SCIENCE INTEGRITY KNOWLEDGE

WALKER ENVIRONMENTAL GROUP INC. SOUTHWESTERN LANDFILL PROPOSAL ENVIRONMENTAL ASSESSMENT

HUMAN HEALTH RISK ASSESSMENT (HHRA) REPORT

DRAFT REPORT

February 20, 2020

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List of Abbreviations

AAQC	Ambient Air Quality Criteria
ADI	Acceptable Daily Intake
ATSDR	Agency for Toxic Substances and Disease Registry
CACs	Criteria Air Contaminants
Cal EPA	California Environmental Protection Agency
CCME	Canadian Council of Ministers of the Environment
COC	Compound or Chemical of Concern
COPC	Chemicals of Potential Concern
CR	Concentration Ratio
CSM	Conceptual Site Model
EA	Environmental Assessment
EPC	Exposure Point Concentration
ESL	Effects Screening Level
TEF	Toxic Equivalency Factor
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
ILCR	Incremental Lifetime Cancer Risk
LADD	Lifetime Average Daily Dose
LCR	Lifetime Cancer Risk
LFG	Landfill Gas
MECP	Ontario Ministry of the Environment, Conservation and Parks
MPOI	Maximum Point of Impingement
NAAQO	National Ambient Air Quality Objective
NOAEL	No Observable Adverse Effect Level
OTR	Ontario Typical Background
PAH	Polycyclic Aromatic Hydrocarbon
PM	Particulate Matter
$PM_{2.5}$	Respirable Particulate Matter of a size less than 2.5 microns (µm)
PM_{10}	Inhalable Particulate Matter of a size less than 10 microns (µm)
RfC	Reference Concentration
RfD	Reference Dose
RIVM	The Dutch National Institute for Public Health and the Environment
SF	Slope Factor
TCEQ	Texas Commission on Environmental Quality
TDI	Tolerable Daily Intake
TEQ	Toxicity Equivalence Factors
ToR	Terms of Reference
TRV	Toxicological Reference Value
UR	Unit Risk
US EPA	United States Environmental Protection Agency
WHO	World Health Organization

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1.0 INTRODUCTION

An Environmental Assessment ("EA") is being prepared by Walker Environmental Group Inc. ("Walker") under Ontario's *Environmental Assessment Act* ("Act") for the '*provision of future landfill capacity at the Carmeuse Lime (Canada) Ltd. (Carmeuse) site in Oxford County for solid, non-hazardous waste generated in the Province of Ontario*'.

This is one in a series of technical studies that have been completed by qualified experts to examine the potential effects of the proposed landfill site on the environment, all in accordance with the requirements set out in the *Approved Amended Terms of Reference* ("ToR") dated May 10, 2016. This report accompanies and supports the *Environmental Assessment Report* prepared by Walker.

Note that Walker has carried out extensive consultation with government agencies, Indigenous Communities and interested members of the public regarding this study; details are provided separately in the EA report.

1.1 Purpose and Objectives

The purpose of this study is to complete a Human Health Risk Assessment (HHRA) of the landfill proposed by Walker.

The overall objectives of the study are listed below, in general accordance with the requirements for the assessment of an undertaking as set out in Section 6.1(2)(c) of the Environmental Assessment Act, and as specifically detailed in Section 8.1 of the ToR:

(a) Describe the **environment potentially affected** by the proposed undertaking, including both the existing environment as well as the environment that would otherwise be likely to exist in the future without the proposed undertaking.

(b) Carry out an evaluation of the **environmental effects** of the proposed undertaking, using the relevant environmental assessment criteria set out in the ToR (see Appendix B).

(c) Carry out an evaluation of any additional impact management actions that may be necessary to **prevent, change or mitigate any (negative) environmental effects**.

(d) Prepare a description and evaluation of the **environmental advantages and disadvantages** of the proposed undertaking, based on the net environmental effects that will result following mitigation.

(e) Prepare monitoring, contingency and impact management plans to **remedy the environmental effects** of the proposed undertaking.

1.2 The Proposed Undertaking

The landfill proposed by Walker is described in detail in the *Environmental Assessment Report*. Following is a brief summary for the benefit of the reader, highlighting aspects of the proposal most relevant to this study.

The landfill is to be located on a portion of Carmeuse's landholdings at its Beachville Quarry Operations in the Township of Zorra, Oxford County. Approximately 17.4 million m^3 of solid, non-hazardous waste and daily/intermediate cover will be deposited within a footprint of about 59 ha. The balance of the 81.6 ha site will be comprised of buffer areas for monitoring, maintenance, environmental controls and other necessary infrastructure (Figure 1-1).

Landfill construction will proceed progressively in a series of cells, generally from north-to-south (Figure 1-1). The former quarry floor will be backfilled to within about 30 to 40 metres below ground surface with engineered fill, and then a *Generic Design Option II – Double Liner* system (as specified by the Ministry of Environment, Conservation & Parks in the *Landfill Standards* under *O. Reg. 232/98;* see Figure 1-2) will be constructed across the bottom and up the sides of the landfill to contain and collect leachate (Figure 1-3). Up to 850,000 tonnes *per* year of solid, non-hazardous waste, and up to 250,000 tonnes per year of daily/intermediate cover soils[1] will then be placed and compacted above the liner in a series of small working areas approximately 0.2 ha in size at any given time, in order to minimize the exposed waste. Waste will be covered with soil on a daily basis, and a final cover with vegetation will be applied when the landfill reaches its final height, which peaks at about 15 m above ground (Figure 1-4). A landfill gas collection system will also be installed as the landfill/cell development progresses.

Most of the supporting infrastructure for the landfill will be located in the buffer area along the northern site perimeter, including the leachate and gas treatment plants. Leachate collected from the liner system will be treated on-site and the clean effluent from the treatment plant will be discharged into the Patterson-Robbins Drain next to the treatment plant. Clean precipitation and groundwater that has not come into contact with waste will be segregated and treated in storm water management ponds before being discharged from the site (Figure 1-1). Landfill gas will be collected in a network of extraction wells and pipes. Initially the landfill gas will be flared (combusted), but when the quantities permit the gas will be beneficially utilized as a renewable fuel.

The site will be open for waste deliveries from 7:00 a.m. to 5:00 p.m. on weekdays and from 7:00 a.m. to 1:00 p.m. on Saturdays but closed on Sundays and statutory holidays. On-site construction activities may start up to one hour before opening and continue up to two hours after closure. The primary designated haul route (*i.e.*, for all waste trucks except deliveries from the local area, if any) is from Highway 401 north along County Road #6, then west into the quarry property; trucks will then follow a newly constructed haul route across the quarry site to a landfill site entrance at the northwestern corner of the site (Figure 1-5). Vehicle traffic, including waste trucks as well as construction vehicles and staff, is expected to average approximately 210 trips per day.

Nuisance controls will include speed enforcement, regular haul road cleaning (on- and off-site), litter fencing and pick-up, and bird/pest management, with a public complaint reporting and response system.

[1] The daily/intermediate cover soil could consist of acceptable and suitable waste soils, and would be reported as waste, so the total reported waste receipts could be up to 1,100,000 tonnes per year.

There will be monitoring programs for equipment operations, leachate, groundwater, surface water, air emissions, gas, noise, and particulates (dust).

The landfill is anticipated to receive waste for approximately 20 years commencing in about 2023. After closure, maintenance and operation of the relevant environmental controls and monitoring will carry on during the post-closure period, until there is no further risk of environmental contamination. The end-use is assumed to be passive green space and agriculture, but the design is flexible to accommodate other potential end-uses.

The landfill will be developed in four (4) main stages where each stage will accommodate approximately five (5) landfill cells (referred to as cell) (Figure 1-1). This assessment relies on the data provided by the Air Quality Study (RWDI, 2020). The haul route portion of the air quality assessment by RWDI (2020) considered a waste filling rate of 850,000 tonnes per year of solid, non-hazardous waste, of which 70% consisted of biodegradable material, plus daily/intermediate cover soils. This waste was assumed to be distributed evenly throughout the landfill over the course of the 20-year lifespan, with filling occurring for 5 years within each Stage, as follows:

- **Stage 1**: Years 2023-2027;
- **Stage 2**: Years 2028-2032;
- **Stage 3**: Years 2033-2037; and,
- **Stage 4**: Years 2038-2042.

The haul route portion of the air assessment considers impacts in stages 1 and 3 of the landfill lifespans as they represent the worst-case scenarios for haul route related emissions. The landfill gas (LFG) assessment considers impacts in stages 1, 3, 4 and post closure. As each cell is developed and filled, the gas collection system, with vertical and horizontal extraction wells will be progressively installed. The efficiency of the LFG collection is estimated at about 85% for Stages of the landfill under final cover, and conservatively assumed to be 50% for an active Stage with daily or interim cover (RWDI, 2020). Although the active face (working area) of the landfill is normally approximately 2,000 m² (0.2 ha) in size, the LFG assessment by RWDI (2020) considered a maximum active face size of 4,000 m² (0.4 ha) as a contingency measure. All collected LFG was assumed to be combusted in an enclosed flare, similar to the existing flares in use at Walker's South Landfill, in Niagara Falls, Ontario.

The haul route and LFG assessments also considered the presence of a waste soil storage pile with a footprint area of up to 32,500 m², present in one of two locations, depending on the current Stage (RWDI, 2020).

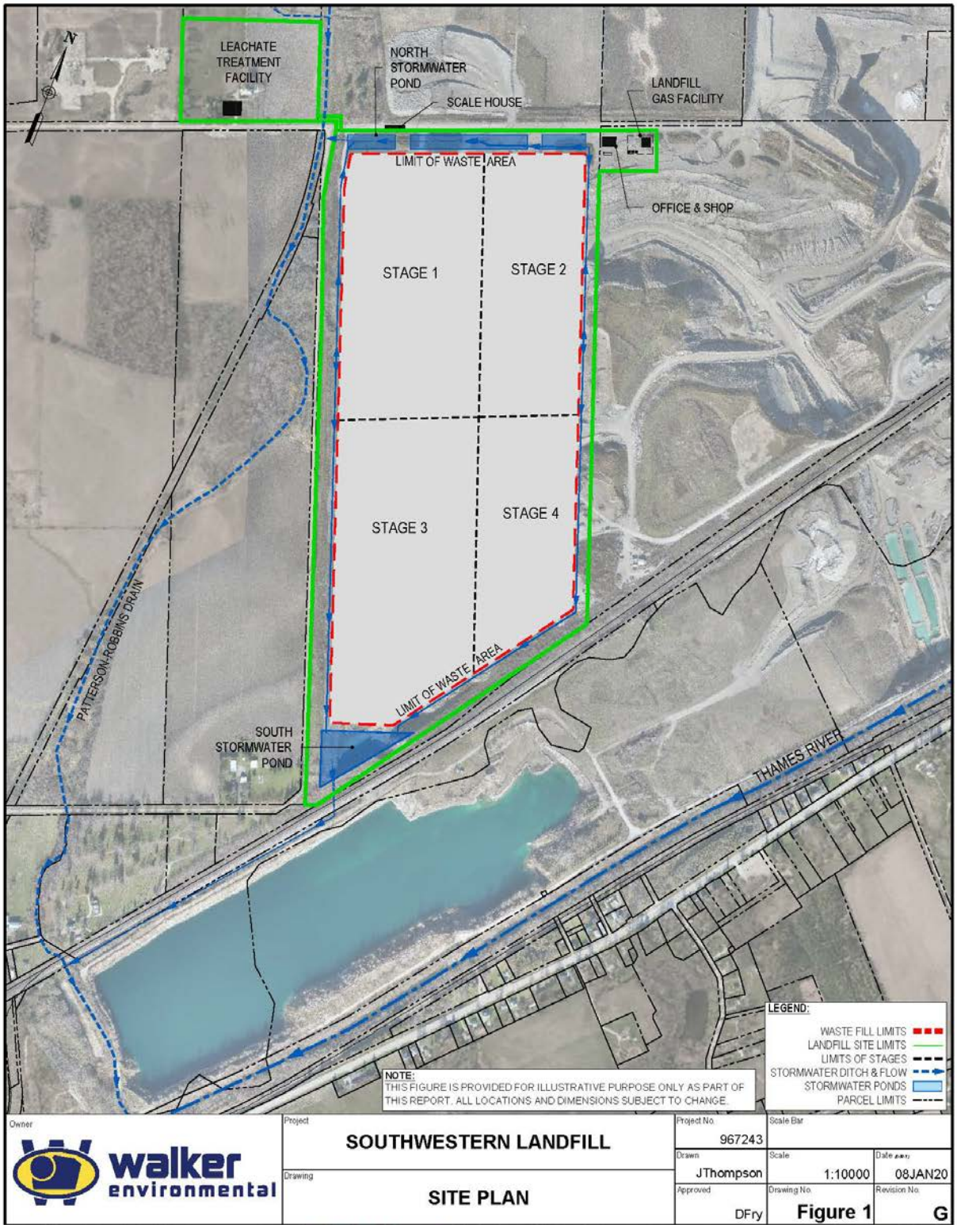

Figure 1-1 Site Plan for the Proposed Southwestern Landfill

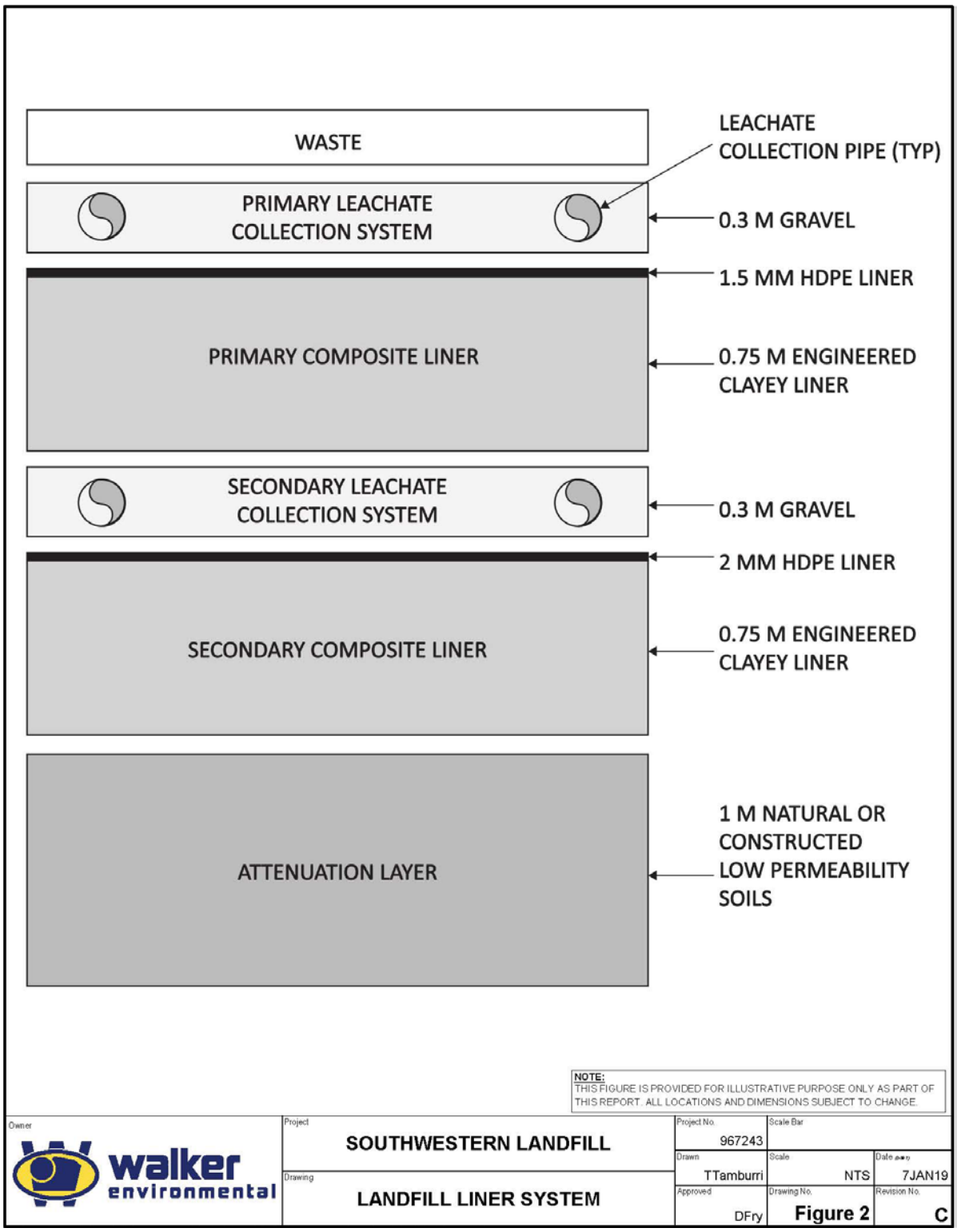

Figure 1-2 Landfill Liner System for the Proposed Southwestern Landfill

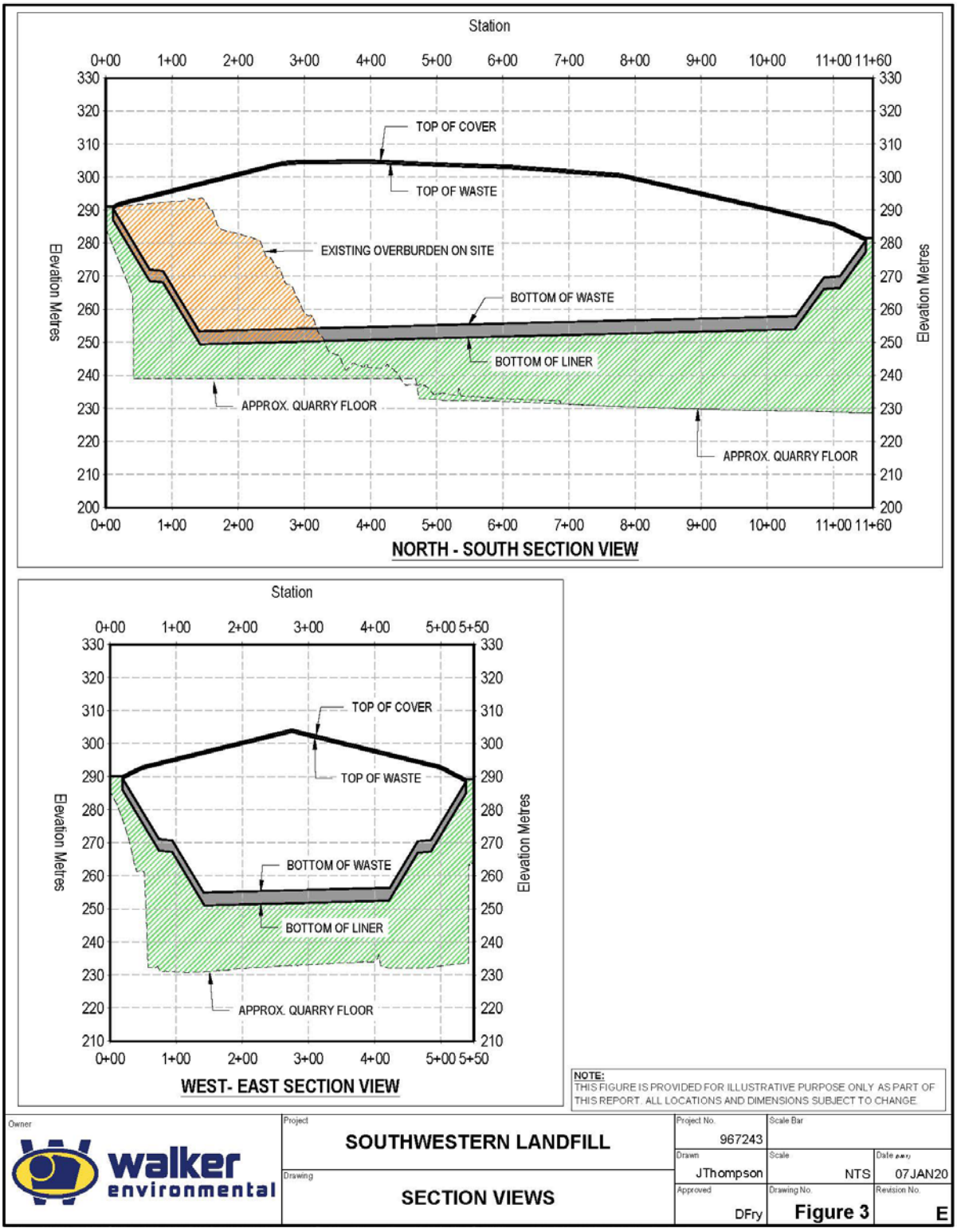

Figure 1-3 Section Views for the Proposed Southwestern Landfill

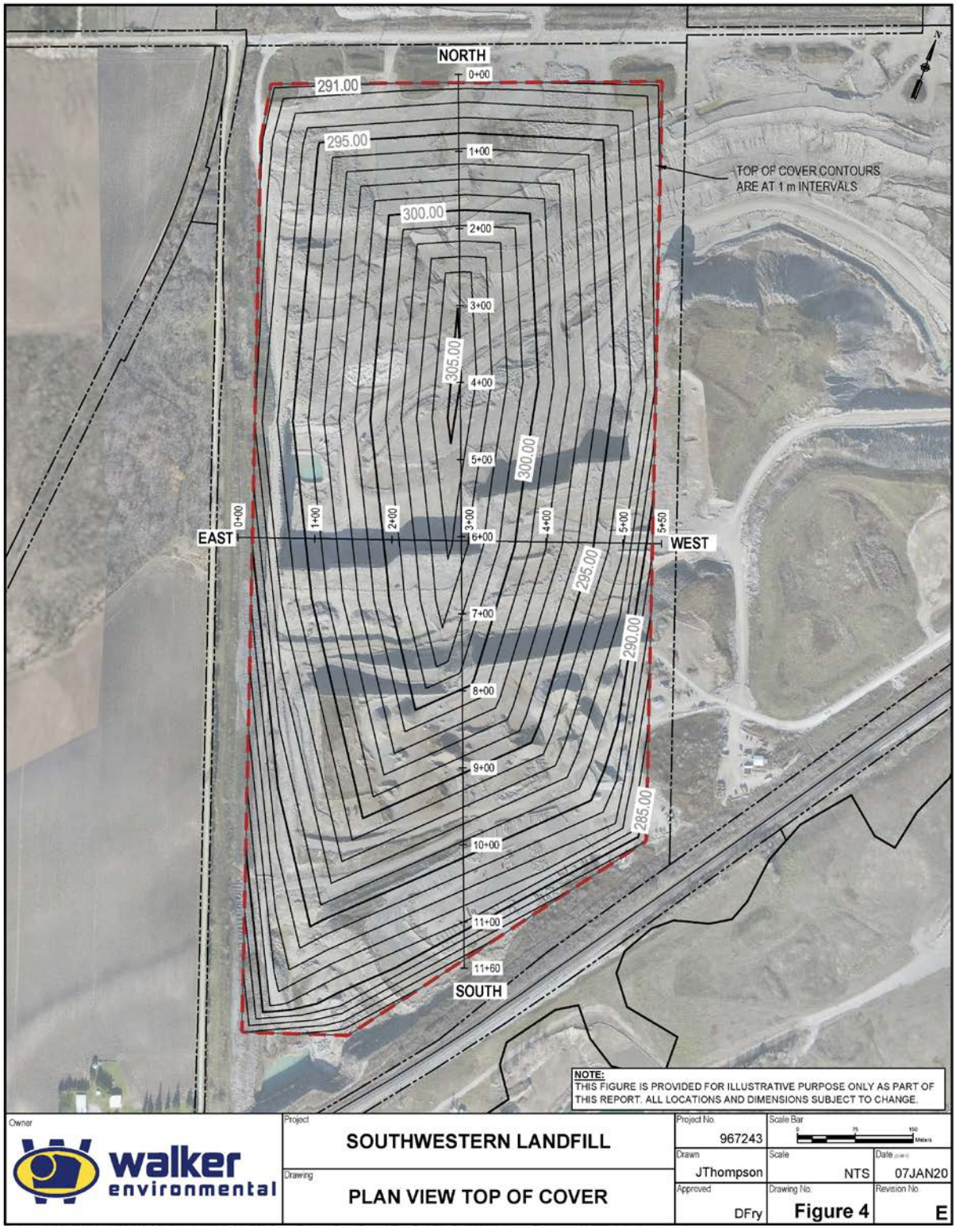

Figure 1-4 Plan View – Top of Cover for the Proposed Southwestern Landfill

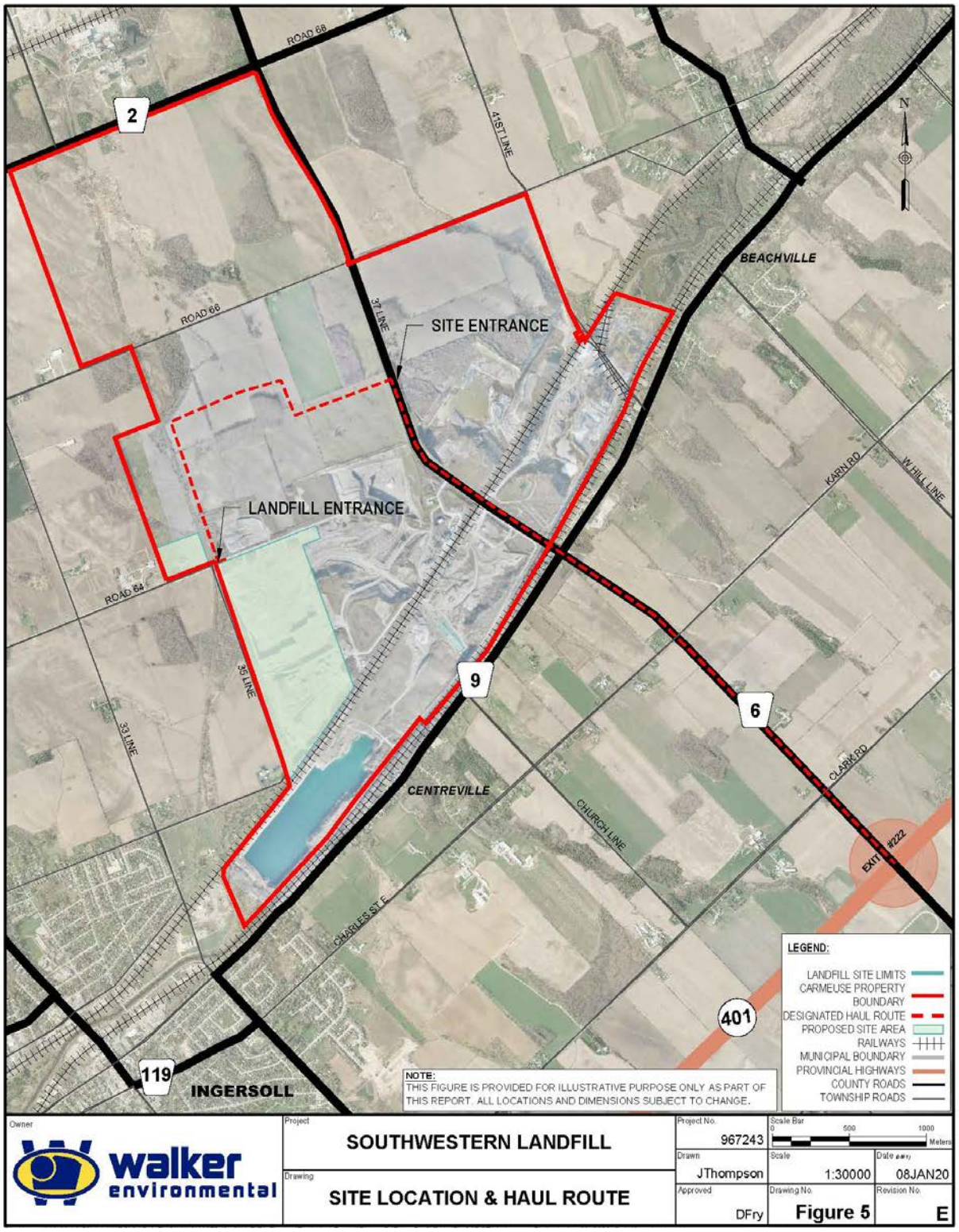

Figure 1-5 Haul Route and Site Entrance of the Proposed Southwestern Landfill

1.3 Environmental Assessment Criteria & Indicators

The **environmental assessment criteria**, as approved in the ToR, are tabulated in Appendix B, Table B-1. In the table, check marks indicate which technical studies are assigned primary ("lead") responsibility for assessing each of the criteria. Following are the EA criteria which are assigned to this study:

Table 1-1 Primary EA Criteria Addressed in the HHRA

EA Criteria	Definition/Rationale
Effects due to exposure to air emissions	Waste disposal facilities can produce gases containing contaminants that degrade air quality if they are emitted to the atmosphere. Other operations, such as leachate collection facilities, can also produce emissions that could degrade air quality in the vicinity of the site. Air Quality in the vicinity of the site should meet regulated air quality standards in order to protect public health.
Effects due to fine particulate exposure	Construction, operation, and truck haulage activities at a waste disposal facility can lead to increased levels of particulate (dust) in the air. Airborne fine particulate is a health concern in certain size ranges and exposure durations.
Effects due to contact with contaminated groundwater or surface water	Contaminants associated with a waste disposal site have the potential to seep into the groundwater or surface water. This could pose a public health concern if it enters local drinking water supplies, or if it mixes with surface water.

Furthermore, the criteria for this EA were designed to be cross-disciplinary to permit an assessment of cumulative effects. Table B-2 in Appendix B from the ToR illustrates some (though not necessarily all) of the key interconnectivities between the studies. As a result, this study provides input/data to additional environmental criteria that will be addressed through studies conducted by other experts including (but not limited to):

- Disruption to use and enjoyment of residential properties;
- Disruption to use and enjoyment of public facilities and institutions;
- Disruption of Farm Use; and,
- Property value impacts.

Indicators identify how the potential environmental effects will be measured for each criterion. Following are the indicators that were applied to each of the primary EA criteria addressed in this assessment:

Table 1-2 Primary EA Criteria Addressed in the HHRA

EA Criteria	Proposed Indicators/Measures
Effects due to exposure to air emissions	Comparisons of predicted air concentrations to acute, sub-chronic, and chronic inhalation health-based benchmarks, or equivalent.
Effects due to fine particulate exposure	Comparisons of predicted air concentrations to acute, sub-chronic, and chronic inhalation health-based benchmarks, or equivalent.
Effects due to contact with contaminated groundwater or surface water	Comparisons of predicted groundwater concentrations to acute, sub-chronic, and chronic oral health-based benchmarks, or equivalent.

1.4 Study Durations

Two main **study durations** (or time frames) for this proposed landfill have been identified in the ToR:

Operational Period	The time during which the waste disposal facility is constructed, filled with waste, and capped. These activities are combined since they occur progressively (*i.e.*, overlap) on a cell-by-cell basis, and they have a similar range of potential effects (*e.g.*, there is heavy equipment active on the site).
Post-Closure Period	The time after the site is closed to waste receipt. Activities are normally limited to operation of control systems, routine property maintenance and monitoring, and thus have a more limited range of potential effects.

The approved EA Criteria in Table B-1, Appendix B of the ToR, indicate the relevant study duration(s) associated with each of the criteria used in this assessment.

In addition, **common reference periods** or milestone dates were also defined for the operational period of the landfill:

Start of Construction	Est. 2021	Just prior to the start of landfill construction and operation, representing the existing baseline conditions.
Mid-Point	Est. 2033	Approximately midway through the landfill construction and operation.
Closure	Est. 2043	At the completion of the landfill construction and operation, representing the full operating size of the proposed landfill.

For the HHRA, all three evaluated criteria (*i.e.*, “effects due to exposure to air emissions”, “effects due to fine particulate exposure”, and “effects due to contact with contaminated groundwater or surface water”) will be considered during the operational period of the landfill. However, “effects due to fine particulate exposure” were not evaluated in the post-closure period due to no further landfill construction or waste haulage activities occurring during that reference period.

1.5 Study Areas

For the purposes of this EA, three general **study areas** were established in the ToR:

On-Site and in the Site Vicinity:	*On-site* includes the proposed waste disposal facility plus the associated buffer zones. *Site vicinity* is the area immediately adjacent to the waste disposal facility property that can be directly affected by the on-site activities. Its size is variable depending on the particular criteria being addressed.
Along the Haul Route:	The primary route along which the waste disposal facility truck traffic would move between a major provincial highway and the proposed waste disposal facility site entrance, plus the properties directly adjacent to these roads.
Wider Area:	The broader community, generally beyond the immediate site vicinity. Depending on the particular criteria this may include neighbourhoods, local municipalities, the Oxford County, or the Province of Ontario.

The tables of approved EA Criteria in Appendix B of the ToR indicate the relevant study duration(s) associated with each of the criteria in this assessment.

Although these three general study areas were common across all of the studies, their actual physical boundaries were not necessarily identical for every study or criterion; a flexible approach was used and the study area boundaries were adjusted as the work progressed to

ensure that they adequately encompassed the potential significant effects of the proposed landfill.

For the purposes of the HHRA, the initial estimate of the study areas based on our current understanding of the proposed site, and other landfills, is as follows:

On-Site and in the Site Vicinity	For the purposes of the evaluation of health impacts of air emissions from the Site, the *on-site and in the site vicinity* area typically extends to approximately 5 kilometres from the proposed landfill. This is based on the maximum extent of air quality effects that can be anticipated. However, the modeling area will predict the full extent of air quality effects from the landfill operations even if they were to extend beyond 5 km, and the study area would then be adjusted accordingly. As contaminants associated with the Site can potentially enter the groundwater or surface water and impact off-site groundwater or surface water, the Site Vicinity will also include the local area where surface water discharge from the Site is currently permitted (*i.e.,* the Thames River) and where the groundwater may potentially be drawn down to below original water levels, due to the existing and proposed activities at the Site (*i.e.*, quarrying).
Along the Haul Route	The *along the haul route* area for this assessment will be limited to 500 metres on both sides of the proposed haul route as provided by the traffic consultant and will apply only to the criteria related to vehicle emissions and retrained roadway dust. This is based on the maximum extent of air quality effects that can be anticipated from typical roadway sources of emissions. However, the modeling area will predict the full extent of air quality effects from the haul route even if they were to extend beyond 500 m area around the haul route, the study area would then be adjusted accordingly.

Where appropriate and relevant, **common receptor points** were also selected collaboratively by the technical experts so that the potential overlapping or cumulative effects of the proposed landfill could be assessed at these common receptor points. The common receptor points used in this study include those locations that represent the following:

- Residences or neighbourhoods nearest the proposed landfill (nearest residential locations to the north, south, east and west of the site);
- Residences or neighbourhoods along the haul route;
- Businesses or commercial/industrial areas, including farms or agricultural areas;
- Community or institutional facilities nearest the proposed landfill (*e.g.*, schools, community centres, hospitals, cemeteries);
- Areas or places with a potential view of the proposed landfill;
- Recreational areas nearest the proposed landfill (*e.g.*, parks, conservation areas, trails);
- Areas or places used by Indigenous peoples for traditional purposes;
- Areas or places of ecological importance; and,
- Areas or places identified for future development (*e.g.*, vacant properties).

2.0 REVIEW OF STUDY METHOLOGIES AND ANALYSIS

2.1 Risk Assessment Framework

In general, a human health risk assessment, or HHRA, is a scientific study that evaluates the potential for the occurrence of adverse health effects from exposures of people (receptors) to chemicals of concern (COCs) present in surrounding environmental media (*e.g.*, air, soil, sediment, surface water, groundwater, food and biota, *etc.*), under existing or predicted exposure conditions. HHRA procedures are based on the fundamental dose-response principle of toxicology. The response of an individual to a chemical exposure typically increases in proportion to the chemical concentration in critical target tissues where adverse effects may occur. The concentrations of chemicals in the target tissues (the dose) are determined by the degree of exposure, which is proportional to the chemical concentrations in the environment where the receptor resides, works or visits.

All chemicals (anthropogenic and natural) have the potential to cause effects in people and the ecosystem. However, it is the chemical concentration, the route of exposure, and the inherent toxicity of the chemical that determines the level of effect and potential for unacceptable risk to the exposed receptor. As illustrated in the diagram to the right, if all three components are present (*i.e.,* where the three circles intersect), the possibility of adverse risk exists.

The prediction of an individual's exposure to specific chemicals in the environment and the potential risks resulting from such exposures can be determined through the completion of a quantitative HHRA. The current HHRA follows the standard HHRA framework (see Figure 2-1) that is composed of the following steps:

i) Problem formulation;

ii) Exposure assessment;

iii) Hazard assessment; and,

iv) Risk characterization.

Typically, where potential adverse impacts are predicted through risk characterization, an additional step providing risk management and recommendations for mitigation measures to address these concerns can be added, if necessary. This risk management step is an integral part of the EA process, to ensure the mitigation of any predicted potential health risks within the HHRA Study Area.

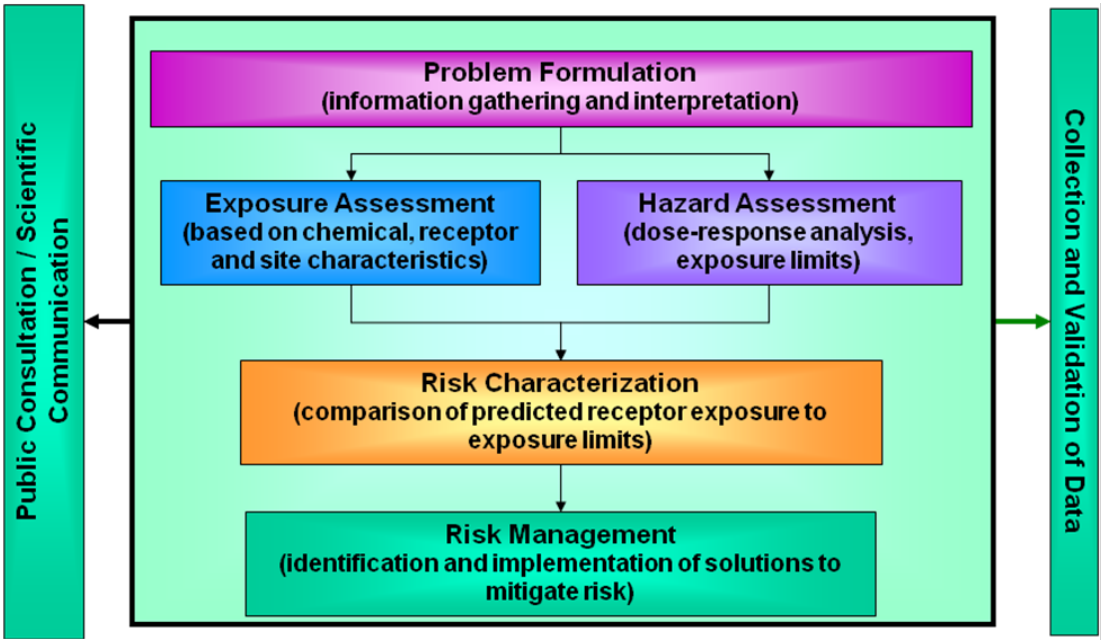

Figure 2-1 Human Health Risk Assessment (HHRA) Paradigm

2.1.1 Problem Formulation

The first step in the HHRA process is an information gathering and interpretation stage that plans and focuses the study on critical areas of concern for the Project. Problem formulation defines the nature and scope of the work to be conducted, permits practical boundaries to be placed on the overall scope of work and ensures that the assessment is directed at the key areas and issues of concern. This step is critical to the success of the HHRA as sound planning during the problem formulation step reduces the need for significant modifications once the HHRA has begun. The data gathered and evaluated in this step provides information into the physical layout and characteristics of the assessment area, possible exposure pathways, potential human receptors, COCs, and any other specific areas or issues of concern to be addressed.

The key tasks that comprise the problem formulation step of this HHRA include the following:

- **Site characterization**, which consists of a review of available project-specific data to identify factors affecting the availability of chemicals to potential receptors;
- **Chemical characterization**, which involves the identification of the COCs;
- **Receptor characterization** to identify “receptors of concern”, which include those individuals with the greatest probability of exposure to chemicals from the proposed facility and those that have the greatest sensitivity to these chemicals; and,
- **Identification of exposure scenarios and pathways** takes into account chemical-specific parameters, such as solubility and volatility, characteristics of the site, such as physical geography, as well as the physiology and behaviour of the receptors.

The outcome of these tasks forms the basis of the approach taken in the HHRA.

2.1.2 Exposure Assessment

The exposure assessment evaluates the available data related to all COCs, receptors and exposure pathways identified during the problem formulation phase. The primary objective of the exposure assessment is to predict, using site-specific data and a series of conservative assumptions, the rate of exposure (*i.e.*, the quantity of chemical and the rate at which that quantity is received) of the selected receptors to the COCs *via* the various exposure scenarios and pathways identified during development of the conceptual model. The rate of exposure to chemicals from many pathways is usually expressed as the amount of chemical taken in per body weight per unit time (*e.g.*, µg chemical/kg body weight/day). However, exposure to volatile chemicals *via* the inhalation pathway are assessed as an amount per volume of air basis, irrespective of inhalation rate, body weight, *etc.*

The magnitude of exposure of receptors to chemicals in the environment depends on the interactions of a number of parameters, including:

- The concentrations of chemicals in various environmental media;
- The physical-chemical characteristics of the chemicals of concern, which affect their environmental fate and transport and determine such factors as efficiency of absorption into the body;
- The influence of site-specific environmental characteristics, such as geology, soil type, topography, hydrology, hydrogeology, local meteorology and climatology *etc.*, on a chemical's behaviour within environmental media; and,
- The physiological and behavioural characteristics of the receptors (*e.g.,* respiration rate, soils/dusts intake, time spent at various activities and in different areas).

In order to evaluate potential exposures, it is necessary to characterize the physiological and behavioural characteristics of each receptor group. Several published sources will be considered in the selection of these parameters, including:

- Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Sites in Ontario. Standards Development Branch, Ontario Ministry of the Environment. April 15th, 2011. (MOE, 2011);
- Federal Contaminated Sites Risk Assessment in Canada. Part I: Guidance on Human Health Risk Preliminary Quantitative Risk Assessment (PQRA), Version 2.0. (Health Canada, 2012a); Compendium of Canadian Human Exposure Factors for Risk Assessment. O'Connor Associates Environmental Inc. 1155-2720 Queensview Dr., Ottawa, Ontario. (Richardson, 1997);
- Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. EPA/540//R/99/005. July, 2004. (U.S. EPA, 2004); and,
- The U.S. EPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities. (U.S. EPA, 2005).

These sources have been used in numerous HHRAs that have been critically reviewed and accepted by regulatory agencies across Canada and the United States. These sources will generally be used in the following order of preference: (i) provincial (MOE); (ii) federal (Health Canada); and, (iii) International (US, EPA). In the case of a deviation from the provincial sources, a detailed justification will be provided. Both the Compendium of Canadian Human Exposure Factors for Risk Assessment (Richardson, 1997) and Health Canada (2012) rely on data from

published and reliable Canadian sources, such as Health Canada, Statistics Canada, and the Canadian Fitness and Lifestyles Research Institute. Where insufficient data are available in these sources to appropriately characterize relevant activity patterns and/or behavioural/physiological characteristics of a certain receptor group, other appropriate sources such as the U.S. EPA Exposure Factors Handbook (U.S. EPA, 2011) will be used to supplement the receptor parameter dataset, if necessary.

2.1.3 Hazard Assessment

The hazard assessment involves identifying and understanding potential health outcomes that can result from exposure to each of the COCs and the conditions under which the outcomes might be observed. The hazard, or toxicity, assessment methodology is based on the fundamental dose response principle. That is, the response of biological systems to chemical exposures increases in proportion to the concentration of a chemical in critical target tissues where adverse health outcomes may occur.

2.1.3.1 Dose-Response Approaches

Two basic and quite different chemical categories are commonly recognized by regulatory agencies, depending on the compound's mode of toxic action, and applied when estimating toxicological criteria for humans (FDA, 1982; US EPA, 1989). These are the *threshold approach* (or the no-observed-adverse-effect levels [NOAELs]/benchmark dose with extrapolation/uncertainty factor approach) typically used to evaluate non-carcinogens, and the *non-threshold approach* (or the mathematical model-unit risk estimation approach), typically used for carcinogenic compounds. While there are other possible dose response relationships that could be used to describe the toxicological outcome related to exposure to a given chemical (*e.g.*, a J-shaped or an inverted U-shaped dose response such as would occur under hormesis conditions), the standard threshold and non-threshold approaches are the standard dose response relationships evaluated in HHRAs of this type.

Threshold Response Chemicals: For most effects, it is thought that there is a dose-response threshold below which no adverse effects would be expected to occur. Thresholds are generally assumed for non-carcinogenic effects because, for these types of effects, it is generally believed that homeostatic, compensating, and adaptive mechanisms must be overcome before toxicity is manifested. A NOAEL can be identified for threshold chemicals, which is the dose or amount of the chemical that results in no observable response in the most sensitive test species and test endpoint. The application of uncertainty or safety factors to the NOAEL provides an added level of protection, allowing for derivation of a *toxicity reference value* (TRV) or exposure limit that is expected to be safe to sensitive individuals following exposure for a prescribed period of time. Exposure limits derived for threshold-response chemicals are called reference concentrations (RfC), reference doses (RfD), acceptable daily intakes (ADI), tolerable daily intakes (TDI) or permissible daily intakes (PDI) and are generally derived by regulatory agencies such as Health Canada and the US EPA. These values indicate doses of chemicals that individuals can be exposed to on a daily basis over an entire lifetime without appreciable risk of the occurrence of adverse health effects.

Non-threshold Response Chemicals: This means that any exposure greater than zero is assumed to have a non-zero probability of causing some type of response or damage. This relationship is typically used for chemicals that can cause cancer by damaging genetic material. Under a "non-threshold" assumption, any exposure has some potential to cause damage, so it is necessary to define an "acceptable" level of risk associated with these types of exposures.

The acceptable level of risk is an issue of policy rather than a scientific decision (CCME, 2006), and is set by regulatory agencies as opposed to risk assessors. Regulatory agencies have typically employed acceptable incremental lifetime cancer risk (ILCR) levels (*i.e.*, over and above baseline) between 1-in-100,000 and 1-in-1,000,000. An ILCR represents the incremental risk of an individual within a given population developing cancer over his or her lifetime due to exposures from a specific carcinogenic compound.

- Health Canada has specified an ILCR of 1-in-100,000, which is considered "essentially negligible" (Health Canada, 2012).
- The Ontario Ministry of the Environment, Conservation and Parks (MECP) considers an ILCR of 1-in-1,000,000 to be acceptable for human health risk assessments in the Province of Ontario.

ILCRs generally consider risks related to a particular Project (the Project alone, excluding any contribution from other background or pre-existing sources) in that the cancer risks are expressed on an incremental or additional basis as compared to cancer risks related to all sources. The current HHRA is being conducted as part of an EA process in the Province of Ontario, and specifically in the Township of Zorra. As such, the ILCRs are reported relative to the Ontario acceptable ILCR of 1-in-1,000,000 (*i.e.*, one-in-one-million or 1×10^{-6}). This acceptable ILCR of 1-in-1,000,000 increases a person's lifetime cancer risk from 0.400000 (based on the existing 40% lifetime probability of developing cancer in Canada) to 0.400001.

Similar to an ILCR, the lifetime cancer risk (LCR) is an additional measure used to assess cancer. Unlike ILCRs, LCRs include the consideration of cancer risks from all sources including the particular facility under consideration. As such, LCRs are expressed on a total or all sources basis. MECP has indicated that it may be appropriate to consider cancer risks in this manner, which has been done in the current assessment. The MECP does not recommend an acceptable LCR for exposure to carcinogens associated with background or existing baseline conditions and, therefore, the LCR values (for "baseline" and "cumulative sources") are typically provided for reference only.

2.1.3.2 Exposure Limit Terminology

The terminology used to define threshold and non-threshold exposure limits differs according to the source/media and type of exposure and often varies between regulatory jurisdictions. The following terms are used to describe exposure limits in the current assessment.

Reference concentration (RfC): The US EPA defines a reference concentration as *"…an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.*" It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used." A reference concentration refers to the acceptable level of an airborne chemical for which the primary route of exposure is inhalation, and applies to either short- (*i.e.*, less than 24 hours) or long-term (*i.e.*, more than three months) exposure periods. The reference concentration is expressed as a concentration of the chemical in air (*i.e.,* micrograms per cubic metre, $\mu g/m^3$) and applies only to chemicals acting through a threshold mode of toxicological action.

For chemicals such as irritants and some combustion gases, short term or acute non-systemic toxicity is frequently observed at the points of entry into the body (*i.e.*, the respiratory tract, eyes, and skin, for air-borne contaminants). In these cases, because the toxicity is enacted simply by direct contact between the receptor and the contaminated medium, the concentration in the air to which the receptor is exposed is the important measure of exposure, rather than the internal dose associated with multiple exposure pathways. For chemicals with these characteristics, short term RfCs are used to characterize health risk, and are intended to be protective of the general population.

Reference dose (RfD): The US EPA defines a reference dose as *"…an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.*" It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used." The reference dose is most commonly expressed in terms of the total intake of the chemical per unit of body weight (*i.e.,* micrograms per kilogram of body weight per day, µg/kg bw/day) and applies only to chemicals acting through a threshold mode of toxicological action.

Inhalation unit risk (IUR): The US EPA defines a unit risk value as "*…the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/L in water, or 1 µg/m^3 in air…"* The risks are referred to as "upper bound" because they are not likely to be underestimated and, in fact, may range from as low as zero to the upper bound value. A unit risk value of 3.0 x 10^{-5} per µg/m^3 would mean that under an upper worst-case estimate, three excess cancer cases would be expected to develop per one hundred thousand (100,000) people, if all 100,000 people were exposed every day for a lifetime to 1 µg of the chemical per m^3 of air.

Cancer slope factor (SF): The US EPA defines a cancer slope factor (SF) as *"…[a]n upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg-day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100.*"

2.1.3.3 Exposure Duration

The toxicity of a chemical has been observed to vary between acute (short term) and chronic (long term) exposure. Thus, it is important to differentiate TRVs based on duration of exposure. The two TRV durations used in the current HHRA can be described as follows:

- ***Acute:*** the amount or dose of a chemical that can be tolerated without evidence of adverse health effects on a short-term basis. These benchmarks are routinely applied to conditions in which exposures extend from minutes through several hours or several days only (ATSDR, 2006). For the current HHRA, risks have been evaluated based upon a 24-hour exposure period, where a relevant acute TRV for that time period is available.
- ***Chronic:*** the amount of a chemical that is expected to be without effect, even when exposure occurs continuously or regularly over extended periods, possibly lasting for periods of at least a year, and possibly extending over an entire lifetime (ATSDR, 2006).

For the current assessment, TRVs endorsed by MECP were given preference unless alternative, more recent or appropriate reference benchmarks were available by another reputable regulatory agency. In circumstances where TRVs were not presented by MECP, and when TRVs for a

particular COC were available from multiple regulatory agencies, values were reviewed, and the professional judgment of an experienced toxicologist and/or risk assessor was used to select the most appropriate TRV.

The most critical considerations in selecting TRVs were the source (it must have been derived by a reputable agency), the data used to derive the benchmark, the date the TRV was derived (it must be as up to date as possible), and its relevance in terms of duration and route of exposure. Both MOE (2005, 2011) and Health Canada (2010) provide lists of acceptable jurisdictions that maybe be used to determine toxicity reference values. The TRVs employed in the HHRA have been obtained from regulatory agencies such as:

- Ontario Ministry of the Environment, Conservation and Parks (MECP);
- Health Canada;
- United States Environmental Protection Agency Integrated Risk Information System (US EPA IRIS);
- Agency for Toxic Substances and Disease Registry (ATSDR);
- Canadian Council of the Ministers of the Environment (CCME);
- World Health Organization (WHO);
- California Environmental Protection Agency (Cal EPA);
- Texas Commission on Environmental Quality (TCEQ); and,
- The Dutch National Institute for Public Health and the Environment (RIVM).

Details on potential health outcomes associated with the COC, along with the basis of the TRVs, are outlined in toxicity profiles provided in Section 5.0 and Appendix A of this report.

2.1.4 Risk Characterization

The final step of a risk assessment is risk characterization. This involves the estimation, description, and evaluation of risk associated with exposure to COCs by comparing the estimated exposure to the appropriate reference benchmark or TRV for a specific chemical or group of compounds. Risk characterization involves the comparison of estimated exposures (identified in the exposure assessment) with reference benchmarks or TRVs (identified during the hazard/toxicity assessment) to identify potential human health risks. This comparison is typically expressed as a Concentration Ratio (CR) or Hazard Quotient (HQ) for non-carcinogenic chemicals and is calculated by dividing the predicted exposure by the reference benchmark/TRV. In the case of direct acting non-threshold carcinogenic chemicals, potential risks are expressed as incremental lifetime cancer risks (ILCRs), and represents the incremental risk of an individual within a given population developing cancer over his or her lifetime due to exposures from a specific carcinogenic chemical of concern.

Separate assessments were completed for short term (acute) and long term (chronic) durations because the health outcomes produced by some COCs depend on the duration of exposure. It is important to distinguish between the health outcomes that might result from short-term exposures *versus* effects that may occur following long-term exposures. In the long-term exposure assessment, further distinction was made between inhalation alone (which included all emitted COCs) and multiple pathway exposures (*i.e.*, inhalation, oral and dermal together) since the pathway of exposure could also influence the potential health outcomes associated with each of the COCs.

In many transportation risk assessments, such as that being conducted for the haul route component of the current Project, the assessment of 1-hour acute exposures is frequently evaluated to ensure potential short-term impacts on local air quality around a given corridor are considered. However, given the nature of the emission sources under consideration in the current assessment (*i.e.*, landfill gas, landfill gas flare byproduct, or a minimal number of trucks travelling on nearby routes), it is unlikely that 1-hour exposures would be significant and were considered outside the scope of the current assessment.

In recognition of the influence of these exposure variables, risk estimates were segregated into:

- Short-term inhalation (24-hour durations, or 8-hour durations in the case of carbon monoxide);
- Long-term inhalation (annual average durations); and,
- Long-term multi-media pathways (*i.e.,* oral and dermal exposures).

2.1.4.1 Concentration Ratios (CRs) and Hazard Quotients (HQs) for Non-Carcinogens

Concentration Ratios (CR)

CR values were used to evaluate the short- and long-term health risk from exposure to chemicals *via* inhalation. CR values have been calculated by dividing the predicted ground-level air concentration (for 24-hour or annual average exposure durations) by the appropriate toxicity reference value (*i.e.*, RfC), according to the following example equation:

$$CR_{duration} = \frac{[Air]_{duration}}{RfC_{duration}}$$

Where:

$CR_{duration}$	=	the duration-specific *CR* (unitless), calculated for 24-hour short-term and long-term durations, as appropriate
$[Air]_{duration}$	=	the predicted ground-level air concentration (µg/m^3) for the specific time duration
$RfC_{duration}$	=	the RfC (µg/m^3) for the specific time duration

For a COC expected to be present in a single environmental media, such as the case with many gases which occur only or predominately in ambient air, a benchmark representing the entire exposure limit (*i.e.*, a CR value of 1.0) is considered appropriate. Therefore, a CR value of 1.0 (*i.e.*, 100% of the exposure limit) was used as acceptable CR value in the inhalation assessment. Short- and long-term CR values less than the selected benchmark (*i.e.*, CR ≤1.0), indicate that predicted concentrations of COC in air were less than the applicable inhalation exposure limit (*e.g.*, RfC) and that adverse health effects would not be expected to occur.

When predicted risks are greater than the inhalation benchmark level (*i.e.*, CR > 1.0), this indicates the potential for adverse health outcomes may exist. This outcome is referred to as an "exceedance" (*i.e.*, the predicted ground-level air concentration is greater than, or exceeds, the corresponding inhalation exposure limit for that averaging period). Re-evaluation of such CR estimates is important since both the exposure estimates and the toxicological criteria are based on a series of conservative assumptions, particularly when considering the maximum "worst-case" exposure scenarios.

In general, interpretation of the CR values proceeded as follows:

CR ≤1:

Signifies that the estimated exposure is less than or equal to the TRV (*i.e.*, the assumed safe level of exposure). This situation is generally indicative of a negligible likelihood of inhalation health effects. Typically, a significant degree of conservatism (or protection) is incorporated during the derivation of a TRV and, therefore, if predicted exposures (under a worst case or highly conservative set of conditions) are less than a properly derived TRV, it can reasonably be concluded that predicted health risks are not of concern. An exception to this may be in the evaluation of certain criteria air contaminants where no threshold for effects has been identified.

CR >1:

Signifies that the exposure estimate exceeds the TRV. This suggests that the potential for an elevated level of risk may be present for a particular COC, and triggers an additional evaluation. The significance of a CR above 1 must be balanced against the degree of conservatism incorporated in the risk assessment (*e.g.,* an accounting of the number of assumptions used within the risk assessment that tend to overestimate, rather than underestimate, exposure and health risks).

Hazard Quotients (HQ)

Hazard Quotient (HQ) values were used to express risk resulting from long-term exposures to systemically acting, non-carcinogenic chemicals. This approach was used where the exposure to the chemical occurs through multiple pathways, and shows the additional risks related to the oral and dermal exposure pathways. HQ values were calculated by dividing the predicted exposure (*via* multiple pathways) by the appropriate toxicity reference value (RfD), according to the following example equation:

$$HQ = \frac{Exposure}{RfD}$$

Where:

HQ	=	the chronic Hazard Quotient (unitless), calculated for long-term exposures resulting from multiple pathways of exposure
Exposure	=	the long-term exposure estimate resulting from multiple pathways of exposure (µg/kg bodyweight/day
RfD	=	the chronic RfD (µg/kg bodyweight/day)

For long-term multi-media exposures, the CCME (2006) typically allocates 20% of the total exposure to any one environmental media during the derivation of its health-based soil quality criteria. This was based on the assumption that the source of exposure to a particular chemical may occur *via* five potential media: air, food, water, soil, and consumer products. A similar source attribution or allocation model has been adopted by the MOE (2011). This means that, in the absence of a multi-media assessment that takes into account multiple sources or media, the exposure limit should be apportioned for the single medium under consideration.

For the current assessment a benchmark of 0.2 was selected for the evaluation of the long-term multi-media assessment of Project alone emissions since not all potential exposure sources were considered (*i.e.*, the contribution of background sources of these chemicals will not be

quantified in the multi-media assessment). HQ values that are less than 0.2 represent a situation in which Project-related exposures (*e.g.*, facility- or transportation-related emissions) account for less than 20% of the oral exposure limit (*e.g.*, oral RfD). As a result, no adverse health risks are expected to be associated with the estimated level of exposure. When predicted health risks resulting from Project alone emissions were greater than the benchmark level (*i.e.*, HQ > 0.2), this may indicate the potential for adverse health outcomes among the most sensitive members of the population and triggers an additional evaluation. Re-evaluation of such HQs is important since both the exposure estimates and the TRV are based on a series of conservative assumptions, particularly when considering the maximum "worst-case" exposure scenarios.

In general, interpretation of the HQ values proceeded as follows:

HQ ≤0.2:

Signifies that the estimated exposure is less than or equal to 20% of the oral exposure limit (*i.e.*, the assumed safe level of exposure). This is generally indicative of a negligible likelihood of adverse human health effects. Typically, an added assurance of protection is provided by the significant degree of conservatism (or protection) used during the development of regulatory exposure limits and predicted exposure estimates.

HQ >0.2:

Signifies that an exposure estimate exceeds 20% of the of the oral exposure limit. This generally suggests that the potential for an elevated level of health risk may exist for the specific COC and triggers an additional re-evaluation. The significance of an HQ above 0.2 must be balanced against the high degree of conservatism incorporated in the risk assessment (*e.g.*, an accounting of the number of assumptions used within the risk assessment that tend to overestimate, rather than underestimate, exposure and health risks)

2.1.4.2 Incremental Lifetime Cancer Risks (ILCRs) for Carcinogens

ILCR estimates were used to evaluate the increased cancer risk resulting from a lifetime of exposure to genotoxic, typically non-threshold carcinogenic chemicals. ILCR estimates provide the incremental lifetime cancer risk resulting from contributions from Project emissions to the surrounding community.

Direct Air Inhalation

For carcinogenic chemicals evaluated as part of the inhalation assessment, ILCR estimates resulting from direct air inhalation were calculated as follows:

$$ILCR = [Air]_{Facility} \times IUR$$

Where:

ILCR	=	the incremental (or additional) lifetime cancer risk (unitless)
$[Air]_{Facility}$	=	the predicted annual average ground-level air concentration (µg/m^3) for the specific chemical arising from facility emissions
IUR	=	the chemical-specific inhalation unit risk value (µg/m^3)$^{-1}$

Multi-Media Exposure

For carcinogenic chemicals evaluated as part of the multi-media assessment, ILCR estimates resulting from a lifetime of exposure through multiple pathways were calculated as follows:

$$ILCR = LADD \times CSF$$

Where:

ILCR	=	the incremental lifetime cancer risk (unitless)
LADD	=	the incremental Lifetime Average Daily Dose *via* multiple pathways resulting from facility emissions (µg/kg bodyweight/day)
CSF	=	the chemical-specific cancer slope factor (µg/kg bodyweight/day)$^{-1}$

The resulting estimated incremental lifetime cancer risk can be compared to an acceptable risk level of cancer to determine if predicted exposures pose an unacceptable health risk. In the Province of Ontario, the acceptable ILCR is one-in-one million (or 1-in-1,000,000).

In general, interpretation of the ILCR values proceeded as follows:

ILCR ≤ 1.0 x 10^{-6} (1E-06):

Signifies that the estimated exposure results in an incremental lifetime cancer risk less than or equal to 1-in-1,000,000 (*i.e.*, within the accepted level of risk set by MECP; Health Canada sets the level of essentially negligible risk at 1-in-100,000). This shows that negligible health risks are predicted. Toronto Public Health encourages actions to reduce exposures when the risk is above one-in-one million. Added assurance of protection is provided by the high degree of conservatism (protection) incorporated in the derivation of the cancer-based unit risk and slope factor and the exposure estimate.

ILCR > 1.0 x 10^{-6} (1E-06):

Signifies the estimated exposure results in an incremental lifetime cancer risk greater than the MECP acceptable regulatory-established cancer risk benchmark of 1-in-1,000,000. This suggests that the potential for an elevated level of risk above MECP's acceptable ILCR (of 1-in-1,000,000) may be present for some COC, the significance of which must be balanced against the high degree of conservatism incorporated in the risk assessment.

2.1.5 Chemical Mixtures

Concurrent exposures to more than one chemical may result in toxicological interactions which produce health outcomes; this may also result in a combined toxicity which is equal to the sum of toxicities of the individual chemicals (additivity or independence), greater than the sum (synergism or potentiation) or less than the sum (antagonism). In general, toxicological interactions depend on the chemicals present, the levels of exposure to each, their mode of action and their concentrations. Most non-additive interactions can only be demonstrated at relatively high exposures, where clear adverse health outcomes are observed. Such interactions have not been observed or quantified at the relatively low rates of exposure typical of those associated with most environmental situations (NAS, 1983; Krewski and Thomas, 1992; US EPA, 2000; Health Canada, 2012).

Because chemical exposures rarely occur in isolation, the potential health outcomes associated with mixtures of the COCs were assessed in the HHRA. The interaction between chemicals can take many forms, with additive interactions being assumed for the HHRA (Health Canada, 2012). Additive interactions apply to chemicals that are structurally similar, act toxicologically through similar mechanisms or affect the same target tissue in the body (*i.e.,* share common health outcome) (Health Canada, 2012).

The evaluation of risks related to chemical exposures in mixtures is an emerging science. There are currently no accepted reference benchmarks or specific guidance (beyond those chemical groups that have established *toxicity equivalency factors* or TEFs) by which one could evaluate whether exposure to a given mixture could pose a health concern. While the MECP has not developed specific guidance on chemical mixtures assessment beyond these chemical types, there is a requirement under the Provincial regulations to consider cumulative effects (*i.e.*, the additive or synergistic effects of chemical mixtures) when conducting risk assessments. Since discussions on acceptable benchmarks for chemical mixtures are emerging, the ministry has previously recommended that as a minimum HQ's and ILCR are summed when toxicologically justified (*e.g.*, common modes of toxicological action) and when significant mixture interactions are identified (*i.e.*, independent modes of action at any level of disposition) that they be qualitatively discussed. It should be noted that this would be considered a conservative approach, as the ILCR represents the incremental risk of an individual within a given population developing cancer over his or her lifetime due to exposures from a *specific* carcinogenic chemical, and has historically not been intended for use in evaluating the risk from a mixture of COCs.

2.2 Data Collection

The following section provides an overview of the data sources used in the current assessment.

2.2.1 Background Data

All background and predicted future air concentrations for the relevant COCs were provided by the Air Quality Assessment Report (RWDI, 2020). The Air Quality study also provided deposition rates for relevant COCs which could be used to predict other exposure media concentrations (*e.g.*, surficial soil, home garden soils, home garden produce, agricultural food chain, *etc.*).

RWDI conducted a monitoring program for the various COCs to determine the existing baseline conditions. The monitoring program is discussed in further detail in Section 3.5.1 and in the Air Quality Assessment Report (RWDI, 2020).

For the haul route assessment, the Air Quality team obtained the background concentrations of certain COCs (*i.e.,* nitrogen oxides, carbon monoxide, sulphur dioxide, benzo(a)pyrene, and formaldehyde) from the MECP Air Quality in Ontario reports for 2014, 2015, and 2016; and through the National Air Pollution Surveillance (NAPS) ambient monitoring database. Background annual average concentrations of VOCs evaluated in the LFG assessment were obtained from provincial monitoring stations in similar geographical and land-use scenarios, where possible (*i.e.*, Kitchener, Simcoe, *etc*.) avoiding those stations in areas heavily dominated by either industrial or vehicle emissions (*e.g.*, stations in the Greater Toronto Area).

Details associated with the air quality data and predictions is available in the Air Quality Assessment Report (RWDI, 2020).

2.2.2 Field Data

RDWI collected ambient monitoring data and was included in the Air Quality Assessment Report (RWDI, 2020). The monitoring program is discussed in further detail in Section 3.5.1 and in the Air Quality Report (RWDI, 2020). The composition of VOCs in the raw LFG was based on LFG analysis from the Walker's East and South landfill sites located in Niagara Falls, Ontario. LFG emission rates were based on flux chamber analysis conducted at Walker's East and South landfill sites in Niagara Falls.

Groundwater and surface water concentrations for the relevant COCs are provided by the Groundwater/Surface Water Assessment Reports (Golder, 2020).

2.3 Supplemental Health Review (SHR)

In his review of the Terms of Reference, the then Acting Medical Officer of Health for Oxford County, Dr. Douglas Neal, identified the potential for health-related effects extending beyond those addressed through the HHRA, in particular "*the inter-relationships of the social and economic constructs of the proposed landfill*" (August 21, 2014). As a result, Walker proposed that an additional review of the social and economic impact assessment studies be carried out by the health expert (Intrinsik), in consultation with Dr. Neal and Dr. Derek Hillis, the Joint Municipal Coordinating Committee peer review health expert (September 12, 2014). The Minister for the Environment adopted this recommendation in approving the Terms of Reference, adding the following amendment:

13. *In addition to the proposed health risk assessment, Walker's health expert shall carry out a screening-level review of the socio-economic assessment results to determine the potential for related health effects. Early in the environmental assessment process, prior to finalizing any work plans associated with the determination of health effects, Walker shall consult with the Joint Municipal Coordinating Committee and local medical officer of health to get input on the criteria and methods of assessment. As part of this consultation, Walker will discuss with the Joint Municipal Coordinating Committee and local medical officer of health, at a minimum, the determinants of health that will be assessed, and the different stages of assessment that will be undertaken including screening, scoping, assessment, mitigation, reporting and monitoring.*

    Walker shall provide detailed documentation of the issues and concerns raised in the finalization of the health studies work plans and the results. The documentation will include how those issues were considered, the steps that were undertaken to address comments received, where possible, and the rationale for why some comments may not have been addressed. If any significant negative effects are identified as part of the health studies, Walker's health expert will work closely with the social, economic and environmental experts, including the Joint Municipal Coordinating Committee and local medical officer of health, to determine what, if any, further studies are necessary and adapt or augment their mitigation recommendations to minimize or eliminate these potential effects, and characterize any residual net effects for the purposes of this environmental assessment. This decision-making will also be documented.

To address these requirements, Intrinsik has completed a *Supplemental Health Review* (SHR) focused primarily on the inter-relationships of the social and economic constructs of the proposed landfill as they pertain to health. This SHR report can be found in Appendix C of this document.

3.0 PROBLEM FORMULATION

The current assessment followed standard risk assessment methods, and was conducted in compliance with the risk assessment procedures endorsed by regulatory agencies including Environment Canada, Health Canada, the Canadian Council of Ministers of the Environment (CCME), and the US EPA, as well as guidance provided by the Ontario Ministry of the Environment (MOE). These guidance documents will be used in the following order of preference: (i) provincial (MECP); (ii) federal (Health Canada); and, (iii) International (US, EPA). In the case of a deviation from the provincial sources, a detailed justification will be provided. These guidance documents include:

- Procedures for the Use of Risk Assessment under Part XV.1 of the Environmental Protection Act. Ontario Ministry of the Environment. Standards Development Branch. October 2005. (MOE, 2005);
- Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. April 15, 2011. Prepared by: Standards Development Branch, Ontario Ministry of the Environment. (MOE, 2011);
- Federal Contaminated Sites Risk Assessment in Canada. Part I: Health Canada Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA) (Health Canada, 2012);
- Federal Contaminated Sites Risk Assessment in Canada. Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors Version 2.0 (Health Canada, 2010);
- Federal Contaminated Sites Risk Assessment in Canada. Part V: Guidance on Complex Human Health Detailed Quantitative Risk Assessment for Chemicals (Health Canada, 2009); and,
- The US EPA Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities. (US EPA, 2005).

3.1 Overview

The landfill proposed by Walker is described in detail in the *Environmental Assessment Report*, however, a summary of the proposed undertaking is presented in Section 1.2.

3.2 Site Characterization

As discussed in Section 1.5, there are three general study areas for the EA and HHRA: i) on-site and in the site vicinity; ii) areas along the proposed haul routes; and, iii) the wider area. Specifically, for data obtained from the air quality assessment, the site vicinity area typically extends to approximately 5 kilometres from the proposed landfill.

3.2.1 Proposed Locations for Sensitive Receptors

Relying on predicted ground-level air concentrations at the maximum point of impingement (MPOI) from a Project emission source to evaluate human health risks, particularly long-term risks, is considered a very conservative (*i.e.*, protective) approach. By definition, predicted ground-level air concentrations at all other locations are lower than those predicted at the MPOI. As such, the standard risk assessment approach is to also evaluate exposures and potential

health risks at several specific sensitive receptor locations beyond the MPOI in the community surrounding the Project-specific emission sources.

To assess potential risks related to the projected emissions from the either Landfill or transportation route emission sources, the project team selected key sensitive locations representative of the surrounding community. Typically, generic sensitive receptors are modelled based upon guidance provided in Section 30 (relating to upper risk thresholds) of Ontario Regulation 419/05. A sensitive receptor is defined as:

- A senior citizen's residence or long-term care facility;
- A health care facility;
- A childcare facility;
- An educational facility; or,
- A dwelling.

As indicated in Section 1.5, common receptor points were selected collaboratively by the technical experts so that the potential overlapping or cumulative effects of the proposed landfill could be assessed at these common receptor points. The common receptor points used in this study include those locations that represent the following:

- Residences or neighbourhoods nearest the proposed landfill (nearest residential locations to the north, south, east and west of the site);
- Residences or neighbourhoods along the haul route;
- Businesses or commercial/industrial areas, including farms or agricultural areas;
- Community or institutional facilities nearest the proposed landfill (*e.g.*, schools, community centres, hospitals, cemeteries);
- Areas or places with a potential view of the proposed landfill;
- Recreational areas nearest the proposed landfill (*e.g.*, parks, conservation areas, trails);
- Areas or places used by Indigenous peoples for traditional purposes;
- Areas or places of ecological importance; and,
- Areas or places identified for future development (*e.g.*, vacant properties).

For the current HHRA, focus was given to areas where community residents were expected to have high occupancy (such as residential dwellings), specifically excluding locations modelled on the Landfill property itself (Table 3-1).

Table 3-1 Residential Receptor IDs for the Haul Route Traffic, Landfill Gas, and Flare/By-product Air Quality Assessments and the Multimedia Assessment

Receptor ID	Description	Township	Receptors
ZOR-1	Intersection of 31st Line and Rd 66	Township of Zorra	Represents the north-west corner of the study area as well as a visual receptor and agricultural receptors
ZOR-2	Intersection of 33rd Line and Rd 66	Township of Zorra	Represents a visual receptor as well as agricultural receptors and potential haul route receptors
ZOR-3	Residence at 663951 Rd 66	Township of Zorra	Represents a visual receptor as well as agricultural receptors
ZOR-4	Intersection of 37th Line and Rd 66	Township of Zorra	Represents agricultural receptors as well as a visual receptor and haul route receptors
ZOR-5	Residence at 334789 33rd Line	Township of Zorra	Represents a visual receptor as well as agricultural receptors and potential haul route receptors
ZOR-6	Residence at 334742 33rd Line	Township of Zorra	Represents a visual receptor as well as agricultural receptors and potential haul route receptors
ZOR-7	Residence at 414774 41st Line (Domtar Line)	Township of Zorra	Represents a visual receptor as well as potential haul route receptors
ZOR-8	Residence at 643743 Road 64	Township of Zorra	Represents a visual receptor as well as agricultural receptors
ZOR-9	Residence at 334647, 334652 and 334655 33rd Line	Township of Zorra	Represents a visual receptor as well as agricultural receptors and potential haul route receptors
ZOR-10	Residence at 334578 33rd Line	Township of Zorra	Represents a visual receptor as well as agricultural receptor, potential haul route receptors and municipal water well location
ZOR-11	Residence at 623851 Rd62/ North Town	Township of Zorra	Represents a visual receptor as well as agricultural receptor, and potential haul route receptors. Also represents ecological receptor (cliff swallow colony and possible significant wildlife habitat).
ZOR-12	Cemetery - 603806 Cemetery Ln	Township of Zorra	Represents a visual receptor, residential receptors as well as haul route receptors and ecological receptors in the Quarry Lake.
ING-1	Intersection of North Town Line E and Pemberton Street	Town of Ingersoll	Represents visual, residential, as well as haul route receptors
ING-2	Laurie Hawkins Public School	Town of Ingersoll	Represents residential neighbourhood and Laurie Hawkins P.S.
ING-3	Ingersoll District Collegiate Institute	Town of Ingersoll	Represents residential neighbourhood and Ingersoll District Collegiate Institute, community services and parks
ING-4	On the river north of 209 County Road 9	Town of Ingersoll	Represents a visual receptor as well as confluence of creek into the Thames
ING-5	Intersection of Thames Road and Charles St. W	Town of Ingersoll	Represents a visual receptor as well as central business district of Ingersoll
ING-6	Royal Road Public School	Town of Ingersoll	Represents a visual receptor as well as residential and Royal Road Public School
ING-7	Intersection of Holcroft St.W and Whiting St.	Town of Ingersoll	Represents residential and parkland/golf course as well as the furthest south receptors
ING-8	Alexandra Hospital (Noxon St and Thames St S)	Town of Ingersoll	Represents the Alexandra Hospital and residential community
ING-9	Intersection of Walker Road and Fuller Drive	Town of Ingersoll	Represents agricultural, residential, potential new build residential and parkland
ING-10	Intersection of Clark Rod and Park Line	Town of Ingersoll	Represents potential new build residential, agricultural and tourist locations
SWO-1	Residence at 584052 Beachville Road	Township of South-West Oxford	Represents Beachville residents, visual receptors and ecological receptors (great blue heron rookery, potential significant wildlife habitat).
SWO-2	Hi-Way Pentecostal Church (584118 Beachville Road)	Township of South-West Oxford	Represents Beachville residents, visual receptors and religious institution

Table 3-1 Residential Receptor IDs for the Haul Route Traffic, Landfill Gas, and Flare/By-product Air Quality Assessments and the Multimedia Assessment

Receptor ID	Description	Township	Receptors
SWO-3	Residence at 584142 Beachville Road	Township of South-West Oxford	Represents Beachville residents, agricultural and visual receptors as well as ecological receptors along the Thames River (potential endangered and threatened species).
SWO-4	Intersection of Beachville Road and 37th Line	Township of South-West Oxford	Represents Beachville residents, visual and haul route receptors
SWO-5	On Beachville Road approximately located in front of 584331 Beachville Road	Township of South-West Oxford	Represents Beachville residents, agricultural and visual receptors
SWO-6	Intersection of W Hill Line and Spruce Road	Township of South-West Oxford	Represents residential community and parkland
SWO-7	Intersection of Hook St and Zorra Line	Township of South-West Oxford	Represents residential community and parkland
SWO-8	On Beachville Road in front of 584844 Beachville Road	Township of South-West Oxford	Represents Beachville residents, business and cemetery
SWO-9	On Beachville Road in front of 585076 Beachville Road	Township of South-West Oxford	Represents Beachville residents, business and religious institution
SWO-10	Residence at 563977 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-11	Residence at 564028 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-12	Residences at 564047, 564058, 564062 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-13	Centreville Pond and Conservation Area	Township of South-West Oxford	Represents parkland receptors as well as visual receptors and ecological receptors (basking area for snapping and painted turtle).
SWO-14	Residences at 564120 and 564128 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-15	Residences at 564146 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-16	Residences at 564162, 564164 and 564168 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-17	Residence at 564226 Karn Road	Township of South-West Oxford	Represents agricultural receptors as well as visual receptors
SWO-18	Intersection of Karn Road and Foldens Line	Township of South-West Oxford	Represents agricultural and visual receptors as well as haul route receptors
SWO-19	Intersection of Clarke Road and Foldens Line	Township of South-West Oxford	Represents agricultural and visual receptors as well as haul route receptors
SWO-20	Intersection of Clarke Road and E Hill Line	Township of South-West Oxford	Represents residential properties and the westly portion of the study area

In addition to residential receptors, agricultural areas (primarily plant crops with little to no cattle farming) broadly surround and abut the site. To determine the potential impacts to food quality and impacts to the agricultural food chain, the common receptor locations are generally residential or farm facility specific. Based on feedback from the Agriculture Assessment team, several agricultural crop receptor locations were identified for the HHRA. The receptors closest to the site that have crops nearby are ZOR 11,16,17 and 18. These are located immediately west and north of the site. Farther away, across the Thames River Valley, the closest receptors with crops nearby are SWO 1,2 and 3. The haul route receptors representative of adjacent cropping include SWO 17, 18 and 19. Furthermore, there is a concentration of dairy, with some swine and poultry operations all along Karn Road. The representative common receptors include SWO 10, 11, 12, 13, 14, 15, 16, 17and 18; where Karn road is the first main East-West road to the south of the site, across the Thames River Valley, beyond Beachville Road. As such, in the HHRA report, in addition to the residential common receptors, common receptors ZOR 11,16,17,18 and SWO1,2,3,10 to19 were also considered for the potential impacts to agriculture as a component of the multi-pathway assessment.

In addition to assessing discrete receptor locations (*i.e.,* Figure 3-1) within the HHRA, the entire Study Area (*i.e.,* the Site-Vicinity and Regional study) was broken down into a grid of exposure areas where similar exposure conditions would be expected. The receptor grid covered the land within approximately five (5) kilometers from the proposed landfill site. Figure 3-2 provides an overview of the individual receptor grid locations within the Study Area evaluating the emission impacts from the proposed facility-based and haul route sources (RWDI, 2020). The Air Quality Assessment team also considered the Carmeuse property line as a boundary as there are some emissions of contaminants in common with the LFG assessment (RWDI, 2020).

For the purpose of the current assessment, and to ensure a conservative approach to evaluating risk, the maximum ground-level air concentrations predicted from the common receptor locations classified as residential (*i.e.,* Table 3-1) were utilized. These worst-case exposures were used in the HHRA to estimate potential health risks related to individuals living within the study area.

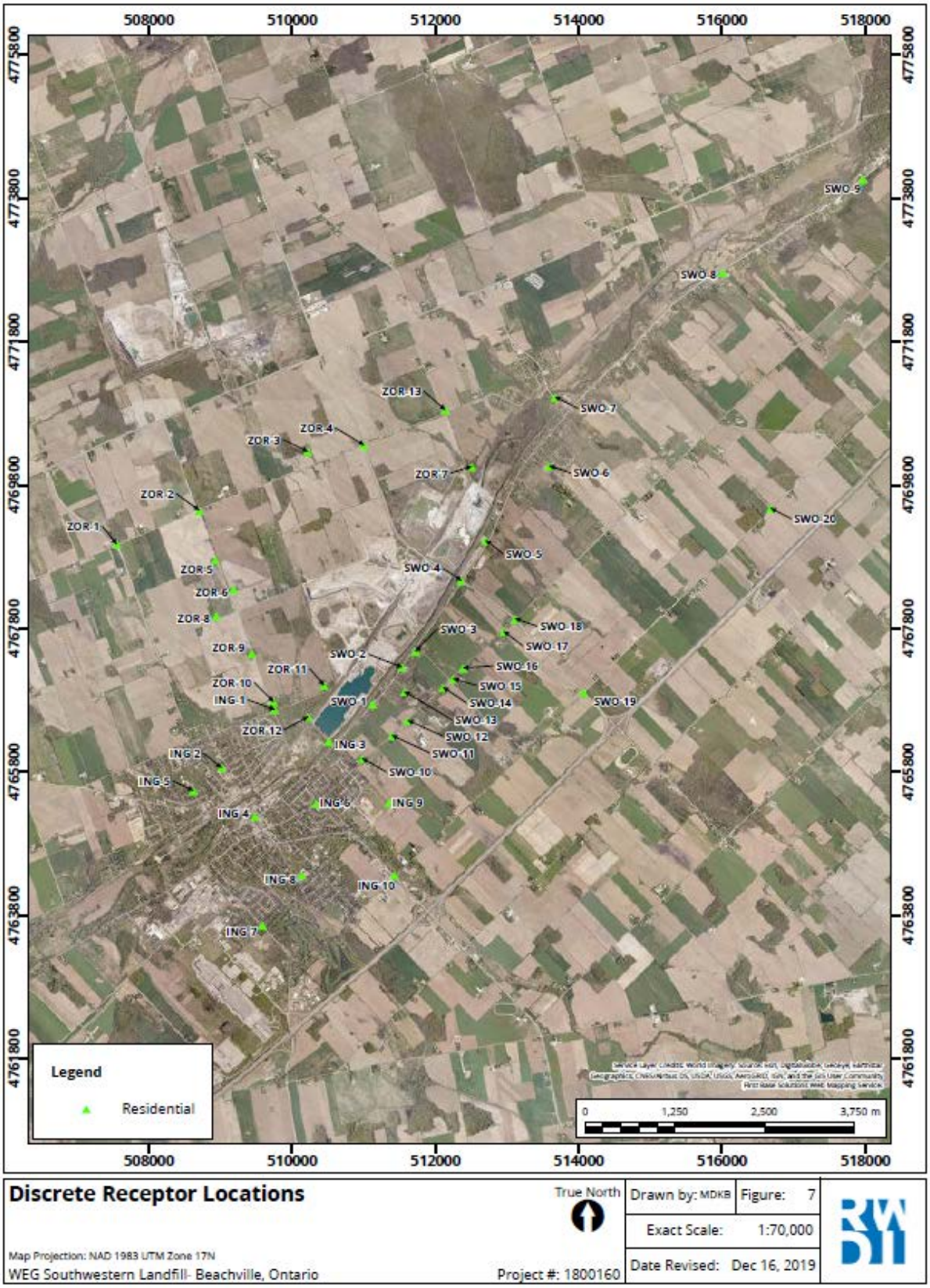

Figure 3-1 Discrete Receptor Locations identified for the Air Quality Assessment (RWDI, 2020)

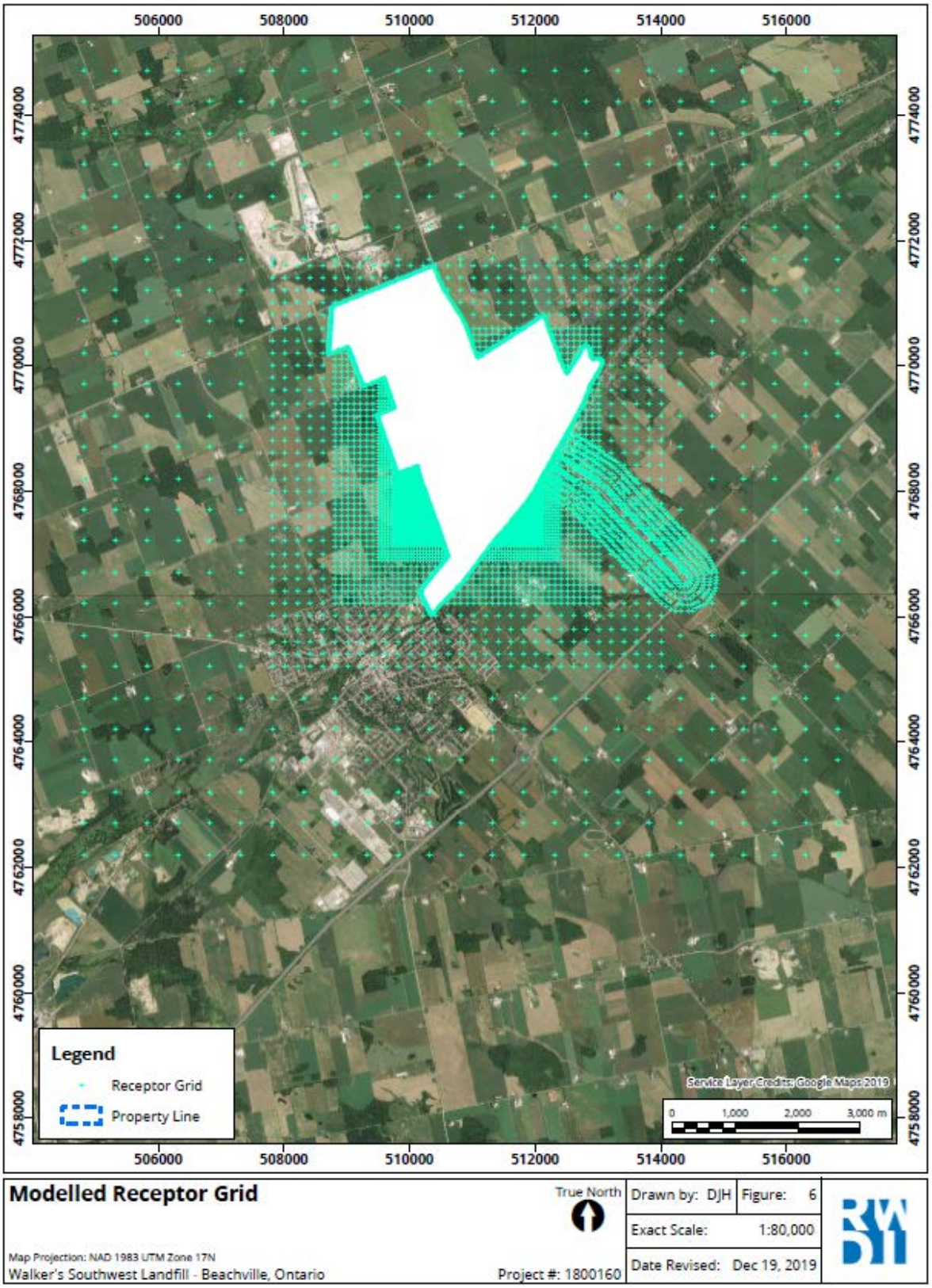

Figure 3-2 Modelled Receptor Grid for the Landfill Gas and Haul Route Assessments (RDWI, 2020)

3.3 Identification of Chemical of Concern

A key element for both the air quality assessment and HHRA components of the Southwestern Landfill EA was identifying a list of chemicals to be assessed in the HHRA. The contaminants of potential concern (COPC) were identified in the Air Quality Study (RWDI, 2020) and are presented in Table 3-2. The COPC were categorized for three (3) general study areas: i) haul route traffic; ii) landfill gas; and, iii) landfill gas flare/by-product.

The selection of COCs for the multimedia assessment from the COPCs presented in Table 3-2 is discussed in Section 3.3.1.2. The final list of the selected COCs for the haul route assessment, landfill assessment and the multi-pathway assessment is presented in Section 3.3.1.3.

Table 3-2 Chemicals of Potential Concern Identified for the Haul Route Traffic, Landfill Gas, and Flare/By-product Air Quality Assessments and the Multimedia Assessment

Chemical of Potential Concern	COCs of Interest for Haul Route Traffic (Inhalation Assessment)	COCs of Interest for Landfill Gas (Inhalation Assessment)	COCs of Interest for Landfill Gas Flare/By-product (Inhalation Assessment)
Acetone		Y	
Benzene	Y	Y	
Benzo(a)pyrene	Y		
Bromodichloromethane		Y	
Butanol (2-)		Y	
Butyl Acetate		Y	
Carbon Monoxide (CO)	Y		Y
Carbon Tetrachloride		Y	
Chlorobenzene		Y	
Chlorodifluoromethane		Y	
Chloroethane		Y	
Chloroform		Y	
Chloromethane		Y	
Cymene (m-)		Y	
Decane		Y	
Dichlorobenzene (1,4-)		Y	
Dichlorodifluoromethane		Y	
Dichloroethane (1,2-)		Y	
Dichloroethylene (1,2-)		Y	
Dichloroethylene (cis-1,2-)		Y	
Dichloroethylene (trans-1,2-)		Y	
Dichlorofluoromethane		Y	
Dichloromethane		Y	
Ethanol		Y	
Ethyl Acetate		Y	
Ethyl Benzene		Y	
Ethyl Toluene (m-)			
Ethyl Toluene (o-)		Y	
Ethyl Toluene (p-)		Y	
Ethylene Dibromide		Y	
Ethylene Dichloride		Y	
Formaldehyde	Y		Y
Heptane		Y	
Hexane		Y	
Inhalable Particulate Matter (PM_{10}) [a]	Y		Y
Isopropyl Alcohol		Y	
Limonene		Y	
Methyl Butane (2-)		Y	

Table 3-2 Chemicals of Potential Concern Identified for the Haul Route Traffic, Landfill Gas, and Flare/By-product Air Quality Assessments and the Multimedia Assessment

Chemical of Potential Concern	COCs of Interest for Haul Route Traffic (Inhalation Assessment)	COCs of Interest for Landfill Gas (Inhalation Assessment)	COCs of Interest for Landfill Gas Flare/By-product (Inhalation Assessment)
Methyl Cyclohexane		Y	
Methyl Ethyl Ketone		Y	
Methyl Hexane (2-)		Y	
Methyl Hexane (3-)		Y	
Methyl Isobutyl Ketone		Y	
Methyl Pentane (2-)		Y	
Methyl Pentane (3-)		Y	
Naphthalene		Y	
n-Butanal		Y	
Nitrogen Dioxide (NO_2)	Y		Y
Nitrogen Oxides (NO_X) (as nitrogen dioxide)			Y
Nonane		Y	
Octane		Y	
Pentane		Y	
Propyl Benzene		Y	
Respirable Particulate Matter ($PM_{2.5}$) [a]	Y		Y
Speciated VOCs			Y
Styrene		Y	
Sulphur dioxide (SO2)	Y		Y
Sulphurs			Y
Tetrachloroethane (1,1,2,2-)		Y	
Tetrachloroethylene		Y	
Toluene	Y	Y	
Total Mercaptans (as methyl mercaptan)		Y	
Total Suspended Particulate Matter (TSP)	Y		Y
Trichloro-1,2,2-Trifluromethane (1,1,2-)		Y	
Trichloroethane (1,1,1-)		Y	
Trichloroethane (1,1,2-)		Y	
Trichloroethylene		Y	
Trichlorofluoromethane		Y	
Trimethyl Benzene (1,2,3-)		Y	
Trimethyl Benzene (1,2,4-)		Y	
Trimethyl Benzene (1,3,5-)		Y	
Vinyl Chloride		Y	
Vinylidene Chloride		Y	
Xylene (m-)		Y	
Xylene (o-)		Y	
Xylene (p-)		Y	

[a] The modelled concentrations of PM_{10} and $PM_{2.5}$ consist of cumulative contributions from both vehicle emissions travelling on the proposed haul routes to/from the Landfill and fugitive particulate matter arising from landfill construction and covering activities. As it is important to evaluate their combined contributions, and the vehicle emissions are likely to be the largest discrete source, the assessment of particulate health risks were included in the haul route scenario.

From the COPCs presented in Table 3-2, the Air Quality Assessment team identified that m-cymene and limonene were not COPCs that were modelled as they did not have AP-42 default values or East and South landfill measured concentrations. As such, m-cymene and limonene were not included in the assessment (RWDI, 2020). In addition, the HHRA focused on the potential impacts of human exposure to the respirable fraction of PM (*i.e.*, $PM_{2.5}$ and PM_{10}) rather

than total suspected particulate matter (TSP); particulate matter is discussed further in detail in Section 4.3. As such, TSP was not included in the assessment.

3.3.1 Chemical Screening

The following provide an overview of the screening approaches used to select the COCs evaluated for inhalation and multi-pathway (*i.e.*, inhalation, oral and dermal) exposures in the HHRA.

3.3.1.1 Inhalation Exposures

The data generated by the Air Quality Assessment provides predicted 8-hr (carbon monoxide only), 24-hr and annual average ground-level air concentrations (as a result of modelled facility-wide air emissions and emissions from diesel trucks travelling on the associated proposed haul routes) for COPCs at a number of different receptor locations within the Study Area (*i.e.*, within an approximate 5 km radius of the proposed Southwestern facility). The COPCs currently identified in the Air Quality Assessment work plan consist of emissions from vehicle tail pipe emissions, fugitive landfill gas emissions, fugitive particulate from landfill construction and covering activities, and combustion by-product emissions from landfill gas flaring operations.

It is common practice (within the context of an HHRA) to limit the number of chemicals evaluated to those that, due to their environmental concentrations, distribution, or chemical and toxicological properties, have the greatest potential to contribute to health risks to individuals residing in the study area. However, it is important to note that the identification of a substance as a COPC does not automatically lead to the conclusion that the substance is, in fact, a contributor to health risk. Rather, the appropriate conclusion is that those substances identified as COPCs should be the subject of further evaluation. It is preferable to comprehensively evaluate a smaller number of chemicals, which represent the greatest concern to people living in the area under consideration, than it is to conduct a less detailed risk assessment on a larger number of chemicals.

For the HHRA, the COPCs that were retained as COCs for the haul route assessment, LFG assessment, and the multi-pathway assessment are presented in Section 3.3.1.3.

It is important to note that the modelled concentrations of PM_{10} and $PM_{2.5}$ evaluated in the HHRA consist of cumulative contributions from both vehicle emissions travelling on the proposed haul routes to/from the Landfill and fugitive particulate matter arising from landfill construction and covering activities. As it is important to evaluate their combined contributions, and the vehicle emissions are likely to be the largest discrete source, the assessment of particulate health risks were included in the haul route scenario.

The COCs were selected for the HHRA based on toxicological benchmarks and properties and the Air Quality Assessment data. A total of 64 COCs were selected to be carried forward for the LFG assessment. A total of nine COCs were selected to be carried forward for the haul route assessment.

3.3.1.2 Multi-Pathway Exposures

Due to the physical-chemical properties of the individual evaluated chemicals, not all COCs emitted from the proposed facility will persist or accumulate in the environment. To identify the COCs that were considered in the multi-pathway risk assessment, the physical-chemical properties of each of the COCs were compared to accepted national and international criteria for the classification of persistent and bio-accumulative substances (Rodan *et al.,* 1999; Environment Canada, 2006).

The multimedia/multi-pathway screening approach used in the current assessment was adapted based upon the methodology presented in the 2005 US EPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities document (US EPA, 2005), and is the standard approach in these types of assessments. The approach accounts for soil loss over time through both degradation and volatilization.

The characterization of persistence and bio-accumulation is provided in detail within Environment Canada's Existing Substances Program and the Health Canada and Environment Canada's Domestic Substances List Categorization, under the *Canadian Environmental Protection Act* (CEPA).

Persistence refers to the length of time a chemical resides in the environment and is measured by its half-life. This is the time required for the quantity of a chemical to diminish or degrade to half of its original amount within a particular environment or medium. For the purposes of this assessment, a chemical was considered persistent if its half-life in soil was greater than or equal to (≥) six months (182 days). The appropriate rate constants (or half-lives) for each of the potential COCs were taken from sources such as the Syracuse Research Corp. (SRC, 2013) or, if a property was not available from SRC (2013), the EPI Suite program developed by US EPA (2012) was searched.

Bio-accumulation is a general term used to describe the process by which chemicals are accumulated in an organism directly from exposure to water, soil, or through consumption of food containing the substances. A chemical's potential to bio-accumulate is related to its octanol-water partition coefficient (K_{ow}). The K_{ow} refers to the ratio of distribution of a substance in octanol compared to that in water. For the purposes of this assessment, a chemical was considered bio-accumulative if its Log K_{ow} was greater than or equal to five. Again, the octanol-water partitioning coefficient was adopted from Syracuse Research Corp. (SRC 2013), or if it was not available from SRC (2013), the EPI Suite program developed by the US EPA (2012) was searched.

The rationale behind this exercise was that if a chemical released to the air does not meet either of these criteria, only a limited opportunity exists for human exposure *via* secondary exposure pathways (*i.e.,* those other than inhalation), as the potential for that chemical to persist and/or accumulate in the environment is negligible. However, if a chemical does meet one or both of these criteria, sufficient opportunity could be present for long term exposure. Finally, in order for COCs to be eligible for inclusion in the multi-pathway assessment, the oral exposure limits are reviewed to determine if a defensible TRV is available. If no oral TRV is available, the likelihood of significant health risk through this pathway is low. Detailed toxicity profiles are provided in Appendix A.

Therefore, COCs retained for full multi-pathway assessment had to have a defensible oral TRV from a reputable regulatory agency and:

- A half-life in soil greater than or equal to six months; and/or,
- An octanol-water partition coefficient (Log K_{ow}) greater than or equal to five.

Table 3-3 identifies the COCs proposed for multimedia assessment based on the results of the persistence screening step and availability of a defensible oral exposure limit.

Table 3-3 Screening of the COCs for the Multi-pathway Evaluation

Chemical of Potential Concern	Octanol-Water Partition Coefficient Screen [a]	Half-Life in Soil Screen [b]	Available Oral TRV?
Acetone	-0.24	3.98E-05	-
Benzene	2.13	1.85E-05	-
Benzo(a)pyrene	**6.13**	**4.71E+02**	**Yes**
Bromodichloromethane	2	1.17E-04	-
Butanol (2-)	0.61	NA	-
Butyl Acetate	1.78	2.73E-05	-
Carbon Monoxide (CO)	1.78	NA	-
Carbon Tetrachloride	2.83	1.58E-05	-
Chlorobenzene	2.84	1.39E-04	-
Chlorodifluoromethane	1.08	5.18E-08	-
Chloroethane	1.43	1.38E-06	-
Chloroform	1.97	3.28E-05	-
Chloromethane	0.91	NA	-
Decane	**5.01**	8.66E+00	**No**
Dichlorobenzene (1,4-)	3.44	7.67E-04	-
Dichlorodifluoromethane	2.16	5.61E-08	-
Dichloroethane (1,2-)	1.79	6.46E-05	-
Dichloroethylene (1,2-)	1.86	NA	-
Dichloroethylene (cis-1,2-)	1.86	1.06E-05	-
Dichloroethylene (trans-1,2-)	1.86	NA	-
Dichlorofluoromethane	1.55	NA	-
Dichloromethane	1.25	4.78E-06	-
Ethanol	-0.31	NA	-
Ethyl Acetate	0.73	4.90E-06	-
Ethyl Benzene	3.15	5.72E-05	-
Ethyl Toluene (m-)	3.98	NA	-
Ethyl Toluene (o-)	3.53	NA	-
Ethyl Toluene (p-)	3.63	4.16E-04	-
Ethylene Dibromide	1.96	4.50E-04	-
Ethylene Dichloride	1.48	NA	-
Formaldehyde	0.35	NA	-
Heptane	4.66	NA	-
Hexane	3.90	NA	-
Inhalable Particulate Matter (PM_{10})	NA	NA	-
Isopropyl Alcohol	0.05	< 7	-
Methyl Butane (2-)	2.72	2.52E-07	-
Methyl Cyclohexane	3.61	NA	-
Methyl Ethyl Ketone	0.29	NA	-
Methyl Hexane (2-)	3.71	NA	-
Methyl Hexane (3-)	3.71	NA	-
Methyl Isobutyl Ketone	1.31	2.27E-04	-
Methyl Pentane (2-)	3.21	6.40E-07	-
Methyl Pentane (3-)	3.6	1.98E-06	-
Naphthalene	3.30	6.85E-03	-
n-Butanal	0.88	NA	-
Nitrogen Dioxide (NO_2)	-0.58	NA	-

Table 3-3 Screening of the COCs for the Multi-pathway Evaluation

Chemical of Potential Concern	Octanol-Water Partition Coefficient Screen [a]	Half-Life in Soil Screen [b]	Available Oral TRV?
Nitrogen Oxides (NO_X) (as nitrogen dioxide)	NA	NA	-
Nonane	**5.65**	7.43E+00	**No**
Octane	**5.18**	6.38E+00	**No**
Pentane	3.39	NA	-
Propyl Benzene	3.69	NA	-
Respirable Particulate Matter ($PM_{2.5}$)	NA	NA	-
Speciated VOCs	NA	NA	-
Styrene	2.95	7.32E-04	-
Sulphur dioxide (SO2)	-2.2	NA	-
Sulphurs	NA	NA	-
Tetrachloroethane (1,1,2,2-)	2.39	8.15E-04	-
Tetrachloroethylene	3.4	4.41E-05	-
Toluene	2.73	4.19E-05	-
Total Mercaptans (as methyl mercaptan)	NA	NA	-
Trichloro-1,2,2-Trifluromethane (1,1,2-)	3.16	NA	-
Trichloroethane (1,1,1-)	2.49	3.06E-05	-
Trichloroethane (1,1,2-)	1.89	2.26E-04	-
Trichloroethylene	2.42	3.06E-05	-
Trichlorofluoromethane	2.53	2.47E-06	-
Trimethyl Benzene (1,2,3-)	3.66	NA	-
Trimethyl Benzene (1,2,4-)	3.63	2.02E-04	-
Trimethyl Benzene (1,3,5-)	3.42	1.88E-04	-
Vinyl Chloride	1.46	7.12E-07	-
Vinylidene Chloride	2.13	3.94E-06	-
Xylene (m-)	3.20	5.82E-05	-
Xylene (o-)	3.12	1.04E-04	-
Xylene (p-)	3.15	8.84E-05	-

Bolded and grey shading indicates that the COCs has an octanol-water partition coefficient (log Kow) greater than or equal to five and/or has a half-life in soil greater than or equal to six months (182 days).
- COC did not meet the initial persistence screening criteria and as such, oral TRVs were not assessed
NA Value is not applicable or available for the COC.

Based on Table 3-3, four (4) COCs (*i.e.,* benzo(a)pyrene, decane, nonane, and octane) were identified to be bioaccumulative and/or persistent. Oral TRVs were not available for decane, nonane, and octane and as such were not retained for the multi-pathway exposure assessment. Furthermore, the chemical half-life in soil for decane, nonane and octane were noted to be less than 9 days. As such, these three (3) COCs are readily biodegradable in soil and are not anticipated to persist in soil. Appendix A provides toxicological profiles for each of the COCs. As such, the findings of the exercise indicate that only benzo(a)pyrene is eligible for inclusion in the multi-pathway assessment.

3.3.1.3 Final List of Selected Chemicals of Concern

The HHRA conducted air quality assessments on the area along the proposed haul routes and arising from the landfill gas emissions for the COCs presented in Table 3-4.

Table 3-4 Chemicals of Concern Identified for the Haul Route Traffic and Landfill Gas Air Quality Assessments and the Multimedia Assessment

Chemical of Potential Concern	COCs Assessed in the Haul Route Traffic Inhalation Assessment	COCs Assessed in the Landfill Gas Inhalation Assessment	COCs Assessed in the Multimedia Assessment
Acetone		Y	
Benzene	Y	Y	
Benzo(a)pyrene	Y		Y
Bromodichloromethane		Y	
Butanal (n-)		Y	
Butanol (2-)		Y	
Butyl Acetate		Y	
Carbon monoxide (8-hour)	Y		
Carbon Tetrachloride		Y	
Chlorobenzene		Y	
Chlorodifluoromethane		Y	
Chloroethane		Y	
Chloroform		Y	
Chloromethane		Y	
Decane		Y	
Dichlorobenzene		Y	
Dichlorodifluoromethane		Y	
Dichloroethane (1,1-)		Y	
Dichloroethene (1,2-)		Y	
Dichloroethylene (cis-1,2-)		Y	
Dichloroethylene (trans-1,2-)		Y	
Dichlorofluoromethane		Y	
Dichloromethane		Y	
Dimethyl Disulphide		Y	
Dimethyl Sulphide		Y	
Ethanol		Y	
Ethyl Acetate		Y	
Ethyl Benzene		Y	
Ethyl Toluene		Y	
Ethyl Toluene (m/p-)		Y	
Ethylene Dibromide		Y	
Ethylene Dichloride		Y	
Formaldehyde	Y		
Heptane		Y	
Hexane		Y	
Hydrogen Sulphide		Y	
Isopropyl Alcohol		Y	
Methyl Butane (2-)		Y	
Methyl Cyclohexane		Y	
Methyl Ethyl Ketone		Y	
Methyl Hexane (2-)		Y	
Methyl Hexane (3-)		Y	
Methyl Isobutyl Ketone		Y	
Methyl Pentane (2-)		Y	
Methyl Pentane (3-)		Y	
Naphthalene		Y	
Nitrogen dioxide	Y		
Nonane		Y	
Octane		Y	

Table 3-4 Chemicals of Concern Identified for the Haul Route Traffic and Landfill Gas Air Quality Assessments and the Multimedia Assessment			
Chemical of Potential Concern	**COCs Assessed in the Haul Route Traffic Inhalation Assessment**	**COCs Assessed in the Landfill Gas Inhalation Assessment**	**COCs Assessed in the Multimedia Assessment**
Particulate Matter – Inhalable (PM_{10}) [a]	Y		
Particulate Matter – Respirable ($PM_{2.5}$) [a]	Y		
Pentane		Y	
Propyl Benzene		Y	
Styrene		Y	
Sulphur dioxide	Y		
Tetrachloroethane (1,1,2,2-)		Y	
Tetrachloroethylene		Y	
Toluene	Y	Y	
Total Mercaptans (as Methyl Mercaptan)		Y	
Total Reduced Sulphurs (TRS)		Y	
Trichloro-1,2,2-Trifluromethane (1,1,2-)		Y	
Trichloroethane (1,1,1-)		Y	
Trichloroethane (1,1,2-)		Y	
Trichloroethylene		Y	
Trichlorofluoromethane		Y	
Trimethyl Benzene (1,2,4-)		Y	
Trimethyl Benzene (1,3,5-)		Y	
Vinyl Chloride		Y	
Vinylidene Chloride		Y	
Xylene (m/p-)		Y	
Xylene (o-)		Y	

[a] The modelled concentrations of PM_{10} and $PM_{2.5}$ consist of cumulative contributions from both vehicle emissions travelling on the proposed haul routes to/from the Landfill and fugitive particulate matter arising from landfill construction and covering activities. As it is important to evaluate their combined contributions, and the vehicle emissions are likely to be the largest discrete source, the assessment of particulate health risks were included in the haul route scenario.

3.4 Identification and Selection of Human Receptors

A human receptor is a hypothetical person (*e.g.*, infant, toddler, child, adolescent, adult) who resides and/or works in the area being investigated and is, or could potentially be, exposed to the chemicals identified as being of potential concern. General physical and behavioural characteristics specific to the receptor type (*e.g.*, body weight, breathing rate, food consumption rate, *etc.*) were used to determine the amount of chemical exposure received by each receptor as part of the multi-media assessment. The potential risks associated with chemicals of concern will be different depending on the receptor chosen for evaluation.

The HHRA must be sufficiently comprehensive to ensure inclusion of those receptors with the greatest potential for exposure to COCs, and those who have the greatest sensitivity, or potential for developing adverse health outcomes from these exposures. With this in mind, the selection of hypothetical, reasonable "worst-case" receptors, with somewhat exaggerated lifestyle habits, were used to ensure a conservative (*i.e.*, protective) assessment.

For the current assessment, only one specific group of sensitive receptors was evaluated – the residential receptor. Due to the residency time at a given receptor location (*i.e.*, conservatively assumed to be present 24-hours per day and 365 days per year), this group is considered to have the highest potential exposure and resultant health risk from chemicals emitted from the Project. Due to this conservatism, this receptor group will also account for those sensitive individuals who may be present at other land uses throughout the Study Area (*e.g.*, hospitals, daycares, schools, retirement homes, commercial establishments, recreational activities, *etc.*).

As per Health Canada (2012) guidance, the *residential receptor* was assumed to be represented by five discrete life stages:

1. Infant (birth to 6 months of age);
2. Preschool child/toddler (7 months to 4 years of age);
3. Child (5 to 11 years of age);
4. Adolescent (12 to 19 years of age); and,
5. Adult (≥ 20 years of age, assuming an 80-year lifespan).

The residential receptor was assumed to be born in the Township of Zorra in Oxford County with the proposed Landfill operating, and conservatively assumed to live at that location for their entire lifetime (*i.e.*, 80 years). The individual was assumed to be exposed *via* inhalation of ambient air to emissions from the proposed Landfill or project-related transportation source (and other nearby significant sources). The resident was also assumed to be exposed to COCs through contact with contaminated soil or home grown produce impacted by the deposition of the emitted COCs onto surface soils in the surrounding community. Predicted soil concentrations, discussed in Sections 4.2, 5.2.2 and 6.3, were conservatively assumed to be the maximum concentration that would be present after the facility's lifetime of deposition, taking into account degradation and soil loss over that time (US EPA, 2005).

For the assessment of inhalation risks, as a straight comparison between predicted short term (*i.e.*, 24-hour exposure durations) and long term (*i.e.*, annual average exposures) air concentrations and the corresponding regulatory inhalation benchmark (*i.e.*, reference concentrations or RfC) is made, the resulting concentration ratio (CR) value is receptor-independent (*i.e.*, the same value is calculated for all receptor types).

In the case of the multi-pathway assessment, exposures *via* the inhalation, oral and dermal pathways to the select COCs were evaluated for the most sensitive receptor groups living in the surrounding community – preschool children. In the case of carcinogenic COCs, potential incremental lifetime cancer risks were evaluated for a lifetime composite receptor, which combined predicted risks each of the life stages described above to produce an overall lifetime composite risk value. As a component of the multi-pathway assessment, food quality impacts to agricultural crops from emissions from the landfill were also considered (discussed in Sections 4.2, 5.2.2 and 6.3).

3.5 Identification of Exposure Scenarios and Pathways

The following section provides an overview of the exposure scenarios and pathways evaluated in the HHRA. The primary exposure scenarios evaluated involve exposures of receptor to airborne contaminants arising from either the proposed Landfill or the associated haul routes.

Potential impacts to both groundwater and surface water related to Landfill operations were also considered for the current Project and evaluated by the Groundwater team. As discussed in Section 1.2, the project design is protective of groundwater quality as it incorporates a MECP-approved double liner design (*i.e.*, *Generic Design Option II – Double Liner* system as specified by the MECP in the *Landfill Standards* under *O. Reg. 232/98*). As such, the assumption is that there will be no impacts on groundwater quality beyond the site boundary. Furthermore, the Groundwater team concluded there would be no significant negative impacts on the groundwater quality or surface water quality related to the Project. As such, it is not anticipated that there will be potential impacts to human health due to exposure to groundwater.

The study areas for the surface water assessment were the watershed catchments of the Patterson-Robbins Drain, the East Tributary and the Thames River (Golder, 2020). Based on the Surface Water Assessment Report (Golder, 2020), no significant effects are presented on the stream baseflow quantity and quality. No significant effects on water quality are anticipated and no potential effects on receiving water quality are anticipated due to contact with contaminated surface water. As such, it is not anticipated that there will be potential impacts to human health due to exposure to surface water. The Surface Water Assessment Report presents further detail on the assessment of the effects due to contact with contaminated groundwater or surface water (Golder, 2020).

Based on these conclusions, potential exposures to COCs in either groundwater or surface water arising from Landfill operations was not considered further in this assessment.

3.5.1 Exposure Scenarios

Landfill Gas (LFG) Assessment

As discussed previously, the LFG assessment considered three (3) future operating scenarios which represent different phases of project (*i.e.,* Stage 1, Stage 3, Stage 4) relevant to these potential emissions from the proposed Landfill. In addition, the post-closure scenario was also assessed.

To conduct the LFG assessment, RWDI conducted an ambient air quality monitoring program for VOCs and sulphurs to determine the existing baseline conditions at the Project site for one year. The baseline air quality data were collected at three ambient monitoring stations as illustrated in Figure 3-3. Sampling for VOCs were collected over 24-hour durations once every six (6) days in concurrence with the National Air Pollution Surveillance schedule provided by the U.S EPA and as outlined by the MECP. Sampling for total reduced sulphurs were collected over 24-hour durations once every six days from June 1 to September 30 and on a 12-day cycle outside of this timeframe, in concurrence with the National Air Pollution Surveillance and Environment and Climate Change Canada schedule (RWDI, 2020). The 90th-percentile was used of the measured 24-hour concentrations whereas the annual average of the measured 24-hour concentrations were used for the annual averaging period.

Figure 3-3 Location of Ambient Monitoring Stations (RWDI, 2020)

In addition to the baseline monitoring program, emission calculations and dispersion modelling were also conducted for the identified operational stages and post-closure. Further details on the baseline data collection is discussed in the Air Quality Assessment Report (RWDI, 2020).

Haul Route Assessment

The haul route assessment considered impacts in Stages 1 and 3 as they represent the worst-case scenarios for haul route-related emissions. The post-closure scenario for the haul route sources was considered insignificant and was not assessed in the haul route assessment (RWDI, 2020). Based on the ToR, the following are the milestone dates assessed for the haul route assessment:

Baseline (Est. 2019)
: Just prior to the start of landfill construction and operation, representing the existing baseline conditions.

Landfill Stage 1 (Est. 2023 – 2027)
: Conditions during filling operations of the landfill stage 1 and construction of the stage 2 liner.

Landfill Stage 3 (Est. 2033 – 2037)
: Conditions during filling operations of the landfill stage 3 and construction of the stage 4 liner.

Emissions calculations and dispersion modelling were conducted for these stages to determine the baseline haul route concentrations and potential off-site impacts due to haul route emissions. The Air Quality report specifies the various emissions sources assessed as a component of the haul route assessment (RWDI, 2020).

As noted previously, the modelled concentrations of PM_{10} and $PM_{2.5}$ consisted of cumulative contributions from both vehicle emissions travelling on the proposed haul routes to/from the Landfill and fugitive particulate matter arising from landfill construction and covering activities. As it is important to evaluate their combined contributions, and the vehicle emissions are likely to be the largest discrete source, the assessment of particulate health risks were included in the haul route scenario rather than the landfill gas scenario.

Multi-pathway assessment

Based on Table 3-3, only benzo(a)pyrene is eligible for inclusion in the multi-pathway assessment.

It should be noted that the HHRA did not quantitatively evaluate an operational upset scenario, where the facility may malfunction or not work as intended. Operational upset scenarios are addressed through a comprehensive set of monitoring and contingency plans regulated through the landfill's Environmental Compliance Approval (ECA) to ensure that any upset conditions that might occur are identified and corrected in a timely manner, resulting in any related exposure be of a short-term nature only.

For each of these stages within the LFG assessment and haul route assessment, two specific exposure conditions were evaluated:

- *Project Alone* exposures; and,
- *Cumulative* exposures.

The *Project Alone* assessment evaluates the potential health impact related to the predicted ground-level air concentrations of each of the COCs contributed by each of the proposed landfill stages to off-site residential locations in the surrounding community, specifically the receptor locations identified in Table 3-1.

The *Cumulative* assessment evaluates the potential health impact related to the predicted ground-level air concentrations of each of the COCs contributed by the proposed landfill at the various stages **plus** the existing background ambient concentrations of the COC. For the LFG assessment, it is conservatively assumed that the background concentrations are constant for the life of the landfill (*i.e.,* 20 years) and as such, the future baseline concentrations are assumed to be equivalent to existing baseline conditions. (RWDI, 2020).

The maximum ground-level air concentrations predicted under the cumulative assessment may not necessarily represent the worst-case Project contribution, as the worst-case local background contribution rarely occurs at the same time as the worst-case project scenario contribution given local traffic and meteorological conditions.

For further details on the air quality modelling, refer to the Air Quality Assessment Report (RWDI, 2020).

3.5.2 Exposure Pathways

The primary exposure pathway evaluated in the HHRA was the inhalation of the COCs by individuals living, working or playing in the surrounding community.

For those COCs evaluated by the multi-pathway assessment (*i.e.*, inhalation, oral and dermal exposures), the following additional exposure pathways were considered concurrently:

- **Inhalation:** Inhalation of air impacted by vapours and particulate emitted from the Project-related sources were evaluated.
- **Incidental Ingestion of Soil and Dust**: Through typical indoor and outdoor activities, individuals may accidentally ingest soil and/or dust particles. Children are typically more susceptible to this exposure pathway, as they spend more time in contact with the ground, and are more likely to put soiled articles, such as toys or hands, into their mouths.
- **Incidental Inhalation of Indoor Dust**: Soils impacted by particles emitted from the Project-related sources were assumed to be carried indoors (*e.g.*, by wind, or human and/pet activities) and present as indoor suspended dust for inhalation by individuals living within the home.
- **Dermal Exposure to Soils and Dusts**: Dermal exposures of human receptors may occur in both indoor and outdoor environments, through direct dermal contact with chemically impacted soil and dust.
- **Ingestion of Locally Grown Produce**: Locally grown produce (such as vegetables and fruits grown in backyard gardens) may itself pose a source of exposure to some COCs. As chemicals are deposited from air-borne emissions, they may come into contact with leaves and fruit of crop plants. Deposition of chemicals onto soil may also result in an accumulation in plants through root uptake.

Figure 3-4 provides an overview of the residential exposure scenario, while Figure 3-5 illustrates the Conceptual Site Model (CSM) used in the assessment and provides an overview of the sources of COCs and the exposure pathways associated with these sources. It should be noted that Figure 3-4 is not intended to specifically represent the proposed Landfill, but instead is intended to broadly illustrate potential exposure pathways for a generic landfill in an unmitigated condition.

As noted in the CSM, for the sake of conservatism, each of the potential pathways and exposure assumptions typically associated with a residential scenario were evaluated at all sensitive receptor locations. For example, when considering multimedia exposures (*i.e.*, non-inhalation), individuals at each of the assessed receptor locations were assumed to spend 24 hours per day, 7 days per week, for 50 weeks per year at this location. This is obviously an overestimation of potential exposures for schools or other similar sensitive receptor locations (*e.g.*, retirement homes, parks, *etc.*), as well as individuals exposed while at their workplace.

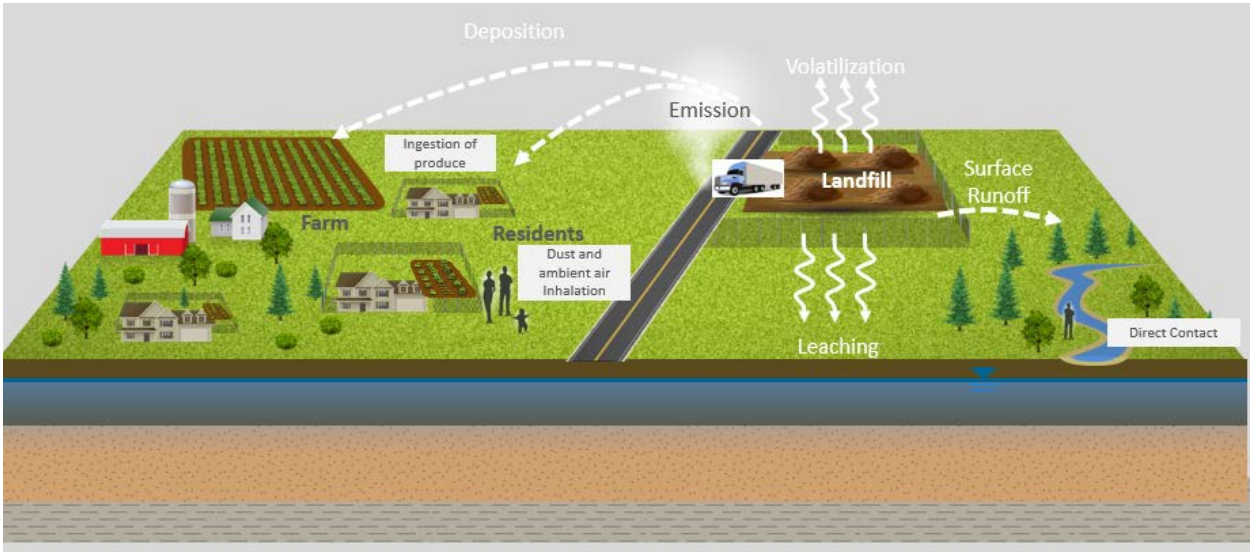

Figure 3-4 Residential Exposure Scenario

Note: This figure is not intended to specifically represent the proposed Landfill, but instead is intended to broadly illustrate potential exposure pathways for a generic landfill in an unmitigated condition.

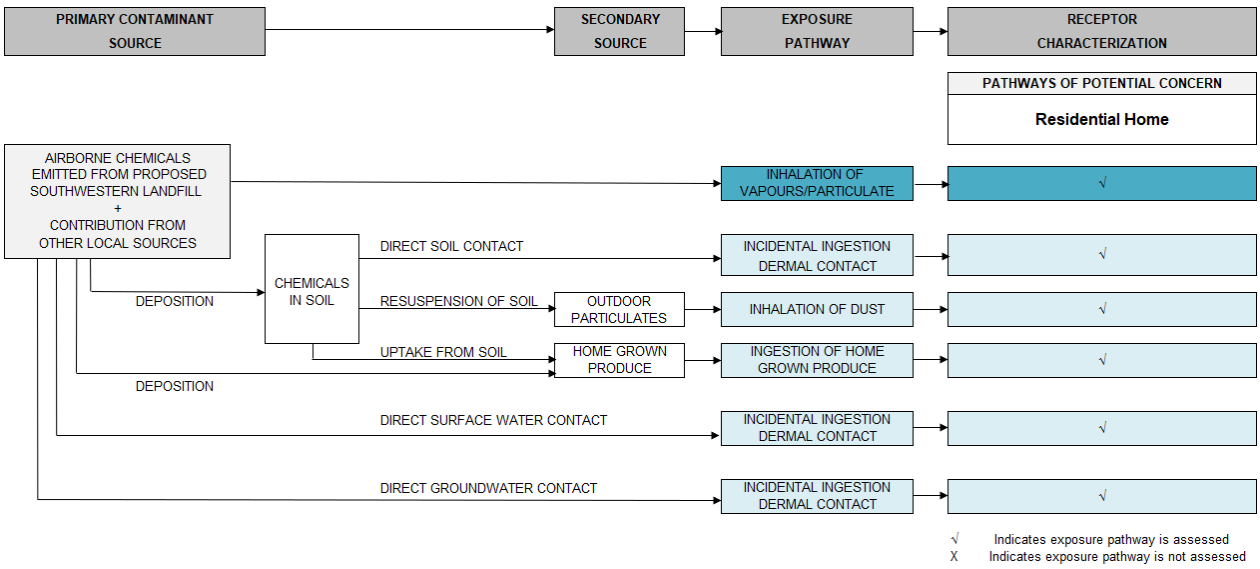

Figure 3-5 Conceptual Site Model (CSM) for Assessment

4.0 EXPOSURE ASSESSMENT

The magnitude of exposure of human receptors to chemicals in the environment typically depends on the interactions of a number of parameters, including:

- The concentrations of chemicals in various environmental media (as determined by the quantities of chemicals entering the environment from various sources, their persistence, fate and behaviour in these media, and the normal ambient, or background concentrations that exist independent of a specific source);
- The physical-chemical characteristics of the chemicals of concern, which affect their environmental fate, transport, behaviour and persistence, and determine the degree or extent by which chemicals can be absorbed into the body;
- The influence of site-specific environmental characteristics, such as geology, soil type, topography, hydrology, hydrogeology, local meteorology and climatology, *etc.*, on a chemical's fate, transport and behaviour within environmental media;
- The physiological and behavioural characteristics of the receptors (*e.g.,* respiration rate, soils/dusts intake rate, food ingestion rates, time spent at various activities and in different areas); and,
- The various exposure pathways for the transfer of the chemicals from the different environmental media to humans (*e.g.,* inhalation of indoor and outdoor air, soil particles and dusts; ingestion of food items, water, soils/dusts; skin penetration of various chemicals from dermal contact with soil/dust, water, sediments).

Exposure estimation in the multi-pathway assessment portion of the HHRA was conducted through the use of an integrated environmental risk assessment model developed by the Study Team. The model is spreadsheet based (Microsoft Excel™) but has a number of more advanced add-ons or features. Models of this type have been used on hundreds of peer-reviewed HHRAs in Canada, including those conducted for contaminated sites, landfills, smelters, refineries, incinerators, and a variety of other industrial facilities. The current model version incorporates the techniques and procedures for exposure modelling developed by various regulatory agencies and published scientific literature sources. Refer to Appendix B for a full description (*i.e.*, worked example) of the equations and parameters used in the HHRA.

4.1 Estimation of Ambient Ground-Level Air Concentrations

Ground-level air concentrations for each of the COCs at all sensitive receptor locations within the Study Area was estimated by the Air Quality Assessment team for use in the HHRA (RWDI, 2020). As indicated previously, the background data is based on the ambient monitoring data, Ministry of Environment, Conservation, and Parks (MECP), Air Quality in Ontario reports for 2014, 2015, and 2016 or the National Air Pollution Surveillance (NAPS) ambient monitoring database.

Table 4-1 and Table 4-2 present the projected 24 hour and annual concentrations of COCs for the LFG assessment, respectively. Table 4-3 and Table 4-4 present the projected 24 hour and annual concentrations of COCs from the haul route assessment, respectively. Predicted concentrations for the project alone and cumulative exposures are presented in all four tables.

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Table 4-1 Projected Maximum 24-Hour Ground-Level Air Concentrations arising from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Maximum Ground-Level 24-Hour Air Concentrations at Residential Receptor Locations (ug/m^3)											
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)			Stage 4 (2038-2042)			Post Closure (2043)	
		Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative	Project Alone	Cumulative
Acetone	19	0.39	2.0%	20	0.89	4.4%	20	0.99	4.9%	20	0.52	2.6%	20
Benzene	0.59	0.15	21%	0.74	0.36	38%	0.94	0.39	40%	0.97	0.21	27%	0.80
Bromodichloromethane	0.01	0.13	93%	0.14	0.31	97%	0.32	0.34	97%	0.35	0.19	95%	0.20
Butanal (n-) [a]	0.00	0.031	100%	0.031	0.072	100%	0.072	0.079	100%	0.079	0.04	100%	0.042
Butanol (2-)	3.1	0.21	6.6%	3.3	0.50	14%	3.6	0.54	15%	3.6	0.30	8.9%	3.3
Butyl Acetate	4.8	0.12	2.4%	4.9	0.27	5.4%	5.0	0.30	5.9%	5.1	0.16	3.2%	4.9
Carbon Tetrachloride	0.50	0.03	6.2%	0.53	0.03	6.1%	0.53	0.03	6.1%	0.53	0.03	6.1%	0.53
Chlorobenzene	0.46	0.01	3.0%	0.47	0.03	6.6%	0.49	0.04	7.3%	0.50	0.02	3.9%	0.48
Chlorodifluoromethane	1.0	0.03	2.7%	1.0	0.07	6.1%	1.1	0.07	6.7%	1.1	0.04	3.7%	1.1
Chloroethane	0.27	0.07	20%	0.33	0.16	38%	0.42	0.17	39%	0.43	0.10	27%	0.36
Chloroform	0.24	0.02	8.7%	0.26	0.02	8.8%	0.26	0.02	8.8%	0.26	0.02	8.6%	0.26
Chloromethane	1.3	0.02	1.2%	1.3	0.04	2.8%	1.3	0.04	3.1%	1.3	0.02	1.7%	1.3
Decane	1.5	0.57	28%	2.0	1.3	48%	2.8	1.5	50%	2.9	0.77	35%	2.2
Dichlorobenzene	0.34	0.04	9.6%	0.38	0.082	20%	0.42	0.09	21%	0.43	0.05	12%	0.39
Dichlorodifluoromethane	2.4	0.49	17%	2.9	1.1	32%	3.5	1.2	34%	3.7	0.66	21%	3.1
Dichloroethane (1,1-)	0.041	0.06	60%	0.10	0.14	78%	0.18	0.15	79%	0.19	0.09	68%	0.13
Dichloroethene (1,2-)	0.079	0.28	78%	0.36	0.655	89%	0.73	0.72	90%	0.80	0.38	83%	0.46
Dichloroethylene (cis-1,2-)	0.040	0.09	69%	0.13	0.18	82%	0.22	0.18	82%	0.22	0.11	74%	0.15
Dichloroethylene (trans-1,2-)	0.040	0.04	52%	0.082	0.043	52%	0.083	0.04	52%	0.082	0.04	52%	0.082
Dichlorofluoromethane	4.2	0.021	0.49%	4.2	0.048	1.1%	4.2	0.053	1.2%	4.3	0.028	0.66%	4.2
Dichloromethane	0.35	0.31	48%	0.66	0.73	68%	1.1	0.79	70%	1.1	0.43	55%	0.77
Dimethyl Disulphide	3.9	0.011	0.27%	3.9	0.045	1.2%	3.9	0.077	2.0%	3.9	0.09	2.2%	3.9
Dimethyl Sulphide	7.5	0.021	0.28%	7.5	0.058	0.77%	7.6	0.053	0.70%	7.6	0.04	0.57%	7.5
Ethanol	7.7	0.46	5.7%	8.2	1.1	12%	8.8	1.2	13%	8.9	0.63	7.5%	8.3
Ethyl Acetate	0.36	0.13	27%	0.49	0.28	44%	0.64	0.31	46%	0.67	0.26	42%	0.62
Ethyl Benzene	0.44	0.37	46%	0.81	0.86	66%	1.3	0.95	69%	1.4	0.50	54%	0.94
Ethyl Toluene (m/p-)	1.0	0.20	16%	1.2	0.46	31%	1.5	0.50	34%	1.5	0.27	21%	1.3
Ethyl Toluene (o-)	0.49	0.11	18%	0.60	0.25	34%	0.74	0.28	36%	0.77	0.15	23%	0.64
Ethylene Dibromide	0.039	0.04	52%	0.081	0.04	52%	0.081	0.04	52%	0.081	0.04	52%	0.081
Ethylene Dichloride	0.087	0.010	11%	0.097	0.024	22%	0.11	0.027	23%	0.11	0.014	14%	0.10

Table 4-1 Projected Maximum 24-Hour Ground-Level Air Concentrations arising from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Maximum Ground-Level 24-Hour Air Concentrations at Residential Receptor Locations (ug/m^3)											
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)			Stage 4 (2038-2042)			Post Closure (2043)	
		Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative	Project Alone	Cumulative
Heptane	0.41	0.20	33%	0.61	0.45	52%	0.86	0.50	55%	0.91	0.26	39%	0.67
Hexane	0.76	0.15	17%	0.91	0.34	31%	1.1	0.38	33%	1.1	0.20	20%	0.96
Hydrogen Sulphide	3.5	0.012	0.3%	3.5	0.038	1.1%	3.5	0.048	1.3%	3.5	0.053	1.5%	3.6
Isopropyl Alcohol	7.5	0.77	9.3%	8.3	1.8	19%	9.3	1.97	21%	9.5	1.0	12%	8.5
Methyl Butane (2-)	2.0	0.22	9.9%	2.2	0.51	20%	2.5	0.56	22%	2.6	0.30	13%	2.3
Methyl Cyclohexane	0.40	0.14	25%	0.54	0.31	44%	0.71	0.34	46%	0.74	0.18	31%	0.58
Methyl Ethyl Ketone	1.4	0.63	31%	2.0	1.5	51%	2.8	1.6	54%	3.0	0.85	38%	2.2
Methyl Hexane (2-)	4.1	0.11	2.5%	4.2	0.24	5.6%	4.3	0.27	6.2%	4.4	0.14	3.4%	4.2
Methyl Hexane (3-)	0.41	0.15	27%	0.56	0.34	46%	0.75	0.38	48%	0.79	0.20	33%	0.61
Methyl Isobutyl Ketone	0.41	0.08	16%	0.49	0.18	31%	0.59	0.20	33%	0.61	0.11	21%	0.52
Methyl Pentane (2-)	0.35	0.054	13%	0.40	0.12	26%	0.47	0.14	28%	0.49	0.073	17%	0.42
Methyl Pentane (3-)	0.35	0.024	6.4%	0.37	0.06	14%	0.41	0.061	15%	0.41	0.032	8.4%	0.38
Naphthalene	0.65	0.02	3.0%	0.67	0.05	6.7%	0.70	0.05	7.3%	0.70	0.03	4.0%	0.68
Nonane	0.50	0.078	13%	0.58	0.18	26%	0.68	0.34	41%	0.84	0.105	17%	0.61
Octane	0.47	0.09	16%	0.55	0.21	31%	0.67	0.22	32%	0.68	0.13	21%	0.59
Pentane	1.1	0.13	11%	1.2	0.31	22%	1.4	0.34	24%	1.4	0.18	14%	1.3
Propyl Benzene	0.49	0.081	14%	0.57	0.19	28%	0.68	0.21	30%	0.70	0.11	18%	0.60
Styrene	0.43	0.01	2.6%	0.44	0.03	5.7%	0.45	0.03	6.3%	0.45	0.01	3.4%	0.44
Tetrachloroethane (1,1,2,2-)	0.001	0.08	99%	0.08	0.13	100%	0.13	0.13	100%	0.13	0.08	99%	0.09
Tetrachloroethylene	0.070	0.16	70%	0.23	0.38	84%	0.45	0.41	85%	0.48	0.22	76%	0.29
Toluene	1.6	0.93	37%	2.5	2.1	57%	3.8	2.4	60%	4.0	1.3	44%	2.9
Total Mercaptans (as Methyl Mercaptan)	4.0	0.016	0.41%	4.0	0.053	1.3%	4.0	0.067	1.7%	4.0	0.066	1.6%	4.0
Total Reduced Sulphurs (TRS)	5.0	0.03	1%	5.03	0.13	3%	5.13	0.22	4%	5.22	0.25	5%	5.25
Trichloro-1,2,2-Trifluromethane (1,1,2-)	0.75	0.0039	0.51%	0.75	0.01	1.1%	0.76	0.01	1.2%	0.76	0.0044	0.58%	0.75
Trichloroethane (1,1,1-)	0.55	0.03	5.6%	0.58	0.05	7.8%	0.60	0.05	7.6%	0.60	0.03	5.5%	0.58
Trichloroethane (1,1,2-)	0.028	0.04	57%	0.064	0.04	57%	0.064	0.04	57%	0.064	0.04	56%	0.063
Trichloroethylene	0.055	0.10	66%	0.16	0.23	81%	0.29	0.25	82%	0.31	0.14	71%	0.19
Trichlorofluoromethane	1.3	0.01	0.75%	1.3	0.02	1.7%	1.3	0.02	1.8%	1.32	0.01	0.96%	1.3
Trimethyl Benzene (1,2,4-)	0.49	0.19	27%	0.68	0.42	46%	0.91	0.46	49%	1.0	0.24	33%	0.73

Table 4-1 Projected Maximum 24-Hour Ground-Level Air Concentrations arising from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Maximum Ground-Level 24-Hour Air Concentrations at Residential Receptor Locations (ug/m^3)											
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)			Stage 4 (2038-2042)			Post Closure (2043)	
		Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative	Project Alone	Cumulative
Trimethyl Benzene (1,3,5-)	0.49	0.02	4.4%	0.51	0.05	8.9%	0.54	0.05	9.8%	0.54	0.03	5.0%	0.52
Vinyl Chloride	0.026	0.12	82%	0.15	0.28	92%	0.30	0.30	92%	0.33	0.17	87%	0.19
Vinylidene Chloride	0.040	0.05	58%	0.093	0.05	58%	0.094	0.05	58%	0.094	0.05	58%	0.093
Xylene (m/p-)	0.85	0.90	51%	1.8	2.1	71%	2.9	2.28	73%	3.1	1.2	58%	2.0
Xylene (o-)	0.44	0.35	44%	0.78	0.80	65%	1.2	0.88	67%	1.3	0.46	52%	0.90

Note: Provided percentages represent the percentage of the cumulative airborne concentration that is predicted to originate from landfill emissions.

[a] n-butanal was not present in the ALS ambient monitoring samples reports and therefore has no background concentration.

Table 4-2 Projected Maximum Annual Average Ground-Level Air Concentrations arising from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Maximum Ground-Level Annual Average Air Concentrations at Residential Receptor Locations (ug/m^3)											
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)			Stage 4 (2038-2042)			Post Closure (2043)	
		Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative
Acetone	11.0	0.027	0.24%	11	0.065	0.59%	11	0.077	0.69%	11	0.042	0.38%	11
Benzene	0.38	0.012	3.1%	0.39	0.026	6.4%	0.40	0.030	7.4%	0.41	0.017	4.3%	0.39
Bromodichloromethane	0.01	0.011	51.4%	0.02	0.023	69.4%	0.03	0.027	72.6%	0.04	0.015	59.5%	0.02
Butanal (n-)	1.3	0.0021	0.16%	1.3	0.0052	0.40%	1.3	0.0062	0.47%	1.3	0.0034	0.26%	1.3
Butanol (2-)	3.1	0.016	0.53%	3.1	0.036	1.2%	3.1	0.043	1.4%	3.1	0.024	0.77%	3.1
Butyl Acetate	4.8	0.0080	0.17%	4.8	0.020	0.42%	4.8	0.023	0.49%	4.8	0.013	0.27%	4.8
Carbon Tetrachloride	0.52	0.0022	0.43%	0.52	0.0022	0.42%	0.52	0.0022	0.42%	0.52	0.0022	0.42%	0.52
Chlorobenzene	0.46	0.00098	0.21%	0.46	0.0024	0.51%	0.46	0.0028	0.61%	0.46	0.0015	0.33%	0.46
Chlorodifluoromethane	0.74	0.0020	0.26%	0.74	0.0049	0.65%	0.74	0.0057	0.77%	0.74	0.0032	0.43%	0.74
Chloroethane	0.27	0.0057	2.1%	0.27	0.011	4.1%	0.28	0.013	4.8%	0.28	0.0074	2.7%	0.27
Chloroform	0.24	0.0016	0.66%	0.24	0.0016	0.65%	0.24	0.0016	0.65%	0.24	0.0015	0.63%	0.24
Chloromethane	1.1	0.0011	0.10%	1.1	0.0027	0.24%	1.1	0.0031	0.28%	1.1	0.0017	0.15%	1.1
Decane	1.5	0.038	2.5%	1.5	0.096	6.0%	1.6	0.11	7.0%	1.6	0.062	4.0%	1.6
Dichlorobenzene	0.16	0.0024	1.5%	0.16	0.0060	3.6%	0.17	0.0071	4.2%	0.17	0.0039	2.3%	0.17
Dichlorodifluoromethane	2.1	0.033	1.57%	2.11	0.082	3.8%	2.2	0.097	4.5%	2.2	0.053	2.5%	2.1
Dichloroethane (1,1-)	0.041	0.0051	11%	0.046	0.010	20%	0.051	0.012	23%	0.053	0.0067	14%	0.048
Dichloroethene (1,2-)	0.085	0.019	18%	0.10	0.048	36%	0.13	0.056	40%	0.14	0.031	27%	0.12
Dichloroethylene (cis-1,2-)	0.045	0.0077	15%	0.052	0.013	22%	0.057	0.015	25%	0.059	0.0083	16%	0.053
Dichloroethylene (trans-1,2-)	0.040	0.0030	6.9%	0.043	0.0030	6.8%	0.043	0.0030	6.9%	0.043	0.0029	6.7%	0.043
Dichlorofluoromethane	4.2	0.0014	0.033%	4.2	0.0035	0.083%	4.2	0.0041	0.098%	4.2	0.0023	0.054%	4.2
Dichloromethane	0.52	0.022	4.1%	0.54	0.053	9.3%	0.57	0.062	11%	0.58	0.034	6.2%	0.55
Dimethyl Disulphide	2.3	0.00073	0.032%	2.3	0.0034	0.15%	2.3	0.0056	0.24%	2.3	0.0064	0.28%	2.3
Dimethyl Sulphide	3.3	0.0015	0.044%	3.3	0.0044	0.13%	3.3	0.0042	0.13%	3.3	0.0032	0.097%	3.3
Ethanol	33	0.031	0.10%	33	0.078	0.24%	33	0.092	0.28%	33	0.051	0.15%	33
Ethyl Acetate	0.37	0.0082	2.1%	0.38	0.020	5.1%	0.39	0.024	6.0%	0.40	0.013	3.4%	0.39
Ethyl Benzene	0.44	0.025	5.5%	0.46	0.063	13%	0.50	0.074	15%	0.51	0.041	8.5%	0.48
Ethyl Toluene	0.49	0.0073	1.5%	0.50	0.018	3.6%	0.51	0.022	4.2%	0.51	0.012	2.4%	0.50
Ethyl Toluene (m/p-)	1.0	0.013	1.3%	1.0	0.033	3.2%	1.0	0.039	3.8%	1.0	0.022	2.1%	1.0
Ethylene Dibromide	0.039	0.0017	4.1%	0.041	0.0017	4.1%	0.041	0.0017	4.1%	0.041	0.0017	4.1%	0.041
Ethylene Dichloride	0.070	0.00070	1.0%	0.071	0.0018	2.4%	0.072	0.0021	2.9%	0.072	0.0011	1.6%	0.071

Table 4-2 Projected Maximum Annual Average Ground-Level Air Concentrations arising from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Maximum Ground-Level Annual Average Air Concentrations at Residential Receptor Locations (ug/m^3)											
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)			Stage 4 (2038-2042)			Post Closure (2043)	
		Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative	Project Alone	Cumulative
Heptane	0.42	0.014	3.1%	0.44	0.033	7.2%	0.46	0.039	8.4%	0.46	0.021	4.7%	0.45
Hexane	0.46	0.010	2.2%	0.47	0.025	5.2%	0.48	0.029	6.0%	0.49	0.016	3.4%	0.47
Hydrogen Sulphide	2.7	0.0011	0.040%	2.7	0.0035	0.13%	2.7	0.0048	0.18%	2.7	0.0049	0.18%	2.7
Isopropyl Alcohol	3.1	0.052	1.7%	3.2	0.131	4.0%	3.2	0.15	4.7%	3.3	0.084	2.6%	3.2
Methyl Butane (2-)	1.1	0.015	1.3%	1.1	0.037	3.2%	1.2	0.044	3.8%	1.2	0.024	2.1%	1.1
Methyl Cyclohexane	0.40	0.0091	2.2%	0.41	0.023	5.4%	0.42	0.027	6.3%	0.43	0.015	3.6%	0.41
Methyl Ethyl Ketone	0.74	0.043	5.4%	0.78	0.11	13%	0.85	0.12	14%	0.86	0.069	8.5%	0.81
Methyl Hexane (2-)	4.1	0.0071	0.17%	4.1	0.018	0.43%	4.1	0.021	0.51%	4.1	0.012	0.28%	4.1
Methyl Hexane (3-)	0.42	0.010	2.4%	0.43	0.025	5.7%	0.44	0.030	6.6%	0.45	0.016	3.7%	0.44
Methyl Isobutyl Ketone	0.41	0.0053	1.3%	0.42	0.013	3.1%	0.42	0.016	3.7%	0.43	0.0086	2.0%	0.42
Methyl Pentane (2-)	0.38	0.0036	0.95%	0.38	0.0091	2.3%	0.39	0.011	2.8%	0.39	0.0059	1.5%	0.38
Methyl Pentane (3-)	0.36	0.0016	0.44%	0.36	0.0040	1.1%	0.37	0.0047	1.3%	0.37	0.0026	0.71%	0.36
Naphthalene	0.74	0.043	5.4%	0.78	0.11	13%	0.85	0.12	14%	0.87	0.069	8.5%	0.81
Nonane	0.50	0.0053	1.0%	0.51	0.013	2.6%	0.51	0.015	3.0%	0.52	0.0085	1.7%	0.51
Octane	0.47	0.0080	1.7%	0.48	0.015	3.1%	0.48	0.017	3.6%	0.49	0.0097	2.0%	0.48
Pentane	0.63	0.0091	1.4%	0.64	0.023	3.5%	0.65	0.027	4.1%	0.65	0.015	2.3%	0.64
Propyl Benzene	0.49	0.0055	1.1%	0.50	0.014	2.7%	0.504	0.016	3.2%	0.51	0.0088	1.8%	0.50
Styrene	0.44	0.00077	0.18%	0.44	0.0019	0.43%	0.438	0.0022	0.50%	0.44	0.0012	0.27%	0.44
Tetrachloroethane (1,1,2,2-)	0.001	0.0072	93%	0.008	0.0090	95%	0.0095	0.010	95%	0.011	0.0063	93%	0.007
Tetrachloroethylene	0.09	0.012	12%	0.10	0.027	23%	0.1167	0.032	26%	0.12	0.018	17%	0.11
Toluene	0.86	0.063	6.8%	0.93	0.16	15.4%	1.020	0.18	18%	1.0	0.10	11%	0.96
Total Mercaptans (as Methyl Mercaptan)	2.3	0.0011	0.049%	2.3	0.0040	0.17%	2.30	0.0050	0.22%	2.3	0.0050	0.22%	2.3
Total Reduced Sulphurs (TRS)	3.9	0.0024	0.061%	3.9	0.011	0.27%	3.90	0.017	0.44%	3.9	0.020	0.51%	3.9
Trichloro-1,2,2-Trifluromethane (1,1,2-)	0.75	0.00027	0.036%	0.75	0.00058	0.077%	0.751	0.00069	0.092%	0.75	0.00035	0.047%	0.75
Trichloroethane (1,1,1-)	0.55	0.0027	0.49%	0.55	0.0032	0.57%	0.553	0.0036	0.65%	0.55	0.0024	0.43%	0.55
Trichloroethane (1,1,2-)	0.031	0.0026	7.8%	0.033	0.0026	7.8%	0.0331	0.0026	7.8%	0.033	0.0025	7.4%	0.033
Trichloroethylene	0.061	0.0084	12%	0.069	0.017	22%	0.0777	0.020	25%	0.081	0.011	15%	0.071
Trichlorofluoromethane	0.92	0.00067	0.073%	0.92	0.0016	0.17%	0.920	0.0019	0.21%	0.92	0.0010	0.11%	0.92
Trimethyl Benzene (1,2,4-)	0.51	0.0126	2.4%	0.52	0.031	5.7%	0.540	0.036	6.6%	0.55	0.019	3.7%	0.53

Table 4-2 Projected Maximum Annual Average Ground-Level Air Concentrations arising from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Maximum Ground-Level Annual Average Air Concentrations at Residential Receptor Locations (ug/m^3)											
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)			Stage 4 (2038-2042)			Post Closure (2043)	
		Project Alone		Cumulative	Project Alone		Cumulative	Project Alone		Cumulative	Project Alone	Cumulative
Trimethyl Benzene (1,3,5-)	0.50	0.0016	0.32%	0.50	0.0035	0.69%	0.499	0.0041	0.81%	0.50	0.0021	0.42%	0.50
Vinyl Chloride	0.026	0.0092	27%	0.035	0.020	44%	0.0457	0.0237	48%	0.049	0.013	34%	0.039
Vinylidene Chloride	0.040	0.0038	8.7%	0.043	0.0038	8.7%	0.0433	0.0038	8.7%	0.043	0.0037	8.5%	0.043
Xylene (m/p-)	0.86	0.061	6.7%	0.92	0.15	15%	1.008	0.18	17%	1.0	0.097	10%	0.95
Xylene (o-)	0.44	0.023	5.1%	0.46	0.058	12%	0.493	0.068	14%	0.50	0.037	7.9%	0.47

Note: Provided percentages represent the percentage of the cumulative airborne concentration that is predicted to originate from landfill emissions.

Table 4-3 Projected Maximum 24-Hour Ground-Level Air Concentrations arising from Haul Route Emissions at each Landfill Cycle Stage

Chemicals of Concern	Maximum Ground-Level 24-Hour Air Concentrations at Residential Locations (ug/m^3)						
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)		
		Project Alone		Cumulative	Project Alone		Cumulative
Benzene	0.59	0.21	27%	0.80	0.42	42%	1.00
Benzo(a)pyrene	0.000032	0.000054	63%	0.000086	0.0000093	23%	0.000041
Carbon monoxide (8-hour)	302	33	9.7%	334	33	9.8%	334
Formaldehyde	0.78	12%	14%	0.9	0.083	9.7%	0.9
Nitrogen dioxide	23	30	56%	53	29	56%	52
Particulate Matter – Inhalable ($PM_{2.5}$) [a]	11	17	60%	28	7.9	42%	19
Particulate Matter – Respirable (PM_{10}) [a]	16	39	71%	55	37	70%	53
Sulphur dioxide	17	2.1	11%	20	2.1	11%	20
Toluene	1.6	0.93	37%	2.5	2.2	57%	3.8

Note: Provided percentages represent the percentage of the cumulative airborne concentration that is predicted to originate from haul route emissions.

[a] The modelled concentrations of PM_{10} and $PM_{2.5}$ consist of cumulative contributions from both vehicle emissions travelling on the proposed haul routes to/from the Landfill and fugitive particulate matter arising from landfill construction and covering activities. As it is important to evaluate their combined contributions, and the vehicle emissions are likely to be the largest discrete source, the assessment of particulate health risks were included in the haul route scenario.

Table 4-4 Projected Maximum Annual Average Ground-Level Air Concentrations arising from Haul Route Emissions at each Landfill Cycle Stage

Chemicals of Concern	Maximum Ground-Level Annual Average Air Concentrations at Residential Locations (ug/m^3)						
	Background	Stage 1 (2023-2027)			Stage 3 (2033-2037)		
		Project Alone		Cumulative	Project Alone		Cumulative
Benzene	0.38	0.017	4.2%	0.39	0.030	7.4%	0.41
Benzo(a)pyrene	0.000032	0.0000070	18%	0.000039	0.0000012	3.6%	0.000033
Formaldehyde	0.78	0.012	1.5%	0.79	0.0062	0.79%	0.79
Nitrogen dioxide	12	3.9	25%	16	2.6	18%	14
Particulate Matter – Inhalable ($PM_{2.5}$) [a]	2.9	1.3	31%	4.3	1.2	29%	4.1
Particulate Matter – Respirable (PM_{10}) [a]	4.5	5.3	54%	10	5.2	53%	10
Sulphur dioxide	6.4	0.12	1.9%	6	0.12	2%	6.5
Toluene	0.86	0.063	6.8%	0.93	0.16	15%	1.0

Note: Provided percentages represent the percentage of the cumulative airborne concentration that is predicted to originate from haul route emissions.

[a] The modelled concentrations of PM_{10} and $PM_{2.5}$ consist of cumulative contributions from both vehicle emissions travelling on the proposed haul routes to/from the Landfill and fugitive particulate matter arising from landfill construction and covering activities. As it is important to evaluate their combined contributions, and the vehicle emissions are likely to be the largest discrete source, the assessment of particulate health risks were included in the haul route scenario.

4.2 Estimation of Soil, Agricultural Produce and Home Garden Produce Concentrations

Another important element of exposure related to the emissions for the proposed Landfill and related proposed haul routes is the potential deposition of airborne particulate-bound (and sometimes gaseous) contaminants from the atmosphere onto ground-level surfaces (such as soil, agricultural crops, home gardens, *etc.*) in the surrounding community. Deposition (both dry and wet) can be affected by a variety of different factors, the most important of which tend to be the characteristics of the atmosphere (*e.g.*, wind speed, temperature, atmospheric stability, *etc.*), the nature of the surface (*e.g.*, its surface roughness, porosity, *etc.*), and the properties of the depositing species (*e.g.*, reactivity, diameter and shape, solubility, *etc.*). This process can be achieved through "dry" deposition where the particles or gas molecules impact upon a surface, or through "wet" deposition where rain or other precipitation scavenges particles and gas molecules from the air and deposits them on surfaces.

To address this particular exposure route, the deposition into the environment (*e.g.,* soil) was estimated at each common receptor location by the air quality assessment team at RWDI. This data was then used to predict exposure concentrations in soil at the sensitive receptor location areas. To capture the potential range of exposures, as no site-specific information was available, the background soil concentrations were estimated on the MECP Table 1 Full Depth Background Site Condition Standards (SCS). The soil standards in the Table 1 are background values which are derived from the Ontario Typical Range (OTR) values for the indicated land uses (*i.e.,* agricultural or other property use; residential/ parkland/institutional/industrial/commercial/community property use). The OTR are representative of the 97.5th percentile upper limit (OTR_{98}) of the typical province-wide background concentrations in soils that are not contaminated by point sources based on the surface soils database used as the basis of the Table 1 SCS.

Table 4-5 presents the predicted annual soil, air and dust concentrations for benzo(a)pyrene for the haul route assessment. The maximum annual concentration of benzo(a)pyrene in air is based on the maximum concentration predicted by the Air Quality Team (*i.e.,* RWDI) for the residential common receptors. In addition, the maximum concentrations also have considered the common receptors identified for the cropping areas. As Section 3.2.1 discusses, the receptors identified to have potential impacts to agriculture were identified to be ZOR 11,16,17,18 and SWO1,2,3,10 to19. In Table 4-5, dust represents re-suspended dust from surface soil. These calculated media concentrations were then used to determine potential cumulative soil concentrations at receptor locations within the Project area over the lifespan of the proposed Landfill.

Table 4-5 Summary of Predicted Annual Media Concentrations for Stage 1 and Stage 2 of the Haul Route for Benzo(a)pyrene

Project Stage	Soil Conc. (mg/kg)[a]	Soil Deposition (mg/kg)	Total Soil Conc. (mg/kg)	Surface Soil (mg/kg)[a]	Surface Soil Deposition (mg/kg)	Surface Soil Total (mg/kg)	Air Conc. (µg/m^3)	Dust (µg/m^3)	Dry Deposition (mg/m^2/yr)
Background	0.05	0.0	0.05	0.05	0.00	0.05	0.0000318	0.0000125	0.0
Project Stage 1 Only	0.0	4.82E-07	4.82E-07	0.0	4.82E-06	4.82E-06	0.00000698	1.21E-09	0.0000828
Project Stage 1+Bkgd	0.05	4.82E-07	0.05	0.05	4.82E-06	0.05	0.0000388	0.0000125	0.0000828
Project Stage 3 Only	0.0	4.8E-07	4.8E-07	0.0	4.8E-06	4.8E-06	0.0000012	1.20E-09	0.0000824
Project Stage 3 + Background (Annual)	0.05	4.8E-07	0.05	0.05	4.8E-06	0.05	0.000033	0.0000125	0.0000824

[a] Baseline soil concentrations were conservatively assumed to be equivalent to the Table 1 SCS published by MOE (2011). The Table 1 SCS are the Full depth Background Site Condition Standards for agricultural or other property use.

4.3 Exposure Analysis of Particulate Matter

The size of the airborne particles to which people are exposed is one of the most important aspects in determining the potential for health risk resulting from PM exposure. Size is directly related to where particles will be deposited in specific parts of the respiratory tract. Particles larger than about 10 microns (µm) in aerodynamic diameter (>PM_{10}) are deposited almost exclusively in the nose, throat, and upper respiratory tract, and tend to be coughed out over a very short period of time. This size range is considered outside the inhalable range for people, since these particles are too large to be deposited in the lung. Health effects associated with particles greater than PM_{10} are considered less critical compared to fractions less than 10 microns in size since they are less likely to be absorbed into the body *via* inhalation. Fine and ultrafine particles (<2.5 µm), on the other hand, are small enough to reach the alveoli (air spaces) deep in the lungs. In general, it may be assumed that the smaller the particle, the greater the potential to reach respiratory structures such as alveoli where blood-gas exchange occurs. Inhaled fine and ultrafine particles can also carry adsorbed chemical pollutants to the deeper lung structures. Smaller particles tend to be present in greater numbers, and they possess a greater total surface area than larger particles of the same mass.

The potential impacts of human exposure to the respirable fraction of PM (*i.e.*, $PM_{2.5}$ and PM_{10}) were emphasized in the current HHRA, rather than the broader size fraction represented by total suspended particulate (*i.e.*, TSP, comprising particles ranging up to 44 µm in size). The inhalable fraction (*i.e.*, PM_{10}) is also widely used to evaluate potential health issues, since this size of particle primarily affects tissues in the upper airways but can also travel deep into the lung. When both sets of data are available (PM_{10} and $PM_{2.5}$), the $PM_{2.5}$ data tends to carry more weight in determining the potential for health risks because of the large body of scientific literature characterizing both the epidemiological and toxicological properties of the finer size fraction. Furthermore, the $PM_{2.5}$ size fraction is typically the most relevant size fraction for vehicle exhaust emissions, and as such is particularly relevant for the transportation scenario.

4.3.1 Uncertainties Related to Ultrafine Particulate Matter (UFP)

The potential health impact of ultrafine particulate matter (*i.e.*, UFP or $PM_{0.1}$) is an emerging area of scientific enquiry. As combustion emission by-products are produced through secondary atmospheric transformations, ambient UFPs have many potential environmental sources whose relative contributions to ambient concentrations vary with location, season, and time-of-day. However, in urban areas, particularly in proximity to major roads, motor vehicle exhaust can be identified as the major contributor to UFP concentrations. In particular, diesel vehicles have been found to contribute substantially, sometimes in disproportion to their numbers in the vehicle fleet (HEI, 2013).

The unique physical properties of UFPs, their interactions with tissues and cells, and their potential for easy movement within the body beyond the lungs have lead researchers to suspect that UFPs may have specific or enhanced toxicity relative to other particle size fractions and may contribute to effects beyond the respiratory system. However, the considerable body of research that has been conducted has not been able to definitively confirm this possibility (HEI, 2013). To date, toxicological studies in animals, controlled human exposure studies, and epidemiologic studies have not provided consistent findings on the effects of exposures to ambient levels of UFPs, particularly in human populations. Most importantly, the current scientific evidence does not support a conclusion that exposures to UFPs alone can account in substantial ways for the adverse effects that have been associated with other ambient pollutants, such as $PM_{2.5}$ (HEI, 2013).

Currently there are no established accepted reference benchmarks or standardized approaches to evaluation of the health impact related to exposures to this particulate matter fraction. As such, the ultrafine fraction was considered as part of the evaluation of health impacts related to the $PM_{2.5}$ (*i.e.*, particulate matter less than 2.5 microns in size) group, and only the PM_{10} and $PM_{2.5}$ size fractions were overtly evaluated in the current assessment.

5.0 HAZARD ASSESSMENT

All chemicals have the potential to cause toxicological effects; however, it is the chemical concentration, the route of exposure, the duration of exposure, and the inherent toxicity of the chemical that determines the level of effect and hence the potential for adverse health effects. In this stage of the HHRA, toxicity reference values (TRVs) to be used to characterize health risks were selected for each COC. Toxicity reference values endorsed by the MECP were utilized as first priority, when available.

In circumstances where TRVs were not presented by MECP, and when TRVs for a particular COC were available from multiple regulatory agencies, values were reviewed, and the professional judgment of an experienced toxicologist and/or risk assessor was used to select the most appropriate TRV. A number of different considerations went into selecting a TRV for use in the HHRA, including:

- The source of the information. Is the TRV derived by a reputable regulatory agency?
- Is there sufficient documentation available concerning the derivation of the TRV (*e.g.,* study, endpoint, point of departure, uncertainty factors applied, *etc.*)?
- How current is the derivation of the TRV?
- How relevant is the TRV in terms of exposure route and duration of interest?

The TRVs employed in the current HHRA were obtained from reputable regulatory agencies including, but not limited to:

- Ontario Ministry of the Environment, Conservation and Parks (MECP);
- Health Canada;
- United States Environmental Protection Agency Integrated Risk Information System (US EPA IRIS);
- Agency for Toxic Substances and Disease Registry (ATSDR);
- Canadian Council of the Ministers of the Environment (CCME);
- World Health Organization (WHO);
- California Environmental Protection Agency (Cal EPA);
- Texas Commission on Environmental Quality (TCEQ); and,
- The Dutch National Institute for Public Health and the Environment (RIVM).

For the current assessment, TRVs endorsed by MECP were given preference unless alternative, more recent or appropriate reference benchmarks were available by another reputable regulatory agency.

A summary of the non-carcinogenic and carcinogenic TRVs used in both the inhalation and multi-media assessments are summarized in Table 5-1 through Table 5-3. Refer to Appendix A for further details concerning each TRV considered and, where necessary, the rationale used to select the specific TRV.

5.1 Acute Toxicity Reference Values

The acute (*i.e.*, 24-hour exposure durations) non-carcinogenic inhalation TRVs for each of the COCs (where they were available), as well as the key critical health outcomes and regulatory source for each TRV, are provided in Table 5-1.

While the MECP has established a series of 24-hour ambient air quality criteria (AAQC), many of these are not based on acute toxicological endpoints and/or outcomes. Rather, in the case of a number of the COCs, these 24-hour AAQC are actually based on chronic toxicological outcomes requiring long-term exposures adjusted to a 24-hour averaging period for regulatory compliance and enforcement purposes.

In response to this issue, the MECP recommended the following (J. Gilmore, personal communication, 2015):

> *"HHRAs should use appropriately supported human health based TRVs (scientifically sound and up to date) and should be linked to the duration of exposure (e.g., acute, sub-chronic or chronic effects on human health) against which an air concentration is assessed. It is noted that AAQCs may:*
>
> - *not differentiate between cancer and non-cancer effects*
> - *not be based on human health effects (e.g., environmental (e.g., ecological) or nuisance effects).*
> - *not differentiate as to whether they are based on an acute, sub-chronic or chronic health effect, let alone for a cancer or non-cancer effect. For example, the ministry uses meteorological conversion factors to adjust averaging times of AAQCs to facilitate the assessment of air quality (e.g., carcinogens are extrapolated from an annual AAQC to a 24 hour AAQC). AAQCs with 24-hour averaging time are usually based on protection in long-term continuous exposures and are not "acute" values (this is often misinterpreted).*
> - *not be based on current science.*
>
> *However, in the absence of a readily identifiable TRV, an AAQC may be used as long as the effect on which it is based is accurately described. For those AAQCs that are not directly based on human health, it is more appropriate to use concentration ratios (CRs) rather than hazard quotients since the exceedance of an AAQC may not reflect the potential for an adverse human health effect."*

Based on this guidance, only those 24-hour AAQC (MOE, 2012) that were identified as health-based on an acute effect toxicological endpoint were considered for the current assessment. In instances where a 24-hour AAQC was not available, other reputable regulatory agencies, as described in Section 5.0, were reviewed. Furthermore, inhalation pathways are evaluated using concentration ratios, while multi-media risks (*e.g.*, from oral and dermal exposures) are evaluated using hazard quotients. Table 5-1 presents the summary of the TRVs and benchmarks selected for use in the HHRA for the LFG and haul route assessments. References are provided in Appendix A of the HHRA report.

Table 5-1 Summary of Acute-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m³)			
	Duration	***Value***	***Critical Effect***	***Source***
Acetone	Acute 24-hour	1.19E+04	Health-based	MOE, 2012
Benzene	24-Hour	2.90E+01	Reduces lymphocyte proliferation following mitogen stimulation	ATSDR, 2007
Benzo(a)pyrene [a]	Acute 24-hour	5.00E-05	Health-based	MOE, 2012
Bromodichloromethane	NV	NV	NV	NV
Butanal (n-)	NV	NV	NV	NV
Butanol (2-)	NV	NV	NV	NV
Butyl Acetate	NV	NV	NV	NV
Carbon Monoxide (CO)	8-Hour	6.00E+03	Carboxyhemoglobin blood level of less than 1%	Health Canada, 2006
Carbon Tetrachloride	24-Hour	2.40E+00	Health-based	MOE, 2012
Chlorobenzene	NV	NV	NV	NV
Chlorodifluoromethane	Acute 24-hour	3.50E+05	Health-based	MOE, 2012
Chloroethane	Acute 24-hour	5.60E+03	Health-based	MOE, 2012
Chloroform	Acute 24-hour	1.00E+00	Respiratory, cardiovascular, hepatic, gastrointestinal, renal, and neurological effects	MOE, 2012
Chloromethane	24-Hour	3.20E+02	Health-based	MOE, 2012
Decane	NV	NV	NV	NV
Dichlorobenzene (1,4-)	24-Hour	9.50E+01	Health-based	MOE, 2012
Dichlorodifluoromethane	Acute 24-hour	5.00E+05	Health-based	MOE, 2012
Dichloroethane (1,1-)	24-Hour	1.65E+02	Health-based	MOE, 2012
Dichloroethylene (1,2-)	Acute 24-hour	1.05E+02	Health-based	MOE, 2012
Dichloroethylene (cis-1,2-)	Acute 24-hour	1.05E+02	Health-based	MOE, 2012
Dichloroethylene (trans-1,2-)	Acute 24-hour	1.05E+02	Health-based	MOE, 2012
Dichlorofluoromethane	NV	NV	NV	NV
Dichloromethane	24-Hour	2.20E+02	Central nervous system depression	MOE, 2012
Dimethyl Disulphide	24-Hour	7.00E+00	Health based	MOE, 2012
Dimethyl Sulphide	24-Hour	7.00E+00	Health based	MOE, 2012
Ethanol	NV	NV	NV	NV
Ethyl Acetate	NV	NV	NV	NV
Ethyl Benzene	Acute 24-hour	1.00E+03	Health-based	MOE, 2012
Ethyl Toluene (o/m/p-)	NV	NV	NV	NV
Ethylene Dibromide	24-Hour	3.00E+00	Health-based	MOE, 2012
Ethylene Dichloride	24- Hour	2.00E+00	Health-based	MOE, 2012
Formaldehyde	24-Hour	6.50E+01	Health-based	MOE, 2012
Heptane	Acute 24-hour	1.10E+04	Health-based	MOE, 2012
Hexane	Acute 24-hour	2.50E+03	Neurological effects (human)	MOE, 2011; MOE 2012
Hydrogen sulphide	Acute 24-hour	7.00E+00	Health-based	MOE, 2012
Inhalable Particulate Matter (PM_{10})	24-Hour	5.00E+01	Respiratory tract irritation	WHO, 2006
Isopropyl Alcohol	Acute 24-hour	7.30E+03	Health-based	MOE, 2012

Table 5-1 Summary of Acute-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m^3)			
	Duration	***Value***	***Critical Effect***	***Source***
Methyl Butane (2-)	NV	NV	NV	NV
Methyl Cyclohexane	NV	NV	NV	NV
Methyl Ethyl Ketone	Acute 24-hour	1,000	Health-based	MOE, 2012
Methyl Hexane (2-)	NV	NV	NV	NV
Methyl Hexane (3-)	NV	NV	NV	NV
Methyl Isobutyl Ketone	NV	NV	NV	NV
Methyl Pentane (2-)	Acute 24-hour	19,000	Decreased fetal body weights	TCEQ, 2017
Methyl Pentane (3-)	Acute 24-hour	19,000	Decreased fetal body weights	TCEQ, 2017
Naphthalene	Acute 24-hour	22.5	Health-based	MOE, 2012
Nitrogen Dioxide (NO_2)	24-Hour	200	Health-based	MOE, 2012
Nonane	NV	NV	NV	NV
Octane	NV	NV	NV	NV
Pentane	NV	NV	NV	NV
Propyl Benzene	NV	NV	NV	NV
Respirable Particulate Matter ($PM_{2.5}$)	24-Hour	27	Respiratory tract irritation	CCME, 2012
Styrene	Acute 24-hour	400	Health-based	MOE, 2012
Sulphur dioxide (SO_2)	24-Hour	275	Respiratory tract irritation	MOE, 2012
Tetrachloroethane (1,1,2,2-)	NV	NV	NV	NV
Tetrachloroethylene	24-Hour	360	Health-based	MOE, 2012
Toluene	Acute	7,600	Minimally adverse neurological effects in a susceptible population in humans	ATSDR, 2017
Total Mercaptans (as methyl mercaptan)	24-Hour	7	Health-based	MOE, 2012
Total Reduced Sulphur (TRS)	Acute 24-hour	7	Health-based	MOE, 2012
Trichloro-1,2,2-Trifluroethane (1,1,2-)	Acute 24-hour	800,000	Health-based	MOE, 2012
Trichloroethane (1,1,1-)	Acute 24-hour	115,000	Health-based	MOE, 2012
Trichloroethane (1,1,2-)	NV	NV	NV	NV
Trichloroethylene	24-Hour	12	Health-based	MOE, 2012
Trichlorofluoromethane	Acute 24-hour	6,000	Health-based	MOE, 2012
Trimethyl Benzene (1,2,4-)	Acute 24-hour	220	Health-based	MOE, 2012
Trimethyl Benzene (1,3,5-)	Acute 24-hour	220	Health-based	MOE, 2012
Vinyl Chloride	24-Hour	1	Central nervous system depression	MOE, 2012
Vinylidene Chloride	Acute 24-hour	10	Health-based	MOE, 2012
Xylene (o/m/p-)	Acute 24-hour	730	Health-based	MOE, 2012
Acetone	Acute 24-hour	11,900	Health-based	MOE, 2012
Benzene	24-Hour	29	Reduces lymphocyte proliferation following mitogen stimulation	ATSDR, 2007
Benzo(a)pyrene [a]	Acute 24-hour	5.00E-05	Health-based	MOE, 2012

Table 5-1 Summary of Acute-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m^3)			
	Duration	***Value***	***Critical Effect***	***Source***
Bromodichloromethane	NV	NV	NV	NV
Butanal (n-)	NV	NV	NV	NV

NV No value is available

[a] The acute value for benzo(a)pyrene was not used because it is a chronic cancer value made into a 24-hour AAQC.

It should be noted that the typical regulatory approach in Canada to evaluating ambient air concentrations of the criteria air contaminants is through a comparison to Canada Wide Standards (CWS) or National Ambient Air Quality Objectives (NAAQOs). These standards and objectives typically provide the benchmark by which emissions from a proposed project are evaluated for acceptability, from both a federal and provincial compliance point-of-view. However, it should be noted that the NAAQOs for NOx and SO_2 are not specifically health risk-based. Many of these standards and objectives are dated (*i.e.*, established in 1974/5), do not include the most recent scientific health-based knowledge, and are impacted by policy decisions in their derivation. As such, any discussion on the effect of air pollution cannot rely on the attainment of such "standards" to guarantee that health within exposed population will be protected.

5.2 Chronic Toxicity Reference Values

5.2.1 Inhalation Exposures

The chronic non-carcinogenic and carcinogenic inhalation TRVs for each of the COCs (where they were available), as well as the key critical health outcomes and regulatory source for each TRV, are provided in Table 5-2.

Table 5-2 Summary of Chronic-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m^3)				Carcinogenic Inhalation Unit Risk ((µg/m^3)$^{-1}$)		
	Duration	*Value*	*Critical Effect*	*Source*	*Value*	*Critical Effect*	*Source*
Acetone	Chronic	12,000	NV	MOE, 2011	NV	NV	NV
Benzene	Chronic	30	Decreased lymphocyte count	US EPA, 2003; MOE 2011	2.20E-06	Leukemia	US EPA, 2001; MOE, 2011
Benzo(a)pyrene	Chronic	0.002	Decreased embryo/fetal survival	MECP, 2018; US EPA IRIS, 2017	6.00E-04	Upper respiratory tract & pharynx tumours, all treated as incidental to the cause of death	MECP, 2018; US EPA IRIS, 2017
Bromodichloromethane	Chronic	70	NV	TCEQ, 2018	3.70E-05	NV	Cal EPA, 2019
Butanal (n-)	Chronic	100	Hyperplasia, inflammation, and squamous metaplasia of the nasal tissues (nasal irritation) in SD rats and male beagle dogs	TCEQ, 2014	NV	NV	NV
Butanol (2-)	Chronic	300	NV	TCEQ, 2018	NV	NV	NV
Butyl Acetate	Chronic	4,7000	Minimal to mild necrosis on the olfactory epithelium, decreased transient motor activity (CNS effects), and decreased growth in rats	TCEQ, 2014	NV	NV	NV
Carbon Monoxide (CO)	NV	NV	NV	NV	NV	NV	NV
Carbon Tetrachloride	Chronic	2	NV	MOE, 2011	6.00E-06	Pheochromocytoma (mouse)	US EPA IRIS, 2010
Chlorobenzene	Chronic	1,000	NV	MOE, 2011	NV	NV	NV
Chlorodifluoromethane	Chronic	50,000	Increased kidney, adrenal and pituitary weights	US EPA IRIS, 1993	NV	NV	NV
Chloroethane	Chronic	10,000	Delayed fetal ossification in mice	US EPA IRIS, 1991	NV	NV	NV
Chloroform	Chronic	100	Hepatomegaly, toxic hepatitis, and hepatosteatosis (human)	ATSDR, 1997	NV	NV	NV
Chloromethane	Chronic	90	Cerebellar lesions (mouse)	US EPA IRIS, 2001	NV	NV	NV
Decane	Chronic	1,100	Increase in body weight gain and decrease in white blood cell count in rats	TCEQ, 2017	NV	NV	NV
Dichlorobenzene (1,4-)	Chronic	60	Incidences of nasal lesions (rat)	MECP; 2019; ATSDR, 2006	4.00E-06	NV	MOE, 2011
Dichlorodifluoromethane	Chronic	1,000	Reduced body-weight gain (guinea pigs, rabbits, dogs, and monkeys)	US EPA, 2010	NV	NV	NV

Table 5-2 Summary of Chronic-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m^3)				Carcinogenic Inhalation Unit Risk ((µg/m^3)$^{-1}$)		
	Duration	*Value*	*Critical Effect*	*Source*	*Value*	*Critical Effect*	*Source*
Dichloroethane (1,1-)	Chronic	170	NV	MOE, 2011	1.60E-06	Female rat mammary gland adenocarcinoma tumor	Cal EPA, 2011
Dichloroethylene (1,2-)	Chronic	790	NV	TCEQ, 2018	NV	NV	NV
Dichloroethylene (cis-1,2-)	Chronic	790	NV	TCEQ, 2018	NV	NV	NV
Dichloroethylene (trans-1,2-)	Chronic	60	Multiple liver and lung effects (rats)	MOECC, 2017	NV	NV	NV
Dichlorofluoromethane	Chronic	4,200	NV	TCEQ, 2018	NV	NV	NV
Dichloromethane	Chronic	400	COHb formation (human)	Cal EPA, 2008	1.00E-06	Lung tumors (mouse)	Cal EPA, 2011
Dimethyl Disulphide	Chronic	2	Health based	TCEQ, 2018			
Dimethyl Sulphide	Chronic	10	Health based	TCEQ, 2018			
Ethanol	Chronic	1,880	NV	TCEQ, 2018	NV	NV	NV
Ethyl Acetate	Chronic	70	Decreased body weights, body-weight gains, food efficiency, and startle response (both sexes), and decreased food consumption (males) (rats)	US EPA, 2013	NV	NV	NV
Ethyl Benzene	Chronic	1,900	Increased severity of nephropathy	TCEQ, 2010	NV	NV	NV
Ethyl Toluene (o/m/p-)	Chronic	125	NV	TCEQ, 2019	NV	NV	NV
Ethylene Dibromide	Chronic	0.8	Reproductive effects (human)	MECP, 2019; Cal EPA, 2008	6.00E-04	Nasal cavity tumours, hemangiosarcomas, and mesotheliomas (rat)	MECP, 2019; US EPA IRIS, 2004
Ethylene Dichloride	Chronic	400	Hepatotoxicity; elevated liver enzyme levels in serum of rats.	Cal EPA, 2000	2.60E-05	Hemangiosarcomas in rats	US EPA IRIS, 1987
Formaldehyde	Chronic	9	Nasal obstruction and discomfort, lower airway discomfort, eye irritation (human)	Cal EPA, 2008	1.30E-05	Incidence of nasal squamous cell carcinoma	US EPA IRIS, 1991
Heptane	Chronic	400	Loss of hearing sensitivity (rats)	US EPA, 2016	NV	NV	NV
Hexane	Chronic	2,500	NV	MOE, 2011	NV	NV	NV
Hydrogen sulphide	Chronic	2	Nasal lesions of the olfactory mucosa	US EPA IRIS, 2003	NV	NV	NV
Inhalable Particulate Matter (PM_{10})	Annual average	20	Lowest levels at which total, cardiopulmonary and lung cancer mortality has been shown to increase (human)	WHO, 2006	NV	NV	NV

Table 5-2 Summary of Chronic-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m^3)				Carcinogenic Inhalation Unit Risk ((µg/m^3)$^{-1}$)		
	Duration	*Value*	*Critical Effect*	*Source*	*Value*	*Critical Effect*	*Source*
Isopropyl Alcohol	Chronic	200	Decreased absolute and relative testes weights in male mice	US EPA, 2014	NV	NV	NV
Methyl Butane (2-)	Chronic	24,000	Free-standing NOAEL	TCEQ, 2011	NV	NV	NV
Methyl Cyclohexane	Chronic	1,610	NV	TCEQ, 2018	NV	NV	NV
Methyl Ethyl Ketone	Chronic	5,000	Developmental toxicity (skeletal variations) in mice	US EPA IRIS, 2003	NV	NV	NV
Methyl Hexane (2-)	Chronic	9,000	Absence of effects on body weight gain, neuromuscular function, and neurotoxicity	TCEQ, 2016	NV	NV	NV
Methyl Hexane (3-)	Chronic	9,000	Absence of effects on body weight gain, neuromuscular function, and neurotoxicity	TCEQ, 2016	NV	NV	NV
Methyl Isobutyl Ketone	Chronic	3,000	Reduced fetal body weight, skeletal variation and increased fetal death in mice and skeletal variation in rats	MOE, 2011	NV	NV	NV
Methyl Pentane (2-)	Chronic	190	Peripheral neuropathy	TCEQ, 2017	NV	NV	NV
Methyl Pentane (3-)	Chronic	190	Peripheral neuropathy	TCEQ, 2017	NV	NV	NV
Naphthalene	Chronic	3.7	Non-neoplastic lesions in nasal olfactory epithelium and respiratory epithelium (rats)	MOE, 2011; ATSDR, 2005	0.00E+00	Based on a Benzo(a)pyrene TEF of 0, and the inhalation unit risk recommended by MECP (2018)	MECP, 2018
Nitrogen Dioxide (NO_2)	Annual average	40	Respiratory effects	WHO, 2006	NV	NV	NV
Nonane	Chronic	20	NV	US EPA, 2009	NV	NV	NV
Octane	Chronic	1,800	Absence of general systemic effects	TCEQ, 2016	NV	NV	NV
Pentane	Chronic	1,000	Free-standing NOAEL	US EPA, 2009	NV	NV	NV
Propyl Benzene	Chronic	1,000	Reduced litter size; increased relative liver, kidney, and spleen weights of dams; skeletal variations	US EPA, 2009	NV	NV	NV
Respirable Particulate Matter ($PM_{2.5}$)	Annual average	8.8	Cardiopulmonary and lung cancer mortality increase (human)	CCME, 2012	NV	NV	NV
Styrene	Chronic	260	NV	MOE, 2011	NV	NV	NV
Sulphur dioxide (SO_2)	Annual average	10	NV	CCME, 2019	NV	NV	NV

Table 5-2 Summary of Chronic-Duration Inhalation TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Inhalation TRVs (µg/m^3)				Carcinogenic Inhalation Unit Risk ((µg/m^3)$^{-1}$)		
	Duration	*Value*	*Critical Effect*	*Source*	*Value*	*Critical Effect*	*Source*
Tetrachloroethane (1,1,2,2-)	Chronic	7	NA	TCEQ, 2018	5.80E-05	NV	MOE, 2011
Tetrachloroethylene	Chronic	40	Neurotoxicity (human)	MECP, 2019; US EPA IRIS, 2012	2.60E-07	Hepatocellular adenomas or carcinomas (mice)	MECP, 2019; US EPA IRIS, 2012
Toluene	Chronic	5,000	NV	MOE, 2011	NV	NV	NV
Total Mercaptans (as methyl mercaptan)	Chronic	1	NV	TCEQ, 2018	NV	NV	NV
Trichloro-1,2,2-Trifluroethane (1,1,2-)	Chronic	3,800	NA	TCEQ, 2018	NV	NV	NV
Trichloroethane (1,1,1-)	Chronic	1,000	Astrogliosis in the sensorimotor cortex (brain) of gerbils	Cal EPA, 2000	NV	NV	NV
Trichloroethane (1,1,2-)	Chronic	55	NV	TCEQ, 2018	1.60E-05	NV	MOE, 2011
Trichloroethylene	Chronic	2	Decreased thymus weights and fetal heart malformations (mouse)	MECP, 2019; US EPA IRIS, 2011	4.10E-06	Renal cell carcinoma (human)	MECP, 2019; US EPA IRIS, 2011
Trichlorofluoromethane	Chronic	5,600	NV	TCEQ, 2012	NV	NV	NV
Trimethyl Benzene (1,2,4-)	Chronic	60	Decreased pain sensitivity in male Wistar rats	US EPA IRIS, 2016	NV	NV	NV
Trimethyl Benzene (1,3,5-)	Chronic	60	Decreased pain sensitivity in male Wistar rats	US EPA IRIS, 2016	NV	NV	NV
Vinyl Chloride	Annual average	60	Centrilobular hypertrophy in the liver (rat)	TCEQ, 2009	8.80E-06	Increased incidence of liver angiosarcomas, angiomas, hepatomas, and neoplastic nodules in female rats	MECP, 2019; US EPA, 2000
Vinylidene Chloride	Chronic	20	Liver toxicity (fatty change)	US EPA IRIS, 2002	NV	NV	NV
Xylene (o/m/p-)	Chronic	700	CNS effects in humans; irritation of the eyes, nose, and throat	MOE,2011; Cal EPA, 2008	NV	NV	NV

NV No value selected or available

5.2.2 Multi-Pathway Exposures

The findings of the chemical screening conducted in Section 3.3.1.2 indicated that only benzo(a)pyrene is eligible for inclusion in the multi-pathway assessment. Based on Table 5-3, benzo(a)pyrene was retained for the multi-pathway assessment as it has defensible oral exposure limits.

The chronic non-carcinogenic and carcinogenic oral/dermal TRVs, as well as the key critical health outcomes and regulatory source for each TRV, are provided in Table 5-3. Refer to the toxicological profile for each of the COCs provided in Appendix A of this report for a detailed discussion of the relevant background information supporting the selected TRV.

Table 5-3 Summary of Oral TRVs and Benchmarks Selected for Use in the HHRA

Chemical of Potential Concern	Non-Carcinogenic Oral/Dermal TRVs (µg/kg bw/d)				Carcinogenic Oral/Dermal Slope Factors ((µg/kg bw/d)$^{-1}$)			
	Exposure Limit		Critical Effect	Source	Exposure Limit		Critical Effect	Source
	Type	*Value*			*Type*	*Value*		
Polycyclic aromatic hydrocarbons (PAHs) as benzo(a)pyrene Toxic Equivalents (TEQ)	RfD	0.3	Neurobehavioural changes	MECP, 2018; US EPA IRIS 2017	SF	1.00E-03	Dose-dependent increase in alimentary tract tumours (forestomach, esophagus, tongue, larynx) (mouse)	MECP, 2018; US EPA IRIS 2017; Kalberlah *et al.*, 1995

Abbreviations: RfD, reference dose; SF, slope factor;

5.3 Chemical Mixtures and Additive Risks

Because chemical exposures rarely occur in isolation, the potential health effects associated with mixtures of COC were considered. The interaction between chemicals can take many forms and as such, Health Canada (2012) recommends that additive interactions be assumed when chemicals (within a given mixture) are structurally similar, act toxicologically through similar mechanisms or affect the same target tissue in the body (*i.e.*, share a common effect).

There are currently no Ontario or Canada reference benchmarks (beyond those chemical groups that have established toxic equivalent factors such as dioxins, furans and polycyclic aromatic hydrocarbons) by which one can evaluate whether exposure to a given mixture from, or in isolation from, multiple sources could pose a health concern. Health effects from mixtures are typically assessed by assuming additive effects of chemicals with similar exposure characteristics (*e.g.*, acute exposure; chronic exposure) and similar toxic effects (*e.g.*, respiratory irritants, nasal irritants, reproductive effects) (Health Canada, 2012). In other words, risk estimates for each chemical in a mixture were summed for illustrative, rather than regulatory compliance purposes.

For the evaluation of chemical mixtures in the HHRA, the health endpoint of the TRVs used in the HHRA provided the basis for the inclusion of an individual chemical in a chemical mixture. Table 5-4 presents those chemicals included in mixtures associated with acute and chronic non-cancer endpoints *via* inhalation. In addition, where toxicologically justified, the carcinogenic risk from a mixture of COCs for the LFG assessment were also presented for illustrative purposes.

Table 5-4 Potential Additive Interactions of the Chemicals of Concern

Exposure Characteristics	***Potential Non-Carcinogenic Health Endpoint of Mixture***	***Chemicals of Concern***
Haul Route Assessment		
Acute air exposure	Eye irritants	• Formaldehyde • Toluene
	Respiratory irritants	• Formaldehyde • Nitrogen dioxide • Respirable Particulate Matter ($PM_{2.5}$) • Inhalable Particulate Matter (PM_{10}) • Sulphur dioxide • Toluene
	Hematological effects	• Benzene • Carbon monoxide (8-hour)
Chronic air exposure	Respiratory effects	• Nitrogen dioxide • Respirable Particulate Matter ($PM_{2.5}$) • Inhalable Particulate Matter (PM_{10}) • Sulphur dioxide

Table 5-4 Potential Additive Interactions of the Chemicals of Concern		
Exposure Characteristics	***Potential Non-Carcinogenic Health Endpoint of Mixture***	***Chemicals of Concern***
Land Fill Gas Assessment		
Acute air exposure	Eye irritants	• Dichlorodifluoromethane • Ethylene Dibromide • Ethylene Dichloride • Naphthalene • Styrene
	Respiratory irritants	• Dichlorobenzene • Dimethyl Disulphide • Dimethyl Sulphide • Isopropyl Alcohol • Total Mercaptans (as Methyl Mercaptan) • Trimethyl Benzene (1,2,4-) • Trimethyl Benzene (1,3,5-) • Vinyl Chloride • Xylene (m/p-) • Xylene (o-)
	Neurological effects	• Acetone • Chloroform • Chloromethane • Dichloromethane • Heptane • Hexane • Hydrogen Sulphide • Methyl Ethyl Ketone • Methyl Pentane (2-) • Methyl Pentane (3-) • Tetrachloroethylene • Toluene • Trichloro-1,2,2-Trifluromethane (1,1,2-) • Trichloroethane (1,1,1-) • Trichloroethylene • Vinylidene Chloride
	Renal effects	• Bromodichloromethane • Chlorodifluoromethane
	Hepatic effects	• Dichloroethane (1,1-) • Dichloroethene (1,2-) • Dichloroethylene (cis-1,2-) • Dichloroethylene (trans-1,2-)
Chronic air exposure	Respiratory irritants	• Butanol (2-) • Dimethyl Sulphide • Ethanol • Total Reduced Sulphurs (TRS) • Xylene (o-)
	Respiratory effects	• Dichlorodifluoromethane • Dichlorofluoromethane • Ethyl Toluene (m/p-) • Ethyl Toluene (o-) • Ethylene Dibromide • Isopropyl Alcohol • Nonane

Table 5-4 Potential Additive Interactions of the Chemicals of Concern		
Exposure Characteristics	***Potential Non-Carcinogenic Health Endpoint of Mixture***	***Chemicals of Concern***
	Liver effects	• Butanal (n-) • Chlorodifluoromethane • Chloroethane • Dichloroethene (1,2-)
	Neurological effects	• Benzene • Butyl Acetate • Carbon Tetrachloride • Decane • Ethyl Acetate • Ethyl Benzene • Hexane • Hydrogen Sulphide • Methyl Cyclohexane • Methyl Ethyl Ketone • Methyl Hexane (3-) • Methyl Isobutyl Ketone • Methyl Pentane (3-) • Naphthalene • Tetrachloroethane (1,1,2,2-) • Tetrachloroethylene • Toluene • Total Mercaptans (as Methyl Mercaptan) • Trichloroethane (1,1,2-) • Trichloroethylene • Trimethyl Benzene (1,3,5-) • Vinyl Chloride • Xylene (o-)
	Reproductive/ developmental effects	• Chloroform • Dichloromethane • Ethylene Dichloride • Methyl Butane (2-) • Methyl Hexane (2-) • Methyl Pentane (2-) • Trichlorofluoromethane
	Hematological effects	• Bromodichloromethane • Dichlorobenzene • Dimethyl Disulphide
	Hepatic effects	• Chlorobenzene • Chloromethane • Dichloroethylene (cis-1,2-) • Dichloroethylene (trans-1,2-) • Dichlorofluoromethane • Heptane
Carcinogenic chronic air exposure	Kidney tumours	• Bromodichloromethane • Trichloroethylene
	Liver cancer	• Dichlorobenzene • Tetrachloroethylene • Vinyl Chloride
	Hemangioscarcomas	• Ethylene Dibromide • Ethylene Dichloride

5.3.1 Toxicity Equivalence Factors for Carcinogenic PAHs

As indicated in Health Canada (2012), as well as most other regulatory guidance, the assessment of risks related to exposures to carcinogenic PAHs is primarily conducted through the use of potency or toxicity equivalence factors (PEF or TEF). TEFs allow large groups of compounds with a common mechanism of action such as PAHs to be assessed when limited data is available for all but one of the compounds (*i.e.*, benzo(a)pyrene). Through this approach, exposures to each of the carcinogenic PAHs are adjusted by their carcinogenic potency relative to benzo(a)pyrene. These potency-adjusted exposures can then be summed to provide an overall exposure to the group of carcinogenic PAHs, based on benzo(a)pyrene as the primary surrogate (*i.e.*, B(a)P-TEQ equivalent).

The primary source of PAHs within the Study Area is from exhaust-related tailpipe emissions from vehicles using the proposed haul routes to and from the landfill. The air dispersion modelling for the proposed haul routes was conducted by RWDI (2020) using the United States Environmental Protection Agency's Motor Vehicle Emission Simulator (MOVES) model. The MOVES model was used to generate vehicle emission factors for the baseline (2020) and future operating years (2027 and 2037). For the haul route assessment, the annual B(a)P concentration was assumed to be representative of the B(a)P TEQ.

6.0 RISK CHARACTERIZATION

The final step of a risk assessment is risk characterization which involves the estimation, description, and evaluation of risk associated with exposure to COCs by comparing the estimated exposure to the appropriate reference benchmark or TRV for a specific chemical or group of compounds. Risk characterization involves the comparison of estimated exposures (identified in the exposure assessment) with reference benchmarks or TRVs (identified during the hazard/toxicity assessment) to identify potential human health risks. This comparison is typically expressed as a CR or HQ for non-carcinogenic chemicals and is calculated by dividing the predicted exposure by the reference benchmark/TRV. In the case of direct acting non-threshold carcinogenic chemicals, potential risks are expressed as ILCRs, and represents the incremental risk of an individual within a given population developing cancer over his or her lifetime due to exposures from a specific carcinogenic chemical of concern.

The following sections provide the worst-case short- and long-term human health risk estimates for both the LFG and the haul route scenarios. The short and long-term human health risks of Stages 1, 3, 4 and post-closure of the LFG assessment are presented in Sections 6.1.1 and 6.2.1, respectively. The short and long-term human health risks of Stages 1 and 3 of the haul route assessment are presented in Sections 6.1.2 and 6.2.2, respectively. The acute (*i.e.,* short term) and non-carcinogenic chronic health risks are expressed as CR values.

As presented in Section 2.1.4.1, CR values were used to evaluate short- and long-term health risks resulting from exposures to COC *via* inhalation. CR values were calculated by dividing the predicted ground-level air concentration (Section 4.1) by the appropriate health-based reference benchmark (Sections 5.1 and 5.2). Long-term health risks associated with exposures *via* multiple pathways and environmental media (*i.e.*, soil, dust, agricultural produce, home garden produce, *etc.*) are discussed in Section 6.3.

In general, a CR value less than or equal to one (CR value ≤1) represents a situation where the predicted ground-level air concentration is less than a corresponding health-based reference benchmark. Considering the various assumptions used that attempt to over predict rather than under predict ground-level air concentrations and the typical uncertainty factors applied during the development of a health-based TRV, a CR value less than or equal to one (CR value ≤ 1) is a strong indicator of negligible health risks resulting from exposure to a particular COC.

A CR value greater than one (CR value > 1) is indicative of a scenario whereby the predicted ground level air concentration is greater than the corresponding health-based reference benchmark, suggesting that the potential for an adverse health effect may be present. The significance of the exceedance must be balanced against the degree of conservatism incorporated in the derivation of the TRVs as well as the predicted ground-level concentrations.

Projected worst-case chronic inhalation ILCR from Project Alone exposure for the LFG and haul route assessments are also presented in Sections 6.2.1 and 6.2.2, respectively. The ILCR are compared to a regulatory benchmark of 1-in-1,000,000 (*i.e.*, one-in-one-million risk level or 1×10^{-6}). It should be noted that comparison of background conditions to the 1×10^{-6} ILCR benchmark is highly conservative, as this benchmark is typically used for the evaluation of one Project source to an existing airshed, and not for the evaluation of risks arising from the existing airshed itself (with multitudes of separate contributing sources).

Section 6.4 discusses additive risks of mixtures for the LFG and haul route assessments. As noted previously, there are currently no Ontario or Canada reference benchmarks (beyond those chemical groups that have established toxic equivalent factors such as dioxins, furans

and polycyclic aromatic hydrocarbons) by which one can evaluate whether exposure to a given mixture from, or in isolation from, multiple sources could pose a health concern. As such, risk estimates for each chemical in a mixture were summed for illustrative, rather than regulatory compliance purposes.

6.1 Short-Term Inhalation Assessment

In this study, the maximum 24-hour air concentrations represent a “worst-case scenario” predicted across the entire Study Area. As outlined in the Air Quality Assessment report (RWDI, 2020), 24-hour air concentrations varied significantly from receptor location to location through the Study Area, particularly as one moves further away from the proposed Landfill site or the associated haul routes.

Using maximum concentrations in this way is a health-protective approach, since it is unlikely that the maximum concentration for any chemical would occur at all locations at the same time. It is also unlikely that the maximum concentration for all chemical would occur simultaneously at any of the locations. Instead, the spatial profile of individual and total concentrations would be in constant flux. Therefore, when characterizing the risk associated with 24-hour maximum concentrations for individual chemical, the risk should be viewed as the “worst-case scenario” for the community based on the maximal exposure location.

6.1.1 Landfill Gas Assessment

Table 6-1 presents worst-case short-term (*i.e.*, 24-hour) inhalation risk estimates (expressed as CR values) for Stages 1, 3, 4 and post-closure of the project. In addition, the cumulative exposures are also presented. The results of the short-term exposure assessment indicate that the background concentration of dimethyl sulphide marginally exceeds the CR benchmark of 1.0. Cumulative concentrations of dimethyl sulphide are dominated almost entirely by existing regional background conditions, likely related to sulphur soil amendments used for agricultural purposes in the surrounding area (see discussion in Section 6.2.1). Exceedances of the target CR are seen for the cumulative exposures at Stages 1, 3, 4 and post closure, again almost entirely due to regional background conditions with little contribution from the proposed Landfill. Certain COCs in Table 6-1 are identified to have no value for the CR; short-term inhalation risk estimates were not determined for certain COCs as there were no appropriate acute 24-hour inhalation TRV selected or available.

Results of the short-term inhalation assessment indicate that none of the predicted fugitive emissions from the proposed Landfill will result in any adverse health risk.

Table 6-1 Projected Worst-Case Acute Inhalation Concentration Ratio from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Acute Inhalation Concentration Ratio (CR) at Worst-Case Residential Receptor Locations								
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)		Stage 4 (2038-2042)		Post Closure (2043)	
		Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative
Acetone	0.0016	0.000033	0.0016	0.000075	0.0017	0.000083	0.0017	0.000043	0.0017
Benzene	0.020	0.0053	0.025	0.012	0.033	0.013	0.033	0.0074	0.028
Bromodichloromethane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Butanal (n-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Butanol (2-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Butyl Acetate	NV	NV	NV	NV	NV	NV	NV	NV	NV
Carbon Tetrachloride	0.21	0.01	0.22	0.014	0.22	0.014	0.22	0.014	0.222
Chlorobenzene	NV	NV	NV	NV	NV	NV	NV	NV	NV
Chlorodifluoromethane	0.0000029	0.000000082	0.0000030	0.00000019	0.0000031	0.00000021	0.0000031	0.00000011	0.00
Chloroethane	0.0000473	0.000012	0.000059	0.000028	0.000076	0.000030	0.000077	0.000017	0.000
Chloroform	0.24	0.023	0.26	0.023	0.26	0.023	0.26	0.022	0.259
Chloromethane	0.00394	0.000050	0.0040	0.00011	0.0041	0.00013	0.0041	0.000066	0.00
Decane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Dichlorobenzene	0.004	0.00038	0.0040	0.00087	0.0044	0.00096	0.0045	0.00050	0.004
Dichlorodifluoromethane	0.0000048	0.0000010	0.0000058	0.0000022	0.0000071	0.0000025	0.0000073	0.0000013	0.00
Dichloroethane (1,1-)	0.000245	0.00037	0.00062	0.00087	0.0011	0.00093	0.0012	0.00052	0.001
Dichloroethene (1,2-)	0.00075	0.0027	0.0034	0.0062	0.0070	0.0069	0.0076	0.0036	0.004
Dichloroethylene (cis-1,2-)	0.00038	0.00082	0.0012	0.0017	0.0021	0.0017	0.0021	0.0011	0.001
Dichloroethylene (trans-1,2-)	0.00038	0.00040	0.00078	0.00041	0.00079	0.00041	0.00078	0.00040	0.0008
Dichlorofluoromethane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Dichloromethane	0.0016	0.0014	0.0030	0.0033	0.0049	0.0036	0.0052	0.0019	0.004
Dimethyl Disulphide	0.55	0.0015	0.55	0.0065	0.56	0.011	0.56	0.012	0.56
Dimethyl Sulphide	**1.1**	0.0030	**1.1**	0.0083	**1.1**	0.0076	**1.1**	0.0061	**1.1**
Ethanol	NV	NV	NV	NV	NV	NV	NV	NV	NV
Ethyl Acetate	NV	NV	NV	NV	NV	NV	NV	NV	NV
Ethyl Benzene	NV	NV	NV	NV	NV	NV	NV	NV	NV
Ethyl Toluene (m/p-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Ethyl Toluene (o-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Ethylene Dibromide	0.013	0.014	0.027	0.014	0.027	0.014	0.027	0.014	0.0269

Table 6-1 Projected Worst-Case Acute Inhalation Concentration Ratio from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Acute Inhalation Concentration Ratio (CR) at Worst-Case Residential Receptor Locations								
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)		Stage 4 (2038-2042)		Post Closure (2043)	
		Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative
Ethylene Dichloride	0.044	0.0052	0.049	0.012	0.056	0.013	0.057	0.0070	0.051
Heptane	0.000037	0.000018	0.000056	0.000041	0.000078	0.000046	0.000083	0.000024	0.000
Hexane	0.00030	0.000060	0.00036	0.00014	0.00044	0.00015	0.00045	0.000078	0.000
Hydrogen Sulphide	0.50	0.0016	0.50	0.005	0.51	0.007	0.51	0.008	0.51
Isopropyl Alcohol	0.0010	0.00011	0.0011	0.00025	0.0013	0.00027	0.0013	0.00014	0.00
Methyl Butane (2-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Methyl Cyclohexane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Methyl Ethyl Ketone	0.0014	0.00063	0.0020	0.0015	0.0028	0.0016	0.0030	0.00085	0.00
Methyl Hexane (2-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Methyl Hexane (3-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Methyl Isobutyl Ketone	NV	NV	NV	NV	NV	NV	NV	NV	NV
Methyl Pentane (2-)	0.000018	0.0000028	0.000021	0.0000066	0.000025	0.0000072	0.000026	0.0000038	0.000
Methyl Pentane (3-)	0.000018	0.0000013	0.000020	0.0000029	0.000021	0.0000032	0.000022	0.0000017	0.000
Naphthalene	0.029	0.00090	0.030	0.0021	0.031	0.0023	0.031	0.0012	0.030
Nonane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Octane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Pentane	NV	NV	NV	NV	NV	NV	NV	NV	NV
Propyl Benzene	NV	NV	NV	NV	NV	NV	NV	NV	NV
Styrene	0.0011	0.000028	0.0011	0.000064	0.0011	0.000071	0.0011	0.000037	0.001
Tetrachloroethane (1,1,2,2-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Tetrachloroethylene	0.00019	0.00045	0.00064	0.0010	0.0012	0.0011	0.0013	0.00062	0.001
Toluene	0.00021	0.00012	0.00033	0.00028	0.00049	0.00031	0.00052	0.00017	0.00
Total Mercaptans (as Methyl Mercaptan)	0.56	0.0023	0.57	0.0076	0.57	0.0096	0.57	0.0094	0.57
Total Reduced Sulphurs (TRS)	0.71	0.004	0.718	0.019	0.733	0.032	0.746	0.035	0.749
Trichloro-1,2,2-Trifluromethane (1,1,2-)	0.00000094	0.0000000048	0.00000094	0.000000010	0.00000095	0.000000011	0.00000095	0.0000000055	0.000
Trichloroethane (1,1,1-)	0.0000048	0.00000028	0.0000051	0.00000040	0.0000052	0.00000039	0.0000052	0.00000028	0.000
Trichloroethane (1,1,2-)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Trichloroethylene	0.0046	0.0087	0.013	0.020	0.024	0.021	0.026	0.011	0.016

Table 6-1 Projected Worst-Case Acute Inhalation Concentration Ratio from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Acute Inhalation Concentration Ratio (CR) at Worst-Case Residential Receptor Locations								
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)		Stage 4 (2038-2042)		Post Closure (2043)	
		Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative
Trichlorofluoromethane	0.00022	0.0000016	0.00022	0.0000037	0.00022	0.0000041	0.00022	0.0000021	0.00
Trimethyl Benzene (1,2,4-)	0.0022	0.00084	0.0031	0.0019	0.0041	0.0021	0.0043	0.0011	0.003
Trimethyl Benzene (1,3,5-)	0.0022	0.00010	0.0023	0.00022	0.0024	0.00024	0.0025	0.00012	0.002
Vinyl Chloride	0.026	0.12	0.15	0.28	0.30	0.30	0.33	0.17	0.192
Vinylidene Chloride	0.0040	0.0054	0.0093	0.0055	0.0094	0.0054	0.0094	0.0054	0.0093
Xylene (m/p-)	0.0012	0.0012	0.0024	0.0028	0.0040	0.0031	0.0043	0.0016	0.00
Xylene (o-)	0.00060	0.00047	0.0011	0.0011	0.0017	0.0012	0.0018	0.00064	0.001

Note: Shaded and **bolded** values indicate CR values which exceed the target CR benchmark of 1.0 (*i.e.*, airborne concentrations exceed the corresponding TRV)
NV The CR was not determined for the COC as there was no appropriate TRV selected or available.

6.1.2 Haul Route Assessment

As discussed previously, in typical transportation risk assessments, the assessment of 1-hour acute exposures is generally evaluated to ensure potential short-term impacts on local air quality around a given corridor are considered. However, given the nature of the emission sources under consideration in the current assessment (*i.e.*, a landfill or a minimal number of trucks travelling on nearby routes), it is unlikely that 1-hour exposures would be significant. In transportation air quality assessments, NO_2 is typically the COC of primary concern for acute 1-hour exposure conditions. Therefore, to confirm the assumption of minimal risk, potential inhalation risks were estimated for worst-case 1-hour exposures to NO_2 for Stage 1 and 3 of the haul route assessment. The maximum worst-case concentrations of NO_2 for Stage 1 and 3 are approximately 145 µg/m^3 and 152 µg/m^3, respectively.

Table 6-2 provides a summary of predicted worst-case acute 1-hour inhalation health risks arising from exposure to NO_2 emitted from the proposed haul routes at Stages 1 and 3. For the purpose of this confirmation assessment, CR values were predicted based on a comparison of predicted worst-case ground-level air concentrations of NO_2 for Stages 1 and 3 to the WHO 1-hour health-based benchmark for NO_2 of 200 µg/m^3 (WHO, 2006).

Table 6-2 Summary of Predicted Worst-Case Acute 1-hour Project Alone Health Risks from Haul Route Exposures

Chemical of Concern	Worst-Case Acute 1-hour Concentration Ratios (CR)	
	Stage 1	Stage 3
Nitrogen Dioxide (NO_2)	0.72	0.76

Based on the results of this worst-case assessment, the predicted worst-case incremental contribution to short-term 1-hour NO_2 air concentrations emitted from the proposed haul routes was which was less than 80% of the health-based acute reference benchmark, and thus did not represent a health risk to individuals living, working or playing along the proposed haul routes. Again, these calculations were based on the worst-case 1-hour NO_2 concentrations arising from worst-case emission and meteorological conditions. Typical 1-hour NO_2 concentrations along the proposed haul routes were generally significantly less than those used in this worst-case confirmation assessment.

Table 6-3 presents the worst-case short-term (*i.e.*, 24-hour) inhalation risk estimates (expressed as CR values) for Stages 1 and 3 of the haul route scenario, both Project Alone and Cumulative.

Table 6-3 Projected Worst-Case Acute Inhalation Concentration Ratio from Haul Route-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Acute Inhalation Concentration Ratio (CR) at Worst-Case Residential Locations				
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)	
		Project Alone	Cumulative	Project Alone	Cumulative
Benzene	0.020	0.0073	0.027	0.014	0.035
Carbon monoxide (8-hour)	0.050	0.0054	0.056	0.0054	0.056
Formaldehyde	0.012	0.0019	0.014	0.0013	0.013
Nitrogen dioxide	0.12	0.15	0.27	0.15	0.26
Respirable Particulate Matter ($PM_{2.5}$)	0.41	0.62	1.0	0.29	0.70
Inhalable Particulate Matter (PM_{10})	0.32	0.78	**1.1**	0.74	**1.1**
Sulphur dioxide	0.06	0.0078	0.07	0.0078	0.07
Toluene	0.00021	0.00012	0.00033	0.00028	0.00049

Note: Shaded and **bolded** values indicate CR values which exceed the target CR benchmark of 1.0 (*i.e.*, airborne concentrations exceed the corresponding TRV)

The results of the short-term assessment of cumulative exposures indicated exceedances of the target CR for 24-hour exposures to particulate matter (*i.e.,* PM_{10}). Based on the results presented in Table 6-6, there are marginal acute inhalation exceedances for cumulative exposures to PM_{10} at the worst-case location. The cumulative concentrations of 55 and 53 ug/m^3 at Stages 1 and 3, respectively, marginally exceed the benchmark of 50 ug/m^3. The maximum concentrations are identified to be from the common residential receptor located at SWO-4 (*i.e.*, the intersection of Beachville Road and 37th Line). All other residential receptor locations throughout the Study Area showed cumulative PM_{10} air concentrations below the regulatory benchmark of 50 ug/m^3.

As this represents a combination of the worst-case emission and meteorological conditions, frequency assessments were conducted to further characterize the maximum concentration at this location for Stage 1 and Stage 3, to determine whether these concentrations provide a good characterization of typical daily PM_{10} air concentrations at this receptor location. The analysis was completed by analyzing the modelled PM_{10} results at SWO4 for each day in five years of meteorological conditions for both stages. The frequency analysis for Stage 1 and 3 are presented in Figure 6-1 and Figure 6-2, respectively.

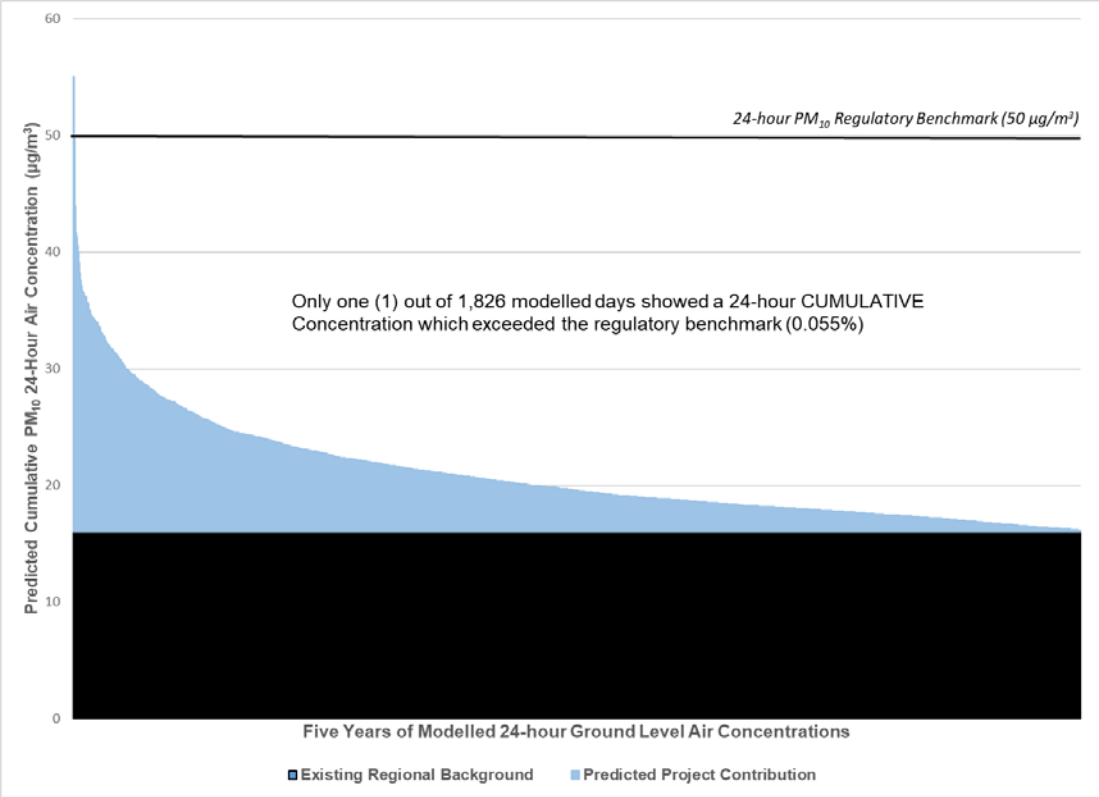


Figure 6-1 Frequency analysis of Predicted Cumulative 24-hour PM_{10} Air Concentrations at Receptor Location SWO-4 in Stage 1

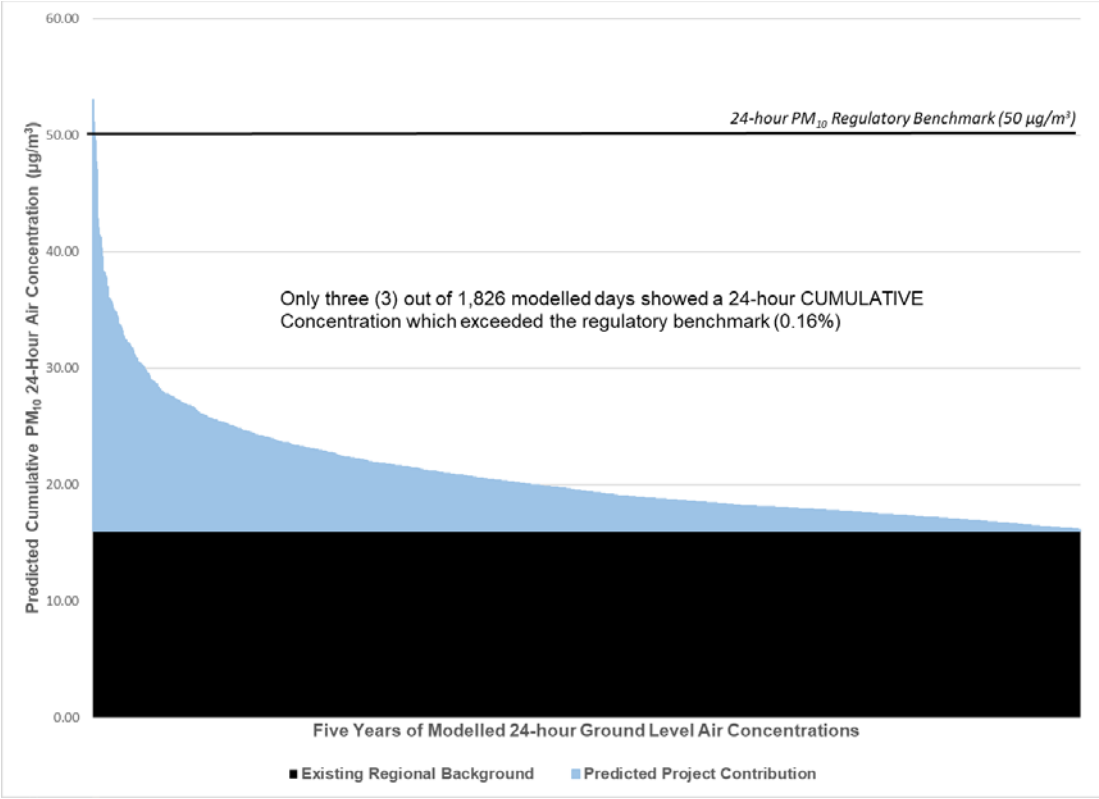


Figure 6-2 Frequency analysis of Predicted Cumulative 24-hour PM_{10} Air Concentrations at Receptor Location SWO-4 in Stage 3

Results of the frequency analysis on cumulative PM_{10} air concentrations predicted for receptor location SWO-4 indicated that for Stage 1 only one (1) out of 1,826 modelled days (*i.e.*, 1 day in five years) showed a 24-hour cumulative concentration which exceeded the regulatory benchmark (*i.e.*, the marginal exceedance was only predicted to occur at most 0.055% of the time). For Stage 3, only three (3) out of 1,826 modelled days (*i.e.*, 3 days in five years) showed a 24-hour cumulative concentration which exceeded the regulatory benchmark (*i.e.*, the marginal exceedance was only predicted to occur at most 0.16% of the time). It is also important to note that this cumulative PM_{10} concentration is based upon the conservative assumption that the reasonable worst-case 24-hour background concentration (*i.e.*, 90th percentile of all 24-hour concentrations over the five-year monitoring period) occurs at the same day as the worst-case particulate emissions for Project-associated sources.

Results of the short-term inhalation assessment indicate that none of the predicted fugitive emissions from diesel trucks using the haul routes associated with the proposed Landfill, or arising from particulate blowing off of the proposed Landfill, will result in any adverse health risk. One receptor location did demonstrate the potential for marginal risks associated with worst-case cumulative concentrations of PM_{10}. However, as noted in the frequency analysis, this very marginal exceedance could potentially occur very rarely, and given the conservatism built into the assessment, is not expected to pose any adverse health risk to nearby residents.

6.2 Long-Term Inhalation Assessment

The potential for chronic adverse health effects resulting from long-term exposures (*via* inhalation) were evaluated at each of the residential common receptors in the Study Area.

6.2.1 Landfill Gas Assessment

Table 6-4 and Table 6-5 provide the worst-case long-term CR and ILCR predictions for the LFG assessment, respectively. The background scenario is presented to help aid in the interpretation of the Project Alone exposures for the Stages.

Table 6-4 Projected Worst-Case Chronic Non-Cancer Inhalation Concentration Ratio from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Chronic NON-CANCER Inhalation Concentration Ratio (CR) at Worst-Case Residential Receptor Locations								
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)		Stage 4 (2038-2042)		Post Closure (2043)	
		Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative
Acetone	0.00092	0.00000222	0.00092	0.00000543	0.00093	0.00000639	0.00093	0.00000347	0.00092
Benzene	0.013	0.00040	0.013	0.00086	0.013	0.00101	0.014	0.00056	0.013
Bromodichloromethane	0.0001	0.000151	0.0003	0.000323	0.0005	0.000379	0.0005	0.000210	0.0004
Butanal (n-)	0.013	0.000021	0.013	0.000052	0.013	0.000062	0.013	0.000034	0.013
Butanol (2-)	0.010	0.000054	0.010	0.000121	0.010	0.000142	0.010	0.000078	0.010
Butyl Acetate	0.0010	0.0000017	0.0010	0.0000042	0.0010	0.0000050	0.0010	0.0000027	0.0010
Carbon Tetrachloride	0.26	0.0011	0.26	0.0011	0.26	0.0011	0.26	0.0011	0.26
Chlorobenzene	0.00046	0.0000010	0.00046	0.0000024	0.00046	0.000003	0.00046	0.0000015	0.00046
Chlorodifluoromethane	0.000015	0.000000039	0.000015	0.000000097	0.000015	0.000000115	0.000015	0.000000063	0.000015
Chloroethane	0.000027	0.0000006	0.000027	0.0000011	0.000028	0.0000013	0.000028	0.0000007	0.000027
Chloroform	0.0024	0.00002	0.0024	0.00002	0.0024	0.00002	0.0024	0.00002	0.0024
Chloromethane	0.012	0.000012	0.012	0.00003	0.012	0.00003	0.012	0.000019	0.012
Decane	0.0014	0.000035	0.0014	0.000087	0.0014	0.00010	0.0015	0.000057	0.0014
Dichlorobenzene	0.0027	0.00004	0.0027	0.00010	0.0028	0.00012	0.0028	0.00006	0.0028
Dichlorodifluoromethane	0.0021	0.0000331	0.0021	0.0000820	0.0022	0.000097	0.0022	0.0000532	0.0021
Dichloroethane (1,1-)	0.00024	0.000030	0.00027	0.000061	0.00030	0.000071	0.00031	0.000040	0.00028
Dichloroethene (1,2-)	0.00011	0.000024	0.00013	0.000060	0.00017	0.000071	0.00018	0.000039	0.00015
Dichloroethylene (cis-1,2-)	0.000057	0.0000097	0.000066	0.000016	0.000073	0.000019	0.000075	0.0000105	0.000067
Dichloroethylene (trans-1,2-)	0.00067	0.00005	0.00072	0.00005	0.00072	0.00005	0.00072	0.00005	0.00072
Dichlorofluoromethane	0.0010	0.00000033	0.0010	0.00000083	0.0010	0.0000010	0.0010	0.00000054	0.0010
Dichloromethane	0.0013	0.000055	0.0013	0.000132	0.0014	0.000155	0.0014	0.000086	0.0014
Dimethyl Disulphide	**1.1**	0.00037	**1.1**	0.0017	**1.1**	0.0028	**1.1**	0.0032	**1.1**
Dimethyl Sulphide	0.33	0.00015	0.33	0.00044	0.33	0.00042	0.33	0.00032	0.33
Ethanol	0.018	0.000017	0.018	0.000042	0.018	0.000049	0.018	0.000027	0.018
Ethyl Acetate	0.0053	0.000117	0.0055	0.00029	0.0056	0.00034	0.0057	0.000188	0.0055
Ethyl Benzene	0.00023	0.0000133	0.00024	0.0000330	0.00026	0.0000389	0.00027	0.0000214	0.00025
Ethyl Toluene (m/p-)	0.0039	0.000059	0.0040	0.00015	0.0041	0.00017	0.0041	0.000095	0.0040
Ethyl Toluene (o-)	0.0080	0.00011	0.0081	0.00027	0.0083	0.00031	0.0083	0.00017	0.0082
Ethylene Dibromide	0.049	0.0021	0.051	0.002	0.051	0.002	0.051	0.0021	0.051
Ethylene Dichloride	0.00018	0.0000018	0.00018	0.0000044	0.00018	0.0000052	0.00018	0.0000028	0.00018

Table 6-4 Projected Worst-Case Chronic Non-Cancer Inhalation Concentration Ratio from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Chronic NON-CANCER Inhalation Concentration Ratio (CR) at Worst-Case Residential Receptor Locations								
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)		Stage 4 (2038-2042)		Post Closure (2043)	
		Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative
Heptane	0.0011	0.000034	0.0011	0.000082	0.0011	0.000097	0.0012	0.000052	0.0011
Hexane	0.00018	0.0000041	0.00019	0.0000099	0.00019	0.0000117	0.00019	0.0000063	0.00019
Hydrogen Sulphide	**1.4**	0.00055	**1.4**	0.0018	**1.4**	0.0024	**1.4**	0.0025	**1.4**
Isopropyl Alcohol	0.016	0.000262	0.016	0.00065	0.016	0.00077	0.016	0.00042	0.016
Methyl Butane (2-)	0.000047	0.00000062	0.000047	0.0000016	0.000048	0.0000018	0.000049	0.0000010	0.000048
Methyl Cyclohexane	0.00025	0.0000057	0.00025	0.000014	0.00026	0.000017	0.00027	0.0000092	0.00026
Methyl Ethyl Ketone	0.00015	0.0000085	0.00016	0.0000213	0.00017	0.0000250	0.00017	0.0000137	0.00016
Methyl Hexane (2-)	0.00046	0.00000079	0.00046	0.0000020	0.00046	0.0000023	0.00046	0.0000013	0.00046
Methyl Hexane (3-)	0.000047	0.0000011	0.000048	0.0000028	0.000049	0.0000033	0.000050	0.0000018	0.000048
Methyl Isobutyl Ketone	0.00014	0.0000018	0.00014	0.0000044	0.00014	0.0000052	0.00014	0.0000029	0.00014
Methyl Pentane (2-)	0.0020	0.000019	0.0020	0.000048	0.0020	0.000056	0.0020	0.000031	0.0020
Methyl Pentane (3-)	0.0019	0.0000085	0.0019	0.000021	0.0019	0.000025	0.0019	0.000014	0.0019
Naphthalene	0.20	0.0115	0.21	0.0287	0.23	0.0337	0.23	0.0185	0.22
Nonane	0.025	0.00026	0.025	0.00066	0.026	0.00077	0.026	0.00043	0.025
Octane	0.00026	0.0000044	0.00026	0.0000083	0.00027	0.0000096	0.00027	0.0000054	0.00027
Pentane	0.00063	0.0000091	0.00064	0.000023	0.00065	0.000027	0.00065	0.000015	0.00064
Propyl Benzene	0.00049	0.0000055	0.00050	0.000014	0.00050	0.000016	0.00051	0.0000088	0.00050
Styrene	0.0017	0.000003	0.0017	0.000007	0.0017	0.000009	0.0017	0.000005	0.002
Tetrachloroethane (1,1,2,2-)	0.0001	0.0010	0.0011	0.0013	0.0014	0.0015	0.0015	0.00090	0.0010
Tetrachloroethylene	0.0022	0.000311	0.0025	0.000681	0.0029	0.000798	0.0030	0.000443	0.0027
Toluene	0.00017	0.0000126	0.00019	0.0000314	0.00020	0.0000369	0.00021	0.0000203	0.00019
Total Mercaptans (as Methyl Mercaptan)	**2.3**	0.0011	**2.3**	0.0040	**2.3**	0.0050	**2.3**	0.0050	**2.3**
Total Reduced Sulphurs (TRS)	NV	NV	NV	NV	NV	NV	NV	NV	NV
Trichloro-1,2,2-Trifluromethane (1,1,2-)	0.00020	0.0000001	0.00020	0.0000002	0.00020	0.0000002	0.00020	0.0000001	0.00020
Trichloroethane (1,1,1-)	0.00055	0.0000027	0.00055	0.0000032	0.00055	0.0000036	0.00055	0.0000024	0.00055
Trichloroethane (1,1,2-)	0.00056	0.00005	0.00060	0.00005	0.00060	0.00005	0.00060	0.00004	0.00060
Trichloroethylene	0.030	0.00418	0.035	0.00842	0.039	0.00987	0.040	0.00533	0.036
Trichlorofluoromethane	0.00016	0.00000012	0.00016	0.00000029	0.00016	0.00000034	0.00016	0.00000018	0.00016

Table 6-4 Projected Worst-Case Chronic Non-Cancer Inhalation Concentration Ratio from Landfill-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Chronic NON-CANCER Inhalation Concentration Ratio (CR) at Worst-Case Residential Receptor Locations								
	Background	Stage 1 (2023-2027)		Stage 3 (2033-2037)		Stage 4 (2038-2042)		Post Closure (2043)	
		Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative	Project Alone	Cumulative
Trimethyl Benzene (1,2,4-)	0.0085	0.00021	0.0087	0.00051	0.0090	0.00060	0.0091	0.00032	0.0088
Trimethyl Benzene (1,3,5-)	0.0083	0.000026	0.0083	0.00006	0.0083	0.00007	0.0083	0.00004	0.0083
Vinyl Chloride	0.00043	0.00015	0.00058	0.00034	0.00076	0.00039	0.00082	0.00022	0.00064
Vinylidene Chloride	0.00020	0.000019	0.00022	0.000019	0.00022	0.000019	0.00022	0.000018	0.00022
Xylene (m/p-)	0.0012	0.0000875	0.0013	0.0002147	0.0014	0.0002531	0.0015	0.0001380	0.0014
Xylene (o-)	0.00062	0.000033	0.00065	0.000083	0.00070	0.000098	0.00072	0.000054	0.00067

Note: Shaded and **bolded** values indicate CR values which exceed the target CR benchmark of 1.0 (*i.e.*, airborne concentrations exceed the corresponding TRV)

NV The CR was not determined for the COC as it was assessed through the other reduced sulphur compounds (*i.e.,* hydrogen sulphide, methyl mercaptan, dimethyl sulphide and dimethyl disulphide)

Table 6-5 Projected Worst-Case Chronic Inhalation Incremental Lifetime Cancer Risks (ILCR) from Landfill-only Exposures at each Landfill Lifecycle Stage

Chemicals of Concern	Chronic Inhalation Incremental Lifetime Cancer Risks (ILCR) at Worst-Case Residential Receptor Locations				
	Background	Stage 1 (2023-2027)	Stage 3 (2033-2037)	Stage 4 (2038-2042)	Post Closure (2043)
		Project Alone	Project Alone	Project Alone	Project Alone
Benzene	8.3E-07	2.6E-08	5.7E-08	6.7E-08	3.7E-08
Bromodichloromethane	3.7E-07	3.9E-07	8.4E-07	9.8E-07	5.4E-07
Carbon Tetrachloride	**3.1E-06**	1.3E-08	1.3E-08	1.3E-08	1.3E-08
Dichlorobenzene	6.5E-07	9.8E-09	2.4E-08	2.8E-08	1.5E-08
Dichloroethane (1,1-)	6.5E-08	8.1E-09	1.7E-08	1.9E-08	1.1E-08
Dichloromethane	5.2E-07	2.2E-08	5.3E-08	6.2E-08	3.4E-08
Ethylene Dibromide	**2.3E-05**	1.0E-06	1.0E-06	1.0E-06	1.0E-06
Ethylene Dichloride	**1.8E-06**	1.8E-08	4.6E-08	5.4E-08	3.0E-08
Tetrachloroethane (1,1,2,2-)	2.9E-08	4.2E-07	5.2E-07	6.0E-07	3.7E-07
Tetrachloroethylene	2.3E-08	3.2E-09	7.1E-09	8.3E-09	4.6E-09
Trichloroethane (1,1,2-)	4.9E-07	4.1E-08	4.1E-08	4.1E-08	3.9E-08
Trichloroethylene	2.5E-07	3.4E-08	6.9E-08	8.1E-08	4.4E-08
Vinyl Chloride	2.2E-07	8.1E-08	1.8E-07	2.1E-07	1.2E-07

Note: Shaded and **bolded** values indicate ILCR values which exceed the target benchmark of a one-in-one-million risk level or 1 x 10^{-6})

The results of the chronic assessment that the background concentration of dimethyl disulphide exceeds the CR benchmark of 1.0. Cumulative concentrations of dimethyl sulphide are dominated almost entirely by existing local background conditions. As such, exceedances of the target CR are seen for the cumulative exposures at Stages 1, 3, 4 and post closure of the project. Similarly, two other sulphur compounds (*i.e.,* hydrogen sulphide and total mercaptans (as methyl mercaptan)) also have local background concentrations which are in exceedance of the target CR. As such, hydrogen sulphide and total mercaptans (as methyl mercaptan) have exceedances for the cumulative exposures at Stage 1, 3, 4, and Post Closure as well. The Project Alone CR values (representing emissions from the proposed Landfill itself) were orders of magnitude below the regulatory benchmark for all evaluated COCs. Therefore, results of the long-term inhalation assessment indicate that none of the predicted fugitive emissions from the proposed Landfill will result in any adverse health risk.

It is Intrinsik's understanding that on November 28, 2018, during the Community Liaison Committee Meeting 34 where a summary of existing conditions (*i.e.*, ambient monitoring data results) was presented, a community member noted that to ensure there is a sufficient source of sulphur for crops, it is a locally common practice to apply sulphur to fields. Through conversations between Walker and local farmers in the area between 2018 and 2019, it was confirmed that the application of sulphur to fields was common practice. Furthermore, Walker monitoring stations were noted to be located close to and/or adjacent to farmlands. As such, it may be appropriate to assume that the application of sulphurs is what has resulted in background concentrations to be above the target CR.

The results presented in Table 6-5 indicate several exceedances of the benchmark ILCR for regional background ambient conditions, specifically the chronic cancer risks for carbon tetrachloride, ethylene dibromide, and ethylene dichloride. However, ILCRs predicted from Project Alone emissions were all below the regulatory benchmark of one-in-one-million cancer risk (*i.e.*, less than 1.0E-06) showing negligible risk from the proposed Project.

As noted previously, it is highly conservative to compare background concentrations to a one-in-one-million regulatory benchmark and are only presented for information purposes. By definition, this 1-in-1,000,000 benchmark is intended to evaluate the incremental risks related to one specific project above-and-beyond existing background conditions and is not intended for evaluation of airshed-wide conditions. The concentrations of these three contaminants measured by the ambient monitoring program within the Study Area by RWDI are not dissimilar to those observed in other studies of background conditions across Canada. For example, a Canada-wide survey reported concentrations of carbon tetrachloride ranging from 0.34-1.02 µg/m^3 (0.60 µg/m^3 average) in nearly 7,000 ambient air samples collected across 17 rural and 40 urban sites (Health Canada, 2011). Therefore, the worst-case measured air concentration of 0.52 µg/m^3 would fall right in the middle of this range.

6.2.2 Haul Route Assessment

Table 6-6 and Table 6-7 provide the predicted worst-case long-term CR and ILCR values for the haul route assessment. The background scenario is presented to help aid in the interpretation of the Project Alone exposures for the Stages.

Table 6-6 Projected Worst-Case Chronic Inhalation CR from Haul Route-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage					
Chemicals of Concern	**Chronic Inhalation Concentration Ratio (CR) at Worst-Case Residential Locations**				
	Background	**Stage 1 (2023-2027)**		**Stage 3 (2033-2037)**	
		Project Alone	**Cumulative**	**Project Alone**	**Cumulative**
Benzene	0.013	0.00056	0.013	0.0010	0.014
Benzo(a)pyrene	0.016	0.0035	0.019	0.00060	0.017
Formaldehyde	0.087	0.0014	0.088	0.00069	0.087
Nitrogen dioxide	0.30	0.098	0.39	0.066	0.36
Particulate Matter – Respirable ($PM_{2.5}$)	0.33	0.15	0.48	0.14	0.47
Particulate Matter – Inhalable (PM_{10})	0.23	0.26	0.5	0.3	0.5
Sulphur dioxide	0.64	0.012	0.6	0.01	0.6
Toluene	0.00017	0.000013	0.00019	0.000031	0.00020

Table 6-7 Projected Worst-Case Chronic Inhalation ILCR from Haul Route-only Exposures and Cumulative Exposures at each Landfill Lifecycle Stage			
Chemicals of Concern	**Chronic Inhalation Incremental Lifetime Cancer Risks (ILCR) at Worst-Case Residential Locations**		
	Background	**Stage 1 (2023-2027)**	**Stage 3 (2033-2037)**
		Project Alone	**Project Alone**
Benzene	8.3E-07	3.7E-08	6.6E-08
Benzo(a)pyrene-TEQ	1.9E-08	4.2E-09	7.2E-10
Formaldehyde	**1.0E-05**	1.6E-07	8.1E-08

Note: Shaded and **bolded** values indicate ILCR values which exceed the target benchmark of one-in-one-million cancer risk (*i.e.*, 1.0×10^{-6})

The results of the long-term haul route assessment of non-carcinogenic annual average exposures indicated that none of the predicted airborne concentrations of any of the COCs exceeded their corresponding regulatory benchmark for either measured background or any of the predicted Project operation stages. When evaluating potential incremental lifetime cancer risks, only the background concentrations of formaldehyde was shown to exceed the regulatory benchmark of one-in-one-million excess cancer risk. Predicted ILCR values for Project Alone were all well below the regulatory benchmark for acceptable cancer risk for both Stage 1 and 3 scenarios showing that the emissions arising from vehicles using the proposed haul routes are not expected to result in any unacceptable health risk.

As noted previously, it is highly conservative to compare background concentrations to a one-in-one-million regulatory benchmark and are only presented for information purposes. By definition, this 1-in-1,000,000 benchmark is intended to evaluate the incremental risks related to one specific project above-and-beyond existing background conditions and is not intended for evaluation of airshed-wide conditions. The formaldehyde background concentrations used in the current assessment (0.78 µg/m^3) was based on measurements taken at the MECP monitoring station in Simcoe and falls within the range typically observed in Canadian cities.

For example, in a study which collected 3,842 24-hour samples from rural, suburban and urban areas, measured at 16 sites in six provinces surveyed from August 1989 to August 1998, concentrations ranged from below the detection limit (0.05 µg/m^3) to a maximum of 27.5 µg/m^3 for eight urban sites, 12.03 µg/m^3 for two suburban sites, 9.11 µg/m^3 for two rural sites considered to be affected by urban and/or industrial influences, and 9.88 µg/m^3 for four rural sites (CEPA, 2001).

6.3 Multimedia Pathway Assessment

As demonstrated by the multimedia screening approach in Section 3.3.1.2, not all COCs identified for evaluation *via* inhalation will persist and/or accumulate in the environment. The multimedia screening approach identified those COC that have the potential to be persist and/or accumulate in the environment, therefore, triggering a quantitative multimedia exposure assessment. The multimedia assessment was conducted for the Project Alone scenarios to determine what additional incremental contribution deposition, from the two Stages assessed for the proposed haul routes (*i.e.,* Stage 1 and Stage 3), may have on existing soil, agricultural produce and home garden quality.

The objective of the multimedia assessment was to predict human health risks resulting from long-term exposures to COC *via* multiple exposure pathways and environmental media. As discussed in Section 4.2, Table 4-5 presents the predicted annual soil, air and dust concentrations for benzo(a)pyrene for the haul route assessment.

As presented in Table 4-5, the background concentration utilized in the determining the predicted concentrations of benzo(a)pyrene in soil and dust was conservatively assumed to be 0.05 µg/g under the agricultural land use (based on the OTR concentration provided in the MECP Table 1 SCS). Table 6-8 indicates that the percentage of the cumulative soil concentration that is predicted to originate from the haul route emissions is negligible, where only 0.001% of the cumulative soil concentration is due to the project for Stages 1 and 3. The predicted surface soil concentration is also negligible, as only 0.01% is due to contribution of Stages 1 and 3. Furthermore, the multimedia model predicted soil levels of benzo(a)pyrene below the rural and urban background levels of benzo(a)pyrene in Ontario (*i.e.,* 0.05 µg/g and 0.3 µg/g, respectively). As such, it is not anticipated that the predicted concentrations of benzo(a)pyrene in soil would adversely impact the soil, agricultural crops and home grown produce within the Project area. Given the conservatism built into the assessment, it is not anticipated that emissions from the Project would result in adverse health impacts to the surrounding community.

Table 6-8 Comparison of Soil Concentrations to Ontario Typical Background (OTR) for Benzo(a)pyrene

Media	Background (µg/g) [a]	Stage 1 (2023-2027)			Stage 3 (2033-2037)		
		Project Alone		Cumulative	Project Alone		Cumulative
Soil	0.050	0.00000048	0.001%	0.050	0.00000048	0.001%	0.050
Surface soil		0.000005	0.010%	0.050	0.0000048	0.010%	0.050

Note: Provided percentages represent the percentage of cumulative soil concentrations that is predicted from haul route emissions.

[a] Ontario Typical Background (OTR) are represented by Table 1 SCS for full depth Background Site Condition Standards for agricultural or other property use (MOE, 2011)

6.4 Additive Risks for Mixtures

As discussed in Section 5.3, health effects from mixtures are typically assessed by assuming additive effects of chemicals with similar exposure characteristics (*e.g.*, acute exposure; chronic exposure) and similar toxic effects (*e.g.*, respiratory irritants, nasal irritants, reproductive effects, cancer) (Health Canada, 2012). However, there are currently no Ontario or Canadian reference benchmarks by which one could evaluate whether exposure to a given mixture from, or in isolation from, multiple sources could pose a health concern. Therefore, in the current assessment, risk estimates for each chemical in the theoretical mixture were summed to produce a cumulative risk prediction for illustrative purposes. In Section 6.4.1, Table 6-9 to Table 6-11 present the CR and ILCR for mixtures by the potential endpoints for the LFG assessment, respectively. In Section 6.4.2, Table 6-12 and Table 6-13 present the acute and chronic CR for mixtures by the potential endpoints for the haul route assessment, respectively.

6.4.1 Landfill Gas Assessment

Tables 6-9 through 6-11 provide the acute and chronic cumulative CR and ILCR for Stage 1, 3, 4 and Post Closure of the predicted LFG emissions by the potential endpoint for each mixture, respectively.

Table 6-9 Summary of Acute Inhalation Concentration Ratios for Mixtures by Endpoint – Project Alone Landfill Gas Assessment Stages

Potential Endpoint of Mixture	Stage 1 (2023-2027)	Stage 3 (2033-2037)	Stage 4 (2038-2042)	Post Closure (2043)
Eye irritants	0.020	0.028	0.030	0.022
Respiratory irritants	0.13	0.31	0.34	0.20
Neurological effects	0.041	0.060	0.063	0.050
Renal effects	0.000000082	0.00000019	0.00000021	0.00000011
Hepatic effects	0.0043	0.0092	0.010	0.0056

Table 6-10 Summary of Chronic Inhalation Concentration Ratios for Mixtures by Endpoint – Project Alone Landfill Gas Assessment Stages

Potential Endpoint of Mixture	Stage 1 (2023-2027)	Stage 3 (2033-2037)	Stage 4 (2038-2042)	Post Closure (2043)
Respiratory irritants	0.0018	0.0065	0.0087	0.0087
Respiratory effects	0.012	0.031	0.037	0.021
Liver effects	0.00018	0.00039	0.00045	0.00025
Neurological effects	0.0020	0.0036	0.0042	0.0024
Reproductive/ developmental effects	0.0065	0.011	0.013	0.0078
Hematological effects	0.00049	0.0011	0.0013	0.00070
Hepatic effects	0.0014	0.0016	0.0017	0.0014

Table 6-11 Summary of Chronic Inhalation Incremental Lifetime Cancer Risks (ILCR) for Mixtures by Endpoint – Project Alone Landfill Gas Assessment Stages

Potential Endpoint of Mixture	Stage 1 (2023-2027)	Stage 3 (2033-2037)	Stage 4 (2038-2042)	Post Closure (2043)
Kidney tumours	4.3E-07	9.1E-07	1.1E-06	5.9E-07
Liver cancer	9.4E-08	2.1E-07	2.4E-07	1.4E-07
Hemangioscarcomas	1.0E-06	1.0E-06	1.0E-06	1.0E-06

6.4.2 Haul Route Assessment

Tables 6-12 and 6-13 provide the acute and chronic mixture CR for Stages 1 and 3 of the Project by the potential mixture endpoint based on the predicted haul route emissions. It should be noted that carcinogenic ILCR mixture risks are already evaluated as part of the benzo(a)pyrene assessment in Section 6.2.2 where B(a)P toxic equivalencies are evaluated.

Table 6-12 Summary of Acute Inhalation Concentration Ratios for Mixtures by Endpoint – Project Alone Haul Route Assessment Stages

Potential Endpoint of Mixture	Stage 1 (2023-2027)	Stage 3 (2033-2037)
Eye irritants	0.002	0.002
Respiratory irritants	1.56	1.19
Hematological effects	0.01	0.02

Table 6-13 Summary of Chronic Inhalation Concentration Ratios for Mixtures by Endpoint – Project Alone Haul Route Assessment Stages

Potential Endpoint of Mixture	Stage 1 (2023-2027)	Stage 3 (2033-2037)
Respiratory effects	0.53	0.47

7.0 UNCERTAINTY ANALYSIS

In any detailed HHRA, the intention is to obtain the most accurate evaluation of risk based upon the available data and state of knowledge, without underestimating the potential health risks. With any such predictive assessment, there are always a number of administrative and technical boundaries that limit the ability of the assessment to quantify risk with absolute certainty. The following section provides an overview of the key administrative and technical uncertainties inherent within the current HHRA.

Quantitative HHRA involves assigning numerical values to input parameters in an appropriate exposure or risk model to obtain a quantitative estimate of risk. Numerical values are required for parameters describing chemical concentrations in environmental media, chemical fate and transport, human exposure and toxic response. These values may be measured, assumed, prescribed, or based on published literature. Variability and uncertainty in the input parameters or risk model result in variability and uncertainty in the estimate of risk. The US EPA (2005) suggests that the risk characterization process maintain transparency, clarity, consistency, and reasonableness. The goal of risk characterization is to clearly communicate the key findings of the assessment and to provide a clear and balanced assessment of the strengths and limitations of the process. Risk characterization involves both scientific and policy-based decision making, thereby resulting in a decision-making process that blends both elements.

When assumptions are made during the risk assessment process, either because of data gaps or knowledge gaps, each can result in some degree of uncertainty in the overall conclusions. In order to understand the uncertainties within the HHRA and to ensure that the implications of these uncertainties are understood and addressed, it is important to document and characterize them. To ensure that the risk assessment does not underestimate the potential for the occurrence of adverse effects, it is necessary to make assumptions that are conservative (protective). In other words, assumptions should be made that tend to overestimate exposure, toxicity, and risk, rather than underestimate these parameters.

The following sections describe uncertainty within the HHRA and discuss the potential impacts of these limitations on the conclusions drawn from the assessment. Given the tendency for the assumptions described below to overestimate both exposure and toxicity, it is likely that the risk characterization errs on the side of caution and over predicts risk. A summary of the conservative assumptions that were incorporated into the HHRA can be found in Table 7-1, arranged according to the steps of the risk assessment paradigm. Examination of the table shows that conservatism was introduced at virtually every step of the assessment, and extended to the problem formulation, exposure assessment, and toxicity assessment of the HHRA.

Table 7-1 Major Assumptions Used in the HHRA

Risk Assessment Paradigm	*Assumption*	*Discussion of Impact on Risk Characterization*	*Degree of Impact*
Problem Formulation	Selection of chemicals of potential concern is adequate to characterize potential project emissions	Chemical selection and identification was based on those identified in the Air Quality Study (RWDI, 2020) as potential emissions from the proposed Landfill either in landfill gas, flaring, or as fugitive emissions, as well as those emitted from diesel trucks travelling the associated haul routes to/from the Landfill.	Neutral
	Air quality assessment scenarios reflect realistic operating conditions of the proposed Landfill	Careful consideration was given to the assessment scenarios evaluated in the HHRA, with reasonable worst-case operating conditions assumed for both the air quality assessment and ultimately the HHRA through all potential operating life stages of the proposed Landfill.	Over Predict
	Potential exposures were evaluated throughout the Study Area.	Care was taken to select locations in the surrounding area that would likely demonstrate the highest potential impacts from the proposed Landfill and the associated haul routes. In addition to assessing discrete receptor locations within the HHRA, the entire Study Area (i.e., the Site-Vicinity and Regional study) was broken down into a grid of exposure areas where similar exposure conditions would be expected. The receptor grid covered the land within approximately five (5) kilometers from the proposed landfill site. By employing a grid approach throughout the Study Area, residential receptor locations representing actual nearby geographical locations that currently have, or have the potential to have, occupied by residential dwellings were evaluated in the HHRA.	Neutral
	Residential receptor locations were primarily evaluated in the HHRA.	Focus was given to areas where community residents were expected to have high occupancy (such as residential dwellings), specifically excluding locations modelled on the Landfill property itself.	Over Predict
	Residential receptors assumed to live their entire lifespan at the same location.	The residential receptor was assumed to be born in the Township of Zorra in Oxford County with the proposed Landfill operating, and conservatively assumed to live at that location for their entire lifetime (i.e., 80 years).	Over Predict
Exposure Assessment	COC concentrations measured at NAPS monitoring stations are representative of background conditions within Project Area.	All background and predicted future air concentrations for the relevant COCs were provided by the Air Quality Study (RWDI, 2020). RWDI conducted a monitoring program for the various COPCs to determine the existing baseline conditions related to the landfill. Where not analyzed in the local monitoring, the Air Quality team obtained the background concentrations from the MECP Air Quality in Ontario reports for 2014, 2015, and 2016; and through the National Air Pollution Surveillance (NAPS) ambient monitoring database. Background annual average concentrations of VOCs evaluated in the LFG assessment were obtained from provincial monitoring stations in similar geographical and land-use scenarios, where possible (i.e., Kitchener, Simcoe, etc.) avoiding those stations in areas heavily dominated by either industrial or vehicle emissions (e.g., stations in the Greater Toronto Area).	Mixed
	Background concentrations were assumed to be consistent throughout entire lifetime of the proposed Landfill.	The 90th-percentile was used of the measured background 24-hour concentrations and assumed to be consistent throughout the entire lifespan of the proposed Landfill. The worst-case annual average background concentration was likewise used.	Over Predict

Table 7-1 Major Assumptions Used in the HHRA

Risk Assessment Paradigm	*Assumption*	*Discussion of Impact on Risk Characterization*	*Degree of Impact*
Exposure Assessment (continued)	Maximum 24-hour air concentrations predicted at each of the grid receptor locations were used to evaluate short-term inhalation risks for a subset of COCs.	This assumption is highly improbable and represents a worst-case scenario. The frequency with which the maximum would occur at any one receptor location varies with respect to the COC and the receptor location. Individual exposure to 24-hour maximum ground-level air concentrations requires that a receptor (person) be present at the same time and duration of the maximum predicted air concentration at that particular receptor location each day that the modelled predicted concentration occurs.	Over Predict
	Ground-level air concentrations of COCs related to emissions from the proposed Landfill and the associated haul routes were estimated based on mathematical air dispersion models.	The HHRA relied on the results of air dispersion modelling to evaluate the health risks from direct inhalation exposure as well as to predict inhalation health risks. The MECP has discussed matters of confidence and uncertainty in the predictions of dispersion models with regard to ground level concentrations and deposition rates. This remains the best mechanism to forecast future distributions of emissions in built environments. The air dispersion models used to provide data for the current assessment are approved by the MECP and the US EPA for use on these types of emission studies. Refer to the Air Quality study for further discussion of the uncertainty inherent in the use of these models.	Mixed
	Diesel emissions evaluated in the Transportation scenarios were assumed to reflect today's emission standards into the future.	Diesel emissions from trucks used in the Transportation scenarios are likely to improve over the planned lifetime of the facility with improvement in engine and fleet technologies over time.	Over Predict
	Residential receptors were assumed to be present at a given receptor grid location for 24 hours/day, 7 days/week, 52 weeks/year for an entire lifetime.	The multi-media assessment assumed all receptors would never leave the assessed receptor location and, in the case of developing ILCR estimates, live an entire lifetime at this location while being exposed to maximum predicted environmental media concentrations. This assumption likely results in an over prediction of risk.	Over Predict
	Multi-media assessment used MECP Ontario Typical Background as baseline.	For comparative purposes, given the absence of site-specific data, the Multimedia assessment assumed the background benzo(a)pyrene soil concentrations were equivalent to the MECP Ontario Typical Background (OTR) which is representative of the 97.5th percentile upper limit (OTR98) of the typical province-wide background concentrations in soils that are not contaminated by point sources based on the surface soils database.	Likely Over Predict
	Particle deposition of benzo(a)pyrene only considered dry deposition.	Wet deposition values were unavailable, so only dry deposition was used for the prediction of future soil concentrations along the haul routes. Dry deposition is expected to be the major source of deposition under normal conditions.	Under Predict

Table 7-1 Major Assumptions Used in the HHRA

Risk Assessment Paradigm	*Assumption*	*Discussion of Impact on Risk Characterization*	*Degree of Impact*
Toxicity Assessment	Toxicity reference values (TRVs) have been developed by regulatory agencies with sufficient conservatism to assure protection of the most sensitive and/or susceptible individuals within the general population (*e.g.*, infants and young children, the elderly, individuals with compromised health). Uncertainty and data gaps are addressed in the derivation of the TRVs through the use of uncertainty factors.	A considerable amount of conservatism is incorporated in the TRVs developed by regulatory agencies. TRVs are deliberately set by regulatory agencies with the protection of the most sensitive individuals in mind. Typically, the TRVs used in the current assessment were derived from the most sensitive health-related endpoints, and then adjusted to account for differences in sensitivity to chemicals among individuals. The use of uncertainty factors (of 10- to 1,000-fold) are directed, in part, toward the protection of sensitive individuals. In most cases, the most conservative TRV was used, unless there was compelling and recent evidence to indicate that a more robust TRV was more appropriate.	Over Predict
	For genotoxic carcinogens, it was assumed that no repair of genetic lesions occurs, and therefore, no threshold can exist for chemicals that produce self-replicating lesions.	The existence of enzymes and biological pathways that routinely repair damage to genetic material (DNA) is well documented in the scientific literature. The potential adverse health outcomes arising from damage to DNA are usually observed only when the ability of these repair enzymes to "fix" the damage is blocked or exceeded. This is a conservative assumption.	Over Predict
	Humans were assumed to be the most sensitive species with respect to toxic effects of COC.	For obvious reasons, toxicity assays are not generally conducted on humans, so toxicological data from the most sensitive laboratory species were used in the estimation of toxicological criteria for humans, as appropriate. In some cases, however, human-specific data was available and was used in the Toxicity Assessment. Uncertainty and data gaps are addressed in the derivation of the TRVs through the use of uncertainty factors. This is a conservative approach.	Over Predict
	Evaluation of chemical mixture risks were based on additive effects.	Health effects from mixtures were assessed by assuming additive effects of chemicals with similar exposure characteristics (*e.g.,* acute exposure; chronic exposure) and similar toxic effects (*e.g.,* respiratory irritants, nasal irritants, reproductive effects). For the evaluation of chemical mixtures in the HHRA, the health endpoint of the TRVs used in the HHRA provided the basis for the inclusion of an individual chemical in a chemical mixture.	Unknown
Risk Characterization	Potential 1-hour acute exposures were not evaluated in the current assessment.	Given the nature of the emission sources under consideration (*i.e.*, a landfill or a minimal number of trucks travelling on nearby routes), it is unlikely that 1-hour exposures would be significant. However, potential worst-case health risks related to 1-hour exposures to NO_2 were assessed to confirm this assumption.	Neutral

8.0 OVERALL FINDINGS AND CONCLUSIONS

The primary purpose of this project is to meet the requirements of the Environmental Assessment process under Ontario's *Environmental Assessment Act* for the '*provision of future landfill capacity at the Carmeuse Lime (Canada) Ltd. (Carmeuse) site in Oxford County for solid, non-hazardous waste generated in the Province of Ontario*'. To address concerns with respect to potential human health impacts related to the construction and operation of the proposed Landfill, a human health risk assessment was conducted evaluating projected emissions from both the Landfill and those arising from vehicle emissions from trucks using the associated haul routes. Potential exposures were evaluated through each of the operating stages of the proposed Landfill, as well as post closure.

The primary objective of the HHRA was to determine the potential short- and long-term human health risks to individuals in the surrounding community who may be impacted by emissions from the proposed Landfill and the associated haul routes. The HHRA involved an evaluation of the potential health impacts related to inhalation of emissions, both project-specific and in the broader cumulative context of the overall airshed (*i.e.*, existing background conditions ***plus*** project-specific contributions). Finally, the assessment also considered the potential impacts emissions may have on soil concentrations throughout the Study Area through long-term deposition, and potential health outcomes that may arise from exposures to impacted soils and dusts, as well the potentially associated impacts on agricultural crops and home garden produce.

Potential impacts to both groundwater and surface water related to Landfill operations were also considered for the current Project. As discussed in Section 1.2, the project design is protective of groundwater quality as it incorporates a MECP-approved double liner design (*i.e.*, *Generic Design Option II – Double Liner* system as specified by the MECP in the *Landfill Standards* under *O. Reg. 232/98*). As such, the assumption is that there will be no impacts on groundwater quality beyond the site boundary. Furthermore, the Groundwater team concluded there would be no significant negative impacts on the groundwater quality or surface water quality related to the Project. As such, it is not anticipated that there will be potential impacts to human health due to exposure to groundwater.

The study areas for the surface water assessment were the watershed catchments of the Patterson-Robbins Drain, the East Tributary and the Thames River (Golder, 2020). Based on the Surface Water Assessment Report (Golder, 2020), no significant effects are presented on the stream baseflow quantity and quality. No significant effects on water quality are anticipated and no potential effects on receiving water quality are anticipated due to contact with contaminated surface water. As such, it is not anticipated that there will be potential impacts to human health due to exposure to surface water.

The results of the assessment indicate that none of the emissions from the proposed Landfill or the associated haul routes would result in any unacceptable short- or long-term health risks, either from air inhalation or soil, agricultural and home garden produce exposure routes, or through impacts to local groundwater or surface water, in any of the evaluated Landfill operating stages. Most predicted acute and chronic air concentrations were many orders of magnitude below their corresponding health-based reference benchmark (*i.e.*, typically between 2- and 6-orders of magnitude below). When one focuses in on the criteria air contaminants (*i.e.*, carbon monoxide, nitrogen dioxide, particulate matter, and sulphur dioxide) arising from vehicle emissions from the haul route scenario, all of the Project-specific emissions were below the relevant regulatory benchmark, indicating no apparent health risks arising from the emissions of trucks transporting waste to the proposed Landfill on the designated haul routes.

The HHRA did note that the worst-case cumulative 24-hour exposures to inhalable particulate matter (*i.e.*, PM_{10}) was marginally above the acute benchmark (*i.e.*, <10% above the benchmark) in both the Stage 1 and 3 assessments at one specific receptor location (*i.e.*, the intersection of Beachville Road and 37th Line). However, when one drilled down into the frequency of such an exceedance at this location, it was noted that such exceedance occurred very rarely (*i.e.*, one day in a five-year period for Stage 1 and three discrete non-contiguous days in a five year period for Stage 3). Given the conservatism built into the assessment (*e.g.*, worst-case background assumed to occur at the same time as worst-case Project emissions), and the marginal nature of the estimated exceedance, these PM_{10} exposures are not expected to result in any adverse health impact to the surrounding community.

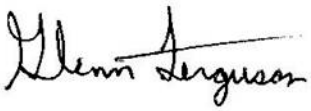
A multimedia assessment was also conducted to determine whether deposition of particle-bound chemicals arising from the Project would adversely impact soil quality over the lifespan of the proposed Landfill, and thereby result in health risks through soil contact, or ingestion of agricultural or home garden food products. The results of this assessment indicated that the percentage of the cumulative soil concentration that is predicted to originate from the haul route emissions is negligible, where only 0.001% of the cumulative soil concentration is due to the Project for Stages 1 and 3. Furthermore, the multimedia model predicted soil levels of benzo(a)pyrene below the typical rural and urban background levels of benzo(a)pyrene in Ontario (*i.e.,* 0.05 µg/g and 0.3 µg/g, respectively). As such, it is not anticipated that the predicted concentrations of benzo(a)pyrene in soil would adversely impact the soil, agricultural crops and home grown produce within the Project area. Given all the inherent conservatism built into the multimedia assessment, it is not anticipated that emissions from the Project would result in adverse health impacts to the surrounding community.

In conclusion, the results of the HHRA indicate that none of the emissions arising from either the proposed Landfill or Project-related vehicle traffic on the associated haul routes are expected to result in any unacceptable health risks to the surrounding community. Furthermore, none of the emissions from the Project provide a significant contribution to short- or long-term cumulative air or soil concentrations in the Study Area. In most cases, predicted emissions from the Landfill in all stages of its lifespan were orders of magnitude below their corresponding regulatory health-based air quality benchmarks.

9.0 DOCUMENT SIGN-OFF

The risk assessment has been performed in accordance with accepted practice and usual standards of thoroughness and competence for the profession of toxicology and environmental risk assessment. The information, opinions and recommendations provided within the aforementioned report have been developed using reasonable and responsible practices, and the report was completed to the best of our knowledge and ability.

Intrinsik Corp.



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APPENDIX A

TOXICITY REFERENCE VALUE IDENTIFICATION AND SELECTION

APPENDIX A: TOXICITY REFERENCE VALUE IDENTIFICATION AND SELECTION

A-1.0 INTRODUCTION

All chemicals have the potential to cause toxicological effects; however, it is the chemical concentration, the route of exposure, the duration of exposure, and the inherent toxicity of the chemical that determines the level of effect and hence the potential for unacceptable health risks. The methods and approaches used to determine Toxicity Reference Values (TRVs) for use in the HHRA are outlined in this appendix. Toxicity Reference Values were obtained for each chemical of concern (COC), where available. For the purpose of this assessment, TRVs were defined as values used to describe acceptable doses of chemicals that will not result in the development of unacceptable adverse health effects (e.g., RfD, RfC) or are benchmarks that are policy derived and health based (e.g., AAQC). Toxicity reference values endorsed by the MECP were utilized as first priority, when available.

In circumstances where TRVs were not presented by MECP, and when TRVs for a particular COC were available from multiple regulatory agencies, values were reviewed and the professional judgment of an experienced toxicologist and/or risk assessor was used to select the most appropriate TRV. A number of different considerations went into selecting a TRV for use in the HHRA, including:

- Is the TRV derived by a reputable regulatory agency?
- Is there sufficient documentation available concerning the derivation of the TRV (*e.g.,* study, endpoint, point of departure, uncertainty factors applied, *etc.*)?
- How current is the derivation and most recent validation of the TRV?
- How relevant is the TRV in terms of route of exposure and durations of interest?

The TRVs employed in the current HHRA were obtained from reputable regulatory agencies including, but not limited to:

- Ontario Ministry of the Environment, Conservation and Parks (MECP);
- Health Canada;
- US EPA Integrated Risk Information System (US EPA IRIS);
- Agency for Toxic Substances and Disease Registry (ATSDR);
- Canadian Council of the Ministers of the Environment (CCME);
- World Health Organization (WHO);
- California Environmental Protection Agency (Cal EPA);
- Texas Commission on Environmental Quality (TCEQ); and,
- RIVM.

A-2.0 TOXICITY REFERENCE VALUES

Inhalation TRVs were evaluated and selected for all COCs outlined in the report. In addition to providing a tabulated summary of TRVs for each COC within the report, the following sections also provide a brief rationale as to why each TRV was selected for use in the assessment. Oral TRVs were provided for benzo[a]pyrene in Section A-2.1.46 Carcinogenic Polycyclic Aromatic Hydrocarbons (PAHs). Decane, nonane, and octane were identified also being eligible for inclusion in the multi-pathway assessment within the report. However, provided that oral exposure limits are not available for these COCs, they were not assessed within the multi-pathway exposure assessment.

A-2.1.1 Acetone

CASRN 67-64-1

The 24-hour inhalation exposure limit of 11,880 µg/m^3 proposed by MOE (2012) was selected for the assessment. Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry.

The chronic inhalation exposure limit of 12,000 µg/m^3 proposed by the Ministry (MOE, 2011) was used for the non-cancer assessment of acetone (Table A - 1).

Table A - 1 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	11,880	NA	NA	NA	NA	MOE, 2012	2012
MRL; 4 hour	Acute	62,000 µg/m^3	Neurobehavioral effects	Dick et al. 1989	LOAEL: 237 ppm (560 mg/m^3)	9	ATSDR, 1994	1994
RfC	Chronic	12,000	NA	NA	NA	NA	MOE, 2011	2011
MRL	Chronic	31,000 µg/m^3	Neurobehavioral effects	Stewart et al. 1975	LOAEL: 1,250 ppm (3,000 mg/m^3)	100	ATSDR, 1994	1994
ReV	Chronic	16,000	Neurotoxicity (heavy feelings in the head, faint feelings, nausea)	Satoh et al. (1996)	POD (HEC): 133.9 ppm (318 mg/m^3)	20 (HQ= 1)	TCEQ, 2013	2013
ESL	Chronic	4,800	Neurotoxicity (heavy feelings in the head, faint feelings, nausea)	Satoh et al. (1996)	POD (HEC): 133.9 ppm (318 mg/m^3)	20 (HQ= 0.3)	TCEQ, 2013	2013

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.2 Benzene

CASRN 71-43-2

The acute inhalation exposure limit of 29 µg/m^3 proposed by the ATSDR (2007), and the chronic inhalation exposure limit of 30 µg/m^3 proposed by the US EPA (2003) and endorsed by the Ministry (MOE, 2011) were used for the non-cancer assessment of benzene (Table A - 2). These exposure limits were chosen as the most conservative values and considering the robustness of the supporting data.

The UR of 2.2x10^{-6} (µg/m^3)$^{-1}$ proposed by the Ministry was used for the assessment of benzene.

Table A - 2 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	2.3	Health based	NA	NA	NA	MOE, 2011a	2011
MRL[b]	Acute	29 µg/m^3	Reduced lymphocyte proliferation following mitogen stimulation in mice	Rozen *et al*., 1984	LOAEL: 2.55 ppm (8,100 µg/m^3)	300	ATSDR, 2007	2007
ReV; 24-hour	Acute	320	Depressed peripheral lymphocytes and depressed mitogeninduced blastogenesis of femoral Blymphocytes (male mice)	Rozen et al. (1984), supported by Dempster and Snyder (1991) and Corti and Snyder (1996)	POD (HEC): 10.2 ppm (32.6 mg/m^3)	100 (HQ= 1)	TCEQ, 2007	2007
RfC	Chronic	30	Decreased lymphocyte count	Rothman *et al*., 1996	BMCL: 8,200 µg/m^3	300	US EPA IRIS, 2003	2003
MRL	Chronic	9.58 µg/m^3	Statistically significant decreased counts of B-lymphocytes	Lan *et al*., 2004	BMCL$_{ADJ}$ (0.25sd): 0.03 ppm (95.8 µg/m^3)	10	ATSDR, 2007	2007
ReV	Chronic	280	Decreased absolute lymphocyte count (workers)	Rothman *et al*., 1996	POD (HEC): 2.6 ppm (8,300 µg/m^3)	30 (HQ= 1)	TCEQ, 2007	2007
ESL	Chronic	84	Decreased absolute lymphocyte count	Rothman *et al*., 1996	POD (HEC): 2.6 ppm (8,300 µg/m^3)	30 (HQ= 0.3)	TCEQ, 2007	2007
REL	Chronic	3 µg/m^3	Decreased peripheral blood cells in workers	Lan *et al*., 2004	POD (HEC): 0.204 ppm (0.665 mg/m^3)	200	Cal EPA, 2014	2014

Table A - 2 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; Annual Average	Chronic	0.45	Incidence of cancer	Crump, 1994	NA	NA	MOE, 2011a	2011
UR	Chronic	$2.2x10^{-6}$ $(\mu g/m^3)^{-1}$	Leukemia	Rinsky *et al*., 1987	NA	NA	US EPA IRIS, 2000	2000
UR	Chronic	$2.2x10^{-6}$ $(\mu g/m^3)^{-1}$	NA	US EPA IRIS, 2000	NA	NA	MOE, 2011b	2011
UR	Chronic	$2.9x10^{-5}$ $(\mu g/m^3)^{-1}$	Leukemia	Yin *et al*., 1994; Yin *et al.,* 1996	NA	NA	Cal EPA, 2011	2009
UR	Chronic	$3.3x10^{-6}$ $(\mu g/m^3)^{-1}$	Acute myelogenous leukemia	Rinsky *et al.,* 1987	NA	NA	Health Canada, 2010	2010
UR	Chronic	$6.0x10^{-6}$ $(\mu g/m^3)^{-1}$	Leukaemia	Crump and Allen, 1984; Paustenbach *et al.,* 1992	NA	NA	WHO, 2000	2000
UR	Chronic	$2.2x10^{-6}$ $(\mu g/m^3)^{-1}$	Leukemia	Crump and Allen, 1984	NA	NA	TCEQ, 2007	2007
MPR	Chronic	20 $\mu g/m^3$ (cancer	NA	NA	NA	NA	RIVM, 2001	1999/2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.
[b] Value taken as 24-hour exposure limit.

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A-2.1.3 Bromodichloromethane

CASRN 75-27-4

The chronic inhalation exposure limit of 70 µg/m^3, proposed by the TCEQ (2018) and the UR of 3.7x10^{-5} (µg/m^3)$^{-1}$ proposed by the Cal EPA (2019) were used for the non-cancer and carcinogenic assessment of bromodichloromethane (Table A - 3). These exposure limits were chosen as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 3 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	3.7x10^{-5} (µg/m^3)$^{-1}$	NA	NA	NA	NA	Cal EPA, 2019	1987
ESL	Chronic	70	NA	NA	NA	NA	TCEQ, 2018	2009

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

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Cal EPA. 2019. Bromodichloromethane. California Environmental Protection Agency. Available at: https://oehha.ca.gov/chemicals/bromodichloromethane

A-2.1.4 Butanal (n-)

CASRN 123-72-8

The chronic inhalation exposure limit of 100 µg/m^3, proposed by the TCEQ (2014) were used for the non-cancer assessment (Table A - 4). This value was selected for use in the assessment as it was the only TRV available.

Table A - 4 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	100	Hyperplasia, inflammation, and squamous metaplasia of the nasal tissues (nasal irritation) in SD rats and male beagle dogs	Union Carbide study (USEPA, 1988)	POD (HEC): 9.16 ppm (27 mg/m^3)	270 (HQ= 1)	TCEQ, 2014	2014
ESL	Chronic	30	Hyperplasia, inflammation, and squamous metaplasia of the nasal tissues (nasal irritation) in SD rats and male beagle dogs	Union Carbide study (USEPA, 1988)	POD (HEC): 9.16 ppm (27 mg/m^3)	270 (HQ= 0.3)	TCEQ, 2014	2014

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.5 Butanol (2-)

CASRN 78-92-2

The long-term effects screening level (ESL) of 300 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (i.e., Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 5 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL	Chronic	300	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

A-2.1.6 Butyl Acetate

CASRN 123-86-4

The chronic inhalation exposure limit of 4,700 µg/m^3, proposed by the TCEQ (2014) were used for the non-cancer assessment of butyl acetate (Table A - 6).

Table A - 6 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	4,700	Minimal to mild necrosis on the olfactory epithelium, decreased transient motor activity (CNS effects), and decreased growth in rats	Bernard et al. 1996	POD (HEC): 89.28 ppm (424 mg/m^3)	90 (HQ= 1)	TCEQ, 2014	2014
ESL	Chronic	1,400	Minimal to mild necrosis on the olfactory epithelium, decreased transient motor activity (CNS effects), and decreased growth in rats	Bernard et al. 1996	POD (HEC): 89.28 ppm (424 mg/m^3)	90 (HQ= 0.3)	TCEQ, 2014	2014

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.7 Carbon Monoxide

The 8-hour acute inhalation exposure limit of 6,000 µg/m^3 proposed by Health Canada (2006) was used for the assessment of carbon monoxide. This acute inhalation exposure limit was selected for use as it was the most conservative value relative to the available values.

Table A - 7 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 8-hour	Acute	15,700	Health-based	NA	NA	NA	MOE, 2012	2012
Acute; 8-hour	Acute	6,000	Carboxyhemoglobin blood level of less than 1%	NA	NA	NA	Health Canada, 2006	2006
Acute; 8-hour	Acute	9 ppm (11,000 µg/m^3)	NA	NA	NA	NA	US EPA, 2011	2011

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.8 Carbon tetrachloride

CASRN 56-23-5

The 24-hour acute inhalation exposure limit of 2.4 µg/m^3 proposed by the MOE (2012), and the annual inhalation exposure limit of 2 µg/m^3 proposed by MOE (2011) were used for the assessment of carbon tetrachloride (Table A - 8). The acute exposure limit was selected for use due to the absence of other viable 24-hour exposure limits. The chronic inhalation exposure limit of 2 µg/m^3 was selected in the assessment as it was more conservative than other exposure limits and it was endorsed by the MECP.

The IUR of 6 x 10^{-6} (µg/m^3)$^{-1}$ derived by US EPA IRIS (2010) was selected as it was also endorsed in the RSL summary table (US EPA, 2019).

Table A - 8 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	2.4	Health-based	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	100	Fatty change in liver (rat, mouse)	JBRC, 1998; Nagano *et al*., 2007	$BMDL_{10}$ (HEC): 14.3 mg/m^3 (14,300 µg/m^3)	100	US EPA IRIS, 2010	2010
MRL	Chronic	190	Increased liver weight, serum enzymes, liver histopathology	JBRC, 1998; Nagano *et al*., 1998	NOAEL (HEC): 0.9 ppm (5,700 µg/m^3)	30	ATSDR, 2005	2005
REL	Chronic	40	Increased liver weight and hepatic fatty infiltration	Adams *et al*., 1952	LOAEL (HEC): 1.7 ppm (~11,000 µg/m^3)	300	Cal EPA, 2000	2000
TCA	Chronic	60	Hepatic effects	NA	NOAEC (ADJ): 6.4 mg/m^3 (6,400 µg/m^3)	100	RIVM, 2001	2001
ESL; Annual average	Chronic	13	NA	NA	NA	NA	TCEQ, 2014	2003
RfC	Chronic	2.0	NA	USEPA Region III 2004	NA	NA	MOE, 2011	2011
Unit risk	Chronic	6.0x10^{-6} (µg/m^3)$^{-1}$	Pheochromocytoma (mouse)	JBRC, 1998; Nagano *et al*., 2007	NA	NA	US EPA IRIS, 2010	2010
Unit risk	Chronic	4.2 x 10^{-5} (µg/m^3)$^{-1}$	Liver tumour	Edwards *et al*., 1942	NA	NA	Cal EPA, 2011	2009

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.

Table A - 8 Inhalation Toxicity Reference Values								
Type	***Duration***	***Value*** [a]	***Critical Effect***	***Reference***	***Point of Departure***	***UF***	***Source***	***Derived***

[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.9 Chlorobenzene

CASRN 108-90-7

The chronic inhalation exposure limit of 1,000 µg/m^3, proposed by the Ministry (MECP, 2019) was used for the non-cancer assessment of chlorobenzene (Table A - 9).

Table A - 9 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
RfC	Chronic	1,000	NA	Cal EPA chREL 2000	NA	NA	MOE, 2011	2000
p-TC	Sub-Chronic	10	Nephrotoxic	Dilley, 1977	LOAEL: 341 mg/m^3	5000	Health Canada, 2010	2010
p-RfC	Sub-chronic	5	Increased liver weights, hepatocellular hypertrophy, renal degeneration and inflammation, and testicular degeneration in rats	Nair et al. (1987)	LED_{10HEC}: 46 mg/m^3	100	US EPA, 2006	2006
p-RfC	Chronic	50	Increased liver weights, hepatocellular hypertrophy, renal degeneration and inflammation, and testicular degeneration in rats	Nair et al. (1987)	LED_{10HEC}: 46 mg/m^3	1000	US EPA, 2006	2006
REL	Chronic	1,000 µg/m^3	Increased liver weights, hepatocellular hypertrophy, renal degeneration and inflammation, and testicular degeneration in rats	Nair et al. (1987)	POD (HEC): 26 ppm (120 mg/m^3)	100	Cal EPA, 1999	1999
ESL	Chronic	46	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
p-TC Tolerable concentration (provisional)
p-RFC Reference concentration (provisional)
[a] Units of µg/m^3 unless otherwise noted.

References:

Cal EPA. 1999. Appendix D.3 Chronic RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Sacramento, CA. Revised December 2000. Available at: https://oehha.ca.gov/media/downloads/crnr/appendixd3final.pdf

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A-2.1.10 Chlorodifluoromethane

CASRN 75-45-6

The chronic inhalation exposure limit of 50,000 µg/m^3, proposed by the US EPA IRIS (1993) was used for the non-cancer assessment of chlorodifluoromethane (Table A - 10). This exposure limit was chosen as the most conservative value.

Table A - 10 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	350,000	NA	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	50,000	Increased kidney, adrenal and pituitary weights	Tinston et al., 1981	NOAEL (HEC): 5,260 mg/m^3	100	US EPA IRIS, 1993	1993
ESL	Chronic	500	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

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A-2.1.11 Chloroethane

CASRN 75-00-3

The acute inhalation exposure limit of 5,600 µg/m^3 proposed by the MOE (2012), and the chronic inhalation exposure limit of 10,000 µg/m^3, proposed by the US EPA IRIS (1991) were used for the non-cancer assessment of chloroethane (Table A - 11). These exposure limits were chosen as the most conservative values and considering the robustness of the supporting data. Furthermore, although there are no supporting documentation available for the 24-hour inhalation exposure limit, this value was selected for use in the assessment as it is proposed by the Ministry.

Table A - 11 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	5,600	NA	NA	NA	NA	MOE, 2012	2012
MRL	Acute	40,000 µg/m^3	Fetotoxicity in mice	Scortichini et al. 1986	NOAEL: 1,504 ppm (4,000 mg/m^3)	100	ATSDR, 1998	1998
RfC	Chronic	10,000	Delayed fetal ossification in mice	Scortichini et al. 1986	NOAEL: 4,000 mg/m^3	300	US EPA IRIS, 1991	1991
REL	Chronic	30,000 µg/m^3	Delayed fetal ossification in mice	Scortichini et al. 1986	NOAEL: 4,000 mg/m^3	30	Cal EPA, 1999	1999
ESL	Chronic	270	NA	NA	NA	NA	TCEQ, 2018	2016

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

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A-2.1.12 Chloroform

CASRN 67-66-3

The 24-hour inhalation exposure limit of 1 µg/m^3 proposed by MOE (2012) and the chronic inhalation minimal risk level (MRL) of 100 µg/m^3 derived by ATSDR (1997) and recommended by MOECC (2014) was adopted in the current risk assessment. Although there are no supporting documentation available for the 24-hour inhalation value, this value was selected for use in the assessment as it is proposed by the Ministry and due to the absence of other viable 24-hour exposure limits. The chronic inhalation MRL of 100 µg/m^3 derived by the ATSDR (1997) and adopted by the MOECC (2014) was selected in the assessment as it was based on an occupational study of workers exposed to 2 to 205 ppm of chloroform over a period of 1 to 4 years.

The IUR of 5.3 x 10^{-6} (µg/m^3)$^{-1}$ derived by the Cal EPA (2009) was initially endorsed by the Ministry. However, based on a MECP review completed in 2014, no IUR was selected (MECP, 2019). The rationale for not selecting a value is provided by MECP in the TRV selection rationale document (MOECC, 2014).

Table A - 12 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	1	Respiratory, cardiovascular, hepatic, gastrointestinal, renal, and neurological effects	NA	NA	NA	MOE, 2012	2012
AAQC; Annual Average	Chronic	0.2	NA	NA	NA	NA	MOE, 2012	2012
MRL	Acute	488 µg/m^3	Centrilobular hepatocyte necrosis in mice	Larson et al., 1994	NOAEL: 3 ppm (14.6 mg/m^3)	30	ATSDR, 1997	1997
MRL	Chronic	100 µg/m^3	Hepatomegaly in humans	Bornski et al. 1967	LOAEL: 2 ppm (9,800 µg/m^3)	100	ATSDR, 1997	1997
RfC	Chronic	100	Hepatomegaly found in 25% of exposed workers	ATSDR, 1997	LOAEL: 10 mg/m^3	100	MOECC (2014)	2014
UR	Chronic	2.3x10^{-5} (µg/m^3)$^{-1}$	Hepatocellular carcinoma in mice	NCI, 1976	NA	NA	US EPA IRIS, 2001	2001
REL	Chronic	300 µg/m^3	Liver toxicity, kidney toxicity, developmental toxicity; increased liver weights in rats	Torkelson et al., 1976	LOAEL: 25 ppm (122 mg/m^3)	300	Cal EPA, 2000	2000

Table A - 12 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	$5.3x10^{-5}$ $(\mu g/m^3)^{-1}$	Liver and renal tumours	NCI, 1976; Jorgenson et al., 1985	NA	NA	Cal EPA, 2009	2009
ESL	Chronic	10	NA	NA	NA	NA	TCEQ, 2018	2003
TCA	Chronic	100 $\mu g/m^3$	Liver, kidney and developmental toxicity	Torkelson et al., 1976	NOAEL: 110,000 $\mu g/m^3$	1,000	RIVM, 2001	1999/2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
TCA Tolerable concentration in air
[a] Units of $\mu g/m^3$ unless otherwise noted.

References:

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A-2.1.13 Chloromethane

CASRN 74-87-3

The acute inhalation exposure limit of 320 µg/m^3 proposed by MOE (2012), and the chronic inhalation exposure limit of 90 µg/m^3 proposed by the US EPA IRIS (2001) were used for the non-cancer assessment (Table A - 13). These exposure limits were chosen as the most conservative values.

Table A - 13 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	320	Health-based	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	90	Cerebellar lesions	Landry *et al*., 1983, 1985	NOAEL(HEC) : 94,600 µg/m^3	1,000	US EPA IRIS, 2001	2001
MRL	Chronic	177	Axonal swelling and degeneration of axons of the spinal cord in mice	CIIT, 1981	LOAEL: 51 ppm (~177,000 µg/m^3)	1,000	ATSDR, 1998	1998
ESL	Chronic	103	Health based	NA	NA	NA	TCEQ, 2014	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.14 Decane

CASRN 124-18-5

The chronic inhalation exposure limit of 1,100 µg/m^3 proposed by the TCEQ (2017) was used for the non-cancer assessment of decane (Table A - 14). This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (i.e., Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011).

Table A - 14 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	1,100	Increase in body weight gain and decrease in white blood cell count in rats	Nau et al. 1966	POD (HEC): 385.95 mg/m^3	360 (HQ= 1)	TCEQ, 2017	2017
ESL	Chronic	330	Increase in body weight gain and decrease in white blood cell count in rats	Nau et al. 1966	POD (HEC): 385.95 mg/m^3	360 (HQ= 0.3)	TCEQ, 2017	2017

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

[a] Units of µg/m^3 unless otherwise noted.

References:

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A-2.1.15 Dichlorobenzene (1,4-)

CASRN 106-46-7

The 24-hour inhalation exposure limit of 95 µg/m^3 proposed by MOE (2012) and the annual inhalation exposure limit of 60 µg/m^3 proposed by ATSDR (2006) were used was used for the assessment of 1,4- dichlorobenzene, (Table A - 15). The acute exposure limit was selected for use due to the absence of other viable 24-hour exposure limits. The chronic inhalation exposure limit of 60 µg/m³ derived by ATSDR (2006) was selected in the assessment as it was more conservative and scientifically defensible than other exposure limits. The chronic inhalation exposure limit was also endorsed by MECP.

The UR of 4.0x10^{-6} (µg/m^3)$^{-1}$ proposed by the Ministry was used for the carcinogenic assessment as the most recent August 2019 human health TRV document recommends this value.

Table A - 15 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC : 24-hour	Acute	95	Health-based	NA	NA	NA	MOE, 2012	NA
MRL	Chronic	60	Incidences of nasal lesions (rat)	Aiso *et al*. 2005 and Japan Bioassay Research Center 1995	$NOAEL_{10HEC}$: 27 ppm	30	MECP, 2019; ATSDR, 2006	NA
RfC	Chronic	800	Increased liver weights (rat)	Chlorobenzene Producers Association. 1986	$NOAEL_{HEC}$: 13 ppm	100	US EPA IRIS, 1996	1996
REL	Chronic	800	Increased liver weights (rat)	Chlorobenzene Producers Association. 1986	$NOAEL_{HEC}$: 13 ppm	100	Cal EPA, 2000	NA
ReV	Chronic	530	Increases in nasal olfactory epithelial lesions (rat)	Aiso *et al*. 2005	$BMCL_{10}$ 14.9 ppm	30	TCEQ, 2009	NA
ESL	Chronic	160	Health-based	NA	NA	NA	TCEQ 2018	2014
Unit Risk	Chronic	1.1x10^{-5} (µg/m^3)$^{-1}$	Liver tumours (mouse)	CDHS, 1988	NA	NA	Cal EPA, 2011	NA
Unit Risk	Chronic	4.0X10^{-6} (µg/m^3)$^{-1}$	NA	NA	NA	NA	MOE, 2011	NA

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.16 Dichlorodifluoromethane

CASRN 75-71-8

The 24-hour inhalation exposure limit of 500,000 µg/m^3 proposed by MOE (2012) was utilized. Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry.

The provisional RfC of 1,000 µg/m^3 proposed by US EPA (2010) was utilized. It is important to notes that there is low confidence in this value. However, the value is more conservative than the long-term effects screening level (ESL) of 5,000 µg/m^3 derived by the Texas Commission on Environmental Quality (TCEQ). In addition, there are no supporting documents associated with TCEQ ESL value.

Table A - 16 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	500,000	NA	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	5,000	NA	NA	NA	NA	TCEQ, 2018	2007
p-RfC	Sub-chronic	1,000	Reduced body-weight gain (guinea pigs, rabbits, dogs, and monkeys)	Prendergast et al., 1967	$LOAEL_{HEC}$: 985 mg/m^3	1000	US EPA, 2010	2010

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

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A-2.1.17 Dichloroethane (1,1-)

CASRN 75-34-3

The 24-hour inhalation exposure limit of165 µg/m^3 proposed by MOE (2012) and the chronic inhalation exposure of 170 µg/m^3 proposed by the Ministry (MOE, 2011) were used for the assessment of 1,1-dichloroethane (Table A - 17). The acute exposure limit was selected for use due to the absence of other viable 24-hour exposure limits. The chronic inhalation exposure limit of 170 µg/m³ was selected in the assessment as it was endorsed by MOE (2011).

The UR of 1.6x10^{-6} (µg/m^3)$^{-1}$ proposed by the Cal EPA (2011) was used for the carcinogenic assessment of 1,1-dichloroethane. This value was selected for use in this assessment as it was endorsed by the US EPA in the Regional Screening Level Summary Table (US EPA, 2019).

Table A - 17 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC : 24-hour	Acute	165	Health-based	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	170	Kidney damage (cats)	Hoffman *et al.* 1971	NA	NA	MOE, 2011;	1984
UR	Chronic	1.6x10-6 (µg/m^3)$^{-1}$	Female rat mammary gland adenocarcinoma tumor	(NCI, 1977)	NA	NA	Cal EPA, 2009	2011

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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US EPA. 2019. Regional Screening Level Summary Table (TR=1E-06, THQ=0.1) Available at: https://semspub.epa.gov/work/HQ/199628.pdf

A-2.1.18 Dichloroethylene (1,2-) (mixture)

CASRN 540-59-0

The 24-hour inhalation exposure limit of 2 µg/m^3 proposed by MOE (2012) was utilized in this assessment (Table A - 18). Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry and is health based.

The long-term effects screening level (ESL) of 790 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was not adopted in the current assessment as details regarding these sources were not available. There were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits. As a result, this chemical parameter was not assessed on a non-carcinogenic inhalation basis.

Table A - 18 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	105	Health-based	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	790	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

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A-2.1.19 Dichloroethene (cis-1,2-)

CASRN 156-59-2 (cis)

The acute inhalation exposure limit of 105 µg/m^3 was utilized in this assessment. Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry and was identified to be health-based.

The long-term effects screening level (ESL) of 790 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits

Table A - 19 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	105	Health-based	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	790	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

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A-2.1.20 Dichloroethene (trans-1,2-)

CASRN 156-60-5

The AAQC 24-hour exposure limit of 105 µg/m^3 was utilized in this assessment as the most conservative value. Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry and is health-based.

The RfC of 60 µg/m^3 proposed by MOECC (2017) was selected in this assessment as it is endorsed by MECP.

Table A - 20 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	105	Health-based	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	60	Multiple liver and lung effects (rats)	Freundt et al., 1977; RIVM 2001; 2009	LOAEL $_{ADJ}$ 185 mg/m^3	3000	MOECC, 2017	MOECC, 2017
RfC	Sub-Chronic	793	Fatty degeneration of the liver (rats)	Freundt et al., 1977; MOE 2011, ATSDR 1996	NA	NA	MOECC, 2017	MOECC, 2017
MRL	Acute	793	Fatty degeneration of the liver	Freundt et al. 1977	LOAEL: 200 ppm (793 mg/m^3)	1000	ATSDR, 1996	1996
ESL	Chronic	790	NA	NA	NA	NA	TCEQ, 2018	2001

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

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A-2.1.21 Dichlorofluoromethane

CASRN 75-43-4

The long-term effects screening level (ESL) of 4,200 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 21 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL	Chronic	4,200	NA	NA	NA	NA	TCEQ, 2018	2013

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

A-2.1.22 Dichloromethane

CASRN 1975-09-02

The 24-hour acute inhalation exposure limit of 220 µg/m^3 proposed by the MOE (2012), and the annual inhalation exposure limit of 400 µg/m^3 proposed by Cal EPA (2008) were used for the assessment of dichloromethane (Table A - 22). The acute exposure limit was chosen as it was the most conservative value. The chronic exposure limit of 400 µg/m^3 derived by Cal EPA (2008) was selected given that it was the most conservative and scientifically defensible value.

The IUR of 1.0 x 10-6 (µg/m^3)$^{-1}$ derived by Cal EPA (2011b) was selected as it was the most conservative value.

Table A - 22 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
MRL; 1-hour	Acute	2,000 (0.6 ppm)	Central nervous system effects	Winneke, 1974	$LOAEL_{ADj}$: 60 ppm	100	ATSDR, 2000	2000
REL; 1-hour	Acute	14,000 (4 ppm)	Central nervous system effects	Putz *et al.*, 1979	LOAEL: 680,000 µg/m^3 (195 ppm)	60	Cal EPA, 2008	2008
ReV; 1-hour	Acute	12,000	Central nervous system effects	Putz *et al.*, 1979	LOAEL: 680,000 µg/m^3 (195 ppm)	63	TCEQ, 2011	2011
MRL; 24-hour	Acute	1,000 (0.3 ppm)	Liver histopathology	Haun *et al.*, 1972	LOAEL: 25 ppm	90	ATSDR, 2000	2000
ESL; 24-hour	Acute	3,000	COHb formation	DiVincenzo and Kaplan, 1981	90,000 µg/m^3	NA	WHO, 2000	2000
AAQC; 24-hour	Acute	220	Central nervous system depression	NA	NA	NA	MOE, 2012	NA
MRL	Chronic	1,000 (0.3 ppm)	Liver histopathology	Nitschke *et al.*, 1988	NOAEL: 50 ppm	30	ATSDR, 2000	2000
TCA	Chronic	3,000	COHb formation	DiVincenzo and Kaplan, 1981	90,000 µg/m^3	NA	RIVM, 2001	1999/2000
REL	Chronic	400	COHb formation (human)	DiVincenzo and Kaplan, 1981	LOAEL: 40 ppm	100	Cal EPA, 2008	2008
RfC	Chronic	400	NA	Cal EPA, 2008	NA	NA	MOE, 2011	NA
ESL; annual average	Chronic	390	Liver histopathology	Nitschke *et al.*, 1988	LOAEL; 199 ppm	100	TCEQ, 2011	2011
RfC	Chronic	600	Liver histopathology	Nitschke *et al.*, 1988	1st percentileHEC: 17,200 µg/m^3	30	US EPA, 2011a	2011
AAQC	Chronic	44	Health based	NA	NA	NA	MOE, 2012	NA

Table A - 22 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	2.3×10^{-8} $(\mu g/m^3)^{-1}$	Pulmonary/hepatic adenomas and carcinomas	NTP, 1986	NA	NA	Health Canada, 2010	1996
UR	Chronic	1.0×10^{-6} $(\mu g/m^3)^{-1}$	Lung tumors (mouse)	NTP, 1986	NA	NA	Cal EPA, 2011	2009
UR	Chronic	2.3×10^{-8} $(\mu g/m^3)^{-1}$	NA	Health Canada, 2010	NA	NA	MOE, 2011	2011
ReV	Chronic	2.3×10^{-8} (350 $\mu g/m^3$)	Liver and lung tumors combined in female mice	NTP, 1986	NA	NA	TCEQ, 2011	2011
UR	Chronic	1.0×10^{-8} $(\mu g/m^3)^{-1}$	Liver and lung tumors	Mennear *et al.*, 1988; NTP, 1986	NA	NA	US EPA, 2011b	2011

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
[a] Units of $\mu g/m^3$ unless otherwise noted.

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A-2.1.23 Dimethyl Disulphide

CASRN 624-92-0

The acute inhalation exposure limit of 7 µg/m^3 proposed by the Ministry (MOE, 2012) for total reduced sulphur compounds was selected for the assessment of dimethyl disulphide.

The long-term effects screening level of 2 µg/m^3, proposed by the TCEQ (2018) was used for the non-cancer assessment (Table A - 23). This exposure limit was chosen as there are no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 23 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	7	Health based	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	2	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.24 Dimethyl Sulphide

CASRN 75-18-3

The acute inhalation exposure limit of 7 µg/m^3 proposed by the Ministry (MOE, 2012) for total reduced sulphur compounds was selected for the assessment of dimethyl dulphide

The long-term effects screening level of 10 µg/m^3, proposed by the TCEQ (2018) was used for the non-cancer assessment (Table A - 24). This exposure limit was chosen as there are no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 24 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	7	Health based	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	10	Health based	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.25 Ethanol

CASRN 64-17-5

The long-term effects screening level (ESL) of 1,880 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits

Table A - 25 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL	Chronic	1,880	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

A-2.1.26 Ethyl Acetate

CASRN 141-78-6

The provisional RfC of 70 µg/m^3 proposed by US EPA (2010) was utilized. It is important to note that there is low confidence in this value. However, the value is more conservative than the long-term effects screening level (ESL) of 1,400 µg/m^3 derived by the Texas Commission on Environmental Quality (TCEQ). In addition, there are no supporting documents associated with TCEQ ESL value.

Table A - 26 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL	Chronic	1,440	NA	NA	NA	NA	TCEQ, 2018	2015
p-RfC	Chronic	70	Decreased body weights, body-weight gains, food efficiency, and startle response (both sexes), and decreased food consumption (males) (rats)	Christoph et al. (2003)	$NOAEL_{HEC}$: 209 mg/m^3	3000	US EPA, 2013	2013
p-RfC	Sub-chronic	700	body weights, body-weight gains, food efficiency, and startle response (both sexes), and decreased food consumption (males) (rats)	Christoph et al. (2003)	$NOAEL_{HEC}$: 209 mg/m^3	300	US EPA, 2013	2013

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

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A-2.1.27 Ethyl Benzene

CASRN 100-41-4

The 24-hour inhalation exposure limit of 1,000 µg/m^3 proposed by MOE (2012) was selected for use in the assessment as it is proposed by the Ministry.

The chronic inhalation exposure limit of 1,900m µg/m^3 proposed by the TCEQ (2010) was used for the non-cancer assessment of ethyl benzene (Table A - 27). The exposure limit was also supported by the MECP (2019).

An inhalation UR value was not selected for ethyl benzene. The MECP recommends that an IUR is not used to assess cancer risk for this ethyl benzene (MOECC, 2016).

Table A - 27 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	1,000	NA	NA	NA	NA	MOE, 2012	2012
TC	Sub-Chronic	1,000	Reduced litter size; increased relative liver, kidney, and spleen weights of dams; skeletal variations	Andrew et al., 1981; Hardin et al., 1981	NOAEL: 434 mg/m^3	300	Health Canada, 2010	2010
MRL	Acute	21,000 µg/m^3	No signs of ill health in rats	Cappaert et al., 2000	BMCL1SD of 81.10 µmol/L	30	ATSDR, 2010	2010
MRL	Chronic	260 µg/m^3	Nephropathy and renal tubule hyperplasia in rats	NTP, 1999	LOAEL: 17.45 ppm (76 mg/m^3)	300	ATSDR, 2010	2010
RfC	Chronic	1,000	Reduced litter size; increased relative liver, kidney, and spleen weights of dams; skeletal variations	Andrew et al., 1981; Hardin et al., 1981	NOAEL:434 mg/m^3	300	US EPA IRIS, 1991	1991
REL	Chronic	2,000 µg/m^3	Liver, kidney, pituitary gland in mice and rats	NTP, 1999; Chan et al., 1998	POD (HEC): 13 ppm (56 mg/m^3)	30	Cal EPA, 1999	1999
UR	Chronic	2.5x10^{-6} (µg/m^3)$^{-1}$	Renal tubule carcinoma or Adenoma in rats	NTP, 1999	NA	NA	Cal EPA, 2009	2009

Table A - 27 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	1,900	Increased severity of nephropathy	NTP (1999)	POD (HEC): 13 ppm (56 mg/m^3)	30 (HQ= 1)	TCEQ, 2010	2010
ESL	Chronic	570	Increased severity of nephropathy	NTP (1999)	POD (HEC): 13 ppm (56 mg/m^3)	30 (HQ= 0.3)	TCEQ, 2010	2010
MPR	Chronic	770 µg/m^3	NA	NA	NA	NA	RIVM, 2001	1999/2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
TC Tolerable concentration
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.28 Ethyl Toluene (o/m/p-)

CASRN 611-14-3, 620-14-4, 622-96-8

The long-term effects screening level (ESL) of 125 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits

Table A - 28 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL	Chronic	125	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

A-2.1.29 Ethylene Dibromide

CASRN 106-93-4

The 24-hour acute inhalation exposure limit of 3 µg/m^3 proposed by the MOE (2012), and the chronic inhalation exposure limit of 0.8 µg/m^3 proposed by Cal EPA (2008) were used for the assessment of ethylene dibromide (Table A - 29). The chronic exposure limit was selected for use in the current assessment as it was based on the robustness of the supporting study data. This value was also adopted by MOE (2011).

The IUR of 6.0 x 10^{-4} (µg/m^3)$^{-1}$ derived by US EPA IRIS (2004) was selected in the assessment as it is the most conservative inhalation cancer risk and also since the value was adopted by MECP.

Table A - 29 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL; 1-hour	Acute	4	NA	NA	NA	NA	TCEQ, 2013	2003
AAQC; 24-hour	Acute	3	Health-based	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	9	Nasal inflammation	NTP, 1982	$BMCL_{10}$ (HEC): 2.8 mg/m^3 (2,800 µg/m^3)	300	US EPA IRIS, 2004	2004
REL	Chronic	0.8	Reproductive effects (human)	Ratcliff *et al*., 1987	LOAEL (HEC): 31 ppb (240 µg/m^3)	300	Cal EPA, 2008	2001
RfC	Chronic	0.8	NA	NA	NA	NA	MOE, 2011	2011
ESL	Chronic	0.4	NA	NA	NA	NA	TCEQ, 2013	2003
Unit risk	Chronic	6.0 x 10^{-4} (µg/m^3)$^{-1}$	Nasal cavity tumours, hemangiosarcomas, and mesotheliomas (rat)	NTP, 1982	NA	NA	US EPA IRIS, 2004	2004
Unit risk	Chronic	6.0 x 10^{-4} (µg/m^3)$^{-1}$	NA	NA	NA	NA	MOE, 2011	2011
Unit risk	Chronic	7.1 x 10^{-5} (µg/m^3)$^{-1}$	Nasal tumour incidence	NTP, 1982	NA	NA	Cal EPA, 2011	2009

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.30 Ethylene Dichloride

CASRN 107-06-2

The acute inhalation exposure limit of 2 µg/m^3 proposed by MOE (2012) and the chronic inhalation exposure limit of 400 µg/m^3 derived by Cal EPA (2000) was selected in the assessment as it was more conservative or more scientifically defensible than other exposure limits. This value was also endorsed by MECP (2019).

The UR of 2.6x10^{-5} (µg/m^3)$^{-1}$ proposed by the US EPA IRIS, 1987 was used for the carcinogenic assessment of dichloroethane, 1,2-. This value was adopted by the MECP (2019).

Table A - 30 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	2	Health-based	NA	NA	NA	MOE, 2012	2012
AAQC; Annual Average	Chronic	0.4	NA	NA	NA	NA	MOE, 2012	2012
REL	Chronic	40	NA	CalEPA, 2000	NA	NA	MOE, 2011	2011
UR	Chronic	2.6x10^{-2} (µg/m^3)$^{-1}$	NA	US EPA IRIS, 1991	NA	NA	MOE, 2011	2011
MRL	Chronic	2,400 µg/m^3	Basophilic focal cellular changes in the pancreas in female rats	Cheever *et al*., 1990	NOAEL: 50 ppm (200 mg/m^3)	90	ATSDR, 2001	2001
UR	Chronic	2.6x10^{-5} (µg/m^3)$^{-1}$	Hemangiosarcomas in rats	NCI, 1978	NA	NA	US EPA IRIS, 1987	1987
REL	Chronic	400 µg/m^3	Hepatotoxicity; elevated liver enzyme levels in serum of rats.	Spreafico et al., 1980	NOAEL (HEC): 3.2 ppm (13 mg/m^3)	30	Cal EPA, 2000	2000
UR	Chronic	2.1x10^{-5} (µg/m^3)$^{-1}$	Hemangiosarcomas in rats	NCI, 1978	NA	NA	Cal EPA, 2009	2009
ReV 24-hour	Acute	380	Degeneration and necrosis of olfactory epithelium	Hotchkiss et al., 2010	POD (HEC – 24-h) 16.67ppm (67 mg/m$^{3)}$	180	TCEQ, 2016	2016
ReV	Chronic	44	Increased ALT and uric acid in the serum, indicative of liver and kidney toxicity	Spreafico et al. 1980	POD (HEC): 2.0833 ppm (8,432 µg/m^3)	180 (HQ= 1)	TCEQ, 2016	2016
ESL	Chronic (threshold)	13	Increased ALT and uric acid in the serum, indicative of liver and kidney toxicity	Spreafico et al. 1980	POD (HEC): 2.0833 ppm (8,432 µg/m^3)	180 (HQ= 0.3)	TCEQ, 2016	2016

Table A - 30 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	$3.4x10^{-6}$ $(\mu g/m^3)^{-1}$	Mammary gland tumors in female rats	Nagano et al., 2006	POD (HEC): 7.1607 ppm (29 mg/m3)	NA	TCEQ, 2016	2016
Time-weighted Average	Acute	700	NA	NA	NA	1,000	WHO, 2000	2000
MPR	Chronic	48 $\mu g/m^3$ (provisional cancer risk)	NA	NA	NA	NA	RIVM, 2001	1999/2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.

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A-2.1.31 Formaldehyde

CASRN 50-00-0

The 24-hour acute inhalation exposure limit of 65 µg/m^3 proposed by the MOE (2012), and the annual inhalation exposure limit of 9 µg/m^3 proposed by the Cal EPA (2008) were used for the assessment of formaldehyde (Table A - 31). The acute exposure limit was selected in the assessment due to the absence of other viable 24-hour exposure limits. The chronic exposure limit was selected in the assessment as it was the most conservative exposure limit.

The IUR of 1.3 x 10^{-5} (µg/m^3)$^{-1}$ derived by US EPA IRIS (1991) was selected for use in this assessment as it was the most conservative and was endorsed in the RSL Summary Tables (US EPA, 2019).

Table A - 31 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV; 1-hour	Acute	50 (0.04 ppm)	Eye and nose irritation	Pazdrak *et al.,* 1993; Krakowiak *et al.,* 1998	LOAEL: 0.4 ppm (500 µg/m^3)	30	TCEQ, 2008	2008
ESL; 1-hour	Acute	15 (HQ=0.3)	Eye and nose irritation	Pazdrak *et al.,* 1993; Krakowiak *et al.,* 1998	LOAEL: 0.4 ppm (500 µg/m^3)	30	TCEQ, 2008	2008
MRL; 2-hour	Acute	50	Nasal and eye irritation	Pazdrak *et al*., 1993	LOAEL: 0.4 ppm (500 µg/m^3)	30	ATSDR, 1999	1999
REL; 1-hour	Acute	55	Mild and moderate eye irritation	Kulle *et al*., 1987	$BMCL_{05}$: 0.44 ppm (540 µg/m^3)	10	Cal EPA, 2008	2008
AAQC; 24-hour	Acute	65	Health-based	NA	NA	NA	MOE, 2012	2012
ReV	Chronic	11	Incidence of eye, nasal, and respiratory irritation	Wilhelmsson and Holmstrom, 1992	NOAEL (HEC): 0.032 mg/m^3 (32 µg/m^3)	3	TCEQ, 2008	2008
REL	Chronic	9	Nasal obstruction and discomfort, lower airway discomfort, eye irritation (human)	Wilhelmsson and Holmstrom, 1992	NOAEL: 0.09 mg/m^3 (90 µg/m^3)	10	Cal EPA, 2008	2008
MRL	Chronic	9.8 (0.008 ppm)	Clinical symptoms of mild irritation of eyes and upper respiratory tract. Mild damage to nasal epithelium	Holmstrom *et al*., 1989	LOAEL: 0.24 ppm (294 µg/m^3)	30	ATSDR, 1999	1999

Table A - 31 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	1.3×10^{-5} $(\mu g/m^3)^{-1}$	Incidence of nasal squamous cell carcinoma	Kerns *et al*., 1983	NA	NA	US EPA IRIS, 1991	1991
UR	Chronic	6.0×10^{-6} $(\mu g/m^3)^{-1}$	Nasal squamous carcinoma incidence (rat)	Kerns *et al*., 1983	NA	NA	Cal EPA, 2011	2009
UR	Chronic	5.3×10^{-6} $(\mu g/m^3)^{-1}$	Incidence of nasal squamous tumours	Monticello *et al*., 1996	NA	NA	Environment Canada and Health Canada (2001)	2001
UR	Chronic	5.6×10^{-7} $(\mu g/m^3)^{-1}$	Cell proliferation and cytotoxicity in rats	Schlosser *et al*., 2003	NA	NA	TCEQ, 2008	2008

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.

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A-2.1.32 Heptane

CASRN 142-82-5

The acute inhalation exposure limit of 11,000 µg/m^3 proposed by the MOE (2012), and the provisional RfC of 400 µg/m^3 proposed by US EPA (2016) was utilized for the non-cancer assessment of heptane (Table A - 32). It is important to note that there is low confidence in the provisional RfC. However, the value is more conservative than the ReV of 9,000 µg/m^3 derived by the Texas Commission on Environmental Quality (TCEQ).

Table A - 32 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	11,000	NA	NA	NA	NA	MOE, 2012	2012
ReV	Chronic	9,000	Absence of effects on body weight gain, neuromuscular function, and neurotoxicity in rats	Frontali et al.,1981	POD (HEC): 401.785 ppm (1,650 mg/m^3)	180 (HQ= 1)	TCEQ, 2016	2016
p-RfC	Chronic	400	Loss of hearing sensitivity (rats)	Simonsen and Lund (1995)	$BMCL_{1SD}$ (HEC): 1170 mg/m^3	3000	US EPA, 2016	2016
p-RfC	Sub-chronic	4000	Loss of hearing sensitivity (rats)	Simonsen and Lund (1995)	$BMCL_{1SD}$ (HEC): 1170 mg/m^3	300	US EPA, 2016	2016
ESL	Chronic	2,700	Absence of effects on body weight gain, neuromuscular function, and neurotoxicity in rats	Frontali et al.,1981	POD (HEC): 401.785 ppm (1,650 mg/m^3)	180 (HQ= 0.3)	TCEQ, 2016	2016

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.33 Hexane

CASRN 110-54-3

The acute inhalation exposure limit of 2,500 µg/m^3 proposed by the MOE (2012) was selected for the assessment of hexane. MECP (2019) selected the chronic inhalation exposure limit of 2,500 µg/m^3 and as such, the value was also used in the chronic assessment.

A final AAQC for n-hexane of 7,500 ug/m^3 was also available for use. MOE (2012) indicated that this AAQC for n-hexane is only appropriate for evaluating n-hexane and hexane isomers, whereas the n-hexane (mixture) AAQC value accounts for the potential interaction of n-hexane with other hydrocarbon solvents. Due to the complex composition of the emissions anticipated, it was determined that the n-hexane (mixture) AAQC was more appropriate for use in the assessment.

Table A - 33 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	2,500	Neurological effects (human)	Sanagi *et al*. 1980	NOAEL (HEC): 73,000 µg/m^3	30	MOE 2012	2005
RfC	Chronic	2,500	NA	MOE, 2005	NA	NA	MOE, 2011	2005
TC	Chronic	700	Peripheral neuropathy in rats	Huang et al. 1989	NOAEL: 50 ppm (1,762,000 µg/m^3)	300	Health Canada, 2010	NA
MRL	Chronic	2,100	Incidence of neurological effects in humans	Sanagi *et al.* 1980	LOAEL: 58 ppm (204,000 µg/m^3)	100	ATSDR, 1999	NA
RfC	Chronic	700	Peripheral neuropathy (rat)	Huang *et al*., 1989	BMCL (HEC): 215 mg/m^3 (215,000 µg/m^3)	300	US EPA IRIS, 2005	2005
REL	Chronic	7,000	Neurotoxicity; electrophysiological alterations (human)	Miyagaki, 1967	LOAEL (HEC): 57.9 ppm (204,000 µg/m^3)	30	Cal EPA, 2000	NA
ReV	Acute 24-hour	19,000	Decreased fetal body weights in rats	Mast et al. 1987	POD (HEC): 1,000 ppm (3,500 mg/m^3)	90	TCEQ, 2017	2017
ReV	Chronic	670	Peripheral neuropathy in humans	Chang *et al*. 1993	LOAEL (HEC): 57 ppm (201,000 µg/m^3)	300 (HQ= 1)	TCEQ, 2017	2007
ESL	Chronic	200	Peripheral neuropathy in humans	Chang *et al*. 1993	LOAEL (HEC): 57 ppm (201,000 µg/m^3)	300 (HQ= 0.3)	TCEQ, 2017	2007

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.34 Hydrogen Sulphide

CASRN 7783-06-4

The acute inhalation exposure limit of 7 µg/m^3 proposed by the MOE (2012) , and the chronic inhalation exposure limit of 2 µg/m^3, also proposed by the US EPA IRIS (2003) were used for the non-cancer assessment of hydrogen sulphide (Table A - 34). These exposure limits were chosen as the most conservative values.

Table A - 34 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	7	Health-based	NA	NA	NA	MOE, 2012	2012
Acute	24 hour	150	Eye-irritation	Savolaine, 1982	LOAEL: 15 mg/m^3	100	WHO, 2000	2000
MRL	Acute (30 minutes)	97.6 µg/m^3	Bronchial obstruction (humans)	Jäppinen et al., 1990	LOAEL: 5ppm	27	ATSDR, 2016	2016
RfC	Chronic	2	Nasal lesions of the olfactory mucosa	Brenneman et al., 2000	NOAEL (HEC) 0.64 mg//m^3	300	US EPA IRIS, 2003	2003
REL	Chronic	10 µg/m^3	Histopathological inflammatory changes in the nasal mucosa in B6C3F1 mice	CIIT, 1983	NOAEL 30.5 ppm (42.3 mg//m^3)	100	CalEPA, 2008	2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.35 Isopropyl Alcohol

CASRN 67-63-0

The acute inhalation exposure limit of 7,300 µg/m^3 proposed by the MOE (2012), and the provisional RfC of 200 µg/m^3 proposed by US EPA (2014) was utilized. It is important to note that there is medium confidence in the provisional RfC value. However, the provisional RfC value is more conservative than the REL of 7,000 µg/m^3 derived by the Cal EPA (2008) (Table A - 35).

Table A - 35 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	7,300	NA	NA	NA	NA	MOE, 2012	2012
REL	Chronic	7,000 µg/m^3	Kidney lesions in mice and rats; fetal growth retardation and developmental anomalies in rats	Burleigh-Flayer et al. (1997)	NOAEL (HEC): 90 ppm (220,000 µg/m^3)	30	Cal EPA, 2008	2000
p-RfC	Chronic	200	Decreased absolute and relative testes weights in male mice	Burleigh-Flayer et al. (1997)	LOAEL (HEC): 221 mg/m^3	1000	US EPA, 2014	2014
ESL	Chronic	492	NA	NA	NA	NA	TCEQ, 2018	2010

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

Burleigh-Flayer H, Garman R, Neptun D, Bevan C, Gardiner T, Kapp R, Tyler T, Wright G. 1997. Isopropanol vapor inhalation oncogenicity study in Fischer 344 rats and CD-1 mice. Fundam. Appl. Toxicol. 36(2):95-111.

Cal EPA. 2008. Appendix D.3 Chronic RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines (OEHHA 1999). California Environmental Protection Agency, Office of Environmental Health Hazard Assessment. Sacramento, CA. Available at: https://oehha.ca.gov/media/downloads/crnr/appendixd3final.pdf

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

U.S. EPA. 2014.Provisional Peer-Reviewed Toxicity Values for Isopropanol (Isobutyl Alcohol). U.S. Environmental Protection Agency, Washington, DC, EPA/690/R-14/009F, 2014. Available at: https://cfpub.epa.gov/ncea/pprtv/documents/Isopropanol.pdf

A-2.1.36 Methyl Butane (2-)

CASRN 78-78-4

The chronic inhalation exposure limit of 24,000 µg/m^3, proposed by the TCEQ (2015) was used for the non-cancer assessment of 2-methyl butane (Table A - 36).

Table A - 36 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	24,000	Free-standing NOAEL	Frontali et al. 1981	POD (HEC): 803.57 ppm (2,300 mg/m^3)	100 (HQ= 1)	TCEQ, 2011	2011
ESL	Chronic	7,100	Free-standing NOAEL	Frontali et al. 1981	POD (HEC): 803.57 ppm (2,300 mg/m^3)	100 (HQ= 0.3)	TCEQ, 2011	2011

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

Frontali N, MC Amantini, A Spagnolo et al. 1981. Experimental neurotoxicity and urinary metabolites of the C5-C7 aliphatic hydrocarbons used as glue solvents in shoe manufacture. *Clin Toxicol* 18: 1357-136.

TCEQ. 2011. Development Support Document. Pentane, All Isomers CAS Registry Numbers: n-Pentane: 109-66-0; Isopentane: 78-78-4; Neopentane: 463-82-1. Texas Commission on Environmental Quality. Available at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=567&fname=pentanes DSD

A-2.1.37 Methyl Cyclohexane

CASRN 108-87-2

The long-term effects screening level (ESL) of 1,6100 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 37 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ESL	Chronic	1,610	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

A-2.1.38 Methyl Ethyl Ketone

CASRN 78-93-3

The 24-hour inhalation exposure limit of 1,000 µg/m^3 proposed by MOE (2012) was selected for use in the assessment as it is proposed by the Ministry and is the only available TRV.

The chronic inhalation exposure limit of 5,000 µg/m^3,proposed by the US EPA (2003) was used for the non-cancer assessment of methyl ethyl ketone (Table A - 38). The exposure limit was chosen as it is the most conservative value. It was also supported by the MOE (2011).

Table A - 38 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	1,000	NA	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	5,000	Developmental toxicity (skeletal variations) in mice	US EPA IRIS, 2003	NA	NA	MOE, 2011	2011
RfC	Chronic	5,000	Developmental toxicity (skeletal variations) in mice	Schwetz et al., 1991	LEC (HEC) 1,517 mg/m^3	300	US EPA IRIS, 2003	2003
ReV	Chronic	8,800	No adverse effects observed	Cavender *et al.*,1983	POD (HEC): 900.2 ppm (2,700 mg/m^3)	300 (HQ= 1)	TCEQ, 2010	2010
ESL	Chronic	2,600	No adverse effects observed	Cavender *et al.*,1983	POD (HEC): 900.2 ppm (2,700 mg/m^3)	300 (HQ= 0.3)	TCEQ, 2010	2010

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

MOE. 2011. Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario. Standards Development Branch. Ontario Ministry of the Environment. PIBS: 7386e01.

Schwetz, B.A., Mast, T.J., Weigel, R.J. *et al.* 1991. Developmental toxicity of inhaled methyl ethyl ketone in Swiss mice. Fund Appl Toxicol 16: 742-748. Cited in: US EPA IRIS, 2003.

TCEQ. 2010. Development Support Document. Methyl Ethyl Ketone CAS Registry Number: 78-93-3. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=558&fname=methyl ethyl ketone DSD

US EPA IRIS. 2003. Chemical Assessment Summary - Methyl ethyl ketone (MEK) (CASRN 78-93-3). Integrated Risk Information System. US Environmental Protection Agency. Available at: https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0071_summary.pdf#nameddest=rfc

A-2.1.39 Methyl Hexane (2-) and Methyl Hexane (3-)

CASRN 591-76-4, 589-34-4

The chronic inhalation exposure limit of 9,000 µg/m^3, proposed by the TCEQ (2016) was used for the non-cancer assessment of 2-methyl hexane (Table A - 39).

TCEQ (2016) identified that "no chronic toxicity data were available describing the potential chronic toxicity of 6 other heptane isomers. For the purpose of effects evaluations for air permit applications and/or ambient air monitoring data, the chronic ReV and ESL of 9,000 and 2,700 µg/m^3 for n-heptane were used as a surrogate".

Table A - 39 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	9,000	Absence of effects on body weight gain, neuromuscular function, and neurotoxicity	Frontali et al. 1981	POD (HEC): 401.785 ppm (1,600 µg/m^3)	180 (HQ= 1)	TCEQ, 2016	2016
ESL	Chronic	2,700	Absence of effects on body weight gain, neuromuscular function, and neurotoxicity	Frontali et al. 1981	POD (HEC): 401.785 ppm (1,600 µg/m^3)	180 (HQ= 0.3)	TCEQ, 2016	2016

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

[a] Units of µg/m^3 unless otherwise noted.

References:

Frontali N, MC Amantini MC, A Spagnolo et al. 1981. Experimental neurotoxicity and urinary metabolites of the C5-C7 aliphatic hydrocarbons used as glue solvents in shoe manufacture. Clin Toxicol 18(12):1357-1367.

TCEQ. 2016. Development Support Document. Heptane, All Isomers CAS Registry Number: n-Heptane: 142-82-5; Other 8 Isomers. Texas Commission on Environmental Quality. Available at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=2522&fname=heptane DSD

A-2.1.40 Methyl Isobutyl Ketone

CASRN 108-10-1

The AAQC presented by the MOE (2012) are flagged to be updated as the MECP plans to update this value to be more relevant to odour effects. It is noted by the MOE (2012) that at this point, the value of 1,200 µg/m^3 is the basis of the half-sour MOE standards and guidelines. As such, this value was not selected for use in the assessment.

The chronic inhalation exposure limit of 3,000 µg/m^3 proposed by US EPA (2003) were utilized in the assessment as they were also endorsed by the Ministry.

Table A - 40 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	1,200	NA	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	3,000	Reduced fetal body weight, skeletal variation and increased fetal death in mice and skeletal variation in rats	Tyl et al., 1987	NOAEL (HEC) 1,026 mg/m^3	300	US EPA IRIS, 2003	2003
ESL	Chronic	82	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

US EPA IRIS. 2003. Methyl Isobutyl Ketone (MIBK) (CASRN 108-10-1). Integrated Risk Information System. US Environmental Protection Agency. Available at http://www.epa.gov/ncea/iris/subst/0173.htm.

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

MOE. 2011. Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario. Standards Development Branch. Ontario Ministry of the Environment. PIBS: 7386e01.

A-2.1.41 Methyl Pentane (2-) and Methyl Pentane (3-)

CASRN 107-83-5, 96-14-0

The acute inhalation exposure limit of 19,000 µg/m^3 and the chronic inhalation exposure limit of 190 µg/m^3, proposed by the TCEQ (2017) was used for the non-cancer assessment of 2-methyl pentane (Table A - 41).

TCEQ (2017) identified that "no acute toxicity data were available describing the potential acute toxicity of other hexane isomers. For the purpose of health effects evaluations for ambient air monitoring data, the acute 1-h and 24-h ReV value of 19,000 µg/m3 (5,500 ppb) for n-hexane will be used as surrogates".

Table A - 41 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Acute (24 hour)	19,000	Decreased fetal body weights	Mast et al. 1987	POD (HEC): 1,000 ppm (3,500 mg/m^3)	180 (HQ= 1)	TCEQ, 2017	2017
ReV	Chronic	190	Peripheral neuropathy	Chang et al. (1993)	POD (HEC): 57 ppm (200 µg/m^3)	300 (HQ= 1)	TCEQ, 2017	2017
ESL	Chronic	57	Peripheral neuropathy	Chang et al. (1993)	POD (HEC): 57 ppm (200 µg/m^3)	300 (HQ= 0.3)	TCEQ, 2017	2017

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

[a] Units of µg/m^3 unless otherwise noted.

References:

Chang, CM, CW Yu, KY Fong, et al. 1993. N-hexane neuropathy in offset printers. J. Neurol Neurosurg Psychiatry 56(5):538-42.

TCEQ. 2017. Development Support Document. Hexane, All Isomers CAS Registry Number: n-Hexane: 110-54-3; Other 4 Isomers. Texas Commission on Environmental Quality. Available at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=2939&fname=hexane DSD

A-2.1.42 Naphthalene

CASRN 91-20-3

The acute inhalation exposure limit of 22.5 µg/m^3 proposed by the MOE (2012) was selected for use in the assessment as it was the only health based TRV available.

The chronic inhalation exposure limit of 3.7 µg/m^3, proposed by ATSDR (2005) and endorsed by the Ministry, was used for the non-cancer assessment (Table A - 42).

The UR of 0 (µg/m^3)$^{-1}$ proposed by the MECP (2018) was used for the assessment of naphthalene. As per the guidance of the MECP's Human Toxicology and Air Standards Section, the toxic equivalency factor (TEF) assigned for Naphthalene is zero. The assessment uses the TEF scheme presented in the MECP (2018) document.

Table A - 42 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	22.5	Health-based	NA	NA	NA	MOE, 2012	NA
RfC	Chronic	3.7	NA	ATSDR, 2005	NA	NA	MOE, 2011	2011
MRL	Chronic	3.7	Non-neoplastic lesions in nasal olfactory epithelium and respiratory epithelium (rats)	NTP, 1992; NTP, 2000; Abdo *et al*., 2001	LOAEL (HEC) 0.2 ppm	300	MOE, 2011; ATSDR, 2005	2007
RfC	Chronic	3	Nasal effects, hyperplasia, and metaplasia in respiratory and olfactory epithelium (mouse)	NTP, 1992	LOAEL (HEC): 9.3 mg/m^3	3000	US EPA IRIS, 1998	1998
REL	Chronic	9 µg/m^3	Respiratory effects (nasal inflammation, olfactory epithelial metaplasia, respiratory epithelial hyperplasia) in mice	NTP, 1992	LOAEL (ADJ): 1.8 ppm (9,400 µg/m^3)	1,000	Cal EPA, 2000	2000
ESL	Chronic	50	NA	NA	NA	NA	TCEQ, 2018	2015
UR	Chronic	0 (µg/m^3)$^{-1}$	Based on a Benzo(a)pyrene TEF of 0, and the inhalation unit risk recommended by MECP (2018)	-	-	-	MECP, 2018	2018

Table A - 42 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	$3.4x10^{-5}$ $(\mu g/m^3)^{-1}$	Nasal respiratory epithelial adenoma and nasal olfactory epithelial neuroblastoma in male rats	NTP (1992; 2000	NA	NA	Cal EPA, 2009	1992, 2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.

References:

ATSDR. 2005. Toxicological Profile for Naphthalene, 1-Methylnaphthalene and 2-Methylnaphthalene. US Department of Health and Human Services. Public Health Service Agency for Toxic Substances and Disease Registry. August, 2005. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp67.pdf. [February 1, 2013].

Cal EPA. 2000. Appendix D.3 Chronic RELs and toxicity summaries using the previous version of the Hot Spots Risk Assessment guidelines. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology Section. April, 2000. Available at: https://oehha.ca.gov/media/downloads/crnr/appendixd3final.pdf

MECP. 2018. Human Health Toxicity Reference Values (TRVs) Selected for Benzo[a]pyrene. Prepared by: Human Toxicology and Air Standards Section, Technical Assessment and Standards Development Branch, Ontario Ministry of the Environment, Conservation and Parks. October 2018.

MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

NTP. 1992. Toxicology and carcinogenesis studies of naphthalene in B6C3F1 mice (inhalation studies). National Toxicology Program Technical Report Series No. 410. NIH Publication No. 92-3141.Cited in US EPA IRIS, 1998 and Cal EPA, 2000

NTP. 2000. Toxicology and Carcinogenesis Studies of Naphthalene (CAS No. 91-20-3) in F344/N Rats (Inhalation Studies). Technical Report Series No. 500. NIH Publication No. 00-4434. U.S. Department of Health and Human Services, Public Health Service, National Institutes of Health. NTP, Research Triangle Park, NC.

Cal EPA. 2009. OEHHA - Air Toxics Hot Spots Program Technical Support Document for Cancer Potencies. Appendix B. https://oehha.ca.gov/air/crnr/technical-support-document-cancer-potency-factors-2009Chemical-specific summaries of the information used to derive unit risk and cancer potency values. Updated 2011. Available at: https://oehha.ca.gov/media/downloads/crnr/appendixb.pdf

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

US EPA IRIS. 1998. Chemical Assessment Summary - Naphthalene (CASRN 91-20-3). United States Environmental Protection Agency Integrated Risk Information System. Available at https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0436_summary.pdf#nameddest=rfc

Abdo KM, Grumbein S, Chou BJ, et al. 2001. Toxicity and carcinogenicity study in F344 rats following 2 years of whole-body exposure to naphthalene vapors. Inhal Toxicol 13:931-950.

A-2.1.43 Nitrogen Dioxide (NO_2)

CASRN 10102-44-0

The 24-hour acute inhalation exposure limit of 200 µg/m^3 proposed by the MOE (2012) and the annual inhalation exposure limit of 40 µg/m^3 proposed by the WHO (2006) were used for the assessment of nitrogen dioxide (Table A - 43). These values were chosen based on their level of conservatism and considering the date of their most recent validation.

Table A - 43 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	200 [b]	Health-based	NA	NA	NA	MOE, 2012	NA
NAAQS (1-hour)	Acute	100	NA	NA	NA	NA	US EPA, 2019	2010
REL (1 hour)	Acute	470-	Respiratory effects	CARB,1992	NA	NA	Cal EPA, 2016	2016
NAAQOMAL; 24-hour	Acute	200	Health based	NA	NA	NA	CCME, 1999	published 1975; reviewed 1989
MDL; Annual Average	Chronic	60	Health based	NA	NA	NA	CCME, 1999	published 1975; reviewed 1989
NAAQS; Annual Average	Chronic	53	Health based	NA	NA	NA	US EPA, 2012	1971
AQG; Annual Average	Chronic	40	Respiratory effects	NA	NA	NA	WHO, 2006	NA

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

[a] Units of µg/m^3 unless otherwise noted.

[b] AACQ for NO_2 with a 24-hour averaging time should only be compared to NO_2 data..

References:

CCME. 1999. Canadian National Ambient Air Quality Objectives: Process and Status. Canadian Council of Ministers of the Environment. Available at: ceqg-rcqe.ccme.ca/download/en/133/

MOE. 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. Available at: http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079182.pdf

US EPA. 2019. NAAQS Table. Available at: https://www.epa.gov/criteria-air-pollutants/naaqs-table. [Accessed December 16, 2019]

US EPA. 2010. Code of the Federal Register. Environmental Protection Agency. 40 CFR Parts 75 (26). Primary National Ambient Air Quality Standard for Nitrogen Dioxide; Final Rule. United States Environmental Protection Agency.

WHO. 2006. Air Quality Guidelines: Global Update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide. World Health Organization. ISBN 92 890 2192 6.

A-2.1.44 Nonane

CASRN 111-84-2

The provisional chronic inhalation exposure limit of 20 µg/m^3 proposed by US EPA (2009) was selected for the assessment (Table A - 44). This exposure limit was chosen as it is the most conservative value. It is important to note that there is low to medium confidence in the principal study (US EPA, 2009) and the confidence in the chronic p-RfC is low.

Table A - 44 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
p-RfC	Sub-chronic	2	NA	Carpenter et al. (1978)	NOAEL $_{HEC}$ 66.4 mg/m^3	300	US EPA (2009)	2009
p-RfC	Chronic	20	NA	Carpenter et al. (1978)	NOAEL $_{HEC}$ 66.4 mg/m^3	3000	US EPA (2009)	2009
ReV	Chronic	1,500	Decrease in body weight gains, transient CNS effects in rats	Carpenter et al. (1978)	POD (HEC): 52.995 ppm (280 mg/m^3)	180 (HQ= 1)	TCEQ, 2016	2016
ESL	Chronic	450	Decrease in body weight gains, transient CNS effects in rats	Carpenter et al. (1978)	POD (HEC): 52.995 ppm (280 mg/m^3)	180 (HQ= 0.3)	TCEQ, 2016	2016

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

Carpenter CP, DL Geary, Jr., RC Myers et al. 1978. Petroleum Hydrocarbon Toxicity Studies XVII. Animal response to n-nonane vapor. Toxicol Appl Pharmacol 44: 53-61.

TCEQ. 2016. Development Support Document. Nonane, All Isomers CAS Registry Number: n-Nonane: 111-84-2 Other 34 Isomers. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=2501&fname=Nonane DSD_Final

U.S. EPA. 2009. Provisional Peer-Reviewed Toxicity Values for Nonane, n-. U.S. Environmental Protection Agency, Washington, DC, EPA/690/R-09/043F, 2009. Available at: https://cfpub.epa.gov/ncea/pprtv/documents/Nonanen.pdf

A-2.1.45 Octane

CASRN 111-65-9

The chronic inhalation exposure limit of 1,800 µg/m^3 proposed by the TCEQ (2016) was used for the non-cancer assessment (Table A - 45). This value was selected for use in the assessment as it was the only TRV available.

Table A - 45 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	1,800	Absence of general systemic effects	Sung et al., 2010	POD (HEC): 210.856 ppm (990 mg/m^3)	540 (HQ= 1)	TCEQ, 2016	2016
ESL	Chronic	540	Absence of general systemic effects	Sung et al., 2010	POD (HEC): 210.856 ppm (990 mg/m^3)	540 (HQ= 0.3)	TCEQ, 2016	2016

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

TCEQ. 2016. Development Support Document. Octane, All Isomers CAS Registry Number: Octane: 111-65-9; 2,2,4-Trimethylpentane (Isooctane): 540-84-1 Other 16 Isomers. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=2500&fname=Octane DSD_Final

Sung JH, BG Choi, HY Kim et al. 2010. Acute and Subchronic Inhalation Toxicity of n-Octane in Rats. Saf Health Work 1(2):192-200

A-2.1.46 Carcinogenic Polycyclic Aromatic Hydrocarbons (PAHs)

As indicated in Health Canada (2010), MECP (2018), as well as most other regulatory guidance, including the US EPA (1993), the assessment of risks related to exposures to carcinogenic PAHs is primarily conducted through the use of potency or toxicity equivalence factors (PEF or TEF). TEFs allow large groups of compounds with a common mechanism of action such as PAHs to be assessed when limited data is available for all but one of the compounds (*i.e.*, B(a)P). Through this approach, exposures to each of the carcinogenic PAHs are adjusted by their carcinogenic potency relative to B(a)P. These potency-adjusted exposures can then be summed to provide an overall exposure to the group of carcinogenic PAHs, based on B(a)P as the primary surrogate. However, in the current assessment, it was assumed that the benzo(a)pyrene values are representative of the B(a)P TEQ.

The UR of $6.0x10^{-4}$ $(\mu g/m^3)^{-1}$ proposed by the MECP (2018) was used for the assessment of carcinogenic PAHs (as toxic equivalents of benzo(a)pyrene) (Table A - 46).

The SF of $1.0x10^{-3}$ $(\mu g/kg/d)^{-1}$ proposed by MECP (2018) was used for the assessment of carcinogenic PAHs (as toxic equivalents of benzo(a)pyrene) (Table A - 47).

Table A - 46 Inhalation Toxicity Reference Values (PAHs as Benzo(a)pyrene Toxic Equivalents)

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	$6.0x10^{-4}$	Upper respiratory tract & pharynx tumours, all treated as incidental to the cause of death	Thyssen et al., 1981	$BMCL_{10}$ of 0.163 mg/m^3	NA	MECP, 2018; US EPA IRIS, 2017	2017
UR	Chronic	$8.7x10^{-2}$	Incidence of lung cancer	WHO, 1998	NA	NA	WHO, 2000	2000
UR	Chronic	$3.1x10^{-5}$	Respiratory tract tumours	Thyssen *et al*., 1981	NA	NA	Health Canada, 2010	2010
UR	Chronic	$1.1x10^{-3}$	Respiratory tract tumours	Thyssen *et al*., 1981	NA	NA	Cal EPA, 2011	2009

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $(\mu g/m^3)^{-1}$ unless otherwise noted.

Table A - 47 Oral Toxicity Reference Values (PAHs as Benzo(a)pyrene Toxic Equivalents)

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
SF	Chronic	$1.0x10^{-3}$	Dose-dependent increase in alimentary tract tumours (forestomach, esophagus, tongue, larynx) (mouse)	US EPA IRIS 2017; Kalberlah et al., 1995	$BMDL_{10HED}$	NA	MECP, 2018	2017
SF	Chronic	$2.3x10^{-3}$	Gastric tumours (mostly squamous cell papillomas, with a few carcinomas)	Neal and Rigdon, 1967	NA	NA	Health Canada, 2010	2010

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $(\mu g/kg/d)^{-1}$ unless otherwise noted.

References:

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A-2.1.47 Respirable Particulate Matter ($PM_{2.5}$)

The Canadian Ambient Air Quality Standards (CAAQS) acute and chronic values, proposed for 2020, of 27 and 8.8 µg/m^3, respectively, were selected for the assessment of $PM_{2.5}$ (Table A - 48). These values were chosen based on their level of conservatism and considering the date of their most recent validation.

Table A - 48 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	30	NA	NA	NA	NA	MOE, 2012	2012
CAAQS; 24-hour	Acute	27[b]	Respiratory tract irritation	NA	NA	NA	CCME, 2012	2012
NAAQS; 24-hour	Acute	35	Mortality and morbidity	NA	NA	NA	US EPA, 2010	2012
AQG; 24-hour	Acute	25	NA	NA	NA	NA	WHO, 2006	NA
CAAQS	Chronic	8.8[b]	Cardiopulmonary and lung cancer mortality increase	NA	NA	NA	CCME, 2012	2012
NAAQS	Chronic	15	NA	NA	NA	NA	US EPA, 2010	NA
AQG	Chronic	10	Lowest levels at which total, cardiopulmonary and lung cancer mortality has been shown to increase	NA	NA	NA	WHO, 2006	NA

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.
[b] Compliance by 2020

References:

CCME. 2012. Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone. Canadian Council of Ministers of the Environment. PN 1483 ISBN: 978-1-896997-91-9 PDF. Available at: https://www.ccme.ca/files/Resources/air/pn_1483_gdad_eng.pdf

CCME. 1999. Canadian National Ambient Air Quality Objectives: Process and Status. Canadian Council of Ministers of the Environment. Available at: ceqg-rcqe.ccme.ca/download/en/133/

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WHO. 2006. Air Quality Guidelines: Global Update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide. World Health Organization. ISBN 92 890 2192 6.

A-2.1.48 Inhalable Particulate Matter (PM_{10})

The 24-hour acute inhalation exposure limit of 50 µg/m³ and the annual inhalation exposure limit of 20 µg/m³, both proposed by the WHO (2006) were used for the assessment of PM_{10} (Table A - 49). The 24-hour AQG recommended by WHO (2006) is consistent with the MOE (2012) 24-hour AAQC. These values were chosen based on their level of conservatism and considering the date of their most recent validation, and in the case of the annual exposure limit, the absence of other available values.

Table A - 49 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC (interim); 24-hour	Acute	50	NA	NA	NA	NA	MOE, 2012	NA
CAAQS; 24-hour	Acute	27[b]	Respiratory tract irritation	NA	NA	NA	CCME, 2012	2012
NAAQS; 24-hour	Acute	150	Cardiovascular and respiratory hospital admissions and respiratory symptoms	NA	NA	NA	US EPA, 2019	2012
AQG; 24-hour	Acute	50	Respiratory tract irritation	NA	NA	NA	WHO, 2006	NA
AQG Annual	Chronic	20	Lowest levels at which total, cardiopulmonary and lung cancer mortality has been shown to increase	NA	NA	NA	WHO, 2006	NA

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m³ unless otherwise noted.

References:

CCME. 1999. Canadian National Ambient Air Quality Objectives: Process and Status. Canadian Council of Ministers of the Environment. Available at: ceqg-rcqe.ccme.ca/download/en/133/

MOE. 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. Available at: http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079182.pdf

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WHO. 2006. Air Quality Guidelines: Global Update 2005. Particulate matter, ozone, nitrogen dioxide and sulphur dioxide. World Health Organization. ISBN 92 890 2192 6.

A-2.1.49 Pentane

CASRN 109-66-0

The provisional RfC of 1,000 µg/m^3 proposed by US EPA (2009) was utilized. It is important to note that there is low confidence in the provisional chronic RfC due to low confidence in the database used to derive the value. However, the value is more conservative than the chronic ReV derived by the Texas Commission on Environmental Quality (TCEQ).

Table A - 50 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
ReV	Chronic	24,000	Free-standing NOAEL	Frontali et al. 1981	POD (HEC): 803.57 ppm (2,300 mg/m^3)	100 (HQ= 1)	TCEQ, 2011	2011
ESL	Chronic	7,100	Free-standing NOAEL	Frontali et al. 1981	POD (HEC): 803.57 ppm (2,300 mg/m^3)	100 (HQ= 0.3)	TCEQ, 2011	2011
p-RfC	Chronic	1,000	Free-standing NOAEL	McKee et al., 1998	NOAEL (HEC) 3,658 mg/m^3	3000	US EPA, 2009	2009
p-RfC	Sub-chronic	10,000	Free-standing NOAEL	McKee et al., 1998	NOAEL (HEC) 3,658 mg/m^3	300	US EPA, 2009	2009

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

Frontali N, MC Amantini, A Spagnolo et al. 1981. Experimental neurotoxicity and urinary metabolites of the C5-C7 aliphatic hydrocarbons used as glue solvents in shoe manufacture. *Clin Toxicol* 18: 1357-136.

TCEQ. 2011. Development Support Document. Pentane, All Isomers CAS Registry Numbers: n-Pentane: 109-66-0 Isopentane: 78-78-4 Neopentane: 463-82-1. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=140&fname=pentanes DSD

U.S. EPA. 2009. Provisional Peer-Reviewed Toxicity Values for Pentane, n-. U.S. Environmental Protection Agency, Washington, DC, EPA/690/R-09/044F, 2009. Available at: https://cfpub.epa.gov/ncea/pprtv/documents/Pentanen.pdf

A-2.1.50 Propyl Benzene

CASRN 103-65-1

The provisional RfC presented by US EPA (2009) of 1,000 µg/m^3 was selected as the chronic inhalation exposure limit. The inhalation values are based on using ethylbenzene as a surrogate. This value was selected for use in the assessment as it was the only TRV available.

Table A - 51 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
pRfC	Chronic	1,000	Reduced litter size; increased relative liver, kidney, and spleen weights of dams; skeletal variations	Andrew et al., 1981; Hardin et al., 1981	NOAEL:434 mg/m^3	300	US EPA, 2009	1991
ESL	Chronic	51	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

Andrew, F.D., R.L. Buschbom, W.C. Cannon, R.A. Miller, L.F. Montgomery, D.W. Phelps et al. 1981. Teratologic ssessment of Ethylbenzene and 2-Ethoxyethanol. Battelle Pacific Northwest Laboratory, Richland, WA. PB 83- 208074, 108.

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U.S. EPA. 2009. Provisional Peer-Reviewed Toxicity Values for Propylbenzene, n-. U.S. Environmental Protection Agency, Washington, DC, EPA/690/R-09/049F, 2009. Available at: https://cfpub.epa.gov/ncea/pprtv/documents/Propylbenzenen.pdf

A-2.1.51 Styrene

CASRN 100-42-5

The acute inhalation exposure limit of 400 µg/m^3 proposed by the MOE (2012) was selected for use in this assessment. While no scientific basis is provided for this limit, this value was selected for use in the assessment as it was the only appropriate TRV identified.

The chronic inhalation exposure limit of 260 µg/m^3 proposed by the Ministry was selected for use in the assessment (MOE, 2011).

Table A - 52 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	400	NA	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	260	NA	Modified from WHO, 2000	NA	NA	MOE, 2011	2011
TC	Chronic	92	decreased pup body weight, decreased neuroamines, neurological /behavioural changes	Kishi et al.,1992	LOAEL: 260 mg/m^3	500	Health Canada, 2010	2010
MRL	Chronic	0.2 ppm (~870 µg/m^3)	Reversible clinical colour vision change (human)	Meta-analysis of multiple studies	LOAEL (ADJ): 4.8 ppm (~21,000 µg/m^3)	30	ATSDR, 2010	2010
RfC	Chronic	1,000	Neurological effects (human)	Mutti *et al.*, 1984	NOAEL (HEC): 34 mg/m^3 (34,000 µg/m^3)	30	US EPA IRIS, 1992	1992
REL	Chronic	900	Neuropyschological deficit in humans	Mutti *et al.*, 1984	BMC_{05} (HEC): 0.61 ppm (~2,600 µg/m^3)	3	Cal EPA, 2000	2000
ReV	Chronic	470	Neurological effects (human)	Mutti *et al.*, 1984; Rabovsky *et al.*, 2001	$BMCL_{05}$ (HEC): 0.11 ppm (470 µg/m^3)	1 (HQ= 1)	TCEQ, 2008	2008
ESL	Chronic	140	Neurological effects (human)	Mutti *et al.*, 1984; Rabovsky *et al.*, 2001	$BMCL_{05}$ (HEC): 0.11 ppm (470 µg/m^3)	1 (HQ= 0.3)	TCEQ, 2008	2008

Table A - 52 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AQG	Weekly average	260	Subtle reductions in visuomotor accuracy and verbal learning skills and subclinical effects on colour vision (human)	NA	LOAEL (ADJ) (25.5 mg/m^3) (25,500 µg/m^3)	100	WHO, 2000	NA
TCA	Chronic	900	Neurological effects in humans	Mutti *et al.*, 1984	NOAEC (ADJ): 6 ppm (26,000 µg/m^3)	30	RIVM, 2001	2001

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

ATSDR. 2010. Toxicological Profile for Styrene. Agency for Toxic Substances and Disease Control, Public Health Service, US Department of Health and Human Services. Available at: https://www.atsdr.cdc.gov/toxprofiles/tp53.pdf

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MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

MOE. 2011. Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario. Standards Development Branch. Ontario Ministry of the Environment. PIBS: 7386e01.

Mutti, A., Mazzucchi, A., Rusticelli, P., Frigeri, G., Arfini, G. and Franchini, I. 1984. Exposure effect and exposure-response relationships between occupational exposure to styrene and neuropsychological functions. Am J Ind Med 5:275-286. Cited in: TCEQ, 2008, Cal EPA, 2000, US EPA IRIS, 1993, and RIVM, 2001.

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TCEQ. 2008. Development Support Document. Styrene CAS Registry Number: 100-42-5. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=toxicology.public_documents_open&docid=164&fname=styrene DSD

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WHO. 2000. Air Quality Guidelines for Europe (2nd Edition) Regional Office for Europe, Copenhagen. World Health Organization Regional Publications, European Series, No. 91. Available at: http://www.euro.who.int/document/e71922.pdf

WHO. 2002. Air Quality Guidelines for Europe, 2nd Edition. WHO Regional Publications, European Series, No. 91. Copenhagen. (2000)

A-2.1.52 Sulphur Dioxide (SO_2)

CASRN 7446-09-5

The 24-hour acute inhalation exposure limit of 275 µg/m^3 proposed by the MOE (2012) and the Canadian Ambient Air Quality Standards (CAAQS) chronic value, proposed for 2025, of 10 µg/m^3 (4 ppb) were selected for the assessment(Table A - 53). The values were chosen considering the date of their most recent validation.

Table A - 53 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	275	Respiratory tract irritation	NA	NA	NA	MOE, 2012	NA
AQG; 24-hour	Acute	20	NA	NA	NA	NA	WHO, 2006	NA
MRL; 14 days or less	Acute	26	Respiratory irritation	Sheppard *et al*., 1981	LOAEL: 0.1 ppm (262 µg/m^3)	9	ATSDR, 1998	NA
CAAQS (Annual)	Chronic	10 (4 ppb)[b]	NA	NA	NA	NA	CCME 2016	2016
AAQC; Annual	Chronic	55	NA	NA	NA	NA	MOE, 2012	NA

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

[a] Units of µg/m^3 unless otherwise noted.

[b] Compliance by 2025

References:

ATSDR. 1998. Toxicological Profile for Sulfur Dioxide. US Public Health Service, Department of Health and Human Services, Atlanta, GA. Agency for Toxic Substances and Disease Registry. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp116.pdf

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MOE. 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. Ontario Ministry of the Environment. Available at: http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079182.pdf

Sheppard, D., Saisho, A., Nadel, J.A., *et al.* 1981. Exercise increases sulfur dioxide-induced bronchoconstriction in asthmatic subjects. Am Rev Respir. 123: 486-491.

A-2.1.53 Tetrachloroethane (1,1,2,2-)

CASRN 79-34-5

The long-term effects screening level (ESL) of 7 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for 1,1,2,2-tetrachloroethane. The Tox ESL-Summary Report indicated that the the long-term ESL was derived on October 1st, 2003 where the source codes were presented as "FRG-MAK; NIOSH; TLV". This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

The UR of 5.8x10^{-5} (µg/m^3)$^{-1}$ proposed by the MOE (2011) was used for the carcinogenic assessment of 1,1,2,2-tetrachloroethane. It is important to note that although MOE (2011) endorsed the US EPA IRIS (1994) IUR of 5.8x10^{-5} (µg/m^3)$^{-1}$ for 1,1,2,2-tetrachloroethane, US EPA IRIS conducted a review of the available toxicological data and derived new exposure limits for 1,1,2,2-tetrachloroethane in 2010. Based on the available data, US EPA IRIS (2010) no longer endorses the IUR derived in 1994 and has not derived a new IUR for 1,1,2,2-tetrachloroethane. As such, there may be uncertainty associated with utilizing the MOE (2011) endorsed IUR. This value is presented in the RSL summary tables (US EPA, 2019).

Table A - 54 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	5.8 x 10^{-5} (µg/m^3)$^{-1}$	Hepatocellular carcinoma in mice	NCI, 1978 cited in US EPA IRIS, 1994	NA	NA	MOE, 2011	2011
ESL	Chronic	7	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

References:

MOE. 2011. Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario. Standards Development Branch. Ontario Ministry of the Environment. PIBS: 7386e01.

NCI. 1978. Bioassay of 1,1,2,2,-Tetrachloro- ethane for possible carcinogenicity. U.S. Dept. Health, Education and Welfare. Pub. No. (NIH) 78-827). Cited In: US EPA IRIS, 1994.

TCEQ. 2018. Texas Air Monitoring Information System Web Interface - Tox ESL-Summary Report. Texas Commission on Environmental Quality. Available on-line at: https://www17.tceq.texas.gov/tamis/index.cfm?fuseaction=home.welcome

US EPA IRIS. 1994. 1,1,2,2-Tetrachloroethane (CASRN 78-34-5): Carcinogencity Assessment. U.S. Environmental Protection Agency Integrated Risk Information System Database. Available at: http://www.epa.gov/ncea/iris/subst/0193.htm.

US EPA. 2019. Regional Screening Level Summary Table (TR=1E-06, THQ=0.1) Available at: https://semspub.epa.gov/work/HQ/199628.pdf

A-2.1.54 Tetrachloroethylene

CASRN 127-18-4

The 24-hour acute inhalation exposure limit of 360 µg/m^3 proposed by the MOE (2012) was used for the assessment of tetrachloroethylene (Table A - 55). The acute exposure limit was chosen as it was a health-based value identified by the Ministry. The chronic inhalation exposure limit of 40 µg/m^3 derived by US EPA IRIS (2012) and endorsed by MECP was selected in the assessment given that it was the most conservative and scientifically defensible value.

The IUR of 2.6 x 10^{-7} (µg/m^3)$^{-1}$ derived by US EPA IRIS (2012) and endorsed by MECP was selected in the assessment due to its scientific defensibility.

Table A - 55 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
MRL	Acute	41	Neurotoxicity in humans	Cavalleri *et al*., 1994	LOAEL: 1.7 ppm	100	ATSDR2014	1997
AAQC; 24-hour	Acute	360	Health-based	NA	NA		MOE, 2012	2012
RfC	Chronic	40	Neurotoxicity (human)	Echeverria *et al*., 1995; Cavalleri *et al*., 1994	LOAEL: 56; LOAEL: 15	1,000	MECP, 2019; US EPA IRIS, 2012	2012
ReV	Chronic	370	Behavioural effects: increased reaction times	Ferroni *et al*., 1992	POD (HEC): 5.4 ppm (37,000 µg/m^3)	100 (HQ=1)	TCEQ, 2015	2015
ESL	Chronic	110	Behavioural effects: increased reaction times	Ferroni *et al*., 1992	POD (HEC): 5.4 ppm (37,000 µg/m^3)	100 (HQ=0.3)	TCEQ, 2015	2008
MRL	Chronic	41	Increased color confusion index	Cavalleri *et al*., 1994; Gobba et al. 1998	LOAEL: 1.7 ppm	100	ATSDR2014	1997
AQG	Chronic	250	Kidney effects	NA	LOAEL (ADJ): 24.3 mg/m^3 (24,300 µg/m^3)	100	WHO, 2000	2000
RfC	Chronic	250	NA	NA	NA	NA	MOE, 2011	2011
TCA	Chronic	250	NA	NA	NA	NA	RIVM, 2001	2001
REL	Chronic	35	Alimentary system (liver), kidney	NA	NA	NA	Cal EPA, 1991	1991
TC	Chronic	360	Nephrotoxic, hepatotoxic, lung congestion, mononuclear cell leukemia	NTP, 1986	LOAEL (ADJ): 363 mg/m^3 (363,000 µg/m^3)	1000	Health Canada, 2010	2010
Unit risk	Chronic	2.6 x10^{-7} (µg/m^3)$^{-1}$	Hepatocellular adenomas or carcinomas (mice)	JISA , 1993	NA	NA	MECP, 2019; US EPA IRIS, 2012	2012

Table A - 55 Inhalation Toxicity Reference Values								
Type	***Duration***	***Value***[a]	***Critical Effect***	***Reference***	***Point of Departure***	***UF***	***Source***	***Derived***
Unit risk	Chronic	3.8×10^{-7} $(\mu g/m^3)^{-1}$	Increase in incidences of hepatocellular carcinomas	NTP, 1986	NA	NA	TCEQ, 2015	2008
Unit risk	Chronic	6.1×10^{-6} $(\mu g/m^3)^{-1}$	NA	NA	NA	NA	Cal EPA, 2019	2019

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.

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A-2.1.55 Toluene

CASRN 108-88-3

The acute inhalation exposure limit of 7,600 µg/m^3 proposed by the ATSDR (2017), and the annual inhalation exposure limit of 3,800 µg/m^3 proposed by the ATSDR (2017) were used for the assessment of toluene (Table A - 56). The acute exposure limit was chosen as it was the only appropriate value available. The chronic exposure limit of 5,000 µg/m^3 was selected in the assessment as it is endorsed by MECP (2019).

Table A - 56 Inhalation Toxicity Reference Values

Type	*Duration*	*Value* [a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
MRL	Acute	7,600	Minimally adverse neurological effects in a susceptible population in humans	Little *et al*., 1999	LOAEL: 15 ppm (57,000 µg/m^3)	9	ATSDR, 2017	2017
RfC	Chronic	5,000	Neurological effects in occupationally-exposed workers	Multiple human studies	NOAEL (ADJ): 46,000 µg/m^3	10	US EPA IRIS, 2005	2005
RfC	Chronic	5,000	NA	US EPA IRIS, 2005	NA	NA	MOE, 2011	NA
MRL	Chronic	3,800	Neurological effects in humans	Multiple human studies	NOAEL: 45 ppm (170 mg/m^3)	10	ATSDR, 2017	2017
TC	Chronic	3,750	Increased relative liver and kidney weight neurotoxic, irritation of the respiratory tract	Andersen *et al*., 1983	NOAEL (ADJ): 37.5 mg/m^3 (37,500 µg/m^3)	10	Health Canada, 2010	2010
REL	Chronic	300	Decreased brain (subcortical limbic area) weight, altered dopamine receptor (caudate-putamen) binding	Hillefors-Berglund *et al*., 1995; Foo *et al*., 1990	NOAEL (ADJ): 7 ppm (26,000 µg/m^3)	100	Cal EPA, 2008	2000
ReV	Chronic	4,100	Colour vision impairment in humans	Zavalic *et al*., 1998	NOAEL: 11 ppm (41,000 µg/m^3)	10 (HQ= 1)	TCEQ, 2015	2008
ESL	Chronic	1,200	Colour vision impairment in humans	Zavalic *et al*., 1998	NOAEL: 11 ppm (41,000 µg/m^3)	10 (HQ= 0.3)	TCEQ, 2015	2008

Table A - 56 Inhalation Toxicity Reference Values								
Type	***Duration***	***Value*** [a]	***Critical Effect***	***Reference***	***Point of Departure***	***UF***	***Source***	***Derived***
TCA	Chronic	400	Neurological effects	NA	NA	NA	RIVM, 2001	1999/2000

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.56 Total Mercaptans (as Methyl Mercaptan)

CASRN 74-93-1

The acute inhalation exposure limit of 7 µg/m^3 proposed by the Ministry (MOE, 2012) for total reduced sulphur compounds was selected for the assessment of total mercaptans.

The long-term effects screening level of 1 µg/m^3, proposed by the TCEQ (2018) was used for the non-cancer assessment (Table A - 57). This exposure limit was chosen as there are no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 57 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	7	Health based	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	1	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.57 Total Reduced Sulphur (TRS)

The acute inhalation exposure limit of 7 µg/m^3 proposed by the Ministry (MOE, 2012) was used for the non-cancer assessment of TRS (Table A - 58).

Table A - 58 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	7	Health based	NA	NA	NA	MOE, 2012	2012

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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MOE (Ontario Ministry of the Environment). 2012. Ontario's Ambient Air Quality Criteria (AAQCs). Standards Development Branch. Ontario Ministry of the Environment. PIBS: 6570e01. Available at: http://www.airqualityontario.com/downloads/AmbientAirQualityCriteria.pdf

A-2.1.58 Trichloro-1,2,2-Trifluroethane (1,1,2-)

CASRN 76-13-1

The long-term effects screening level (ESL) of 3,800 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for 1,1,2-Trichloro-1,2,2-Trifluroethane. The Tox ESL-Summary Report indicated that the long-term ESL was derived on October 1st, 2003 where the source codes were presented as "FRG-MAK". This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

The MOE (2012) has derived a 24-hour AAQC of 800,000 µg/m^3. Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry and was identified to be health based.

Table A - 59 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	800,000	Health-based	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	3,800	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.59 Trichloroethane (1,1,1-)

CASRN 71-55-6

The acute inhalation exposure limit of 115,000 µg/m^3 proposed by MOE (2012), and the chronic inhalation exposure limit of 1,000 µg/m^3, proposed by the Cal EPA (2014) and endorsed by MECP, were used for the non-cancer assessment of 1,1,1-trichloroethane (Table A - 60). The MOE (2012) was selected as the value is a health-based value endorsed by the Ministry.

Table A - 60 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	115,000	Health-based	NA	NA	NA	MOE, 2012	2012
MRL	Acute	10,900 µg/m^3	Reduced performance of psychomotor tests in humans	Mackay et al. (1987)	LOAEL: 175 ppm (µg/m^3)	100	ATSDR, 2006	2006
RfC; 24-hour	Acute	6,000	Performance on neurobehavioral tests	Mackay et al. (1987)	LOAEL: 950 mg/m^3	100	US EPA IRIS, 2007	US EPA IRIS, 2007
RfC	Chronic	5,000	Liver histopathologic changes	Quast et al. (1988, 1984); McNutt et al. (1975)	NOAEL (HEC): 1,553 mg/m^3	100	US EPA IRIS, 2007	US EPA IRIS, 2007
REL	Chronic	1,000 µg/m^3	Astrogliosis in the sensorimotor cortex (brain) of gerbils	Rosengren et al. (1985)	LOAEL: 210 ppm (1,146 mg/m^3)	300	Cal EPA, 2000	2000
ReV	Chronic	5,100	Slight microscopic hepatic changes	Quast et al. (1988)	POD (HEC): 283.1 ppm (1,500 µg/m^3)	300 (HQ = 1)	TCEQ, 2011	2011
ESL	Chronic	1,500	Slight microscopic hepatic changes	Quast et al. (1988)	POD (HEC): 283.1 ppm (1,500 µg/m^3)	300 (HQ = 0.3)	TCEQ, 2011	2011

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

REL: reference exposure level, ReV: reference value, RfC: reference concentration, MRL: minimal risk level, ESL,

NA Not available.

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A-2.1.60 Trichloroethane (1,1,2-)

CASRN 79-00-5

The UR of $1.6x10^{-5}$ $(\mu g/m^3)^{-1}$ endorsed by MOE (2011) and referencing US EPA was used for the assessment of 1,1,2-trichloroethane (Table A - 61). It is important to note that US EPA has stated that the unit risk should not be used if the air concentration exceeds 600 $\mu g/m^3$, since above this concentration the unit risk may not be appropriate. The inhalation unit risk was calculated from oral exposure data, where the extrapolation method was identified to be through linearized multistage procedure.

Table A - 61 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
UR	Chronic	$1.6x10^{-5}$ $(\mu g/m^3)^{-1}$	NA	US EPA IRIS, 1994	NA	NA	MOE, 2011	2011
UR	Chronic	$1.6x10^{-5}$ $(\mu g/m^3)^{-1}$	Hepatocellular carcinomas in mice	NCI, 1978	NA	NA	US EPA IRIS, 1987	1987
UR	Chronic	$1.6x10^{-5}$ $(\mu g/m^3)^{-1}$	Hepatocellular carcinomas in mice	NCI, 1978	NA	NA	Cal EPA, 2009	1987
ESL	Acute	550	NA	NA	NA	NA	TCEQ, 2018	2003
ESL	Chronic	55	NA	NA	NA	NA	TCEQ, 2018	2003

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.

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A-2.1.61 Trichloroethylene

CASRN 79-01-6

The 24-hour acute inhalation exposure limit of 12 µg/m^3 proposed by the MOE (2012), and the annual inhalation exposure limit of 2 µg/m^3 proposed by the US EPA (2011) were used for the assessment of trichloroethylene (Table A - 62). The acute exposure limit was chosen as it was the most conservative value. The chronic exposure limit of 2 µg/m^3 derived by US EPA IRIS (2011) was selected as it was also endorsed by MECP.

The IUR of 4.1 x 10^{-6} (µg/m^3)$^{-1}$ derived by US EPA IRIS (2011) and endorsed by MECP (2019) was selected for use in this assessment as it was the most scientifically defensible and conservative value.

Table A - 62 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC;24-hour	Acute	12	Health-based	NA	NA	NA	MOE, 2012	NA
RfC	Chronic	2	Decreased thymus weights and fetal heart malformations (mouse)	Keil *et al.*, 2009; Johnson *et al.*, 2003	Keil *et al*., 2009; $HEC_{99,\ LOAEL}$: 0.19 mg/m^3 Johnson *et al.*, 2003; $HEC_{99,\ BMDL01}$ 0.021	Keil *et al*., 2009; 100 Johnson *et al.*, 2003; 30	MECP, 2019; US EPA IRIS, 2011	2011
MRL	Chronic	2	NA	US EPA, 2011	NA	NA	ATSDR, 2013	NA
REL	Chronic	600	Neurotoxicological effects (drowsiness, fatigue and headache) and eye irritation	Vandervort and Polnkoff, 1973	LOAEL(ADJ): 11.4 ppm (~60,000 µg/m^3)	100	Cal EPA, 2008	NA
pTCA	Chronic	200	Hypatotoxicity	Kjellstrand *et al.*, 1983	LOAEL: 200 mg/m^3 (200,000 µg/m^3)	1,000	RIVM, 2001	NA
ESL	Chronic	54	NA	NA	NA	NA	TCEQ, 2018	2007
Unit risk	Chronic	6.1 x 10^{-7} (µg/m^3)$^{-1}$	Testicular tumours in rats	Maltoni *et al.*, 1986 ; 1988 ;	NA	NA	Health Canada, 2010	NA
Unit risk	Chronic	2.0 x 10^{-6} (µg/m^3)$^{-1}$	Hepatocellular adenomas and carcinomas (males); lung adenocarcinomas and malignant lymphomas (females)	Bell *et al*., 1978; Henschler *et al*., 1980; Fukuda *et al*., 1983; Maltoni *et al*., 1986	NA	NA	Cal EPA, 2009	NA
Unit risk	Chronic	4.3 x 10^{-7} (µg/m^3)$^{-1}$	Leydig-cell tumours in testes	Maltoni *et al*., 1986	NA	NA	WHO, 2000	NA
Unit risk	Chronic	4.1 x 10^{-6} (µg/m^3)$^{-1}$	Renal cell carcinoma (human)	Charbotel *et al*., 2006	NA	NA	MECP, 2019; US EPA	2011

Table A - 62 Inhalation Toxicity Reference Values								
Type	***Duration***	***Value***[a]	***Critical Effect***	***Reference***	***Point of Departure***	***UF***	***Source***	***Derived***
							IRIS, 2011	

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.62 Trichlorofluoromethane

CASRN 75-69-4

The 24-hour inhalation exposure limit of 6,000 µg/m^3 proposed by MOE (2012) was selected this value was selected for use in the assessment as it is proposed by the Ministry and was the only TRV available.

The long-term effects screening level (ESL) of 5,600 µg/m^3 derived by the Texas Commission on Environmental Quality is the only available chronic inhalation TRV for this chemical parameter. This value was adopted in the current assessment as there were no health-based non-carcinogenic inhalation exposure limits available from other recommended agencies (*i.e.,* Health Canada, US EPA IRIS, ATSDR, WHO, Cal EPA), and MOE (2011) did not recommend any limits.

Table A - 63 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	6,000	NA	NA	NA	NA	MOE, 2012	2012
ESL	Chronic	5,600	NA	NA	NA	NA	TCEQ, 2018	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.63 Trimethyl Benzene (1,2,3-) and Trimethyl Benzene (1,2,4-)

CASRN 526-73-8, 95-63-6

The acute AAQC 24-hour value of 220 µg/m^3 was utilized in this assessment. Although there are no supporting documentation available for this value, this value was selected for use in the assessment as it is proposed by the Ministry. The chronic inhalation exposure limit of 60 µg/m^3, proposed by the US EPA IRIS (2016), was used for the non-cancer assessment of 1,2,3-trimethyl benzene and 1,2,4-trimethyl benzene as it is the most conservative value (Table A - 64).

Table A - 64 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	220	NA	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	60	Decreased pain sensitivity in male Wistar rats	Korsak and Rydzynski (1996)	BMCL1SD (HEC): 18.15 mg/m^3	300	US EPA IRIS, 2016	2016
ReV	Chronic	180	Neurotoxicity (e.g., decreased pain sensitivity) in rats	Korsak and Rydzynski (1996)	POD (HEC): 16 mg/m^3	90 (HQ= 1)	TCEQ, 2015	2015
ESL	Chronic	54	Neurotoxicity (e.g., decreased pain sensitivity) in rats	Korsak and Rydzynski (1996)	POD (HEC): 16 mg/m^3	90 (HQ= 0.3)	TCEQ, 2015	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.64 Trimethyl Benzene (1,3,5-)

CASRN 108-67-8

The chronic inhalation exposure limit of 60 µg/m^3, proposed by the US EPA IRIS (2016), was used for the non-cancer assessment of 1,3,5-trimethyl benzene as it is the most conservative value (Table A - 65).

Table A - 65 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	220	NA	NA	NA	NA	MOE, 2012	2012
RfC	Chronic	60	Decreased pain sensitivity in male Wistar rats	Korsak and Rydzynski (1996)	BMCL1SD (HEC): 18.15 mg/m^3	300	US EPA IRIS, 2016	2016
ReV	Chronic	180	Neurotoxicity (e.g., decreased pain sensitivity) in rats	Korsak and Rydzynski (1996)	POD (HEC): 16 mg/m^3	90 (HQ= 1)	TCEQ, 2015	2015
ESL	Chronic	54	Neurotoxicity (e.g., decreased pain sensitivity) in rats	Korsak and Rydzynski (1996)	POD (HEC): 16 mg/m^3	90 (HQ= 0.3)	TCEQ, 2015	2015

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.65 Vinyl Chloride

CASRN 75-01-4

The 24-hour acute inhalation exposure limit of 1 µg/m^3 proposed by the MOE (2012), and the annual inhalation exposure limit of 60 µg/m^3 proposed by TCEQ (2009) were used for the assessment of vinyl chloride (Table A - 66). The acute exposure limit was chosen as it was the most conservative value. The chronic exposure limit was selected for use in the current assessment given that it was based on a more recent study and it was a more conservative exposure limit. In addition, the Ministry (MECP, 2019) endorses the chronic RfC of 60 µg/m^3 proposed by TCEQ (2009).

The RfC derived by RIVM (2001) was not adopted in the current assessment as it was based on adverse effects to the testicular seminiferous tubules, a less sensitive endpoint than the liver effects identified by the oral and inhalation key studies from US EPA IRIS (2000) and TCEQ (2009). Further, the AAQC derived by MOE (2012) was not appropriate as it is based on carcinogenic effects as the critical endpoint

The UR of 8.8 x 10^{-6} (µg/m^3)$^{-1}$ proposed by the US EPA (2000) was used for the carcinogenic assessment of vinyl chloride. This value was selected for use in this assessment given that it was also selected by the Ministry (MECP, 2019).

Table A - 66 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
MRL	Acute	0.5 ppm (1,278 µg/m^3)	Maternal and developmental toxicity	John *et al.* 1977; John *et al.* 1981	NOAEL(ADJ): 15 ppm (38,344 µg/m^3).	30	ATSDR, 2006	NA
AAQC; 24-hour	Acute	1	NA	NA	NA	NA	MOE, 2012	NA
AAQC	Chronic	0.2	NA	NA	NA	NA	MOE, 2012	NA
RfC	Chronic	100	Liver cell polymorphism	Til *et al.,* 1983; 1991	NOAEL (HEC): 2,500	30	US EPA IRIS, 2000	2000
RfC	Chronic	100	Liver cell polymorphism	Til *et al.,* 1983; 1991 as cited in US EPA, 2000	NOAEL (HEC): 2,500	30	MOE, 2011	2000
ReV;	Chronic	60	Centrilobular hypertrophy in the liver (rat)	Thornton *et al*., 2002	BMCL10 (ADJ): 0.680 ppm (1,738 µg/m^3)	30	TCEQ, 2009	NA
Unit Risk	Chronic	8.8 x 10^{-6} (µg/m^3)$^{-1}$	Increased incidence of liver angiosarcomas, angiomas, hepatomas, and neoplastic nodules in female rats	Maltoni *et al.,* 1981, 1984	NA	NA	US EPA, 2000	NA
Unit Risk	Chronic	8.8 x 10^{-6} (µg/m^3)$^{-1}$	NA	US EPA, 2000	NA	NA	MOE, 2011	NA
Unit Risk	Chronic	7.8 x 10^{-5} (µg/m^3)$^{-1}$	Increased lung tumor incidence	Drew *et al.,* 1983	NA	NA	Cal EPA, 2011	1990
RfC	Chronic	56	Biologically significant testicular changes	Bi et al., 1985	NOAEL (ADJ): 5,600 µg/m^3	100	RIVM, 2001	NA

Table A - 66 Inhalation Toxicity Reference Values								
Type	***Duration***	***Value***[a]	***Critical Effect***	***Reference***	***Point of Departure***	***UF***	***Source***	***Derived***
Unit Risk	Chronic	2.8×10^{-5} $(\mu g/m^3)^{-1}$	Increased incidence of liver angiosarcomas, angiomas, hepatomas, and neoplastic nodules in female rats	Maltoni *et al.*, 1981, 1984	NA	NA	RIVM, 2001	NA
Unit Risk	Chronic	1.0×10^{-6} $(\mu g/m^3)^{-1}$	NA	NA	NA	NA	WHO, 2000	1987
Unit Risk	Chronic	8.4×10^{-6} $(\mu g/m^3)^{-1}$	NA	US EPA, 2000	NA	NA	TCEQ, 2009	NA

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
[a] Units of $\mu g/m^3$ unless otherwise noted.

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A-2.1.66 Vinylidene Chloride

CASRN 75-35-4

The 24-hour acute inhalation exposure limit of 10 µg/m^3 proposed by the MOE (2012) was selected for the use in this assessment. While no scientific basis is provided for this limit, this value was selected for use in the assessment as it was the only TRV available.

The chronic inhalation exposure limit of 200 µg/m^3 proposed by the US EPA (2002) were used for the non-cancer assessment (Table A - 67). The exposure limit was selected as it was the value presented for the Regional Screening Levels (US EPA, 2019).

Table A - 67 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	10	NA	NA	NA	NA	MOE, 2012	2012
REL	Chronic	70	NA	Cal EPA, 2000	NA	NA	MOE, 2011	2011
RfC	Chronic	200	Liver toxicity (fatty change)	Quast *et al.*, (1986)	$BMCL_{10HEC}$: 6,900 µg/m^3	30	US EPA IRIS, 2002	2002
REL	Chronic	70 µg/m^3	Increased mortality; hepatic effects in guinea pigs	Prendergast *et al.,* (1967)	POD (HEC): 20 mg/m^3	300	Cal EPA, 2000	2000
ReV	Chronic	340	Focal necrosis of liver	Prendergast *et al.,* (1967)	POD (HEC): 25 ppm (101 µg/m^3)	300 (HQ= 1)	TCEQ, 2007	2007
ESL	Chronic	100	Focal necrosis of liver	Prendergast *et al.,* (1967)	POD (HEC): 25 ppm (101 µg/m^3)	300 (HQ= 0.3)	TCEQ, 2007	2007

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.

NA Not available.

[a] Units of µg/m^3 unless otherwise noted.

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A-2.1.67 Xylenes (o/m/p-)

CASRN 1330-20-7

The 24-hour acute inhalation exposure limit of 730 µg/m^3 proposed by the MOE (2012) was selected for the use in this assessment. While no scientific basis is provided for this limit, this value was selected for use in the assessment as it was the most conservative TRV available.

The chronic inhalation exposure limit of 700 µg/m^3 derived by the Cal EPA (2005) was used for the non-cancer assessment of xylenes as this value was also endorsed by the Ministry (Table A - 68).

Table A - 68 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
AAQC; 24-hour	Acute	730	Health-based	NA	NA	NA	MOE, 2012	2012
pTC	Chronic	180	Maternal effects, fetal retardation, increased proportion of fetal mortality and resorbed fetuses	Ungvary and Tantrai, 1985	LOAEL (HEC): 180,000 µg/m^3	1,000	Health Canada, 2010	2010
MRL	Acute	8,700 µg/m^3	Slight respiratory effects and subjective symptoms of neurotoxicity in humans	Ernstgard *et al*., 2002	LOAEL: 50 ppm (217 mg/m^3)	30	ATSDR, 2007	2007
MRL	Chronic	220 µg/m^3	Subjective symptoms of neurotoxicity and respiratory toxicity	Uchida *et al*., 1993	LOAEL: 14 ppm (61,000 µg/m^3)	300	ATSDR, 2007	2007
RfC	Chronic	700	NA	Cal EPA chREL 2005	NA	NA	MOE, 2011	2011
RfC	Chronic	100	Impaired motor coordination (decreased rotarod performance)	Korsak *et al.,* 1994	NOAEL (HEC): 39 mg/m^3 (39,000 µg/m^3)	300	US EPA IRIS, 2003	2003
REL	Chronic	700	CNS effects in humans; irritation of the eyes, nose, and throat	Uchida *et al*., 1993	LOAEL (ADJ): 5.1 ppm (22,000 µg/m^3)	30	Cal EPA, 2008	2000
ReV	Chronic	610	Mild respiratory and subjective neurological	Uchida *et al*., 1993	LOAEL: 14 ppm (61,000 µg/m^3)	100 (HQ= 1)	TCEQ, 2014	2009

Table A - 68 Inhalation Toxicity Reference Values

Type	*Duration*	*Value*[a]	*Critical Effect*	*Reference*	*Point of Departure*	*UF*	*Source*	*Derived*
			effects in factor workers					
ESL	Chronic	180	Mild respiratory and subjective neurological effects in factor workers	Uchida *et al*., 1993	LOAEL: 14 ppm (61,000 µg/m^3)	100 (HQ= 0.3)	TCEQ, 2014	2009
TCA	Chronic	870	Developmental neurotoxicity	Hass and Jakobsen, 1993; Hass *et al*., 1995	LOAEL: 870 mg/m^3 (870,000 µg/m^3)	1,000	RIVM, 2001	2001

Shaded exposure limits were selected as toxicological reference values for the current risk assessment.
NA Not available.
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[a] Units of µg/m^3 unless otherwise noted.

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APPENDIX B

WORKED EXAMPLE FOR THE HUMAN HEALTH MULTIPLE PATHWAY EXPOSURE MODEL

APPENDIX B: WORKED EXAMPLE FOR THE HUMAN HEALTH MULTIPLE PATHWAY EXPOSURE MODEL

B-1.0 INTRODUCTION

The human health risk assessment (HHRA) focused on both direct and indirect health risks associated with air emissions from the Landfill proposed by Walker and the associated haul routes. The proposed landfill will emit chemicals of concern (COCs) directly into air from various sources, thus people residing near the study area, as well as people visiting the area could be directly exposed to the COCs *via* inhalation. Specifically, the Air Quality assessment conducted and assessment of the landfill gas (LFG) and the associated landfill haul route.

The landfill gas (LFG) assessment considers impacts in stages 1, 3, 4 and post closure whereas the haul route assessment considers impacts in stages 1 and 3 of the landfill lifespans as they represent the worst-case scenarios for haul route related emissions.

The primary pathway of exposure is inhalation; however, people that reside in the area might be exposed to the COCs *via* secondary exposure pathways. Some COCs emitted to the atmosphere *via* air emissions may be deposited onto the soils and plants surrounding the proposed landfill. Depending on the fate, transport, and persistence of the COCs in the environment, chemical deposition could affect the chemical concentrations in local soils and foods (*i.e.,* locally grown produce).

As presented in the HHRA report, benzo(a)pyrene is the only COC retained for the multimedia or multi-pathway assessment and as such stages 1 and 3 were assessed.

Health risks from air emissions were characterized by comparing modelled long-term air concentrations of COCs with regulatory criteria considered protective of human health and these air concentrations were incorporated into the multimedia exposure model. Health risks associated with indirect exposure pathways such as consumption of locally grown produce and fruits were characterized through determining the incremental change in media concentration of the COC (*i.e.,* soil) based on the predicted deposition of benzo(a)pyrene.

This appendix provides summaries of the calculations used to estimate the soil and surface soil concentrations of benzo(a)pyrene exposures from the landfill, along with example calculations. Many of the methods, equations and assumptions used to predict concentrations in various environmental media were obtained from the United States Environmental Protection Agency Office of Solid Waste (US EPA, 2005), Health Canada (2012), and the Ontario Ministry of the Environment, Conservation and Parks (MOE, 2011). Potential exposures to benzo(a)pyrene in soil were predicted for residents using the highest annual concentrations at the residential common receptor locations. As discussed in the report, the percentage of the cumulative soil concentration that is predicted to originate from the haul route emissions is negligible, where only 0.001% of the cumulative soil concentration (tilled soil) and only 0.01% of the cumulative surface soil concentrations (untilled soil) is due to the project for Stages 1 and 3. As the change in predicted soil concentration was identified to be negligible, it is not anticipated that the predicted concentrations of benzo(a)pyrene in soil would adversely impact the soil, agricultural crops and home grown produce within the Project area.

B-2.0 ENVIRONMENTAL MEDIA CONCENTRATIONS

In order to quantify potential human exposures (and associated health impacts) through the oral and dermal pathways as a result of emissions from the proposed landfill project, predicted chemical concentrations in soil were required to estimate exposures and characterize risks.

B-2.1 Chemical Concentrations in Air

Table C-1 presents the benzo(a)pyrene air concentrations that were used to estimate media concentrations for the human health risk assessment (HHRA) model. The air concentrations are the maximum concentrations of the residential common receptor locations. In addition, as indicated in the HHRA report, there were specific receptor locations identified in order to assess the potential for the landfill operations to impact the crop production in the study area. As such, the concentrations presented in Table C-1 identify the maximum concentrations of benzo(a)pyrene at the residential and crop receptor locations.

Table C-1 Air Concentration used in the Worked Example

Chemical of Concern	*Concentration [µg/m³]*	
	Stage 1	**Stage 3**
Benzo(a)pyrene	6.98E-06	6.93E-06

B-2.2 Chemical Deposition

The dry deposition rate was modelled by RWDI in order to predict the concentration of benzo(a)pyrene in the soil. Table C-2 provides the deposition rate for benzo(a)pyrene.

Table C-2 Deposition Rate used in the Worked Example

Chemical of Concern	*Concentration [µg/m³]*	
	Stage 1	**Stage 3**
Benzo(a)pyrene	6.98E-06	6.93E-06

B-2.3 Chemical Concentration in Soil (C_s)

This section presents the equations used to calculate the predicted chemical concentrations in soil. The soil concentrations were estimated based on the modelled dry depositions rates provided by RWDI. RWDI provided the following discussion associated with how deposition was calculated:

> *Particulate matter plumes differ from gaseous plumes in that the particles can settle out due to gravity. Heavier particles will tend to settle out quickly, reducing the particulate concentration in the plume as it moves farther from the source. The AERMOD dispersion model, used in the Air Quality Assessment, allows the user to account for this settling through the use of deposition and plume depletion algorithms. The deposition results that are produced by the model represent the deposition flux rate, in grams per square metre (g/m^2). With the deposition algorithm, the model does not reduce the plume size by the deposition flux rate; it merely predicts the amount of deposition that could occur from the plume at any receptor point. In order to decrease the plume by the deposited amount, the plume depletion algorithm must also be activated. For the purposes of this assessment, only the effects of dry deposition and dry plume depletion were considered.*
>
> *The deposition values for particulate matter were calculated using the dry deposition and dry plume depletion algorithms in the AERMOD dispersion model. For benzo(a)pyrene, the dry deposition algorithm was applied without plume depletion as a conservative*

measure. In order to apply the deposition and depletion parameters, the modelling requires additional inputs; namely particle size ranges, mass fractions within each particle size category, and the density of the material. As requested by the MECP, surface samples from paved and unpaved roadways at the Carmeuse site as well as samples of overburden material from the Carmeuse site were collected and used to determine particle size distributions for use in the modelling. For other sources, default particle size data were derived from AP-42 or other references.

B-2.3.1 Cumulative COC Concentration in Soil

US EPA (2005) recommended three (3) equations for the calculation of cumulative soil concentrations. Two (2) of these equations are recommended for the calculation of carcinogens:

Equation 1 – *For $T_2 \leq tD$:*

$$C_s = \frac{D_s}{ks \cdot (tD - T_1)} \cdot \left[\left(tD + \frac{exp(-ks \cdot tD)}{ks}\right) - \left(T_1 + \frac{exp(-ks \cdot T_1)}{ks}\right)\right]$$

Equation 2 – *For $T_1 < tD < T_2$:*

$$C_s = \frac{\left(\frac{D_s \cdot tD - Cs_{tD}}{ks}\right) + \left(\frac{Cs_{tD}}{ks}\right) \cdot (1 - exp[-ks \cdot (T_2 - tD)])}{(T_2 - T_1)}$$

Where:

C_s	=	Average soil concentration over exposure duration (mg/kg)
D_s	=	Deposition term (mg/kg/yr)
ks	=	COC soil loss constant due to all processes (yr^{-1})
tD	=	Time period over which deposition occurs (yr)
T_1	=	Time period at the beginning of combustion (yr)
Cs_{tD}	=	Soil concentration at time tD (mg/kg)
T_2	=	Length of exposure duration (yr)

US EPA (2005) recommended the following equation for calculating cumulative soil concentrations for noncarcinogenic COCs:

Equation 3:

$$C_s = \frac{D_s \times [1 - exp(-ks \times tD)]}{ks}$$

Where:

C_s	=	Average soil concentration over exposure duration (mg/kg)
D_s	=	Deposition term (mg/kg/yr)
ks	=	COC soil loss constant due to all processes (yr^{-1})
tD	=	Time period over which deposition occurs (yr)

The operating lifetime of the project is anticipated to be 20 years. Equation 1 is recommended when the exposure duration being modelled is less than or equal to the operating lifetime of the project. Equation 2 is recommended when the exposure duration being modelled is greater than the operating lifetime of the project. Equation 3 is used to predict the COC concentration in soil over the operating lifetime of the project (*i.e.,* landfill is anticipated to have a lifetime of 20 years). For the purposes of calculating cumulative COC soil concentrations, the US EPA (2005) recommended equation for noncarcinogenic COCs (*i.e.,* Equation 3) was selected for the current assessment given that it results in the most conservative prediction of COC concentrations in soil.

The calculation of the deposition term (D_s) and the soil loss constant (*ks)* are presented in the sections below.

As part of the *Ds* calculation, the soil mixing zone depth is considered. The soil mixing zone depth is an important variable when calculating an appropriate soil concentration. Tilled soil will generally have lower COC concentrations than untilled soil given that tilling activities allow deposited COCs to mix with a greater volume of soil. US EPA (2005) recommended soil mixing zone depths of 0.2 m for tilled soil (soil)and 0.02 m for untilled soil (surface soil). Soil concentrations in the HHRA model were modelled using both mixing zones.

Example 1 *Concentrations of Benzo(a)pyrene in tilled soil for the prediction of human exposure (Stage 1)*

$$C_s = \frac{2.76E-07 \times [1 - exp(-0.572 \times 20)]}{0.572}$$
$$C_s = 4.82E-7\ mg/kg$$

Example 2 *Concentrations of Benzo(a)pyrene in untilled surface soil for the prediction of human exposure (Stage 1)*

$$C_s = \frac{2.76E-06 \times [1 - exp(-0.572 \times 20)]}{0.572}$$
$$C_s = 4.82E-06\ mg/kg$$

Example 3 *Concentrations of Benzo(a)pyrene in tilled soil for the prediction of human exposure (Stage 3)*

$$C_s = \frac{2.75E-07 \times [1 - exp(-0.572 \times 20)]}{0.572}$$
$$C_s = 4.80E-07\ mg/kg$$

Example 4 *Concentrations of Benzo(a)pyrene in untilled surface soil for the prediction of human exposure (Stage 3)*

$$C_s = \frac{2.75E-06 \times [1 - exp(-0.572 \times 20)]}{0.572}$$
$$C_s = 4.80E-06\ mg/kg$$

B-2.3.2 Deposition Term (D_s)

Soil concentrations were estimated based on the calculated chemical-specific deposition rates. Deposition to soil on a mass basis was calculated using the following equation:

$$D_s = \frac{D_{tot}}{Z_s \times BD}$$

Where:

D_s = chemical-specific deposition (mg/kg/yr)
D_{tot} = chemical-specific deposition rate (mg/m²/yr)
Z_s = soil mixing zone depth (m)
BD = soil bulk density (kg/m³)

For the current assessment, the bulk density was assumed to be 1,500 kg/m³, and soil concentrations were predicted for two mixing depths (i.e., 2 cm and 20 cm) to calculate surface soil and soil concentrations, respectively.

Example 5 *Deposition for Benzo(a)pyrene to tilled soil for prediction of Concentration in Soil (Stage 1)*

$$D_s = \frac{8.28E-05}{0.2 \times 1{,}500}$$
$$D_s = 2.76E-07\ mg/kg/yr$$

Example 6 *Deposition for Benzo(a)pyrene to untilled surface soil for prediction of Concentration in Soil (Stage 1)*

$$D_s = \frac{8.28E-05}{0.02 \times 1{,}500}$$
$$D_s = 2.76E-06\ mg/kg/yr$$

Example 7 *Deposition for Benzo(a)pyrene to tilled soil for prediction of Concentration in Soil (Stage 3)*

$$D_s = \frac{8.24E-05}{0.2 \times 1{,}500}$$
$$D_s = 2.75E-07\ mg/kg/yr$$

Example 8 *Deposition for Benzo(a)pyrene to untilled surface soil for prediction of Concentration in Soil (Stage 3)*

$$D_s = \frac{8.24E-05}{0.02 \times 1{,}500}$$
$$D_s = 2.75E-07\ mg/kg/yr$$

B-2.3.3 Soil Loss Constant (ks)

Chemicals may be lost from soil by leaching, runoff, erosion, biotic and abiotic degradation and volatilization. The COC soil loss constant (*ks*) accounts for these processes using the following equation (US EPA 2005):

$$Ks = Ksg + Kse + Ksr + Ksl + Ksv$$

Where:

Ks	=	Soil loss constant due to all processes (yr^{-1})
Ksg	=	Soil loss constant due to biotic and abiotic degradation (yr^{-1})
Kse	=	Soil loss constant due to soil erosion (yr^{-1})
Ksr	=	Soil loss constant due to surface runoff (yr^{-1})
Ksl	=	Soil loss constant due to leaching (yr^{-1})
Ksv	=	Soil loss constant due to volatilization (yr^{-1})

Only abiotic and biotic degradation and volatilization processes were considered for this assessment. The calculation of each COC loss constant is described in the sections below.

Example 9 *Soil Loss Constant due to All Processes for Benzo(a)pyrene.*

Ks = 0.48 + 0 + 0 + 0 + 9.24*E*-02
Ks =0.572

The *Ks* for benzo(a)pyrene was calculated to be 0.572 yr^{-1}.

C-2.3.3.1 Soil Loss Constant due to Biotic and Abiotic Degradation (*Ksg*)

The US EPA (2005) Companion Database provides the *Ksg* values for benzo(a)pyrene. The US EPA (2005) Companion Database provided a *Ksg* value of 0.48 yr^{-1} for benzo(a)pyrene.

C-2.3.3.2 Soil Loss Constant Due to Volatilization (*Ksv*)

Chemical loss from volatilization was predicted as follows (Swan et al. 1979):

$$t_{1/2} = 1.58E-08 \times \left(\frac{K_{oc} \times S}{VP} \right)$$

Where:

$t_{1/2}$	=	soil half-life (days)
K_{oc}	=	organic carbon partition coefficient (L/kg)
S	=	water solubility (mg/L)
VP	=	vapour pressure (mmHg)

The half-life is then converted to a rate constant (yr^{-1}) using the following equation:

$$kv = \frac{0.693}{\left(t_{1/2} / 365 \right)}$$

Example 11 Chemical loss or degradation from soil as a result of volatilization of benzo(a)pyrene

Soil half-life: $t_{\frac{1}{2}} = 1.58E-08 \times \left(\frac{5.87E+05 \times 1.62E-03}{5.49E-09} \right)$

$t_{\frac{1}{2}} = 2.74E+03 \ days$

Loss as a result of volatilization: $ksv = \frac{0.693}{(2.74E+03/365)}$

$$ksv = 9.24E-02\ yrs^{-1}$$

B-3.0 REFERENCES

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APPENDIX C

SUPPLEMENTARY HEALTH REVIEW OF THE SOUTHWESTERN LANDFILL PROPOSAL

SCIENCE INTEGRITY KNOWLEDGE

SUPPLEMENTARY HEALTH REVIEW OF THE SOUTHWESTERN LANDFILL PROPOSAL

February 2020

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SUPPLEMENTARY HEALTH REVIEW OF THE SOUTHWESTERN LANDFILL PROPOSAL

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LIST OF ACRONYMS

EA	Environmental Assessment
HHRA	Human Health Risk Assessment
LFG	Landfill gas
MECP	Ministry of the Environment, Conservation and Parks
PM_{10}	Particulate Matter ≤ 10 µm diameter
$PM_{2.5}$	Particulate Matter ≤ 2.5 µm diameter
SHR	Supplementary Health Review
WHO	World Health Organization

1.0 INTRODUCTION

Intrinsik Corp. (Intrinsik) has been retained by Walker Environmental Group Inc. (Walker) to conduct a Supplementary Health Review (SHR) for the Southwestern Landfill Proposal (hereafter referred to as 'the Proposal'). The Proposal includes a facility that would accept up to 850,000 tonnes of Ontario-generated solid, non-hazardous waste per year (plus daily cover). The Proposal is currently undergoing the provincial Environmental Assessment (EA) process. The completed EA, of which this SHR is a component, will be submitted to the Ontario Ministry of the Environment, Conservation and Parks (MECP) in early 2020.

1.1 Purpose

In his review of the Terms of Reference, the then Acting Medical Officer of Health for Oxford County, Dr. Douglas Neal, identified the potential for health-related effects extending beyond those addressed through the Human Health Risk Assessment (HHRA), in particular "*the inter-relationships of the social and economic constructs of the proposed landfill*" (August 21, 2014). As a result, Walker proposed that an additional review of the social and economic impact assessment studies be carried out by the health expert (Intrinsik), in consultation with Dr. Neal and Dr. Derek Hillis, the Joint Municipal Coordinating Committee peer review health expert (September 12, 2014). The Minister for the Environment adopted this recommendation in approving the Terms of Reference, adding the following amendment:

13. *In addition to the proposed health risk assessment, Walker's health expert shall carry out a screening-level review of the socio-economic assessment results to determine the potential for related health effects. Early in the environmental assessment process, prior to finalizing any work plans associated with the determination of health effects, Walker shall consult with the Joint Municipal Coordinating Committee and local medical officer of health to get input on the criteria and methods of assessment. As part of this consultation, Walker will discuss with the Joint Municipal Coordinating Committee and local medical officer of health, at a minimum, the determinants of health that will be assessed, and the different stages of assessment that will be undertaken including screening, scoping, assessment, mitigation, reporting and monitoring.*

    Walker shall provide detailed documentation of the issues and concerns raised in the finalization of the health studies work plans and the results. The documentation will include how those issues were considered, the steps that were undertaken to address comments received, where possible, and the rationale for why some comments may not have been addressed. If any significant negative effects are identified as part of the health studies, Walker's health expert will work closely with the social, economic and environmental experts, including the Joint Municipal Coordinating Committee and local medical officer of health, to determine what, if any, further studies are necessary and adapt or augment their mitigation recommendations to minimize or eliminate these potential effects, and characterize any residual net effects for the purposes of this environmental assessment. This decision-making will also be documented.

The following approach has been developed for completion of a SHR within the EA process for the proposed Southwestern Landfill. This approach is based on the steps identified by the MECP in their comment (#13) above, including: screening, scoping, assessment, mitigation, reporting and monitoring (**Figure 1-1**). In addition, documentation showing Walker response to comments from stakeholders on the scope of the SHR or SHR work plan are attached in **Appendix A**.

1.2 Project Description

The landfill proposed by Walker is described in detail in the EA Report. Following is a brief summary for the benefit of the reader, highlighting aspects of the proposal most relevant to this study.

The landfill is to be located on a portion of Carmeuse's landholdings at its Beachville Quarry Operations in the Township of Zorra, Oxford County. Approximately 17.4 million m^3 of solid, non-hazardous waste and daily/intermediate cover will be deposited within a footprint of about 59 ha. The balance of the 81.6 ha site will be comprised of buffer areas for monitoring, maintenance, environmental controls and other necessary infrastructure (**Figure 1-1**).

Landfill construction will proceed progressively in a series of cells, generally from north-to-south (**Figure 1-1**). The former quarry floor will be backfilled to within about 30 to 40 metres below ground surface with engineered fill, and then a *Generic Design Option II – Double Liner* system (as specified by the MECP in the *Landfill Standards under O. Reg. 232/98*; see **Figure 1-2**) will be constructed across the bottom and up the sides of the landfill to contain and collect leachate (**Figure 1-3**). Up to 850,000 tonnes per year of solid, non-hazardous waste, and up to 250,000 tonnes per year of daily/intermediate cover soils will then be placed and compacted above the liner in a series of small working areas approximately 0.2 ha in size at any given time, in order to minimize the exposed waste. Waste will be covered with soil on a daily basis, and a final cover with vegetation will be applied as the landfill reaches its final height, which peaks at about 15 m above ground (**Figure 1-4**). A landfill gas (LFG) collection system will also be installed as the landfill/cell development progresses.

Most of the supporting infrastructure for the landfill will be located in the buffer area along the northern site perimeter, including the leachate and gas treatment plants. Leachate collected from the liner system will be treated on-site and the clean effluent from the treatment plant will be discharged into the Patterson-Robbins Drain next to the treatment plant. Clean precipitation and groundwater that has not come into contact with waste will be segregated and treated in a stormwater management pond before being discharged from the site (**Figure 1-1**). Landfill gas will be collected in a network of extraction wells and pipes. Initially the LFG will be flared (combusted), but when the quantities permit the gas will be beneficially utilized as a renewable fuel.

The site will be open for waste deliveries from 7:00 a.m. to 5:00 p.m. on weekdays and from 7:00 a.m. to 1:00 p.m. on Saturdays, but closed on Sundays and statutory holidays. On-site construction activities may start up to one hour before opening and continue up to two hours after closure. The primary designated haul route (i.e., for all waste trucks except deliveries from the local area, if any) is from Highway 401 north along County Road #6, then west into the quarry property; trucks will then follow a newly constructed haul route across the quarry site to a landfill site entrance at the northwestern corner of the site (**Figure 1-5**). Vehicle traffic, including waste trucks as well as construction vehicles and staff, is expected to average approximately 210 trips per day.

Nuisance controls will include speed enforcement, regular haul road cleaning (on- and off-site), litter fencing and pick-up, and bird/pest management, with a public complaint reporting and response system.

There will be monitoring programs for equipment operations, leachate, groundwater, surface water, air emissions, gas, noise, and particulates (dust).

The landfill is anticipated to receive waste for approximately 20 years commencing in about 2023. After closure, maintenance and operation of the relevant environmental controls and monitoring will carry on during the post-closure period, until there is no further risk of

environmental contamination. The end-use is assumed to be passive green space and agriculture, but the design is flexible to accommodate other potential end-uses.

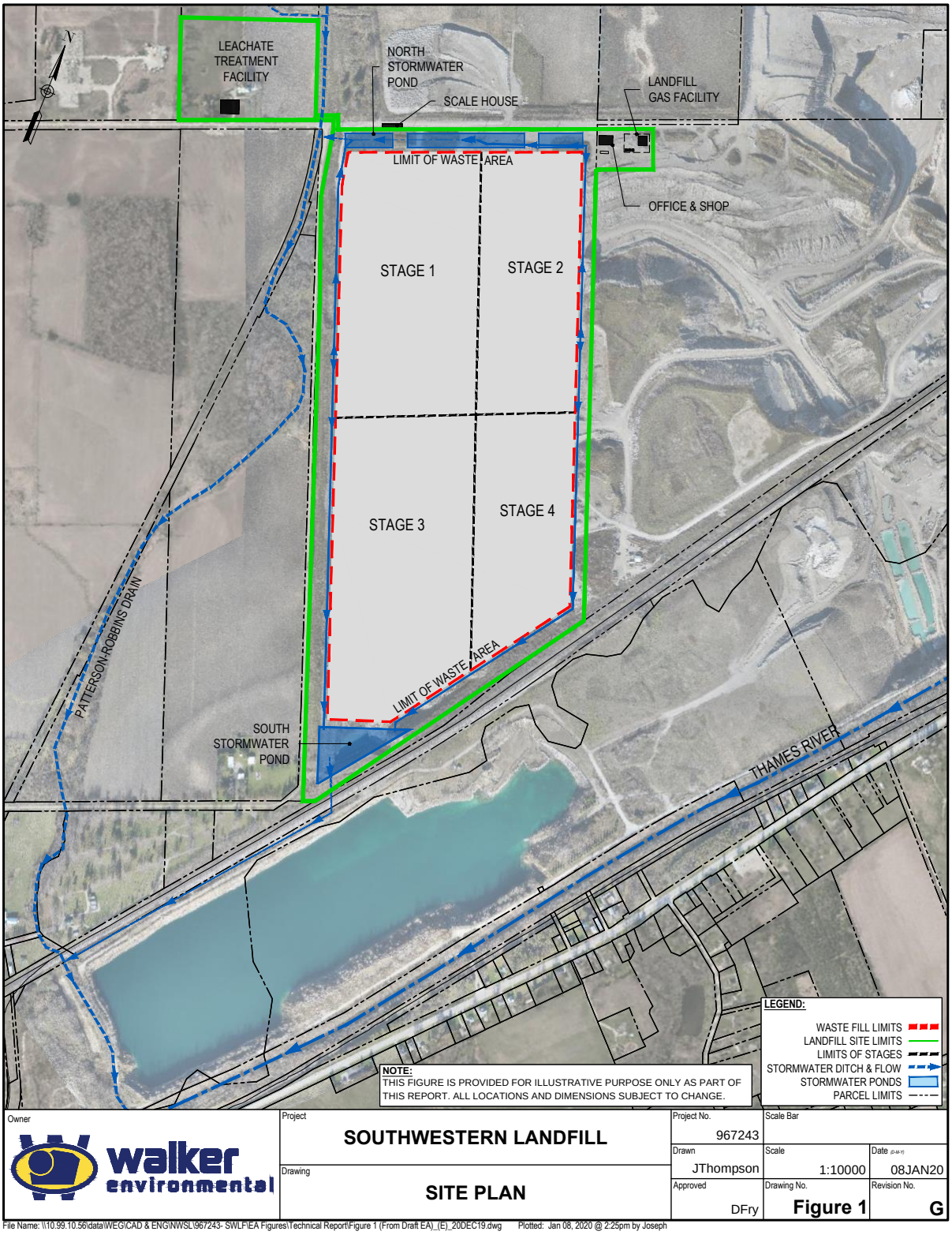


Figure 1-1 Site Plan

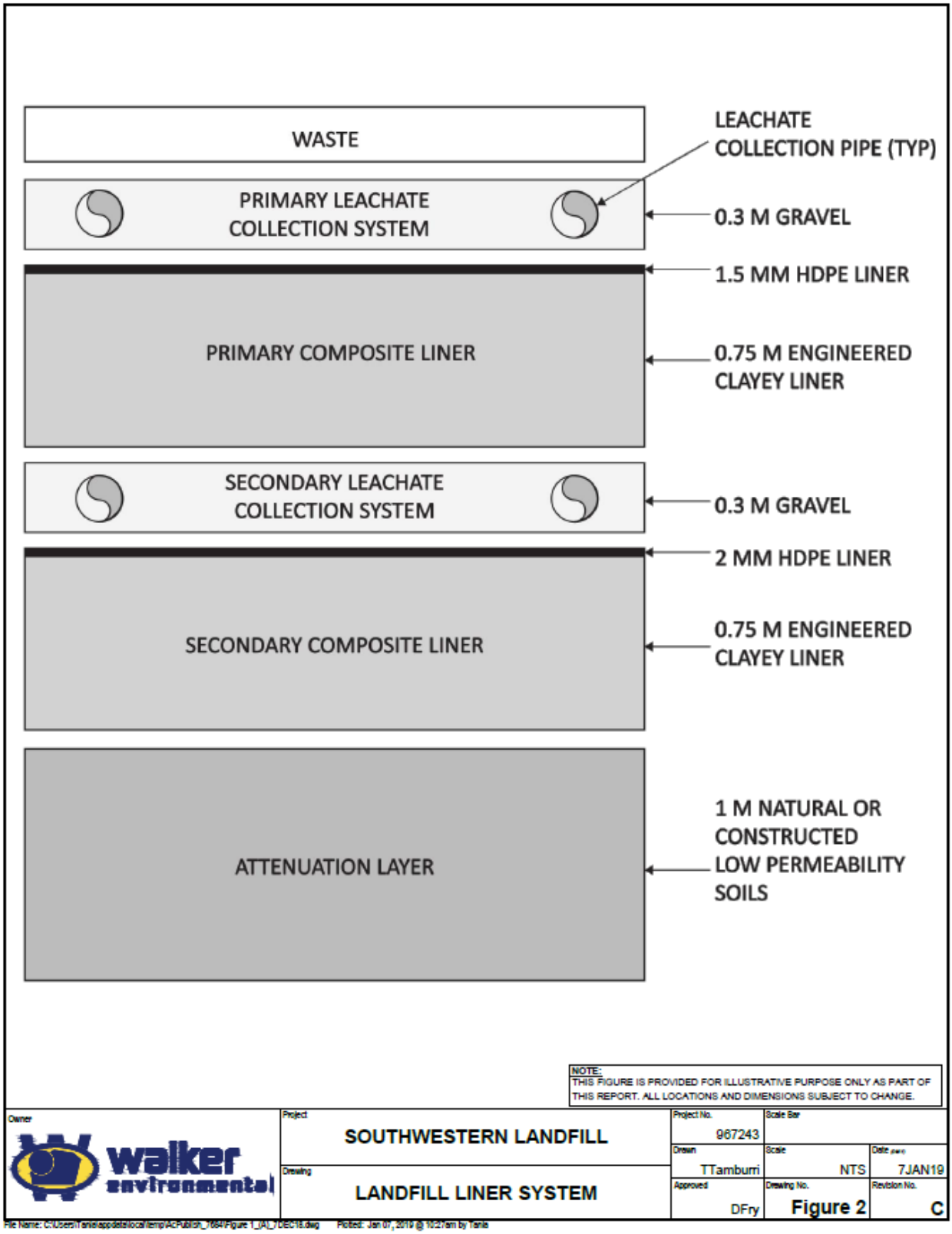


Figure 1-2 Landfill Liner System

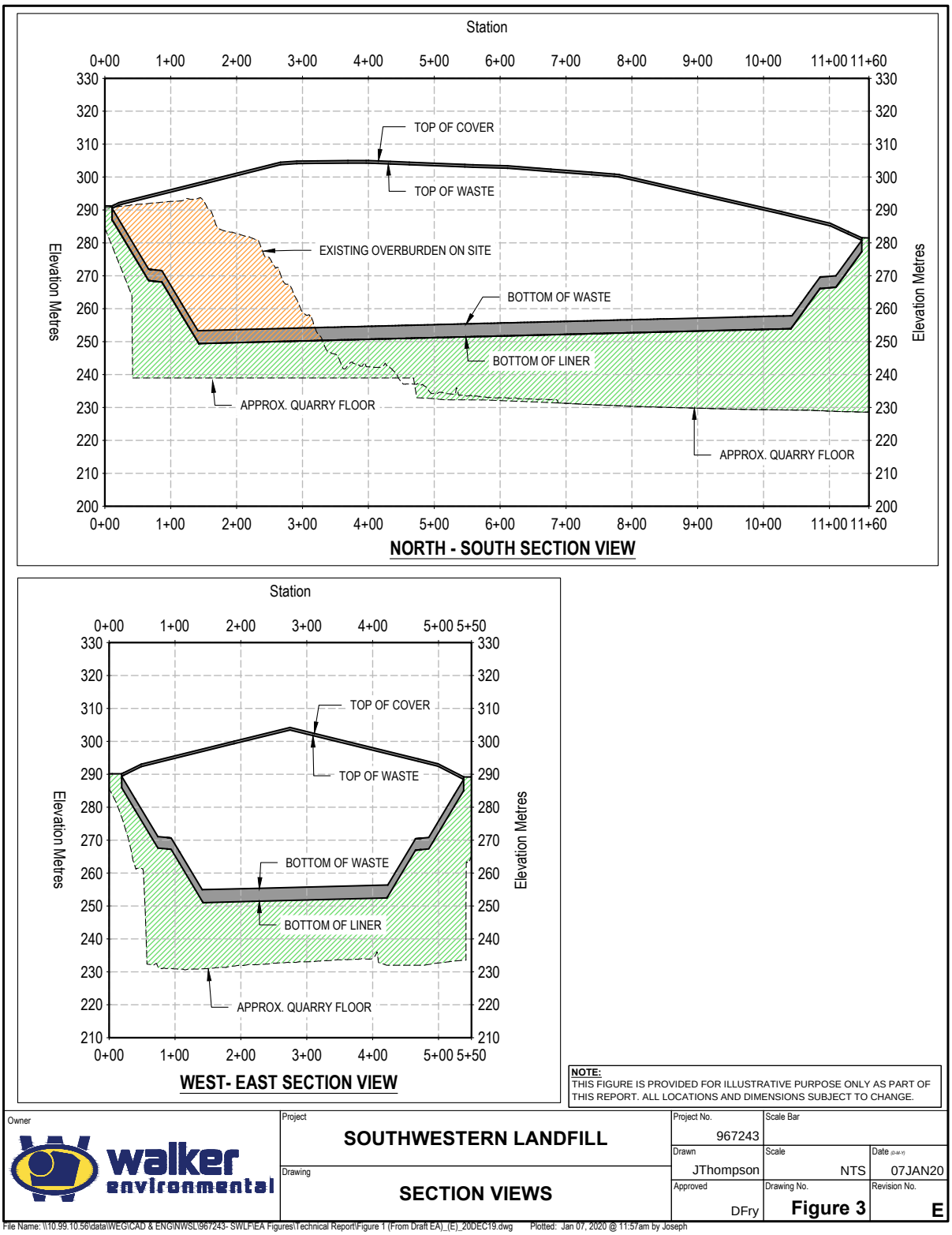


Figure 1-3 Section Views

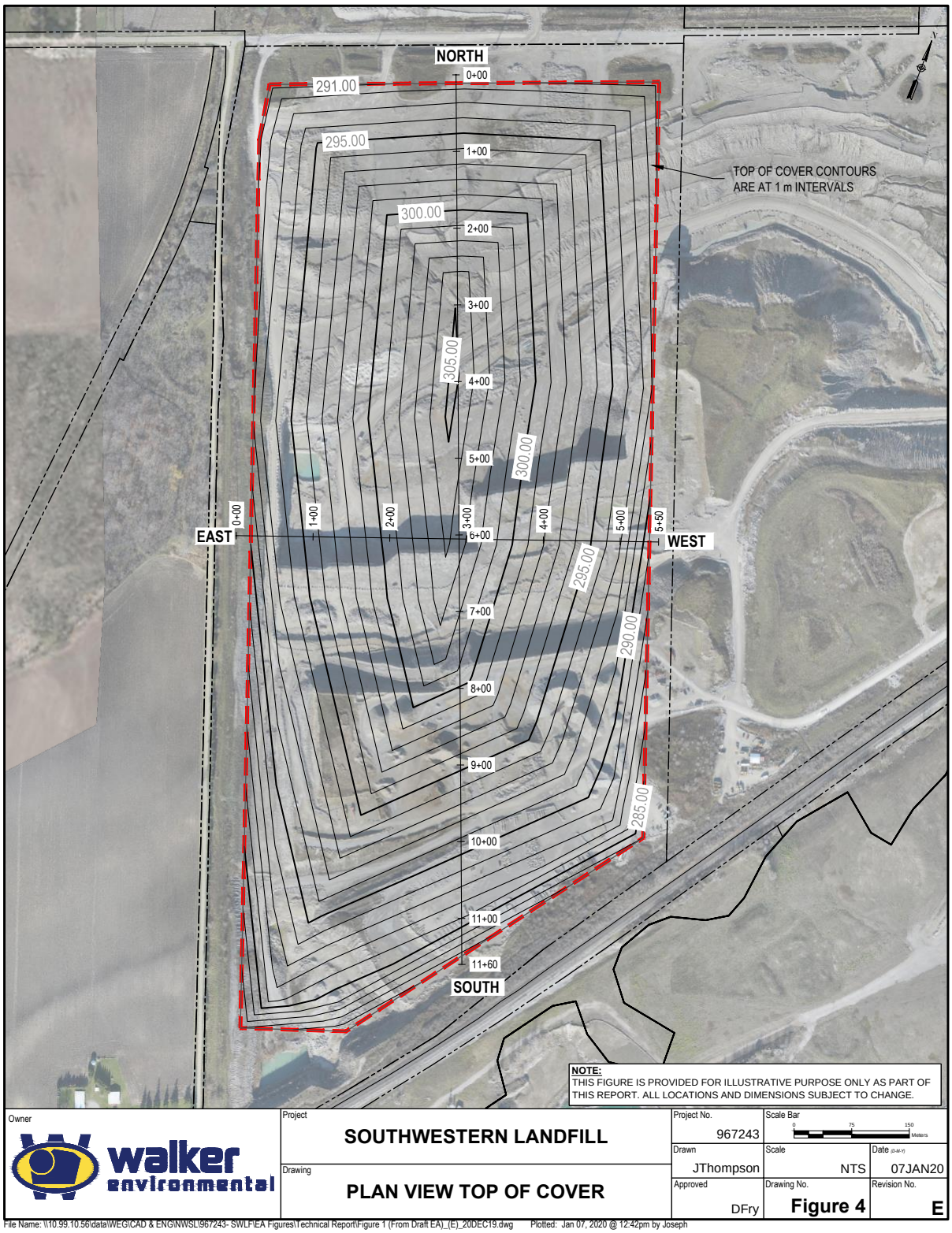


Figure 1-4 Plan View – Top of Cover

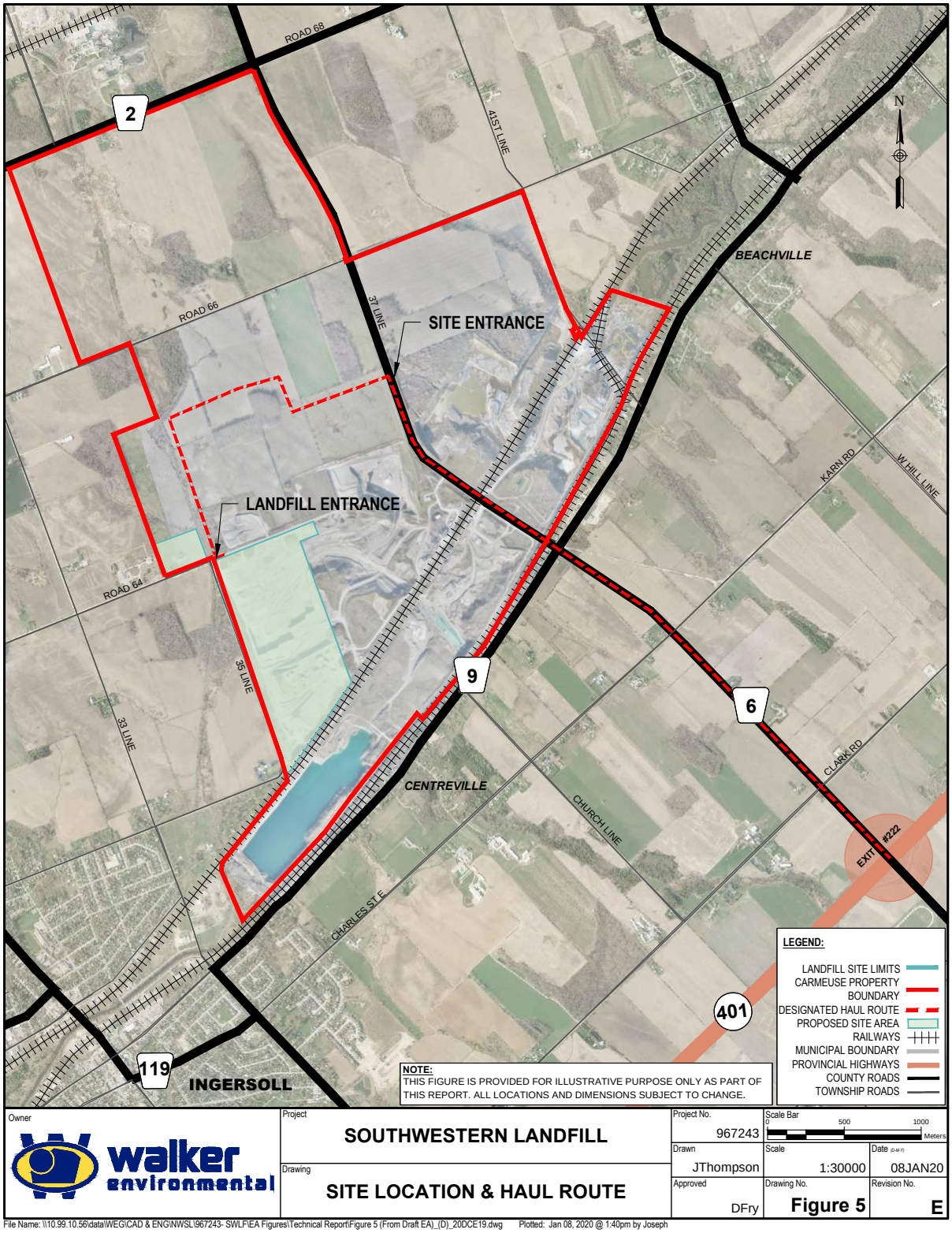


Figure 1-5 Haul Route and Site Entrance

2.0 METHODOLOGY AND APPROACH OF THE SUPPLEMENTARY HEALTH REVIEW

The following methodology (**Figure 2-1**) was recommended by the Minister for the Environment, Conservation and Parks, and further developed by Intrinsik. Subsequently, it was approved by the then acting Medical Officer of Health of Oxford County, Dr. Douglas Neal, and incorporated into the final Terms of Reference of the EA. This recommended approach is loosely based on the Health Impact Assessment framework, which is a combination of procedures, tools and methods to assess the overall impact of a project, policy or program on the health of a community, and the distribution of the impacts within the community (WHO, 1999).

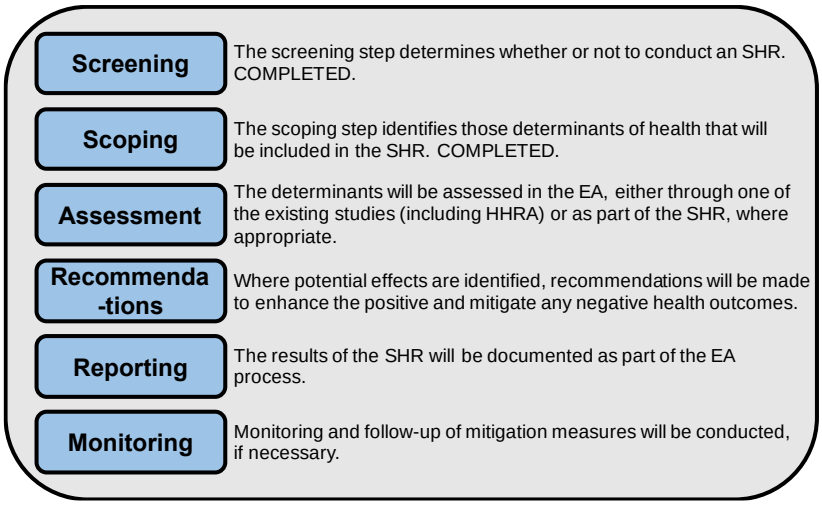


Figure 2-1 Supplementary Health Review Approach

2.1 Methodology

As with the other EA studies, the SHR is a neutral and transparent evaluation of potential impacts. This is to ensure that the proposed project considers protection of community health with respect to development and operations. This SHR does not make judgements on the Proposal, but simply highlights the potential health impacts due to the Proposal on the surrounding communities based on the data and information available in the different EA studies. This approach places the health assessment within the EA context, and not as a separate process, which is in line with Health Canada's recommendation for including health in EA:

> "*Health assessment needs to be integrated in EA and not done as a separate entity because decision-makers require information on economic issues, health and environmental effects concurrently. As such, the obvious decision should be to perform all tasks simultaneously. It would be time consuming and often a duplication of information if one were to assess health separately from EA since information is often common for both. Equally important, the public expects health assessments to be part of the EA process*" (Health Canada; Cited in Walker Correspondence, September 2, 2014).

A brief overview of the SHR methodology and approach is described below.

2.1.1 Screening

The screening step, which determines whether or not a health assessment is needed, has already been completed, i.e., the requirement to conduct this supplementary health review was included in the Approved Amended Terms of Reference of the EA.

2.1.2 Scoping

The scoping step, which identifies those determinants to be included in the SHR, has also been completed, in consultation with the acting Medical Officer of Health, Public Health Ontario, the Joint Municipal Coordinating Committee's Peer Review Team, the Ingersoll Peer Review Team and the Ministry of the Environment, Conservation and Parks (MECP). The scoping step was also used to define boundaries for the assessment, including health issues to be examined as well as spatial and temporal boundaries for the assessment.

Temporal and Geographic Boundaries

It is important to understand the temporal and geographic boundaries that are included in the SHR.

Operational Period	The time during which the waste disposal facility is constructed, filled with waste, and capped. These activities are combined since they occur progressively (i.e., overlap) on a cell-by-cell basis, and they have a similar range of potential effects because of things like heavy equipment on site and active landfill operations.
Post-Closure Period	The time after the site is closed to waste receipt and final cover is applied. Activities are normally limited to operation of the leachate and gas control systems, routine property maintenance and monitoring, and thus have a more limited range of potential effects.

This EA considers the landfill construction to be within the *Operational Period*, since they will be concurrent (i.e., in most years new landfill cells will be under construction at the same time that waste is being placed in other cells).

The geographical scope comprises those regions and populations that have the potential to be affected by the proposed facility, and includes both locations that are proximate to the facility and a broader regional area in which either direct or indirect effects may be experienced. As per the Terms of Reference for the EA, the general established study area includes:

On-Site and in the Site Vicinity	*On-site* includes the proposed waste disposal facility plus the associated buffer zones. *Site vicinity* is the area immediately adjacent to the waste disposal facility property that is directly affected by the on-site activities. Its size is variable depending on the particular criteria being addressed.

Along the Haul Route — The primary route along which the waste disposal facility truck traffic would move between a major provincial highway and the proposed waste disposal facility site entrance, plus the properties directly adjacent to these roads.

Wider Area — The broader community, generally beyond the immediate site vicinity. Depending on the particular criteria this may include neighbourhoods, local municipalities, the Oxford County, or the Province of Ontario.

Health Issues Included in the Assessment

The scope and final list of determinants of health for the SHR were selected based on Dr. Neal's recommendations, in collaboration with Public Health Ontario, and included consideration of the public comments received from the HHRA and SHR work plans (Walker Correspondence dated April 2, 2014) (**Table 2-1**). As per the final work plan for the SHR, and based on the integrated approach identified above, each of the determinants is evaluated as part of the EA. **Table 2-1** outlines the list of determinants of health to be assessed, the corresponding EA study and the assessment approach. The review will evaluate the potential positive and negative health effects of each of the determinants, provided they are not already assessed through the HHRA and/or in another study within the EA. For example, the HHRA assesses potential health impacts of exposure to air (emissions and dust), water and soil; therefore, the SHR will not re-assess these determinants, instead it will point to the appropriate section for reference. This approach will ensure streamlined integration of health into EA to address a wide range of health determinants without unnecessarily duplicating efforts.

Table 2-1 Selected Determinants of Health and Approach

Health Determinants	Focus Areas	Corresponding EA Section	Health Assessed?
Air	➢Emissions	➢HHRA	YES: Health effects from air emissions exposure assessed in the HHRA.
	➢Odour	➢Air Quality Study ➢Social Assessment	YES: Odour will be assessed in the SHR; using data and information from the Air Quality and Social studies, and supplemented with public health data and scientific literature.
Dust	➢Particulates	➢HHRA ➢Air Quality Study	YES: Health effects from dust exposure assessed in the HHRA and Air Quality study.
Water (groundwater and surface)	➢Chemical exposures ➢Recreational use	➢HHRA ➢GW/SW Study	YES: Health effects from groundwater and surface water exposure assessed in the HHRA.
Soil	➢Chemical exposures and recreational use	➢HHRA	YES: Health effects from soil exposure assessed in the HHRA.
Neighbourhood aesthetics	➢Visual impact	➢Visual Impact Study ➢Social Assessment	YES: Visual impact will be assessed in the SHR; using data and information from the Visual Impact and Social Assessments, and supplemented with public health data and scientific literature.
Noise	➢Noise levels and vibrations	➢Noise/ Vibration Study ➢Social Assessment	YES: Noise and vibration will be assessed in the SHR; using data and information from the Noise and Vibration study and Social Assessments, and supplemented with public health data and scientific literature.

Table 2-1 Selected Determinants of Health and Approach			
Health Determinants	**Focus Areas**	**Corresponding EA Section**	**Health Assessed?**
Pests	➢Vermin and wildlife	➢Ecological Assessment ➢Social Assessment	YES: Pests will be assessed in the SHR; using data and information from the Ecological Assessment, and supplemented with public health data and scientific literature.
Traffic	➢Emissions	➢HHRA	YES: Health effects from traffic emissions assessed in the HHRA.
	➢Pedestrian safety	➢Traffic Study	YES: Health effects from traffic safety assessed in the Traffic Study.
Economic	➢Property values ➢Employment ➢Municipal revenues	➢Economic Assessment	YES: Economic-related effects will be assessed in the SHR; using data and information from the Economic Assessment, and supplemented with public health data and scientific literature.
Social	➢Perception of hazards, including socio-psychological impacts ➢Recreational access and enjoyment	➢Social Assessment	YES: Social-related effects will be assessed in the SHR; using data and information from the Social Assessment, and supplemented with public health data and scientific literature.
Cultural heritage	➢Cultural heritage	➢Cultural Heritage Study ➢Social Assessment	YES: Social/cultural-related effects will be assessed in the SHR; using data and information from the Cultural Heritage Study, and supplemented with public health data and scientific literature.
Built Environment	➢Land use planning and recreational spaces	➢Land Use Study	YES: Built Environment-effects effects will be assessed in the SHR; using data and information from the HHRA and Land Use study, and supplemented with public health data and scientific literature.

Hence, this supplementary review focuses on those aspects of health that are not otherwise addressed through the HHRA or other EA studies, primarily related to social and economic factors as suggested by Dr. Neal.

2.1.3 Assessment

The assessment approach consisted of:

- Developing a baseline community health profile for the study area (or Oxford County as a whole, depending on available data);
- Analyzing the social and economic assessment findings to determine whether or not those predicted effects could also result in significant health effects; and
- Collating and summarizing relevant findings for each of the determinants of health that have been assessed through other EA studies (see **Table 2-1**).

For the analyses of the social and economic determinants, relevant information included: EA studies (e.g., social and economic, along with related source documents such as air quality, noise, etc.); peer-reviewed and grey literature to identify potential health effects; data on current conditions in the local area (also from EA reports); and, published research linking the

determinant of health to changes in the health. Broadly, the following assessment approach was carried out for each of the health determinants (except those already assessed in the HHRA) included in the SHR:

- Making the connection to health (e.g., Odour and Health);
- A discussion of the current conditions, as per the EA report; and,
- Characterization and assessment (qualitative) of Landfill Proposal Impact.

Health linkages

The first step in assessing potential impacts is to identify the relevance to health. For those determinants of health not assessed in the HHRA, a description of how the determinant is relevant to health and well-being outcomes in the context of the Proposal is provided. Where available, both peer-review and grey literature data on health impacts due to landfills via the determinant of health being assessed is provided.

Current Conditions

Information on current conditions is presented in two ways:

- The Baseline Community Health Profile section of this report presents information on the overall current health status of the community, or the local area (Oxford County). The purpose is to provide context for the assessment, by describing at a high level how healthy the local population currently is, in comparison to other areas of Ontario, and what health issues are of top concern.
- In addition, each assessment section contains specific information on current baseline conditions, as per the respective EA study reports, that have the potential to change as a result of the proposed landfill facility.

Landfill Proposal Impact

Using information from the relevant EA studies as well as the literature, an assessment is made for determinants of health on the overall potential for related health impacts due to the proposed landfill.

Effect Characterization

For effect characterization, the assessment of effects combines information about current conditions with evidence from the literature to arrive at conclusions about the nature and extent of change that is likely to be observed with the proposed landfill. In order to present these conclusions in a standardized way, a number of effect characterization parameters have been selected (**Table** 2-2).

Table 2-2 Effect Characterization Definitions		
Parameter	**Rating**	**Definition**
Affected populations Who is likely to experience the effect?	**Specific**	Effect is limited to certain individuals or specific groups
	Proximate	Effect may be experienced generally by those living in proximity to the facility
	Regional	Effect may be experienced generally on a broader scale (*i.e.*, beyond the area that contains the facility)
Magnitude What is the potential severity of the effect on human health?	**Low**	Effects are small or may be experienced by a few individuals
	Medium	Effects are moderate or may be experienced by a wide range of individuals or be noticed by agencies and organizations
	High	The effects are severe or could create a change at a system level
Likelihood What is the probability of the impact occurring?	**Low**	The impact is anticipated to occur rarely, if ever. This classification is appropriate for those situations where impacts are not zero but they are limited to very rare occurrences, catastrophic events, or highly unlikely system failures.
	Medium	The impact may happen, but is not certain to occur
	High	The impact will almost certainly occur
Potential Health Consequence Will the effect be helpful or harmful to human health?	**Positive**	The effect is anticipated to improve health and well-being
	Negative	The effect is anticipated to diminish health and well-being
	Mixed	The effect may both improve and diminish health and well-being
	Neutral	The effect is negligible and is anticipated to have little to no effect on health and well-being
Level of Confidence How conclusive are these predictions?	**Low**	The effect characterization based on very limited (low quality) data and/or the information is general in nature without any site-specific consideration
	Medium	The effect characterization based on some (moderate quality) data and/or the information is general in nature with limited site-specific consideration
	High	The effect characterization based on substantial (high quality) data and/or the information is site-specific in nature

2.1.4 Recommendations

Finally, high-level recommendations are presented in **Section 5**. These recommendations take into account mitigation or impact management strategies proposed in the EA. From the health perspective, the SHR further emphasizes the importance of some of these mitigation strategies,

2.1.5 Reporting and Monitoring

Reporting and Monitoring are the last two steps of the SHR. In the reporting phase, the design, methods and findings of the SHR are communicated to a spectrum of stakeholders. This SHR report is the main method of communication being used.

Monitoring is addressed in **Section 6**.

Section 7 includes a discussion of Data Gaps, Limitations and Uncertainties that were pertinent to this SHR, and **Section 8** provides the overall conclusions of the SHR. The references used in the preparation of this report are provided in **Section 9**.

3.0 BASELINE COMMUNITY HEALTH PROFILE

As per the methodology adapted for this SHR, the first step in the assessment stage is to create a baseline health profile that describes, at a high level, the current health conditions in the community. The baseline health assessment establishes the current health status of Oxford County, and where data availability allows, the Township of Zorra. This allows for the evaluation of vulnerable groups within the community, and also provides a benchmark to assess change due to the Proposal.

Existing health and demographic data has been obtained for Oxford County as a whole, but little or old (2006) information was available that was specific to the Township of Zorra. During the course of this SHR, Oxford County Public Health Unit amalgamated with Elgin St. Thomas Public Health, to form Southwestern Public Health in 2018, which serves a population of approximately 200,000 across Oxford County, Elgin County and the City of St. Thomas. As such, recent health status data was available at the level of Southwestern Public Health and is also presented here.

Oxford County

Oxford County is a 2,040-square kilometre area located in the heart of southwestern Ontario. The County is home to over 110,000 people across eight municipalities: Blanford-Blenheim, East Zorra-Tavistock, Ingersoll, Norwich, South-West Oxford, Tillsonburg, Woodstock and Zorra. Of these, some are rural and others urban (OHMS, 2017):

- Rural: Zorra, East Zorra-Tavistock, Blandford-Blenheim, Norwich and South-West Oxford.
- Urban: Woodstock, Ingersoll and Tillsonburg.

As seen from **Figure 3-1**, Oxford County is part of a broader economic area that includes the City of London as well as the urban areas within the Region of Waterloo. This provides Oxford County residents with strong employment and leisure connections to these nearby centres. Oxford County is recognized mainly by its three large urban centres: Woodstock, Tillsonburg, and Ingersoll. Woodstock is the centre for employment, commerce, recreation and administration in Oxford, and Tillsonburg plays a similar role for southern Oxford and areas of Elgin and Norfolk Counties. The Town of Ingersoll is a major centre of employment and commerce. The rural municipalities in Oxford are recognized for agriculture and aggregate extraction. The County of Oxford and its constituent area municipalities are represented in **Figure 3-1**, along with the neighbouring municipalities and urban centres. **Figure 3-2** shows the location of the Proposal within the Township of Zorra, with respect to its surrounding areas and municipalities.

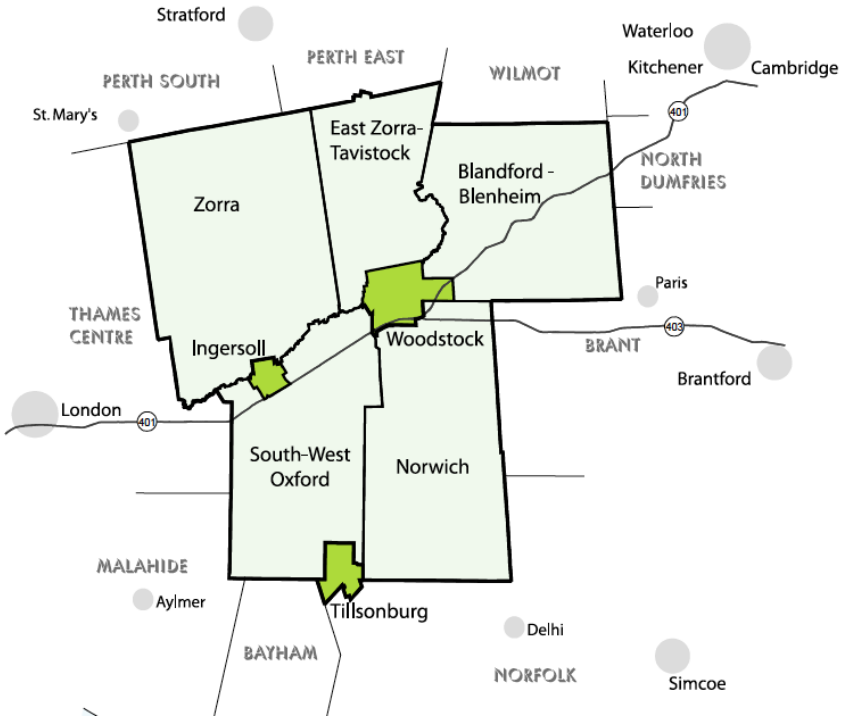


Figure 3-1 Map of Municipalities within Oxford County
(From Oxford County Official Plan, 2017)

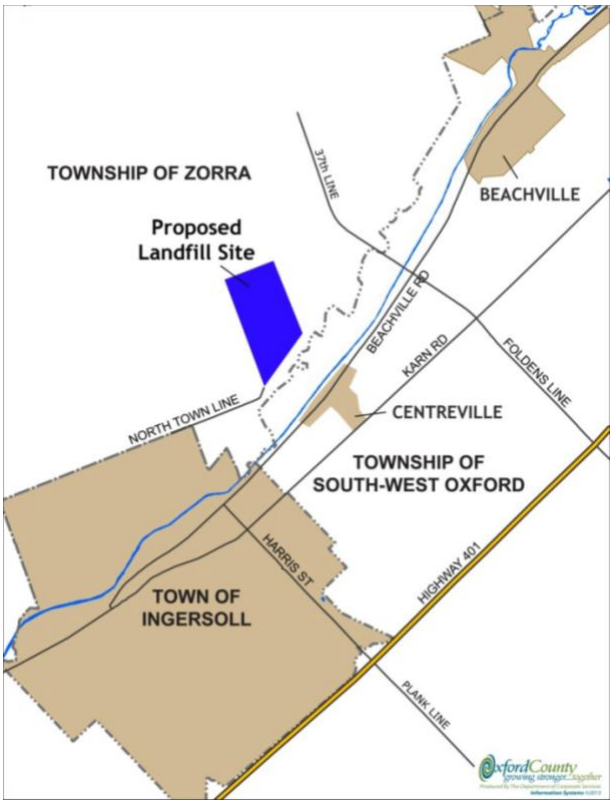


Figure 3-2 Map of Oxford County Municipalities around proposed landfill

3.1 Demographics

In Oxford County, three urban municipalities, Woodstock, Ingersoll and Tillsonburg, represent an area comprising 79 km2, which is 3.9% of the total land area, while the remaining five areas represent rural Oxford County, comprising 1,960 km2 and 96.1% of the total land area. The largest land area in the County is the Township of Zorra, with 25.9% representation. The land area of Zorra is 528.94 square kilometres and the population density was 15.4 people per square kilometre. 89% of the land in Oxford County is farmed, with the County farms being the second most productive in Ontario in 2001 (Oxford County Official Plan, 2017). The largest population in Oxford County is in the City of Woodstock, with over 40,000 residents, whereas the Township of Zorra has a population of 8,138 (Statistics Canada, 2017a).

Table 3-1 Demographic indicators

	Township of Zorra	Oxford County	Ontario
Population			
Total Population	8,138	110,862	13,448,494
Median Age of Population	42.5	42.3	41.3
Children (19 years old and under)	985 (12%)	26,440 (24%)	3,019,640 (22%)
Seniors (65 years and older)	1,360 (17%)	20,680 (19%)	2,251,655 (17%)
Ethnicity			
Aboriginal identity[a]	55 (1%)	3,540 (3%)	518,300 (4%)
Visible minority population[b]	160 (2%)	3,440 (3%)	3,885,585 (29%)
Immigrant population[c]	510 (6%)	10,785 (10%)	3,852,145 (29%)
Income			
Median total income in 2015 among recipients (in $)	40,094	36,025	33,539
In low income based on the Low-income measure, after tax (LIM-AT)[d] (in $)	655 (8%)	11,835 (11%)	1,898,975 (14%)

Source: Statistics Canada (2017)
Notes: numbers in brackets provide percentages of total population

a 'Aboriginal identity' includes persons who are First Nations (North American Indian), Métis or Inuk (Inuit) and/or those who are Registered or Treaty Indians (that is, registered under the Indian Act of Canada) and/or those who have membership in a First Nation or Indian band. Aboriginal peoples of Canada are defined in the Constitution Act, 1982, section 35 (2) as including the Indian, Inuit and Métis peoples of Canada.

b Visible minority refers to whether a person belongs to a visible minority group as defined by the *Employment Equity Act* and, if so, the visible minority group to which the person belongs. The *Employment Equity Act* defines visible minorities as "persons, other than Aboriginal peoples, who are non-Caucasian in race or non-white in colour."

c 'Immigrants' includes persons who are, or who have ever been, landed immigrants or permanent residents.

d Low-income measure, after tax (LIM-AT) - The Low-income measure, after tax, refers to a fixed percentage (50%) of median-adjusted after-tax income of private households. The household after-tax income is adjusted by an equivalence scale to take economies of scale into account. This adjustment for different household sizes reflects the fact that a household's needs increase, but at a decreasing rate, as the number of members increases.

As seen from **Table 3-1**, Zorra has a lower percentage of residents under the age of 19, than in Oxford County as a whole, or within the province overall (Smale and Gao, 2018). In addition, the County is one of the least ethnically diverse regions in the entire Province (3% visible minority population when compared to the Province's 29%).

Since 2011, the population of Oxford County has shown an increasing trend, with the increase from 2011 to 2016 being as much as 4.9% (**Figure 3-3**). Zorra, however has seen a population increase of 1% in the same time period (Statistics Canada, 2017b).

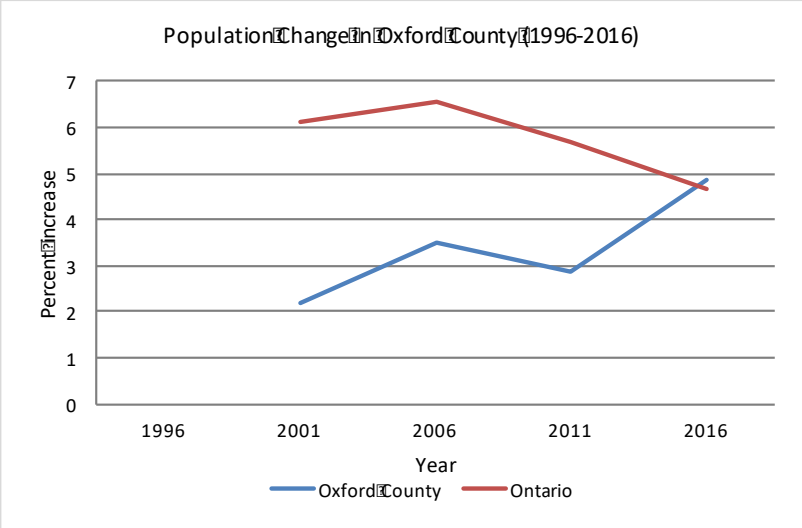


Figure 3-3 Oxford County Population Change Over time (1996-2016)
(Statistics Canada, 2017a)

Oxford County also has a higher employment rate (63.5%) than the province (59.9%) and Canada overall (60.2%) (Smale and Gao, 2018). In keeping with this, the County also has a lower unemployment rate (4.8%) than the province (7.4%) and Canada overall (7.7%).

As per the Economic and Financial Assessment report (Keir, 2020) prepared for this EA, using 2016 Statistics Canada data and applying consumer price index inflation, the average income for a full-time job in Oxford County in 2018 dollars was approximately $61,000. Using the same method, in Zorra the average income was $62,500, and for the study area municipalities the income range was approximately between $59,000 and $64,000 (Keir, 2020).

3.2 Health status and wellness

Having access to a regular health physician, such as a family doctor, is a useful indicator of the capacity and appropriateness of the primary health care system. The vast majority of residents of Oxford County have access to a regular health physician (95.1%), which is 10% higher than that in Canada overall (85.1%), and also higher than Ontario (92.5%).

In a survey conducted in the spring of 2016 by the Canadian Index of Wellbeing (Smale and Gao, 2018), a greater percentage of Oxford County residents reported their overall health as better (62%) than those in the province as a whole (59.2%). However, residents self-reported their mental health as very good or excellent in slightly lower numbers (65.8%) as compared to the West Region of Ontario as a whole (68.8%), the province (70.4%) or the country (71.1%), indicating that this could potentially be an area of concern for the County.

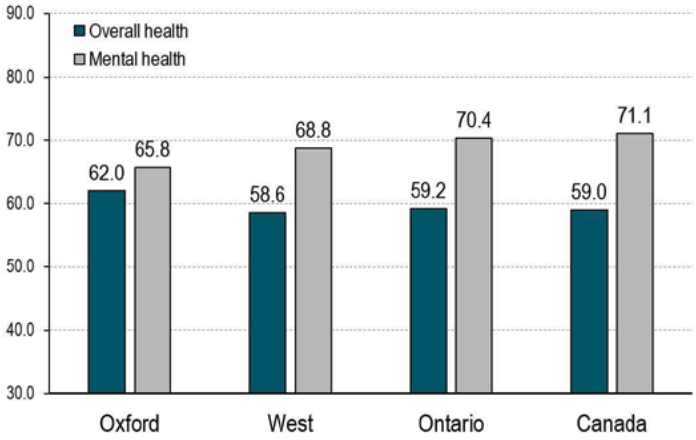
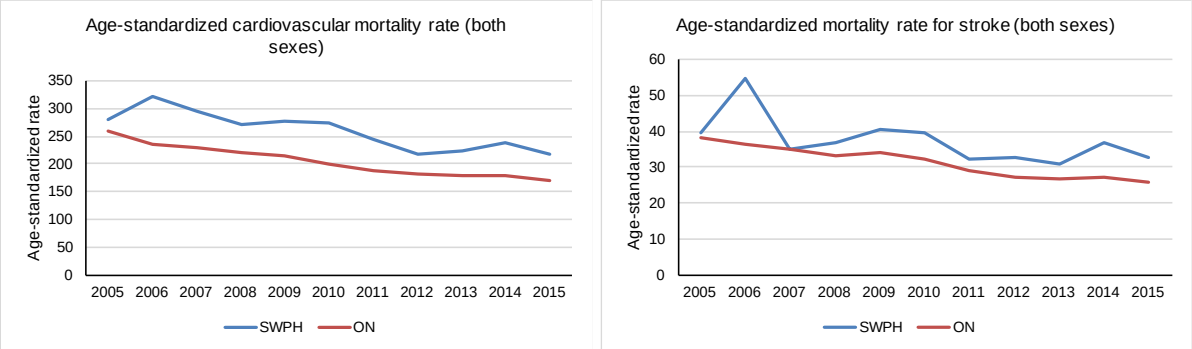


Figure 3-4 Self-reported mental health in Oxford County, West Region of Ontario, Ontario and Canada (Smale and Gao, 2018)
(Statistics Canada, 2016)

However, as per Southwestern Public Health (MacLeod and Hussain, 2019b), from 2015 to 2016, a lower proportion of people living within urban municipalities in the region self-reported as having very good or excellent mental health (70.1%) when compared to people in rural municipalities (77.9%). As discussed, Zorra falls in the rural municipality category, and only Ingersoll, Woodstock and Tillsonburg fall in the urban category. Moreover, as expected, self-reported mental health rates in the Southwestern Public Health region varied by household income, where those in the lower quintiles reported lower rates of very good or excellent mental health (Q1=54.1%; Q2=62.7%), when compared to those in the higher quintiles (Q3= 78.7%; Q4=77.8%; and Q5=82.7%) (MacLeod and Hussain, 2019b). Not unique to Oxford County by any means, this almost 30% difference in self-reported very good or excellent mental between the lowest and highest quintiles is noteworthy. As is discussed in **Section 4.9**, socioeconomic status is often an indicator of overall health and well-being.

Morbidity and mortality

In order to provide a general understanding of the overall health status of the local population, morbidity and mortality information, available at the level of Southwestern Public Health (population ~ 200,000), is provided below. Graphs presented below provide age-standardized mortality rates for cardiovascular disease, stroke, asthma, diabetes and all cancers, for Southwestern Public Health, as compared to the same rates across Ontario (**Figure 3-5**). Information for these graphs was gathered from Public Health Ontario's Chronic Disease Mortality Snapshot tool (Public Health Ontario, 2016).



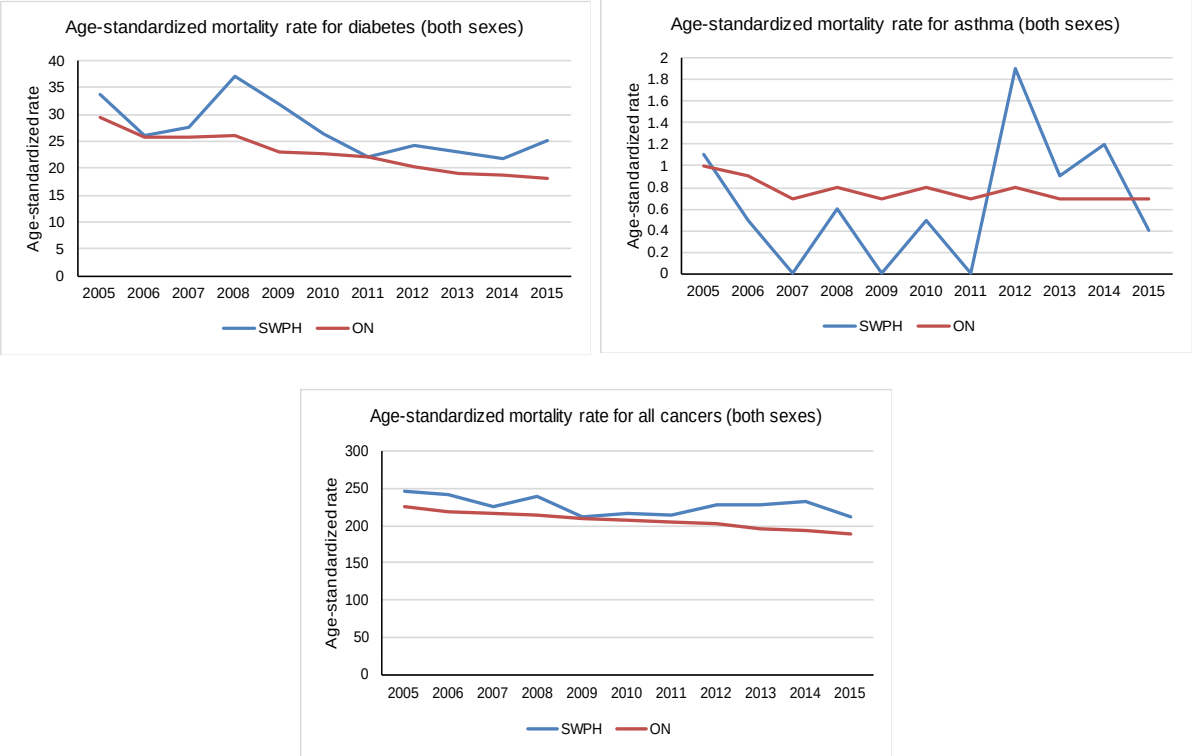


Figure 3-5 Age-standardized mortality rates for cardiovascular disease, stroke, asthma, diabetes and all cancers for Southwester Public Health and Ontario (Public Health Ontario, 2016)

(Source: Vital Statistics Mortality, 2003 – 2015, Ontario Ministry of Health and Long-Term Care, IntelliHEALTH Ontario, extracted 2017 Apr 5 (2003 - 2012); 2019 Feb 13 (2013 - 2015).)

As per Public Health Ontario (and as seen from **Figure 3-5)**, overall, from 2003 to 2015, only the age-standardized mortality rates for cardiovascular disease for Southwestern Public Health were significantly higher, when compared to the age-standardized mortality rates for cardiovascular disease for Ontario (Public Health Ontario, 2016). Hence, overall, health status in Oxford County is generally comparable to Ontario.

3.3 Built Environment in Oxford County

The built environment is an important determinant of health, as it has the potential to influence a range of behaviours, such as physical activity/exercising, and social interactions. These behaviours, in turn, impact rates of chronic disease and overall mental, physical and spiritual wellbeing. The built environment can also affect an individual's exposure to health hazards, for example, living close to a busy highway provides higher exposure to poor air quality.

According to the Oxford Health Matters Survey, conducted in 2016, currently, 84.4% of rural Oxford County residents believe that their neighbourhood is an excellent, very good or good place to walk for leisure, when compared to 98% of urban County residents (Oxford County Public Health, 2017) (**Figure 3-6**). The Township of Zorra is part of 'rural' Oxford County. The built environment, as a determinant of health is discussed in **Section 4.12**.

Indicator	Per cent of residents (95% CI)		
	Overall	Rural	Urban
Current Neighbourhood Characteristics			
Current neighbourhood is an excellent, very good or good place to walk for leisure	93.4% (89.9%-95.8%)	84.4% † (75.2%-90.7%)	98.0% † (96.4%-98.9%)
Current neighbourhood is an excellent, very good or good place to walk for reasons *other than leisure*	70.0% (64.7%-74.8%)	54.8% † (45.1%-64.2%)	77.7% † (71.8%-82.6%)
Ideal Neighbourhood Characteristics			
Having sidewalks or pathways that are connected to each other is very or somewhat important	86.4% (82.0%-89.8%)	73.6% † (63.8%-81.5%)	92.9% † (89.0%-95.5%)
Living in a neighbourhood where one can walk to places such as stores, restaurants, community centres or schools is very or somewhat important	74.6% (69.5%-79.1%)	55.5% † (45.7%-64.8%)	84.5% † (79.5%-88.4%)
Living in a neighbourhood with public and open spaces and other areas that create a place where people in the community can get together and talk is very or somewhat important	86.3% (82.5%-89.4%)	78.7% † (70.2%-85.3%)	90.2% † (86.3%-93.1%)
Things such as pedestrian street lighting, shade trees and benches or places to rest are very or somewhat important	90.0% (86.4%-92.8%)	83.6% † (74.6%-89.9%)	93.4% † (90.5%-95.5%)

Figure 3-6 Perceptions of built environment characteristics, by rural or urban residence, Oxford County, 2016 (Oxford County Public Health, 2017)
(† Statistically significant difference between groups based on a 95% confidence interval)

3.4 Environmental Quality

Air Quality

In 2015, total greenhouse gas emissions from the largest facilities in Oxford County were about 0.8 megatonnes of CO_2, representing a small proportion of the provincial total (1.8%) (Smale and Gao, 2018). Therefore, currently, Oxford County is not a major contributor to the overall greenhouse gas emissions in Ontario.

From 2016 through to 2017, Southwestern Public Health monitored particulate matter at six sites across South-West Oxford, Zorra and Ingersoll. Air samples were taken every five minutes using DustTrak air quality monitors, over periods ranging from two weeks to a little over one month. The results showed that (Southwestern Public Health, 2018):

- $PM_{2.5}$, PM_{10} and total particulate were observed at levels that were considered safe for human health;
- Average $PM_{2.5}$ levels were well below the health-based 24-hour Canada Ambient Air Quality Standard;
- Average PM_{10} levels were well below the 24-hour Ambient Air Quality Criteria; and,
- Four of the six sites identified very brief high levels of $PM_{2.5}$, PM_{10} and total particulate matter, indicating peak events. It was concluded that these brief peaks could occur from time to time due to cases of high motor vehicle traffic, lawn mowing or industrial activity. In addition, several sites also experienced elevated levels of PM_{10} and total particulate, but not elevated $PM_{2.5}$ levels, which is indicative of dust events. These brief high levels were not considered to be of concern for adverse health effects for the area.

Water Quality

Ontario has a relative abundance of fresh water, which is a tremendous benefit enjoyed by all in the Province, including those in Oxford County, which draws most of its drinking water from ground water (Smale and Gao, 2018). The pH level of fresh water in the West Region, which is an indicator of quality, is 8.3, which is slightly alkaline, but well within acceptable limits. In Oxford County, fresh water has a pH level of 8.2, which is identical to the province as a whole.

3.5 Discussion of Vulnerable and Sensitive Populations

In general, when conducting a health assessment, in keeping with best practices, it is prudent to consider the potential impact on vulnerable populations of society that may be disproportionately affected by the project. Invariably, children and the elderly are considered to be vulnerable populations with respect to numerous different types of environmental exposure. In Oxford County, Tillsonburg had the highest proportion of older adults (27.8%) as well as a high proportion of older adults living alone (27.4%) (MacLeod and Hussain, 2019a). This concentration highlights an area of vulnerability and social isolation among older adults, which does not appear to be the case in Zorra, where 16.7% of the population was elderly, and 18.8% of the older adults lived alone (MacLeod and Hussain, 2019a). This is a smaller percentage of the population when compared to the County as a whole, where 18.7% are 65 years of age or over, and 24.6% of this population lives alone.

In addition, as seen from **Table 3-1** above, the Township of Zorra has a lower percentage of children (residents under the age of 19), than in Oxford County as a whole, or within the province overall. As well, Oxford County is one of the least ethnically diverse regions in the entire Province (3% visible minority population when compared to the Province's 29%).

Hence, the community immediately surrounding the proposed landfill does not seem to contain a significant vulnerable population, which could also indicate a higher level of resilience to any potential adverse impacts.

4.0 ASSESSMENT

As described previously, the assessment process in this SHR involves (1) developing a baseline community health profile (**Section 3**), and (2) assessing and characterizing the likelihood of health impacts (either positive or negative), using both literature and information/data from the EA (see **Table 2-1**).

4.1 Air Quality

The HHRA, drawing on the Air Quality Assessment (RWDI, 2020a) characterizes the potential health impacts of changes to air quality that could occur as a result of the Proposal, specifically due to the concern that waste disposal facilities, including leachate treatment facilities can produce emissions that degrade air quality. Traffic-related impacts to air quality are discussed in **Section 4.8** and impacts due to particulate matter are discussed in **Section 4.2**.

Two potential issues associated with changes in air quality that have been identified in the health determinants and have the potential to impact human health include:

- Emissions; and,
- Odour.

4.1.1 Emissions

The HHRA evaluates health impacts due to emissions. As such, the SHR provides a summary of the HHRA results and characterizes impacts on health.

Current Conditions

As per the Air Quality Assessment report produced by RWDI (2020a), as well as the Draft EA Report (Walker, 2020), the background concentrations for most compounds are low, relative to their criteria. Air quality in the study area reflects the predominant land uses, including urban development, agriculture and industry. It is also influenced by the proximity of major transportation corridors, such as rail lines and Highway 401. It generally remains within government standards and guidelines for a wide range of constituents, with a couple of notable exceptions. One is chloroform, whose baseline concentrations exceed the applicable criterion by about 20% on average. Another is benzo(a)pyrene (a combustion residual) whose background levels are about three times the applicable criterion. However, it is important to note that, in the absence of local monitoring information, the background levels of benzo(a)pyrene used by RWDI was obtained from MECP air quality monitoring data from Simcoe, and does not specifically represent local air quality in the area around the Proposal.

Moreover, future baseline conditions for background ambient volatile organic compounds and sulphur are assumed to be equivalent to existing baseline conditions (RWDI, 2020a). No new industrial sources of volatile organic compounds or sulphur compounds are expected to be developed in the immediate vicinity of the landfill in the future.

Landfill Proposal Impact

The assessment of landfill gas (LFG) impacts resulting from the proposed landfilling activities focused on emissions generated from the following landfilling activities (RWDI, 2020a):

- Fugitive LFG releases from landfill stages under final cover;

- Fugitive LFG releases from the active stages of the landfill under interim cover;
- The LFG flare;
- The waste soil storage piles;
- The raw leachate storage pond; and,
- The leachate aeration pond.

In addition, the following sources were considered as sources of similar emissions:

- Carmeuse Kilns

Modelling demonstrates that air quality at off-site residences and public facilities when the residual emissions from all landfill related sources are combined with the background air quality and other local emission sources (i.e., lime kilns) will continue to meet provincial standards (RWDI, 2020a). Two exceptions are chloroform and benzo(a)pyrene, where background levels already exceed their respective provincial criteria. However, the landfill is not a major additional contributor to these (less than 15% chloroform contribution and less than 10% benzo(a)pyrene contribution at any off-site receptor) (RWDI, 2020a). The HHRA evaluated the risk to human health based on the Air Quality Assessment results and concluded that the emissions from the proposed Landfill would not result in any unacceptable short- or long-term health risks, either from air inhalation or soil, agricultural and home garden produce exposure routes, in any of the evaluated Landfill operating stages (Intrinsik, 2020).

Hence, as per the Air Quality Assessment report (RWDI, 2020a) and the Draft EA Report (Walker, 2020):

> "*Air emissions from the landfill site will not exceed provincial air quality standards at any off-site residence or public facility. As a result, the landfill emissions will not be a significant contributor to any cumulative air quality effects from other baseline sources.*"

Effect Characterization

The air quality assessment considered both a regional and proximate context. As per the Air Quality Assessment Report, as well as the HHRA, after modelling impacts due to the proposed landfill, the magnitude of adverse impacts is characterized as low, and unlikely to occur. As such, there is no net impact on the current air quality due to emissions from the landfill. Overall, given that the data and information being used to assess the potential for impacts has been collected and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-1 Effect Characterization for Air Quality Effects – Emissions

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Emissions	Regional/ Proximate	Low	Low	Neutral	High

4.1.2 Odour

Odour and health

Where landfills are managed improperly, odours can be a frequent concern. Landfill-related odours are mainly associated with activities such as the handling of odorous wastes, covering of biodegradable wastes or with the presence of trace components in landfill gas or leachates

(HPA, 2011). According to research, landfills account for about 10 – 25% of all odour-related complaints made to local authorities (DEFRA, 2004). Hence, proper management of landfills is extremely important.

Odour-related complaints can also be accompanied by health concerns from the surrounding local communities. The reported health concerns could be a wide range of non-specific symptoms, all subjectively attributed to odour exposure: nausea, headaches, drowsiness, fatigue and respiratory problems (DEFRA, 2004). Health symptoms related to perceived odours may be reported at olfactory detectable concentrations that are "well below the levels associated with toxic effects or thresholds for mucous membrane irritation" (HPA, 2011). Depending on an individual's sensitivity, age and prior exposure, the response to odour may vary significantly. Also at play are psychological and social factors, including an individual's level of concern about their health. There is a plethora of studies that have been published showing a strong correlation between annoyance related to perceived odour and subjective symptoms (Dalton et al., 1997; Dalton, 2003; HPA, 2011).

Current Conditions

As the odours produced from a landfill are distinctive, the EA Odour Assessment (RWDI, 2020a), assumed no current existing source of landfill-related odours in the study area for the baseline conditions. And although agricultural odours can be similar to landfill type odours, the study did not include agricultural odours as local background sources. Hence, the predicted odour levels due to the proposed landfill site evaluated the change in perceived odours from no odours (baseline) and evaluated the potential for odour impacts based on the MECP nuisance guideline level and frequency of occurrence (1 Odour Unit detectable no more than 0.5% of the time), and for odour events above 1 OU, 3 OU and 5 OU at sensitive receptor locations (RWDI, 2020a).

Landfill Proposal Impact

As per the Odour Assessment (RWDI, 2020a), one of the major potential odour sources at the facility is the leachate treatment ponds, due to their proximity to the property line. These odours would occur in a localized area, adjacent to the leachate ponds. Odour levels were noted to decrease with increasing distance from the leachate ponds, hence, the maximum predicted odour concentration occurring from the landfill sources are influenced by the proximity of these sources to the property line. The predicted odour emissions from the landfill itself are expected to increase over time, as a result of increased waste present in the landfill in future years, which results in increased LFG generation, and thus increased odour emissions, from this source. Post-closure odours will decrease relative to the operational stages, since during the post-closure period all landfill areas are under final cap with full gas collection. Although the maximum predicted odour concentrations at the property line are predicted to exceed the 3 OU annoyance threshold from time to time, the MECP guidance document indicates that odour concentrations need only be assessed at odour-sensitive receptor locations, such as residences, commercial buildings, and outdoor parks and recreation areas.

With additional mitigation consisting of odour covers over at least 30% of the leachate treatment pond surface, landfill odours are predicted to be detectable less than 0.5% of the time at all off-site residences (i.e., meeting provincial guidelines) with the exception of the nearest resident to the southwest (where detectable odours may occur very rarely, i.e., 0.9% of the time) (RWDI, 2020a).

Effect Characterization

Any odour impacts from the landfill would be experienced in the immediate proximity. In this case, odour impacts exceeding the provincial guidelines for nuisance are predicted to occur at only one closest residence to the site (RWDI, 2020a), and at that location only very rarely. Therefore, the overall magnitude of adverse impacts is determined to be low, and the likelihood of impacts is low, as it is mainly one proximate residence where the frequency of odour detection is minimally elevated. As such, there is no net impact on health due to odour from the landfill (neutral). Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-2 Effect Characterization for Air Quality Effects – Odour

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Odour	Proximate	Low	Low	Neutral	High

4.2 Dust

The HHRA evaluated particulate matter (PM) emissions due to the Proposal, and as such the SHR summarizes the HHRA results and provides a characterization of health impacts based on the information and data provided in the HHRA as well as the Air Quality Assessment (RWDI, 2020a).

Current Conditions

Particulate matter is present in the site vicinity primarily as a result of road traffic and to a lesser degree quarrying activities and other background sources such as farming, although remaining within the standards at off-site residences and public facilities for inhalable (PM_{10}) and respirable ($PM_{2.5}$) particulate matter (RWDI, 2020a; Walker, 2020). The exception is around the intersection of Beachville Road and County Road 6 where PM_{10} levels are forecast to slightly exceed standards on occasion with expected future population and traffic growth.

Proposed Landfill Impact

With additional mitigation strategies, as per the Air Quality Assessment (RWDI, 2020a) and the Draft EA Report (Walker, 2020):

> "*Particulate (dust) emissions from the landfill and landfill traffic on their own will not exceed provincial criteria at any off-site residence, but will add to exceedances when combined with other sources. Enhanced dust controls are proposed for the landfill to further minimize its contribution.*"

The HHRA used the results from the Air Quality Assessment report to evaluate risks to human health due to particulate matter (Intrinsik, 2020). The risk assessment noted that the worst-case cumulative 24-hour exposures to inhalable particulate matter (i.e., PM_{10}) was marginally above the acute benchmark (i.e., <10% above the benchmark) in both the Stage 1 and 3 assessments at one specific receptor location (i.e., the intersection of Beachville Road and County Road 6). However, when one drilled down into the frequency of such an exceedance at this location, it was noted that such exceedance would occur very rarely, i.e., one day in a five-year period for Stage 1 and three discrete non-contiguous days in a five-year period for Stage 3 (Intrinsik,

2020). Given the conservatism built into the assessment (e.g., worst-case background assumed to occur at the same time as worst-case Project emissions), and the marginal nature of the estimated exceedance, as per the HHRA, these PM_{10} exposures are not expected to result in any adverse health impact to the surrounding community.

Particulate matter levels at off-site locations are within government health standards for inhalable and respirable particle sizes (PM_{10} and $PM_{2.5}$, respectively). Similarly, aesthetic/nuisance criteria for suspended dust and dust fall are also currently met at all off-site locations except around the intersection of Beachville Road and County Road 6, where visible (suspended) dust levels are slightly higher on occasion (Walker, 2020).

Effect Characterization

Any dust emissions from the proposed landfill would be experienced proximate to the landfill. As per the Air Quality Assessment report (RWDI, 2020a) and the HHRA (Intrinsik, 2020), after modelling impacts due to the proposed landfill, the magnitude of adverse impacts is determined to be low, and the likelihood of impacts is also low, as it relates mainly to one off-site location where airborne dust levels are slightly elevated occasionally. As such, there is no net impact on health due to dust emissions from the landfill (neutral), except for the one off-site location. Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-3 Effect Characterization for Dust

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Dust	Proximate	Low	Low	Neutral	High

4.3 Water (Surface and Ground Water) Quality

This section characterizes the potential health impact of changes in surface and ground water quality assessed through the HHRA, and drawing on information presented in the groundwater and surface water studies (both Golder, 2020). Two potential areas of impact were considered:

- Chemical exposures
- Recreational use

4.3.1 Chemical Exposures

Current Conditions

The proposed landfill site is situated within the (natural) sub-catchment of the Patterson-Robbins Drain which flows south into the South Thames River (Golder, 2020; Walker, 2020). Hence, the study areas for the surface water assessment were the watershed catchments of the Patterson-Robbins Drain and the Thames River (Golder, 2020). Flow in this agricultural drain ranges from dry in the summer up to an estimated 20 m_3/s for the 100-year storm. The flow here, and in the Thames, can be expected to increase somewhat over time with climate change. The water quality is typical of an agricultural drain and it was found that some constituents did not meet provincial water quality objectives (Golder, 2020; Walker, 2020).

The main groundwater aquifer found in the vicinity of the site is in the upper 10 m of the limestone; most of the private residential water wells in the vicinity draw their water from this

aquifer (Golder, 2020; Walker, 2020). There is another, deeper aquifer at about 65 m depth where some industrial and commercial wells in the area draw their water (Golder, 2020; Walker, 2020). Ingersoll is serviced with piped, municipal water supply. The nearest municipal well is Ingersoll Well 8 (Dunn's Well) about 1 km southwest of the proposed landfill site. It is 125 m deep and draws its water from the northwest, away from the site.

Proposed Landfill Impact

The Ministry's *Generic Design Option II* double composite liner and leachate collection system will ensure that the leachate generated in the landfill is contained and collected for treatment, preventing leachate from contaminating off-site groundwater or surface water (Golder, 2020). Furthermore, stormwater will be collected and treated in a stormwater management system prior to discharge into the Patterson-Robbins Drain, ensuring no significant degradation of water quality. As such, the conclusion is that there will be no significant negative impacts on the groundwater quality or surface water quality related to the proposed landfill (Golder, 2020) Therefore, as per the HHRA, it is not anticipated that there will be potential impacts to human health due to exposure to groundwater or surface water (Intrinsik, 2020).

Effect Characterization

An appropriate regional context was considered in the groundwater and surface water assessments, with detailed assessment at the proximate scale. As per the Surface Water Assessment Report and the HHRA, after modelling impacts due to the proposed landfill, the magnitude of adverse impacts is determined to be low, and the likelihood of impacts is also low. As such, there is no net impact on health due to contamination of ground or surface water as a result of landfilling activities (neutral). Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-4 Effect Characterization for Water Quality – Chemical exposures

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Chemical exposures	Regional/ Proximate	Low	Low	Neutral	High

4.3.2 Recreational Use

Current Conditions

The Patterson-Robbins Drain directly adjacent to the proposed landfill site is an agricultural drain and, as such, has no identified recreational uses. The Thames River to the south of the site can be assumed to be used for a variety of recreational purposes.

Proposed Landfill Impact

As mentioned above, the Ministry's *Generic Design Option II* double composite liner and leachate collection system will ensure that the leachate generated in the landfill is contained and collected for treatment, preventing leachate from contaminating off-site groundwater or surface water (Golder, 2020). In addition, the storm water management system will also ensure that water quality in the Thames River is not degraded, and that there is no increased flood risk off-site (Golder, 2020).

Effect Characterization

The Surface Water Assessment Report (Golder, 2020) considered an appropriate regional (watershed) context, with detailed assessment at the proximate scale. Given that the water quality and flow in the Thames will not be materially affected by the proposed landfill, the magnitude of adverse impacts related to any recreational uses in the Thames River is determined to be low, and the likelihood of impacts is also low. As such, there is no net impact on health due to contamination of surface water as a result of landfilling activities (neutral). Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-5 Effect Characterization for Water Quality – Recreational water use

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Recreational water use	Regional/ Proximate	Low	Low	Neutral	High

4.4 Soil Quality

The HHRA evaluated impacts to soil quality due to the Proposal, and as such the SHR summarizes the HHRA results and provides a characterization of health impacts based on the information and data provided in the HHRA (Intrinsik, 2020).

4.4.1 Chemical Exposures and Recreational Use

Current Conditions

Individuals can be exposed to soil particulates when they inhale, through incidental ingestion of dust, ingestion of home-grown produce from backyards where they may have been deposition of contaminants onto the soil, or in rare cases, children may intentionally consume soil (a behavior called pica). Depending on the naturally occurring and anthropogenic components of soil, particulates can present varying degrees of human health risk.

Recreational uses involving children playing in their backyards and coming into contact with contaminated soil.

The HHRA included a multi-media risk assessment that evaluated the human health risk due to deposition of contaminants in the air and water (ground and surface) onto soil and human contact with contaminated soil (Intrinsik, 2020). For the purposes of the HHRA, a chemical was considered persistent in soil if its half-life in soil was greater than or equal to (≥) six months (182 days). Bio-accumulation potential of a chemical was evaluated based on whether the chemical released to the air meets the criteria for persistence (based on half-life in soil), and the fact that only a limited opportunity exists for human exposure via secondary exposure pathways (i.e., those other than inhalation), as the potential for that chemical to persist and/or accumulate in the environment is negligible (Intrinsik, 2020). Hence, chemicals retained for full multi-pathway assessment had a valid chronic oral reference value from a reputable regulatory agency, and:

- A half-life in soil greater than or equal to six months; or,
- An octanol-water partition coefficient (Log K_{ow}) greater than or equal to five.

Following evaluation, only benzo(a)pyrene was retained for the assessment of chemical contaminants in soil (Intrinsik, 2020). The background baseline concentration utilized in the determining the predicted concentrations of benzo(a)pyrene in soil and dust was conservatively assumed to be 0.05 µg/g under the agricultural land use (based on the Ontario Typical Range background values provided in the MECP Table 1 Site Condition Standards) (Intrinsik, 2020).

Proposed Landfill Impact

The deposition into the environment (e.g., soil) for benzo(a)pyrene was estimated at each receptor location by the air quality assessment team at RWDI (2020a). This data was then used to predict exposure concentrations in soil at the sensitive receptor location areas. Results from the assessment of future impacts due to the landfill indicated that the deposition would not significantly change existing background concentrations and thus the predicted concentrations of benzo(a)pyrene in soil would not adversely impact the soil, agricultural crops and home grown produce within the project area (Intrinsik, 2020). Given all the inherent conservatism built into the multimedia assessment, it is not anticipated that emissions from project would result in adverse health impacts to the surrounding community.

Effect Characterization

Effects of contaminant deposition in soil, would be experienced proximal to the landfill. As per the HHRA and the Air Quality Assessment, after modelling impacts due to the proposed landfill, the magnitude of adverse impacts is determined to be low, and the likelihood of impacts is also low. As such, there is no net impact on health due to contamination of soil as a result of landfilling activities (neutral). Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-6 Effect Characterization for Soil Quality – Chemical exposures and recreational use

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Chemical exposures and recreational use	Proximate	Low	Low	Neutral	High

4.5 Neighbourhood Aesthetics

4.5.1 Visual impact

Visual Impact and Health

Development and operation of a waste disposal facility can affect the visual appeal of a landscape. Annoyance and stress from negative perceptions of a landfill and anxiety over project aesthetics has the potential to impacts health. This is a socio-psychological impact, and as such it is very subjective and depends on the level of individual sensitivity not only to the presence of a landfill facility, but also to perception of overall neighbourhood aesthetics. Places that are identified as having a high aesthetic quality have been associated with increased contemplation, personal reflection, enjoyment, relaxation. As reviewed by Menatti and Casado da Rocha (2016), a large body of literature exists affirming the role played by landscape in the treatment, recovery and maintenance of human health. Studies that have considered the impact of aesthetics in our physical environment, have demonstrated a consensus that general well-

being and quality of life can be enhanced as a result of interaction with environments considered to have high aesthetic value (reviewed in Galindo and Rodriguez, 2000; Brady, 2006). One of the main ways in which a pleasing visual landscape positively impacts health is by allowing an individual to relax, and thereby reduce stress. Hence, changes in the aesthetics of a local environment have the potential to cause annoyance and stress, particularly if the change is viewed as intrusive or unwanted.

Current Conditions

As per the Visual Impact Assessment (MHBC, 2020), currently, the proposed landfill site is located on industrial lands used for quarrying and lime manufacturing. The quarries here have been in operation for many decades. Within the site, there are several bedrock quarries at various stages of development, along with a lime processing plant. Quarrying operations will remain functioning during landfill site development, and will continue to function after the landfill operations are complete. Other lands owned by Carmeuse, generally to the north of the current quarries, remain in agricultural or rural uses. Some of this land is licensed for future extraction. Two major railway corridors pass by and through the southern portion of the site. Beyond the southern limit of the site is the south branch of the Thames River which has been historically straightened and channelized in this stretch.

There is woodland coverage of the proposed site from the north and north-west and existing vegetation around the site that currently provides a significant amount of screening of views into the site. The majority of the proposed haul route located along County Road #6 is currently screened from view of existing residences by existing vegetation and tree lines.

Proposed Landfill Impact

The visual impact assessment (MHBC, 2020) describes existing views and anticipated changes. Affected views have been given a no/low/medium/high change ranking generally described below (MHBC, 2019):

- *No impact – existing views of the site are non-existent or very limited. Changes on the site will not be noticeable to most observers.*
- *Minor impact – the anticipated change will occur on a portion of the site that is well screened from the view location and/or the proposed change is in the distance (background of the view).*
- *Medium impact – the anticipated change will occur on a visible or partially visible portion of the site in an area setback from the view location (middle of view).*
- *High impact – the anticipated change will be very noticeable as it will occur in the foreground on a portion of the site that is clearly visible from the viewpoint.*

The assessment noted that a high impact does not necessarily mean an unacceptable condition, as a view screened by a berm with landscaping may be a ‘high impact’ from the original condition, as it a noticeable change, but still considered acceptable.

Based on these ranking criteria, and the fact that the study area is already currently defined by the presence of an operational quarry, the proposed landfill site is described as "a disturbed landscape of industrial character and is considered a low-value landscape in terms of visual landscape character” (MHBC, 2020). The proposed haul route is described as a “low- to medium-value landscape as it is comprised of commonplace elements”.

In the evaluation of visual sensitivity of receptors, it was concluded that the majority of visual receptors in and around the study area were low sensitivity receptors, due to the extreme viewing distance (more than 1 km) from the receptor locations (MHBC, 2020). Some receptors were able to view only a small part of the overall view of the subject lands due to existing vegetation or existing buildings that blocked or framed views. However, the assessment noted that one receptor (ZOR-11) was considered of medium-high potential due to the close proximity to the proposed landfill site (approximately 237 m) "*that could potentially have had negative impacts. However, the existing berms, vegetation, tree lines and accessory buildings at the rear of the property provide screening of the subject lands. Therefore, given the proximity to the subject site, this receptor could be highly sensitive to a change in view. However, the existing berms and vegetation moderate that sensitivity.*" (MHBC, 2020). In order to further mitigate this potential visual effect, though, Walker proposes to construct a screening berm or barrier along the southwestern perimeter of the site during the later stages of the landfill operation, eliminating any visual impact.

As such, a negative health impact due to the aesthetic value of the proposed landfill is not expected.

Effect Characterization

Effects due to change in the landscape would be experienced by receptor locations that are proximate to the proposed landfill site. As per the visual impact assessment (MHBC, 2020), the magnitude of adverse impacts is characterized as low, and the likelihood of impacts is also low. As such, there is no net impact on health due to changing neighbourhood landscape as a result of the proposed landfill and related activities (neutral). Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-7 Effect Characterization for Neighbourhood Aesthetics – Visual impact

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Visual impact	Proximate	Low	Low	Neutral	High

4.6 Noise

Noise Levels, Vibrations and Health

Noise impacts due to landfill can arise due to three scenarios: during construction, during operation of the landfill, with all associated activities on-site, and increased traffic along the haul route.

According to the World Health Organization (WHO), evidence from epidemiological studies on the association between exposure to high levels of road traffic and aircraft noise and hypertension and ischaemic heart disease has increased (WHO, 2011). High levels of both, road traffic and aircraft noise, increase the risk of high blood pressure. In addition, exposure to high levels of noise during night lead to disturbed sleep, which can result in adverse health impacts (WHO, 2009).

In addition, using available evidence, a hypothetical exposure–response relationship between noise level (L_{dn}) and risk of cognitive impairment in children was formulated (WHO, 2011). It was

found that all of the noise-exposed children were cognitively affected at noise level as high as 95 dB(A) L_{dn}, and no children were affected at a relatively low level, such as 50 dB(A) L_{dn} (WHO, 2011). According to WHO, the recommended night noise guideline is 40 dB $L_{night,outside}$ with an interim target of 55 dB $L_{night,outside}$ (WHO, 2009).

One of the major effects of exposure to environmental noise is annoyance. Noise-related annoyance, typically described as a feeling of displeasure evoked by a noise, has been extensively linked to a variety of common noise sources such as rail, road, and air traffic (Berglund and Lindvall, 1995; Laszlo et al., 2012; WHO Europe, 2011). Although annoyance is considered to be the least severe potential impact of community noise exposure (Babisch, 2002; WHO Europe, 2011), it has been hypothesized that sufficiently high levels of noise-related annoyance could lead to negative emotional responses (e.g., anger, disappointment, depression, or anxiety) and psychosocial symptoms (e.g., tiredness, stomach discomfort and stress) (Fields et al., 2001; WHO Europe, 2011; Öhrström, 2004; Öhrström et al., 2006). Therefore, regulations exist in many jurisdictions around the world to limit community noise exposure from stationary sources (e.g., factories) as well as road, rail, and air traffic in order to curtail community levels of annoyance and more severe impacts of community noise exposure.

Current Conditions

As per the Noise and Vibration Assessment Report (RWDI, 2020b), noise is present in the vicinity of the site from urban, industrial and farming activities, along with the associated road traffic. Existing noise levels in the vicinity of the site generally meet provincial guidelines with one notable exception – traffic noise in the area around the intersection of Beachville Road and County Road 6.

There is also a substantial amount of impulsive (sharp and almost instantaneous) noise in the vicinity of the site due to activities such as passing trains, quarry blasts, and other quarry operations. Measurements taken to the south of the site revealed with 29 to 59 impulses exceeding 65 decibels on a typical day.

Similarly, there are a number of existing sources of vibration in the area, with the most notable including the blasting events at the local quarry operations, and trains passing on the two rail lines to the south of the site.

Proposed Landfill Impact

Information on noise considerations for landfilling sites in Ontario is provided in the Ontario Ministry of the Environment publication “Noise Guidelines for Landfill Sites” (MOE, 1998).

Noise from the landfill site is calculated to meet provincial guidelines at all off-site locations, even when combined with other noise sources in the area (RWDI, 2020b). The increase in noise levels from landfill traffic along the County Road 6 haul route is estimated to be insignificant. The only exception is one adjacent residence to the southwest where noise during a certain period of the landfill construction would exceed guidelines and a noise barrier is required for further mitigation (RWDI, 2020b), which will bring the impact at that residence within provincial guidelines.

Vibration from the landfill construction and operation is not expected be a significant issue (RWDI, 2020b).

Effect Characterization

Any impacts to health due to higher than acceptable levels of noise and vibration would be experienced by those located proximate to the proposed landfill facility. Based on the noise assessment results noted above, the landfill operations (incorporating the proposed noise barrier) and the related traffic on the haul route will not result in significant noise impacts. It is expected that the magnitude of impacts will be low and likelihood of impacts will be low at all receptor locations. As such, the potential health consequence is neutral at all receptor locations. Overall, given that the data and information being used to assess the potential for impacts has been collected, modelled and evaluated specifically for the purposes of this EA, this effect characterization can be made with a high level of confidence.

Table 4-8 Effect Characterization for Noise

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Noise levels and vibration	Proximate	Low	Low	Neutral	High

4.7 Pests – Vermin and Wildlife

Pests and Health

Pests such as vermin or gulls can be a nuisance and affect how residents use and enjoy their property as well as agricultural operations. A waste disposal facility, if not managed appropriately, may result in an increase of vermin and gulls. These could affect areas surrounding the proposed landfill or along the haul routes. The potential for disease transmission via insects or vermin during and following the operation of a landfill is associated with the increased quantities of insects and animals, like gulls, which are known to carry zoonotic diseases (disease that can be passed from wildlife to humans) such as: salmonella, campylobacter and histoplasmosis (Beacon, 2020). While an increase in these types of animals and insects represents a potential increase in the risk in the spread of disease to humans and domestic animals, even without mitigation that reduces the presence of potential vectors, this risk is considered to be very low due to the limited interactions between insects or vermin from the landfill and humans and the tenuous pathways through which transmission to occur (Beacon, 2020).

Climate change has also been linked with the establishment and geographical expansions of zoonotic diseases, such as Lyme disease (Germain et al. 2019).

Current Conditions

As per the Social Assessment Report (SLR, 2020), there are no significant occurrences of vermin or pests on site (in the quarry); any occurring in the surrounding vicinity would be those typical of rural and agricultural landscapes. Also, as per the Ecology Assessment Report (Beacon, 2020), populations of insects, rodents, birds and other vermin that may be associated with disease transmission are not significant within the current quarry area (due to lack of shelter and food sources). In the vicinity of the site they are likely present in numbers typical in rural and agricultural settings.

Proposed Landfill Impact

The pathway for disease transmission via insects or vermin that could potentially be associated with the landfill directly or indirectly to humans is insubstantial due to the limited opportunity for interaction between vectors and humans within the Site, Haul Route, Site Vicinity and Wider study areas. Accordingly, the proposed landfill is not expected to have any significant effects disease transmission to humans via insects or vermin (Beacon, 2020).

The risk of disease transmission to humans from any vermin at the landfill is very unlikely in any event, but it is even further reduced with the modern landfill operations and pest controls that will be employed at this site. As an indicator of what can be expected in terms of vermin-related issues at the proposed landfill facility in the Township of Zorra, it is important to note that vermin issues have proven to be negligible at Walker's Niagara Region landfills (Walker, 2020). In addition, the recommended mitigation strategy, the *Integrated Bird Management Program* will further reduce bird populations on and around the site.

Effect Characterization

Impact due to increase in pest population would be experienced proximate to the proposed landfill. Given the mitigation strategies that have been proposed and will be put in place, as well as the negligible impacts noted at Walker's existing Niagara Region landfills, the magnitude and likelihood of impacts will be low, and the potential for health impacts is neutral. As the data and information used for this assessment has been sourced from the EA, this effect characterization can be made with a high level of confidence.

Table 4-9 Effect Characterization for Pests – Vermin and wildlife

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Vermin and wildlife	Proximate	Low	Low	Neutral	High

4.8 Traffic

This section characterizes potential health impacts due to changes in traffic conditions as a result of the proposed landfill. Two main concerns have been addressed with respect to changes in traffic conditions:

- Emissions
- Pedestrian safety

4.8.1 Emissions

The HHRA evaluates emissions due to the proposed haul route. As such, the SHR summarizes the results of the HHRA and characterizes health impacts based on the data and information available through the HHRA as well as the Air Quality Assessment (RWDI, 2020a).

Current Conditions

County Road 6, the proposed primary haul route from Highway 401 to the proposed landfill site, is a paved, two-lane arterial road suitable for heavy truck traffic. It has adequate capacity and service levels (i.e., stable flow and low potential for congestion) to accommodate the average of

about 9,000 vehicles per day that use the road (of which about one-third are trucks), as well as the expected growth in traffic over the next 20 years (Walker, 2020).

According to the Profile of Wellbeing in Oxford County (Smale and Gao, 2018), residents currently enjoy higher air quality than those living in several other parts of Ontario.

For the EA, baseline conditions were assessed to show predicted impacts on discrete receptors. The baseline scenario considers both the local background traffic along County Road 6 and the existing Carmeuse quarry operations (RWDI, 2020a). The baseline concentrations for most air quality parameters are within their respective criteria. The exceptions to this are 24-hour benzo(a)pyrene and annual benzo(a)pyrene, both of which exceed their respective criteria (RWDI, 2020a). These exceedances are a result of elevated background concentrations of both contaminants. However, as noted previously, in the absence of local monitoring information, the background levels of benzo(a)pyrene used by RWDI was obtained from MECP air quality monitoring data from Simcoe, and does not specifically represent local air quality in the area around the proposed Project.

Proposed Landfill Impact

The dispersion modelling analysis was completed by RWDI (2020a) for each contaminant at each of the identified air quality receptors. Some of the receptors represented residential locations, while others represented other key points of interest, such as intersections, wetlands, etc. These non-residential receptors often had residences in the vicinity, and were included in the modelling. All contaminants, except 24-hour benzo(a)pyrene and annual benzo(a)pyrene, were within their respective provincial criteria (RWDI, 2020a).

The current background concentrations of 24-hour and annual benzo(a)pyrene already exceed their respective provincial criteria. The landfill contribution to off-site impacts is low (RWDI, 2020a). Therefore, the predicted exceedances are a result of the higher than standard background concentration, and the incremental contribution from the proposed landfill is considered to be low (RWDI, 2020a).

To evaluate the risk to human health, the HHRA further assessed the results of the air quality study dealing with emissions along the haul route (RWDI, 2020a). The HHRA results indicate that none of the emissions along the associated haul routes would result in any unacceptable short- or long-term health risks, either from air inhalation or soil, agricultural and home garden produce exposure routes, in any of the evaluated landfill operating stages (Intrinsik, 2020). The HHRA assessed that most predicted acute and chronic air concentrations were many orders of magnitude below their corresponding health-based reference benchmark (i.e., typically between 2- and 6-orders of magnitude below). Evaluation of the criteria air contaminants (i.e., carbon monoxide, nitrogen dioxide, particulate matter, and sulphur dioxide) arising from vehicle emissions from the haul route scenario indicated that all of the project-specific emissions were within the relevant regulatory benchmark, indicating no apparent health risks arising from the emissions of trucks transporting waste to the proposed Landfill on the designated haul routes (Intrinsik, 2020).

Effect Characterization

The health impacts due to traffic-related emissions would be proximate (along the haul route). Given that the background concentrations of two air quality constituents were already in excess of their respective criteria, and the potential incremental change due to the proposed landfill was

considered to be low (RWDI, 2020a) and not a risk to human health (Intrinsik, 2020), the magnitude and likelihood of impacts to health can be characterized as low, and the potential for health impacts is neutral. As the data and information used for this assessment has been sourced from the EA, this effect characterization can be made with a high level of confidence.

Table 4-10 Effect Characterization for Traffic – Emissions

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Emissions	Proximate	Low	Low	Neutral	High

4.8.2 Pedestrian Safety

Pedestrian Safety and Health

Walking is the most elementary form of mobility. Not only does it have personal health benefits (improved physical fitness, reduced risk for chronic diseases, such as diabetes, obesity, heart disease, etc.), but a high level of pedestrian traffic indicates a healthy walkable neighbourhood. One of the main deterrents of walking as a form of active transport, are safety concerns due to adjacent traffic. Moreover, the perception of risks to safety due to high levels of truck traffic can also serve as a deterrent to walking. Hence, evaluating and addressing these safety concerns is of paramount important to encouraging walking within the local community.

Current Conditions

According to the Traffic Assessment Report (HDR, 2020), the proposed haul route along County Road 6 generally has lower than average collision rates except at the Beachville Road intersection and the stretch between Clarke Road and Hwy 401, which is the only segment in the study area that has a higher collision rate than the provincial average (HDR, 2019). Sight lines are good at all private driveways and intersections with the exception of Beachville Road (due to trees/vegetation) and Karn Road (trees/road curve). The Ontario Southlands level rail crossing operates adequately given its low volume of train traffic. Also, no major roadway improvements are planned by the County in this area, so traffic safety is expected to remain similar in the future.

Proposed Landfill Impact

The landfill will add about 210 vehicle round-trips per day. County Road 6 is an arterial road designed and designated by the County for truck traffic, and carries more than approximately 6,000 to 9,000 vehicles per day. The landfill traffic would only incrementally increase traffic volumes and the potential road safety hazard. However, landfill trucks turning off County Road 6 could potentially increase safety risk due to the slowing and turning movement in a live through-lane of traffic. However, with the implementation of the following mitigation strategies, the overall impact due to the proposed landfill and the resulting haul route traffic, become insignificant (HDR, 2019; Walker, 2020):

- Provision of truck queuing space along the private portion of the haul route (i.e., the landfill access road) to prevent early-morning queuing along the shoulder of County Road 6.
- Extension of the second northbound lane on County Road 6 to permit safe passing of turning trucks.
- Installation of advance warning signs along County Road 6 where trucks will be turning.

Effect Characterization

Any potential health impacts due to traffic-related risk to pedestrian safety would be proximate (along the haul route). With the implementation of the above-mentioned mitigation strategies, the magnitude and likelihood of impacts to health can be characterized as low, and the potential for health impacts is neutral. As the data and information used for this assessment has been sourced from the EA, and prepared specifically for the assessment of this proposed landfill project, this effect characterization can be made with a high level of confidence.

Table 4-11 Effect Characterization for Traffic – Pedestrian safety

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Pedestrian safety	Proximate	Low	Low	Neutral	High

4.9 Economic

4.9.1 Employment

Employment and Health

Income and social status are closely connected and often combined into the term *socio-economic status*. Socio-economic status is a long-established risk factor for population health (Winkleby et al*.,* 1992). In general, higher income and social status are associated with better health status, whereas lower income and social status are linked to the opposite. There is abundant research that connects specific health outcomes with income and social status, including birth weight and infant mortality; self-rated health (see **Section 3.2**); adult mortality; chronic and acute infectious diseases; mental well-being; social pathologies; and health service utilization (Yen and Syme, 1999, McIntosh et al. 2009, Mikkonen and Raphael, 2010). According to Coffee and others (2013), socio-economic status can typically be represented by a triad of indicators: education, income and employment/occupation.

Current Conditions

According to the Economic and Financial Assessment Report (Keir, 2020), the economy in the vicinity of the proposed landfill is strong and will continue to grow. In Zorra, South-west Oxford and the County as a whole, labour force employment concentration is in the resource-based industry sector (i.e., agriculture, pits and quarries) (Keir, 2020).

Between 2011 and 2016 the employed labour force in Oxford County grew approximately 6% to roughly 57,000 (Keir, 2020). Growth was pronounced in Woodstock and Ingersoll, and marginal in Zorra and South-west Oxford. Annual job growth is projected to be around 125 jobs per year within the study area municipalities, and approximately 700 per year for Oxford County as a whole. While job growth is forecast for manufacturing activities very little is expected in agriculture and quarrying going forward. Economic development and employment agencies note that the economy of Oxford County is booming (Keir, 2020). Two big employers in the area are the Toyota and GM Cami plants. Labour availability, currently, is very tight across all sectors with employers needing to recruit from outside.

Also, most businesses in Oxford County contract with private-sector waste disposal companies that export industrial, commercial and institutional wastes to regional landfills located outside of Oxford County.

Proposed Landfill Impact

The proposed landfill will contribute to the economy of Zorra, South-west Oxford and Ingersoll. Projected direct economic impacts in the wider study area (Oxford County and vicinity) over the life of the operating life of the landfill include (Keir, 2020):

- Gross Output: $ 643 million
- GDP: $349 million
- Labour Income: $173 million
- FTE Jobs: About 2,300 (~ 104 jobs / year on average)

The economy in the area is expected to grow, with the proposed landfill making a positive contribution. In addition, the added strategy to develop a hiring policy that gives preference to local candidates, where possible, has the potential to enhance the net positive impact.

In addition, the landfill is also projected to have indirect and induced economic impacts over its operating life, by influencing employment opportunities in local firms supplying products or services directly, or as secondary suppliers (Keir, 2020).

The overall economic outputs for Ontario have also been estimated:

- Gross Output: $ 809 million
- GDP: $435 million
- Labour Income: $222 million
- FTE Jobs: 2,900 (~ 133 jobs / year on average)

As for the indirect employment impact, a procurement policy that gives preference to local suppliers, where possible, would boost this potential positive impact on employment and economic growth locally (Keir, 2020). Moreover, the proposed landfill will also provide convenient local disposal capacity to businesses in Oxford County that currently export waste to landfills located in other Ontario municipalities, saving these employers up to approximately $10 per tonne, which amounts to a gross annual savings between $200,000 to $250,000 per year per business (Keir, 2020).

Effect Characterization

Economic impacts due to increased employment opportunities (both direct and indirect) would be experienced regionally. Given that the job growth in Zorra is otherwise predicted to be modest, and higher in other areas of the County, the magnitude is medium and the likelihood is high. Overall, there is potential for significant positive health impacts, that can be further enhanced by applying the hiring and procurement policy strategies. As the data and information used for this assessment has been sourced from the EA, and prepared specifically for the assessment of this proposed landfill project, this effect characterization can be made with a high level of confidence.

Table 4-12 Effect Characterization for Economic – Employment

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Employment	Regional	Medium	High	Positive	High

4.9.2 Property Values

Property Values and Health

Residential property is one of the most valuable assets an individual may own and as such, it provides a useful measure of socioeconomic status. Hence, housing characteristics (e.g., housing tenure, housing type, number of bedrooms, property value, etc.) have also been used as a proxy. Property values are driven by a number of different factors including global and local economic market changes, national borrowing rates, local property value trends, 'reputation' of local area, and proximity to services such as reputable schools, green spaces, commuter train stations and other amenities. To demonstrate the association between property values and health outcomes, a recent study correlated higher residential property values with lower cardiovascular risk, lower obesity risk, reduced cholesterol scores and lower diabetes risk (Coffee et al., 2013).

Current Conditions

Property values in the vicinity of the landfill are expected to continue rising due to strong demand from home buyers, including a substantial number pushing out from the Greater Toronto Area. However, the long-term and continuous heavy industry presence in this vicinity (i.e., quarries and lime processing) is indicative that property values are already adjusted to this type of land use (Keir, 2020).

Proposed Landfill Impact

According to the Economic and Financial Assessment (Keir, 2020), the demographic and economic forces that are driving the upward trend in the local real estate market in the study area and surrounding municipalities, and pushing up property values, are not likely to slow down. A strong economy contributes to job and income growth, which in turn have a positive influence on the real estate market (Keir, 2020).

Since 2012, no significant changes in property values (other than the strong upward trend noted through much of the Greater Toronto Area) have been noted, despite a high degree of ongoing negative publicity. A proposed impact management strategy is to offer property value protection agreements to neighbours whose properties are within 500 m of the landfill site, thereby proactively addressing any potential drop in property values due to the landfill (Walker, 2020).

Once in operation, limited off-site effects due to the proposed landfill are anticipated and will be managed, as per established protocols. Hence, no significant impacts on property values are expected.

Effect Characterization

Economic impacts due to change in property values would be proximate. Given that no significant change has been noted in property values, and the overall prediction is for the local area to experience a general upward trend in the real estate market, the magnitude is low and the likelihood is low. Overall, the potential health consequence is neutral, with the potential for maintaining this neutral impact by applying a property value protection agreement to immediate neighbours to the proposed landfill. As the data and information used for this assessment has been sourced from the EA, and prepared specifically for the assessment of this proposed landfill project, this effect characterization can be made with a high level of confidence.

Table 4-13 Effect Characterization for Economic – Property values

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Property values	Proximate	Low	Low	Neutral	High

4.9.3 Municipal Revenues

Municipal Revenues and Health

The economic health of municipalities has important effects on the health of its residents. Municipalities are responsible for providing a broad range of infrastructure and services to their residents that are linked to health and wellbeing outcomes, such as social services; police, ambulance and fire services; the provision of clean drinking water; safe and accessible travel options; economic development opportunities for individuals; child development opportunities; services for seniors; and many more. Cities and towns with more economic resources are able to enhance the health of their citizens by investing in and improving these services, as well as the infrastructure. Hence, activities or developments that increase municipal economic health can also positively impact the health of the local community.

Current Conditions

Currently, the quarry operation on the site pays the municipal taxes at an industrial (quarry) rate as mining and progressive rehabilitation occur (Keir, 2020).

Proposed Landfill Impact

As mentioned above, economic growth, accompanied by population in-migration/growth along the Highway 401 corridor from the Greater Toronto Area, does not show any signs of abatement. Also, it is important to note that housing growth, enhanced by population and job growth, will generate both revenues and expenditure for the municipalities in the local study area as well as Oxford County as a whole (Keir, 2020).

Overall, the proposed landfill is estimated to generate approximately $77,400 annually, in direct property taxes distributed accordingly (Keir, 2020):

- Lower Tier: $28,500
- Upper Tier: $20,400
- Education: $28,500

Moreover, over its lifetime, product and production taxes associated with the landfill are projected to generate an additional $12.8 million in municipal tax contributions across the Province (Keir, 2020). A proposed impact management strategy to further enhance revenue for the host municipality, is a supplementary payment offer, by Walker, to augment the property taxes. This payment offer to the host municipality will be made through royalty payments on waste tonnages received and disposed at the landfill (Walker, 2020).

Effect Characterization

Economic impacts due to increased municipal revenues (both direct and indirect) would be experienced regionally. Together with the annual property taxes, the municipal tax contribution, as well as the host municipality funding offered by Walker, the magnitude is medium and the likelihood is high. Overall, there is potential for significant positive health impacts to the community as a result of increased municipal revenues, especially if the excess revenue is invested by the municipality to address the most pressing concerns of the community. As the data and information used for this assessment has been sourced from the EA, and prepared specifically for the assessment of this proposed landfill project, this effect characterization can be made with a high level of confidence.

Table 4-14 Effect Characterization for Economic – Municipal revenues

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Municipal revenues	Regional	Medium	High	Positive	High

4.10 Social Impacts

This section characterizes potential health impacts due to changes in social conditions, or to the social fabric of the local communities, as a result of the proposed landfill. Two main concerns have been addressed with respect to social impacts:

- Perception of hazards, including socio-psychological impacts
- Recreational access and enjoyment

4.10.1 Perception of Hazards, Including Socio-psychological Impacts

Perception of Hazards, Including Socio-psychological Impacts and Health

Psychosocial impacts related to landfills (or other perceived environmental hazards), and the *perception* of hazards, is a complex reaction that may manifest in a wide range of social, psychological, behavioural and health outcomes (Taylor et al., 1991). These effects may manifest at the individual level, in a social network, or at a community level (Taylor et al., 1994). Health impacts include stress, distress, concern, anxiety, family or community disruption, fatigue and depression (reviewed in Hampson, 1997).

Research has shown that individual and community well-being can also be impacted by the siting process of a landfill, while the EA process is ongoing (Wakefield, 1998). In the context of the siting, construction and operation of a landfill site in a community such as Milton, in southern Ontario, the psychosocial effects experienced by local residents were particularly interesting: although there was no plausible association of the landfill with negative physical health outcomes, anxiety and fear of these outcomes was generated by a stereotypical perception of landfills as a ‘dumps’ (Hampson, 1997). Moreover, the study noted that the fears decreased

following the approval of the landfill, and further decreased once the landfill became operational and was no longer an 'unknown' element within the community.

In addition, there is also the perception that living close to a landfill will result in a lowering of one's social standing, and in extreme cases, the perception that one might be socially ostracized. These fears and concerns can lead to potential mental health impacts, and manifest as stress and anxiety.

In a review of the epidemiological literature that investigated the link between self-reported socio-psychological health effects and living near landfill sites (Vrijheid 2000), the author noted that in 10 of the reviewed papers, there was an increased prevalence of self-reported health symptoms such as fatigue, sleepiness and headaches (HPA, 2011). These 10 studies mainly evaluated populations living on or close to old and poorly maintained waste dumps that were clearly evident to have issues related to odour and leakage of noxious chemicals, i.e., these were not controlled or maintained landfill sites. Moreover, in case studies, where specific landfills were evaluated, it was not obvious how these results would generally apply to landfill sites (HPA, 2011).

Current Conditions

According to the Social Assessment (SLR, 2020), residents in Oxford County described their community character and cohesiveness as generally positive – friendly, supportive and welcoming, with a peaceful "small town" feel and a spirit of volunteerism for community events. The majority (82%) reported their feeling of overall health and well-being as good to excellent. Crime and drugs were noted as the most significant concerns, while about 16% reported the proposed landfill as the most important issue facing the community. Nevertheless, it was noted that 95% of Oxford County residents are satisfied with living in their community (SLR, 2020).

The current character and cohesiveness of the County and the local communities is likely to continue into the future even as further growth is experienced.

Proposed Landfill Impact

Apart the limited nature and range of effects that have been predicted due the operation of the proposed landfill, surveys undertaken as part of this EA suggested that some individuals may remain mistrustful of Walker and/or the Province, and some have indicated that they would leave the community, based on pre-determined concerns and perceptions about the proposed landfill (SLR, 2020). As part of this EA, it is difficult to evaluate how many individuals would follow-through on these intentions. Evidence from other sites, and Walker's own experience in Niagara Region, suggests that once landfills are in operation and establish a good track record, concerns will appreciably diminish (Walker, 2020).

However, it is reasonable to conclude that the controversy surrounding this proposal for the landfill will have generated some residual social impacts. Further enhanced mitigation measures are proposed by Walker that are intended to address and reduce any residual social impact (SLR, 2020; Walker, 2020):

- Formation of a Public Liaison Committee to exchange information and discuss concerns with local community members throughout the operating life of the landfill; and,
- Regular community updates regarding activities and performance of the landfill, in a publically accessible style and format;

Effect Characterization

Any effect would be regional, as there are community groups who have organized in opposition to the proposal. The magnitude and likelihood are both low, as there is no indication that negative health impacts will occur. However, the potential health consequence has been characterized as neutral-to-negative based on two factors: (i) there are potentially significant socio-psychological implications for some individuals within the community (especially sensitive individuals), which, even if they are perceptions, should be acknowledged and registered, and (ii) concerns resulting from a perception of hazards may diminish over time; however, until such a time, these concerns should be acknowledged and regularly addressed. As the data and information used for this assessment has been sourced from the EA, and prepared specifically for the assessment of this proposed landfill project, this effect characterization can be made with a high level of confidence.

Table 4-15 Effect Characterization for Social Impacts – Perception of hazards, including socio-psychological impacts

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Perception of hazards, including socio-psychological impacts	Regional	Low	Low	Neutral-to-negative	High

4.10.2 Recreational Access and Enjoyment

Recreational Access and Enjoyment and Health

Recreational resources include parks, conservation areas, trails and other resources that people access in pursuit of their personal and community health and well-being. A waste disposal facility may affect the use and enjoyment of recreational resources if the facility results in measurable adverse effects such as traffic, odour, noise, vibration, water quality, dust and visual effects. The waste disposal facility, along with other project and activities may contribute to cumulative effects which may affect the operation, use and enjoyment of recreational resources. These could affect areas surrounding the landfill or along the haul routes.

Current Conditions

Two recreational features were identified within 500 m of the site: an “unofficial” railway trail (i.e., on private property owned by the quarry operator) west of the site, and an on-road bike route along Beachville Road (SLR, 2020). Further from the site there are a variety of parks, playgrounds, sports fields, etc.

There is also a priority proposal to construct a new trail along Beachville Road.

Proposed Landfill Impact

According to the Social Impact Assessment (SLR, 2020), the landfill will not result in the physical displacement of any public or private recreational facilities, lands or waters used for recreational purposes. Physical disturbances (nuisance effects) from the project that might affect use and enjoyment of recreational facilities are generally limited to an area within about 1 km of the proposed landfill. Facilities beyond this distance are not expected to experience any

significant physical disturbances that would affect their use and enjoyment (SLR, 2020). However, with further mitigation measures that have been recommended and incorporated into this proposal (Walker, 2020), occasional nuisance effects from the landfill that might affect use and enjoyment of public facilities and institutions are expected to be limited to an area within about 500 m of the proposed landfill (SLR, 2020).

Use of the unofficial railway trail and walking/cycling/driving along public roadways nearest the site are casual recreational activities that could potentially be subject to occasional, though typically infrequent, nuisances from the landfill operations.

Effect Characterization

The effect would be proximate and impact recreational resources close to the proposed landfill or along the haul route. The magnitude and likelihood are both low, as there is no indication that any physical displacement of any public or private recreational facilities, lands or waters used for recreational purposes will occur, and any nuisances would be occasional and infrequent. As such the potential health consequence is neutral. As the data and information used for this assessment has been sourced from the EA, and prepared specifically for the assessment of this proposed landfill project, this effect characterization can be made with a high level of confidence.

Table 4-16 Effect Characterization for Social Impacts – Recreational access and enjoyment

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Recreational access and enjoyment	Proximate	Low	Low	Neutral	High

4.11 Cultural Heritage

Cultural Heritage and Health

There is a growing recognition that the protection and conservation of cultural heritage is not just about the preservation of material things, but more so, it is about safeguarding and sharing heritage with the aim of improving people's lives and the environment. In general, cultural heritage resources comprise three types of resources: archaeology, built heritage resources and cultural heritage landscapes (MHBC, 2020c). Our physical environment plays a significant role in maintaining our health, as well as in providing a spiritual and psychological boost, when we connect with a heritage resource.

Current Conditions

There are no designated cultural heritage resources on-site or within 1 km, nor were any of the structures or landscapes determined to have significant cultural heritage value in accordance with the regulations (MHBC, 2020c). There are also no designated cultural heritage resources along the haul route on County Road 6.

Proposed Landfill Impact

There will be no removal of any significant cultural heritage resources or landscapes due to the proposed landfill, nor will there be any physical disturbance to any significant cultural heritage resources or landscapes in the site vicinity (MHBC, 2020c).

Effect Characterization

Any health impacts due to changes to cultural heritages resources or landscapes would be proximate. Given that no designated cultural heritage resources occur on-site or within 1 km, the magnitude and likelihood of impacts to health can be characterized as low, and the potential for health impacts is neutral. As the data and information used for this assessment has been sourced from the EA, this effect characterization can be made with a high level of confidence.

Table 4-17 Effect Characterization for Cultural Heritage

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Cultural heritage	Proximate	Low	Low	Neutral	High

4.12 Built Environment

4.12.1 Land Use Planning and Recreational Spaces

Land Use Planning and Recreational Spaces and Health

How we think of and plan our built environment has enormous impacts on our health. When planning for their long-term growth and land use changes, most municipalities consider how best to achieve a land use plan that addresses not just future economic growth, but also how population growth and the evolving needs of the municipality can be accommodated. One major consideration in land use planning is allocating land and resources to develop and expand recreational spaces and areas for the enjoyment of the local communities. Community centres, and green spaces, such as parks, encourage regular physical activity, which has been shown to have a multitude of positive health implications including (CDC, 2014):

- Weight control;
- Reducing the risk of cardiovascular disease;
- Reducing the risk of type 2 diabetes and metabolic syndrome;
- Reducing the risk of some cancers;
- Strengthening bones and muscles;
- Improving mental health and mood; and,
- Increasing the chance of living longer.

A large number of studies show that access to recreational spaces and outdoor green spaces benefits the overall physical and mental well-being of communities. Providing recreational areas as well as green spaces allow people to gather and interact, thereby increasing social cohesion within the community. At the same time, these spaces reduce stress by connecting with natural environment and encouraging physical activity. Additionally, increased levels of physical activity are associated with improved mental health and well-being.

Current Conditions

The proposed landfill site is currently utilized for an approved rural industrial use (quarry operation), which will continue in conjunction with the proposed landfill site. The location of the leachate plant is between the existing quarry and another existing industrial use (hydro transformer station). The areas within the Township of Zorra, north of the Town of Ingersoll, that are designated resource areas (aggregate and agricultural), will limit the potential growth and land use changes in these area in keeping with the Provincial and Official Plan policies that stipulate the protection of these areas for the same long-term use (MHBC, 2020b).

The Land Use Assessment (MHBC, 2020b) conducted for this EA, predicts that, overall, land use in Oxford County will experience modest residential and employment growth to the year 2045. The City of Woodstock represents the largest growth area for both residential and employment land within the County. The surrounding Townships of South-West Oxford and Zorra will experience minimal change and/or growth, and may remain relatively like the current built conditions, with agriculture and existing quarries as the dominant land use. No new residential and/or employment development is proposed in the immediate vicinity of the proposed landfill, defined as the area within a 1 km radius of the site (MHBC, 2020b).

Proposed Landfill Impact

As the proposed landfill will be located within an existing quarry operation, and is proposed to retain the quarry designation and zoning for the property, adding landfill as a permitted use, no other significant land use changes due to the landfill are expected in the site vicinity during the operating period of the landfill (MHBC, 2020b).

Effect Characterization

Any health impacts with respect to the changes in the built environment would be experienced proximate to the proposed landfill. Given that the proposed landfill would be in an area that is already designated as industrial, and no new residential and/or employment development is proposed in the immediate vicinity of the proposed landfill, defined as the area within a 1 km radius of the site, the magnitude and likelihood of impacts to health can be characterized as low, and the potential for health impacts is neutral. As the data and information used for this assessment has been sourced from the EA conducted specifically for this project, this effect characterization can be made with a high level of confidence.

Table 4-18 Effect Characterization for Built Environment

	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Land use planning and recreational spaces	Proximate	Low	Low	Neutral	High

5.0 RECOMMENDATIONS

The assessment of potential health impacts in the SHR (**Section 4**) provided the foundation for the development of recommendations in order to maintain, protect and improve the community`s health and well-being, as it relates to the Southwestern Landfill Proposal. These recommendations take into account the mitigation and impact management strategies provided in the EA, and either reinforce the EA mitigation measures from a health perspective, or provide additional recommendations to support and enhance the continuing health and well-being of the community.

The following recommendations have been made based on assessment of health determinants in the SHR (**Table 5-1**):

Table 5-1 Recommendations based on results of the SHR

No.	Recommended Action	Health determinant(s) to be addressed	Responsible or contributing organization(s)
1.	Keep the community updated using a regular newsletter (or other forms of public communication) that discusses activities at the site, the site's environmental performance and monitoring results, and any issues raised and how they are being addressed.	• Social – Perception of hazards, including socio-psychological impacts	• Walker
2.	Ensure compliance monitoring is conducted and that the results of monitoring are shared with the local community in user-friendly reports, as and when they become available (see above).	• Air quality • Groundwater • Surface Water	• Walker
3.	Track odour-related complaints and ensure that action is taken to mitigate odour impacts.	• Air quality – Odour	• Walker
4.	Offer property value protection agreements to neighbours whose properties are within 500 m of the landfill site, thereby proactively addressing any potential drop in property values due to the landfill.	• Economic – Property values	• Walker
5.	Ensure that the proposed mitigation strategies to address pedestrian safety due to traffic impacts are implemented and monitor the results to evaluate whether additional mitigation strategies are required.	• Traffic – pedestrian safety	• Walker
6.	Implement hiring and procurement policies to hire locally, and give preference to local suppliers for goods and services needed for landfill maintenance and operation.	• Economic – Employment	• Walker
7.	Circulate to the Medical Officer of Health all reports and communications regarding the landfill site.	• All	• Walker/ Medical Officer of Health
8.	Invite the Medical Officer of Health (or representative) to attend the proposed Public Liaison Committee, to act as a public resource regarding any health issues related to the landfill.	• All	• Walker/ Medical Officer of Health

6.0 MONITORING

Throughout the life of the proposed landfill, there will be regulatory monitoring requirements (e.g., leachate, groundwater, surface water, etc.). Diligent monitoring and updating community residents will ensure that the predictions made in the EA (and subsequently relied upon in this SHR) were accurate and that conclusions on environment and health were based on accurate, verifiable information.

The recommendations in the SHR do not require formal monitoring outside those already required by the EA.

7.0 DATA GAPS, LIMITATIONS AND UNCERTAINTIES

The following data gaps, limitations and uncertainties were noted as part of the SHR process:

- Data has been provided at the level of Southwestern Public Health and Oxford County, and only where available for the Township of Zorra. Oxford County and Southwestern Public Health are comprised of both rural and urban populations, and it stands to reason that there may be differences in health status, for example, self-reported mental health, between these two different population categories. Hence, health status information may slightly differ for the immediate vicinity of the proposed landfill site, when information at the level of Oxford County or Southwestern Public Health has been provided.
- This SHR is not a comprehensive health assessment, and has not been undertaken in direct consultation with relevant stakeholders and community interest groups. As such, only the topics of most concern as noted by the public in 2017 were assessed. However, the scope of the SHR was prepared in collaboration with the acting Medical Officer of Health, as well as the Joint Municipal Coordinating Committee.
- Data for this SHR has mainly been supplied by the various EA stream reports as well as by primary and grey literature. The SHR does not provide a quantitative assessment of the impacts to health, but rather uses the quantitative data from the EA reports to qualitatively assess how the determinants of health will be impacted due to the project.
- In the cases where the impact due to proposed landfill is qualitatively discussed due to the social and subjective nature of issues like “socio-psychological impacts”, “perception of safety” and “social cohesion”, a discussion of potential impacts and associated assumptions was provided; however, it is acknowledged that a certain degree of professional judgement is required under these circumstances. In this scenario, the SHR team erred on the side of caution to acknowledge that given negative social perceptions with respect to the landfill currently exist, there may be potential for negative impacts to health for sensitive individuals.
- As mentioned, the SHR relied on data and information from the EA study streams; therefore, this assessment is subject to the same uncertainties, limitations and assumptions within these reports.

8.0 CONCLUSIONS

The purpose of this SHR was to evaluate potential positive and negative impacts on health and well-being of the communities surrounding the proposed Southwestern Landfill that may result due to social or economic effects related to the landfill, supplementing the findings of the human health risk assessment (HHRA). In doing so, the SHR has also proposed additional measures to either reduce or mitigate harmful effects and to enhance positive effects, while providing a platform to enhance communication and address local community concerns.

Table 8-1 below provides an overall summary of the results of the HHRA and SHR for each of the twelve evaluated determinants of health. The majority of the determinants of health assessed indicated neutral impacts on health due to the proposed landfill.

The results of the SHR indicated a low-level potential negative health impact only in one area:

- Socio-psychological impacts to health are highly subjective and not easily identifiable or mitigated. For those who perceive the proposed landfill negatively, its potential presence could have a potential negative psycho-sociological impact on health. Some individuals may experience increased personal stress stemming from decreased satisfaction with community and a decreased sense of health, safety and well-being and potential mistrust of Walker and others during the initial years following Provincial approval and the commencement of landfill operations.

While current research suggests that advanced landfill facilities, with ongoing community engagement and communications, as proposed for the Southwestern Landfill Proposal, will effectively address concerns, a key element of future monitoring and reporting should be related to demonstrating to regulators, community leaders and members of the public and Indigenous community leaders, Walker's full compliance with all landfill design and operational measures and its mitigation commitments aimed at avoiding or minimizing the physical disturbances of the Proposal (i.e., odour, noise, particulate matter, dustfall), effects on the traffic network, visual intrusion, and effects of the landfill operations on groundwater and surface water resources.

Finally, it is recommended that the identified positive economic benefits be enhanced by ensuring that the economic growth experienced as a result of the proposed landfill is experienced primarily by the communities within the vicinity and local area around the landfill.

Table 8-1 Supplementary Health Review – Summary of Results

Health Determinant	Affected Populations	Magnitude	Likelihood	Potential Health Consequence	Level of Confidence
Air quality					
Emissions	Regional/ Proximate	Low	Low	Neutral	High
Odour	Proximate	Low	Low	Neutral	High
Dust					
Dust	Proximate	Low	Low	Neutral	High
Water (surface and ground water) quality					
Chemical exposures	Regional/ Proximate	Low	Low	Neutral	High
Recreational water use	Regional/ Proximate	Low	Low	Neutral	High

Table 8-1 Supplementary Health Review – Summary of Results					
Health Determinant	**Affected Populations**	**Magnitude**	**Likelihood**	**Potential Health Consequence**	**Level of Confidence**
Soil quality					
Chemical exposures and recreational use	Proximate	Low	Low	Neutral	High
Neighbourhood Aesthetics					
Visual impact	Proximate	Low	Low	Neutral	High
Noise					
Noise levels and vibration	Proximate	Low	Low	Neutral	High
Pests					
Vermin and wildlife	Proximate	Low	Low	Neutral	High
Traffic					
Emissions	Proximate	Low	Low	Neutral	High
Pedestrian safety	Proximate	Low	Low	Neutral	High
Economic					
Employment	Regional	Medium	High	Positive	High
Property values	Proximate	Low	Low	Neutral	High
Municipal revenues	Regional	Medium	High	Positive	High
Social					
Perception of hazards, including socio-psychological impacts	Regional	Low	Low	Neutral-to-negative	High
Recreational access and enjoyment	Proximate	Low	Low	Neutral	High
Cultural heritage					
Cultural heritage	Proximate	Low	Low	Neutral	High
Built environment					
Land use planning and recreational spaces	Proximate	Low	Low	Neutral	High

9.0 DOCUMENT SIGN-OFF

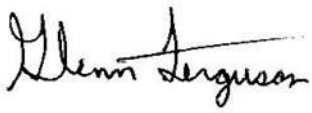
This supplementary health review has been prepared using the best available scientific information as well as the data and information from the other EA draft reports. The information and recommendations provided within this report have been developed using reasonable and responsible practices, and the report was completed to the best of our knowledge and ability.

Intrinsik Corp.

Prepared by:

Faiza Waheed, Ph.D., M.Env.Sc.
Health Impact Assessment (HIA) Lead | Environmental Risk Analyst

Reviewed by:



Glenn Ferguson, Ph.D., QP$_{RA}$
Vice-President and Senior Environmental Health Scientist

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APPENDIX A

SUPPORTING DOCUMENTS

Comment Disposition (*DRAFT FOR DISCUSSION*)
Comments On: WEG Southwestern Landfill Proposal Terms of Reference (August 29, 2013)
Received From: Ministry of the Environment Government Review Team (GRT)

Received From: Donald McKay, Warden – County of Oxford
Dated: October 28, 2013

TERMS OF REFERENCE	DISCIPLINE: XX	WALKER ENVIRONMENTAL GROUP
Comment Received By	**Comment**	**Response**
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	Oxford County Public Health & Emergency Services has prepared the following comments with regards to the proposed Health Risk Assessment (EA). Despite our best efforts, we acknowledge that this review is constrained by our limited staff expertise on some topics.	Thank you for your comments.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	Foundationally, the work plan is sound; however, the following gaps were noted: 1. The work plan focuses heavily on carcinogenic risks, and there is little mention of other mortality and morbidity risks associated with landfills. Further description is required to identify how health risks other than cancer will be addressed. These include but are not limited to neurotoxicity; chemical sensitivity; non-toxicological social impacts; exposures to combinations of chemical, biological and physical agents; and, endocrine disruptions.	As noted in Section 8.3.2 of the draft HHRA workplan, the toxicity of a particular chemical of potential concern (COPC) will be evaluated based upon the dose-response principle that is inherent to any risk assessment. The workplan notes that two main types of dose-response relationships are typically used in risk assessment of chemicals: 1) threshold response (*i.e.*, non-cancer causing chemicals); and, 2) non-threshold response (*i.e.*, cancer causing chemicals). Endpoints such as neurotoxicity, chemical sensitivity, and even endocrine disruptions are typically evaluated through the use of an Exposure Ratio (ER) or Hazard Quotient (HQ) as non-carcinogenic toxic modes of action, as noted in Section 8.3.3 of the draft workplan. While risk characterization for chemicals with a non-threshold-type dose response (*i.e.*, carcinogens) involves the calculation of an

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Comment Received By	**Comment**	**Response**
		incremental lifetime cancer risk (ILCR). It is the intention of the HHRA to evaluate the most sensitive endpoint, be it cancer or non-cancer, as it pertains to exposures to each of the COPC evaluated in the proposed risk assessment. Furthermore, as noted in Section 8.4 of the draft workplan, exposures to combinations of like-acting chemicals will also be evaluated as part of the mixture assessment within the HHRA. Further information on the approach used to evaluate potential mixture effects will be provided in the detailed EA workplan. Finally, non-toxicological social impacts are not typically evaluated as part of a quantitative human health risk assessment, as they do not respond to the traditional dose-response evaluation that chemical, biological, and physical agents do. However, social impacts can be evaluated as part of a larger Health Impact Assessment (HIA) framework, of which an HHRA can be one component. Further discussion of the HIA framework, and its potential application to the current EA, is provided later in this response document.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	2. Currently, the work plan focuses on a single outcome (cancer) due to an exposure to a single toxin. We would like to see how the cumulative health impacts of two or more toxins will be analyzed.	As noted in Section 8.4 of the draft HHRA workplan, exposures to combinations of like-acting chemicals will also be evaluated as part of the mixture assessment within the HHRA. Further information on the approach used to evaluate potential mixture effects will be provided in the detailed EA workplan.

TERMS OF REFERENCE	DISCIPLINE: XX	WALKER ENVIRONMENTAL GROUP
Comment Received By	**Comment**	**Response**
		For example, while the final chemicals of concern (COC) list has not been yet established for the current proposed Project, these are some COC related to diesel emissions that are typically additively grouped as part of a mixtures assessment based on the most sensitive toxicological end point: • **Acute Respiratory Irritants** – Group includes acetaldehyde, acrolein, formaldehyde, NO_x, $PM_{2.5}$, and SO_2; • **Chronic Respiratory Irritants** – Group includes acetaldehyde, acrolein, formaldehyde, NO_x, $PM_{2.5}$, and SO_2; • **Leukemia** – Group includes 1,3-butadiene and benzene; and, • **Nasal Cancer** – Group includes acetaldehyde and formaldehyde. The various mixture groups will be established for the proposed HHRA once the final list of COC has been established.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	3. The work plan addresses only the effect of environmental contaminants on the mortality rate (rate of death) and does not identify the morbidity rate (incidence of disease).	The intention of the HHRA is to evaluate whether potential future emissions from the proposed landfill would result in any adverse health outcomes from a morbidity point-of-view based on predicted worst-case exposure conditions, and if so require risk mitigation to prevent it. Morbidity is explicitly considered as part of an HHRA component within an EA, in that by design you are not permitted to exceed the threshold which could result in morbidity (or mortality) outcomes.

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Comment Received By	**Comment**	**Response**
		Mortality is never an endpoint considered in an HHRA, as assessments of this nature are designed to prevent health effects well before mortality outcomes are of concern. This is done by evaluating sensitive toxicological endpoints that occur at much lower concentrations (*e.g.*, morbidity outcomes or changes that point to potential morbidity or mortality with continued exposure) than those that would result in death. Even the evaluation of incremental lifetime cancer risk (ILCR) due to exposure to a specific carcinogenic chemical are based on the increased probability of getting cancer from such exposures within one's lifetime, not of dying. Ultimately, the intention of the HHRA is to identify circumstances where unacceptable health risks may exist under conservative exposure conditions, and to permit further investigations or implementation of risk management measures to mitigate and/or prevent such potential health risks.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	4. The work plan must incorporate adaptive monitoring and management criteria to accommodate changing conditions and new information.	Walkers Environmental Group (WEG) is committed to using adaptive monitoring and management throughout the operational lifetime of the proposed landfill. Ongoing air quality and groundwater monitoring will be conducted post-construction on an annual basis around the Project site. As part of this annual environmental status report, WEG will commit to conducting an annual review of the results of the ongoing monitoring programs to evaluate if any changes in the process or changes in the regulatory environment (*i.e.*, new regulatory benchmarks, revised risk assessment approaches, emerging issues, *etc*.) could potentially impact on the conclusions of the original HHRA conducted as part of the EA process. Should unacceptable risks be noted as part of this assessment

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		review process, further evaluation or risk mitigative measures can be undertaken in consultation with the MOE and other key stakeholders such as the Medical Officer of Health.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	5. The precautionary principle should be included in the assessment and its importance in responding to adverse health and environmental conditions. This is particularly important when cause and effect relationships cannot be established and/or validated.	As noted in the draft workplan, the proposed HHRA will follow standard risk assessment methods, and will be conducted in compliance with the risk assessment procedures endorsed by regulatory agencies including Environment Canada, Health Canada, the Canadian Council of Ministers of the Environment (CCME), and the US EPA, as well as guidance provided by the Ontario Ministry of the Environment (MOE). The HHRA, and its inherent methodologies and assumptions, is designed to err on the conservative side, so as to ensure that potential exposures to COCs, and relatedly potential health risks, are not under-estimated. This entire process is inherently precautionary, as it tends to evaluate risks for scenarios that in many cases are not likely to occur in reality due to the application of worst-case assumptions on top of worst-case assumptions. Ultimately, where potential risks are predicted, risk management measures are typically implemented to prevent any unacceptable risk. This type of preventive action by the proponent is a central tenant of the precautionary principle, and is a core element of the proposed HHRA approach.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	In general, the Human health Risk Assessment ToR and Work plan addresses the quantitative impacts of chemical, biological and physical agents as these relate to disease morbidity and mortality rates in humans. However, it is unclear whether consideration has been given to studying the cumulative and synergistic impacts that may arise from both direct and indirect health risks.	Dr. Neal indicates the workplan does address the quantitative impacts of chemical, biological and physical agents as these relate to disease morbidity and mortality rates in humans, but he feels it is "unclear whether consideration has been given to studying the cumulative and synergistic impacts that may arise from both direct and indirect health risks". He cites the WHO's definition of health as "a state of complete physical, mental and social well-being and not merely the absence of

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Comment Received By	**Comment**	**Response**
		disease." As such, he would like the EA to consider a broader definition of health to include socio-economic, cultural and psychological well-being, and the ability to adapt to stress, so that the workplan ensures "there is a more comprehensive examination of potential health impacts related to the Southwestern Landfill proposal." The design of this environmental assessment is such that it already presents an integrated approach to the assessment of environmental, social and economic effects, based on the broad definition of "environment" in Ontario's *Environmental Assessment Act* (see Section 6.3, p. 22 of the Terms of Reference). The EA criteria are fully inter-disciplinary (Appendix B) and characterize the widest possible range of potential effects on receptors, rather than just those related to each individual study. For instance, the definition of Criterion #11 "*Disruption to use and enjoyment of residential properties"* combines the effects of a wide range of environmental factors (noise, dust, litter, odour, etc.), any or all which could individually meet regulatory standards, but when examined from a combined perspective could nevertheless result in direct or indirect socio-economic effects. The social criteria for this EA are structured to address such human health-related indicators as *enjoyment, community cohesion and community character* (see the criteria definitions in Table A-1, Appendix B). As a result, this EA design will provide a suitable platform for a further review of potential health-related effects of any socio-economic impacts. In addition to the proposed health risk assessment, we will therefore agree to carry out a screening-level review of the socio-economic assessment results to determine the potential for related health effects, and, if any significant negative effects can be identified, to work closely with the social, economic and environmental experts to adapt or augment their mitigation recommendations to minimize or eliminate

TERMS OF REFERENCE	DISCIPLINE: XX	WALKER ENVIRONMENTAL GROUP
Comment Received By	**Comment**	**Response**
		these potential effects, and characterize any residual net effects for the purposes of this EA.
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	The World Health Organization defines health as a "state of complete physical, mental and social well-being and not merely the absence of disease." Using a broader definition of health to include socio-economic, cultural and psychological well-being, and ability to adapt to stress, ensures there is a more comprehensive examination of potential health impacts related to the Southwestern Landfill proposal. Issues such as odours, dust, an increase in vermin and other accidents in the surrounding area, and the possible decline in property value, can contribute to increased stress and other psychological problems in the community. Many of these issues have been identifies as components with other proposed impact assessment study plans. However, it is unclear as to how, or if these issues will be considered along with the quantitative Human Health Risk Assessment data.	Please see comment above
Dr. Douglas Neal, M.D., B.Sc., C.C.F.P Acting medical Officer of Health County of Oxford Received by WEG – November 19, 2013	Therefore, a more comprehensive assessment of the cumulative and synergistic impacts of all factors that may impact overall health and well-being of people needs to be addressed through the EA process. It is likely that environmental risks which may have impacts on disease morbidity and mortality may not be the risks that will be found to have the greatest impact on resident's perception of overall health, well-being, and quality of life.	Please see comment above

August 22, 2014

JOINT MUNICIPAL COORDINATING COMMITTEE

Michelle Whitmore
Special Projects Officer
Environmental Assessment Branch
Ministry of the Environment and Climate Change
2 St. Clair Ave. West, 14th Floor
Toronto, ON M4V 1L5

Dear Ms. Whitmore:

Re: Walker Environmental Group Inc. ("WEG")
Southwestern Landfill Proposal

I am writing on behalf of the Oxford Joint Municipal Coordinating Committee (JMCC), a committee composed of the Warden, Mayors and municipal CAOs of four municipalities within the County of Oxford: the County, Town of Ingersoll and Townships of South-West Oxford and Zorra. This letter in response to a letter dated July 18, 2014, from Ms. Agatha Garcia-Wright to South-West Oxford Township Mayor, David Mayberry, requesting further details regarding the content of the framework of an In-Depth Health Impact Assessment relating to Walker Environmental Group's Southwestern Landfill Proposal.

Dr. Douglas Neal, Oxford County Acting Medical Officer of Health, has prepared the attached comments in response to Ms. Garcia-Wright's correspondence. The JMCC would like to note WEG's commitment to conduct a screening-level review of the socio-economic assessment results is an important first step within the HIA process. However, WEG is non-committal about moving forward with an In-depth Human Health Impact Assessment if any negative effects are identified. The JMCC concurs with Dr. Neal's recommendation that any such findings of potential negative effects should automatically trigger the second stage of a HIA; namely, the scoping stage which would establish the blueprint of the HIA. Further, any approved Terms of Reference should require the WEG to seek the input and assistance of the Joint Municipal Coordinating Committee (JMCC) and/or its agents in the development of the blueprint, and the comprehensive work plan to implement it. Further, the final HIA comprehensive work plan should require endorsement from the JMCC and formal approval from the Ministry of Environment and Climate Change.

The JMCC endorsed Dr. Neal's response and requests the Ministry to accept the recommendations put forth by Dr. Neal.

Thank you for your consideration of this matter.

Sincerely,

Margaret Lupton

Margaret Lupton,
Mayor, Township of Zorra
Chair, Joint Municipal Coordinating Committee

cc. All JMCC members
Walker Environmental Group
Ms. Agatha Garcia-Wright, Director, Environmental Approvals Branch, MOE

Public Health & Emergency Services
410 Buller Street, Woodstock, Ontario N4S 4N2
519-539-9800, ext. 3410 | Fax: 519-539-6206
www.oxfordcounty.ca/health

August 21, 2014

Deputy Warden Margaret Lupton
Chair, Joint Municipal Coordinating Committee
Township of Zorra
274620 27th Line, R. R. # 3
Ingersoll, Ontario N5C 3J6

Dear Deputy Warden Lupton,

Thank you for the opportunity to provide further feedback to the Joint Municipal Coordinating Committee (JMCC) on our recommendation to the Walker Environmental Group (WEG) to conduct a comprehensive Human Health Impact Assessment (HIA) of the cumulative and synergistic impacts of all factors (exposure pathways, determinants of health and health equity) that may impact the overall health and well-being of the community. I believe a HIA is an important addition to the overall Environmental Assessment (EA) process because it will determine whether present or new environmental conditions resulting from the proposed landfill will influence future health outcomes. Oxford County Public Health considers the proposed landfill to have the potential to create significant human health impacts which may arise from the indirect or direct influences of the development. In particular, the inter-relationships of the social and economic constructs associated with the proposed landfill.

In the Southwest Landfill Proposal Amendment to the TORS issued on April 2, 2014, the WEG added the following commitment (#12):

In addition to the proposed health risk assessment, WEG's health expert will carry out a screening-level review of the socio-economic assessment results to determine the potential for related health effects. If any significant negative effects are identified, WEG's health expert will work closely with the social, economic and environmental experts to adapt or augment their mitigation recommendations to minimize or eliminate these potential effects, and characterize any residual net effects for the purposes of this EA.

Although WEG's commitment to conduct a screening-level review of the socio-economic assessment results is an important first step within the HIA process, WEG is non-committal about moving forward with an In-depth Human Health Impact Assessment if any negative effects are identified.

It is my recommendation that any such findings of potential negative effects should automatically trigger the second stage of a HIA; namely, the scoping stage which would establish the blueprint of the HIA. It would be expected that members of the Joint Municipal Coordinating Committee (JMCC) would assist in the development of the blueprint, and the comprehensive work plan to implement it.

As noted in HIA frameworks established by Health Canada, the National Collaborating Centre for Healthy Public Policy, Centers for Disease Control and Prevention, and the World Health Organization, the scoping step found within a HIA is critical in identifying potential significant health impacts and their pathways.

In consultation with Public Health Ontario, a series of HIA topics were identified based on direct and indirect effects on health and are summarized in Table 1. Direct effects were considered complete exposure pathways for the surrounding public such as inhalation, dermal and ingestion exposures to project-impacted air, water and soil. Indirect effects on public health were influenced by the determinants of health. These topics can be applied and further evaluated in any of the frameworks named above.

The analysis during the scoping stage would identify vulnerable subgroups of the affected population and more importantly provide a platform to study decision alternatives. A key outcome of the scoping stage would be the identification of any potential inequities and their impacts based on population characteristics such as, but not limited to, age, gender, income, employment, place (disadvantaged locations), education and social support.

The information retrieved from the scoping process would be applied to the assessment stage which includes a baseline conditions analysis and qualified judgements of potential health impacts. This would include documentation of both population health vulnerabilities and inequalities in health outcomes among subpopulations and potential exposure pathways. The evaluation of these impacts would be based on the best available evidence and include experiences of affected members of the public.

Based on these observations and conclusions, it would be expected that WEG make specific recommendations in the HIA on how to manage potential health impacts, include modifications to the proposal based on these new found impacts and report their findings to the JMCC. It would be also expected that the final HIA report be made publicly accessible.

As previously stated, there are several reputable and established HIA frameworks that incorporate high standards of practice and evidence-based research. Any of the suggested HIA frameworks supported by Oxford County Public Health and Public Health Ontario are listed in Table 1 could be applied to facilitate a comprehensive HIA process. Upon the Ministry of the Environment and Climate Change accepting Oxford County Public Health's request for an In-Depth Human Health Impact Assessment, the JMCC and Public Health would continue to work with Public Health Ontario and WEG on the development and implementation of a HIA framework that is representative of the characteristics that make up the landfill proposal and the demographics of the community.

Should you wish to discuss this matter further please contact my office at 519.539.9800 or dneal@oxfordcounty.ca.

Sincerely yours,

Dr. Douglas Neal, M.D., B.Sc., C.C.F.P.
Acting Medical Officer of Health
County of Oxford

Southwestern Landfill Environmental Assessment, Updated Draft Technical Work Plans – Human Health Risk Assessment
Comments Received From: Dr. Douglas A. Neal, M.D., B.Sc., C.C.F.P., Acting Medical Officer of Health, County of Oxford (September 20, 2017)

Comment	Walker Response	Disposition
Oxford County Public Health met via teleconference with the Peer Review consultants on Tuesday, August 21, 2017, to examine Walker Environmental Group's *Draft Environmental Assessment Work Plans* dated May 23, 2017.	--	--
As next step, a face-to-face meeting between the Joint Municipal Co-ordinating Committee (JMCC), Walker Environmental Group (WEG) and Public Health should be held to review this draft document. Teleconference attendees agreed that the document failed to address a multitude of issues. As the Acting Medical Officer of Health for the County of Oxford, I have a number of serious concerns:	Walker agrees that a meeting should occur.	Walker has coordinated a meeting on November 28, 2017 to discuss the Human Health Risk Assessment (HHRA) work plan.
i. What evidence proves the effectiveness of the liner system to contain hazardous material?	The proposed Southwestern Landfill would be approved to receive only solid non-hazardous materials. Leachate would be contained using the generic double composite liner system in accordance with O. Reg. 232/98. When this liner was designed under the direction of the Ministry of Environment and Climate Change, leachate characteristics from sampling at a wide variety of non-hazardous waste landfills were used to ensure that it would be effective in containing this type of leachate. We also note that the leachate characteristics used by the Ministry in the liner design probably did reflect the disposal of some amount of co-mingled hazardous waste, since their leachate data stretched back to a period when household hazardous waste programs were not in place. Nowadays with significantly improved hazardous waste removal programs enacted, and with the enhanced waste acceptance procedures that Walker uses at its landfill sites, this liner system will be more than adequate.	--
ii. How durable is the liner over a long period of time?	The generic double composite liner is designed to be fully protective of the environment throughout the contaminating lifespan of the landfill (the years in which contact between landfill leachate and groundwater would negatively impact groundwater). Schedules 1 and 2 of the Ontario Landfill Standards Guideline cite that the primary and secondary liners may be assumed to have a service life of 100 and 1000 years, respectively.	--

Comment	Walker Response	Disposition
iii. What is the safety record for this system?	The generic double composite liner system was designed by the Ministry of Environment and Climate Change in 1998 and there has not been any recorded failures of this liner system. Walker has constructed and operated this liner system at the South Landfill in Niagara Falls and it has operated as expected with no issues to date. One of the benefits of a double liner system is that the secondary liner can be checked to see if any leachate has migrated from the primary system. At the South Landfill, we have not detected any leachate in the secondary liner system. Monitoring of the secondary liner system and surrounding groundwater is a standard part of landfill monitoring and reporting requirements.	--
iv. What provisions mitigate against potential failure?	Despite the fact that the Ministry's generic double composite liner system is designed to be fully protective of groundwater throughout the entire contaminating lifespan of the landfill, O. Reg. 232/98 nevertheless requires that performance of the liner be monitored and that there are additional contingency plans in place should an unexpected failure and leakage ever occur during this period. Walker will be establishing a comprehensive performance monitoring and contingency plan in its submission to the Ministry for an Environmental Compliance Approval for the landfill. It is also worth noting that private landfill owners are required to submit Financial Assurance to the MOECC, which is a secure fund intended to pay for landfill maintenance in the event that the owner cannot support the landfill financially in the future (e.g., bankruptcy).	--

Comment	Walker Response	Disposition
v. Given that this is a very porous rock formation with both surface and deep water in the area, possible contamination from a landfill is a genuine fear. A significant population derives their water from this area and the community has heightened knowledge about water issues.	Walker recognizes that the primary water source for potable water in the area is groundwater, as well as the importance of protecting that water source. It is noted that, through the JMCC, Walker is funding a peer review of this EA by a qualified professional hydrogeologist on behalf of the local municipalities.. The proposed generic double composite liner system is designed to be fully protective of the environment in a variety of hydrogeological settings. From the Ontario Landfill Standards Guideline: *"To ensure the generic designs can be used within a broad range of hydrogeologic settings, the designs have been developed such that the Reasonable Use limits for groundwater protection will be met without reliance on contaminant attenuation in the landfill buffer area."* In addition, Walker has experience successfully implementing this liner system in a similar limestone quarry setting in Niagara Falls, Ontario.	--
vi. The community treatment facilities do not have the necessary resources for leachate disposal. What provisions for leachate disposal are being considered for this necessity?	As described in the Facility Characteristics Assumptions report, Walker has proposed to build a treatment facility specifically designed to treat leachate from this landfill, and will not be relying on the County waste water treatment facilities.	--

Comment	Walker Response	Disposition
vii. We are concerned about air quality and gases produced by the landfill. This is a community with heightened awareness of air quality issues. The Ministry of Environment and Climate Change has not been able to reassure this community. How will this be addressed?	Effective management of landfill gases is an essential part of normal landfill operations. Walker has extensive experience designing and operating landfill gas management systems at our landfills as well as through our partnership company, Integrated Gas Recovery Services. Walker has proposed that the Southwestern Landfill would manage landfill gas through flaring and by using it as renewable energy resource. While we would prefer to use 100% of the landfill gas for energy, flaring is required to manage the gas at the start and end of life of the landfill gas system, when there is only a small amount of gas, as well as any excess gas the cannot be used. The burning of landfill gas, whether by flare or to produce energy, is required to reduce greenhouse gas emissions. As part of the studies, the greenhouse gas emissions of the proposed landfill will be quantified. Regarding air quality, Walker is carrying out an air quality study that will add to the data already collected by the MOECC about the current air quality of the area. The study will then model the emissions from the landfill facility, as well as the cumulative emissions from the landfill and other sources (e.g., Carmeuse operations). We also note that, through the JMCC, Walker is funding an independent peer review of this EA by qualified professional air quality experts on behalf of the local municipalities.	--
viii. A major issue is the socio-psychological effects of imposing a landfill on a community that clearly does not want it and will derive little benefit from it. It must be considered that if problems occur, this community suffers the consequences.	Agreed. The social assessment will evaluate the potential social/cultural effects of the proposed landfill, and these will be further reviewed by the health expert to determine whether there is a potential for any significant related socio-psychological health effects. Information will be drawn from the Social Assessment report and supplemented with scientific literature. Table 11-1 in the HHRA and SHR Work Plan has been updated to reflect this addition. We also note that, through the JMCC, Walker is funding an independent peer review of this EA by qualified professional social assessment experts on behalf of the local municipalities.	--
Dave Hardy of Hardy Stevenson and Associates Ltd. (HSA) gave an overview of his comments on the Human Health Risk Assessment (HHRA) and the Supplementary Health Review Work Plan relevant to health effects:	--	--

Comment	Walker Response	Disposition
i. Cumulative Effects Assessment (CEA) was conducted in discipline-specific silos without sufficient interdisciplinary analysis and findings;	The HHRA will be incorporating the findings from multiple streams to conduct the health evaluation for the CEA, specifically not in discipline-specific silos. There has also been considerable communication between disciplines both at the workplan development stages, and as the actual analysis moves forward.	
ii. Impacts on air, noise, water and traffic are particularly relevant to human health and should be addressed in the CEA, and those findings should be included in the Supplementary Health Review Work Plan (with consideration also to disease transmission via insects or vermin; potential for traffic collisions; effects on other public services.)	The SHR will be evaluating the findings of the other disciplines to address the specific health questions raised by the MOH and other key stakeholders as part of the scoping stage of the Study.	
Mark Chappel summarized NovaTox's findings of the HHRA work plan as follows:	--	--
i. Details regarding the Supplementary Health Review are sparse in the Work Plan without reference to a specific frame-work, but this information will be added following completion of the socio-economic studies and in consultation with the Medical Officer of Health (MOH) and the Peer Review Team (PRT) which includes NovaTox and HSA;	Agreed. The proposed approach for the SHR to addressing the key questions raised by the MOH and PRT will be expanded following upcoming face-to-face meetings with these key stakeholders.	
ii. The Chemicals of Potential Concern (COPC) anticipated to be included in the HHRA should be provided in the Work Plan, or at a minimum, details of the COPC selection process from the other disciplines should be provided. The selection of concentrations of each COPC (exposure levels) should be discussed in the Work Plan, which could comprise a brief summary of the proposed approach/methodology from the Air Quality Assessment and Groundwater/Surface Water Assessment and how trigger values from the other disciplines will be incorporated into the HHRA.	Information on the methodology used in the Air Quality and Groundwater/Surface Water Assessments to produce an initial COPC candidate list will be summarized in the HHRA to provide the necessary transparency on how the final COPC list was developed.	

Southwestern Landfill Environmental Assessment, Draft Human Health Assessment Work Plan

Comments Received From: Dr. Jennifer Kirk, Arcadis Canada on behalf of the Town of Ingersoll (May 26, 2017)

Comment	Walker Response	Disposition
The proposed human health risk assessment is in line with a typical risk assessment completed to address exposure to parameters in the environment. There are some additional considerations that have been proposed below, however, the general approach for this type of assessment is acceptable as proposed.	Noted.	--
What does not appear to be adequately addressed are the health impacts resulting from the proposed project that are not related directly to chemical exposure. A screening level SHR has been added to the ToR; however, from the information provided in the work program it is not possible to evaluate whether the SHR will be of sufficient depth to adequately address the concerns of the community and stakeholders, or to provide meaningful information into the process. The objective of the SHR should be to improve the knowledge of the potential impacts and to propose adjustments to mitigate the negative and maximize the positive impacts (National Collaborating Centre for Healthy Public Policy, 2010). While the work plan discusses the steps involved in the SHR and the health determinants, it does not adequately provide information on how the results of each of the health determinants are to be evaluated, related back to impacts to human health or how the results will be incorporated into operation and post-closure of the landfill. The steps and the process of the SHR were outlined but it was not clear how the results of the process would be evaluated with respect to impacts to human health.	"*The objective of the SHR should be to improve the knowledge of the potential impacts and to propose adjustments to mitigate the negative and maximize the positive impacts*." Because this health assessment is integrated within an EA framework, and not a separate health assessment, the potential impacts and any necessary mitigation will have already been assessed in conjunction with a wide array of criteria and disciplines within the EA that have inherent health components (See Table 11-1 in the work plan.). Therefore, the scope of the supplementary review is simply to determine whether there is a potential for any <u>additional</u> indirect health effects that could arise and, if so, whether any further assessment is required.	--
The proposed HHRA is following a format that is typical for HHRAs for contaminated sites; however, it does not address the concerns of the public. The main omissions may be covered in the SHR, but it appears that this SHR will be preliminary, hence the word "screening" and will not be comprehensive enough to address the community's concerns. From my perspective, major shortcomings are:	The Supplementary Health Review (SHR) is not intended to address the potential direct effects of the landfill operation (groundwater, surface water, air and soil contamination), which are the subject of the Human Health Risk Assessment (HHRA). Rather, as specified by the Minister in Amendment #13 to the ToR, the SHR is required to carry out "*a screening-level review of the socio-economic assessment results to determine the potential for related health effects*" (Section 11.0).	--
1. Addressing the potential for engineering designs to fail and the impacts to groundwater and surface water	The EA will be based on normal operating conditions of the site, not possible emergency or upset conditions; those will be dealt with through the development of contingency/emergency response plans set out in the Design and Operations Report submitted for approval under the *Environmental Protection Act*.	--

Comment	Walker Response	Disposition
2. How the quality of the Thames River for human use (i.e., recreational use and consumption of fish) is being (or is not being) addressed by WEG.	The HHRA will incorporate information from the Groundwater and Surface Water Assessment conducted by Golder. As part of the work plan, Golder aims to: "*Grab surface water samples will be collected on a seasonal basis (spring, summer, fall and winter), in addition to data available from the existing annual monitoring program, in an effort to capture the full range of flow conditions present at the Site, in the Thames River, upstream and downstream and in the representative tributary streams. Each sample will be analyzed by a certified laboratory for surface water quality indicator parameters (e.g., metals and hydrocarbons), including target parameters that are routinely tested for the detection of leachate.*" Data from this assessment will inform the HHRA conducted by Intrinsik.	--
3. Consideration of contaminants of emerging concerns (i.e., PFAS), how these are being addressed.	The HHRA will assess potential risks to these COPCs predicted by both the Air Quality and Groundwater/Surface water Studies, where data is available. If a particular COPC, for example a contaminant of emerging concern such as PFAS, does not have an existing appropriate health-based regulatory standard or TRV, this COPC will be evaluated qualitatively within the assessment, using information where available from literature or jurisdictional resources, such as the MOECC.	--
4. Acknowledgement and consideration of the effects of stress on the residents/communities and how stress affects human health.	The acknowledgement of health effects related to stress will be identified through the health review of the socio-economic assessments, which will assess criteria such as use and enjoyment of property, community character and social cohesion (see Appendix A to the work plan).	--
5. Consideration of collection of rainwater for irrigation.	The Groundwater/Surface Water Assessment does not take into consideration the collection of rainwater for irrigation purposes. As such, this is out of scope of work for the HHRA. The Groundwater/Surface Water Assessment does, however, consider that: "*The establishment and operation of the waste disposal facility may affect agricultural crop or livestock production and related agriculture activities*."	--
6. Consideration of effects on crop species (HHRA indicates livestock, not crops) for both consumption and yield for cash crops.	Acknowledged. This has been updated in Section 9.3.1 of the latest work plan: "If it is determined that these types of agricultural or small livestock operations exist with the Study Area (i.e., a 5 km radius from the proposed facility), the HHRA will consider this type of exposure scenario."	This has been updated in Section 9.3.1 of the HHRA work plan.

Comment	Walker Response	Disposition
It appears that the SHR is focusing primarily on dust and soil impacts, with some consideration for potable groundwater. However, there are other exposure pathways, such as vapour intrusion, significant impacts to potable water supplies (municipal and private), impacts to irrigation and livestock water, and extensive impacts to surface water, that have not been considered in the event that the landfill design and treatment system lose efficacy or there is a failure. In addition, chemical concentrations would be expected to be higher than those predicted if loss in efficacy or design failure were to occur.	The EA will be based on normal operating conditions of the site, not possible emergency or upset conditions; those will be dealt with through the development of contingency/emergency response plans set out in the Design and Operations Report submitted for approval under the *Environmental Protection Act*.	--
Why is the potential impacts on home garden or the agricultural food chain from vehicle deposition not considered?	Particulates along the haul routes due to traffic is being assessed and supplied as input to the HHRA (see Section 5.2 of the Air Quality Assessment work plan).	--
Are there people on the haul route that capture rain water for irrigation or livestock water; deposition onto roofs and followed by precipitation could impact the water quality. Is this being considered?	The groundwater assessment will include a water well inventory to confirm the water supplies used in the site vicinity. This information will be available to the HHRA. Refer to the groundwater/surface water assessment work plan. Deposition on captured rain water for irrigation or livestock purposes is not considered a significant pathway for exposure and as such will not be evaluated in the HHRA.	--
Section 5: The study areas are very loosely defined. At what point will these be determined so that the appropriateness of the study areas and receptors can be evaluated?	The “study areas” for the health assessment are essentially an amalgam of those of the individual studies that will be supplying the input (groundwater, surface water, air, etc.). Furthermore, in some cases there are unique study areas for different criteria within each study. And lastly, this EA reflects a flexible (adaptive) approach to study areas that may evolve as the studies are completed. For all of these reasons, the study areas for the health assessment are not easily defined at this stage of the EA, but will be in the EA reporting, which will be made available for peer review.	--
Section 6: Effects due to contact with contaminated surface water and groundwater: Is the consumption of fish from the Thames River being considered? Is dermal contact from surface water being considered? Section 5 indicates that impacts to groundwater and surface water would be expected. How will these be evaluated within the HHRA and/or SHR?	The selection of specific exposure groundwater and surface water pathways for consideration in the HHRA will be conducted in collaboration with the Groundwater/Surface Water Assessment conducted by Golder. Where exposure to groundwater and/or drinking water is identified as a complete exposure pathway in the problem formulation step of the HHRA, these pathways will be carried forward for further assessment. Since the wider study area includes the Thames River, this pathway will be considered for inclusion in the HHRA and has been added as a potential pathway in Section 9.1.3.	Section 9.1.3 of the HHRA work plan has been updated in response to the comment.
Section 6: It is not clear if the proposed indicator of predicted air concentrations (for emissions and for fine particulate) are predicted based on landfill activity only or on the incremental increase resulting from the landfill. Will the indicators consider the additive effects of the landfill to the existing quarry and other local background sources?	This EA is designed to characterize the cumulative effects; therefore, the landfill emissions will be superimposed on the baseline emissions from other local sources (see the air quality assessment work plan).	--

Comment	Walker Response	Disposition
Section 6: The proposed provincial and federal groundwater standards to be relied upon should have been provided to allow for appropriate comparison with the measured and modeled predicted contaminant of potential concern (COPC) concentrations.	These standards are published and readily available; they are referenced in the groundwater/surface water assessment work plan. Further information on the selection of COPCs is presented in Section 9.2.2 of the work plan.	--
It is not clear how COPCs in surface water will be evaluated within the HHRA as only groundwater standards/guidelines have been mentioned.	Section 6.0 of the groundwater/surface water assessment work plan provides a more comprehensive list of the applicable water quality standards. The standards address drinking water quality from both sources.	--
Section 7.3: It is not clear how climate change is being considered in the HHRA. Please clarify.	Section 7.3 is simply common language included in all work plans to convey Walker's commitment to consider climate change in this EA, where relevant, and to supply the standard reference material. In fact, it is not directly relevant to the health assessment given that the supporting studies supplying the input will have already incorporated climate change into their analyses.	--
Section 8.0: No information was provided regarding the data relied upon or consideration for background, therefore an evaluation of the data being used could not be completed.	Noted; the background data do not exist until the other studies are completed.	--
Section 9.1.3: The receptors and exposure pathways have not yet been identified. The Work Plan should have included the receptors and the exposure pathways that the receptors could be exposed to allow evaluation of the comprehensiveness of the study. Since only a list of possible exposure pathways were provided, comments are limited to this and have not been fully evaluated: a. Will consideration of dermal contact from groundwater and surface water be considered? Residual impacts in treated leachate would be expected. b. Will consideration of ingestion of local crops be considered? c. Will consideration of consumption of fish be considered? d. Will consideration of incidental ingestion and dermal contact of surface water and groundwater be considered?	It is noted in the work plan that the receptors, exposure pathways and conceptual model will be established once the associated studies have carried out their assessments. The discussions in Section 9.1.3 are indicated as preliminary based on the currently available study area information and professional judgment, and Figure 9-3 is labeled as an "example" at this time.	--
Figure 9-3 should also show the potential for landfill leachate to impact groundwater and discharge to surface water. The conceptual site model does not show the source of impacts and the potential for distribution within the environment.	Figure 9-3 does illustrate both groundwater and surface water as potential pathways and links the two together (although the arrow joining them could perhaps be double-ended). Regardless, Figure 9-3 is an example only and the conceptual model will not be fully established until the associated studies are more advanced.	--
Section 9.2, p. 15: The level of effort should be the same to assess any COPC originating (or predicted to originate) from the landfill. What process is proposed to choose the smaller number of chemicals on which to focus?	The process for selecting the COPCs is described further in Sections 9.2.1 through 9.2.4.	--

Comment	Walker Response	Disposition
Section 9.2.2: The standards/guidelines proposed in this Section may not be protective of all operable exposure pathways. For example, how will COPCs relevant for the consumption of fish and dermal contact of surface water be identified using MOECC groundwater standards and Canadian Drinking water guidelines?	If predicted COPC concentrations in surface water do not exceed the Ontario Drinking Water Standard, one can assume the concentration does not pose a dermal contact risk for recreational swimmers using the surface water body. Assuming concentrations do not exceed appropriate ecological aquatic protection value (APV) benchmarks (as specified in the MOECC MGRA model) or drinking water standards, the only fish consumption risk might be from chemicals that are persistent and/or bioaccumulative in nature, such as PCBs, pesticides, *etc*. These particular chemicals are also outlined in the annual Ontario Sport Fishing Guide. Should any of these chemicals be predicted within the surface water around or downstream of the landfill, based on emissions from the landfill, risks arising from fish consumption for these COPCs will be formally assessed in the detailed HHRA.	--
Section 9.2.3: It appears that the HHRA approach is only considering COPCs through deposition from air; however, the potential for leachate to impact groundwater if the design fails and for groundwater and/or leachate to reach the Thames River does not appear to be considered. This is particularly important given the Arcadis comments on surface and groundwater, relating to the greater potential at this proposed landfill for the sudden failure of the liner and release of contaminants and gas to the groundwater. The HHRA should also account for the potential for exposure to occur via these exposure pathways.	The EA is based on normal or typical operating conditions, so that the environmental advantages and disadvantages of the proposed undertaking are characterized in the way that it is expected to operate day-to-day and year-to-year. Walker will be developing monitoring, contingency and emergency response plans for the landfill (including the liner system) as part of the application for an Environmental Compliance Approval (ECA) under the Environmental Protection Act.	--
Section 9.2.4: How will COPCs be evaluated where an appropriate health-based regulatory air standard or toxicity value CANNOT be identified?	Should COPCs will be identified in the Air Quality or the Groundwater / Surface Water Assessment that do not have an appropriate health-based regulatory standards or TRVs, they will be assessed in the HHRA. In such a case, a qualitative assessment of potential risks will be conducted for that COPC, using information where available from literature or jurisdictional resources, such as the MOECC.	--
Section 9.2.4: Any COPC that meets the requirements of persistent or bioaccumulative substance that could be associated with the landfill should be retained and assessed for multi-media exposure, not only those that show an increasing trend or that are already present.	Yes, as outlined in the workplan, any COPC that meets the requirements of persistent or bioaccumulative will be retained and assessed for multi-media exposure.	--
Section 9.2.4: How will contaminants of emerging concern be addressed in the HHRA (for example PFAS are associated with landfill leachates, standards do not currently exist at the Provincial level and they typically are not part of a standard routine monitoring)? Please provide an indication of how the HHRA assessment will address contaminants of emerging concern and failure or under performance of the design of the landfill.	The HHRA will assess potential risks to these COPCs predicted by both the Air Quality and Groundwater/Surface water Studies, where data is available. If a particular COPC does not have an existing appropriate health-based regulatory standard or TRV, this COPC will be evaluated qualitatively within the assessment, using information where available from literature or jurisdictional resources, such as the MOECC.	--

Comment	Walker Response	Disposition
Section 9.2.4: Please clarify how parameters identified in groundwater and/or surface water that have not been flagged previously for the multimedia assessment will be addressed.	Please see responses above.	--
Section 9.3.1: Will the updated Compendium of Canadian Human Exposure Factors for Risk Assessment be considered?	The Compendium of Canadian Exposure Factors for Risk Assessment is listed in Section 9.3.1 as one of the resources to be considered when characterizing receptors in the HHRA. However, those receptor characteristics recommended by the MOECC under O. Reg. 153/04 will be primarily used in the current assessment.	--
Section 9.3.1: Since only "potential" human exposure scenarios were provided and not the actual ones that will be considered in the HHRA, a thorough review of the exposure scenarios could not be completed at this time.	Noted.	--
Section 11.2: Scoping of the Health Assessment: a. How will stress from negative impacts of the project be considered with respect to human health effects of the project? b. While the determinants are listed, it is not clear the approach proposed to be taken to address each of the determinants. Therefore, detailed comments on the work plan for the SHR could not be made at this time.	Any potential effects related to stress will be identified through the health review of the socio-economic assessments, which will assess criteria such as use and enjoyment of property, community character and social cohesion (see Appendix A to the work plan).	--
Appendix A: Would impact to surface water and groundwater not be considered for the wider area? Would impacts to groundwater and surface water also not impact ecology, social and land use (future)?	The definition for "Wider Area" in Section 5 of the work plan indicates that it is more regional and intended for "some of the general or indirect effects of a landfill that are not resulting from specific physical activities on the site". In this case the groundwater and surface water studies have defined their Site & Site Vicinity study areas as large enough to encompass all of the related effects. Yes, the groundwater, surface water ecology, social and land use effects are interrelated. However, this is not intended to be depicted in the tables in Appendix A (although it is described in the criteria definitions/rationale in these tables). Table A-2 in the approved ToR illustrates many of the key discipline inter-relationships in the EA.	--
Appendix A: Would disease transmission via insects and vermin not also be a concern for human health? Please clarify.	Yes, and this information will be conveyed to the health assessment if any evidence is found that there could be disease vectors. (However, it should be noted that these are no longer typically experienced at well-run modern engineered landfills.)	--
Appendix A: Stress is an adverse health effect, is there any reason that criteria that could result in stress are not assessed in the SHR? Example: displacement of residents from houses, disruption to use and enjoyment of public facilities, disruption of local traffic networks etc.	Agreed. These issues are within the scope of the social assessment, which will be reviewed by the health expert as part of the SHR, as stated in the work plan.	--

Comment	Walker Response	Disposition
Additional Comments on the Air Quality Assessment Work Plan		
Section 5.2.1: According to the HHRA, the HHRA is identifying COPCs based on the results of other studies, such as the Air Quality study. This section suggests that based on the results of the HHRA, additional parameters may be considered in the Air Quality study, this appears to be a circular argument. The Air Quality study should identify any and all COPCs associated with vehicular exhaust and include these in their modeling to be incorporated into the HHRA.	This simply reflects the collaborative approach that is being used in this EA; the two studies will work cooperatively on the development of the appropriate parameters.	--
Section 5.2.1: It is not clear how the list of parameters were identified for vehicle exhaust. Is there a reason that other constituents of automobile exhaust, such as carbon dioxide, TSP, benzene, acrolein, acetaldehyde, 1,3-butadiene and formaldehyde were not included?	The MOECC has provided a list of compounds they have deemed as applicable for the evaluation of automobile emissions. This list of compounds has been revised to accommodate the MOECC's requested list.	Updated Compound List for Haul Route is provided in Section 5.2.1
Table 6.2.2.1: 1,1,2,2-tetrachloroethane does not have criteria, how will this be evaluated within the study?	Information for all compounds will be provided to the HHRA. For compounds without standards/guidelines from the MOECC, additional information from the HHRA Technical Team will be utilized for evaluation.	--
Section 5.3: The consideration of an objectionable level for odour of 3 to 5 OU was stated, despite the recommendation by the MOECC of 1 OU. Since complaints at other landfills would be dependent on any number of factors, the assessment should support the rationale that 3 to 5 OU would be appropriate for this landfill given site specific considerations (distance to nearest receptor etc.).	The statement about 3 to 5 OU will be removed and the evaluation criteria will be 1 OU and will also include an evaluation of frequency of occurrence.	Language amended for clarity.
Section 7.3.1: Since there appears to be mistrust from the community with respect to the historical monitoring data, it would be advisable for RWDI to complete additional monitoring around the existing Carmeuse site to validate the historical data.	"Community mistrust" is not, of itself, a suitable rationale to disregard existing data. RWDI has proposed to carry out a critical review of the historical data in consultation with the MOECC.	--
Section 7.3.2: To clarify, is it a total of ten receptor locations for both study areas or 10 receptor locations for each study area (dust dispersion).	For clarity, the presentation of the results for 10 receptor areas is only part of the evaluation. In addition, concentration isopleths will be provided as noted in the Air Quality Work Plan	--
The modeling for odour and dust indicate a maximum of ten receptors to be modelled. There is no indication of what the minimum number will be. This should be understood so that it can be confirmed that sufficient modelling is completed to address receptors in the vicinity of the landfill site and the haul route.	The receptor locations will be chosen collaboratively among the Walker study team once sufficient background data has been collected, and may be further refined as the analyses progress. The final receptors will be fully documented in the EA.	--
Additional Comments on the Visual Assessment Work Plan		
It is not clear how the potential effects to human health (annoyance and stress) are being evaluated or addressed if visual impacts are deemed unacceptable. Once further details for the study design are presented, a review of potential impacts to health can be completed.	Noted. As discussed above, these issues are within the scope of the social assessment, which will be reviewed by the health expert as part of the SHR, as stated in the work plan.	--
Section 4.0: Along the Haul Routes: Other work plans have considered properties within a certain distance of the haul route (i.e., 500 m), not just those directly adjacent to these roads. Please explain why the visual assessment is only considering properties directly adjacent to the haul routes?	It is the visual expert's opinion at this time that those most likely to be affected by the visibility of additional trucks along the haul routes are those whose properties have frontage along the haul routes. However, following the initial reconnaissance if there are additional properties fronting on other roads (e.g., side streets) but with similar views, they can also be considered.	--

Comment	Walker Response	Disposition
Additional Comments on the Cumulative Effects Assessment Work Plan		
Section 4: It appears that the cumulative effects of the quarry (and other local activities) and the proposed landfill are being considered through the evaluation of baseline conditions. What is not apparent is if "background" conditions are being considered i.e., those without the quarry and/or landfill.	A scenario whereby the quarry is not considered as part of the baseline has no relevance or value. There is no indication that the quarry will be closing within the time frame of the proposed landfill.	--
Section 5.2: The report indicates that certain types of impacts will be characterized to the extent possible. The footnote (number 8) indicates that noise, odour and visibility cannot easily be added quantitatively. What is not clear, is if the potential health impacts associated with the above, such as stress caused by the annoyance of noise, odour and visibility will be evaluated within the cumulative effects? Please clarify.	As discussed above, these issues are within the scope of the social assessment, which will be reviewed by the health expert as part of the SHR, as stated in the work plan.	--
Additional Comments on the Social Assessment Work Plan		
The Social Assessment Work Plan appears to be inclusive of concerns raised by the community. However, it is not clear how the results of the Social Assessment will be incorporated into an overall evaluation of human health.	As specified by the Minister in Amendment #13 to the ToR, the SHR is required to carry out "*a screening-level review of the socio-economic assessment results to determine the potential for related health effects*" (Section 11.0). The acknowledgement of health effects related to stress will be identified through the health review of the socio-economic assessments, which will assess criteria such as use and enjoyment of property, community character and social cohesion (see Appendix A to the work plan).	--
Section 7.2.2: What is the expected response rate of the questionnaire? For people in close proximity to the landfill it would be advisable to provide all residents with the questionnaire, not 1 in 4 households as suggested, so that the sample size of returned questionnaires is suitable to draw meaningful information from.	A professional polling firm will be retained to ensure that the response rate is statistically suitable. In that same section: "*An attempt will be made to sample more households closer to the site and in areas where the greatest potential for impacts are anticipated (i.e., within 500 m of the landfill and along the haul route).*" The next section of the work plan (Section 7.2.3) also discusses the use of personal interviews with nearest neighbours.	--
Additional Comments on the Groundwater & Surface Water Assessment Work Plan		
It is not clear, based on the human health work plan whether recreational use of surface water bodies has been considered including the consumption of fish.	The presence of, and potential effects on, fish in and around the site will be determined through the ecological assessment, and recreational uses around the site will be documented through the social assessment. See those respective work plans. All of these data will be available as input to the health assessment.	--
Suggest that groundwater quality in private drinking wells or wells used for irrigation within the study area be characterized to establish pre-landfill conditions.	Baseline water quality will be established using purpose-built groundwater monitoring installations. It is generally not as useful to rely on private water supplies to characterize baseline groundwater quality since they can be influenced by a variety of factors such as the construction and condition of the well and the piping system, etc.	--

Comment	Walker Response	Disposition
Additional Comments on the Agricultural Assessment Work Plan		
It doesn't appear that the work plan is considering the potential loss of yield resulting from impacts to air quality or groundwater impacted by the landfill.	Section 3 of the agricultural work plan indicates the potential linkages, through the EA criteria, between groundwater, surface water, air quality and agriculture. Furthermore, in Section 5 of the same work plan, the indicators for the agricultural assessment include: • Area of cropland potentially affected by emissions, fine particulates (dust), flooding or drainage disruption; and • Number of farm operations with potential for loss of water quality or quantity affecting livestock or crop production.	--
Additional Comments on the Noise/Vibration Assessment Work Plan		
It is recommended that a review of the final receptor locations be completed prior to completing the studies to allow input from the community and stakeholders.	See previous responses re: receptors.	--

Southwestern Landfill Environmental Assessment, Updated Draft Human Health Risk Assessment & Supplementary Health Review Work Plan
Comments Received From: JMCC Peer Review – NovaTox Inc. (May 2, 2017)

Comment	Walker Response	Disposition
6.0 Indicator/ Measures, page 8, 2/3-7. Chemicals of Potential Concern (COPC) selection. Refers to MOECC documentation and Air Quality Assessment Work Plan. The COPC selection process associated with the Air Quality Assessment was discussed with the relevant members of the PRT and was deemed acceptable. In the interest of transparency and complete documentation, the COPCs should ideally be included in the HHRA work plan or, at a minimum, details should be provided as to how COPC selection will be carried out.	The COPC selection process is presented in the Air Quality Assessment Work Plan, for reference, and will be included in the EA report.	--
6.0 Indicator/ Measures, page 8, 3/1-4. COPC contaminant selection. Refers to Groundwater/Surface Water Assessment Work Plan being completed by Golder. The COPC selection process associated with the Groundwater/Surface Water Assessment was discussed with the relevant members of the PRT and was deemed acceptable. In the interest of transparency and complete documentation, the COPCs should be included in the HHRA work plan or, at a minimum, details should be provided as to how COPC selection will be carried out.	The COPC selection process is presented in the Groundwater/Surface Water Assessment Work Plan, for reference, and will be included in the EA report.	--
9.0 Data Analysis, page 11, 4/3-5. It is stated: "This risk management step is an integral portion of the current EA process, to ensure the mitigation of any predicted potential health risks along the selected corridor candidate." It is unclear how the "selected corridor candidate" pertains to the EA for the Southwestern Landfill Proposal. It is recommended that "along the selected corridor candidate" be replaced with "within the HHRA study area".	Agreed.	Revision made to replace "selected corridor candidate" with "within the HHRA study area".
9.0 Data Analysis, page 12, 1. A clear order of preference should be provided for the use of the guidance documents. It is recommended that provincial policy/guidance be given priority, followed by federal policy/guidance, with additional jurisdictions considered only in the event that guidance is not provided either at the provincial or federal level.	The order of preference for the use of HHRA guidance documents is as follows: (i) Provincial; (ii) Federal; and, (iii) International. This has been clarified in the updated version of the work plan (Section 9.0).	Clarification made to indicate order of preference of guidance documents.

Comment	Walker Response	Disposition
9.1.1 Identification of Chemicals of Potential Concern, page 13, 2. While it is clear that the Chemicals of Potential Concern (COPCs) associated with air emissions will be evaluated based on the baseline, existing and future predicted emissions from the proposed landfill and haul routes, the evaluation of groundwater/surface water appears to be only for existing conditions. The list of chemicals to be evaluated in ground/surface water is associated with only "background" conditions. Reference should also be made to the potential future conditions and COPCs associated with the proposed landfill. Details associated with the predictive modeling were presented in the work plans of their respective disciplines. It is also recommended that the HHRA work plan include a brief summary of the how the COPCs and concentrations for the Air Quality Assessment and Groundwater/Surface Water Assessment will be selected for inclusion in the HHRA. For example, some indication of temporality should be incorporated into the discussion. Whether COPCs will be based on Operational Life of the landfill, Contaminant Generation Life of the landfill, or a combination of the two should be stated. In addition, there is no discussion with respect to which concentrations will be assessed in the risk assessment. It should be made clear whether the maximum concentration generated will be used to evaluate the potential for Control/Management Measure failure, or whether trigger values from the other disciplines will be incorporated into the HHRA.	In keeping with the overall methodology approved for this assessment, the groundwater & surface water assessment will forecast future conditions as well as existing conditions. The full contaminating lifespan of the landfill leachate will be considered. However, the EA will be based on normal operating conditions of the site, not possible emergency or upset conditions; those will be dealt with through the development of contingency/emergency response plans set out in the Design and Operations Report submitted for approval under the *Environmental Protection Act*.	--
9.2.1 Selection of COPCs in Air, page 16, 1/1. The term "existing conditions data" is not clear in the context of this sentence. Data to be assessed include air quality concentrations predicted once the facility is operational and following post-closure as per Section 4.0 Study Durations and Section 9.1.1, as well as other locations throughout the report. Existing conditions implies background without the Landfill and should not be the basis of COPC selection. The intention of this paragraph may in fact be that COPCs are selected based on operational and post-closure conditions and these COPCs will also be modeled as baseline conditions to be compared to predicted conditions, but if so, this is not clear.	Noted.	The term "existing conditions" has been removed to improve clarity.
9.2.1 Selection of COPCs in Air, page 16, 1/3. Twenty-eight chemicals in air are referenced for evaluation in the HHRA. In the interest of transparency and complete documentation the COPCs should be included in the HHRA work plan and details provided as to each COPCs selection.	The proposed COPCs are presented in the Air Quality Assessment Work Plan, for reference, and the final list will be included and described in the EA report. The HHRA work plan has also been updated to include the list of COPCs in Air in Section 9.2.1.	Section 9.2.1 has been updated to include the list of COPCs in air.
9.2.1 Selection of COPCs in Air, page 17, 1/2. Editorial. Bullet 5. Reference should be O. Reg. 153/04, as amended.	Noted.	This has been updated in the updated work plan (Section 9.2.1).
9.2.1 Selection of COPCs in Air, page 17, 1. The list of chemicals to be evaluated in ground/surface water is associated with existing conditions to identify COPCs associated with the proposed landfill. Operational conditions / post closure conditions should be considered assuming leakage or failure of Risk Management systems and could be used to develop critical values for monitoring evaluation. The evaluation of only existing "baseline" conditions has little use in evaluating the potential risks associated with operational and post-closure conditions.	See response re: Section 9.1.1, above.	--

Comment	Walker Response	Disposition
9.2.4 Developing the Final List of COPCs for Inclusion in the Qualitative HHRA, page 18, 1/1-3. There are 28 COPCs that were previously noted to be included in the HHRA associated with air emissions. It is not clear that the statement "all chemicals where appropriate health-based regulatory air standard or toxicity value can be identified" is consistent with the previous statement referencing 28 COPCs.	The assessment will develop a list of COPCs to be evaluated in the HHRA, based on data and information from the Air Quality and Groundwater/Surface water studies. The text referring to "28 chemicals" has been removed from the updated work plan (Section 9.2.1).	--
Section 9.2.4, page 19, 1/1. Editorial: Spelling should be Multi-media (not Mulfi-media).	Noted.	This has been revised in the updated work plan (Section 9.2.4).
Section 9.3.1 Exposure Assessment, page 19, 1/7-9. Suggest revision or clarification. Work plan states that "The rate of exposure to chemicals from many pathways is usually expressed as the amount of chemical taken in per body weight per unit time (e.g., µg chemical/kg body weight/day)." While this is the case for exposures associated with soil, groundwater and particulates a significant focus of the risk assessment is likely to be air contaminants of a gaseous or volatile nature. An additional sentence here detailing that exposures to these chemicals are expressed as an amount per volume of air basis irrespective of inhalation rate, body weight, etc. is warranted for clarity.	Agreed.	The following sentence has been added: "However, exposure to volatile chemicals via the inhalation pathway are assessed as an amount per volume of air basis, irrespective of inhalation rate, body weight, etc." This has been revised in the updated work plan (Section 9.3.1).
Section 9.3.1 Exposure Assessment, page 19, 3. A clear order of preference should be provided for the use of the guidance documents. It is recommended that provincial policy/guidance be given priority, followed by federal policy/guidance, with additional jurisdictions considered only in the event that guidance is not provided at either the provincial or federal level.	The order of preference for the use of HHRA guidance documents is as follows: (i) Provincial; (ii) Federal; and, (iii) International. This has been clarified in the updated work plan (Section 9.3.1).	Clarification made to indicate order of preference of guidance documents.
Section 9.3.3 Risk Characterization, page 22, 5/4-5. "The more sensitive of the two endpoints will be used to calculate land use specific PSSS for that particular COPC." Is the intention of this risk assessment to develop Property Specific Standards? If so, further details should be provided on how these will be calculated and how they will be used to govern Site conditions and Risk Management. If not, then this sentence should be removed.	Noted.	The sentence has been removed. This has been revised in the updated work plan (Section 9.3.3).
Section 11.0 Supplementary Health Review, page 25 and 26, 3 and Figure 11-1. Further reference for the Supplementary Health Review and Figure should be provided, with a minimum of a date to the document so that it can be linked to the corresponding document detailed in the reference section.	The steps of the Supplementary Health Review were identified in the comment that Walker received from the MOECC as part of the ToR process and required the SHR to include additional analysis with regards to the process. As such, the steps of the process "screening, scoping, assessment, mitigation, reporting and monitoring" were developed. The figure was developed by the Intrinsik Team as a visual representation of these steps. No additional references are provided at this time.	--
Appendix B – HHRA Comment (May 9, 2013). The majority of the comments and revisions recommended for the original 2013 HHRA Work Plan were accepted and agreed upon by the Work Plan authors and Walker Environmental Group Inc. In general however the agreed to changes are not reflected in the HHRA and Supplementary Health Review Work Plan of March 2017.	Noted. The work plan now contains a list of acronyms as requested previously. However, additional detail around the Conceptual Site Model (CSM), specific receptors and exposure scenarios cannot be determined until detailed assessments have been conducted by the various other key disciplines (e.g., Air Quality, Groundwater/Surface Water, Agricultural, etc.) to provide the necessary information on chemicals of concern.	--