conclusions regarding groundwater age difficult. The highest tritium concentration was in the shallow soil core sample at each borehole location: 3.7 TU for BH19-3 and 4.1 TU at BH19-5 at 4.6 m depth. Enriched tritium concentrations were less than 1 TU in three deeper soil cores and less than 2.3 TU in the other 3 deeper soil cores. Overall, the tritium results, while inconclusive, are consistent with a low vertical groundwater velocity.

Table 6: Summary of Enriched Tritium Results

Borehole	Sample Depth (m)	Enriched Tritium (TU)	Standard Deviation
BH19-3	4.6	3.7	1
	6.1	<0.8	0.7
	9.1	2	0.8
	12.2	<0.8	0.7
BH19-5	4.6	4.1	0.8
	9.1	1.4	0.7
	13.7	0.9	0.6
	16.8	2.3	0.9

5.0 Summary of Existing Conditions

This section provides a summary of the existing hydrogeological conditions at, and in close vicinity, to the landfill. It is based on the previous hydrogeological investigations and the supplemental investigation described in Section 3 and Section 4, respectively.

5.1 Hydrostratigraphic Unit Description

The hydrostratigraphic units described are shown graphically on cross-sections shown on **Figure 8**. The cross-sections show the stratigraphy west – east along the Scotland Drive Wells (Section A-A') and in a north - south direction for the drilling locations east of the existing landfill (Section B-B'). The thickness of the Surficial Aquitard is shown on the sections. In addition to the cross-sections, maps were prepared that illustrate either the surface of various geological and hydrostratigraphic layers using contour lines or the thickness of the layers (referred to as isopachs) using information from new boreholes installed in the expansion area and historical boreholes installed at, and in the vicinity, of the landfill. To provide context beyond the immediate vicinity of the landfill, the Area Study completed in 2005 that relied on water well record information was also used in the interpretation.

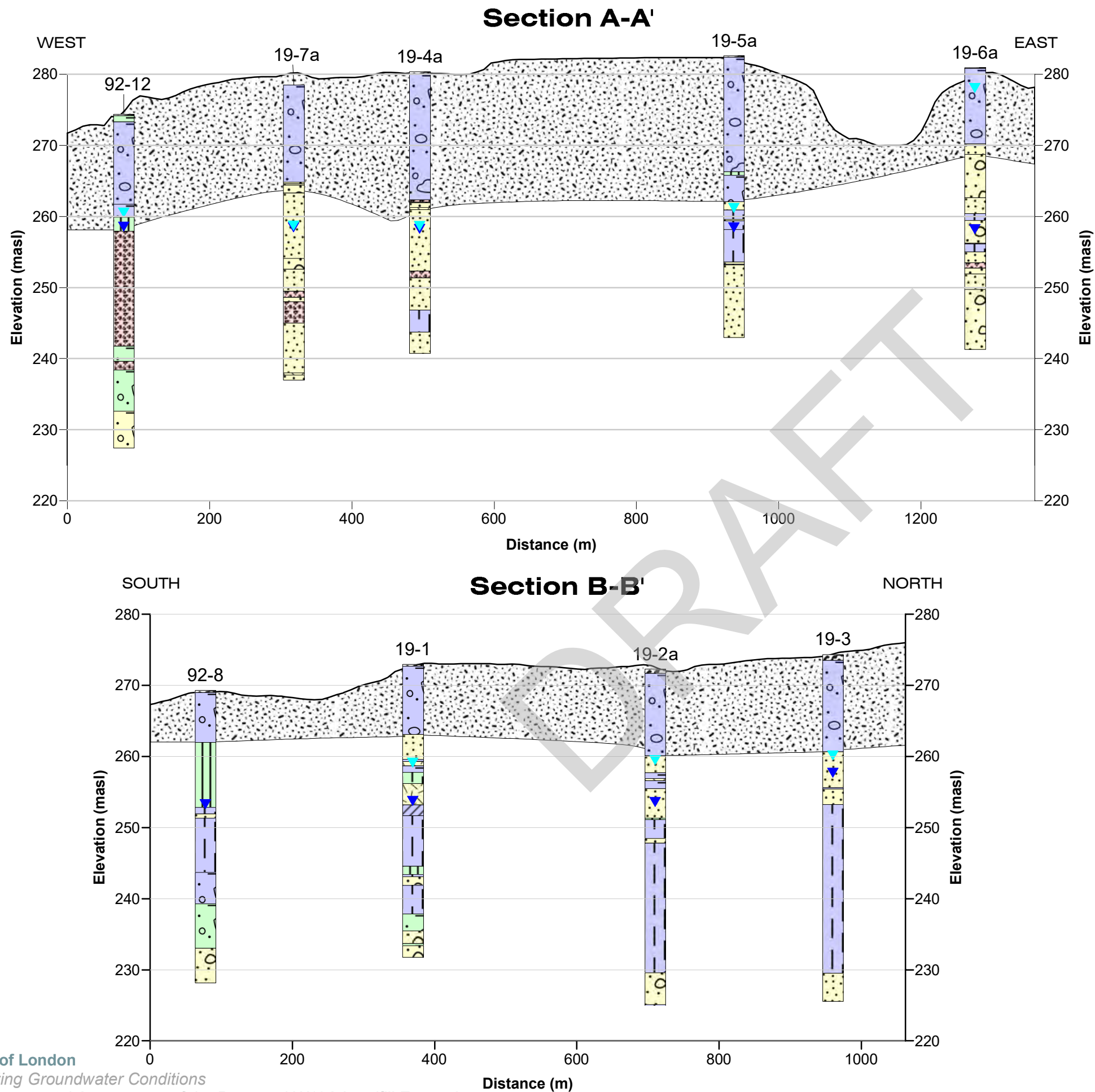
The following figures were prepared:

Figure 9 shows the interpreted surface of the Upper Aquifer

Figure 10 illustrates the thickness of the Surficial Aquitard. It is important to note that the original ground surface elevation was used to produce this figure (does not include the elevation of the fill areas of the existing landfill).

5.1.1 Surficial Aquitard

As shown on **Figure 10**, the thickness of the Surficial Aquitard varies from as much as 20 m in the northwest corner of the existing W12A Landfill site, to 15 m or greater below much of the existing landfill, and to about 8 m at the southeast corner of the site along Manning Drive. The new boreholes drilled east of the landfill (19-1, 19-2, and 19-3) confirmed the identified thickness of the Upper Aquitard at previously installed monitoring wells (19-3, 92-7 and 92-4, respectively).



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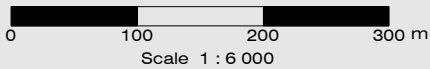
GEOLOGIC CROSS SECTIONS

Figure 8

LEGEND

- Surficial Aquitard
- Groundwater Level Upper Aquifer
- Groundwater Level White Oak Aquifer
- topsoil
- clay
- silty clay
- silty clay till
- clayey silt
- clayey silt till
- sandy silt
- sandy silt till
- silty sand
- silty sand till
- sand
- sand and gravel
- gravel

Note: See Figure 1 for Geologic Section Locations



NOTE: VERTICAL SCALE EXAGGERATED 10x

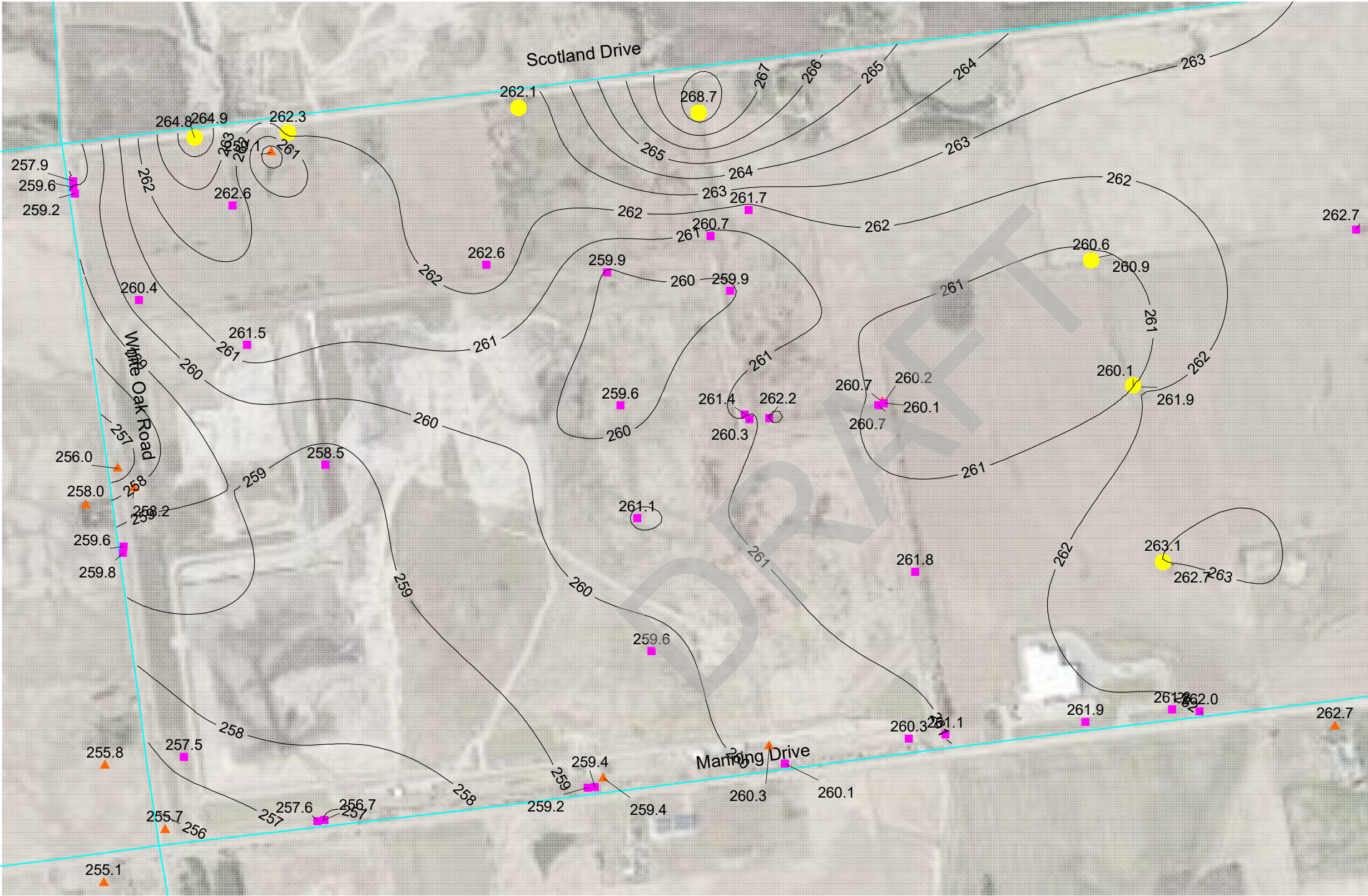
MAP CREATED BY : LOM
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**UPPER AQUIFER
SURFACE ELEVATION**

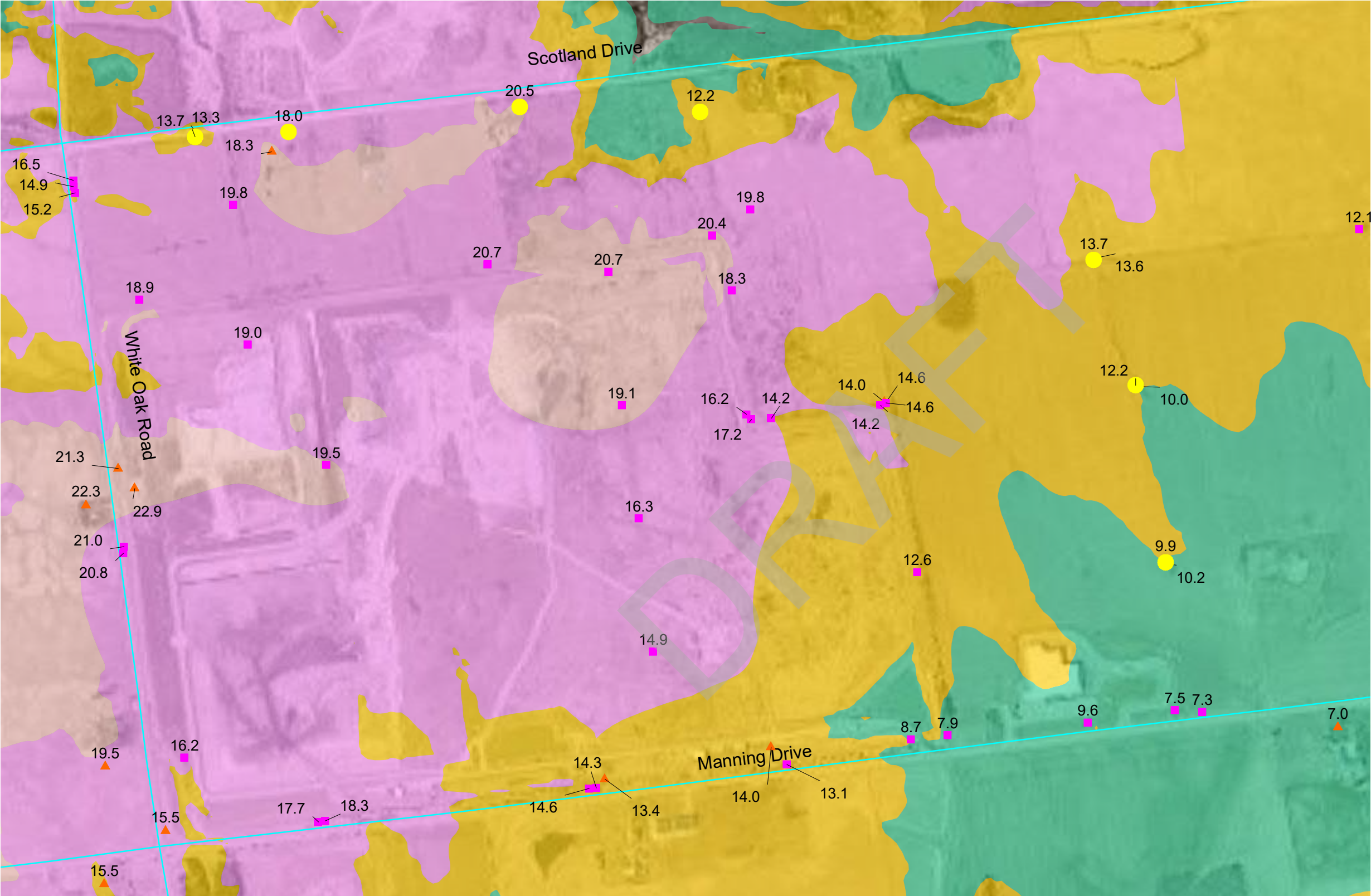
Figure 9

LEGEND

- 2019 Drilling Location
- Historical Borehole Data
- Water Well Record Data
- 260.1 Elevation of Upper Aquifer (masl)
- Upper Aquifer Surface Contour (masl)



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MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO



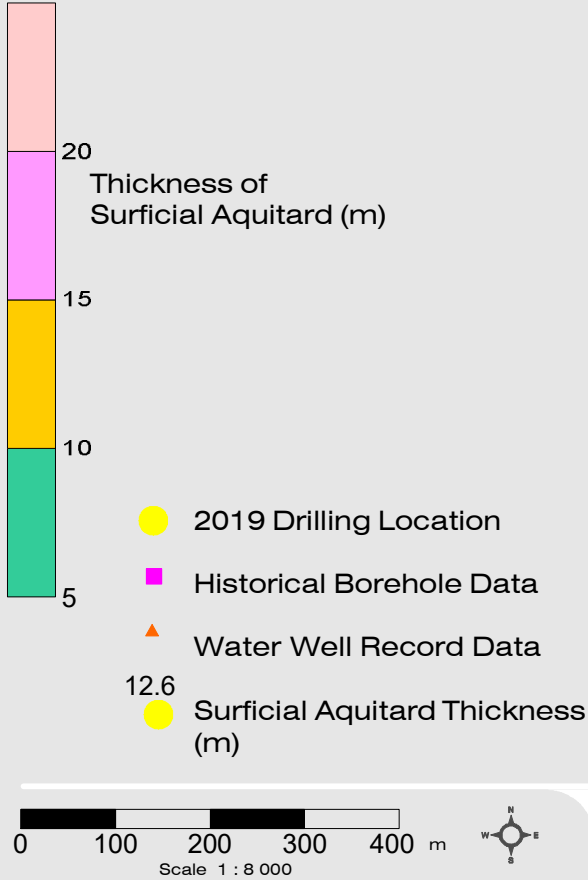
Existing Groundwater Conditions

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SURFICIAL AQUITARD THICKNESS

Figure 10

LEGEND



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MAP CHECKED BY: RFK
MAP PROJECTION: NAD 1983 UTM Zone 18N
2017 AIR PHOTO



PROJECT: 19-1230
STATUS: FINAL
DATE: AUGUST 2020

North of the landfill, the boreholes drilled just south of Scotland Drive indicated a consistent Surficial Aquitard thickness of 18 m to 20 m with the exception of BH19-6, the eastern-most borehole location, where a permeable layer of gravelly sand was encountered at a depth of 12.2 m and extended to a depth of 18.3 m (based on groundwater levels, the upper sand layers are probably hydraulically isolated from the Upper Aquifer - see Section 6.1.2).

Figure 9, which shows the interpreted surface elevation of the Upper Aquifer, indicate a relatively even surface (with the exception at BH19-6 noted above) that slopes from the northeast at an elevation of 263 masl to the southwest where it was encountered at an elevation of 256 masl (a slope of less than 0.5 %). From this figure it is concluded that the variations in the Surficial Aquitard thickness are more related to surface topography changes than variations in the elevation of the base of the aquitard unit. This is evident in the topographic low east of the Material Recovery Facility where the thickness of the Surficial Aquitard is consistently less than 10 m thick.

The results of the test pit excavation indicated a pattern of significant weathering and fracturing within the upper approximately 3 m from surface. The fracture spacing was generally less than 0.3 m. The colour of the till changed from mostly brown at ground surface to a mottled grey and brown appearance from about 1 m transitioning to mostly grey at a depth of 4 m. At depths below 4 m, the fracture frequency noticeably decreased to a separation distance greater than 0.5 m. Although, at the bottom of the test pit, one distinctive fracture was noted but did not extend below the base of the test pit.

Significant fracturing was noted in the soil cores taken below the Phase 1 landfill waste and subsequently tested at the University of Western Ontario in 2000. The effect of fracturing was most evident at one testing location where the upper 0.6 m of the core had significant chloride penetration in one core sample. However, beneath this depth, the chloride concentration profile with depth became diffusion dominated consistent with the other testing location. A flexible wall hydraulic conductivity test where a discoloured fracture was noted in the core sample had a hydraulic conductivity of 1.4×10^{-10} m/s, consistent with the unfractured core samples. It was concluded in that study that, even though the clay was observed to be fractured in the core samples, that consolidation due to the effective stress applied by the weight of the overlying waste effectively closed the fracture and did not cause preferential flow in the fracture (UWO, 2000).

Grain size testing of soil samples from soil cores taken in 2019 confirm visual observations that the till soils do not vary by location and are uniformly consistent. Overall, the Surficial Aquitard was encountered at all 2019 drilling locations and consistent with previous hydrogeological investigations completed in and in the vicinity of the landfill.

5.1.2 Upper Aquifer

The Upper Aquifer consists of layered sand and gravel soils found beneath the Surficial Aquitard. The layered nature of these soils indicates that they were deposited not directly by glaciers as were the till soils but are water-lain sediments. Like most local aquifers, there is considerable variability in the composition of the aquifer material but mainly the aquifer can be characterized as a sand aquifer with gravelly sand at some locations. The thickness of the Upper Aquifer is likewise variable ranging from less than 2 m to more than 8 m thick. The soil cores taken in 2019 also indicated some layers of silt and clay soil within the aquifer which is consistent with water-laid sediment. The Upper Aquifer is not present north of Scotland Drive, but extends south of Manning Drive.

5.1.3 Lower Aquitard

The Lower Aquitard occurs beneath the Upper Aquifer and separates the Upper Aquifer from the lower White Oak Aquifer. The Lower Aquitard consists mainly of silty clay soils. Unlike the Surficial Aquitard, there is considerable variation in the composition of the aquitard with silt water-laid sediments encountered immediately beneath the Upper Aquifer and clayey silt till soil generally found beneath the silt soils. Overall, the logging of continuous soil cores taken from the 2019 boreholes indicates more variability in the composition (in particular less till soils and more water-laid silt and clay soils) of the Lower Aquitard than previous investigations. Previous investigations did not continuously core through the Lower Aquitard and overburden conditions were inferred from the drilling process and discontinuous soil sampling. The Lower Aquitard was not encountered at BH19-7 where the Upper Aquifer occurs immediately above the White Oak Aquifer and the two aquifer systems are not distinguishable.

5.1.4

White Oak Aquifer

The White Oak Aquifer occurs beneath the Lower Aquitard and consist of stratified sand and gravel deposits most likely part of the Catfish Creek Drift. Regionally extensive, the White Oak Aquifer has been estimated to be 100 km² in area and extends from south of Lambeth (north of the Landfill) to approximately Glanworth Drive (south of the landfill). Groundwater flow in the White Oak Aquifer is from the northwest, where groundwater elevations are elevated due to a recharge zone north of Scotland Drive (gravel pit area) where ponds are directly hydraulically connected to the aquifer. Groundwater elevations decrease to the southeast. New monitoring wells installed in 2019 in the White Oak Aquifer (19-1, 19-2a and 19-3) indicate an area of low hydraulic gradient. The reason for the lack of hydraulic gradient in this area is not known but may be related to a decrease in recharge from surface and /or less influence from the recharge zone north of Scotland Drive (the gravel pit ponds) due to a greater distance from the recharge zone.

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