Supporting Document 1-7

Human Health Existing Conditions Report

Twin Creeks Environmental Centre Landfill Optimization Project Environmental Assessment

WM Canada

Watford, Ontario

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Executive Summary

Intrinsik Corp. (Intrinsik) was contracted by HDR Corporation on behalf of WM Canada (WM) to prepare this Human Health Existing Conditions Report as part of the Twin Creeks Environmental Centre (TCEC) Landfill Optimization Project Environmental Assessment (EA). The purpose of this report is to provide a description of existing human health conditions primarily within 1 km of the TCEC.

The TCEC is located approximately 1 km north of the Village of Watford in the Township of Warwick, southeast of the intersection of Zion Line and Nauvoo Road. For Human Health, the On-Site Study Area corresponds to the existing 301-hectare TCEC site, and the Off-Site Study Area extends approximately 1 km outside the limits of the On-Site Study Area.

Most of the land surrounding the TCEC is agricultural, as well as portions of Hwy 402, Nauvoo Road, and Confederation Line, and the village of Watford which has several small businesses. On-site operations, activities from nearby agricultural operations, and traffic on local roads are all sources of air emissions (HDR, 2022). There are approximately 6 years of approved landfill airspace capacity remaining at the TCEC (i.e., capacity will be reached in approximately 2031). The proposed optimization would provide additional airspace of approximately 14 million cubic metres (m^3), which could extend the site life by approximately 12 years (from 2031 to 2043) and may be achieved through alternative landfill configurations or alternative methods within the existing 301-hectare TCEC site area. No changes are being proposed to the current 101.8 ha landfill footprint, the approved service area, or the annual fill rate. An evaluation of potential health effects was conducted in 2005 for the proposed expansion of the Warwick Landfill in the form of a detailed HHRA by Cantox Environmental Inc. (now Intrinsik Corp.). A review of the assumptions made in the 2005 HHRA was completed. Based on this review, the assumptions previously used in the 2005 HHRA are still valid, and therefore, the results of the assessment remain valid.

No field studies were undertaken specifically for Human Health. The results of field studies to determine existing baseline conditions completed for the air quality, surface water quality, and groundwater quality disciplines were examined to aid in the characterization of Human Health existing conditions.

To characterize existing conditions for Human Health, the following data collection and review was undertaken:

- A review of assumptions from the 2005 HHRA;
- A review of results from recent WM TCEC Annual Monitoring Reports;
- A review of field studies and existing conditions from the air quality, surface water quality, and groundwater quality disciplines including off-site receptors;

- A comparison of the results of the chemical analyses from the recent TCEC annual monitoring program against assumptions made in the 2005 HHRA;
- An assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA; and
- A review of recent toxicological literature (WHO, 2021; MECP, 2022) for changes to the exposure limits applied to chemicals described in the 2005 HHRA, and to identify exposure limits for new chemicals of concern (COCs) (Section 4.5).

An assessment was conducted to determine if any new chemicals identified as potential health risks, and a reassessment was conducted for chemicals detected in the recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA.

There are a significant number of chemicals modelled in the 2005 HHRA for which monitoring was not (or could not be) conducted in the 2019, 2020, 2021 and 2022 annual monitoring programs. As such, it is not possible to evaluate existing conditions for these chemicals, in comparison to the predicted 2020 modelled concentrations. Additionally, many chemicals were measured at non-detectable concentrations. As a result, these chemicals do not represent a potential risk to human health. Benzene, lead, nickel, and Total Suspended Particulate (TSP) have had detectable concentrations measured in the Air Quality Monitoring Program through to the 2022 Annual Monitoring Report (RWDI, 2023). Total Suspended Particulate (TSP) was not modelled in the Original 2005 HHRA. Measured concentrations of benzene, lead, and nickel from the Annual Monitoring Report were greater than the predicted emissions for ground-level air from the 2005 HHRA. Therefore, these chemicals were evaluated to determine whether these higher concentrations may represent a potential risk to human health.

A review was also conducted of recent toxicological literature for any changes to the exposure limits applied to chemicals described in the 2005 HHRA, and to identify exposure limits for new COCs. Based on this evaluation, the only new COC to be flagged as a potential risk based on the modelled emissions for the 2005 HHRA was hydrogen sulphide due to a change in the toxicological benchmark since 2005 which has lead to an increase in inhalation risk estimate of about 21-fold.

A review of the results from the recent WM TCEC Annual Monitoring Reports for air quality, ground water quality, and surface water quality monitoring programs for 2019 to 2022 are outlined in Sections 4.2.1 through 4.2.3.

Concentrations of total suspended particulate (TSP) exceeded the MECP Ambient Air Quality Criteria (AAQC) of 120 µg/m³ in numerous samples from the 2019 to 2022 Annual Monitoring Programs. For each TSP exceedance, watering activities for dust control purposes, including watering on-site roadways and construction sites occurred (RWDI, 2023). Measured metal concentrations were consistently below the applicable criteria in the 2019 to 2022 Annual Monitoring Reports (RWDI, 2020; 2021; 2022; 2023).

Concentrations of VOCs from 2019, 2020, 2021, and 2022 Annual Monitoring Programs were quite low and less than their respective air quality standards (RWDI, 2020; 2021; 2022; 2023).

Despite changes in elevation to leachate, water quality was found to be acceptable during the Site investigations and leachate elevations were not negatively affecting water resources at the Site (RWDI, 2023). Monitoring results for the active aquitard, interstadial silt and sand, and the interface aquifer satisfied the relevant Primary Leachate Indicator List (PLIL) and Secondary Leachate Indicator List (SLIL) trigger concentrations (RWDI, 2023).

Groundwater quality monitoring did not show an unacceptable landfill leachate or operations effect. Therefore, no additional chemicals were retained based on the investigations completed by RWDI.

Based on the 2022 Annual Monitoring Report, routine quarterly surface water monitoring demonstrated results which satisfied the relevant trigger concentrations with seven (7) exceptions (RWDI, 2023). Verification monitoring events were completed due to these exceptions, and results indicated acceptable chemical and biological results. Therefore, no further verification monitoring was required.

Overall, surface water quality did not show an unacceptable landfill leachate or operations effect in 2022. Therefore, no chemicals were retained based on the investigations completed by RWDI.

The Human Health Existing Conditions Report focuses on the natural environment, including the atmospheric environment, geology and hydrogeology, and the surface water environment. Specifically, air quality, groundwater quality and surface water quality will be assessed.

Between 2009 and 2022 no landfill gas-related complaints, other than those that may have been denoted as odour issues by the complainant, have been received. Similarly, between 2009 and 2022, no complaints related to combustion by-products have been received at the landfill (RWDI, 2023).

Based on the Hydrogeology Existing Conditions Report completed by RWDI, groundwater monitoring wells were installed and utilized to evaluate impacts from landfill leachate to the subsurface groundwater (2025a). Each hydrostratigaphic unit was analyzed and was not shown to be negatively impacted by either the landfill operations or leachate (RWDI, 2025a). Additionally, groundwater quality was also acceptable to groundwater users within the Off-Site Study Area and was shown to not be impacted by the TCEC operation. Existing leachate management practices have been in place within the Existing Landfill and have not indicated any adverse effects to nearby groundwater or surface water quality (RWDI, 2023).

Surface water quality data was evaluated for the On-Site Study Area (existing landfill and expansion landfill) in the Surface Water Quality Existing Conditions Report completed by RWDI (2025b). Four (4) sedimentation ponds as well as on-site drainage features (e.g., ditches, swales), are used to manage the surface water at the TCEC (RWDI, 2025b). Runoff from the operational areas of the TCEC is managed by the sedimentation ponds. In 2022, field monitoring was completed to assess and evaluate potential impacts to surface water quality associated with automobile shredder reside (ASR) track-outs along the road allowance (RWDI, 2025b). It was identified that PAHs could potentially negatively affect off-site surface water quality near the TCEC. However, based on the 2022 off-site temporary supplemental surface water monitoring program, PAH impacts were not found (RWDI, 2025b). Although surface water quality may deviate over time, this is primarily due to periods of construction activity that result in exposed soil surfaces and erosional effects (RWDI, 2025b).

Risk predictions from the 2005 HHRA were updated based on revised exposure limits from a toxicological literature search. Based on the expected impact on previous risk estimations compared to the exposure limits used in the 2005 HHRA (Table 4-5), several chemicals resulted in predicting an increase in inhalation or oral risk estimate.

However, annual concentration ratio (CR) values predicted for chronic exposures to all combustion gases (i.e., CO_2, CO, SO_2, NOx and HCl) were predicted to be within acceptable levels (i.e., all CR values were less than one) (Intrinsik, 2005). Long-term cancer and non-cancer human health risks as a result of predicted exposures to landfill gases from the Warwick Landfill expansion were considered minimal. Chronic human health risks associated with exposure to emissions resulting from the landfill flare plus evaporation/incineration activities (dioxin/furans, benzo(a)pyrene, lead, cadmium, arsenic, nickel and mercury) were not considered significant. Long-term human health risks associated with exposure to emissions resulting from the landfill flare only scenario (PAHs, dioxin/furans) were also considered insignificant. This suggests that no measurable long-term adverse health impacts were predicted to result from landfill combustion gas emissions.

Additionally, all ½-hour and 1-hour CR values calculated at the maximum fence-line location were predicted to be less than a value of 1.0 (Intrinsik, 2005).Therefore, no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases, with the exception of the worst-case 24-hour hydrogen sulphide value which showed a exceedance of the benchmark due to a change in the toxicological benchmark of about 21-fold compared to that used in the 2005 HHRA.

Although there is a potential risk to human health from hydrogen sulphide due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. Hydrogen sulphide was measured as part of the 2025 Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023 (RWDI, 2025c). The H_2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H_2S and TRS are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H_2S and TRS from landfill operations at all discrete receptors and the property boundary are low (RWDI, 2025c). Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H_2S and TRS concentrations are below detection and elevated concentrations of H_2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour (RWDI, 2025c). The 2025 Air Quality Existing Conditions Report has recommended that WM should continue to manage emissions of landfill gas by routine maintenance of the final cap and interim cover areas (RWDI, 2025c).

The 2005 HHRA concluded that no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases under the *landfill flare only or landfill flare plus evaporation/incineration* options.

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location, and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was predicted to be extremely low in the 2005 HHRA.

The majority of ILCR values calculated for both inhalation and oral risk were below the 1 in a million-cancer risk with the exception of benzo(a)pyrene (TEF) (SF of 1.23E-06), bromodichloromethane (SF of 1.04E-06), 1,1,2,2-trichloroethane (SF of 1.19E-06), and vinyl chloride (SF of 7.87E-06). The measured concentrations of bromodichloromethane and 1,1,2,2-trichloroethane as part of the annual monitoring programs has been below detection in all samples across all five years. The maximum concentration of vinyl chloride was measured at 0.41 µg/m³ in the 2019 annual monitoring program, was below detection in 2020, 2021 and 2022, and was measured at 0.08 µg/m³ in 2023. As such, risks associated with bromodichloromethane, 1,1,2,2-trichloroethane and vinyl chloride are anticipated to be minimal. We have no current measured or modelled data for benzo(a)pyrene. However, original modelling from the 2005 HHRA was likely related to diesel vehicle emissions and the specifically from the landfill itself.

Based on the review of results from the recent annual monitoring programs, the review of existing conditions for air quality, groundwater quality and surface quality, and the review of assumptions as well as the conclusions from the 2005 HHRA, no measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case hydrogen sulphide concentrations, under existing conditions.

It is recommended that polycyclic aromatic hydrocarbons, using benzo(a)pyrene as a surrogate, be added to the suite of chemicals being monitored in future air quality sampling events.

Acronyms, Units and Glossary

Acronyms

Acronym	Definition
AAQC	Ambient Air Quality Criterion
AQG	Air Quality Guideline
AQS	Air Quality Standard
CO	Carbon Monoxide
COC	Chemicals of Concern
COPC	Contaminant of Potential Concern
CR	Concentration Ratio
EA	Environmental Assessment
ER	Exposure Ratio
EAA	Environmental Assessment Act
ECA	Environmental Compliance Approval
GHG	Greenhouse Gas
H_2S	Hydrogen Sulphide
HHRA	Human Health Risk Assessment
ILCR	Incremental Lifetime Cancer Risk
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$
JSL	Jurisdictional Screening Levels
LFG	Landfill Gas
MECP	Ontario Ministry of Environment, Conservation and Parks
MOE	Ontario Ministry of Environment (now MECP)
NO_X	Nitrogen Oxides
OEAA	Ontario Environmental Assessment Act
PAH	Polycyclic Aromatic Hydrocarbon
PCDD/PCDFs	Polychlorinated dibenzodioxins / polychlorinated dibenzofurans (Dioxins and Furans)
PM	Particulate Matter
POI	Provincial Point of Impingement
RfC	Reference Concentration $(\mu g/m^3)$
RfD	Reference Dose (µg/kg/day)
RS	Reduced Sulphur Compounds
SF	Slope Factor $(\mu g/kg/day)^{-1}$
SO_2	Sulphur Dioxide
TCDD	2,3,7,8-Tetrachlorodibenzodioxin
TCEC	Twin Creeks Environmental Centre

Acronyms

Acronym	Definition
TLV-TWA	Threshold limit value – Time-Weighted Average
TLV-STEL	Threshold limit value – Short-Term Exposure Limit
ToR	Terms of Reference
TRS	Total Reduced Sulphurs
TSP	Total Suspended Particulate
US EPA IRIS	United States Environmental Protection Agency Integrated Risk Information System
WM	WM Canada
WHO	World Health Organization
VOC	Volatile Organic Compound

Units

Unit	Definition
ha	hectare
km	kilometre
m	metre
m^3	cubic metres
masl	metres above sea level
ug/m^3	micrograms per cubic metre

Glossary

Term	Definition
Ambient Air Quality Criterion (AAQC)	An AAQC is not a regulatory value. It is a concentration of a contaminant in air that is protective against adverse effects on health and/or the environment. AAQCs are used to assess general (ambient) air quality resulting from all sources of a contaminant to air.
Approval	Permission granted by an authorized individual or organization for an undertaking to proceed. This may be in the form of program approval, certificate of approval or provisional certificate of approval.
Atmospheric Environment	The atmospheric environment includes air quality, odour, noise, and litter.
Capacity (Disposal Volume)	The total volume of air space available for disposal of waste at a landfill site for a particular design (typically in m^3); includes both waste and daily cover materials, but excludes the final cover.
Combustion Gases	Combustion Gases include sulphur dioxide, nitrogen dioxide, carbon monoxide, hydrogen chloride and hydrogen sulphide (evaluated within the “combustion gases” group due to its presence as a gas under ambient conditions and its irritating effects to the eyes and respiratory system)

Glossary

Term	Definition
Composting	The controlled microbial decomposition of organic matter, such as food and yard wastes, in the presence of oxygen, into finished compost (humus), a soil-like material. Humus can be used in vegetable and flower gardens, hedges, etc.
Composting facility	A facility designed to compost organic matter either in the presence of oxygen (aerobic) or absence of oxygen (anaerobic).
Contaminant of Concern (COC)	Chemical substances found at the site that are determined to pose an unacceptable risk to human health or the environment.
Contaminant of Potential Concern (COPC)	A contaminant which may or may not be causing risk or adverse effects to human health or the environment at a site.
Concentration Ratio (CR)	For combustion gases, potential health risks to residents for acute and chronic exposures were assessed as concentration ratio values (CR). CR values were calculated by dividing the predicted air concentration with the reference concentration (RfC), according to the following equation: Concentration Ratio = Predicted Air Concentration / Reference Concentration
Environment	As defined by the Environmental Assessment Act, environment means: • air, land or water; • plant and animal life, including human life; • the social, economic and cultural conditions that influence the life of humans or a community; • any building, structure, machine or other device or thing made by humans; • any solid, liquid, gas, odour, heat, sound, vibration or radiation resulting directly or indirectly from human activities; or • any part or combination of the foregoing and the interrelationships between any two or more of them (ecosystem approach).
Environmental Assessment (EA)	A systematic planning process that is conducted in accordance with applicable laws or regulations aimed at assessing the effects of a proposed undertaking on the environment.
Exposure Ratio (ER)	Risk characterization for non-carcinogenic compounds consists of a comparison of the exposure limits (i.e., the rate of exposure that would not be expected to produce adverse effects) against the total estimated exposure. For non-carcinogenic chemicals, this comparison is expressed as an Exposure Ratio (ER), calculated by dividing the predicted exposure by the exposure limit. If the total exposure to a chemical is equal to or less than the exposure limit, i.e., the ER is 1.0 or less, then no adverse health effects would be expected.
Evaluation criteria	Evaluation criteria are considerations or factors taken into account in assessing the advantages and disadvantages of various alternatives being considered.
Greenhouse gas (GHG)	Any of the gases whose absorption of solar radiation is responsible for the greenhouse effect, including carbon dioxide, methane, ozone, and the fluorocarbons.
Guideline B-7	Groundwater quality management tool adopted by the MECP for the reasonable use of groundwater resources adjacent to waste disposal sites (Procedure B-7-1). The reasonable use concept outlines the MECP's expectation of sites that discharge contaminants that could impact groundwater resources and provides guidance toward the establishment of contaminant attenuation zones (CAZ).
Incremental Lifetime Cancer Risk (ILCR)	For carcinogenic chemicals, potential risks are expressed as an Incremental Lifetime Cancer Risk Level (ILCR) which is calculated by multiplying the estimated exposure by the cancer slope factor (q_1^*). An ILCR of 1×10^{-6} is considered to be an acceptable risk level per pathway by the Ontario Ministry of the Environment.

Glossary

Term	Definition
Indicators	Indicators are specific characteristics of the evaluation criteria that can be measured or determined in some way, as opposed to the actual criteria, which are fairly general.
Landfill gas (LFG)	The gases produced from the wastes disposed in a landfill; the main constituents are typically carbon dioxide and methane, with small amounts of other organic and odour-causing compounds.
Landfill site	An approved engineered site/facility used for the final disposal of waste. Landfills are waste disposal sites where waste is spread in layers, compacted to the smallest practical volume, and typically covered by soil.
Leachate	Liquid that drains from solid waste in a landfill and which contains dissolved, suspended and/or microbial contaminants from the breakdown of this waste.
Metals	Metals: arsenic, cadmium, lead, and mercury
Mitigation	Measures taken to reduce adverse impacts on the environment.
Natural Environment	The natural environment, as defined for the EA, includes the atmospheric environment, geology and hydrogeology, the surface water environment, and the ecological environment.
Particulate Matter	Particulate Matter includes: Total Suspended Particulate, PM_{10} and $PM_{2.5}$
Proponent	A person who: • carries out or proposes to carry out an undertaking; or • is the owner or person having charge, management or control of an undertaking.
Receptor	The person, plant or wildlife species that may be affected due to exposure to a contaminant.
Terms of Reference (ToR)	A terms of reference is a document that sets out detailed requirements for the preparation of an Environmental Assessment.
Undertaking	Is defined in the Environmental Assessment Act as follows: • An enterprise or activity or a proposal, plan or program in respect of an enterprise or activity by or on behalf of Her Majesty in right of Ontario, by a public body or public bodies or by a municipality or municipalities; • A major commercial or business enterprise or activity or a proposal, plan or program in respect of a major commercial or business enterprise or activity of a person or persons other than a person or persons referred to in clause (1) that is designated by the regulations; or • An enterprise or activity or a proposal, plan or program in respect of an enterprise or activity of a person or persons, other than a person or persons referred to in clause (a), if an agreement is entered into under section 3.0.1 in respect of the enterprise, activity, proposal, plan or program (“enterprise”).
Volatile Organic Compounds (VOCs)	Volatile organic compounds are compounds that have a high vapor pressure and low water solubility. Volatile Organic Compounds include: 1,1-Dichloroethane, Methylene chloride, Dimethylsulphide, 1,2-Dichloroethane, Methyl mercaptan, Chloroethane, Butan-2-ol, Trichloroethylene, 1,1,2-Trichloroethane, Bromodichloromethane, Benzene, 1,1,2,2-Tetrachloroethane, Vinyl Chloride, Ethyl mercaptan, 1,1-Dichloroethylene, and Octane
Waste	Refuse from places of human or animal habitation; unwanted materials left over from a manufacturing process.

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Appendices

1 Introduction

This report presents a description of the Human Health existing conditions for the WM Canada (WM) Twin Creeks Environmental Centre (TCEC) Landfill Optimization Project in support of the environmental assessment (EA). The EA is being carried out in accordance with the requirements of the *Ontario Environmental Assessment Act* (*OEAA*) and Terms of Reference (ToR), which was approved by the Ministry of Environment, Conservation and Parks (MECP) on December 13, 2022.

WM, the owner and operator of the TCEC in Watford, Ontario, has initiated the EA seeking approval to optimize the landfill design and operation, maximizing the use of the constructed infrastructure and the significant investment made at the TCEC. There are approximately 6 years of approved landfill airspace capacity remaining at the TCEC (i.e., capacity will be reached in approximately 2031). The proposed optimization would provide additional airspace of approximately 14 million cubic metres (m^3), which could extend the site life by approximately 12 years (from 2031 to 2043), and may be achieved through alternative landfill configurations or alternative methods within the existing 301 hectare TCEC site area. No changes are proposed to the size of the TCEC site area, approved service area, or annual fill rate.

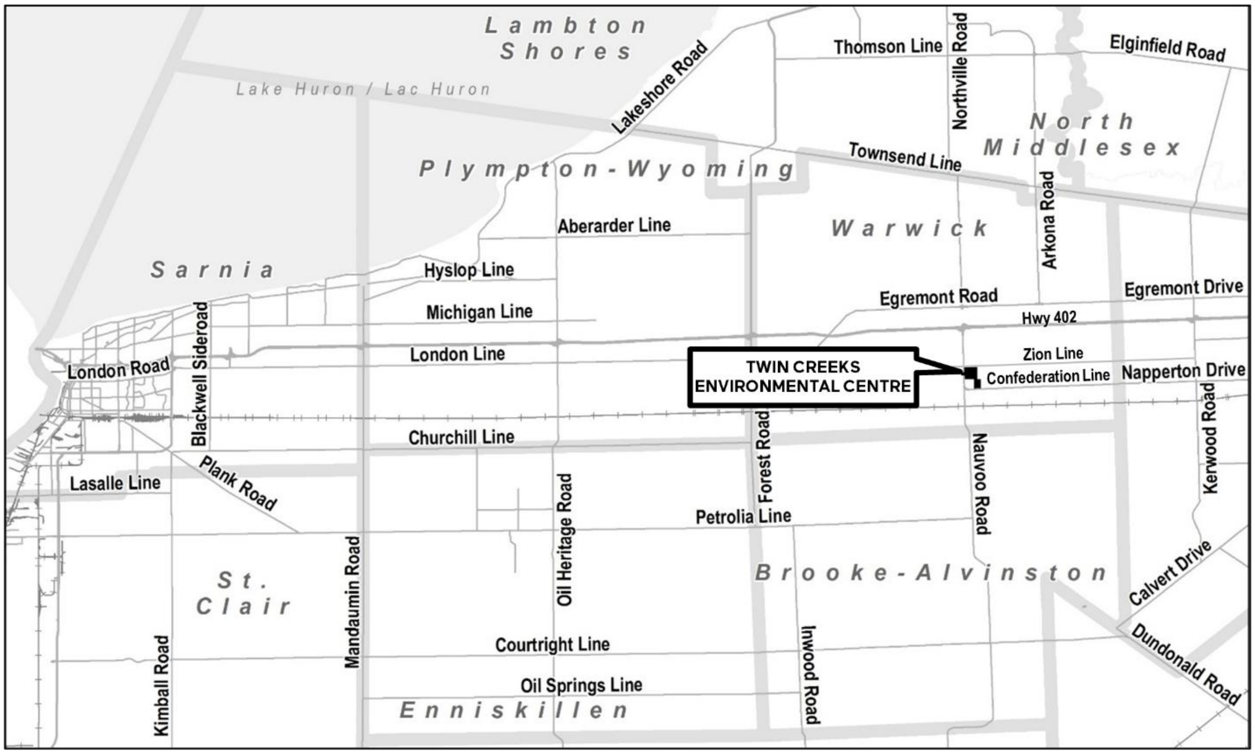
The approved ToR included a preliminary description of the existing conditions within the area surrounding the TCEC, with the commitment that a more detailed description of existing environmental conditions would be prepared as part of the EA. In accordance with the approved ToR, additional investigative studies were carried out as necessary to generate a more detailed description of the existing natural, cultural, socio-economic, and built environments for use in the assessment of the effects of the alternative methods for the TCEC Landfill Optimization Project during the EA.

This Human Health Existing Conditions Report is one component of the EA. The EA Study Report will incorporate the information presented herein as appropriate, and this report will be included with the EA Study Report as a supporting document.

2 TCEC and Study Areas

The TCEC is a regional landfill facility located in the Township of Warwick at the corner of Nauvoo Road and Zion Line (**Figure 2-1**), which originally began operation in 1972 as the ‘Warwick Landfill’. The landfill provides safe and convenient disposal services for communities, businesses and industries serving the Province of Ontario. This landfill is approved to receive municipal, industrial, commercial, and institutional solid non-hazardous wastes, including nonhazardous contaminated soil.

Figure 2-1. Site Location



Source : HDR, 2022.

WM has owned and operated the TCEC since 1996. The landfill was approved under the O*EAA* for expansion in 2007, and waste was first deposited into the expansion in November 2009. The pre-existing site was originally approved for a waste capacity of 3,072,000 m³ within an area of 32.4 ha. The approval of the expansion landfill increased the total airspace capacity to 26,508,000 m³ over an area of 101.8 ha, within a total site area of 301 ha.

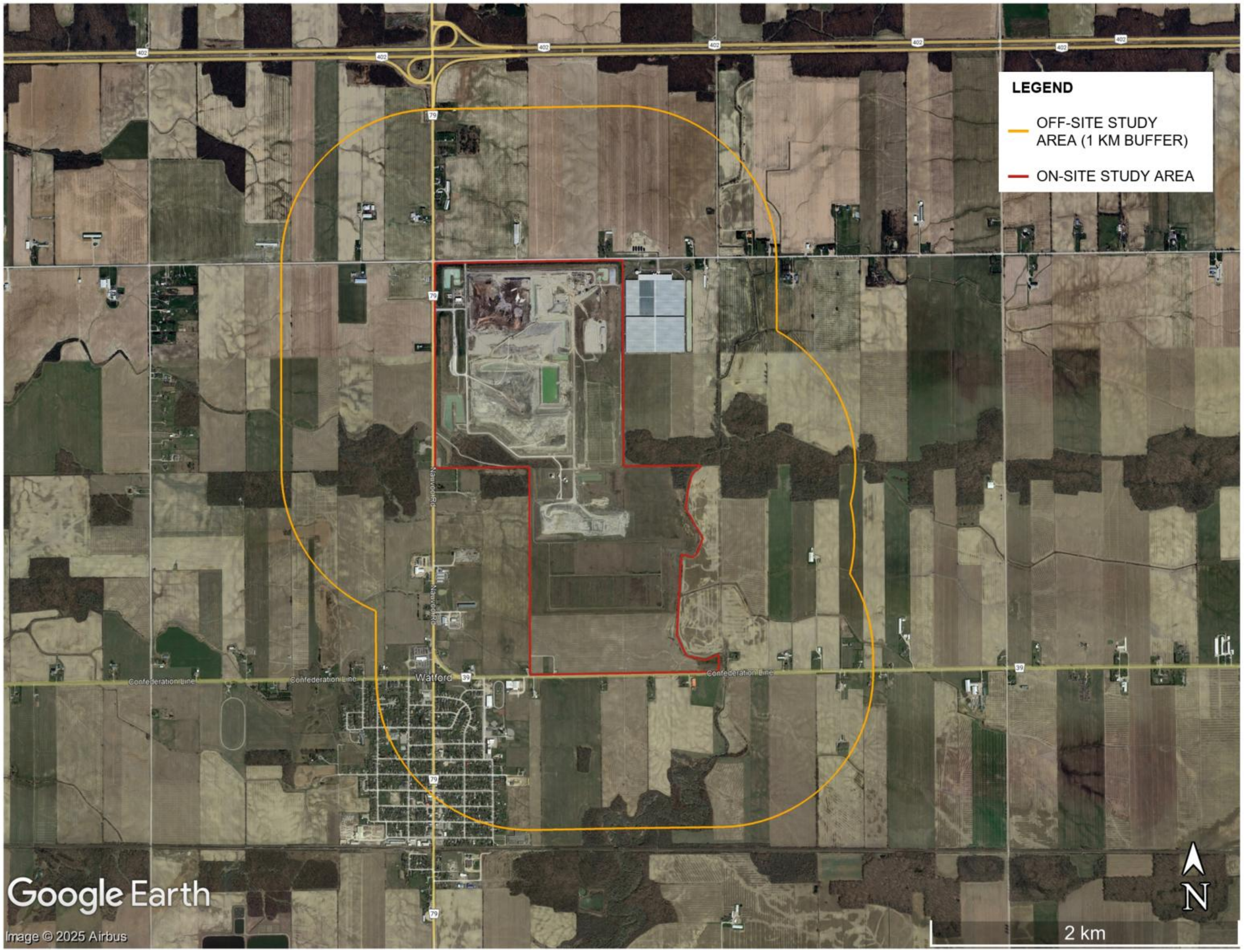
The Environmental Compliance Approval (ECA Waste) A032203 for the TCEC allows the landfill to receive up to a maximum of 1,400,000 tonnes per year of waste including contaminated soil for disposal at the site. There is approximately 6 years of approved airspace capacity remaining at the expansion landfill (i.e., capacity will be reached in approximately 2031). The approved landfill airspace is currently achieved with 4:1 side slopes to an elevation of 265.7 metres above sea level (masl) and then with 20:1 side slopes up to the landfill peak elevation of 278 masl. A two-metre thick final cover results in a landfill peak at 280 masl. The existing natural surface elevation in the area is approximately 245 masl. This optimization project could provide additional airspace capacity of up to approximately 14M m³, which could extend the site life by about 12 years (from 2031 to 2043) (HDR, 2022).

The general study areas defined for the EA include both the On-site Study Area (the existing TCEC) and the Off-site Study Area (the lands within the vicinity of the TCEC extending approximately 1 km out from the On-site Study Area) (**Figure 2-2**). An EA was conducted in 2005 (the Warwick Landfill Expansion EA) to expand the landfill in the 301 ha site boundary. A Human Health Risk Assessment (HHRA) was prepared as part of the EA. The Off-site Study Area used in the 2005 HHRA extended to 3.5 km from the site boundary consistent with the air quality study completed at the time. The air quality discipline for the TCEC Landfill Optimization EA has extended the Off-site Study Area to 5 km from the TCEC site boundary. While data from the current air quality study will be used as comparison to the 2005 HHRA, the highest ground-level air concentrations would be expected to occur in close proximity to the landfill. As such, the additional 1.5 km of Off-site Study Area used for Air Quality (i.e., 5 km versus 3.5 km) is unlikely to affect the comparison to the 2005 HHRA.

The 2005 HHRA utilized the air quality study completed by RWDI which encompassed receptors within 3.5 km of the landfill site, extending past Highway 402 to the north and including the nearby village of Watford to the south (Intrinsik, 2005). According to the 2025 Air Quality Existing Conditions Report, the off-site study area extended approximately 5 km from the existing TCEC (RWDI, 2025c). However, the focus of the modelling for the Air Quality Existing Conditions Report was on identified residential receptors in the immediate vicinity (within ~1 kilometer) of the active landfill area (RWDI, 2025c).

For Human Health existing conditions, the general Off-site Study Area has been extended to include lands within approximately 1 km from the TCEC, consistent with the Air Quality discipline as shown on **Figure 2-2**.

Figure 2-2. On-site and Off-site Study Areas for Human Health



Source : HDR, 2022

3 Methods

This Human Health Existing Conditions Report was developed based on the evaluation criteria, indicators, and data sources included in the approved ToR, which were developed in consultation with government agencies and other stakeholders. The evaluation criteria, rationale, indicators and data sources used for Human Health as per the approved ToR are provided in **Table 3-1**.

Table 3-1. Evaluation Criteria, Indicators and Data Sources for Human Health

Evaluation Criteria	Rationale	Indicators	Data Sources
Human Health	Construction and operation activities at a waste disposal site can lead to increase to increased levels of particulates (dust) and related metals in the air.	• Predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals at identified sensitive receptor locations within the Study Area. Refer to **Table 4-1** for a complete list of assessed contaminants. • Frequency of any exceedance of applicable standards, limits, or guidelines at identified receptors.	• Data used in the previous 2005 risk assessment. • Available background ambient air data. • Ground-level air concentrations modelled by Air Quality team for proposed preferred alternative and associated frequency data. • Results from Existing Conditions Reports for Air Quality, Surface Water Quality and Hydrogeology • Off-site receptors identified in coordination with other disciplines. • Published health-based regulatory benchmarks or toxicity reference values (TRVs) for each contaminant of concern (e.g., WHO, 2021; MECP, 2022; HC, 2021). • WM Annual Monitoring Reports for the TCEC.
	Waste disposal site and associated operations can emit gaseous contaminants that can degrade air quality.	• Predicted acute and chronic health-based concentration ratios arising from air concentrations of gaseous contaminants at identified sensitive receptor locations within the Study Area. Refer to **Table 4-1** for a complete list of assessed contaminants. • Frequency of any exceedance of applicable standards, limits, or guidelines at identified receptors.	

3.1 Data Collection and Review

An evaluation of potential health effects was conducted in 2005 for the proposed expansion of the Warwick Landfill in the form of a detailed HHRA by Cantox Environmental Inc. (now Intrinsik Corp.).

In general, an HHRA is a scientific study that evaluates the potential for the occurrence of adverse health effects from exposures of people (receptors) to contaminants of concern (COCs) present in surrounding environmental media (e.g., air, soil, sediment, surface water, groundwater, food, 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 contaminant exposure increases in proportion to the contaminant concentration in critical target tissues where adverse effects may occur. The concentrations of contaminants in the target tissues (the dose) are determined by the degree of exposure, which is proportional to the contaminant concentrations in the environment where the receptor resides, works, or visits. All contaminants, both natural and man-made, have the potential to cause effects in people and the ecosystem. It is the contaminant concentration, the route and amount of exposure, and the inherent toxicity of the contaminant that determines the level of risk for adverse health effects to occur. As such, an HHRA allows stakeholders to evaluate the potential health implications of a proposed project and address potential mitigation options should potential health risks be identified.

The 2005 HHRA evaluated the potential human health impacts on nearby residential communities that could arise from expected airborne emissions associated with the proposed landfill expansion. Future air emissions associated with the Warwick Landfill expansion were predicted by air dispersion modellers using a series of Ministry-approved computer models (previously Ontario Ministry of Environment (MOE), now Ontario Ministry of Environment, Conservation and Parks (MECP)). The estimated future ground-level air concentrations of contaminants resulting from the proposed landfill expansion were then used in the HHRA study. This study was based on the data available at the time and was found to support the position that the operation of the expanded Warwick Landfill posed no significant health risk to the surrounding community.

To characterize existing conditions for Human Health, the following data collection and review was undertaken:

- A review of assumptions from the 2005 HHRA;
- A review of results from recent WM TCEC Annual Monitoring Reports;
- A review of field studies and existing conditions from the air quality, surface water quality, and groundwater quality disciplines including off-site receptors;
- A comparison of the results of the chemical analyses from the last five (5) TCEC annual monitoring programs (i.e., 2019, 2020, 2021, 2022, and 2023) against assumptions made in the 2005 HHRA;
- An assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA; and
- A review of recent toxicological literature (WHO, 2021; MECP, 2022) for changes to the exposure limits applied to chemicals described in the 2005 HHRA, and to identify exposure limits for new COCs (**Section 4.5**).

3.2 Field Studies

No field studies were undertaken specifically for Human Health. The results of field studies to determine existing baseline conditions completed for the air quality, surface water quality, and groundwater quality disciplines were examined to aid in the characterization of Human Health existing conditions.

3.3 Characterization of Existing Conditions

The existing conditions for Human Health were characterized as follows:

1. Information collected from the sources identified in **Section 3.1** were reviewed and summarized;
2. A review of field studies was undertaken to review the existing environment and understand existing baseline conditions with respect to air quality, surface water quality, and ground water quality (**Section 4.3**); and
3. Information from all sources was compiled by environmental criterion.

4 Data Collection and Review

As noted in **Section 3.1**, to characterize existing conditions for Human Health, the following data collection and review was undertaken:

- A review of assumptions from the 2005 HHRA;
- A review of results from recent WM TCEC Annual Monitoring Reports (2019, 2020, 2021, 2022 and 2023);
- A review of field studies and existing conditions from the air quality, surface water quality, and groundwater quality disciplines;
- A comparison of the results of the chemical analyses from the recent TCEC annual monitoring program against assumptions made in the 2005 HHRA;
- An assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA; and
- A review of recent toxicological literature (WHO, 2021; MECP, 2022) for changes to the exposure limits applied to chemicals described in the 2005 HHRA, and to identify exposure limits for new COCs.

The 2005 HHRA employed the standard HHRA framework to assess COCs. At the time, the Ontario Ministry of the Environment (MOE, now MECP) required that WM include an initial list of 17 non-methane organic compounds which were identified as posing the greatest concern to human health at landfill sites in Ontario. As a result of the peer review process and consideration of leachate treatment options, additional compounds, including products of incomplete combustion, particulate matter and metals, were selected for inclusion in the 2005 HHRA as shown in **Table 4-1**.

Table 4-1. Contaminants of Concern for Human Health

COC Group	COC Source	COC		
Landfill Gases	Landfill gases produced by decomposition of landfill wastes	• 1,1-dichloroethane • 1,2-dichloroethane • Butan-2-ol • 1,1,2-trichlorethane • 1,1,2,2-tetrachloroethylene • 1,1-dichloroethylene	• Methylene chloride • Methyl mercaptan • Trichloroethylene • Bromodichloromethane • Vinyl chloride • Octane	• Dimethylsulphide • Chloroethane • Hydrogen sulphide • Benzene • Ethyl mercaptan
Combustion Gases and Products of Incomplete Combustion	Landfill flare and leachate treatment options (evaporation/ incineration)	• Sulphur dioxide • Hydrogen chloride	• Nitrogen dioxide • Benzo(a)pyrene-TEQ (representing carcinogenic PAH group)	• Carbon monoxide • Dioxin/Furans (TEQ)
Particulate	Crustal sources (i.e., soil) due to on- and off-site activities; contaminated soils; and various combustion sources including motor vehicle exhaust	• Total Suspended Particulate (TSP)	• PM_{10}	• $PM_{2.5}$
Metals	Leachate treatment option (evaporation/ incineration)	• Arsenic • Mercury	• Cadmium • Nickel	• Lead

An assessment was conducted to determine if any new chemicals identified as potential health risks, and a reassessment was conducted for chemicals detected in the recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA. The results of this assessment are provided in **Section 4.4**.

A review was conducted of recent toxicological literature for any changes to the exposure limits applied to chemicals described in the 2005 HHRA, and to identify exposure limits for new COCs. The results of this review are provided in **Section 4.5**.

As mentioned in the 2005 HHRA, health risks resulting from exposure to combustion gases are generally associated with respiratory irritation and as such, background concentrations in drinking water and soil were not considered.

It should be noted that although Health Canada health-based cancer limits are available for diesel particulate matter (DPM), DPM was not specifically assessed a group in either the 2005 HHRA or the current health reviews. However, it is not the particulate matter that causes cancer; rather, it is the chemicals that are carried by or absorbed to the particulate matter. Typically, the air dispersion modelling predicts emission concentrations of these cancer-causing constituents already, so cancer risk can be assessed directly through the causal agents, rather than a surrogate in the form of DPM.

4.1 Review of Assumptions from 2005 HHRA

A review of the assumptions made in the 2005 HHRA was completed and is presented in **Table 4-2** below. Based on **Table 4-2**, the assumptions previously used in the 2005 HHRA are still valid, and therefore, the results of the assessment remain valid.

Table 4-2. Assumptions Used in the 2005 HHRA vs. Current HHRA Assumptions

Assumption Description	2005 Assumption	Current HHRA Assumption	Difference
Body Weight (kg)	• 8.2 kg infant • 16.5 kg toddler • 32.9 kg child • 59.7 kg teen • 70.7 kg adult	Same as 2005 assumptions	No change
Surface area of hands (m^2)	• 0.032 m^2 infant • 0.043 m^2 toddler • 0.059 m^2 child • 0.08 m^2 teen • 0.089 m^2 adult	Same as 2005 assumptions	No change
Breathing/Inhalation Rate (m^3/day)	• 2.2 m^3/day infant • 8.3 m^3/day toddler • 14.5 m^3/day child • 15.6 m^3/day teen • 16.6 m^3/day adult	Same as 2005 assumptions	No change
Soil Ingestion Rate (g/day)	• 0.03 g/day infant • 0.2 g/day toddler • 0.05 g/day child • 0.05 g/day teen • 0.05 g/day adult	Same as 2005 assumptions	No change
Human Receptors (e.g., infant, toddler, child, adolescent, adult)	Female preschool child (7 months to 4 years) was used to represent the most sensitive individual. For highly bioaccumulative compounds such as dioxins and furans, exposures to mother's milk during the infant life stage were also considered. In order to conservatively assess potential incremental lifetime cancer risk levels (ILCR) to carcinogenic chemicals, a female composite or lifetime receptor, which includes all life stages, was included: • Infant (0 to 6 months); • preschool child or toddler (7 months to 4 years); • child (5 to 11 years); • adolescent (12 to 19 years); and • adult (>20 years).	Same as 2005 assumptions	No change
Exposure Pathways (people were assumed to be exposed to COPCs in the emissions of the proposed Warwick Landfill expansion via	• Inhalation of Air • Inhalation of Soils and Dusts • Ingestion of Soils and Dusts • Ingestion of Locally Grown Produce • Ingestion of Locally Derived Beef and Dairy Products • Ingestion of Breast Milk	Same as 2005 assumptions	No change

Table 4-2. Assumptions Used in the 2005 HHRA vs. Current HHRA Assumptions

Assumption Description	2005 Assumption	Current HHRA Assumption	Difference
the following pathways)	• Dermal Exposure to Soils and Dust It was conservatively assumed that all hypothetical residential receptors would spend 24 hours per day, 7 days per week, 52 weeks per year for 70 years at the maximum residential receptor location while supplementing their typical diet with fruits, produce, meat and dairy products from the nearby farming community.		
Receptor Location	• Maximum fence-line location • Maximum discrete receptor location	Total Suspended Particulate and Metals in ambient air • Southeast • Northeast • Western Fence line ambient VOCs sampling (RWDI, 2020; 2021; 2022; 2023; 2025c; 2024): • Concurrent upwind and downwind samples Groundwater Sampling (RWDI, 2025a): • Select monitoring well locations at the landfill • Off-site monitoring location Cemetery Well • Interface aquifer monitoring wells for VOCs Surface Water sampling (RWDI, 2025b): • Surface Water Compliance Monitoring Program (SS1, SS10, SS16, SP1, SP2, SP3, SP4) • Surface water poplar system monitoring program (SS14A, SS14B SS15A) • Surface water poplar plantation (SS17A, SS17B) • SS18A, SS18B) • Off-site (SW1, SW2, SW3, SW4, SW5)	Yes
Exposure Scenarios	• Baseline/Background (i.e., current conditions) • Year 1 (2005) • Year 6 (2010) • Year 11 (2015) • Year 16 (2020) • Year 21 (2025) • Year 26 (2030)	Annual Monitoring Reports for 2019, 2020, 2021, 2022, 2023	Yes

The main findings of the 2005 HHRA are outlined below in **Section 4.1.1** through **4.1.3**. The conclusions from the review and assessment of assumptions in the 2005 HHRA are presented in **Section 5**. The 2005 HHRA evaluated health risks at the maximum discrete receptor location during six operating years (or scenarios) within the landfill's projected 25-year lifespan between 2005 and 2030. For each operating year (or scenario), health risks associated with exposures to the following emission sources were addressed:

- Landfill gases as a result of naturally decaying waste;
- Combustion gases and products of incomplete combustion (PIC) from of flaring landfill gases;
    - Dust, including total suspended particulate and fine particulate matter (i.e., PM_{10} and $PM_{2.5}$) arising from truck traffic on paved and unpaved roads and earthworks activities; and,
- Metals and products of incomplete combustion (PICs) from the leachate incineration treatment option.

4.1.1 Predicted Chronic Human Health Impacts

Chronic (long-term) human health impacts were examined in the 2005 HHRA at individual receptor locations. Different time frames which are representative of different landfill operating periods were evaluated. A baseline/background scenario which reflects the current conditions at the landfill site were first considered. Six (6) future operating time frames within the projected lifespan of the facility were also considered including Year 2005, Year 2010, Year 2015, Year 2020, Year 2025 and Year 2030 and represent predicted emissions following expansion through to closure of the facility. Risks were determined using both deterministic and stochastic analyses. A deterministic approach involves using conservative (i.e., protective), discrete values for each parameter (e.g., a child is assumed to play outside 5 hours per day) to generate a single point estimate health risk value. A stochastic approach involves using probability distributions of exposure parameters rather than single point estimate values (e.g., a child is assumed to play outside between 3 and 7 hours per day) to generate a possible range or distribution of health risk estimates. Long term exposure ratios (ERs) and incremental lifetime cancer risk levels (ILCR) were calculated by either dividing the estimated exposure by the chemical reference dose (RfD), or multiplying the estimated average lifetime exposure by an appropriate slope factor (q1*), respectively.

ER values were referenced to a value of 1.0 since for threshold chemicals, an ER value greater than 1.0 indicates that estimated exposures exceeded the RfD, the level at which adverse effects to more sensitive members of a population may occur. Similarly, ER values less than 1.0 indicate that estimated exposures are below the level where adverse effects may occur. When considering risks related to threshold (non-carcinogenic) compounds, it is important to consider exposures from all pathways, media and sources. The acceptable risk level (an ER < 1.0), although quite conservative, is considered a threshold above which health effects may occur. As a result, it is necessary to consider background/baseline (current) conditions in addition to the incremental contribution of the facility when evaluating risks in the future.

For chemicals assumed to be direct acting, non-threshold carcinogens, the calculated ILCR value is compared to an acceptable risk benchmark (acceptable ILCR). In Ontario, the acceptable ILCR, arising from any one exposure pathway related to a particular point source, is one-in-one million (1-in-1,000,000; 1.0e-06; 10^{-6}). A background assessment is not conducted for non-threshold carcinogenic compounds since it is the additional or incremental risk of developing cancer from a point source that is evaluated, not overall cancer risk. The acceptable ILCR of 1-in-1,000,000 is considered to be a *de minimis* risk level (i.e., a negligible or insignificant risk level).

For combustion gases, potential health risks to residents for acute and chronic exposures were assessed as concentration ratio values (CR). CR values were calculated by dividing the predicted air concentration with the reference concentration (RfC), according to the following equation:

Concentration Ratio = Predicted Air Concentration / Reference Concentration

ERs and CRs and ILCRs were used to express potential adverse health impacts from exposures to the selected chemicals for several reasons:

- to allow comparisons of potential adverse effects on health between chemicals and different exposure scenarios (e.g., typical Ontario versus site-specific conditions);
- to estimate potential adverse effects on health from exposures to mixtures of chemicals that act on similar biological systems (e.g., all chemicals that cause liver toxicity, or kidney toxicity, or respiratory tract cancers); and,
- to simplify the presentation of the assessment results so that the reader may have a clear understanding of these results, and an appreciation of their significance.

The predicted chronic human health impacts of the Warwick Landfill expansion in the 2005 HHRA were as follows:

- All predicted landfill gas exposure ratios (ERs) are less than a value of 1.0. Therefore, long-term non-cancer human health risks as a result of predicted exposures to landfill gases from the Warwick Landfill expansion were considered minimal at the maximum discrete receptor location.
- Incremental lifetime cancer risk (ILCR) estimates for all COCs, including metals, products of incomplete combustions and volatile organics compounds (VOCs) from all sources (landfill gases produced by decomposition of landfill waste, landfill flare, and leachate treatment options (evaporation/incineration)), were below the acceptable risk level of one-in-one million (1×10^{-6}). The upper 95th percentile ILCR estimate for total chlorinated VOCs as a group were also predicted to be less than an ILCR of one-in-one million. Therefore, cancer risks were not predicted for COCs.

- Chronic human health risks associated with exposure to emissions resulting from the *landfill flare plus evaporation/incineration* activities (dioxin/furans, benzo(a)pyrene, lead, cadmium, arsenic, nickel and mercury) were not considered significant. The upper 95th percentile ILCR for benzo(a)pyrene of 4.3×10^{-11} at the maximum discrete receptor location is approximately 23,000-fold lower than the acceptable ILCR of one-in-one million (1×10^{-6}). For many non-carcinogenic compounds (e.g., dioxins and furans), predicted *landfill flare and evaporation/ incineration* emissions from the Warwick Landfill expansion produced human health risks several orders of magnitude lower than those associated with background and/or existing levels. Predicted *landfill flare plus evaporation/incineration* related exposures to dioxins at Year 26 (the highest projected emissions rate) were predicted to be approximately 15,000-fold lower than those associated with ambient or background levels in Ontario and more than 10,000-fold less than the level considered acceptable. It is noted that the contribution from the *leachate treatment* option (i.e., evaporation/ incineration*)* to polycyclic aromatic hydrocarbons (PAHs) and dioxin exposure estimates was predicted to be minimal, if not indistinguishable in the case of PAHs, relative to the contribution from the *landfill flare only scenario* (discussed below).
- Long-term human health risks associated with exposure to emissions resulting from the *landfill flare only scenario* (e.g., PAHs, dioxin/furans) were also considered insignificant. Estimates of ILCRs resulting from exposure to PAHs were predicted to be several orders of magnitude lower than the acceptable level of one-in-one million. As in the landfill *flare plus evaporation/incineration* scenario, exposure to dioxins in Year 26 were predicted to be substantially lower (26,000-fold lower) than ambient or background exposures in Ontario.
- Annual concentration ratio (CR) values predicted for chronic exposures to all combustion gases (e.g., CO_2, CO, SO_2, NO_x and HCl) at the maximum discrete receptor location (location unspecified in original HHRA) for both the *landfill flare only* and the *landfill flare plus leachate incineration* were predicted to be within acceptable levels (i.e., all CR values were less than a value of one). This suggests that no measurable long-term adverse health impacts were predicted to result from landfill combustion gas emissions at the maximum discrete receptor location. Facility-related annual CR values were predicted to be almost 10-fold lower than baseline/background (scenario which reflects the current conditions at the landfill site were first considered) NO_x and SO_2 CR values.

In conclusion, long-term cancer and non-cancer human health risks as a result of predicted exposures to landfill gases from the Warwick Landfill expansion were considered minimal. Chronic human health risks associated with exposure to emissions resulting from the landfill flare plus evaporation/incineration activities (dioxin/furans, benzo(a)pyrene, lead, cadmium, arsenic, nickel and mercury) were not considered significant. Long-term human health risks associated with exposure to emissions resulting from the landfill flare only scenario (PAHs, dioxin/furans) were also considered insignificant. No measurable long-term adverse health impacts were predicted to result from landfill combustion gas emissions (Intrinsik, 2005).

4.1.2 Predicted Short-term Human Health Impacts

Short-term human health impacts were examined at individual receptor locations in the 2005 HHRA. Short-term exposure durations were evaluated in the 2005 HHRA for combustion gases and particulate matter. Short-term air data (i.e., ½-hour, 1-hour and 24-hour durations) at the maximum discrete receptor location and at the fence-line locations were used in the acute (or short-term) assessment. It is noted that maximum fence-line locations were used for ½-hour and 1-hour exposure durations to combustion gases only.

The predicted short-term human health impacts of the Warwick Landfill expansion in the 2005 HHRA were as follows:

- All 24-hour exposure durations were evaluated at the maximum discrete receptor location and the maximum fenceline location (exact location not specified in 2005 HHRA). No short-term adverse health effects were predicted to occur as a result of exposure to combustion gases at the maximum receptor location (exact location not specified in 2005 HHRA) under the *landfill flare only or landfill flare plus evaporation/incineration* options; and,
- With the exception of SO_2 in Year 26, all ½-hour and 1-hour CR values calculated at the maximum fenceline location were predicted to be less than a value of 1.0 under both the *landfill flare only* and *landfill flare plus evaporation/incineration* options. Given the conservatism of the SO_2 air quality benchmark and the exposure assumptions employed, the 1-hour SO_2 CR value of 1.1 observed in operational year 2030 at the maximum fenceline location under the *landfill flare plus evaporation/incineration* option was considered to be of minimal significance in the original 2005 HHRA.

The 2005 HHRA concluded that no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases under the *landfill flare only or landfill flare plus evaporation/incineration* options.

4.1.3 Predicted Particulate Matter Impacts

Human health impacts from particulate matter examined in the 2005 HHRA included TSP, PM_{10} and $PM_{2.5}$. Particulate matter data from the *Additional Dust Assessment – West Entrance* report by RWDI was used to evaluate health risks associated with this preferred access route (i.e., the west entrance or County Rd. 79) in the 2005 HHRA.

There has been considerable debate related to whether there is a threshold in the dose-response curve for PM exposures. For the purposes of this project, the health-based regulatory guidelines were used as benchmarks of comparison for the estimated air concentrations. These guidelines are considered to be highly conservative for this specific project for the following reasons:

- The guidelines consider a vast array of scientific literature which present epidemiology studies conducted in large urban centres with huge populations, with complex combustion oriented air pollution exposures (i.e., exposure to high concentrations of vehicular exhaust, atmospheric releases from coal-fired power plants, and other point and diffuse sources of emissions).

- The area under assessment in this project is a rural environment, as opposed to urban, with a small population. This greatly restricts the applicability of the statistical relationships between increased concentrations of PM and health effects (such as death) which have been developed from the epidemiology literature. Such relationships require large exposed populations to adequately assess the small difference expected from exposure to particulate matter at relatively low ambient concentrations. In addition, the primary source of the particulate at this site is expected to be crustal dust (ground-up inorganic matter) rather than particulate matter from combustion sources. Crustal sources of particulate matter are generally not positively associated with mortality (Laden et al., 2000), and several studies have reported a negative association with PM_{10} from fugitive dust (Janssen et al., 2002; Mar et al., 2000). This information suggests that the regulatory benchmarks for PM_{10} and $PM_{2.5}$ have limited applicability in this project, but they will still be applied for illustrative purposes.

Based on the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ is extremely low due to:

- the dominant source of PM was predicted to be crustal (i.e., soil, dirt particles), as opposed to combustion-related, which has a markedly lower toxicity;
- air concentrations of PM_{10} and $PM_{2.5}$ were modelled using very conservative assumptions, and as a result are likely to be overestimated;
- the PM guidelines applied in the 2005 HHRA were based on epidemiology literature related to adverse health outcomes associated with exposure to combustion-related PM, and as such, they are highly conservative benchmarks for this site;
- no exceedances were predicted on an annual average basis for at both the fenceline and worst-case receptor locations for either PM_{10} or $PM_{2.5}$;
- the degree of, and frequency of, exceedance over the PM guidelines for 24-hr time frames for $PM_{2.5}$ were predicted to be extremely small (less than 1.3 times the guidelines, for less than 1 day/year in Year 6), and were restricted to only a very small area near the facility; and
- the degree of, and frequency of, exceedance over guidelines for 24-hr time frames for PM_{10} was slightly greater than those predicted for $PM_{2.5}$, but still not considered to represent a health concern due to the characteristics of the PM emitted from landfill operations.

Thus, while TSP exceedances have been noted in the annual monitoring data, as there were infrequent and minor exceedances for PM_{10} and $PM_{2.5}$, this suggests that any TSP exceedances are primarily due to the airborne presence of larger crustal materials arising from earthworks. While a nuisance, this particulate size fraction is not generally believed to have significant health concerns (i.e., they do not penetrate deep into a person's airway due to the larger size).

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location (exact location not specified in the 2005 HHRA), and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was predicted to be extremely low in the 2005 HHRA.

4.2 Review of Results from Recent Annual Monitoring Programs

A review of the results from the recent WM TCEC Annual Monitoring Reports for air quality, ground water quality, and surface water quality monitoring programs for 2019 to 2023 are outlined below.

4.2.1 Air Quality

Based on a review of the Air Quality Monitoring Program reports included as part of the Annual Monitoring Reports (RWDI, 2020; 2021; 2022; 2023; 2024), the information presented below was extracted for consideration in the Human Health assessment of existing conditions. The most recent Monitoring Program for groundwater, surface water, landfill gas, leachate, air quality and noise are presented in Table B-2, Appendix B of the 2023 Annual Monitoring Report. This sampling program was completed by RWDI between January 1 and December 31, 2023 (RWDI, 2024).

4.2.1.1 Dust Monitoring for Total Suspended Particulate (TSP) and Metals

Dust monitoring as part of the Annual Monitoring Programs include measurements of TSP at three (3) locations around the landfill footprint (Southeast, Northeast, Western), see **Figure 4-1** below (RWDI, 2023).

In comparison to the MECP Ambient Air Quality Criteria (AAQC) of 120 µg/m³, the maximum predicted concentration of TSP at a nearby sensitive receptor location off-site was 238 µg/m³ at receptor R7 (See **Figure 4-2** below) (RWDI, 2025c). However, the standard was only predicted to be exceeded 0.9% of the time at this receptor location. Other receptors (R2, R3, and R6), which were situated to the northwest of the facility, had maximum predicted concentrations ranging from 174 to 187 µg/m³ but had predicted frequencies of exceedance of the AAQC in the range of 4 to 5% of the time (RWDI, 2025c). The effects at these receptors were generally based on the impact of off-site traffic, as opposed to landfill-based sources, due to the proximity of these receptor locations to Nauvoo Road.

Only receptors R3 and R7 (see **Figure 4-2** below) were predicted to exceed the MECP AAQC of 120 µg/m³ when considering on-site sources, without any off-site sources or background contribution. The predicted frequency of exceedance based on on-site sources was only 0.1% and 0.3% of the time, respectively. At any of the other sensitive receptor locations, no exceedances were observed when modelling only for on-site sources.

From the 2017 Air Quality Monitoring Program, the maximum predicted concentration of TSP at the Southeast stations was exceeded once during the fourth quarter sampling period (i.e., 162 µg/m³ vs. 120 µg/m³).

From the 2019 Annual Monitoring Report, the maximum predicted concentration of TSP exceeded the AAQC of 120 µg/m³ in the following samples (RWDI, 2020):

- On April 3, 2019, the AAQC was exceeded at the Northeast station, with a concentration of 164 µg/m³.
- On May 9, 2019, the AAQC was exceeded at the Western station, with a concentration of 215 µg/m³.
- On June 26, 2019, the AAQC was exceeded at the Southeast, and Northeast stations, with concentrations of 588 µg/m³ and 177 µg/m³ respectively.
- On July 2, 2019, the AAQC was exceeded at the Southeast station, with a concentration of 399µg/m³; and at Northeast station, with a concentration of 240 µg/m³.
- On August 7, 2019, the AAQC was exceeded at the Western station, with a concentration of 126 µg/m³.
- On September 18, 2019, the AAQC was exceeded at the Western station, with a concentration of 195 µg/m³.

From the 2020 Annual Monitoring Report, the maximum predicted concentration of TSP exceeded the AAQC of 120 µg/m³ in the following samples (RWDI, 2021):

- On February 21, 2020, the AAQC was exceeded at the Northeast station, with a concentration of 189 µg/m³.
- On April 3, 2020, the AAQC was exceeded at the Southeast station, with a concentration of 158 µg/m³.
- On April 15, 2020, the AAQC was exceeded at the Southeast station, with a concentration of 158 µg/m³.
- On April 27, 2020, the AAQC was exceeded at the Southeast and Northeast station, with a concentration of 141 and 124 µg/m³ respectively.
- On May 21, 2020, the AAQC was exceeded at the Western station, with a concentration of 131 µg/m³.
- On June 5, 2020, the AAQC was exceeded at the Northeast station, with a concentration of 137 µg/m³.
- On June 8, 2020, the AAQC was exceeded at the Western station, with a concentration of 168 µg/m³.
- On June 17, 2020, the AAQC was exceeded at the Western station, with a concentration of 184 µg/m³.

- On June 26, 2020, the AAQC was exceeded at the Northeast station, with a concentration of 147 µg/m³.
- On August 7th, 2020, the AAQC was exceeded at the Western station, with a concentration of 153 µg/m³.
- On August 13th, 2020, the AAQC was exceeded at the Western station, with a concentration of 263 µg/m³.
- On September 18th, 2020, the AAQC was exceeded at the Western, with a concentration of 142 µg/m³.

From the 2021 Annual Monitoring Report, the maximum predicted concentration of TSP exceeded the AAQC of 120 µg/m³ in the following samples (RWDI, 2022):

- On May 10th, 2021, the AAQC was exceeded at the Northeast and Southeast stations, with concentrations of 123 µg/m³ and 134 µg/m³ respectively.
- On May 16th, 2021, the AAQC was exceeded at the Southeast station, with a concentration of 125 µg/m³.
- On June 24th, 2021, the AAQC was exceeded at the Southeast station, with a concentration of 126 µg/m³.

From the 2022 Annual Monitoring Report, the maximum predicted concentration of TSP exceeded the AAQC of 120 µg/m³ in the following samples (2023):

- On May 5th, 2022, the AAQC was exceeded at the Western station, with a concentration of 127 µg/m³.
- On May 11th, 2022, the AAQC was exceeded at the Western station, with a concentration of 127 µg/m³.
- On June 1st, 2022, the AAQC was exceeded at the Northeast and Southeast stations, with concentrations of 210 µg/m³ and 150 µg/m³ respectively.
- On June 16th, 2022, the AAQC was exceeded at the Northeast and Southeast stations, with concentrations of 300 µg/m³ and 125 µg/m³ respectively.
- On June 22nd, 2022, the AAQC was exceeded at the Northeast station, with a concentration of 188 µg/m³.
- On July 4th, 2022, the AAQC was exceeded at the Northeast and Southeast stations, with concentrations of 241 µg/m³ and 347 µg/m³, respectively.
- On July 19th, 2022, the AAQC was exceeded at the Northeast and Southeast stations, with concentrations of 159 µg/m³ and 133 µg/m³.
- On July 28th, 2022, the AAQC was exceeded at the Northeast station, with a concentration of 209 µg/m³.
- On August 3rd, 2022, the AAQC was exceeded at the Southeast station, with a concentration of 141 µg/m³.

- On September 14th, 2022, the AAQC was exceeded at the Southeast station, with a concentration of 131 µg/m³.
- On November 7th, 2022, the AAQC was exceeded at the Southeast station, with a concentration of 162 µg/m³.

From the 2023 Annual Monitoring Report, the maximum predicted concentration of TSP exceeded the AAQC of 120 µg/m³ in the following samples (2024):

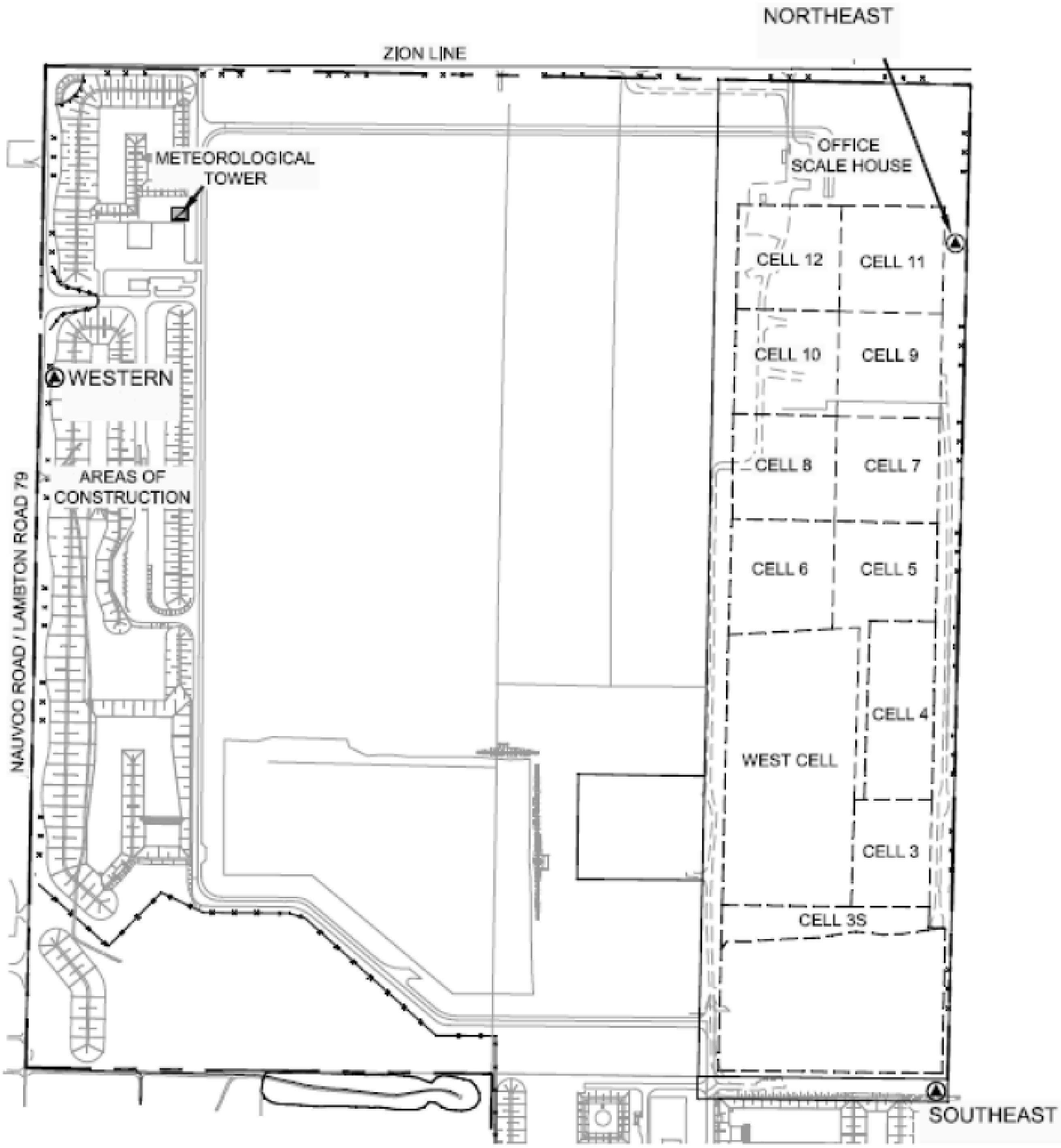
- On April 12th, 2023, the AAQC was exceeded at the Northeast station, with a concentration of 201 µg/m³.
- On May 12th, 2023, the AAQC was exceeded at the Northeast, Southeast and Western stations, with concentrations of 200 µg/m³, 145 µg/m³, and 128 µg/m³.
- On May 18th, 2023, the AAQC was exceeded at the Western station, with a concentration of 148 µg/m³.
- On May 24th, 2023, the AAQC was exceeded at the Northeast and Southeast stations, with concentrations of 170 µg/m³ and 122 µg/m³.
- On June 2nd, 2023, the AAQC was exceeded at the Western and Southeast stations, with concentrations of 130 µg/m³ and 137 µg/m³.
- On June 8th, 2023, the AAQC was exceeded at the Northeast station, with a concentration of 159 µg/m³.
- On June 20th, 2023, the AAQC was exceeded at the Western station, with a concentration of 212 µg/m³.
- On July 11th, 2023, the AAQC was exceeded at the Northeast station, with a concentration of 130 µg/m³.
- On October 3rd, 2023, the AAQC was exceeded at the Northeast station, with a concentration of 236 µg/m³.

For each TSP exceedance, watering activities for dust control purposes, including watering on-site roadways and construction sites occurred (RWDI, 2023; 2024).

Although some of the measured exceedances were found to be the result of off-site sources (such as agricultural activities and traffic on local roads), the air quality review concluded that the greater part of these exceedance events were attributable in whole or in part to on-site sources, specifically landfill operations and landfill construction.

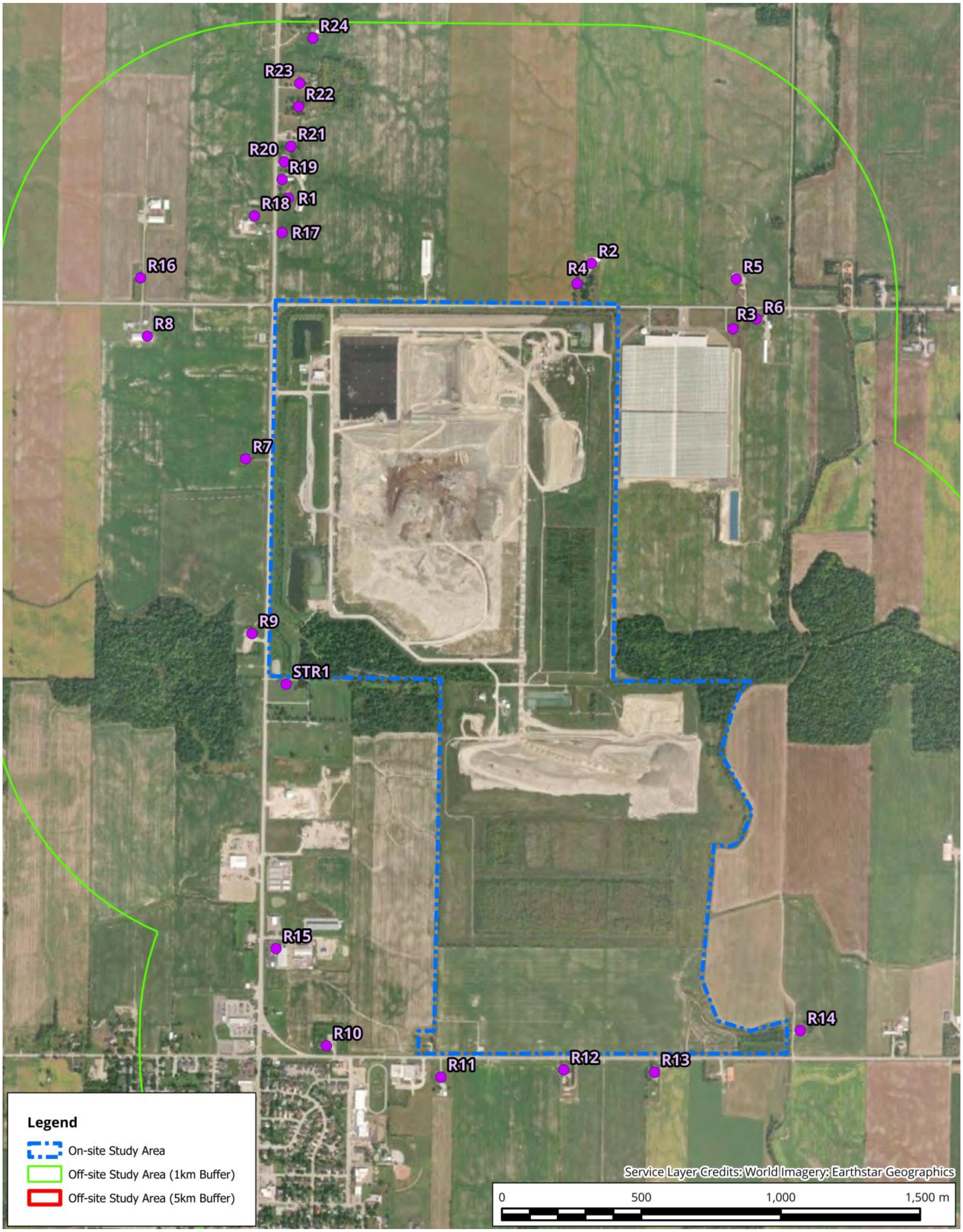
As noted previously, while TSP exceedances have been noted in the annual monitoring data, as there were infrequent and minor exceedances for PM_{10} and $PM_{2.5}$, this suggests that any TSP exceedances are primarily due to the airborne presence of larger crustal materials arising from earthworks. While a nuisance, this particulate size fraction is not generally believed to have significant health concerns (i.e., they do not penetrate deep into a person's airway due to the larger size).Measured metal concentrations were consistently below the applicable criteria in the 2019 to 2022 Annual Monitoring Reports (RWDI, 2020; 2021; 2022; 2023; 2024).

Figure 4-1. Dust Monitoring Locations



Source: RWDI, 2023

Figure 4-2. Off-Site Sensitive Receptors



Source: RWDI, 2025c

4.2.1.2 Landfill Gas and Combustion Byproducts

Landfill Gas consists mainly of methane and carbon dioxide; however, it also contains trace amounts of volatile organic compounds (VOC) and reduced sulphur compounds (RS), and combustion by-products (nitrogen oxides (NO_X), carbon monoxide (CO), sulphur dioxide (SO_2), certain VOCs, benzo(a)pyrene, and dioxins and furans) (RWDI, 2025c).

A portion of the landfill gas produced at TCEC is emitted through the landfill surface as fugitive emissions, while the bulk of the landfill gas created is collected by the landfill gas collection system and sent for destruction or for utilization (RWDI, 2025c).

Gas probes in 2022 did not detect methane gas, which is consistent with historical observations (RWDI, 2023). Therefore, landfill gas is being effectively captured by the landfill gas collection system and is not migrating in the subsurface beyond the waste footprint (RWDI, 2023).

The maximum predicted concentrations for all VOC and RS compounds were less than the applicable Regulation 419/05 standards at all sensitive receptor locations as well as at the property line of the facility.

The maximum predicted concentrations for all combustion by-product compounds were less than the applicable standards in place in the 2005 HHRA at all sensitive receptor locations as well as at the property line of the facility. Although the model and the standards have changed (see Section 4.4), the overall impacts from landfill-related tailpipe emissions and combustion sources remain in compliance with current MECP standards. The ECA modelling for the flares and generators demonstrated compliance with current MECP standards at the property line and at all sensitive receptor locations.

The Air Quality Existing Conditions Report measured H_2S and total reduced sulphurs (TRS) as indicator contaminants for reduced sulphur compounds. TRS represents the cumulative impact from all sulphur compounds including carbonyl sulphide, H_2S, carbon disulfide, methyl mercaptan, ethyl mercaptan, dimethyl sulphide, 1-propyl mercaptan, methyl ethyl sulphide, and dimethyl disulphide. In addition to being assessed as a component of TRS, H_2S was assessed independently as the primary contributor to TRS emissions (RWDI, 2025c). Results indicated three (3) exceedances of the applicable criteria for H_2S and 38 exceedances of the TRS criteria (RWDI, 2025c). The majority of the TRS exceedances were the result of the detection limit being above the criteria. Most samples were below detection and remained below detection once the detection threshold was lowered. Three (3) exceedances of the H_2S criteria and four (4) exceedances of the TRS criteria were identified after excluding exceedances due to detection levels. The 2025 Air Quality Existing Conditions Report has indicated that predicted concentrations of H_2S for the 24-hour averaging period are below the applicable criteria without background, and that the maximum predicted concentration occurs at the property boundary with a predicted concentration of 0.9 $\mu g/m^3$ or 13% of the criteria (RWDI, 2025c). Once the ambient monitoring campaign has been completed, background concentrations of H_2S and TRS will be added to the predicted concentrations (RWDI, 2025c). The predicted concentrations of H_2S and TRS at all discrete receptors and the property boundary are low. Therefore, impacts associated with landfilling operations are expected to be low based on results from the Air Quality Existing Conditions Report (RWDI, 2025c).

The VOC concentrations measured since the onset of the program have been below detection and were less than their applicable Air Quality standards (RWDI, 2025c). Benzene, vinyl chloride, 1,2-dichloroethane, ammonia, SO_2, NO_x, dioxins and furans, H_2S and TRS comply with all criteria at all discrete receptors as well as the property boundary and beyond based on dispersion modelling (RWDI, 2025a).

4.2.1.3 Fence Line Ambient Volatile Organic Compounds (VOCs) Sampling

In the Annual Monitoring Reports, VOCs were sampled during the summer months for 24-hours in duration and compared to POI (Provincial Point of Impingement) standards (RWDI, 2023). If a POI standard was unavailable, concentrations were compared to MECP's Jurisdictional Screening Levels (JSLs) or Ambient Air Quality Criteria (AAQCs). The VOCs sampled and analyzed included those shown in **Table 4-3**.

Table 4-3. Summary of VOCs Samples

Compound	
1,1,2-Trichloro-1,2,2-Trifluoroethane	m/p-Ethyl Toluene
1,2,3-Trimethyl Benzene	m/p-Xylene
1,2,4 Trimethyl Benzene	m-Cymene
1,3,5-Trimethyl Benzene	MEK
2-Methyl Hexane	Methyl Cyclohexane
2-Methyl Pentane	MIBK
2-Methyl Butane	Chlorodifluoromethane
3-Methyl Pentane	n-Butanal
3-Methyl Hexane	Naphthalene
Acetone	Nonane
Benzene	o-Ethyl Toluene
Butyl Acetate	o-Xylene
Decane	Pentane
Dichlorodifluoromethane	Ethanol
Dichloromethane	Propyl Benzene
Ethyl Benzene	Styrene
Heptane	Tetrachloroethylene
Hexane	Toluene
Isopropyl Alcohol	Trichlorofluoromethane
Limonene	Trichloroethylene
Vinyl Chloride	Ethyl Acetate
Carbon Tetrachloride	1,1,1-Trichloroethane
Chloroform	Vinylidene Chloride

Table 4-3. Summary of VOCs Samples

Compound	
Ethylene Dibromide	1,2-Dichloroethene
Ethylene Dichloride	Total VOCs
Chloroethane	2-Butanol
Methylene Chloride	Bromodichloromethane
1,2-Dichloroethylene (cis)	Octane
1,2-Dichloroethane	1,1,2,2-Tetrachloroethane
1,2-Dichloroethylene (trans)	1,1,2-Trichloroethane
Chlorobenzene	Dichlorobenzene
Chloromethane	Dichlorofluoromethane

Source: RWDI, 2023

Concentrations of VOCs from the 2019, 2020, 2021, 2022, and 2023 Annual Monitoring Programs were quite low and less than their respective air quality standards (RWDI, 2020; 2021; 2022; 2023; 2024).

4.2.2 Groundwater Quality

As discussed in the Annual Monitoring Reports for 2019 to 2023, the groundwater within each hydrostratigraphic unit has shown acceptable quality since monitoring began. Groundwater quality monitoring occurred according to the groundwater monitoring schedule within the approved landfill EMP (RWDI, 2023). An updated schedule including the monitoring well samples, the frequency of sampling as well as the parameters analyzed is presented in the Annual Monitoring Report (RWDI, 2023). Groundwater is monitored semi-annually in the spring and fall as per the Environmental Monitoring Plan (Jagger Hims Limited, December 2007) (EMP), dated December 20, 2007. Groundwater samples were collected using dedicated low flow bladder pumps. Field chemical results in the active aquitard, interstadial silt and sand, and the interface aquifer included pH, conductivity, turbidity, and temperature. Parameters measured in groundwater included metals and inorganics, BTEX (benzene, toluene, ethylbenzene, xylenes), and select VOCs (RWDI, 2023). Overall, groundwater quality monitoring did not show an unacceptable landfill leachate or operations effect in 2019 to 2022. Although from November 2021 to May 2022 leachate elevations were found to increase, and from May 2022 to November 2022 leachate elevations were found to decrease, the elevations were within historical ranges (RWDI, 2023). Despite the changes in elevation to leachate, water quality was found to be acceptable at the Site during the investigations and leachate elevations were not negatively affecting water resources at the Site (RWDI, 2023). Monitoring results for the active aquitard, interstadial silt and sand, and the interface aquifer satisfied the relevant Primary Leachate Indicator List (PLIL) and Secondary Leachate Indicator List (SLIL) trigger concentrations (RWDI, 2023).

Since groundwater quality monitoring did not show an unacceptable landfill leachate or operations effect, no chemicals were retained based on the investigations completed by RWDI, and the 2005 HHRA did not discuss or evaluate ground water.

4.2.3 Surface Water Quality

As discussed in the 2019 to 2022 Annual Monitoring Reports, surface water sampling/monitoring is precipitation dependent and has been ongoing since 2003. Surface water is sampled on a quarterly basis as part of the required routine monitoring for the Site. Biomonitoring testing, which is included as part of the precipitation event monitoring, is completed as outlined in the Waste and Sewage Environmental Compliance Approvals (ECAs), as well as the conditions approved in the 2014 MECP Letter (RWDI, 2023). If an exceedance of a trigger concentration is found, verification monitoring is complete and corrective action, if warranted.

Field chemical results included pH, conductivity, turbidity, as well as dissolved oxygen. Parameters measured in surface water included metals and inorganics, select semi volatile organics, and select volatile organics (RWDI, 2023). Based on the 2022 Annual Monitoring Report, routine quarterly surface water monitoring demonstrated results which satisfied the relevant trigger concentrations with seven (7) exceptions (RWDI, 2023). Verification monitoring events were completed due to these exceptions, and results indicated acceptable chemical and biological results. Therefore, no further verification monitoring was required.

As surface water quality did not show an unacceptable landfill leachate or operations effect, no chemicals were retained based on the investigations completed by RWDI, and the 2005 HHRA did not discuss or evaluate surface water.

4.3 Review of Existing Conditions for Other Disciplines

The Human Health Existing Conditions Report focuses on the natural environment, including the atmospheric environment, geology and hydrogeology, and the surface water environment. Specifically, air quality, groundwater quality and surface water quality will be assessed.

4.3.1 Air Quality

The majority of the land surrounding the TCEC is agricultural, as well as portions of Hwy 402, Nauvoo Road, and Confederation Line, and the village of Watford which has several small businesses. On-site operations, activities from nearby agricultural operations, and traffic on local roads are all sources of air emissions (HDR, 2022).

Vehicle traffic on paved and unpaved roadways, material handling of soil, wind erosion of exposed areas, construction activities, and combustion are all on-site sources of dust at TCEC. Agricultural activities and traffic on nearby roads are examples of off-site dust sources. At the TCEC, WM has implemented a plan for managing dust.

At three MECP-approved locations around the landfill footprint, total suspended particulate (TSP) sampling has been completed since 2009. Only about 4% of samples exceeded the TSP Ambient Air Quality Criterion of 120 µg/m³ between 2009 and 2022 (HDR, 2022). Most of these exceedance events were entirely or partially caused by landfill operations and landfill construction. Metal concentrations measured consistently fell below the applicable criteria.

Decomposition of waste within the landfill generates landfill gas. This landfill gas consists mainly of methane and carbon dioxide; however, it also contains trace amounts of volatile organic compounds (VOCs) and reduced sulphur compounds (RS) (HDR, 2022). The landfill gas collection system collects the majority of the landfill gas produced by the existing TCEC and sends it to be used or destroyed; however, a portion of the landfill gas is released through the landfill surface as fugitive emissions.

On-site combustion equipment such as landfill gas flares and diesel-fired generators as well as tailpipe emissions from on-site traffic and mobile equipment leads to impacts from combustion by-products. Nitrogen oxides (NO_X), carbon monoxide (CO), sulphur dioxide (SO_2), certain VOCs, benzo(a)pyrene, and dioxins and furans are examples of the common contaminants of combustion by-products.

Since 2009, VOC sampling has been carried out during the summer months (July, August, and September). Since the onset of the monitoring program, the VOC concentrations measured have been generally quite low. All concentrations measured have consistently been less than their respective air quality standards (HDR, 2022).

In the vicinity of TCEC, no ambient monitoring of combustion by-product contaminants resulting from traffic has been carried out. It is anticipated that the background concentration is comparable to other locations throughout Southwestern Ontario. Overall, only a small portion of traffic on the external haul route is generated by landfill traffic.

Between 2009 and 2023 no landfill gas-related complaints, other than those that may have been denoted as odour issues by the complainant, have been received. Similarly, between 2009 and 2023, no complaints related to combustion by-products have been received at the landfill (RWDI, 2024).

4.3.2 Groundwater Quality

In the past, groundwater was used for both domestic and agricultural purposes (HDR, 2022). Water was sourced from water supply wells, which were typically constructed within the interface aquifer. Shallower water supply wells are also developed within the interstadial sand, the surficial sand and gravel deposits (HDR, 2022). The Lambton Area Water Supply System provides a piped municipal water supply by obtaining its water from Lake Huron, a surface water source. The Village of Watford is serviced by the same system, which is also available along numerous rural roads in the Site's vicinity. Groundwater resources are being used less as a result of the growing reliance on municipal water supplies (HDR, 2022).

Minerals are added to groundwater as a result of the slow movement through the aquitards (HDR, 2022). The overburden’s chemical characteristics dissolve into a hard and bicarbonate groundwater quality. The water quality in the interface aquifer is also bicarbonate, with sodium as the predominant cation; however, the presence of hydrocarbons and natural gas in some areas naturally influences the chemical characteristics of the groundwater within the interface aquifer (HDR, 2022).

There has not been any detected, or reported, impact on groundwater resources in the area as a result of the landfill (HDR, 2022). Since monitoring began, this has been confirmed by ongoing groundwater quality monitoring at the Site. In accordance with the Environmental Monitoring Plan, groundwater is monitored semi-annually in the spring and fall (HDR, 2022). Groundwater compliance is assessed based on criteria calculated with respect to the MECP's Guideline B-7 Reasonable Use Concept and evaluated at the Site boundaries (HDR, 2022). Since the beginning of the monitoring, the quality of the groundwater within each hydrostratigraphic unit has been acceptable.

Based on the Hydrogeology Existing Conditions Report completed by RWDI, groundwater monitoring wells were installed and utilized to evaluate impacts from landfill leachate to the subsurface groundwater (2025a). Each hydrostratigaphic unit was analyzed and was not shown to be negatively impacted by either the landfill operations or leachate (RWDI, 2025a). Additionally, groundwater quality was also acceptable to groundwater users within the Off-Site Study Area and was shown to not be impacted by the TCEC operation. Existing leachate management practices have been in place within the Existing Landfill and have not indicated any adverse effects to nearby groundwater or surface water quality (RWDI, 2023).

4.3.3 Surface Water Quality

In the regional area, surface water typically flows from the northeast to the southwest in the direction of Lake St. Clair, which connects Lake Erie and Lake Huron at the Michigan-Ontario border (HDR, 2022). This region had numerous low-grade wetlands that had been produced historically and were drained at the turn of the century to improve agricultural practices.

Land use practices, including but not limited to soil erosion, have an effect on the majority of Lambton County's streams. This, in combination with the deficiency of natural vegetation to cradle these streams, has prompted poorer water quality that experiences both turbid water clarity and nutrient enhancement.

Aluminum (Al), iron (Fe), and zinc (Zn) are examples of trace metals that are bound to the suspended solids, mostly clays and silts, that enter the waterways. Waters receiving contributions from manure fertilizer (i.e., phosphorus and nitrogen) as well as suspended solids from erosion, effects runoff quality. As a result, the area's environmental baseline includes mineral- and nutrient-rich waters, and any influences from the landfill are compared to these reference conditions (HDR, 2022). In the vicinity of the TCEC, runoff and groundwater inputs to surface drainage are minimal. Interpretation of water quality results must factor in the intermittent and agricultural influenced nature of these waterways.

The Bear, Black, and Brown Creeks serve as the Sydenham River drainage system's headwaters, which include the TCEC. Bear Creek's definition and channel size expand downstream of the TCEC. Along its 11 km journey to the Sydenham River, the creek receives numerous small tributaries. The majority of the land use in the downstream area is agricultural land used for livestock and crop harvesting.

The headwaters of Brown Creek originate northeast of the TCEC. Along the eastern border of the southern half of the TCEC, Brown Creek runs south. Before joining the Sydenham River, Brown Creek travels 37.5 kilometers. The creek's first and second order tributaries appear to be channelized in large parts due to changes in drainage caused by previous agricultural practices. Continuous flow is typical in the Brown Creek section that runs parallel to the eastern portion of the TCEC.

Due to soil erosion, overland flow, and agricultural drainage from the surrounding land, the surface water is naturally turbid. As a result of the sediment load within the surface water, metal and nutrient concentrations within the surface water are naturally elevated. The concentrations of metals and nutrients, as well as the water's turbidity, typically rise after prolonged or intense precipitation events.

Since 2008, the development of the expansion landfill, site upgrades to safeguard the surface water were executed to additionally shield downstream conduits from runoff from the TCEC (HDR, 2022). These enhancements include four (4) stormwater management ponds and an extensive watercourse drainage network involving grasses, drainage ditches with rockcheck dams, numerous straw bale check dams, and drainage berms. In addition, as part of landfill cell expansion/construction needs, temporary water storage areas were developed.

The TCEC discharges surface water into the following areas: 1) Kersey Drain (Brown Creek) to the east; and 2) to drains and ditches associated with Bear Creek to the west. There are ten (10) monitoring stations situated surrounding the site (HDR, 2022).

When there are flowing conditions following a precipitation event, surface water sampling is initiated and completed quarterly. This sampling is dependent on precipitation events. Verification monitoring is initiated when there is an exceedance of a trigger concentration at one of the surface water monitoring compliance points.

Since 2003, TCEC has been monitoring the quality of the surface water. Since then, periodic site influences like the effects of soil erosion on surface water quality have been observed through monitoring. The discharge from the site has not been impacted by landfill leachate. Since monitoring began, acceptable surface water quality has been discharged from the site, as demonstrated by the chemical and biological monitoring program approved by MECP (HDR, 2022).

Surface water quality data was evaluated for the On-Site Study Area (existing landfill and expansion landfill) in the Surface Water Quality Existing Conditions Report completed by RWDI (2025b). Four (4) sedimentation ponds as well as on-site drainage features (e.g., ditches, swales), are used to manage the surface water at the TCEC (RWDI, 2025b). Runoff from the operational areas of the TCEC is managed by the sedimentation ponds. In 2022, field monitoring was completed to assess and evaluate potential impacts to surface water quality associated with automobile shredder reside (ASR) track-outs along the road allowance (RWDI, 2025b). It was identified that PAHs could potentially negatively affect off-site surface water quality near the TCEC.

However, based on the 2022 off-site temporary supplemental surface water monitoring program, PAH impacts were not found (RWDI, 2025b). Although surface water quality may deviate over time, this is primarily due to periods of construction activity that result in exposed soil surfaces and erosional effects (RWDI, 2025b). For additional details, please see the Surface Water Quality Existing Conditions Report prepared by RWDI (2025b).

4.4 Potential Changes since 2005 HHRA

An assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA was completed as part of the Existing Conditions assessment. The predicted concentrations of COCs in air in the year 2020 from the 2005 HHRA were compared to the data from the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports for air quality (**Table 4-4**).

There are a significant number of COCs not listed in the 2019, 2020, 2021,2022 and 2023 Annual Monitoring datasets as many of these are not included in standard monitoring regimes but can be theoretically modelled as was done for the 2005 HHRA. The data set also includes modelling and measurements from the Air Quality Report (RWDI, 2025c) for a more fulsome analysis. Monitoring results showing “ND” values in the table below indicate sampled COCs for which concentrations were below the analytical detection limit, while results showing “-” indicate these COCs were either not sampled and/or modelled.

Table 4-4. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2020 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2021 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2022 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2023 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	Maximum Concentration
Landfill Gases:	Landfill gases produced by decomposition of landfill wastes	1,1-Dichloroethane	2.09E-03[3]	ND	ND	ND	ND	ND	ND
		1,2-Dichloroethane	4.37E-03[3]	ND	ND	ND	ND	0.49	0.49
		Butan-2-ol	2.04E-02[1]	-	-	-	-	ND[7]	ND
		1,1,2-Trichloroethane	5.35E-04[3]	ND	ND	ND	ND	ND	ND
		1,1,2,2-Tetrachloroethane	5.94E-03[3]	ND	ND	ND	ND	ND	ND
		1,1-Dichloroethylene	1.96E-03[1]	ND	ND	ND	ND	ND	ND
		Methylene chloride	-	2.12	5.87	ND	ND	4.20	5.87
		Mercuric Chloride	1.90E-08[1]	-	-	-	-	-	-
		Methyl Mercury	1.90E-08[1]	-	-	-	-	-	-
		Methyl mercaptan	1.57E-01[1]	-	-	-	-	ND	ND
		Trichloroethylene	2.14E-03[3]	ND	0.70	ND	ND	0.97	0.97
		Bromodichloromethane	1.68E-02[3]	ND	ND	ND	ND	ND	ND
		Vinyl Chloride	5.62E-03[3]	0.41	ND	ND	ND	0.08	0.41
		Octane	1.75E-02[1]	-	-	-	-	ND[7]	ND
		Dimethylsulphide	1.08E-02[1]	-	-	-	-	ND	ND
		Ethylmercaptan	1.08E-02[1]	-	-	-	-	-	-
		Chloroethane	6.69E-03[3]	ND	ND	ND	ND	ND	ND
		Hydrogen sulphide – annual maximum	5.20E-01[2]	-	-	-	-	-	-
		Hydrogen sulphide – 1-hr maximum	2.33E+01[2]	-	-	-	-	-	-

Table 4-4. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2020 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2021 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2022 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2023 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	Maximum Concentration
		Hydrogen sulphide – 24-hr maximum	-	-	-	-	-	27[6]	27
		Benzene	4.34E-03[3]	0.83	0.70	1.12	0.38	0.54	1.12
Combustion Gases and Products of Incomplete Combustion	Landfill flare and leachate treatment options (evaporation/incineration)	Sulphur dioxide – annual maximum	1.31E+00[2]	-	-	-	-	3.4[6]	3.4
		Sulphur dioxide – 1-hr maximum	1.26E+02[2]	-	-	-	-	77[6]	77
		Sulphur dioxide – 24-hr maximum	2.50E+01[2]	-	-	-	-	2.0[6]	2.0
		Hydrogen chloride– annual maximum	8.34E-02[2]	-	-	-	-	-	-
		Hydrogen chloride– ½-hr maximum	9.23E+00[2]	-	-	-	-	-	-
		Hydrogen chloride– 24-hr maximum	1.61E+00[2]	-	-	-	-	-	-
		Nitrogen Oxides– annual maximum	9.91E-01[2]	-	-	-	-	-	-
		Nitrogen Oxides– 1-hr maximum	9.50E+01[2]	-	-	-	-	299[6]	299
		Nitrogen Oxides– 24-hr maximum	1.91E+01[2]	-	-	-	-	57[6]	57
		Benzo(a)pyrene	1.23E-09[3]	-	-	-	-	-	-
		Carbon dioxide – annual maximum	3.41E+03[2]	-	-	-	-	-	-

Table 4-4. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2020 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2021 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2022 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2023 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	Maximum Concentration
		Carbon dioxide – ½-hr maximum	3.77E+05[2]	-	-	-	-	-	-
		Carbon dioxide – 24-hr maximum	6.57E+04[2]	-	-	-	-	-	-
		Carbon monoxide – annual maximum	2.55E+00[2]	-	-	-	-	-	-
		Carbon monoxide – ½-hr maximum	2.82E+02[2]	-	-	-	-	-	-
		Carbon monoxide – 24-hr maximum	4.90E+01[2]	-	-	-	-	-	-
		Dioxin/Furans (TEQ)	-	-	-	-	-	0.02[6]	0.02
		2,3,7,8-TCDD (TEQ)[4]	2.48E-12[1]	-	-	-	-	-	-
		2,3,7,8-TCDD (TEQ)[5]	2.20E-12[1]	-	-	-	-	-	-
Particulate	Crustal sources (*i.e.*, soil) due to on- and off-site activities; contaminated soils; and various combustion sources including motor vehicle exhaust	Total Suspended Particulate (TSP)	-	588	263	134	347	211	588
		PM_{10} – Annual maximum	2.23E-01[2]	-	-	-	-	-	-
		PM_{10} – 24-hr maximum	4.30E+00[2]	-	-	-	-	103[6]	103
		$PM_{2.5}$ – Annual maximum	2.23E-01[2]	-	-	-	-	8.6[6]	8.6
		$PM_{2.5}$ – 24-hr maximum	4.30E+00[2]	-	-	-	-	29[6]	29
Metals	Leachate treatment option (evaporation/incineration)	Arsenic	1.05E-07[3]	ND	0.005	ND	ND	ND	0.005
		Cadmium	2.85E-07 [1]	ND	0.002	ND	ND	0.001	0.002
		Lead	3.32E-06[1]	0.029	0.119	0.036	0.01	0.091	0.119

Table 4-4. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2020 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2021 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2022 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	2023 Annual Monitoring Report (AQMR) Maximum Sampling Results (µg/m³)	Maximum Concentration
		Mercury	1.90E-08[1]	-	-	-	-	-	-
		Nickel	1.42E-06[1]	0.007	0.026	0.007	0.005	0.013	0.026

Source: Intrinsik Corp. (formerly Cantox Environmental), 2006; RWDI, 2020; 2021; 2022; 2023; 2025c; 2024.

ND Non-detect concentration. Monitoring results showing "ND" values in the table below indicate sampled COCs for which concentrations were below the analytical detection limit.

'-' Indicates these COCs were either not sampled and/or modelled.

1 Annual Ground-Level Air Concentrations of Non-Carcinogenic COPCs for each Future Operating Year at the Maximum Discrete Receptor Location (µg/m³) (RWDI, 2003a).

2 Predicted Emissions from Year 2020 for Ground-level Air Concentrations (µg/m³) of Combustion Gases and Particulate Matter (PM_{10} and $PM_{2.5}$) at the Maximum Residential Location under the Landfill Flare plus the Evaporation/Incineration Leachate Treatment Option.

3 70-year Annual Average Ground-Level Air Concentrations of all Carcinogenic COPCs at the Maximum Discrete Receptor.

4 Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare plus the evaporation/incineration treatment option.

5 Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare only scenario. In other words, the contribution from the evaporation/incineration treatment methods is excluded from these predictions.

6 Value is modelled from the 2025 Air Quality Existing Conditions Report (RWDI, 2025c).

7 The following compounds were not detected above 1ppbv via a library search: 1,2,3-Trimethylbenzene, 2-Methylhexane, 2-Methylpentane, 3-Methylpentane, 3-Methylhexane, 2-Methylbutane, Butyl Acetate, Decane, Limonene, m/p ethyl toluene, m-cymene, methyl cyclohexane, chlorodifluoromethane, n-butanal, nonane, o-ethyl toluene, propylbenzene, 2-butanol, pentane, and octane (RWDI, 2024).

Based on the above evaluation, there are a significant number of chemicals modelled in the 2005 HHRA for which monitoring was not (or could not be) conducted in the 2019, 2020, 2021,2022, and 2023 annual monitoring programs. As such, it is not possible to evaluate existing conditions, in comparison to the predicted modelled concentrations, for these chemicals. Additionally, many chemicals were measured at non-detect concentrations. As a result, these chemicals do not represent a potential risk to human health. Benzene, lead, nickel, and Total Suspended Particulate (TSP) had detected concentrations measured in the Air Quality Monitoring Program as part of the 2022 Annual Monitoring Report (RWDI, 2023). Benzene, cadmium, 1,2-dichloroethane, lead, methylene chloride, nickel, trichloroethylene, TSP, and vinyl chloride, had detected concentrations measured in the Air Quality Monitoring Program as part of the 2023 Annual Monitoring Report (RWDI, 2024). Total Suspended Particulate (TSP) was not modelled in the Original 2005 HHRA. Measured concentrations of benzene, cadmium, 1,2-dichloroethane, lead, nickel, trichloroethylene, and vinyl chloride from the Annual Monitoring Report were greater than the predicted emissions for ground-level air from the 2005 HHRA. However, when benzene, cadmium, 1,2-dichloroethane, lead, nickel, trichloroethylene and vinyl chloride were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the conclusions of the 2005 HHRA, the predicted risk for all of the chemicals were still orders of magnitude below the health-based benchmark (see **Section 4.5** below).

Ultimately, all COCs modelled in the 2005 HHRA have been evaluated in the current health effects assessment by at least one relevant exposure period so as to be able to flag any significant change in conditions that might impact overall conclusions on health outcomes related to the proposed project.

4.5 Toxicological Literature Changes and Expected Impact

A review of recent toxicological literature for changes to the exposure limits applied to COCs described in the 2005 HHRA, and to identify exposure limits for new COCs, was completed as part of the Existing Conditions assessment. Exposure limits used in the 2005 HHRA were compared to the current exposure limits to determine if there was a reduction in risk, an increase in risk, or no change in risk (**Table 4-5**). The current risks were also predicted using the current exposure limits and the expected impact on previous risk estimations.

Based on this evaluation, the only new COC to be flagged as a potential risk based on the modelled emissions for the 2005 HHRA was hydrogen sulphide due to an increase in inhalation risk estimate of about 21-fold. This resulted in a worst-case predicted CR of 3.3 or in other words a predicted concentration that is slightly higher than 3-fold above the 24-hour AAQC (regulatory value changed from 150 to 7 µg/m³).

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Combustion Gases						
Carbon Dioxide	Inhalation	RfC	214,000	*214,000*	→ assumed no change	0.016
		TLV-TWA	-	9,000	-	-
		TLV-STEL	-	54,000	-	-
Carbon Monoxide	Inhalation	RfC	3,140	*3,140*	→ assumed no change	0.00081
		15-min AQG	-	100,000	-	-
		1-hr AAQC	38,200	36,200	→ little change	0.0078
		8-hr AQG	-	15,700	-	-
		24-hr AAQC	15,700	4,000	↑ increase in inhalation risk estimate of about 4-fold	0.12
Hydrogen Chloride	Inhalation	RfC	20	*20*	→ assumed no change	0.0042
		1-hr AAQC	2,100	*2,100*	→ assumed no change	0.0044
		24-hr AAQC	20	20	→ no change	0.081
Hydrogen Sulphide	Inhalation	RfC	1	*1*	→ assumed no change	0.52
		1-hr AAQC	30	*30*	→ assumed no change	0.78
		24-hr AAQC	150	7	↑ increase in inhalation risk estimate of about 21-fold	**3.3**
NO_x	Inhalation	RfC	40	*40*	→ assumed no change	0.025
		1-hr AAC	400	200	↑ increase in inhalation risk estimate of about 2-fold	0.48
		24-hr AAQC	200	25	↑ increase in inhalation risk estimate of about 8-fold	0.76
		Annual AQG	-	10	-	-
SO_x	Inhalation	RfC	50	*50*	→ assumed no change	0.026
		10-minute AQG	-	500	-	-
		1-hr AQS	350	*350*	→ assumed no change	0.36
		24-hr AQS	125	40	↑ increase in inhalation risk estimate of about 3-fold	0.63

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Metals						
Arsenic	Inhalation	IUR	0.0043	0.00015	↓ reduction in risk estimate of about 29-fold	1.58E-11
	Oral	SF	0.0015	0.0095	↑ increase in risk estimate	9.98E-10
		RfD	0.3	0.12	↑ increase in oral risk estimate of about 2.5-fold	8.75E-07
Cadmium	Inhalation	IUR	0.0018	0.0098	↑ increase in risk estimate of about 5.5-fold	2.79E-09
		RfC	-	0.03	-	9.50E-06
	Oral	RfD	0.5	0.032	↑ increase in oral risk estimate of about 15-fold	8.91E-06
Lead	Inhalation	RfC	6.48	0.5	↑ increase in inhalation risk estimate of about 13-fold	6.64E-06
	Oral	RfD	1.85	None Selected	-	-
Mercury	Inhalation	RfC	0.301	0.09	↑ increase in inhalation risk estimate of about 3.3-fold	2.11E-07
	Oral	RfD	0.3 (Mercuric chloride)	0.3	→ no change	6.33E-08
	Sub-chronic Oral	RfD	NV	3	-	6.33E-09
Methyl Mercury	Oral	RfD	0.1	0.1	→ no change	1.90E-07
Nickel	Inhalation	IUR	0.00038	0.00024	↓ slight reduction in inhalation risk estimate	3.41E-10
		RfC	NV	0.06	-	2.37E-05
	Oral	RfD	20	2.8	↑ increase in oral risk estimate of about 7-fold	5.07E-07

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Particulate Matter						
TSP	NA	Annual AAQC (visibility)	60	60	→ no change	**4.4**
		24-hour AAQC (visibility)	120	120	→ no change	**2.2**
PM_{10}	Inhalation	Annual AQS	50	15	↑ increase in inhalation risk estimate of about 3.3-fold	0.015
		24-hour AAQC	50	45	→ little change	0.096
$PM_{2.5}$	Inhalation	Annual mean	15	8.8	↑ increase in inhalation risk estimate of about 1.7-fold	0.025
		24-hour WM	30	27	→ little change	0.16
Chlorinated Polycyclic Aromatics						
2,3,7,8-substituted TCDD	Inhalation	RfC	0.000035	0.000035[d]	→ no change	7.1E-08[e] 6.3E-08[f]
	Oral	RfD	0.00001	0.00001[d]	→ no change	2.48E-7[e] 2.20E-7[f]
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene (TEF)	Inhalation	IUR	0.087	0.0006	↓ reduction in inhalation risk estimate of about 145-fold	7.38E-13
		RfC	-	0.002	-	6.15E-07
	Oral	SF	0.0005	0.001	↑ increase in risk estimate	**1.23E-06**
		RfD	-	0.3	-	4.10E-09
		Sub-chronic RfD	-	5	-	2.46E-10
Benzo(a)pyrene (whole mixture model)	Inhalation	IUR	0.027	-	-	-
	Oral	SF	0.00028	-	-	-
	Dermal	q_1*	0.013	-	-	-

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Volatile Organic Compounds						
Benzene	Inhalation	IUR	0.0000077	0.0000022	↓ reduction in inhalation risk estimate of about 3.5-fold	9.55E-09
		RfC	1.7	30	↓ reduction in risk estimate	0.00015
	Oral	SF	0.000055	0.000085	↑ increase in risk estimate	3.69E-07
		RfD	3	4	↓ reduction in risk estimate	0.0011
Bromodichloromethane	Inhalation	IUR	0.000018	-	-	-
		RfC	70	-	-	-
	Oral	SF	0.000062	0.000062	→ no change	**1.04E-06**
		RfD	20	20	→ no change	0.00084
2-Butanol (1-butanol used as surrogate chemical)	Inhalation	RfC	9.1	*9.1*	→ assumed no change	0.0022
		24-hr AAQS	-	920	-	2.22E-05
	Oral	RfD	100	*100*	→ assumed no change	0.00020
Chloroethane	Inhalation	IUR	0.00000083	*0.00000083*	→ assumed no change	5.54E-09
		RfC	10,150	*10,150*	→ assumed no change	6.59E-07
		24-hr AAQS	-	5,600	-	1.19E-06
	Oral	SF	0.0000029	*0.0000029*	→ assumed no change	1.94E-08
		RfD	400	*400*	→ assumed no change	1.67E-05
1,1-Dichloroethane	Inhalation	IUR	0.0000016	-	-	-
		RfC	490	170	↑ increase in risk estimate of about 2.8-fold	1.23E-05
	Oral	SF	0.0000057	-	-	-
		RfD	100	40	↑ increase in oral risk estimate of about 2.5-fold	5.23E-05
		Sub-chronic RfD	-	400	-	5.23E-06

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
1,2-Dichloroethane	Inhalation	IUR	0.0000024	0.000026	↑ increase in risk estimate	1.14E-07
		RfC	4.9	400	↓ reduction in risk estimate	1.09E-05
	Oral	SF	0.00000833	0.000091	↑ increase in risk estimate	3.98E-07
		RfD	30	20	↑ increase in oral risk estimate of about 1.5-fold	0.00022
		Sub-chronic RfD	-	200	-	2.19E-05
1,1-Dichloroethylene	Inhalation	RfC	200	200	→ no change	9.80E-06
		Sub-chronic RfC	-	79.3	-	2.47E-05
	Oral	RfD	50	50	→ no change	3.92E-05
Dimethyl sulphide	Inhalation	RfC	875	*875*	→ assumed no change	1.23E-05
	Oral	RfD	250	*250*	→ assumed no change	4.32E-05
Ethyl mercaptan (methyl mercaptan used as a surrogate)	Inhalation	RfC	2.0	*2.0*	→ assumed no change	5.41E-03
	Oral	RfD	0.57	*0.57*	→ assumed no change	0.019
Methyl mercaptan	Inhalation	RfC	2.0	*2.0*	→ assumed no change	7.87E-02
	Oral	RfD	0.57	*0.57*	→ assumed no change	0.28
Methylene chloride	Inhalation	IUR	0.00000047	0.000000023	↓ reduction in inhalation risk estimate of about 20.5-fold	4.37E-16
		RfC	-	400	-	4.75E-11
		Sub-chronic RfC	-	400	-	4.75E-11
	Oral	SF	0.0000075	0.000002	↓ reduction in oral risk estimate of about 3.75-fold	3.80E-14
		RfD	60	6	↑ increase in oral risk estimate of about 10-fold	3.17E-09
Octane	Inhalation	RfC	18,410	*18,410*	→ assumed no change	9.51E-07
	Oral	RfD	5,000	*5,000*	→ assumed no change	3.50E-06

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
1,1,2,2-Tetrachloroethane	Inhalation	IUR	0.00000833	-[b]	-	-
	Oral	SF	0.00000833	0.0002	↑ increase in risk estimate	**1.19E-06**
		RfD	-	20	-	0.00030
		Sub-chronic RfD	-	500	-	1.19E-05
1,1,2-Trichloroethane	Inhalation	IUR	0.000016	0.000016	→ no change	8.56E-09
	Oral	SF	0.000057	0.000057	→ no change	3.05E-08
		RfD	4	4	→ no change	0.00013
		Sub-chronic RfD	-	40	-	1.34E-05
Trichloroethylene	Inhalation	IUR	0.00011	0.0000041	↓ reduction in inhalation risk estimate of about 28-fold	8.77E-09
		RfC	35	2	↑ increase in inhalation risk estimate of about 17-fold	0.0011
	Oral	SF	0.0004	0.000046	↑ increase in oral risk estimate of about 9-fold	9.84E-08
		RfD	0.3	0.5	↓ reduction in risk estimate	0.0043
Vinyl chloride	Inhalation	IUR	0.0000088	0.0000088[c]	→ no change	4.95E-08
		RfC	102	60	↑ increase in risk estimate of about 1.7-fold	9.37E-05
	Oral	SF	0.0014	0.0014	→ no change	**7.87E-06**
		RfD	3	3	→ no change	0.0019

Table 4-5. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)

Note: IUR values in the original 2005 HHRA were presented in $(\mu g/kg/d)^{-1}$. For comparison purposes, these were converted to $(\mu g/m^3)^{-1}$ values by multiplying by (20/70).
Italicized current exposure limits were assumed to be the same as the exposure limit used in original 2005 HHRA (Cantox).
Bolded values were identified to exceed a value of 1.0 for CRs/ERs or a value of 1 in a million-cancer risk (ILCRs)
NV No value selected.
[a] Units: Reference Concentration (RfC): µg/m³; Reference Dose (RfD): µg/kg/day; Inhalation Unit Risk (IUR): $(\mu g/m^3)^{-1}$; Oral Slope Factor (SF): $(\mu g/kg/day)^{-1}$.
[b] MECP (2022) endorsed the US EPA IRIS (1994) IUR of 5.8x10-5 (µg/m³)-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. Therefore, it was not considered appropriate to adopt the MECP (2022) endorsed IUR for 1,1,2,2-tetrachloroethane for the assessment.
[c] The US EPA IRIS (2000) established two distinct unit risk values for vinyl chloride – one protective of exposure during adulthood (i.e., 4.4x10-6 per µg/m³) and one protective of exposure from birth (i.e., 8.8x10-6 per µg/m³). MOE (2011) has selected the child-specific unit risk value as their recommended value to be protective of all sensitive members of the population in the derivation of the generic site conditions standards. However, as the current assessment is evaluating the potential long-term health risks to the adult worker under a commercial exposure scenario, the adult-specific US EPA unit risk value was selected.
[d] An updated exposure limit was not available. Therefore, the exposure limit used in the Cantox HHRA (2005) was selected.
[e] Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare plus the evaporation/incineration treatment option.
[f] Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare only scenario. In other words, the contribution from the evaporation/incineration treatment methods is excluded from these predictions.
[g] Updated risk predictions were based on the current exposure limits as well as the Year 2020 Predicted Emissions for Ground-level Air Concentrations from the original 2005 HHRA.

5 Description of Existing Conditions

An evaluation of potential health effects was conducted in 2005 for the proposed expansion of the Warwick Landfill in the form of a detailed HHRA by Cantox Environmental Inc. (now Intrinsik Corp.). A review of the assumptions made in the 2005 HHRA was completed and based on this review, the assumptions previously used in the 2005 HHRA are still valid, and therefore, the results of the assessment remain valid.

Updated risks were predicted based on revised exposure limits from a toxicological literature search. Based on the expected impact on previous risk estimations compared to the exposure limits used in the 2005 HHRA (Table 4-5), a number of chemicals resulted in predicting an increase in inhalation or oral risk estimate.

However, annual concentration ratio (CR) values predicted for chronic exposures to all combustion gases (i.e., CO_2, CO, SO_2, NOx and HCl) were predicted to be within acceptable levels (i.e., all CR values were less than one) (Intrinsik, 2005). This suggests that no measurable long-term adverse health impacts were predicted to result from landfill combustion gas emissions.

Additionally, all ½-hour and 1-hour CR values calculated at the maximum fence-line location were predicted to be less than a value of 1.0 (Intrinsik, 2005). Therefore, no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases, with the exception of the 24-hour hydrogen sulphide CR value which had an increase in inhalation risk estimate of about 21-fold compared to the 2005 HHRA.

Although there is a potential risk to human health from hydrogen sulphide due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. Hydrogen sulphide was measured as part of the 2025 Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023 (RWDI, 2025c). The H_2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H_2S and TRS are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H_2S and TRS from landfill operations at all discrete receptors and the property boundary are low (RWDI, 2025c). Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H_2S and TRS concentrations are below detection and elevated concentrations of H_2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour (RWDI, 2025c). The 2025 Air Quality Existing Conditions Report has recommended that WM should continue to manage emissions of landfill gas by routine maintenance of the final cap and interim cover areas (RWDI, 2025c).

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location, and the level of conservatism used in the HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was predicted to be extremely low in the original 2005 HHRA.

The dominant source of PM at this site was predicted to be crustal (i.e., soil, dirt particles), as opposed to combustion-related, which has a markedly lower toxicity. Air concentrations of PM_{10} and $PM_{2.5}$ were modeled using very conservative assumptions, and as a result are likely to be overestimated. The PM guidelines applied in this assessment were based on epidemiology literature related to adverse health outcomes associated with exposure to combustion-related PM, and as such, they are highly conservative benchmarks for this site. No exceedances were predicted on an annual average basis for either PM_{10} or $PM_{2.5}$. The degree of, and frequency of exceedance over these PM guidelines for 24-hr time frames for $PM_{2.5}$ were predicted to be extremely small (less than 1.3 times the guidelines, for less than 1 day/year in Year 6), and were restricted to only a very small area near the facility. The degree of, and frequency of, exceedance over guidelines for 24-hr time frames for PM_{10} was slightly greater than those predicted for $PM_{2.5}$, but still not considered to represent a health concern due to the characteristics of the PM present at this site.

As mentioned in **Section 4.2.1**, as part of the Annual Monitoring Programs, concentrations of total suspended particulate (TSP) exceeded the MECP Ambient Air Quality Criteria (AAQC) of 120 µg/m³ in numerous samples 2019 to 2022. For each TSP exceedance, watering activities for dust control purposes, including watering on-site roadways and construction sites occurred (RWDI, 2023). Measured metal concentrations were consistently below the applicable criteria in the 2019 to 2022 Annual Monitoring Reports (RWDI, 2020; 2021; 2022; 2023). Concentrations of VOCs from 2019, 2020, 2021, and 2022 Annual Monitoring Programs were quite low and less than their respective air quality standards (RWDI, 2020; 2021; 2022; 2023).

The majority of ILCR values calculated for both inhalation and oral risk were below the 1 in a million-cancer risk with the exception of benzo(a)pyrene (TEF) (SF of 1.23E-06), bromodichloromethane (SF of 1.04E-06), 1,1,2,2-trichloroethane (SF of 1.19E-06), and vinyl chloride (SF of 7.87E-06). The measured concentrations of bromodichloromethane and 1,1,2,2-trichloroethane as part of the annual monitoring programs has been below detection in all samples across all five years. The maximum concentration of vinyl chloride was measured at 0.41 µg/m³ in the 2019 annual monitoring program, was below detection in 2020, 2021 and 2022, and was measured at 0.08 µg/m³ in 2023. As such, risks associated with bromodichloromethane, 1,1,2,2-trichloroethane and vinyl chloride are anticipated to be minimal. We have no current measured or modelled data for benzo(a)pyrene. However, original modelling from the 2005 HHRA was likely related to diesel vehicle emissions and the specifically from the landfill itself.

Based on the review of results from the recent annual monitoring programs, the review of existing conditions for air quality, groundwater quality and surface quality, and the review of assumptions as well as the conclusions from the 2005 HHRA, no measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case hydrogen sulphide concentrations, under existing conditions.

It is recommended that polycyclic aromatic hydrocarbons, using benzo(a)pyrene as a surrogate, be added to the suite of chemicals being monitored in future air quality sampling events.

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APPENDIX A

SUMMARY OF EXPOSURE LIMITS FOR HUMAN RECEPTORS

A-1.0 SUMMARY OF EXPOSURE LIMITS FOR HUMAN RECEPTORS

The following table provides a summary of the exposure limits used in the original Cantox (2005) HHRA as well as the updated exposure limits used in the current Existing Conditions assessment. The updated exposure limits are identified with the light green row shading. IUR values in the original Cantox (2005) were also presented as q_1^* with $(\mu g/kg/d)^{-1}$ units. These are presented in the table below and were converted to $(\mu g/m^3)^{-1}$ units by multiplying by (20/70) to facilitate comparison to the updated IUR benchmarks.

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Combustion Gases						
Carbon Dioxide	Inhalation	RfC	0.0000214	Asphyxiation	-	-
Carbon Monoxide	Inhalation	RfC	3,140	Health effects	Not specified	Calculated from MOE, 2001
		1-hr AAQC	30,820			Calculated from MOE, 2001
		24-hr AAQC	15,700			MOE, 2001
Hydrogen Chloride	Inhalation	RfC	20	Mild hyperplasia of the nasal, tracheal and laryngeal mucosa	Albert *et al.*, 1982; Sellakumar, 1985	U.S. EPA, 1995a
		1-hr AAQC	2,100	Upper respiratory symptoms (humans)	Stevens *et al.*, 1992	Cal EPA, 2000a
		24-hr AAQC	20	Health effects	Not specified	MOE, 2001
Hydrogen Sulphide	Inhalation	RfC	1.0	Inflammation of the nasal mucosa (mice)	CIIT, 1983	U.S. EPA, 1995b
		1-hr AAQC	30	Odour effects	Not specified	MOE, 2001
		24-hr AAQC	150	Eye irritation (humans)	Savolainen, 1982	WHO, 2000
Hydrogen Sulphide	Inhalation	24-hr AAQC	7	Health effects	Not specified	MECP, 2020
NO_x	Inhalation	RfC	40	Respiratory effects	Numerous; weight of evidence assessment	WHO, 1997
		1-hr AAC	400	Health effects	Not specified	MOE, 2001
		24-hr AAQC	200	Health effects	Not specified	MOE, 2001
NOx	Inhalation	1-hr AAQC	200	Health effects	Not specified	MECP, 2020
		24-hr AAQC	25	Health effects	Not specified	MECP, 2020
SO_x	Inhalation	RfC	50	Respiratory effects in asthmatics	Numerous; weight of evidence assessment	WHO, 1987
		1-hr AQS	350	Changes in lung function is asthmatics	Not specified	WHO, 1987
		24-hr AQS	125	Exacerbation of respiratory symptoms in sensitive individuals	Not specified	WHO, 1987; 2000
SOx	Inhalation	24-hr AQS	40	Health effects	Not specified	MECP, 2020
Metals						
Arsenic	Inhalation	IUR	0.0043 (0.015 per µg/kg/d)	Lung tumours (human)	Brown and Chu, 1983a,b,c; Lee-Feldstein, 1983; Higgins, 1982; Enterline and Marsh, 1982	U.S. EPA, 1995c

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
	Oral	SF	0.0015	Vascular and dermal effects (rats)	Tseng, 1977; Tseng *et al.*, 1968	U.S. EPA, 1995c
		RfD	0.3	Hyperpigmentation, keratosis, and possible vascular complications	Tseng, 1977; Tseng *et al.*, 1968	U.S. EPA, 1995c
Arsenic	Inhalation	IUR	0.00015	Occupational lung cancer	Based on occupational exposure studies on the Tacoma smelter cohort (Enterline et al., 1995), the Swedish Ronnskar smelter cohort (Jarup et al., 1989; Viren and Silvers, 1994), and the Montana cohort (Lubin et al., 2000; 2008)	MOECC, 2017; TCEQ, 2012
	Oral	SF	0.0095	Lung and bladder cancer prevalence (humans)	Based on meta-analysis of epidemiological studies evaluating chronic environmental exposure (drinking water) to arsenic in Southwestern Taiwan (Chen et al., 1985; 1988); Cordoba, Argentina (Hopenhayn-Rich et al., 1996; 1998); and Chile (Smith et al., 1998)	Cal EPA, 2004
		RfD	0.12	Cerebrovascular disease (humans)	Chiou et al., 1997	MOECC, 2017; Cal EPA, 2004
Cadmium	Inhalation	IUR	0.0018 (0.0063 per µg/kg/d)	Cancer mortality (humans)	Thun *et al.*, 1985	U.S. EPA, 1991d
	Oral	RfD	0.5	Proteinuria from drinking water exposure (humans)	U.S. EPA, 1985a	U.S. EPA, 1991d
Cadmium	Inhalation	IUR	0.0098	Lung tumours (rats)	Takenaka *et al.*, 1983; Oldiges *et al.*, 1984	MOE, 2011; HC, 1996
		RfC	0.03	Not provided	Not provided	MOE, 2011
	Oral	RfD	0.032	Kidney effects (humans)	Buchet *et al.*, 1990	MOE, 2011
Lead	Inhalation	RfC	6.48 (1.85 µg/kg/d)	Subclinical neurobehavioural and developmental effects in children	Not specified	MOE, 1996
	Oral	RfD	1.85			
Lead	Inhalation	Risk-specific does (provisional)	0.5	Neuro-developmental Toxicity (cognitive function)	EFSA, 2013 (based on Lanphear et al., 2005)	Health Canada, 2021
Elemental Mercury	Inhalation	RfC	0.301 (0.086 µg/kg/d)	CNS and neurobehavioural effects (humans)	Fawer *et al.*, 1983; Piikivi and Tolonen, 1989; Piikivi and Hanninen, 1989; Piikivi,1989; Ngim *et al.*, 1992; Liang *et al.*, 1993	U.S EPA, 1995e
Mercury	Inhalation	RfC	0.09			MOE, 2011
	Oral	RfD	0.3	Autoimmune effects (rats)	Druet *et al.*, 1978; Bernaudin *et al.*, 1981; Andres, 1984; US EPA, 1987	MOE, 2011; U.S. EPA, 1995e
	Sub-Chronic Oral	RfD	3	Not provided	Not provided	MOE, 2011; modified from U.S. EPA, 1995e

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit Type	Exposure Limit Value[a]	Endpoint	Study	Reference
Mercuric Chloride	Oral	RfD	0.3	Autoimmune effects	U.S. EPA, 1987	U.S. EPA, 1995f
Methyl Mercury	Oral	RfD	0.1	Developmental neuropsychological impairment (humans)	Grandjean *et al*., 1997; Budtz-Jurgensen *et al*., 1999	U.S. EPA, 2001
Nickel	Inhalation	IUR	0.00038 (0.00133 per µg/kg/d)	Lung cancer (humans)	Andersen, 1992; Andersen *et al*., 1996; Doll *et al*., 1977; Chovil *et al*.,1981; Magnus *et al*., 1982.	WHO, 2000
	Oral	RfD	20	Decreased body and organ weights	Ambrose *et al*., 1976	U.S. EPA, 1991a
Nickel	Inhalation	IUR	0.00024	Lung cancer (occupational study)	Chovil *et al.,* 1981; Enterline and Marsh, 1982; Peto *et al*., 1984; Magnus *et al*., 1982	MOE, 2011; U.S. EPA, 1991a
		RfC	0.06	Not provided	Not provided	MOE, 2011; modified from TERA 1999
	Oral	RfD	2.8	Post-implantation/perinatal mortality (rats)	SLI, 2000a; SLI, 2000b	MECP, 2019; EFSA, 2015
Particulate Matter						
TSP	NA	Annual AAQC	60	Visibility/soiling	not cited	MOE, 2001
	NA	24-hour AAQC	120	Visibility/soiling	not cited	MOE,2001
PM_{10}	Inhalation	Annual AQS	50	health effects (respiratory/cardiac)	Multiple epidemiology studies	U.S. EPA, 1997
	Inhalation	24-hour AAQC	50	health effects (respiratory/cardiac)	Multiple epidemiology studies	MOE, 2001
PM_{10}	Inhalation	Annual AQS	15	Health effects	Not specified	MECP, 2020
	Inhalation	24-hour AAQC	45	Health effects	Not specified	MECP, 2020
$PM_{2.5}$	Inhalation	Annual mean	15	health effects (respiratory/cardiac)	Multiple epidemiology studies	U.S. EPA, 1997
	Inhalation	24-hour WMCC	30	health effects (respiratory/cardiac)	Multiple epidemiology studies	WMCCDCPMO,1999
$PM_{2.5}$	Inhalation	Annual mean	8.8	Health effects	Not specified	MECP, 2020
	Inhalation	24-hour WMCC	27	Health effects	Not specified	MECP, 2020
Chlorinated Polycyclic Aromatics						
2,3,7,8-substituted TCDD	Inhalation	RfC	0.000035 (0.00001 µg/kg/d)	Reproductive dysfunction	Murray *et al*., 1979	MOE, 1996
	Oral	RfD	0.00001			
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene (TEF)[b]	Inhalation	IUR	0.087 (0.3 per µg/kg/d)	Increased cancer risk (humans)	Numerous studies	WHO, 2000
	Oral	SF	0.0005	Squamous cell papillomas and carcinomas in mice	Neal & Rigdon, 1967	WHO, 1998a
Benzo(a)pyrene (Whole Mixture Model)	Inhalation	IUR	0.027 (0.095 per	Tumors (rodents; humans)	Numerous studies	MOE, 1997; personal communication with

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit Type	Exposure Limit Value[a]	Endpoint	Study	Reference
			µg/kg/d)			MOE
	Oral	SF	0.00028	Route extrapolation (in accordance with MOE)	-	MOE, 1997; personal communication with MOE
	Dermal	SF	0.013	Route extrapolation (in accordance with MOE)	-	MOE, 1997; personal communication with MOE
Benzo(a)pyrene	Oral	RfD	0.3	Neurodevelopmental effects and neurobehavioural changes	HC DW, 2016; US EPA IRIS, 2017	MECP, 2019; US EPA, 2017
		Sub-chronic RfD	5.0	Kidney abnormalities in males (rats)	Knuckles et al., 2001	MECP, 2019; modified Cal EPA DW, 2010
		SF	0.001	Increase in alimentary tract tumours (forestomach, esophagus, tongue, larynx) (mouse)	Beland & Culp, 1998;	MECP, 2019; US EPA, 2017; Kalberlah et al., 1995
	Inhalation	RfC	0.002	Decreased embryo/fetal survival (rats)	Archibong et al., 2002	MECP, 2019; US EPA, 2017
		IUR	0.0006	Respiratory tract and pharynx tumours (hamsters)	Thyssen *et al.,* 1981	MECP, 2019; US EPA, 2017; Kalberlah et al., 1995
Volatile Organic Compounds						
Benzene	Inhalation	IUR	0.0000077 (0.000027 per µg/kg/d)	Leukemia (humans)	Rinsky *et al.*, 1981, 1987; Paustenbach *et al.*, 1993; Crump and Allen, 1984; Crump, 1994; U.S. EPA, 1998	U.S. EPA, 2003
		RfD	1.7	Not specified	NCEA value	U.S. EPA Region IX, 2002
	Oral	SF	0.000055	Leukemia (humans)	Rinsky *et al.*, 1981, 1987; Paustenbach *et al.*, 1993; Crump, 1994; U.S. EPA, 1998, 1999	U.S. EPA, 2003
		RfD	3	Not specified	NCEA value	U.S. EPA Region IX, 2002
Benzene	Oral	SF	0.000085	Not provided	Not provided	MOE, 2011
		RfD	4	Decreased lymphocyte cell count (occupational exposure)	Rothman *et al.,* 1996	MOE, 2011; US EPA IRIS, 2003
	Inhalation	IUR	0.0000022	Leukemia (occupational exposure)	Rinsky *et al.*, 1981; 1987; Paustenbach *et al.*, 1993; Crump and Allen, 1984; Crump, 1994	MOE, 2011; US EPA, 2000a
		RfC	30	Decreased lymphocyte cell count (occupational exposure)	Rothman *et al.*, 1996	MOE, 2011; US EPA, 2003
Bromodichloromethane	Inhalation	IUR	0.000018 (0.000062 per µg/kg/d)	Route extrapolation by U.S. EPA	-	U.S. EPA Region IX, 2002
		RfC	70 (20 µg/kg/d)	Route extrapolation by U.S. EPA	-	U.S. EPA Region IX, 2002

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
	Oral	SF	0.000062	Tubular cell adenoma and adenocarcinoma	NTP, 1987	U.S. EPA, 1993
		RfD	20	Renal effects	NTP, 1986	U.S. EPA, 1993
Bromodichloromethane	Oral	SF	0.000062	Kidney tumours (mice)	NTP, 1987a	MOE, 2011; US EPA, 1993
		RfD	20	Kidney and liver lesions (mice)	NTP, 1986; 1987a	MOE, 2011; US EPA, 1991; ATSDR, 1989
2-Butanol (1-butanol used as surrogate chemical)	Inhalation	RfC	9.1 (2.6 µg/kg/d)	Not specified	NCEA value	U.S. EPA Region IX, 2002
	Oral	RfD	100	Hypoactivity and ataxia in rats	U.S. EPA, 1986	U.S. EPA, 1991b
Chloroethane	Inhalation	IUR	0.00000083 (0.0000029 per µg/kg/d)	Route extrapolated (by U.S. EPA Region IX)	-	U.S. EPA Region IX, 2002
		RfC	10,150 (2,900 µg/kg/d)	Delayed fetal ossification	Scortichini *et al.*, 1986	U.S. EPA, 1991c
	Oral	SF	0.0000029	Not specified	NCEA value	U.S. EPA Region IX, 2002
		RfD	400	Not specified	NCEA value	U.S. EPA Region IX, 2002
1,1-Dichloroethane	Inhalation	IUR	0.0000016 (0.0000057 per µg/kg/d)	Route extrapolation by Cal EPA	-	U.S. EPA Region IX, 2002
		RfC	490 (140 µg/kg/d)	Not specified	HEAST value	U.S. EPA, Region IX, 2002
	Oral	SF	0.0000057	Mammary gland adenocarcinoma (in rats)	NCI, 1977	U.S. EPA Region IX, 2002
		RfD	100	Not specified	HEAST value	U.S. EPA, Region IX, 2002
1,1-Dichloroethane	Oral	RfD	40	Kidney damage (cats)	Hoffman *et al.* 1971	MOE, 2011; modified from Cal EPA, 2003
		Sub-chronic RfD	400	Kidney damage (cats)	Hoffman *et al.* 1971	MOE, 2011; Cal EPA, 2003
	Inhalation	RfC	170	Kidney damage (cats)	Hoffman *et al.* 1971	MOE, 2011
1,2-Dichloroethane	Inhalation	IUR	0.0000024 (0.00000833 per µg/kg/d)	Route extrapolation (by WHO)	-	WHO, 1998b
		RfC	4.9 (1.4 µg/kg/d)	Not specified	NCEA value	U.S. EPA, Region IX, 2002
	Oral	SF	0.00000833	Various tumours in rats and mice	NCI, 1978a	WHO, 1998b
		RfD	30	Not specified	NCEA value	U.S. EPA, Region IX, 2002

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Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
1,2-Dichloroethane	Oral	SF	0.0000091	Hemangiosarcomas (rats)	NCI, 1978a	MOE, 2011; US EPA, 1991d
		RfD	20	Not provided	Not provided	MOE, 2011; modified from ATSDR, 2001
		Sub-chronic RfD	200	Increased absolute and relative kidney weights (rats and mice)	NTP, 1991	MOE, 2011; ATSDR, 2001
	Inhalation	IUR	0.000026	Route extrapolation from US EPA IRIS (1991) oral carcinogenicity assessment	NCI, 1978	MOE, 2011; US EPA, 1991d
		RfC	400	Hepatotoxicity (elevated liver enzyme levels in serum of rats)	Spreafico *et al.*, 1980	MOE, 2011; Cal EPA, 2000a
1,1-Dichloroethylene	Inhalation	RfC	200 (57.1 µg/kg/d)	Liver toxicity (fatty changes in rats)	Quast *et al.*, 1986	U.S. EPA, 2002
	Oral	RfD	50	Liver toxicity (fatty changes in rats)	Quast *et al.*, 1983	U. S. EPA, 2002
1,1-Dichloroethylene	Oral	RfD	50	Hepatocellular mid-zonal fatty changes (rats)	Quast *et al.*, 1983	MOECC, 2017; US EPA, 2002; WHO CICAD, 2003
	Inhalation	RfC	200	Fatty changes in liver (rats)	Quast *et al.*, 1986	MOECC, 2017; US EPA, 2002; WHO CICAD, 2003
		Sub-chronic RfC	79.3	Hepatic effects in guinea pigs	Prendergast *et al.* 1967	MOE, 2011, ATSDR 1994
Dimethyl sulphide	Inhalation	RfC	875 (250 µg/kg/d)	Route extrapolation (by Cantox)	-	Derived "*de novo*" from primary literature
	Oral	RfD	250	Increased thyroid weight	Butterworth *et al.*, 1974	Derived "*de novo*" from primary literature
Ethyl mercaptan (methyl mercaptan used as a surrogate)	Inhalation	RfC	2.0 (0.57 µg/kg/d)		NCEA value	U.S. EPA Region IX, 2002
	Oral	RfD	0.57	Route extrapolation (by U.S. EPA)	-	U.S. EPA Region IX, 2002
Methyl mercaptan	Inhalation	RfC	2.0 (0.57 µg/kg/d)		NCEA value	U.S. EPA Region IX, 2002
	Oral	RfD	0.57	Route extrapolation (by U.S. EPA)	-	U.S. EPA Region IX, 2002
Methylene chloride	Inhalation	IUR	0.00000047 (0.00000165 per µg/kg/d)	Combined adenomas and carcinomas	NTP, 1986b	U.S. EPA, 1991e
	Oral	SF	0.0000075	Hepatocellular adenomas or carcinomas (NTP) and hepatocellular cancer and neoplastic nodules (NCA)	NTP, 1986b; NCA, 1983	U.S. EPA, 1991e
		RfD	60	Liver toxicity	NCA, 1982	U.S. EPA, 1991e

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Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Methylene chloride	Oral	SF	0.000002	Hepatocellular carcinomas or adenomas (mice)	Serota *et al.*, 1986b	US EPA, 2011a
		RfD	6	Hepatic effects (hepatic vacuolation, liver foci) (rats)	Serota *et al.*, 1986a	US EPA, 2011 a
	Inhalation	IUR	0.000000023	Not available	Not available	MOE, 2011
		RfC	400	Significantly elevated carboxyhemoglobin levels (> 2%) (occupational exposure)	DiVincenzo and Kaplan, 1981	MOE, 2011; Cal EPA 2000b
		Sub-chronic RfC	400	Significantly elevated carboxyhemoglobin levels (> 2%) (occupational exposure)	DiVincenzo and Kaplan, 1981	MOE, 2011; Cal EPA 2000b
Octane	Inhalation	RfC	18,410 (5,260 µg/kg/d)	Neurotoxicity	Edwards *et al.*, 1997	CCME, 2000
	Oral	RfD	5,000	Neurotoxicity	Edwards *et al.*, 1997	CCME, 2000
1,1,2,2- Tetrachloroethane	Inhalation	IUR	0.00000238 (0.00000833 per µg/kg/d)	Route extrapolation (by WHO)	-	WHO, 1998c
	Oral	SF	0.00000833	Hepatocellular carcinoma (mice)	NCI, 1978b	WHO, 1998c
1,1,2,2-Tetrachloroethane	Oral	SF	0.0002	Hepatocellular carcinoma (mice)	NCI, 1978b	MOE, 2011; US EPA, 2010
		RfD	20	Increased relative liver weight (rats)	NTP, 2004	US EPA, 2010
		Sub-chronic RfD	500	Increased relative liver weights (rats)	NTP, 2004	MOE, 2011; ATSDR, 2008
	Inhalation	IUR	-[b]	-	-	-
1,1,2-Trichloroethane	Inhalation	IUR	0.000016 (0.000056 per µg/kg/d)	Route extrapolation (by U.S. EPA)	-	U.S. EPA,1991f
	Oral	SF	0.000057	Hepatocellular carcinoma (mice)	NCI, 1978c	U.S. EPA, 1991f
		RfD	4	Clinical serum chemistry	Sanders *et al.*, 1985; White *et al.*, 1985	U.S. EPA, 1991f
1,1,2-Trichloroethane	Oral	SF	0.000057	Hepatocellular carcinomas (mice)	NCI, 1978c	MOE 2011; US EPA,1994
		RfD	4	Clinical serum chemistry changes as indicator of liver effects (mice)	Sanders *et al.*, 1985; White *et al.*, 1985	MOE 2011; US EPA, 1995g
		Sub-chronic RfD	40	Not provided	Not provided	MOE 2011; modified from US EPA, 1995g
	Inhalation	IUR	0.000016	Hepatocellular carcinomas (mice)	NCI, 1978c	MOE 2011; US EPA, 1994

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Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Trichloroethylene	Inhalation	IUR	0.00011 (0.0004 per µg/kg/d)	Not specified	NCEA value	U.S. EPA Region IX, 2002
		RfC	35 (10 µg/kg/d)	Not specified	NCEA value	U.S. EPA Region IX, 2002
	Oral	SF	0.0004	Not specified	NCEA value	U.S. EPA Region IX, 2002
		RfD	0.3	Not specified	NCEA value	U.S. EPA Region IX, 2002
Trichloroethylene	Oral	SF	0.000046	Kidney cancer risk (occupational exposure)	Charbotel *et al.*, 2006	MOECC, 2017; US EPA, 2011b
		RfD	*0.5*	*Decreased thymus weight (mice), decreased plaque-forming cell (PFC) response and increased delayed-type hypersensitivity (mice), increased fetal cardiac malformations (rats)*	*Keil et al., 2009; Peden-Adams et al., 2006; Johnson et al., 2003*	*MOECC, 2017; US EPA, 2011b; ATSDR, 2013*
	Inhalation	IUR	0.0000041	Kidney cancer risk (occupational exposure)	Charbotel *et al.*, 2006	MOECC, 2017; US EPA, 2011b
		RfC	*2*	*Decreased thymus weight (mice), increased fetal cardiac malformations (rats)*	*Keil et al., 2009; Johnson et al., 2003*	*MOECC, 2017; US EPA, 2011b; ATSDR, 2013*
Vinyl chloride	Inhalation	IUR	0.00000088 (0.000031 per µg/kg/d)	Liver tumors (rats) – Continuous lifetime exposure from birth	Maltoni *et al.*, 1981, 1984	U.S. EPA, 2000b
		RfC	102 (29 µg/kg/d)	Liver cell polymorphisms (rats) – route extrapolation	Til *et al.*, 1983, 1991	U.S. EPA, 2000b
	Oral	SF	0.0014	Liver tumors (rats) – Continous lifetime exposure from birth	Feron *et al.*, 1981	U.S. EPA, 2000b
		RfD	3	Liver cell polymorphisms (rats)	Til *et al.*, 1983, 1991	U.S. EPA, 2000b
Vinyl chloride	Oral	SF	0.0014	Liver angiosarcoma, hepatocellular carcinoma, and neoplastic nodules (rats)	Feron *et al.*, 1981	MOE, 2011; US EPA, 2000b
		RfD	3	Liver cell polymorphism (rats)	Til *et al.*, 1983; 1991	MOE, 2011; US EPA, 2000b; ATSDR, 2006
	Inhalation	IUR[c]	0.0000088	Liver angiosarcomas, angiomas, hepatomas, and neoplastic nodules (rats)	Maltoni *et al.*, 1981; 1984	MOE, 2011; US EPA, 2000b
		RfC	60	Centrilobular hypertrophy in livers (rats)	Thornton *et al.*, 2002	MOECC, 2017; TCEQ., 2009

[a] units – RfC/AAQC/AQS – ug/m^3; RfD – ug/kg/d; SF - (ug/kg/day)$^{-1}$; IUR – (ug/m^3)$^{-1}$

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Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			

[b] 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. Therefore, it was not considered appropriate to adopt the MOE (2011) endorsed IUR for 1,1,2,2-tetrachloroethane for the assessment.

[c] The US EPA IRIS (2000) established two distinct unit risk values for vinyl chloride – one protective of exposure during adulthood (*i.e.*, 4.4x10^{-6} per µg/m^3) and one protective of exposure from birth (*i.e.*, 8.8x10^{-6} per µg/m^3). MOE (2011) has selected the child-specific unit risk value as their recommended value to be protective of all sensitive members of the population in the derivation of the generic site conditions standards. However, as the current assessment is evaluating the potential long-term health risks to the adult worker under a commercial exposure scenario, the adult-specific US EPA unit risk value was selected.

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