PATERSON GROUP

Human Health and Ecological Risk Assessment

1518, 1524, and 1526 Stittsville Main Street, Ottawa, Ontario

Prepared for: Inverness Homes Inc.

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EXECUTIVE SUMMARY

Paterson Group Inc. (Paterson) was retained by Inverness Homes Inc. to conduct a human health and ecological risk assessment for a portion of the property located at 1518, 1524, and 1526 Stittsville Main Street, Ottawa, Ontario (the 'RA Property).

Based on the findings of a Phase I and Phase II Environmental Site Assessment (ESA), Paterson identified several Areas of Potential Environmental Concern (APECs) on the subject site or neighbouring lands which were considered to have the potential to impact the subject site, including a former dry cleaners and fill material of unknown quality. Several historical investigations identified impacted soil and groundwater throughout the subject site.

The portion of the property fronting Stittsville Main Street is designated for commercial purposes and does not require a Record of Site Condition (RSC) prior to development. Therefore, a due diligence risk assessment (DDRA) was prepared for the commercial portion of the site to evaluate risks to workers from contaminants in soil and groundwater.

Contaminants of concern (COC) were identified by comparing maximum measured concentrations of soil and groundwater parameters to the Ontario Ministry of the Environment, Conservation and Parks (MECP) Table 3 full-depth Site Condition Standards (SCS) for non-potable groundwater conditions, coarse soil texture, and industrial/commercial/community (I/C/C) land use. The following parameters exceeded Table 3 SCS and were carried forward for further evaluation:

- ❑ Soil: Lead;
- ❑ Groundwater: Tetrachloroethylene.

Because a chlorinated ethylene compound was detected in groundwater, Paterson also evaluated potential risk from vinyl chloride that may form in the future through the degradation (reductive dechlorination) of tetrachloroethylene.

Human Health Risk Assessment

Receptors that are assessed in the HHRA include (i) full-time adult workers, (ii) adult construction workers, (iii) adult outdoor workers, and (iv) visitors/patrons (all ages).

Based on comparison with S2 and S3 MECP component values, lead in soil posed no risk to workers in a commercial setting at the concentrations present at the site; therefore, lead was not evaluated quantitatively in the HHRA. Concentrations of tetrachloroethylene and vinyl chloride (future) exceeded GW2 components and were carried forward in the HHRA for evaluation. Exposure pathways evaluated quantitatively in the HHRA included

(i) groundwater dermal contact in a trench (construction workers); (ii) incidental groundwater ingestion in a trench (construction workers); (iii) inhalation of vapours from groundwater COCs in trench air (construction workers); (iv) inhalation of vapours sourced from groundwater in outdoor air (all receptors); and (v) inhalation of vapours from groundwater COCs in indoor air (indoor workers and patrons).

Exposure estimates were calculated using industry-standard models and equations approved by MECP. Indoor vapour modelling was performed for (i) a generic commercial building with properties defined by MECP, and (ii) the proposed site building with distinct areas designated for a restaurant and a retail/office space. Site-specific soil and groundwater parameters were used as input to models where available.

Quantitative risk estimates were generated for each relevant COC/pathway/ receptor by comparing exposure estimates to MECP toxicity reference values (TRV). A hazard quotient (HQ) describing non-cancer risk and an Incremental Lifetime Cancer Risk (ILCR) were calculated for each receptor. The findings of the HHRA were as follows:

- ❑ Groundwater oral/dermal pathways – HQ values and ILCR values for tetrachloroethylene and future vinyl chloride were within acceptable limits.
- ❑ Groundwater inhalation pathways:
  - Outdoor workers – HQ and ICLR values were within acceptable limits for all COCs.
  - Construction workers – HQ and ICLR values were within acceptable limits for all COCs.
  - Indoor workers – Unacceptable ILCR values were calculated for workers exposed in a generic commercial building and in the proposed site building (both the restaurant space and the retail/office space) to vinyl chloride that may form in groundwater in the future as a result of degradation of tetrachloroethylene over time.

Risk management (RM) measures for the protection of human health are not necessary. Modelling of the site-specific building proposed for the RA Property indicates risks to indoor workers from vapour intrusion of tetrachloroethylene into indoor air are within acceptable limits. Vapour intrusion modelling of theoretical future concentrations of vinyl chloride in groundwater indicates that this chemical, if produced at levels assumed by MECP in their generic model, may pose a slightly elevated risk of cancer to indoor workers. However, the vinyl chloride concentration evaluated in the vapour intrusion modelling was based on a very conservative MECP assumption protective of worst-case situations where the production of vinyl chloride through reductive dechlorination is maximized under anaerobic conditions. Vinyl chloride has never been detected in soil or groundwater at the site, despite numerous soil samples and multiple groundwater sampling events. The absence of vinyl chloride or any other degradation products of tetrachloroethylene in groundwater suggests that subsurface conditions at the RA Property are not conducive to reductive dechlorination or the formation of vinyl chloride.

Ecological Risk Assessment

The following terrestrial ecological receptors were identified as on-site Valued Ecosystem Components (VECs): (i) terrestrial plants; (ii) soil invertebrates; (iii) mammals (herbivorous meadow vole, insectivorous short-tailed shrew, carnivorous red fox); and (iv) birds (herbivorous red-winged blackbird; insectivorous American woodcock, carnivorous red-tailed hawk). Off-site aquatic receptors consisted of aquatic plants, aquatic invertebrates, amphibians, and fish.

Based on comparison to MECP component values, risks to plants and invertebrates from lead in soil were negligible. Risks to off-site aquatic receptors also were determined to be negligible. However, lead concentrations in soil exceeded the MECP's component value for mammals and birds; therefore, risks to mammals and birds were evaluated in the ERA.

Risks to mammals and birds from ingestion of soil and food items that may have accumulated lead from soil were evaluated quantitatively by comparing average daily doses (ADD) of lead for each receptor to the MECP TRVs for mammals and birds. Exposure ratios in the absence of RM measures were greater than one for the red-winged blackbird and the American woodcock from which it was inferred that, in the absence of RM measures, the survival, growth, and reproduction of herbivorous and insectivorous birds may be inhibited. The maintenance of a fill cap (clean soil) or hard cap barrier (buildings, concrete, asphalt, etc.) in areas of the site with concentrations of lead exceeding risk-based values was recommended. With RM measures in place, all direct contact and soil ingestion pathways for mammals will be blocked. Alternatively, excavation/remediation of soil with lead impacts from the RA Property also will eliminate risk to ecological receptors.

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1.0 INTRODUCTION

Paterson Group Inc. (Paterson) was retained by Inverness Homes Inc. to conduct a human health and ecological risk assessment (RA) for a portion of the property located at 1518, 1524, and 1526 Stittsville Main Street, Ottawa, Ontario (the 'RA Property). Figure 1 shows the general location of the RA Property, while the layout of the property (including property limits) is depicted in Figure 2.

A Phase I Environmental Site Assessment (ESA) and Phase II ESA were previously prepared for the subject site. Based on the findings of the Phase I ESA, Paterson identified several Areas of Potential Environmental Concern (APECs) on the subject site or neighbouring lands which were considered to have the potential to impact the subject site, including a former dry cleaners and fill material of unknown quality. Several historical investigations identified impacted soil and groundwater throughout the subject site. Based on analytical test results, metals in soil and fill material and volatile organic chemical (VOC) parameters in groundwater are present at concentrations exceeding the Ontario Ministry of the Environment, Conservation and Parks (MECP) Table 3 residential site condition standards (SCS).

The western portion of 1518, 1524, and 1526 Stittsville Main Street being redeveloped for residential land use requires a Record of Site Condition (RSC); however, the eastern portion fronting Stittsville Main Street that is designated for commercial land use does not. Based on the presence of contaminants in groundwater at the site, as well as the property not requiring an RSC for development, a due diligence risk assessment (DDRA) approach was applied for the commercial portion of the site.

1.1 Risk Assessment Objectives and Approach

The objectives of the RA were to:

- Complete a due diligence risk assessment for a portion of the RA Property located at 1518, 1524, and 1526 Stittsville Main Street, Ottawa, Ontario;
- Quantitatively or qualitatively assess the risk from exposure to contaminants of concern (COC) in groundwater at the RA Property to the human and ecological receptors that may use the property based on residential land use;
- Develop risk-based soil and groundwater standards for COCs at the RA Property; and

- Where unacceptable risks are identified to either human or ecological receptors, propose risk management (RM) measures to mitigate risks associated with COCs present in groundwater at the RA Property.

The RA consisted of identifying the COCs, based on historical evidence and site investigation activities, followed by the identification of appropriate pathways and receptors based on the current and proposed future land use for the RA Property. The last stage of the RA consisted of developing risk-based standards for all the COCs that were screened into the RA in Section 3. Where risks to human or ecological receptors were identified, RM measures to ameliorate or eliminate risks have been provided.

As no change in land use is planned, an RSC under Ontario Regulation 153/04 (as amended) is not required. The RA will not be used to support an RSC application and will not be submitted for review to the MECP. However, the RA has been prepared pursuant to MECP guidance and has employed the same standards, assumptions, models, and calculations as those used in RAs prepared under O.Reg. 153/04.

2.0 SITE CHARACTERIZATION

2.1 Property Information

The RA Property is located on the southwest side of Stittsville Main Street, approximately 50 m southwest of the intersection of Abbott Street West and Stittsville Main Street, in the City of Ottawa. The RA Property is situated in a mixed commercial and residential zone. Figure 1 shows the general location of the RA Property. Property details are provided in Table 2-1.

Table 2-1: Site Identification Information	
Civic Address	1518, 1524, and 1526 Stittsville Main Street, Ottawa, Ontario
Current/Proposed Future Land Use	Commercial; proposed commercial
Zoning	TM – Traditional Mainstreet Zone
Latitude & Longitude Coordinates	45° 15' 28" N, 75° 55' 15" W
Property Owner	Inverness Homes Inc.
Site Area	4,760 m^2 (entire property)

The proposed development of the property consists of a two-storey commercial building fronting Stittsville Main Street. The commercial building will be connected by an archway to a four-storey residential building located on the western portion of the property. Both the residential and commercial buildings will be slab-on-grade construction with no below-grade storage or parking garage.

The neighbouring lands within the study area consist of institutional, residential, and commercial/retail properties.

Based on the availability of municipal services, no drinking water wells are expected to be present within the study area.

2.2 Physical Setting

2.2.1 Topography and Surface Water Drainage

The site is relatively flat and at the grade of the adjacent streets and neighbouring lands. Site drainage occurs through both infiltration of the gravel and landscaped areas.

2.2.2 Geology

The Geological Survey of Canada website on the Urban Geology of the National Capital Area was consulted as part of this assessment. Based on the information from NRCAN, bedrock within the area of the RA Property consists of limestone and interbedded dolomite of the Gull River Formation. The overburden consists of glaciofluvial deposits, with a drift thickness of 5 to 10 m.

Paterson conducted a subsurface investigation in July 2020 as part of a Phase II ESA investigation. Twelve boreholes were advanced across the RA Property and the residential portion of the site. The boreholes were terminated at depths ranging from 4.22 to 9.04 metres below ground surface (mbgs). Five additional boreholes were drilled in June 2022, in support of a supplemental Phase II ESA. Based on observations during these drilling programs, the site stratigraphy from ground surface to the deepest aquifer or aquitard investigated consists of:

- ❑ Topsoil from ground surface to 0.2 mbgs;
- ❑ Brown silty sand below the topsoil to approximately 4.5 mbgs;
- ❑ Glacial till material, intermittently identified between the silty sand and the bedrock surface, with a thickness of approximately 0.25 m;
- ❑ Limestone bedrock identified approximately 4.75–5.9 mbgs.

Groundwater was encountered at depths ranging from approximately 4.5 to 5.5 mbgs.

2.2.3 Hydrogeology

Seven of the boreholes advanced at the RA Property were instrumented with groundwater monitoring wells (BH2-11, BH1-19, BH2-19, BH1-20, BH3-20, BH1-22, BH2-22). Based on groundwater levels measured on multiple occasions, groundwater was encountered within the overburden at depths ranging from 4.5 m to 5.5 m below the existing ground surface. Based on the 2020 Phase II ESA and supplemental 2022 groundwater monitoring wells, groundwater water beneath the RA Property and the adjacent residential property was inferred to flow in a westerly direction. A horizontal hydraulic gradient of approximately 0.038 m/m was calculated.

2.3 Contaminants of Concern

2.3.1 Potentially Contaminating Activities

Based on the Phase I and II ESAs prepared for 1518, 1524, and 1526 Stittsville Main Street, two potentially contaminating activities (PCAs) resulting in two areas of potential environmental concern (APEC) were identified on the RA Property. PCAs and APECs are identified in Table 2-2.

Table 2-2: Areas of Potential Environmental Concern

APEC	Location of APEC	PCA	Location of PCA	Contaminants of Potential Concern	Media Potentially Impacted
APEC 1 Former Dry Cleaners: 1520 Stittsville Main Street	Eastern section of 1524 Stittsville Main Street	PCA 37 – *"Operation of Dry Cleaning Equipment (where chemicals are used)"*	On-Site	VOCs	Soil and/or Groundwater
APEC 2 Fill Material of unknown quality	Former building footprints along eastern portion of RA Property	PCA 30 – *"Importation of Fill Material of Unknown Quality"*	On-Site	Metals (Mercury, CrVI) PAHs	Soil

The contaminants of potential concern (COPCs) associated with the APECs were considered to be:

- ❑ Volatile organic compounds (VOCs);
- ❑ Polycyclic Aromatic Hydrocarbons (PAHs);
- ❑ Metals (including mercury and chromium VI).

2.3.2 Previous Investigations

Phase I & II Environmental Site Assessment, 1524 and 1526 Stittsville Main Street, Ottawa, Ontario –Paterson Group Inc. – November 23, 2011

The 2011 Phase I & II ESA conducted by Paterson assessed properties 1524 and 1526 Stittsville Main Street. Based on a historical review and on-site observations, a former dry cleaner was identified at 1524 Stittsville Main Street. A Phase II ESA was conducted in November 2011. Five boreholes, two of which were instrumented with groundwater monitoring wells, were advanced across the site; of these, four (BH1 through BH4) were located on the RA Property. The groundwater monitoring wells were located on the footprint of the former drycleaners (BH2) and the footprint of a former residential structure (BH4).

One soil sample collected from BH1 was submitted for PAH analysis, while one sample collected from BH2 and one sample collected from BH4 were submitted for VOC analysis. Based on the analytical test results, no PAH concentrations above the applicable MECP standards were detected in the sample collected from BH1; however, it was noted that fill material was present and consisted of gravel and pieces of coal. Tetrachloroethylene was detected in samples collected from BH2 and BH4. The detected tetrachloroethylene concentration for BH2 exceeded the current MECP soil standard.

Two groundwater samples were collected and submitted for VOC and PHC analysis. Based on the analytical test results, no PHC concentrations were detected in both samples. Concentrations of 1,2-*cis*-dichloroethylene and tetrachloroethylene exceeded the MECP standards in the groundwater sample from BH2, and tetrachloroethylene exceeded in the sample from BH4.

Phase I & II Environmental Site Assessment, 1520 Stittsville Main Street, Ottawa, Ontario – Paterson Group Inc. – November 23, 2019

Based on the previously identified historical dry cleaners on the adjacent property, a subsurface investigation was conducted in June of 2019 at 1520 Stittsville Main Street (currently part of 1518 Stittsville Main Street). Three boreholes (BH1, BH2 and BH3), instrumented with groundwater monitoring wells, were advanced on the property.

One soil sample was collected from BH2 and submitted for metal analysis; all metals were present at concentrations less than Table 3 SCS. Three samples collected from BH1, BH2, and BH3 were submitted for VOC analysis. No detectable VOC parameter concentrations were identified in the BH3 sample; however, tetrachloroethylene concentrations were found to exceed the MECP Table 3 Standard in the BH1 sample.

Three groundwater samples were collected and submitted for VOC analysis. No VOCs were detected in the groundwater samples analyzed.

Phase II Environmental Site Assessment, 1518, 1524, 1526 Stittsville Main Street, Ottawa, Ontario – Paterson Group Inc. – November 23, 2020

A Phase II ESA was completed for the three land parcels to assess the subsurface conditions based on the former presence of a dry cleaners and the quality of the fill material that had been placed on-site. The field program consisted of 12 boreholes, three of which were instrumented with groundwater monitoring wells.

Six soil samples were submitted for laboratory analysis of metals, PAHs and/or VOCs. All soil samples complied with the MECP Table 3 Standards, with the exception of lead and mercury concentrations at BH4-20.

Groundwater samples were recovered from the monitoring wells BH1-20, BH2-20, BH3-20, BH2-19 and BH2-11. No visual or olfactory signs of contamination were noted in the groundwater. The groundwater samples were submitted for analysis of PHCs, VOCs, and metals. Concentrations of tetrachloroethylene in all monitoring wells exceeded MECP Table 3 Standards. Chloroform in groundwater from BH2 also exceeded Table 3 Standards; however, the presence of chloroform was attributed to the use of municipal water during drilling.

Phase II Environmental Site Assessment Update, 1518, 1524, 1526 Stittsville Main Street, Ottawa, Ontario – Paterson Group Inc. – January 11, 2024

A Supplemental Phase II ESA Investigation was conducted to supplement existing test data. In June 2022, five boreholes (BH1-22 through BH5-22) were drilled on the Phase II Property, two of which (BH1-22 and BH2-22) were located on the eastern portion of the site now considered the RA Property. Both test holes on the RA Property were instrumented with groundwater monitoring wells.

Two soil samples from BH1-22 and one from BH2-22 were submitted for analysis of metals, VOCs, benzene/ethylbenzene/toluene/xylene (BTEX), and petroleum hydrocarbons (PHC) F1–F4. Concentrations of all metal parameters were less than Table 3 SCS. No VOCs, BTEX, or PHCs were detected in soil samples.

Groundwater samples were collected from select monitoring wells on 20 June 2022, 4 November 2022, and 5 June 2023 and analyzed for VOCs and BTEX. Concentrations of chloroform exceeded Table 3 SCS in groundwater from BH2-11 and BH1-20. Concentrations of tetrachloroethylene exceeded Table 3 SCS in groundwater from BH2-11, BH1-20, BH3-20, BH1-22, and BH2-22.

Summary of Data Used in Risk Assessment

Paterson investigated the subsurface conditions at the RA Property through a soil and groundwater sampling program. Soil and/or groundwater analyses were conducted in 2011, 2019, 2020, 2022, and 2023. All available data were used to characterize the site conditions in the risk assessment, with the exception of the following:

- ❑ Soil: 2011 VOC, BTEX (BH2-SS7 – 9 November 2011);

- Groundwater: 2011 VOC, BTEX, PHC F1-F4 (BH2-11 & BH4-11 – 14 November 2011).

For volatile parameters, including VOCs, BTEX, and PHC F1/F2, analytical results that are >5 years past are generally not considered to represent current site conditions because migration in soil and degradation from biotic and abiotic processes can significantly alter concentrations of these parameters over time. PAH data from 2011 (soil sample BH1-SS1) were retained; PAH parameters as well as metals are less likely to undergo significant changes over time.

The 2011 and 2019 subsurface investigations identified tetrachloroethylene in soil samples that exceed the MECP Table 3 SCS for residential land use. The contaminated soil samples were collected from the eastern portion of the RA Property on and adjacent to the footprint of the former dry cleaners.

The subsurface investigation in 2022 identified lead and mercury in the soil samples exceeding Table 3 SCS. The soil samples were collected from the fill material from the northeastern portion of the RA Property on the footprint of the former restaurant.

Chloroform, 1,2-*cis*-dichloroethylene, and tetrachloroethylene in groundwater were detected at concentrations exceeding Table 3 SCS. The contaminated groundwater samples were collected from monitoring wells installed on the eastern portion of the RA Property within proximity to the footprint of the former dry cleaners.

Paterson completed six groundwater sampling events including existing and newly installed groundwater monitoring wells in order to update the groundwater quality.

2.3.3 Site Condition Standards

The SCS for the RA Property were obtained from Table 3 of the document entitled, *“Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act”*, prepared by the MECP and dated April 15, 2011. The selected MECP standards were based on the following considerations:

- Full depth soil conditions – The site is not considered to have a shallow soil condition hereby one-third of the site consists of soil equal to or less than two meters in depth (Section 43.1 of O.Reg. 153/04 does not apply);
- Coarse-grained soil conditions – Coarse-grained soil standards were chosen as a conservative approach; grain size analysis was not completed;

- ❑ Non-potable groundwater conditions – The City of Ottawa does not rely on groundwater as a source of potable water; the RA Property is situated in a municipally serviced area;
- ❑ Commercial land use;
- ❑ The RA Property is not a sensitive site (Section 41 of O.Reg. 153/04 does not apply):
    - o The site consists of lands more than 30 m from surface water and there are no environmentally sensitive areas within 30 m of the site; and
    - o The pH of the surface soil is assumed to be between 5 and 9 and the pH of the subsurface soil is assumed to be between 5 and 11.

2.3.4 Identification of Contaminants of Concern

COCs were identified by comparing maximum measured concentrations to the Table 3 SCS for coarse soil texture and industrial/commercial/community (I/C/C) land use. Any chemical detected at the RA property that exceeded the applicable SCS was considered to be a COC and was assessed within the RA.

The COCs identified through the chemical screening process were further evaluated in Section 3 (HHRA) and Section 4 (ERA). Chemicals retained for either quantitative and/or qualitative analysis are discussed in the respective human health or ecological secondary screening sections.

2.3.4.1 Contaminants of Concern in Soil

Contaminants of concern in soil (full-depth soil profile) were determined by screening the maximum measured concentrations of chemical parameters against the applicable Table 3 SCS. The COC screening of soil is summarized in Table 2-3, while full data are provided in Appendix B.

Table 2-3: Soil Contaminant Inventory

Parameter	Maximum concentration (µg/g)	Table 3 SCS [a] (I/C/C) (µg/g)	COC	Rationale
Metals and inorganics				
Antimony	<1	40	No	RDL < Table 3 SCS
Arsenic	5.8	18	No	Max. < Table 3 SCS
Barium	198	670	No	Max. < Table 3 SCS
Beryllium	<0.5	8	No	RDL < Table 3 SCS
Boron (total)	10.3	120	No	Max. < Table 3 SCS

Table 2-3: Soil Contaminant Inventory

Parameter	Maximum concentration (µg/g)	Table 3 SCS [a] (I/C/C) (µg/g)	COC	Rationale
Cadmium	<0.5	1.9	No	RDL < Table 3 SCS
Chromium VI	<0.2	8	No	Max. < Table 3 SCS
Chromium (total)	22.9	160	No	RDL < Table 3 SCS
Cobalt	5.8	80	No	Max. < Table 3 SCS
Copper	43.3	230	No	Max. < Table 3 SCS
Lead	268	120	**Yes**	**Max. > Table 3 SCS**
Mercury	0.5	3.9	No	RDL < Table 3 SCS
Molybdenum	<1	40	No	RDL < Table 3 SCS
Nickel	13.1	270	No	Max. < Table 3 SCS
Selenium	<1	5.5	No	RDL < Table 3 SCS
Silver	0.3	40	No	Max. < Table 3 SCS
Thallium	<1	3.3	No	RDL < Table 3 SCS
Uranium	<1	33	No	RDL < Table 3 SCS
Vanadium	27.5	86	No	Max. < Table 3 SCS
Zinc	236	340	No	Max. < Table 3 SCS
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	<0.02	96	No	RDL < Table 3 SCS
Acenaphthylene	0.07	0.15	No	Max. < Table 3 SCS
Anthracene	0.04	0.67	No	Max. < Table 3 SCS
Benz[a]anthracene	0.12	0.96	No	Max. < Table 3 SCS
Benzo[a]pyrene	0.17	0.3	No	Max. < Table 3 SCS
Benzo[b]fluoranthene	0.25	0.96	No	Max. < Table 3 SCS
Benzo[ghi]perylene	0.17	9.6	No	Max. < Table 3 SCS
Benzo[k]fluoranthene	0.12	0.96	No	Max. < Table 3 SCS
Chrysene	0.13	9.6	No	Max. < Table 3 SCS
Dibenz[a,h]anthracene	0.05	0.1	No	Max. < Table 3 SCS
Fluoranthene	0.24	9.6	No	Max. < Table 3 SCS
Fluorene	<0.02	62	No	RDL < Table 3 SCS
Indeno[1,2,3-cd]pyrene	0.15	0.76	No	Max. < Table 3 SCS
Methylnaphthalene, 1-, 2-	<0.04	76	No	RDL < Table 3 SCS
Naphthalene	<0.01	9.6	No	RDL < Table 3 SCS
Phenanthrene	0.09	12	No	Max. < Table 3 SCS
Pyrene	0.2	96	No	Max. < Table 3 SCS
Biphenyl, 1,1-	<0.03	52	No	RDL < Table 3 SCS
Petroleum Hydrocarbons				
Benzene	<0.02	0.32	No	RDL < Table 3 SCS
Ethylbenzene	<0.05	9.5	No	RDL < Table 3 SCS
Toluene	<0.05	68	No	RDL < Table 3 SCS
Xylenes	<0.05	26	No	RDL < Table 3 SCS
PHC F1	<7	55	No	RDL < Table 3 SCS
PHC F2	<4	230	No	RDL < Table 3 SCS
PHC F3	<8	1,700	No	RDL < Table 3 SCS
PHC F4	<6	3,300	No	RDL < Table 3 SCS
Volatile Organic Chemicals				
Acetone	<5	16	No	RDL < Table 3 SCS

Table 2-3: Soil Contaminant Inventory				
Parameter	**Maximum concentration (µg/g)**	**Table 3 SCS [a] (I/C/C) (µg/g)**	**COC**	**Rationale**
Bromodichloromethane	<0.5	18	No	RDL < Table 3 SCS
Bromoform	<0.5	0.61	No	RDL < Table 3 SCS
Bromomethane	<0.5	0.05	No	RDL < Table 3 SCS
Carbon Tetrachloride	<0.2	0.21	No	RDL < Table 3 SCS
Chlorobenzene	<0.5	2.4	No	RDL < Table 3 SCS
Chloroethane	<0.05	NV	No	Not detected
Chloroform	<0.5	0.47	No	RDL < Table 3 SCS
Chloromethane	<0.05	NV	No	Not detected
Dibromochloromethane	<0.5	13	No	RDL < Table 3 SCS
Dichlorodifluoromethane	<1	16	No	RDL < Table 3 SCS
1,2-Dichlorobenzene	<0.5	6.8	No	RDL < Table 3 SCS
1,3-Dichlorobenzene	<0.5	9.6	No	RDL < Table 3 SCS
1,4-Dichlorobenzene	<0.5	0.2	No	RDL < Table 3 SCS
1,1-Dichloroethane	<0.5	17	No	RDL < Table 3 SCS
1,2-Dichloroethane	<0.5	0.05	No	RDL < Table 3 SCS
1,1-Dichloroethylene	<0.5	0.064	No	RDL < Table 3 SCS
1,2-cis-Dichloroethylene	<0.5	55	No	RDL < Table 3 SCS
1,2-trans-Dichloroethylene	<0.5	1.3	No	RDL < Table 3 SCS
1,2-Dichloropropane	<0.5	0.16	No	RDL < Table 3 SCS
1,3-Dichloropropene	<0.5	0.18	No	RDL < Table 3 SCS
Ethylene dibromide	<0.2	0.05	No	RDL < Table 3 SCS
(n)-Hexane	<1	46	No	RDL < Table 3 SCS
Methyl Ethyl Ketone	<5	70	No	RDL < Table 3 SCS
Methyl Isobutyl Ketone	<5	31	No	RDL < Table 3 SCS
Methyl tert-Butyl Ether (MTBE)	<2	11	No	RDL < Table 3 SCS
Methylene Chloride	<5	1.6	No	RDL < Table 3 SCS
Styrene	<0.5	34	No	RDL < Table 3 SCS
1,1,1,2-Tetrachloroethane	<0.5	0.087	No	RDL < Table 3 SCS
1,1,2,2-Tetrachloroethane	<0.5	0.05	No	RDL < Table 3 SCS
Tetrachloroethylene	1.01	4.5	No	Max. < Table 3 SCS
1,2,4-Trichlorobenzene	<0.05	3.2	No	RDL < Table 3 SCS
1,1,1-Trichloroethane	<0.5	6.1	No	RDL < Table 3 SCS
1,1,2-Trichloroethane	<0.5	0.05	No	RDL < Table 3 SCS
Trichloroethylene	<0.5	0.91	No	RDL < Table 3 SCS
Trichlorofluoromethane	<1	4	No	RDL < Table 3 SCS
Vinyl Chloride	<0.5	0.032	No	RDL < Table 3 SCS

[a] Table 3 Full Depth Generic Site Condition Standards (SCS) in a Non-Potable Ground Water Condition, industrial/commercial/community land use, coarse-textured soil – April 15, 2011 Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act* (MOE 2011)
NV – No value; RDL – Reported detection limit

Lead was considered to be the only soil COC at the site.

2.3.4.2 Contaminants of Concern in Groundwater

Contaminants of concern in groundwater were determined by screening the maximum measured concentrations of chemical parameters against applicable Table 3 SCS. The COC screening of groundwater is summarized in Table 2-4. All groundwater data are provided in Appendix B

Table 2-4: Identification of Contaminants of Concern in Groundwater

Parameter	Max. conc. (µg/L)	Table 3 SCS [a] (µg/L)	COC	Rationale
Metals and inorganics				
Antimony	<0.1	20,000	No	RDL < Table 3 SCS
Arsenic	<0.5	1,900	No	RDL < Table 3 SCS
Barium	114	29,000	No	Max. < Table 3 SCS
Beryllium	<1	67	No	RDL < Table 3 SCS
Boron	101	45,000	No	Max. < Table 3 SCS
Cadmium	<10	2.7	No	RDL < Table 3 SCS
Chromium (Total)	<0.1	810	No	RDL < Table 3 SCS
Chromium VI	<1	140	No	RDL < Table 3 SCS
Cobalt	<10	66	No	RDL < Table 3 SCS
Copper	<0.5	87	No	RDL < Table 3 SCS
Lead	<0.5	25	No	RDL < Table 3 SCS
Mercury	<0.1	0.29	No	RDL < Table 3 SCS
Molybdenum	1.5	9,200	No	Max. < Table 3 SCS
Nickel	<1	490	No	RDL < Table 3 SCS
Selenium	<1	63	No	RDL < Table 3 SCS
Silver	<0.1	1.5	No	RDL < Table 3 SCS
Sodium	94,500	2,300,000	No	Max. < Table 3 SCS
Thallium	<0.1	510	No	RDL < Table 3 SCS
Uranium	3.4	420	No	Max. < Table 3 SCS
Vanadium	<0.5	250	No	RDL < Table 3 SCS
Zinc	6	1,100	No	Max. < Table 3 SCS
Petroleum Hydrocarbons				
Benzene	<0.5	44	No	RDL < Table 3 SCS
Ethylbenzene	<0.5	2,300	No	RDL < Table 3 SCS
Toluene	<0.5	18,000	No	RDL < Table 3 SCS
Xylenes	<0.5	4,200	No	RDL < Table 3 SCS
Volatile Organic Chemicals				
Acetone	<5	130,000	No	RDL < Table 3 SCS
Bromodichloromethane	3	85,000	No	Max. < Table 3 SCS
Bromoform	<0.5	380	No	RDL < Table 3 SCS
Bromomethane	<0.5	5.6	No	RDL < Table 3 SCS
Carbon Tetrachloride	<0.2	0.79	No	RDL < Table 3 SCS
Chlorobenzene	<0.5	630	No	RDL < Table 3 SCS
Chloroethane	<1	NV	No	Not detected
Chloroform	28.1	2.4	No	Not a COC [b]
Chloromethane	<3	NV	No	Not detected
Dibromochloromethane	<0.5	82,000	No	RDL < Table 3 SCS

Table 2-4: Identification of Contaminants of Concern in Groundwater

Parameter	Max. conc. (µg/L)	Table 3 SCS [a] (µg/L)	COC	Rationale
Dichlorodifluoromethane	<1	4,400	No	RDL < Table 3 SCS
1,2-Dichlorobenzene	<0.5	4,600	No	RDL < Table 3 SCS
1,3-Dichlorobenzene	<0.5	9,600	No	RDL < Table 3 SCS
1,4-Dichlorobenzene	<0.5	8	No	RDL < Table 3 SCS
1,1-Dichloroethane	<0.5	320	No	RDL < Table 3 SCS
1,2-Dichloroethane	<0.5	1.6	No	RDL < Table 3 SCS
1,1-Dichloroethylene	<0.5	1.6	No	RDL < Table 3 SCS
1,2-cis-Dichloroethylene	<0.5	1.6	No	RDL < Table 3 SCS
1,2-trans-Dichloroethylene	<0.5	1.6	No	RDL < Table 3 SCS
1,2-Dichloropropane	<0.5	16	No	RDL < Table 3 SCS
1,3-Dichloropropene	<0.5	5.2	No	RDL < Table 3 SCS
Ethylene dibromide	<0.2	0.25	No	RDL < Table 3 SCS
(n)-Hexane	<5	51	No	RDL < Table 3 SCS
Methyl Ethyl Ketone	<10	470,000	No	RDL < Table 3 SCS
Methyl Butyl Ketone	<10	NV	No	Not detected
Methyl Isobutyl Ketone	<10	140,000	No	RDL < Table 3 SCS
Methyl tert-Butyl Ether (MTBE)	<2	190	No	RDL < Table 3 SCS
Methylene Chloride	<5	610	No	RDL < Table 3 SCS
Styrene	<0.5	1,300	No	RDL < Table 3 SCS
1,1,1,2-Tetrachloroethane	<0.5	3.3	No	RDL < Table 3 SCS
1,1,2,2-Tetrachloroethane	<0.5	3.2	No	RDL < Table 3 SCS
Tetrachloroethylene	**57.1**	1.6	**Yes**	**Max. > Table 3 SCS**
1,1,1-Trichloroethane	<0.5	640	No	RDL < Table 3 SCS
1,1,2-Trichloroethane	<0.5	4.7	No	RDL < Table 3 SCS
Trichloroethylene	<0.5	1.6	No	RDL < Table 3 SCS
Trichlorofluoromethane	<1	2,500	No	RDL < Table 3 SCS
1,3,5-Trimethylbenzene	<0.5	NV	No	Not detected
Vinyl chloride	<0.5	0.5	No	RDL < Table 3 SCS

[a] Table 3 Generic Site Condition Standards (SCS) in a Non-Potable Groundwater Condition, of the April 15, 2011 Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act* (MOE 2011)
[b] The presence of chloroform is considered to be related to the use of municipal water during drilling.
NV – No value; RDL – Reported detection limit

Tetrachloroethylene was the only groundwater parameter at the site that exceeded Table 3 SCS.

Because a chlorinated ethylene compound was detected in groundwater, Paterson evaluated potential risk from vinyl chloride formed by the degradation of five chlorinated ethylene compounds: tetrachloroethylene, trichloroethylene, and three isomers of dichloroethylene (1,1-, *cis*-1,2-, and *trans*-1,2-dichloroethylene). The theoretical future concentration of vinyl chloride was calculated by assuming that 10% of each of the five parent compounds could break down to yield vinyl chloride, and then summing those contributions to the maximum measured concentration of vinyl chloride (Table 2-5).

Table 2-5: Calculation of Potential Future Vinyl Chloride Concentrations in Groundwater

Parameter	Maximum measured concentration or RDL (µg/L)	Potential future concentration (µg/L)	Theoretical future vinyl chloride concentration (µg/L)
1,1-Dichloroethylene	<0.5	0.05	6.41
1,2-*cis*-Dichloroethylene	<0.5	0.05	
1,2-*trans*-Dichloroethylene	<0.5	0.05	
Tetrachloroethylene	57.1	5.71	
Trichloroethylene	<0.5	0.05	
Vinyl chloride	<0.5	0.5	

To ensure that a conservative assessment of potential health concerns for human and ecological receptors, potential analytical variance in the sampling programs completed above was addressed using reasonable estimated maximum (REM) estimates for each parameter screened into the RA. The REM estimate was calculated as the maximum measured concentration plus 20%. Because of the inherent conservatism of the future vinyl chloride estimate, the REM value for this parameter was not calculated and risks were evaluated at the maximum (future) concentration.

3.0 HUMAN HEALTH RISK ASSESSMENT (HHRA)

Human health risks were assessed using methodology developed by Ontario MECP and other health and environment authorities in Canada (e.g., Health Canada) and internationally (e.g., US EPA) that stepwise identifies, characterizes, and integrates the elements of risk.

3.1 Problem Formulation

The problem formulation identifies the human receptors at the RA Property and the potential pathways by which they could be exposed to COCs. This information is summarized in a conceptual exposure model (CEM).

3.1.1 Human Health Conceptual Exposure Model

The human health CEM provides an integrated representation of how environmental media and human receptors are connected. The human health CEM is illustrated in Figure 3.

Subsurface investigations at the RA Property identified the presence of metals (lead, mercury) and a chlorinated VOC (tetrachloroethylene) in soil and tetrachloroethylene in groundwater at concentrations exceeding Table 3 SCS.

Environmental transport pathways relevant to the site include: (i) suspension/entrainment of soil in outdoor air and transport to off-site properties; (ii) volatilization of soil and groundwater COCs into outdoor air; and (iii) vapour intrusion of soil and groundwater COCs into the commercial building proposed for the RA Property.

Receptors that are assessed in the HHRA include (i) full-time adult workers, (ii) adult construction workers, (iii) adult outdoor workers, and (iv) visitors/patrons (all ages). Receptors are discussed in detail in Section 3.2.1.

Exposure pathways that are considered in the HHRA include (i) soil ingestion (all receptors); (ii) soil dermal contact (all receptors); (iii) inhalation of entrained soil particles (all receptors); (iv) inhalation of vapours sourced from soil or groundwater in outdoor air (all receptors); (v) dermal contact with vapours of soil or groundwater COCs in outdoor air (all receptors); (vi) groundwater dermal contact in a trench (construction workers); (vii) incidental groundwater ingestion in a trench (construction workers); (ix) inhalation of vapours from soil and groundwater COCs in trench air (construction workers); (x) dermal contact with vapours of soil or groundwater COCs in trench air (construction workers); (xi) inhalation of vapours from soil and groundwater COCs in indoor air (indoor workers and patrons/ visitors); and (xii) dermal contact with vapours of soil or groundwater COCs in indoor air (indoor workers and patrons/visitors). Exposure pathways are discussed in detail in Section 3.2.2.

3.1.2 Identification of COCs for HHRA

A total of three COCs were identified in soil and groundwater by comparing maximum-detected concentrations to MECP Table 3 SCS (as summarized above in Section 2.3). To determine which groundwater COCs required quantitative human health assessment, REM concentrations were screened against component values for human health.

3.1.2.1 Soil COCs

The REM concentration of lead, the only soil COC, was screened against the following component values:

- S2 – Soil ingestion/dermal contact pathways under a lower-frequency, lower-intensity scenario for surface soil at a commercial/industrial/community property without children;
- S3 – Soil ingestion/dermal contact pathways under a low-frequency, high-intensity human health exposure scenario without children present that is protective of a worker exposed to sub-surface soils at commercial /industrial/community sites;
- S-IA – Soil component for vapour intrusion into buildings protective of toxicity from vapours and odour in indoor air; and
- S-OA – Soil component protective of toxicity from inhalation of vapours in outdoor air.

The component value screening for soil COCs is shown in Table 3-1.

Table 3-1: Screening of Soil COCs for Quantitative Evaluation in HHRA

COC	Maximum concentration (µg/g)	REM concentration (µg/g)	Contact		Inhalation		Quantitative assessment
			S2 (µg/g)	S3 (µg/g)	S-IA (µg/g)	S-OA (µg/g)	
Lead	268	321.6	420	420	NV	NV	None

Refer to Appendix C for component values for odour, leaching (S-GW3), free-phase threshold.

As the REM concentration of lead in soil was less than all component values, it was concluded that this COC poses no risk to full-time workers, patrons, construction workers, or outdoor workers via soil dermal contact and soil ingestion pathways. As lead is not volatile, its presence in soil poses no risk from inhalation of vapours in indoor air or outdoor air.

3.1.2.2 Groundwater COCs

The REM concentrations of groundwater COCs were screened against the following component values:

- ❑ GW2 – Groundwater component for vapour intrusion into buildings protective of toxicity from vapours and odour in indoor air.

As groundwater is not used as a potable water source, screening against the component value for direct contact (GW1) was not required. The component value screening is shown in Table 3-2.

Table 3-2: Screening of Groundwater COCs for HHRA

COC	Maximum concentration (µg/L)	REM concentration (µg/L)	Commercial inhalation GW2 (µg/L)	Quantitative assessment
Tetrachloroethylene	57.1	68.52	**30**	Inhalation
Vinyl chloride (future)	6.41	6.41	**3.0**	Inhalation

Bold – component value exceeded by REM concentration.

Both tetrachloroethylene and future vinyl chloride required quantitative assessment via inhalation of indoor air in a commercial building.

Both COCs were also assessed for risk from pathways for which no component values are available (e.g., construction worker exposure to vapours while in a trench or excavation; exposure to groundwater vapours in outdoor air).

3.2 Exposure Assessment

3.2.1 Receptor Characteristics

3.2.1.1 Indoor Workers

Indoor workers are adults working full-time inside a commercial building. Indoor workers were assumed to be exposed to COCs in groundwater via groundwater vapour inhalation in a commercial building with slab-on-grade construction. Indoor workers were assumed to have no direct exposure to groundwater. Exposure parameters for indoor workers are provided in Table 3-3. Default MECP values were used for all parameters.

Table 3-3: Exposure Parameters – Indoor Workers

Characteristic		Units	Adult	Pregnant female	Reference
Body weight		kg	70.7	63.1	MOE (2011)
Groundwater ingestion		L/day	2.3	2.1	MOE (2011)
Inhalation rate		m^3/hour	0.692	0.692	Health Canada (2021)
Time indoors		hours/day	9.8	24	MOE (2011)
		days/year	250	365	MOE (2011)
Exposure duration		years	56	56	MOE (2011)
Averaging period	Non-carcinogens	years	56	56	MOE (2011)
	Carcinogens	years	56	56	MOE (2011)

3.2.1.2 Construction Workers

People performing subsurface work (e.g., construction activities or utility maintenance) were quantitatively assessed with regard to the following exposure pathways: inhalation of groundwater vapours in trench air, and direct contact (ingestion and dermal contact) with groundwater in a trench. The extent to which construction/utility work may occur at the site following redevelopment is unknown, but standard HHRA practice is to assess an adult construction worker as a receptor due to their potential for higher intake of COCs. Biological characteristics and exposure frequency/duration parameters to quantitatively assess these pathways are provided in Table 3-4. As shown, default values recommended by MECP for a “construction/subsurface worker” were used for most parameters, with the exception of the following:

- *Days per year working in a trench*: MECP does not provide default exposure frequency values for a construction worker working in a trench or excavation. A frequency of 50 days/year was assumed in exposure calculations. This frequency is >25% of the overall exposure frequency of 195 days per year assumed by MECP for the frequency of exposure at a construction site and is deemed reasonably conservative.
- *Groundwater ingestion rate while working in a trench*: Construction workers have been assumed to incidentally ingest groundwater at a rate of 0.15 L/day (150 mL/day, or ~15.3 mL/hour, every hour during a 9.8-hour workday). This is considered conservative, as it is approximately 1/15th MECP’s daily rate for the ingestion of potable water by an adult (the MOE 2011 *Rationale* document lists a rate of 2.3 L/day), and approximately 1/5th US EPA’s hourly rate for the

incidental ingestion of water by swimmers (US EPA 2011 *Exposure Factors Handbook* lists a rate of 71 mL/h).

- *Groundwater dermal contact rate while working in a trench*: Construction workers have been assumed to have 10 groundwater-contact events through the course of their workday (i.e., periodic splashing of groundwater onto their hands or arms), with each event lasting 20 seconds (0.006 hours) before the small amounts of water on the skin evaporate or are wiped away. The assumption of 10 events/day at 0.006 hours/event gives final dose estimates results approximately equal to the dose estimates that would be calculated with an assumption of one event/day at 0.58 hours/event. This latter set of assumptions is the Reasonable Maximum Exposure (RME) scenario from US EPA 2004 *RAGS Part E* guidance for an adult who is showering/bathing.

Table 3-4: Construction Worker Exposure Parameters

Characteristic		Units	Typical adult	Reference
Body weight		kg	70.7	MOE (2011)
Skin	Surface area	cm^2	3,400	MOE (2011)
Intake rates	Groundwater ingestion	L/day	0.15	US EPA (2011) Exposure Factors Handbook
	Inhalation	m^3/hour	1.5	MOE (2011)
Time outdoors		hours/day	9.8	MOE (2011)
		days/year	195	MOE (2011)
Time in trench		hours/event	0.006	Assumed
		events/day	10	Assumed
		days/year	50	Assumed
Exposure duration		years	1.5	MOE (2011)
Averaging period	Non-carcinogens	years	1.5	MOE (2011)
	Carcinogens	years	56	MOE (2011)

3.2.1.3 Outdoor Workers

People working outside (e.g., maintenance or landscaping duties) were quantitatively assessed with regard to inhalation of groundwater vapours in outdoor air. Biological characteristics and exposure frequency/duration parameters to quantitatively assess these pathways are provided in Table 3-5. As shown, default values recommended by MECP for a “long-term outdoor worker” were used for all applicable parameters.

Table 3-5: Outdoor Worker Exposure Parameters

Characteristic		Units	Typical adult	Reference
Body weight		kg	70.7	MOE (2011)
Inhalation		m^3/hour	1.5	Assumption (same as construction worker)
Time outdoors		hours/day	9.8	MOE (2011)
		days/year	195	MOE (2011)
Exposure duration		years	56	MOE (2011)
Averaging period	Non-carcinogens	years	56	MOE (2011)
	Carcinogens	years	56	MOE (2011)

3.2.1.4 Patrons/Visitors

Visitors of all age groups may visit the business at the RA Property. The greatest potential source of exposure to COCs for commercial visitors is inhaling groundwater vapours that have migrated to the indoor environment. Default exposure frequency values are not provided by MECP for such receptors. However, the frequency of exposure would reasonably be expected to be much less than that of an actual indoor worker. Therefore, the results for full-time workers (i.e., the calculated human health-based values) will be protective of commercial patrons. On this basis, patrons/visitors were not quantitatively assessed in the remaining sections of the HHRA.

3.2.2 Pathway Analysis

The equations used to quantitatively estimate exposure to groundwater COCs are presented in Appendix C. The applicability of these pathways at this site is summarized in Table 3-6.

Table 3-6: Exposure Pathway Summary – Groundwater

Source	Pathway	Receptor	Assessment	Rationale	Exposure frequency and duration
Ground-water	Drinking water ingestion	All receptors	None	Non-potable site	–
	Incidental ingestion and dermal contact in situ	Construction workers	Quantitative	Incidental exposure while in a trench is a pathway of concern	0.006 hours/event, 10 events/day, 50 days/year, 1.5 years
		All other receptors	None	Not reasonably expected to contact groundwater *in situ*	–
	Vapour inhalation	Construction workers	Quantitative (trench air)	Assessed to be conservative	9.8 hours/day, 50 days/year, 1.5 years

Table 3-6: Exposure Pathway Summary – Groundwater					
Source	**Pathway**	**Receptor**	**Assessment**	**Rationale**	**Exposure frequency and duration**
		Outdoor workers	Quantitative (outdoor air)	Assessed to be conservative	9.8 hours/day, 195 days/year, 56 years
		Indoor workers	Quantitative (indoor air)	Pathway of concern and component values were exceeded	9.8 hours/day, 250 days/year, 56 years
		Patrons/ visitors	Qualitative (indoor air)	Receptor will have less exposure than workers	–
	Vapour dermal contact	All receptors	Qualitative	Contribution to overall COC exposure is considered negligible	–

Vapour skin contact was qualitatively identified, but not assessed quantitatively or discussed further in the RA as its contribution to overall COC exposure is considered negligible. In addition, the development of a reliable exposure estimate for this pathway has not been identified in the scientific literature or through other recognized regulatory agencies.

3.2.3 Indoor Vapour Modelling

Indoor vapour modelling was performed for (i) a generic commercial building with properties defined by MECP, and (ii) the proposed site building based on plans provided to Paterson Group. The ground floor layout will consist of two structurally and mechanically distinct components: (1) a restaurant with a kitchen, a hall, cloak room, washrooms, etc., with dimensions 17.38 m x 21.76 m; and (2) a retail/office space with dimensions 11.47 m x 6.03 m. As the two spaces on the ground floor will have separate ventilation systems, vapour intrusion into each space was modelled separately.

The scenarios that were modelled used the following building parameters:

- ❑ Dimensions:
    - i. Restaurant: 2,176 cm by 1,738 cm;
    - ii. Retail/office area: 1,147 cm by 603 cm.
- ❑ Height: 366 cm – The interior height of the indoor area on the ground floor will be 3,664 mm or 3.66 m.
- ❑ Slab thickness: 11.25 cm.
- ❑ Depth below grade to bottom of floor: 11.25 cm (thickness of slab).

All other parameters were set equal to a generic commercial building. Groundwater contamination was modelled at 450 cm below grade (minimum depth to groundwater measured at the site was 4.5 m). All model inputs are provided in Appendix C.

3.2.4 Exposure Estimates

Exposure estimates were calculated using standard models and equations (refer to Appendix C). For direct contact exposure pathways, exposure estimates were calculated as average daily does (ADD) summing contributions from dermal contact and incidental groundwater ingestion. These summed values were compared to TRVs in the risk characterization phase.

Exposure estimates for groundwater COCs are presented in Table 3-7 (oral/dermal pathways) and Table 3-8 (inhalation pathways). All exposure estimate results are provided in detail in Appendix C.

Table 3-7: Exposure Estimates – Groundwater COC Oral/Dermal Contact

COC	Indoor worker (mg/kg-day)	Outdoor worker (mg/kg-day)	Construction worker (mg/kg-day)
Tetrachloroethylene	–	–	6.04E-05
Vinyl chloride (future)	–	–	3.22E-06

Table 3-8: Exposure Estimates – Groundwater COC Inhalation

COC	Indoor worker			Outdoor worker (mg/m^3)	Construction worker (mg/m^3)
	Generic commercial building (mg/m^3)	Site building: Restaurant (mg/m^3)	Site building: Retail/Office (mg/m^3)		
Tetrachloroethylene	1.09E-03	8.50E-04	1.06E-03	4.85E-05	2.72E-04
Vinyl chloride (future)	2.82E-04	2.16E-04	2.93E-04	1.05E-05	5.89E-05

3.2.4.1 Uncertainties in the Exposure Assessment

Each of the areas of the exposure assessment described above is associated with some level of uncertainty. To ensure that estimates of exposure to COCs were not underestimated, conservative assumptions were used throughout the exposure assessment. In combination, these conservative assumptions have the effect of almost certainly overestimating exposure to the COCs. Uncertainties and the ways in which they were addressed include the following.

Groundwater concentrations of the COCs at the site exhibit variability. It was assumed in the risk assessment that the maximum detected concentration of each COC was representative of the entire site. This is a highly conservative assumption when one considers the frequency of detection, the frequency of exceeding the SCS, and the measures of central tendency and variability at the site. Notwithstanding, this assumption ensures that health risks are not underestimated, and in fact means that the results of this risk assessment almost certainly overestimate potential health risks associated with the site.

The maximum concentrations plus 20% of COCs detected in the soil and groundwater were used for this assessment rather than estimates developed using the central tendency (CT) or upper bound estimates such as the 95% upper confidence limit (UCL) on the mean. Consequently, exposure estimates (ADDs), while taking into account sampling variability, are likely conservatively overestimated. Consequently, the actual exposure (and ultimately hazard and risk) associated with COCs at the site is likely to be lower.

A number of conservative assumptions have also been made regarding estimates of receptor characteristics (e.g., daily ingestion rates, inhalation rates, skin surface areas, days per year on site, exposure durations). Combining the conservative point estimates of each of these parameters with the REM concentration effectively overestimates the calculated exposures for receptors potentially exposed to COCs at the site.

Exposure estimates were conservatively assessed in the absence of risk management measures. For example, construction worker exposure to groundwater in a trench was assessed, even though it is expected that trenches will be dewatered prior to commencing work (as required under O. Reg. 231/91, Section 230), and that appropriate basic personal protective equipment (PPE) will be worn during construction activities.

The use of any mathematical model to estimate ingestion, dermal or inhalation exposure of COCs in groundwater introduces a moderate degree of uncertainty. For example, a number of assumptions are typically fundamental to Johnson and Ettinger subsurface vapour intrusion modelling (e.g., vapour transport is through a homogeneously porous medium; steady state conditions exist at the site; an infinite source of contamination exists; mixing in the building is uniform; no preferential pathways exist; and transformation processes such as biodegradation do not occur). Although these assumptions are not necessarily realistic, they are nonetheless conservative and ensure that the predicted concentrations of COC vapour reaching indoor air are not underestimated.

COC vapour concentrations were estimated in trench air, despite no component values being available for this pathway, and were estimated in outdoor air, despite component values for this pathway being unavailable (groundwater-to-outdoor air).

3.3 Toxicity Assessment

3.3.1 Hazard Assessment

The hazard assessment categorizes the types of adverse health effects a COC may potentially cause. COCs are typically categorized with respect to the nature of their toxicity in three main ways:

- Chemicals that cause adverse health effects other than cancer;
- Chemicals that cause cancer; and
- Chemicals that act as developmental toxicants.

The COCs in this HHRA both have the potential to cause adverse health effects unrelated to cancer, and both are considered carcinogens. Neither COC is classified as a developmental toxicant.

3.3.2 Dose-Response Assessment

Dose-response assessment is the process of characterizing the relationship between the dose of an agent administered or received and the incidence of an adverse health effect in the exposed population. Once the relationship is characterized then a toxicological reference value (TRV) can be established. TRVs were obtained from MECP (mostly Canadian and US EPA sources) or, if not available, other recognized regulatory jurisdictions.

3.3.2.1 Threshold-Acting Chemicals

TRVs for non-carcinogenic chemicals are classified based on whether the exposure is from oral/dermal contact or from inhalation pathways. For oral and dermal pathways, TRVs may be reported as a tolerable daily intake (TDI) or a reference dose (RfD) and are expressed in units of mg/k/day. For inhalation pathways, TRVs may be reported as a tolerable concentration (TC) or a reference concentration (RfC) and are reported in units of mg/m^3.

The TRVs used to assess non-cancer hazard in the HHRA are provided in Table 3-9. MECP-recommended TRVs were used for all COCs.

Table 3-9: Human Health TRVs – Threshold Health Effects				
COC	**Type**	**Value**	**Units**	**Source**
Tetrachloro-ethylene	Oral	0.006	mg/kg/day	MOE (2011) TRV was superseded by an MOE guidance memorandum dated April 28, 2014. The recommended TRV is that developed by the US EPA and listed on IRIS (2012). It is based on multiple toxic effects to multiple systems (multiple points of departures and uncertainty factors) that support the final RfD.
	Inhalation	0.04	mg/m^3	MOE (2011) TRV was superseded by an MOE guidance memorandum dated April 28, 2014. The recommended TRV is that developed by the US EPA and listed on IRIS (2012). It is based on multiple toxic effects to multiple systems (multiple points of departures and uncertainty factors) that support the final RfC.
Vinyl chloride	Oral	0.003	mg/kg/day	MOE (2011) recommended the TRV developed by the US EPA and listed on IRIS (2000). An MOECC (2017) policy document contains preferred TRVs for selected COCs, including vinyl chloride, but the recommended oral chronic non-cancer TRV remained the same as MOE (2011) and continues to reference US EPA (2000). The US EPA (2000) Reference Dose is based on studies in which rats were chronically exposed via the diet (Til et al., 1983, 1991). The critical endpoint was liver effects (liver cell polymorphism). US EPA took a NOAEL of 0.13 mg/kg-day, converted it using PBPK modelling to a human equivalent dose ($NOAEL_{HED}$) of 0.09 mg/kg-day, then applied a total UF of 30 to arrive at the RfD.
	Inhalation	0.1	mg/m^3	MOE (2011) recommends the TRV developed by the US EPA and listed on IRIS (2000). An MOECC (2017) policy document contains preferred TRVs for selected COCs, including vinyl chloride, but the recommended inhalation chronic non-cancer TRV remained the same as MOE (2011) and continues to reference US EPA (2000). The US EPA (2000) Reference Concentration is based on studies in which rats were chronically exposed via the diet (Til et al., 1983, 1991). The critical endpoint was liver effects (liver cell polymorphism). US EPA took a NOAEL of 0.13 mg/kg-day, converted it using PBPK modelling and route-to-route extrapolation to a human equivalent concentration ($NOAEL_{HEC}$) of 2.5 mg/m^3, then applied a total UF of 30 to arrive at the RfC.

nv – no value available.

3.3.2.2 Non-Threshold-Acting Chemicals

TRVs for a non-threshold-acting chemicals (carcinogens) for oral/dermal pathways are referred to as cancer slope factors (CSF) and are expressed in units of $(mg/kg/day)^{-1}$. The CSF can be defined as an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. TRVs for inhalation pathways are referred to as unit risk factors (URF) with units of $(mg/m^3)^{-1}$. URFs represent excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 mg/m^3 in air.

The TRVs used to assess cancer risk in the HHRA are summarized and referenced in Table 3-13. MECP recommended TRVs were used for all COCs.

Table 3-10: Human Health TRVs – Non-Threshold Health Risks

COC	Type	Value	Units	Basis
Tetrachloro-ethylene	Oral	0.0021	$(mg/kg/day)^{-1}$	MOE (2011) TRV has been superseded by an MOE guidance memorandum dated April 28, 2014. The recommended TRV is that developed by the US EPA and listed on IRIS (2012). It is based on hepatocellular adenomas and carcinomas in mice and rats after inhalation exposure. US EPA used a multistage model followed by route-to-route extrapolation to the oral route and interspecies extrapolation using a PBPK model.
	Inhalation	2.6E-04	$(mg/m^3)^{-1}$	MOE (2011) TRV was superseded by an MOE guidance memorandum dated April 28, 2014. The recommended TRV is that developed by the US EPA and listed on IRIS (2012). It is based on hepatocellular adenomas and carcinomas in mice and rats after inhalation exposure. US EPA used a multistage model with linear extrapolation from the point of departure, followed by extrapolation to humans using a PBPK model.
Vinyl chloride	Oral	0.72	$(mg/kg/day)^{-1}$	MOE (2011) recommends the TRV developed by the US EPA and listed on IRIS (2000). It is based on cancer of liver in female rats after oral exposure (Feron et al., 1981). US EPA calculated human-equivalent doses and also accounted for age-dependent sensitivities in developing two CSF values. The value for adults is used here.
	Inhalation	0.0044	$(mg/m^3)^{-1}$	MOE (2011) recommends the TRV developed by the US EPA and listed on IRIS (2000). It is based on cancer of liver in female rats after inhalation exposure (Maltoni et al., 1981, 1984). US EPA calculated human-equivalent concentrations and also accounted for age-dependent sensitivities in developing two IUR values. The value for adults is used here.

3.3.2.3 Developmental Toxicants

As previously stated, none of the COCs in this RA is classified as a developmental toxicant.

3.3.2.4 Uncertainties in the Toxicity Assessment

In the dose-response assessment, the major sources of uncertainty concerning the toxicity assessment include the extrapolation from high doses in animals to low doses in humans, and conservative assumptions built into the derivation of TRVs. Each of the toxicologically based exposure limits used to estimate potential health risks have uncertainty factors associated with them. These factors largely account for the strength of the toxicological data and incorporate uncertainty factors to account for intra-species and interspecies extrapolations of toxicological data as well as extrapolations from acute and sub-chronic exposure studies to chronic exposures.

The assumed cancer slope factors and unit risks provided by the regulatory jurisdictions were assumed to be reliable and accurate in characterizing the relationship between chemical concentrations, doses and adverse health effects. Most regulatory agencies typically derive cancer slope factors by evaluating the 95% upper confidence limit of the slope of the dose response curve. The use of this upper limit is highly conservative and is intended to account for uncertainties that are brought upon, for example, by the use of experimental animals. This linear relationship assumption implies that any concentration of a carcinogen other than zero increases the risk of developing cancer by some extent, which could lead to a significant overestimation of the total risk.

3.4 Risk Characterization

3.4.1 Quantitative Interpretation of Human Health Risks

Quantitative risk estimates were generated for each relevant COC/pathway/receptor by calculating one or both of:

- ❑ A hazard quotient (HQ) for potential non-cancer health effects. The method/equation to calculate a HQ value is presented below. All HQ output/results are presented in the tables that follow, as well as in Appendix A. The HQ considered acceptable for most COCs is 0.2 (i.e., 20% of one's allowable exposure to a contaminant is permitted to come from a single contaminated site, thereby providing an allowance for 80% of allowable exposure to come from sources unrelated to the site).

$$\mathrm{HQ} = \frac{\text{Exposure estimate}}{\text{Threshold TRV}}$$

- ❑ An incremental lifetime cancer risk (ILCR) for potential risk of developing cancer. The method/equation to calculate an ILCR value is presented below. All ILCR output/results are presented in the tables that follow, as well as in Appendix A. The ILCR considered acceptable by MECP is 0.000001 (i.e., 1×10^{-6}, one-in-one-million, or 0.0001%).

$$\mathrm{ILCR} = \text{Exposure estimate} \times \frac{\text{Years exposed}}{\text{Amortization period}} \times \mathrm{TRV}$$

Quantitative risk estimates are interpreted as follows:

- Groundwater oral/dermal pathways (Table 3-11) – HQ values and ILCR values for tetrachloroethylene and future vinyl chloride were within acceptable limits.
- Groundwater inhalation pathways:
  - Indoor workers (Table 3-12) – Unacceptable ILCR values were calculated for workers exposed in a generic commercial building and in the proposed site building (both the restaurant space and the retail/office space) to vinyl chloride that may form in groundwater in the future as a result of degradation of tetrachloroethylene over time.
  - Outdoor workers (Table 3-13) – HQ and ICLR values were within acceptable limits for both COCs.
  - Construction workers (Table 3-14) – HQ and ICLR values were within acceptable limits for both COCs.

Table 3-11: Risk Results from Groundwater COC Oral/Dermal Contact – Construction Worker

		Non-cancer hazard			Cancer risk		
COC	Groundwater REM (µg/L)	Total oral/dermal dose (mg/kg-day)	Oral TRV (mg/kg-day)	HQ	Amortized oral/dermal dose (mg/kg-day)	Oral TRV $(mg/kg\text{-}day)^{-1}$	ILCR
Tetrachloroethylene	68.52	6.04E-05	6.00E-03	1.01E-02	1.62E-06	2.10E-03	3.40E-09
Vinyl chloride (future)	6.41	3.22E-06	3.00E-03	1.07E-03	8.63E-08	1.40E+00	1.21E-07

Table 3-12: Risk Results from Groundwater COC Inhalation – Indoor Worker

		Non-cancer hazard			Cancer risk		
COC	Groundwater REM (µg/L)	Total inhaled conc. (mg/m^3)	Inhalation TRV (mg/m^3)	HQ	Amortized inhaled conc. (mg/m^3)	Inhalation TRV $(mg/m^3)^{-1}$	ILCR
Generic Commercial Building (Slab-on-Grade)							
Tetrachloroethylene	68.52	1.09E-03	4.00E-02	2.73E-02	1.09E-03	2.60E-04	2.84E-07
Vinyl chloride (future)	6.41	2.82E-04	1.00E-01	2.82E-03	2.82E-04	8.80E-03	**2.48E-06**
Site Commercial Building – Restaurant							
Tetrachloroethylene	68.52	8.50E-04	4.00E-02	2.12E-02	8.50E-04	2.60E-04	2.21E-07
Vinyl chloride (future)	6.41	2.16E-04	1.00E-01	2.16E-03	2.16E-04	8.80E-03	**1.90E-06**
Site Commercial Building – Retail/Office							
Tetrachloroethylene	68.52	1.06E-03	4.00E-02	2.65E-02	1.06E-03	2.60E-04	2.76E-07
Vinyl chloride (future)	6.41	2.93E-04	1.00E-01	2.93E-03	2.93E-04	8.80E-03	**2.57E-06**

Table 3-13: Risk Results from Groundwater COC Inhalation – Outdoor Workers

		Non-cancer hazard			Cancer risk		
COC	Groundwater REM (µg/L)	Total inhaled conc. (mg/m^3)	Inhalation TRV (mg/m^3)	HQ	Amortized inhaled conc. (mg/m^3)	Inhalation TRV $(mg/m^3)^{-1}$	ILCR
Tetrachloroethylene	1,860	4.85E-05	4.00E-02	1.21E-03	4.85E-05	2.60E-04	1.26E-08
Vinyl chloride (future)	169.28	1.05E-05	1.00E-01	1.05E-04	1.05E-05	8.80E-03	9.23E-08

Table 3-14: Risk Results from Groundwater COC Inhalation – Construction Workers							
		Non-cancer hazard			Cancer risk		
COC	Groundwater REM (µg/L)	Total inhaled conc. (mg/m^3)	Inhalation TRV (mg/m^3)	HQ	Amortized inhaled conc. (mg/m^3)	Inhalation TRV $(mg/m^3)^{-1}$	ILCR
Tetrachloroethylene	1,860	2.72E-04	4.00E-02	6.81E-03	7.29E-06	2.60E-04	1.90E-09
Vinyl chloride (future)	169.28	5.89E-05	1.00E-01	5.89E-04	1.58E-06	8.80E-03	1.39E-08

3.4.1.1 Summary of Required Risk Reduction and Human Health Effects-Based Values

A summary of the HHRA quantitative assessment is presented in Table 3-15.

For threshold-acting chemicals, a *risk reduction factor* for each applicable receptor/pathway/COC that poses a potentially unacceptable risk was calculated using a ratio approach. For most chemicals, the acceptable HQ limit is 0.2. Risk reduction factors were calculated as:

$$\text{Risk reduction} = {}^{\text{HQ}}/_{0.2}$$

For non-threshold-acting chemicals, the risk reduction factor was calculated as:

$$\text{Risk reduction} = {}^{\text{ILCR}}/_{10^{-6}}$$

A human health *effects-based value* below which no adverse effects are anticipated was calculated for each receptor/pathway/COC that posed a potentially unacceptable risk. Effects-based values were calculated as:

$$\text{Effects based value} = \frac{\text{REM concentration}}{\text{Risk reduction factor}}$$

Risk-based values and risk reduction factors are presented in Table 3-15.

Table 3-15: Summary of Human Health-Based Standards for Groundwater COCs

COC	REM conc. (µg/g)	Risk-based value		Minimum risk-based value (µg/g)	REM conc. exceeds	Risk reduction factor
		Oral/dermal exposure (µg/g)	Vapour exposure (µg/g)			
Indoor Workers – Site Commercial Building						
Tetrachloroethylene	68.52	–	249	249	No	
Vinyl chloride (future)	6.41	–	**2.49**	**2.49**	**Yes**	2.57
Outdoor Workers						
Tetrachloroethylene	68.52	–	5,440	5,440	No	–
Vinyl chloride (future)	6.41	–	69.5	69.5	No	–
Oral/dermal Contact – Construction Workers						
Tetrachloroethylene	68.52	1,360	2,010	1,360	No	–
Vinyl chloride (future)	6.41	53.1	462	53.1	No	–

3.4.2 Qualitative Interpretation of Human Health Risks

3.4.2.1 Pathways Assessed Qualitatively

Vapour Skin Contact

The vapour skin contact pathway was not evaluated quantitatively because its contribution to overall COC exposure is considered negligible. In addition, the development of a reliable exposure estimate for this pathway has not been identified in the scientific literature or through other recognized regulatory agencies.

Odours

Odour exposure pathways were not evaluated quantitatively because there is no means to complete a quantitative assessment, as a dose-response relationship between nuisance odours and direct health impacts cannot be quantified. Odours arising from COCs would not be expected to adversely affect human health.

Free-Phase Product

Groundwater component values for the expected development of free-phase product (half-solubility limit) were not exceeded by any COC. Exposure to free phase product was not evaluated quantitatively because all COCs were less than free phase thresholds for soil and groundwater. There is also no evidence of free product at the site.

3.4.2.2 Receptors Assessed Qualitatively

As discussed in Section 3.2.1, some on-Site receptors were assessed qualitatively in this HHRA:

- Patrons represent people who may visit the commercial business at the Site. These receptors were not evaluated quantitatively because risks to these receptors are assumed to be conservatively represented by potential risks to indoor full-time workers who work in the building (i.e., it is unlikely a visitor would be at the site longer than the person working there). Health standards protective of indoor workers are considered to provide adequate protection for patrons.

3.5 Discussion of Uncertainty

Within many of the steps of the risk assessment process, assumptions must be made due to a lack of scientific certainty. The use of assumptions introduces some degree of uncertainty into the risk assessment process. As such, to the extent possible conservative assumptions are made throughout the risk assessment to ensure that estimates of risks to human receptors are exaggerated rather than underestimated. While some uncertainty stems from the variability in sample data due to heterogeneity, this has been addressed through the sampling program conducted for the site, and the use of the maximum plus 20% to account for sampling variability.

The predominant uncertainties in the risk were discussed throughout each section of the RA.

In summary, some typical areas of uncertainty encountered in the risk assessment may include:

- ❑ Adequacy of site characterization;
- ❑ Quality of analytical data;
- ❑ Accuracy of modelling;
- ❑ Accuracy of the assumption concerning frequency, duration and magnitude of exposures; and
- ❑ Availability and accuracy of toxicity data.

Although the magnitude of the uncertainties may not be possible to quantify, the nature of the risk assessment process is to err on the side of public health safety.

3.5.1 Quality of the Analytical Data

Overall, it is the opinion of the risk assessor that there is a sufficient description of the subsurface conditions and the soil and groundwater data are of sufficient quality for assessing exposure pathways and risk to relevant human receptors.

To ensure that a conservative assessment of potential health concerns for human receptors was evaluated, the RA considered potential analytical variance in environmental samples. REM estimates were used for each parameter screened into the RA to evaluate risk. The REM estimate is calculated as the maximum concentration plus 20%.

3.5.2 Accuracy of Modelling

Vapour intrusion modeling was completed using the same formulas as outlined and available in the 2004 J&E models (for soil and groundwater). A fundamental aspect of the J&E model is that vapour transport is through a homogeneously porous medium, which is typically not the case. In addition, there are a number of other assumptions that are often used to develop the attenuation coefficient, including:

- Steady state conditions exist at the site;
- An infinite source of contamination exists;
- Mixing in the building is uniform;
- No preferential pathways exist; and
- Biodegradation (or any other transformation process) does not occur.

In general, some concern has been expressed with the model as it is sensitive to several input parameters that are difficult to validate with the type of information that is collected in a typical field investigation. Where the model is used as a screening tool, the U.S. EPA cautions that *reasonably conservative assumptions based on* available *data be used as input parameters* (U.S. EPA 2004). Overall, the use of J&E is considered to be acceptable.

3.5.3 Availability and Accuracy of Toxicity Data

In the dose-response assessment, the major sources of uncertainty concerning the toxicity assessment include the extrapolation from high doses in animals to low doses in humans, and conservative assumptions built into the derivation of TRVs. Some of the toxicological based exposure limits used to estimate potential health risks have uncertainty factors associated with them. These factors largely account for the strength of the toxicological data and incorporate uncertainty factors to account for intra-species and interspecies extrapolations of toxicological data as well as extrapolations from acute and sub-chronic exposure studies to chronic exposures.

TDI values incorporate uncertainty factors to address the following sources of uncertainty:

- The expected differences in responsiveness between humans and animals;
- Variability among individuals within the human population;
- Extrapolation from a LOAEL to a NOAEL;

- ❑ Extrapolation from a sub-chronic to chronic exposure; and
- ❑ An inadequate toxicity database.

These uncertainty factors reflect the adequacy (or inadequacy) of the toxicological data available for each compound. Where toxicological data is poor or limited to one or two studies, large uncertainty factors are applied to ensure adequate protection of sensitive members of the population.

The assumed cancer slope factors and unit risks provided by the regulatory jurisdictions were considered to be reliable and accurate in characterizing the relationship between chemical concentrations, doses and adverse health effects. Most regulatory agencies typically derive cancer slope factors by evaluating the 95% upper confidence limit of the slope of the dose response curve (U.S. EPA, etc.). The use of this upper limit is highly conservative and *is intended to account for uncertainties that are brought upon, for example, by the use of experimental animals. This linear relationship assumption implies that any concentration of a carcinogen other than zero increases the risk of developing cancer by some extent, which could lead to a significant overestimation of the total risk. To reduce uncertainty, and ensure an overall conservative assessment, the most appropriate TRVs have been used from credible agencies to reduce, as much as possible, uncertainty in the TRVs.

Overall, based on our review and investigation, we have concluded that the uncertainties, while present, do not affect the conclusions obtained in the risk assessment.

4.0 ECOLOGICAL RISK ASSESSMENT (ERA)

4.1 Problem Formulation

4.1.1 Ecological Conceptual Exposure Model

The ecological CEM summarizes the on-site and off-site ecological receptors and exposure pathways by which they may be exposed to contaminants in soil and groundwater. A graphical depiction of the ecological CEM is provided in Figure 5.

Subsurface investigations at the RA Property identified the presence of lead in soil and tetrachloroethylene in groundwater at concentrations greater than Table 3 SCS. Vinyl chloride (future concentrations) also was identified as a COC based on the presence of the parent chemical tetrachloroethylene.

COCs at the RA Property are subject to several environmental transport pathways:

- ❑ Volatilization to atmosphere – Tetrachloroethylene and vinyl chloride may volatilize from groundwater and migrate to shallow soil strata, where they may discharge to the atmosphere. Vapours are rapidly diluted in outdoor air such that effects on ecological receptors typically are not a concern.
- ❑ Subsurface transport – COCs with sufficient aqueous solubility may undergo subsurface transport, potentially discharging to a down-gradient surface water body. The MECP refers to this exposure pathway as the GW3 pathway.
- ❑ Degradation – VOCs can be degraded over time by both abiotic and biotic pathways.

The nearest water body to the site is the Poole Creek, located approximately 600 m northwest of the site. The creek is assumed to provide suitable habitat for a variety of aquatic receptors, including aquatic plants, aquatic invertebrates, amphibians, and fish. As COCs are capable of subsurface transport via groundwater flow, the potential discharge of contaminated groundwater to the creek is considered a complete exposure pathway.

Potential ecological receptors on and in the vicinity of the RA Property include plants, soil invertebrates, mammals, and birds. The following terrestrial ecological receptors were identified as on-site Valued Ecosystem Components (VECs):

- ❑ Terrestrial plants, including trees, shrubs, herbs, and grasses typically used in landscaping;
- ❑ Soil invertebrates, represented by earthworms;

- Mammals: herbivorous meadow vole, insectivorous short-tailed shrew, carnivorous red fox;
- Birds: herbivorous red-winged blackbird; insectivorous American woodcock, carnivorous red-tailed hawk.

Off-site receptors consisted of the following aquatic receptors (not identified at the species level):

- Aquatic plant community;
- Aquatic invertebrate community;
- Amphibian community; and
- Fish community.

Given the distribution of contaminants and the conditions at the site, ecological receptors potentially may be exposed to contaminants via the following exposure pathways:

- Root uptake/contact – It was assumed for the ERA that terrestrial plants can potentially be exposed to contaminants in soil via root uptake/contact, either through active uptake or passive migration into root tissues, or via impacts from root contact with contaminated soil. Based on the depth to groundwater at the site, root uptake from groundwater was considered to be an incomplete exposure pathway. Most plants extend roots to no more than 1 mbgs. Groundwater at the RA Property was determined to be >3 mbgs.
- Direct/dermal contact – Soil invertebrates are potentially exposed to lead in soil via direct contact. This pathway is considered to be minor for mammals and birds.
- Ingestion of soil – Mammals and birds are exposed to lead in soil via ingestion of soil during foraging.
- Ingestion of food/prey – Mammals and birds are exposed to lead in soil that may accumulate in vegetation, soil invertebrates, and prey.
- Inhalation of soil – Mammals and birds may inhale soil that is entrained in the air. This exposure pathway is considered to be minor.
- Inhalation of vapours – Mammals and birds may inhale volatile COCs in ambient air. This exposure pathway is considered to be minor.
- Groundwater migration and discharge to surface water (GW3) – Off-site aquatic receptors may be exposed to COCs in soil and groundwater via leaching of soil

contaminants into groundwater and discharge of contaminated groundwater to a surface water body. Uptake pathways for aquatic receptors include root uptake (aquatic plants) and direct contact (aquatic invertebrates, amphibians, fish).

4.1.2 Identification of Chemicals of Concern for ERA

4.1.2.1 Soil COCs

The REM concentration of lead in soil was screened against the following ecological component values used to develop the Table 3 SCS, to determine which exposure pathways required quantitative assessment in the ERA:

- ❑ Plants and soil organisms (P&SO) – Component values for plants and soil organisms are protective of terrestrial plants and soil invertebrates exposed to contaminants in soil via root uptake and direct contact pathways.
- ❑ Mammals and birds (M&B) – Component values for mammals and birds are protective of wildlife exposed to soil contaminants via ingestion of soil and ingestion of food items (vegetation, soil invertebrates, small mammal prey) that may accumulate contaminants from soil.
- ❑ S-GW3 – S-GW3 values are protective of the pathway in which contaminants leach from soil to groundwater and discharge to a down-gradient surface water body. No S-GW3 value was identified for lead. MECP did not develop S-GW3 values for most metals because leaching of inorganic parameters from soil to groundwater varies considerably from site to site depending on soil conditions (pH, redox, moisture, organic content, etc.) and is not easily predicted using soil parameters typically measured in a Phase II investigation. The risk to off-site aquatic receptors from lead via the S-GW3 pathway is considered to be negligible. Cationic heavy metals such as lead have poor aqueous solubility and tend to bind strongly to soil particles, exhibiting very low mobility in groundwater.

The ecological soil screening is presented in Table 4-1.

Table 4-1: Screening of Soil COCs for Quantitative Evaluation in the ERA

COC	REM conc. (µg/g)	Plant/soil org. (µg/g)	Mammal/ bird (µg/g)	S-GW3 (µg/g)	Pathways quantitatively evaluated
Lead	321.6	1,100	**32**	NV	Mammals and birds

NV – No value

Table 4-1: Screening of Soil COCs for Quantitative Evaluation in the ERA					
COC	**REM conc. (µg/g)**	**Plant/soil org. (µg/g)**	**Mammal/ bird (µg/g)**	**S-GW3 (µg/g)**	**Pathways quantitatively evaluated**

Bold values: REM exceeds component value

As the REM concentration of lead exceeded the MECP mammal and birds (M&B) component value for mammals and birds, lead was carried forward for further evaluation of risks to mammals and birds via ingestion pathways in the ERA.

4.1.2.2 Groundwater COCs

In Section 2, tetrachloroethylene and vinyl chloride were identified as COCs in groundwater of the site based on comparison to Table 3 SCS. REM concentrations of COCs in groundwater were screened against GW3 component values to identify those requiring further examination. The GW3 component value refers to the pathway involving discharge of groundwater to surface water and is intended to protect aquatic receptors. However, the MECP also considers GW3 values to be protective of terrestrial receptors exposed to groundwater (e.g., via root uptake or ingestion of water that daylights in a shallow seep).

The secondary screening of COCs using the ecological component value for groundwater is presented in Table 4-2.

Table 4-2: Screening of Groundwater COCs for ERA

COC	**REM conc. (µg/L)**	**Table 3 GW3 (µg/L)**	**Pathways evaluated quantitatively**
Tetrachloroethylene	57.1	11,000	(none)
Vinyl chloride (future)	6.41	450,000	(none)

REM concentrations of both groundwater COCs were much less than generic Table 3 GW3 values. No groundwater COCs were carried forward in the ERA.

4.2 Receptor Characterization

The receptor characterization step includes the characterization of the site with respect to the ecological habitats or resources present or likely to be present, description of Valued Ecosystem Components (VEC) both on-site and off-site, and identification of plausible exposure pathways.

4.2.1 Ecological Habitat

The RA Property is located in an urban environment and surrounded by commercial and residential properties. Given the characteristics of the site, it is not considered to be sensitive, and is not expected to provide pristine or high-quality habitat for ecological receptors. There is no natural habitat on the RA Property. Following redevelopment, much of the site will be covered by the proposed building and hard surfaces (asphalt, concrete, pavers, etc.).

4.2.2 At-Risk Species

A search of the Ontario National Heritage Information Center (NHIC) online database was conducted to identify threatened and endangered species within a 2-km^2 area (grids 18VR2711 and 18VR2712) that includes the RA Property. The results of this search listed the following species listed as Threatened or Endangered:

- ❑ Butternut – Butternut (Juglans cinerea) is listed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and Species at Risk in Ontario (SARO). Endangered species identified by COSEWIC are species facing imminent extirpation from Canada or extinction. An endangered species listed by SARO is a species facing imminent extinction or extirpation is Ontario that has been regulated under Ontario's *Endangered Species Act*. The predominant threat to butternut is butternut canker (*Sirococcus clavignenti-juglandacearum*), a fungal disease which has had a devastating impact on the populations of this tree species. Individual trees of this species are protected by Regulation in the hopes that some trees are resistant to this disease, and that these resistant individuals or populations of butternut can be used in the recovery of this species. No butternut are present at the RA Property.
- ❑ Least bittern – The least bittern (*Ixobrychus exilis*) is an insectivorous/ carnivorous marsh bird and the smallest member of the heron family. In Ontario, the least bittern breeds in marshes, usually greater than 5 ha, with emergent vegetation, relatively stable water levels and areas of open water. Preferred habitat has water less than 1 m deep (usually 10–50 cm). Nests are built in tall stands of dense emergent or woody vegetation (Woodliffe 2007). Clarity of water is important as siltation, turbidity, or excessive eutrophication hinders foraging efficiency (COSEWIC 2009). This species is unlikely to forage or nest at the Site. Least Bittern need emergent vegetation, including cattails, that are inundated to support their life cycle needs. Suitable habitat for the least bittern is not present at the RA Property.

- Wood thrush – The wood thrush (*Hylocichla mustelina*) is a medium-sized bird that preferentially inhabits deciduous and mixed forests that have good canopy cover, moderate subcanopy and shrub density, shade, a fairly open forest floor, moist soil, and decaying leaf litter. It is relatively tolerant of forest fragmentation and can nest in small woodlots. It forages in leaf litter or on semi-bare ground under the forest canopy and primarily consumes insects and berries. The preferred habitat for the wood thrush is not present at the RA Property.

- Eastern whip-poor-will – The eastern whip-poor-will (*Antrostomas vociferus*) is an aerial-foraging insectivorous bird that feeds actively on moon-lit nights. Adults roost by day on the open leaf litter of forests or on a stub or the horizontal limb of a tree. It is a species of open woodlands, savannahs, regenerating burns, and other scrubby habitats, generally avoiding open or heavily forested habitats. Whip-poor-wills prefer areas of open to semi-open successional and woodland habitats. Open regenerating forest stands have a positive effect on the density of whip-poor-wills because open habitats provide greater access to prey, especially moths, the primary food item of whip-poor-wills (Cink 2002). Open habitats receive greater lunar illumination, which is critical for a bird species that forage on aerial prey using only a visual field exploiting back-lit insects. Regenerating stands therefore provide a richer prey base and better foraging conditions compared to closed canopies. For a species such as the whip-poor-will that requires more than one habitat type (i.e., closed forest for nesting, open areas for foraging), regenerating forest stands adjacent to mature stands may allow whip-poor-wills to exploit foraging and nesting habitats in close proximity (Dunning et al. 1992; Watts 1996; Ries and Sisk 2004). The RA Property does not provide suitable habitat for the whip-poor-will.

- Blanding's turtle – Blanding's Turtle (*Emydoidea blandingii*) are found throughout southern, central, and eastern Ontario. They live in shallow water, usually in large wetlands and shallow lakes with lots of water plants, and hibernate in the mud at the bottom of permanent water bodies. No habitat for Blanding's turtle is present at the site.

- Western chorus frog (Great Lakes/St. Lawrence-Canadian Shield population) – The western chorus frog (*Pseudacris triseriata*) is a small brown/grey tree frog about 2.5 cm long and weighing about 1 g when adult. In Canada, *P. triseriata* is found in the lowlands of southern Ontario and southwestern Quebec. The Great Lakes/St. Lawrence-Canadian Shield population of the western chorus frog is listed as Threatened by COSEWIC due to a dwindling population. The western chorus frog requires both terrestrial and aquatic habitats in close proximity. Terrestrial habitat consists mostly of humid prairie, moist woods, or meadows. For reproduction and tadpole development, this species requires seasonally dry, temporary ponds that are devoid of predators such as fish. Habitat for the western chorus frog is not present at the RA Property.

Given the absence of suitable habitat for any of the SAR listed in the NHIC database, the presence of SAR at the RA Property is considered to be unlikely.

4.2.3 Identification of Potential Receptors

VECs are receptors that have an intrinsic, economic, or social value. VECs are typically selected based on surveys of the site and knowledge of receptors typically found in similar environments.

The following terrestrial ecological receptors were identified as VECs:

- Terrestrial plants, represented by ornamental trees, shrubs, and turf grass used in landscaping;
- Soil invertebrates, represented by earthworms;
- Mammals: herbivorous meadow vole, insectivorous short-tailed shrew, carnivorous red fox;
- Birds: herbivorous red-winged blackbird, insectivorous American woodcock, carnivorous red-tailed hawk.

The following off-site aquatic receptors were identified as VECs:

- Aquatic plant community;
- Aquatic invertebrate community;
- Amphibian community; and
- Fish community.

Given that habitat off-site is similar to on-site habitat, off-site terrestrial VECs are assumed to be identical to on-site VECs.

Descriptions of VECs are provided below.

4.2.3.1 Terrestrial Plants

Following redevelopment, the RA Property is assumed to support typical urban plants including grass, ornamental shrubs, and trees. As autotrophs, plants are the foundation of any terrestrial ecosystem, including those heavily modified or influenced by humans. Consistent with Ministry guidance (MOE 2005), plants were assessed as a group, rather than as separate species. Plants are potentially exposed to COCs in soil via root uptake and root contact.

4.2.3.2 Soil Invertebrates

Soil is assumed to support indigenous soil invertebrates such as earthworms, grubs, arthropods, etc. In terms of sensitivity to toxicants, earthworms are considered to be one of the most sensitive receptors for soil contaminants. Earthworms are in near-constant direct dermal contact with soil. Earthworms are probably the most important soil invertebrate in promoting soil fertility (Edwards 1992). The feeding and burrowing activities of worms break down organic matter and release nutrients and improve aeration, drainage, and aggregation of soil. Earthworms are also important components of the diets of many higher animals. Due to their importance in a healthy ecosystem, as well as their ubiquity in the environment, earthworms were selected as a representative surrogate for all soil invertebrate species.

4.2.3.3 Meadow Vole

Of the mammals that may be present at residential sites, voles are most likely to receive relatively large doses of COCs, as they have a small home range (0.083 ha; U.S. EPA 1993) and therefore are likely to spend more time within contaminated areas and consume a relatively high proportion of soil in their diet. The meadow vole (*Microtus pennsylvanicus*) was chosen as a representative surrogate for small herbivorous mammals that may be found at the site. Voles are small (44 g; Sample and Suter 1994) herbivorous rodents found throughout Canada and the U.S. wherever there is grass cover. The meadow vole makes its burrows along surface runways in grasses or other herbaceous vegetation. Voles inhabit grassy fields, marshes, and bogs (Getz 1961). Microtus voles consume green vegetation, sedges, seeds, roots, bark, fungi, insects, and animal matter. Meadow voles favor green vegetation when it is available and consume other foods more when green vegetation is less available (Riewe 1973; Johnson and Johnson 1982; Getz 1985). Although there is some evidence of food selection, meadow voles generally eat the most common plants in their habitat (Zimmerman 1965). The overall ingestion rate of meadow voles has been estimated to be 0.005 kg/day (Sample and Suter 1994).

4.2.3.4 Short-tailed Shrew

The shrew is proposed as a VEC representative of small insectivorous mammals. The northern short-tailed shrew (*Blarina brevicauda*) is the most widespread shrew species in southern Canada and the north-central and northeastern U.S. (George et al. 1986). Shrews are an important component of the diet of many raptors (Palmer and Fowler 1975) and are also prey for carnivores such as fox and weasels (Buckner 1966). Shrews inhabit a wide variety of habitats and are common in areas with abundant vegetative cover (Miller and Getz 1977). Shrews burrow in the upper layers of soil. Underground runways and nests are usually constructed within the upper 10 cm of soil (George et al. 1986). The diet of the short-tailed shrew consists of small arthropods such as grasshoppers and beetles, worms, and limited amounts of seeds and berries (Sample and Suter 1994). For the purposes of the ERA, a food ingestion rate of 9 g/day (wet weight) was assumed (Sample and Suter 1994).

4.2.3.5 Red Fox

The red fox (*Vulpes vulpes*) was selected as a VEC representing larger carnivorous/omnivorous mammals. Red foxes are abundant throughout North America, except in parts of the central and southwestern U.S. Red foxes are approximately 56 to 63 cm in length, and weigh 3 to 7 kg. Red foxes prey extensively on small rodents such as meadow vole, field mice, and hare, but also consume game birds, insects, and occasionally fruit, berries, seeds, and nuts (Palmer and Fowler 1975). The home range of the red fox varies considerably according to landscape; in a non-urban area, home ranges can be as large as 3,000 ha (U.S. EPA 1993).

4.2.3.6 Red-winged Blackbird

The red-winged blackbird (*Agelarius phoeniceus*) is a passerine bird very common near freshwater marshes, lakes, and rivers across Ontario during summer months. The red-winged blackbird inhabits open grassy areas and prefers wetlands, particularly if cattail (*Typha*) is present. It is also found in dry upland areas, where it inhabits meadows, prairies, and old fields. The red-winged blackbird nests in cattails, rushes, grasses, sedge, or in alder or willow bushes over the water. The most sensitive life stage of this species (developmental stage) is spent in Ontario. During most of the year, the red-winged blackbird is herbivorous or granivorous, consuming primarily grains and seeds. However, during breeding season, insects such as dragonflies, damselflies, butterflies, moths, and flies form a significant fraction of the diet. Consistent with assumptions employed by the Ministry in the development of the generic SCS, the red-winged blackbird was assumed in the ERA to be strictly herbivorous. The red-winged blackbird was selected as a surrogate for all herbivorous passerine birds that may be found at the site.

4.2.3.7 American Woodcock

The American woodcock (*Scolopax minor*), or timberdoodle, was chosen as a surrogate for vermivorous or omnivorous avian species that may forage at the site. The American woodcock is a medium-sized (200 g) shorebird species related to sandpipers. The woodcock is found throughout the eastern U.S. and southern Ontario during summer months. The woodcock prefers rural areas with both woodlands and open abandoned agricultural fields. Woodcocks nest in mature hardwood or early successional mixed forest. They roost at night in open pastures and abandoned fields. Preferred foraging habitat is moist upland soil that can be probed using their bill to search for soil invertebrates, primarily earthworms. Woodcocks are intolerant of human disturbance; the decline of this species throughout North America has been attributed to urbanization and diminished habitat due to forest maturation; i.e., the succession of open, disturbed woodlots to mature forest.

4.2.3.8 Red-tailed Hawk

The red-tailed hawk (*Buteo jamaicensis*) is a large carnivorous bird that tolerates a variety of human-dominated ecosystems, including urban landscapes. Red-tailed hawks are found in a wide range of habitats, but prefer landscapes with a mixture of fields, wetlands, pastures, and trees (U.S. EPA 1993). Hawks are migratory, except in the southern areas of their distribution. Red-tailed hawks are territorial, hunting in open areas such as marshes, meadows, fields, and brushy areas that attract rodents. Craighead and Craighead (1969) estimated the food consumption rate of red-tailed hawks ranges from 0.073 to 0.136 kg/d. In pasture lands, small mammals constitute approximately 80% of the diet (Janes 1984). Janes (1984) estimated a home range of 233 ha for this species, but larger home ranges (>2,400 ha) have been documented in prairie/woodland landscapes in the western U.S. (Andersen and Rongstad 1989).

4.2.3.9 Aquatic Plants

Aquatic plants are an important component of freshwater ecological systems. Aquatic plants take a variety of forms, including submerged, emergent, and free-floating forms. Aquatic plants, including algae, oxygenate water and form the basis of the aquatic food chain. Submerged macrophytes also provide habitat/cover for a variety of fish. Emergent forms, such as cattails, bulrushes, and reeds, are used by birds for cover and food.

4.2.3.10 Aquatic Invertebrates

Invertebrates, as a group, play a critical role in the ecology of aquatic systems, as primary consumers, detritivores, and as prey for organisms at higher trophic levels. Aquatic invertebrates, as prey for many fish species, are critical for the proper functioning of riverine ecosystems. Many invertebrates are epibenthic and are in direct contact with sediments, and as such, receive more exposure to sediment-borne contaminants than any other group. Additionally, aquatic invertebrates as a group tend to be one of the most sensitive to environmental contaminants, so protection of invertebrates also tends to result in protection of other species. Invertebrates are often used as ‘indicators’ of environmental degradation, because of their rapid and predictable response to various environmental contaminants and other stressors.

4.2.3.11 Amphibians

Down-gradient water bodies are assumed to provide habitat for a number of amphibians, such as frogs and salamanders. Reproduction and development of amphibians occurs in water; however, adults are not obligate water dwellers and may forage some distance from surface water bodies, inhabiting forests, fields, muskegs, marshes, wet meadows, and moist woodlands. While some species remain close to water throughout their life, some adult amphibians (e.g., wood frog) range over remarkably large areas hunting terrestrial invertebrates such as insects, spiders, snails, slugs, and earthworms.

4.2.3.12 Fish

Fish may be potentially affected by contaminants in surface water. Because there are numerous fishes that may be potentially impacted by contaminants and no single species is known to be of particular importance in the vicinity of the site, no single species was selected. Rather, effects to fish as a group were evaluated. Fish can be exposed to contaminants in surface water and sediment, but regardless of the source, uptake across the gills occurs via the aqueous pathway; therefore, for the purposes of this assessment it was assumed that fish are exposed primarily via uptake of aqueous constituents across the gills. It is important to note that, unlike some other receptors, fish are mobile and capable of avoiding contaminants; fish in an unconfined water body can ameliorate their exposure to contaminants in surface water by moving to another location.

4.2.4 Assessment Endpoints

Assessment endpoints in an ERA are explicit expressions of the environmental value that is to be protected. Assessment endpoints evaluated in this ERA were:

- ❑ Survival, growth, and reproduction of terrestrial plants (including grasses, shrubs, bushes, and trees);
- ❑ Survival, growth, and reproduction of soil invertebrates (represented by the earthworm);
- ❑ Survival, growth, and reproduction of mammal populations (meadow vole, short-tailed shrew, red fox);
- ❑ Survival, growth, and reproduction of bird populations (American woodcock, red-winged blackbird, red-tailed hawk); and
- ❑ Survival, growth, and reproduction of aquatic community (aquatic plants, aquatic invertebrates, amphibians, fish).

In addition to these assessment endpoints, measurement endpoints were identified. Measurement endpoints are conceptually related to assessment endpoints but are quantifiable using standard toxicological methods such as laboratory exposures. The reference values identified in the ERA for plants and soil invertebrates were the plant and soil organism component values used by the Ministry in the development of generic SCS. For plants and invertebrates, it is not possible to estimate concentrations that would constitute thresholds for toxic effects at a particular site from published toxicity data, due to the diversity of soils, chemical forms, species, and test procedures used in the generation of these data. Therefore, for these VECs, measurement endpoints sometimes consisted of benchmark concentrations derived from multiple endpoints (e.g., 25^{th} or 50^{th} percentile of data from several different endpoints).

The measurement endpoints for aquatic plants, fish, and aquatic invertebrates were based on the MECP Aquatic Protection Value (APV) used in the development of component values for the GW3 exposure pathway (MOE 2011a).

Unless otherwise noted, TRVs used in the ERA were the same as those used by the Ministry in the development of generic SCS.

4.3 Exposure Assessment

The exposure assessment includes an analysis of the pathways by which VECs may be exposed to COCs and an estimate of the concentrations to which they may be exposed. For COCs to have deleterious effects on ecological receptors, they must gain access to the organism or receptor. The route by which this occurs is referred to as an exposure pathway and is dependent on the properties of the chemical and the nature of the receptor. A complete exposure pathway is one that meets the following criteria:

- A source of constituents of interest must be present;
- Release and transport mechanisms and media must be available to move the constituents from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the constituent is taken up by ecological receptors, such as ingestion, inhalation, or direct contact with skin or membranes.

4.3.1 Pathway Analysis

Potentially complete exposure pathways identified in the ecological conceptual site model for ecological receptors were:

- Root uptake from and contact with soil (terrestrial plants);
- Direct/dermal contact (soil invertebrates, mammals and birds);
- Ingestion of soil;
- Ingestion of food/prey;
- Inhalation of soil;
- Root uptake from surface water;
- Direct contact with surface water;
- Ingestion of surface water; and
- Ingestion of aquatic invertebrates that accumulated COCs from surface water.

Not all exposure pathways were evaluated quantitatively. Some pathways (e.g., pathways for plants and soil organisms, uptake pathways for aquatic receptors) were screened out of the ERA based on comparison to component values, and some (e.g., dermal contact with soil by wildlife, inhalation of soil) were evaluated qualitatively because insufficient information is available to evaluate them quantitatively. Summaries of exposure pathways are provided below.

4.3.1.1 Root Uptake/Contact

Root contact and uptake of COCs is assumed to be a complete exposure pathway for terrestrial plants. In general, plants may be exposed to chemicals via root uptake or foliar uptake. Root uptake is the primary route of exposure for most contaminants, including those identified at the site.

For inorganic parameters including ions and metals, root uptake is partly determined by chemical characteristics determining the mobility of the element in the soil environment, partly by soil characteristics (e.g., pH, clay and organic matter content and type, and moisture content), and partly by the selective absorption from soil solution by the root. Many metals and most ions tend to be taken up easily through plant roots if dissolved in water. Metals may be taken up passively with the mass flow of soil water into roots, or by membrane transport systems responsible for uptake of nutrient elements.

Based on the depth of groundwater at the site (>3 mbgs), root uptake of COCs from groundwater is considered to be an incomplete exposure pathway.

4.3.1.2 Direct Contact

The primary route of exposure for soil invertebrates is direct contact with COCs in soil. Soil invertebrates such as earthworms may ingest COCs adhered to soil particles or dissolved in the aqueous phase, or they may take them up via direct contact with the moist dermis used for gas exchange. Earthworms are known to take up various inorganic and organic soil contaminants through consumption of humus (well-decomposed organic material) in surface soil and less decomposed leaf litter at the ground surface. Uptake of chemicals into the tissue of earthworms depends primarily on physicochemical properties. Site-specific factors such as organic content of the soil can also affect availability.

Although soil contact (dermal) is a potential exposure pathway for terrestrial wildlife including small mammals and birds, the contribution from this pathway in most cases is negligible compared to other pathways such as ingestion. For most receptors, feathers or fur effectively prevents dirt from the accessing the dermal surface, and soil adhered to feathers of fur is ultimately ingested during grooming (Sample and Suter 1994) and contributes to the soil ingestion exposure pathway.

4.3.1.3 Soil Ingestion

Soil comprises a small fraction of the diet for many organisms; the actual quantity of soil ingested depends on the life history traits of the species. For burrowing mammals such as the vole that are frequently in direct contact with soil, quantities of soil ingested can be significant. A major source of soil ingested by both mammals and birds is soil adhered to the surface and the gut of prey items, such as earthworms. Quantities of soil ingested from these different sources are not typically distinguished; rather, exposure is quantified through the estimation of average overall soil consumption (as a fraction of diet) for each species.

Of the COCs consumed by an organism, only a fraction is absorbed through the gut and is available to cause toxicity. However, uptake depends on a number of site-specific and organism-specific factors. Therefore, for the purposes of this risk assessment, it is assumed that the entire quantity of COCs in soil consumed by wildlife is available and can potentially result in adverse effects.

4.3.1.4 Foliar Deposition and Soil Inhalation

Entrainment of surface soil by wind can result in airborne contaminants that may be deposited on plant surfaces or inhaled by wildlife. As entrained soil may be transferred to off-site properties, both on-site and off-site plants and wildlife may be exposed to soil contaminants via these pathways.

Foliar deposition of contaminants onto plant leaves can be a significant exposure pathway under certain conditions; i.e., where dust generation/deposition is substantial. At most brownfield properties, dust deposition is not a significant exposure pathway. Compared to root uptake, foliar uptake is considered a minor exposure pathway for most chemicals.

In general, inhalation of soil is considered a minor exposure pathway for wildlife, and inhalation-based TRVs are generally lacking for this pathway (FCSAP 2012). Accordingly, risks from this pathway were evaluated using a qualitative approach.

4.3.1.5 Ingestion of Food/Prey

Herbivorous and omnivorous wildlife (meadow vole, red-winged blackbird) can be exposed to certain COCs in soil via consumption of vegetable matter (e.g., leaves, berries) of plants that have accumulated COCs from soil. Plants growing in soils containing elevated concentrations of chemicals or in contact with contaminated groundwater may accumulate chemicals via root uptake and can potentially distribute those chemicals to portions of the plant consumed by herbivores and omnivores.

Insectivorous/omnivorous wildlife may be exposed to COCs through ingestion of prey. The diets of the insectivorous shrew and the American woodcock include soil invertebrates. Soil invertebrates in contact with contaminated soil can accumulate COCs that can be assimilated by the shrew or woodcock upon consumption.

Accumulation of chemicals into vegetation or animal tissue is primarily a function of the physico-chemical properties of each chemical and the ability of plants and animals to metabolize or excrete the chemical. Some chemicals readily bioaccumulate, while others do not. Uptake/accumulation is predicted using generic uptake factors (bioaccumulation factors) or equations that are derived from measurements of contaminant concentrations in soil and vegetation/tissue from multiple locations/studies.

4.3.1.6 Exposure of Aquatic Receptors

Aquatic receptors may be exposed to COCs in surface water via several uptake pathways.

Uptake of COCs from surface water by aquatic plants occurs via roots or directly through stems and leaf surfaces. The relative proportion of uptake from various routes varies among different plant species. For some species (e.g., floating plants), uptake across the leaf surface is the only relevant pathway. Like terrestrial plants, uptake from the aqueous phase is most rapid for dissolved chemicals. For the purposes of the ERA, it was assumed that all COCs are potentially available for uptake by aquatic plants.

Aquatic receptors such as fish, amphibians, and aquatic invertebrates are potentially exposed to COCs via several distinct uptake pathways, including dermal contact, uptake across the gills, ingestion of water, etc. However, separate exposure pathways for aquatic receptors were not distinguished because available toxicological data do not allow examination of separate pathways. Nevertheless, all the pathways identified are potentially present for both invertebrates, amphibians, and fish, and may contribute in part to the overall uptake of chemicals from surface water.

4.3.2 Exposure Estimates

Exposure estimates are provided for ecological receptors with complete exposure pathways. For terrestrial plants and soil invertebrates that are only exposed to COCs in soil via root uptake or direct contact, exposure estimates are represented by the estimated maximum soil concentrations. For wildlife potentially exposed to COCs via different uptake pathways (i.e., ingestion of soil, ingestion of food/prey), exposure estimates are presented as weight-normalized daily doses.

The secondary screening indicated that quantitative evaluation of risks to wildlife was required for lead.

Wildlife are potentially exposed to COCs via several pathways, with ingestion of soil and food items being the primary exposure route. The ecological conceptual exposure model identified accumulation of lead in plants and soil invertebrates as a potential exposure pathway. Exposure of wildlife receptors via ingestion pathways was calculated using the following equation:

$$\mathrm{ADD} = \sum_{\mathrm{i}=1}^{\mathrm{m}} \frac{\mathrm{IR_i}\ \mathrm{C_{ij}}}{\mathrm{BW}}$$

where: ADD = average daily dose of lead (mg/kg/d);
m = Number of media;
IR_j = ingestion rate for medium *i* (kg/d);
C_{ij} = concentration of lead in medium *i* (mg/kg); and
BW = body weight (kg).

The REM concentration of lead in soil was used in exposure calculations for wildlife. As wildlife are potentially capable of amortizing exposure from areas of low and high concentrations, the use of the maximum resulted in conservative estimates of exposure that are likely greater than those actually received by wildlife.

Dietary composition (Table 4-3) was based on values reported by Sample and Suter (1994) or the US EPA Wildlife Exposure Factors Handbook (1993). Ingestion rates for each food item were converted to a dry weight basis using moisture content for various foods as reported by Sample and Suter (1994).

Table 4-3: Diets of Ecological Receptors					
	Dietary Fraction by Wet Weight				
Receptor	Terrestrial plant foliage	Terrestrial plant seeds	Earthworms	Other soil invert.	Mammals
Meadow vole	0.9	0.05	0	0.05	0
Short-tailed shrew	0	0.138	0.314	0.548	0
Red fox	0.07	0	0	0.03	0.9
Red-winged blackbird	0	1	0	0	0
American woodcock	0	0	1	0	0
Red-tailed hawk	0	0	0	0	1

Body weight and soil consumption rates (Table 4-4) were taken from Sample and Suter (1994) or US EPA (1993) and were the same as those used by the MECP in development of the generic standards (MOE 2011).

Table 4-4: Exposure Factors for Ecological Receptors				
Receptor	Body weight (kg)	Food ingestion rate (kg wet weight/d)	Food ingestion rate (kg dry weight/d)	Soil ingestion rate (kg/d)
Meadow vole	0.044	0.005	9.79E-04	1.80E-05
Short-tailed shrew	0.015	0.009	0.00311	1.87E-04
Red fox	4.5	0.43	0.132	0.00385
Red-winged blackbird	0.064	0.091	0.0825	0.00109
American woodcock	0.198	0.15	0.024	0.0025
Red-tailed hawk	1.13	0.0987	0.0316	0.0018

The ecological conceptual exposure model identified accumulation of lead in plants, soil invertebrates, and small mammal prey as potential exposure pathways. Concentrations of COCs in vegetation and soil invertebrates were estimated using uptake equations describing the relationship between soil concentrations and vegetation/tissue concentrations based on data from numerous studies with different soil types. Uptake factors/equations for lead were those compiled by US EPA (2005) in the derivation of Ecological Soil Screening Levels (Eco-SSL) and were based on data from Bechtel-Jacobs et al. (1998), Sample et al. (1998a, 1998b, 1999), and Baes et al. (1984). Concentrations calculated on a fresh weight basis were converted to a dry weight concentration prior to calculation of the ADD:

$$C_{dw} = C_{fw} \cdot \left[1 - \left(\frac{\%\ moisture}{100}\right)\right]$$

where the moisture content of food items were those identified by Sample and Suter (1994) for dicot leaves (85%), dicot seeds (9.3%), earthworms (84%), grasshoppers/crickets (69%), and mice/voles/rabbits (68%). Refer to Appendix D for uptake equations and media concentrations.

Exposure estimates (ADD) for terrestrial wildlife receptors are presented in Table 4-5.

Table 4-5: Exposure Estimates for Wildlife Receptors

	Average daily dose					
COC	Meadow vole (mg/kg/d)	Short-tailed shrew (mg/kg/d)	Red fox (mg/kg/d)	Red-winged blackbird (mg/kg/d)	American woodcock (mg/kg/d)	Red-tailed hawk (mg/kg/d)
Lead	4.20E-01	1.57E+01	7.39E-01	1.42E+01	1.43E+01	9.03E-01

4.3.3 Uncertainty

It is recognized that some residual uncertainty in exposure estimates always remains due to constraints of the data (i.e., sampling provides only an estimate of actual contaminant concentrations). Because no modeling of exposure concentrations was necessary for terrestrial plants and soil invertebrates, and the exposure estimates were based on an adequate number of samples, there is a relatively high degree of confidence in this aspect of the exposure estimate for plants and soil invertebrates. Uncertainty associated with exposure for terrestrial plants and soil invertebrates was addressed by using conservative estimates of exposure based on maximum concentrations plus 20% from all soil strata, regardless of depth.

The level of uncertainty in the exposure estimates for terrestrial wildlife receptors is considered acceptable. Estimated doses from the ingestion pathway are dependent only on soil intake. For some receptors, soil ingestion was well described; but for others a conservative estimate of soil ingestion was selected using the best available information. Use of maximum concentrations plus 20% was a conservative approach meant to ensure risks were not underestimated as a result of other uncertainties.

4.4 Hazard Assessment

Mammalian and avian TRVs for lead were those identified by MECP and used in the MGRA model.

4.4.1 Mammals

In mammals, lead causes cumulative toxicity through interference with hemoglobin synthesis and disruption of nerve cells (Eisler 1988). Clinical signs of lead toxicity include encephalopathy preceded and accompanied by gastrointestinal malfunction (Booth and McDonald 1982). The TRV for lead is based on a study conducted by Azar et al. (1973) in which rats were exposed to lead acetate for three generations. Rats were exposed orally to 10, 50, 100, 1,000, or 2,000 mg/kg lead in food. Rats in the two highest dose levels exhibited reduced offspring weights and kidney damage in offspring; no adverse effects were noted in lower doses. A LOAEL of 80 mg/kg/d was calculated. This value was used as the mammalian TRV for lead.

4.4.2 Birds

The clinical effects of lead toxicity in avian species are similar to those in mammals, but birds in general are more sensitive to the adverse effects of lead. The MOE (2011) developed a TRV for birds based on a study by Edens and Garlich (1983) in which the diet of chickens was supplemented with lead acetate. Hens exposed to lead at 3.26 mg/kg/d for five weeks exhibited diminished egg production. This chronic LOAEL was adopted as the avian TRV for lead.

The TRV for the red-tailed hawk was based on a study cited in CCME (1999) in which American kestrels were exposed to lead at concentrations of 0.5, 120, 212, or 448 mg/kg in food for 60 days (Custer, Franson et al. 1984). No effects on blood chemistry, growth, or survival were observed in any test group. The highest concentration in food was converted to a daily dose of 28 mg/kg/d assuming a 120-g kestrel with an average daily consumption of 25 g wet weight homogenized chicken diet. This dose was considered the NOAEL and was adopted as the TRV for the red-tailed hawk.

4.4.3 Uncertainty

Uncertainties associated with TRVs for plants and soil invertebrates are considered to be acceptable. TRVs for these receptors generally were the same as those identified by the Ministry in the generic model and are based on toxicological studies conducted in support of the CCME Canada Wide Standards for PHCs. The assumptions and uncertainties associated with these TRVs have been evaluated previously (CCME 2008).

The application of TRVs to a mammalian or avian receptor developed using data for different test species introduces some uncertainty in the ERA. Although the relationship between acute toxicity and body size of mammals is well known, and allometric relationships have been described for extrapolating effects data from a test species to a wildlife receptor (Sample et al., 1996), relationships between *chronic* toxicity and body size are less clear. The application of a single TRV developed from (typically) exposure of a test species in a laboratory setting to all mammal receptors in the ERA introduces conservatism to the ERA. Overall, the uncertainty in the hazard assessment was considered to be acceptable for meeting the objectives of the ERA.

4.5 Risk Characterization

4.5.1 Quantitative Interpretation of Ecological Risks

Risks to mammals, and birds were assessed using a quantitative approach. Risks were assessed in the absence of RM measures.

Exposure ratios (ER) represent a simple approach that provides a quantitative estimate of overall risk. The ER is a unitless value defined as the ratio of the magnitude of exposure to magnitude of a standard effect:

$$\text{Exposure ratio} = \frac{\text{Exposure level or ADD}}{\text{TRV}}$$

Exposure ratios are interpreted as follows: if the ER is less than one, no unacceptable risks to ecological receptors would be expected, because concentrations are below levels known to cause adverse effects. Conversely, if the ER exceeds one, it may be inferred that adverse effects to individuals are possible. Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made.

Mammalian and avian receptors are potentially exposed to lead in soil via ingestion of soil, vegetation, soil invertebrates, and/or small mammals (prey). Exposure ratios in the absence of RM measures were greater than one for the red-winged blackbird and the American woodcock (Table 4-6). It may be inferred from this result that in the absence of RM measures, the survival, growth, and reproduction of herbivorous and insectivorous birds may be inhibited.

Table 4-6: Exposure Ratios for Wildlife Receptors

VEC	TRV (mg/kg/d)	ADD (mg/kg/d)	ER
Meadow vole	80	0.420	0.0052
Short-tailed shrew		15.7	0.20
Red fox		0.739	0.0092
Red-winged blackbird	3.3	14.2	**4.3**
American woodcock		14.3	**4.4**
Red-tailed hawk	28	0.903	0.032

ADD – Average daily dose; ER – Exposure ratio; TRV – Toxicity reference value;
VEC – Valued ecological component

RM measures are recommended to diminish risks to birds. RM measures proposed include the use of a fill cap (clean soil) or hard cap barrier (buildings, concrete, asphalt, etc.) in areas of the site with concentrations of soil COCs exceeding risk-based values. With RM measures in place, all direct contact and soil ingestion pathways for mammals will be interrupted, and exposure to COCs in soil will be negligible.

4.5.1.1 Recommended Ecological Standards

Risk-based values were calculated for each VEC evaluated quantitatively in the ERA. Because uptake equations for lead were not linear, it was necessary to calculate risk-based values iteratively to determine the soil concentration that resulted in an exposure ratio of one. For VECs with REM concentrations exceeding risk-based values, RM measures are recommended to interrupt ingestion exposure pathways.

Table 4-7: Summary of Ecological Risk-Based Standards for Soil COCs

VEC	REM conc. (µg/g)	Risk-based value (µg/g)	REM conc. exceeds	Risk reduction factor
Meadow vole	321.6	137,000	No	–
Short-tailed shrew		2,140	No	–
Red fox		80,600	No	–
Red-winged blackbird		**38.4**	**Yes**	8.4
American woodcock		**57.7**	**Yes**	5.6
Red-tailed hawk		16,100	No	–

4.5.2 Qualitative Interpretation of Ecological Risks

A qualitative evaluation of ecological risks is provided for:

1. COCs screened out of the ERA based on comparison with ecological component values; and
2. Exposure pathways considered to result in negligible exposure.

4.5.2.1 COCs Screened Against Component Values

A qualitative evaluation (Section 4.1) was conducted by screening REM concentrations of COCs in soil against component values. The following soil COCs/pathways were screened out:

- ❑ Lead: Plant/soil organisms, S-GW3.

The following groundwater COCs were screened out based on comparison to GW3 values:

- ❑ Tetrachloroethylene, vinyl chloride (future).

For all the COCs/pathways listed above, negligible risk exists.

4.5.2.2 Negligible Exposure Pathways

Foliar Deposition

Soil particulates entrained in outdoor may be taken up by terrestrial plants via foliar deposition. Foliar uptake is limited to atmospheric contaminants (i.e., those released into the air from incineration, etc.) and those that volatilize from soil. For brownfields properties with no significant or active air emissions other than volatilization of chemicals from soil and/or groundwater that were contaminated by historic activities, uptake from the atmosphere is negligible. Suter et al. (2000) note that the atmospheric route can be ignored in ecological risk assessment if concentrations of the chemical in air are in equilibrium with soil and soil is the only source of the contaminant in the vicinity of the plant. Compared to root uptake, foliar uptake is considered a minor exposure pathway for most chemicals. Risks from this exposure pathway are considered to be negligible.

Soil Dermal Contact

Dermal contact with soil by wildlife is mitigated by the presence of fur and feathers. Contaminants in soil accumulated on the surface of feathers or fur is not adsorbed to any significant degree. Through periodic grooming, some soil on feathers or fur is ingested, and contributes a minor component to the soil ingestion pathway (which is captured through analysis of soil ingestion). Risk to wildlife via dermal contact is considered to be minimal. RMM proposed for soil COCs to address soil ingestion also will eliminate the potential for exposure of wildlife via dermal contact.

Vapour & Particulate Inhalation

Wildlife both on- and off-site may be exposed to volatile COCs via inhalation. Exposure levels from inhalation are considered to be minimal, as dilution in outdoor air prior to uptake typically results in negligible concentrations available for uptake.

The evaluation of exposure and effects via inhalation of particles is hampered by the lack of data for wildlife species. However, in general, inhalation of soil particles is considered a minor contributor to the overall dose of contaminants in terrestrial wildlife receptors relative to other sources of exposure (FCSAP 2012). A significant proportion of entrained particles are captured prior to entering the lungs (e.g., deposition in nasal epithelium). Therefore, the risk to wildlife from exposure via inhalation of soil is considered to be minimal. It is noted that RM measures proposed for soil COCs to address soil ingestion also will eliminate the potential for exposure of wildlife via soil inhalation.

4.5.3 Special Considerations

Section 41 of O.Reg 153/04 (as amended) does not apply to the property. The RA property is not located in an environmentally sensitive area. The site also is not adjacent to (<30 m from) a water body. Furthermore, the soil pH is found in the standard range (pH 5–9 in surface soils and pH 5-11 in subsurface soils). Section 43.1 also does not apply in the case of soil; the RA Property is not a shallow soil property. As a result, no special considerations were required to justify the ecological standards proposed in the ERA.

4.5.4 Interpretation of Off-Site Ecological Risks

Surrounding land use and ecological habitat at adjacent properties are similar to those found at the RA property, i.e., residential and commercial land use. Therefore, off-site terrestrial ecological receptors are anticipated to be identical to on-site VECs included in the ERA, and exposure parameters are expected to be similar. Given the prevailing land use in the areas around the site, applicable SCS at the nearest off-site property are assumed to the same as those used for the RA property: Table 3 SCS. Based on the exposure pathways assumed to be complete at the RA Property (root uptake, direct contact, soil and food ingestion), no off-site impacts are anticipated. Therefore, the ecological standards for soil COCs proposed are unlikely to result in concentrations in soil exceeding the Table 3 full-depth SCS at the nearest ecological receptor located off the RA property.

Off-site groundwater standards are assumed to be the same as those for the RA property: Table 3 SCS for commercial land use. According to the ecological CSM, migration of some COCs in groundwater to adjacent properties may occur. Based on the depth to groundwater in this area (>3 mbgs), exposure of ecological receptors on adjacent properties is not anticipated. The nearest off-site receptors potentially impacted are aquatic receptors in Poole Creek, located approximately 600 m to the northwest of the site. As concentrations of all groundwater COCs were less than GW3 values, no off-site impacts are anticipated.

4.5.5 Discussion of Uncertainty

Uncertainty in risk assessment is introduced by the necessary use of assumptions concerning various aspects or characteristics of the system that cannot be measured accurately. Incomplete understanding of environmental processes is inherent in any ERA. Uncertainty is acknowledged, documented, and addressed primarily by the use of conservative assumptions that ensure risk is overestimated rather than underestimated. Uncertainty associated with certain aspects of the ERA (e.g., exposure assessment) was addressed within the appropriate sections of the ERA. In this section, various sources of uncertainty associated with the current ecological risk assessment are discussed.

Regardless of the level of sampling effort expended in characterizing contaminant distribution at a site, some inherent uncertainty always remains with respect to actual levels of contaminants in various environmental media. Although the number of samples collected at the site provided very good coverage, the data distribution suggests COCs are not uniformly distributed across the site, and additional sampling may improve estimates of the actual concentrations to which ecological receptors may be exposed. The use of the Reasonable Estimated Maximum values in ERA calculations was intended to minimize the likelihood that site maxima were underestimated.

Uncertainty in the exposure assessment was related primarily to assumptions regarding the presence of ecological VECs at the site. Conservative assumptions (as would be required by MECP for a regulatory RA) were made to ensure any ecological receptors that might use the site in the future were provided sufficient protection.

Because of the inherent uncertainty in predicting toxicological responses from literature studies rather than directly measuring toxicity at the site, there is some uncertainty associated with toxicity reference values. In most cases, TRVs are assumed to be conservative; i.e., no toxicity is anticipated if site concentrations are below TRVs. This is because most reference values are based on the most sensitive species tested or a similar low effect level, and toxicity tests upon which they are based are typically conducted under conditions that maximize toxicity (i.e. the use of soluble metal salts).

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main findings of the HHRA were as follows:

- **Soil direct contact pathways** – Lead in soil at the concentration found on the RA Property poses no risk to human receptors in a commercial land use scenario.
- **Groundwater oral/dermal pathways** – HQ values and ILCR values for tetrachloroethylene and future vinyl chloride were within acceptable limits. Contaminants in groundwater pose no risk to construction workers from direct contact pathways.
- **Groundwater inhalation pathways:**
  - Indoor workers – Unacceptable ILCR values greater than 10^{-6} were calculated for workers exposed in a generic commercial building and in the proposed site building (both the restaurant space and the retail/office space) to vinyl chloride that may form in groundwater in the future as a result of degradation of tetrachloroethylene over time.
  - Outdoor workers – HQ and ICLR values were less than acceptable limits for all COCs. VOCs in groundwater pose no risk to outdoor workers via inhalation of outdoor air.
  - Construction workers – HQ and ICLR values were less than acceptable limits for all COCs. VOCs in groundwater pose no risk to construction workers via inhalation of air in a trench or excavation.

The main findings of the ERA were as follows:

- **Soil direct contact pathways** – Lead in soil poses no risk to plants and soil organisms exposed via root uptake or direct contact.
- **Soil ingestion pathways** – Lead in soil poses an unacceptable risk to herbivorous and insectivorous birds that may forage on the RA Property. The maintenance of a hard cap barrier is recommended to interrupt exposure for wildlife in areas of the RA Property where lead concentrations exceed the Table 3 SCS.
- **Aquatic exposure pathways** – Risks to off-site receptors from soil and groundwater contaminants are negligible. Concentrations of groundwater contaminants at the site were less than GW3 values considered to be protective of aquatic life in the nearest water body.

5.2 Recommendations

It is recommended that risk management (RM) measures be implemented at the RA Property to mitigate or block potential exposure to lead in soil. A fill cap barrier consisting of a layer (min. 0.5 m) of clean, uncontaminated soil or a hard cap barrier consisting of asphalt, concrete (including a building foundation), paver stones, or similar would effectively block soil ingestion pathways for wildlife receptors. With a fill cap or hard cap barrier in place, ingestion of soil by wildlife and accumulation of lead in plants and soil invertebrates would be prevented. With this RM measure in place, risks to wildlife receptors from lead in soil would be negligible.

No RM measures for human receptors are recommended. At the concentration detected in soil at the RA Property, lead poses no risk to workers in a commercial setting based on the MECP component value protective of these receptors. Although tetrachloroethylene concentrations in groundwater at the RA Property exceed the MECP GW2 component for commercial land use, modelling of the site-specific building proposed for the RA Property indicates risks to indoor workers from vapour intrusion of tetrachloroethylene into indoor air are within acceptable limits.

Vapour intrusion modelling of theoretical future concentrations of vinyl chloride in groundwater indicates that this chemical, if produced at levels assumed by MECP in their generic model, may pose a slightly elevated risk of cancer to indoor workers. However, the vinyl chloride concentration evaluated in the vapour intrusion modelling was based on a very conservative MECP assumption that future concentrations of vinyl chloride will be 10% of current levels of chlorinated VOCs (the so-called “10% rule”). The 10% rule is intended to represent worst-case situations where the production of vinyl chloride through reductive dechlorination is maximized under anaerobic conditions, but few properties have subsurface conditions that will result in these levels. In fact, when MOE (2011) examined available data on concentrations of parent and daughter products of chlorinated aliphatic compounds at various contaminated sites across Ontario, they found that concentrations of vinyl chloride frequently represented <1% and at most 5.9% of the sum of parent chlorinated VOCs and suggested that the 10% rule was “possibly overly protective.” Vinyl chloride has never been detected in soil or groundwater at the site, despite numerous soil samples and multiple groundwater sampling events. The absence of vinyl chloride or any other degradation products of tetrachloroethylene in groundwater suggests that subsurface conditions at the RA

Property are not conducive to reductive dechlorination or the formation of vinyl chloride.

6.0 RISK MANAGEMENT PLAN

6.1 Risk Management Performance Objectives

The objective of the RM Plan is to ensure that the potential risks to wildlife receptors (i.e., birds) from lead in soil at the RA Property are mitigated. The RM measures are compatible with the proposed future land use of the property (commercial building) and provide the required level of risk reduction with minimal maintenance or inspection.

The required risk reductions for the COCs that were quantitatively assessed in the RA are the following:

- ❑ Soil – Lead – Herbivorous birds (red-winged blackbird): 8.4x
- ❑ Soil – Lead – Insectivorous birds (American woodcock): 5.6x

All other soil and groundwater COCs were found to pose no risk to human or ecological receptors.

A fill cap or hard cap barrier is required in areas of the RA property where lead concentrations are greater than the effects-based standards for birds. Impacted site soils (i.e., soils that exceed the effects-based standards outlined in the RA) should be covered with a suitable fill cap (clean soil) or hard cap barrier (i.e., the proposed new building, asphalt paved areas, concrete walkways, or landscape pavers) underlain by a suitable sub-grade that can act as a sufficient barrier to prevent direct contact with soil.

Alternatively, excavation and removal of lead-contaminated soils (i.e., soils with lead concentrations greater than effects-based standards presented in Table 4-7) also will eliminate risk for birds.

6.2 Risk Management Measures

6.2.1 Fill Cap or Hard Cap Barrier System

The strategy for addressing direct contact pathways consists of ensuring that the impacts are covered by barriers that will prevent ecological receptors from being exposed to lead in soil.

The fill cap and hard cap barrier RMM must be designed and consider the following:

- ❑ The fill cap barriers must be at least 0.5 m thick and be installed over any impacted soil that is present or proposed to be left in place at the site. Soil to be used or re-installed as a fill cap barrier must meet the Ministry's Table 3 SCS for industrial/commercial/community land use.
- ❑ Hard cap barriers must include non-soil surface treatments such as asphalt, concrete or concrete pavers, stone pavers, brick or aggregate. The hard cap layers should be at least 225 mm thick and consist of at least 75 mm of the hard capping materials underlain by appropriate granular materials (e.g., granular A) aggregate or equivalent. The footprint of the new building (i.e., walls over the footings and the floor slabs) and any existing asphalt roads or concrete walkways at the site also are sufficient to ensure that soil contact will not occur.

The fill caps or hard caps are required to cover areas of the RA Property where lead is present within 0.5 m of the surface at concentrations greater than Table 3 standards.

6.3 Duration of Risk Management Measures

RMMs are required until such time as the site is either remediated (cleaned to applicable SCS), or the levels are shown to meet the existing health-based standards or applicable SCS to the Site through natural attenuation processes.

6.4 Requirements for Monitoring and Maintenance

A monitoring plan is recommended to ensure soil and hard capping barriers are properly maintained. Monitoring is recommended to be conducted on a semi-annual (summer and fall) basis consisting of a thorough inspection of the measures, as noted below:

- ❑ Assessment of any visual evidence of disturbance to the barriers such as through loss of hard capping layers (degradation of asphalt layers) or soil cover (in landscaped areas).
- ❑ Inspection to detect and assess cracks in pavement or other hard surface treatments (if necessary, e.g., asphalt or concrete if present).

- Consideration of any unusual site conditions that may result in damage to the RMM such as future site alterations or development on, or adjacent to, the property.

In the event that the monitoring program for the surface barrier systems indicates the requirement for maintenance, maintenance should be conducted as soon as practical. Maintenance will consist of the proper repair of any RMM which has become damaged or diminished in its function. Typically, this would include the following:

- Replacement or repair of damaged surface treatment such as asphalt, concrete or pavers;
- Replacement of clean soil cover in the event that soil cover has been removed and no longer meets the minimum thickness requirements;
- Repair of any cracks, settlement or damage which may occur to the concrete walls and floor of the building, and which may result in exposure of the underlying soil; and
- Ensure that the current floor slab is intact and that any noticeable cracks are filled in and re-grouted with non-shrink concrete.

In addition to the above, there may be a requirement in the future for maintenance that may involve excavation and repair of underground utilities placed at the site. These activities should be supervised by a person knowledgeable with the design of the RMMs. Soil removed from any excavation should be carefully inspected to ensure that any impacted soils are properly identified and either removed off-site or replaced appropriately on the property (i.e., beneath an area where RMM is in place). The excavation for underground utilities should be backfilled with clean soil (MECP Table 3 industrial/commercial/community SCS) to restore the RMM.

6.5 Contingency Plans

The surface barrier systems will be completely effective at blocking the direct exposure to soil at the site. In the event that cracks, breeches or any loss of integrity occur in the barriers, then contingency measures will be required to be implemented to ensure that no exposure to contaminants occurs. These will consist of:

- Repairing the barrier immediately, if possible, to restore it fully; or

- ❑ Conducting temporary repairs as soon as possible, such as covering the affected area with a tarpaulin or physical barrier, until such time as permanent repairs can be undertaken.

Provisions should be made to fence off or otherwise prevent access to areas where the barrier has either not yet been installed or has been breached and not yet repaired. These measures are required until the areas have been covered or repaired.

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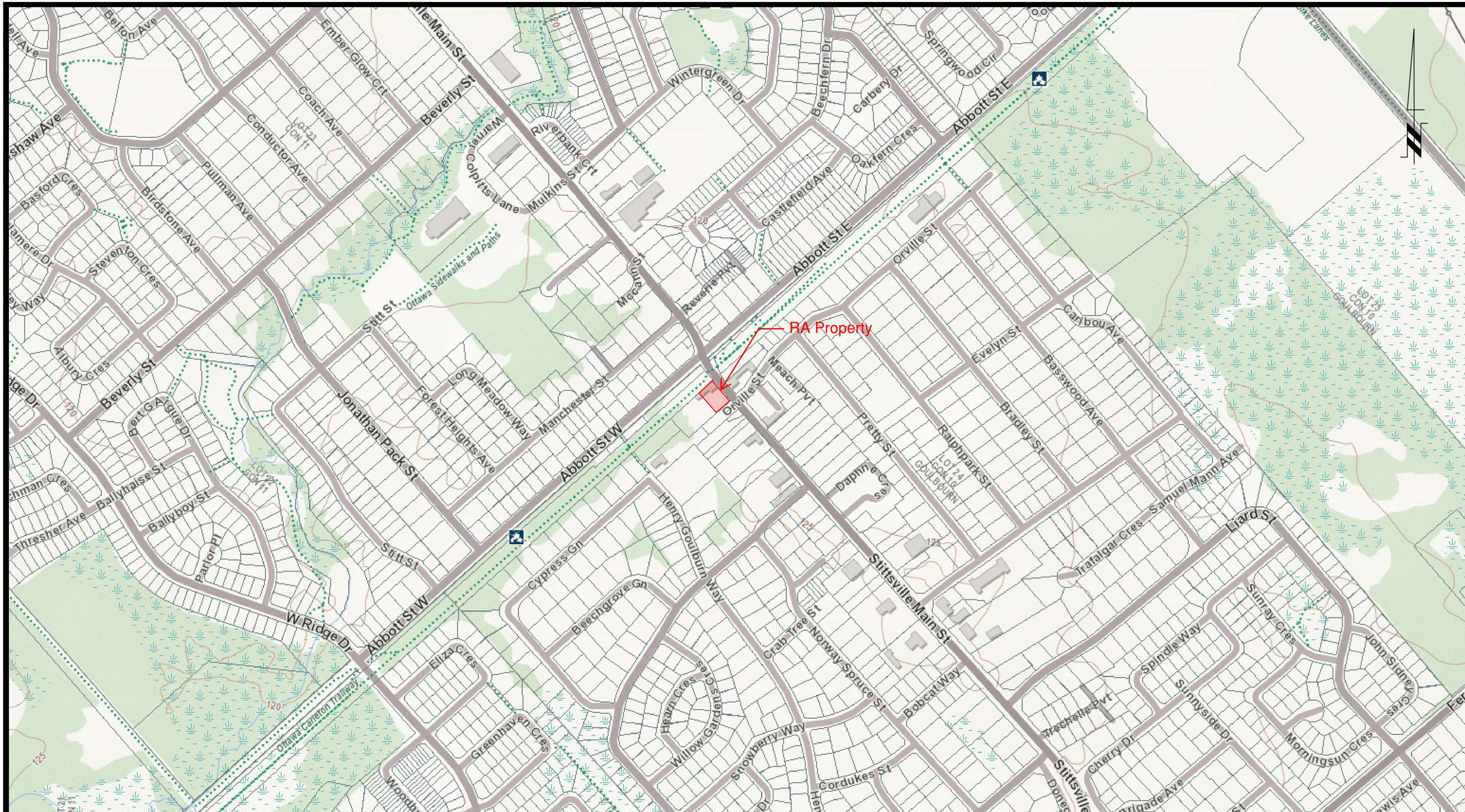

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Checked by:	MB	Dwg. No.:	PE4767-FIG.01
Approved by:	MB	Revision No.:	

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INVERNESS HOMES
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
1518, 1524, 1526 STITTSVILLE MAIN STREET

OTTAWA ONTARIO

Title:

SITE LOCATION

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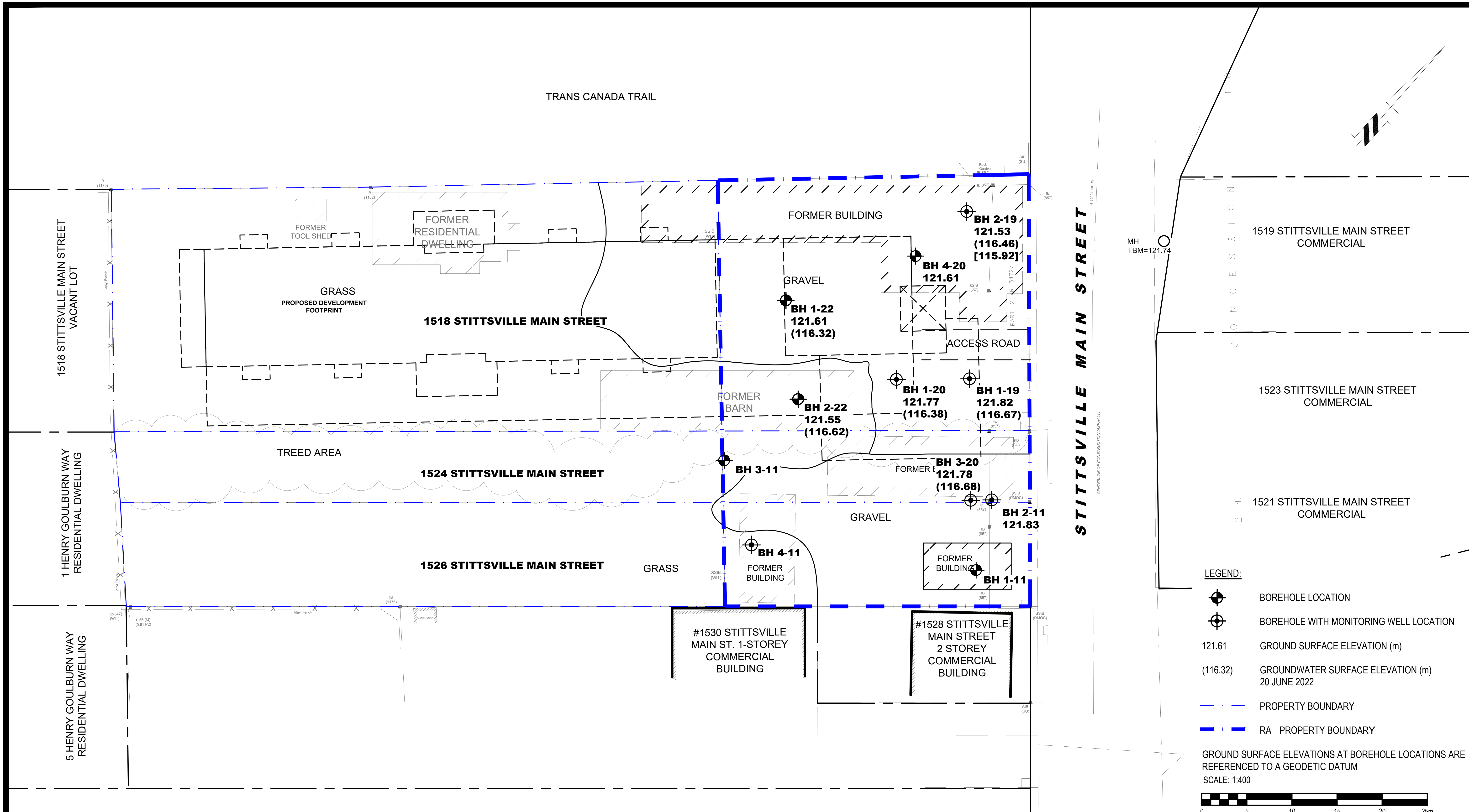

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1.	2022 BOREHOLES ADDED TO THE PLAN	05/07/2022	MB

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PHASE II - ENVIRONMENTAL SITE ASSESSMENT
1518, 1524, 1526 STITTSVILLE MAIN STREET

STITTSVILLE, ONTARIO

Title:

ANALYTICAL TESTING PLAN

Scale: 1:400	Date: 08/2024
Drawn by: GK	Report No.: PE4767-RA
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Approved by: MB	Revision No.:

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Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site Receptors: Const. Worker	Outdoor Worker	Indoor Worker	Patron	Resident	Res. Visitor	Trespasser	Off-Site Receptors: Const. Worker	Outdoor Worker	Indoor Worker	Community Mem.
Soil	Soil	Soil	Ingestion	○	○									
Soil	Soil	Soil	Dermal Contact	○	○									
Soil	Entrainment	Particulates	Inhalation	○	○						○	○		○
Soil	Volatilization	Outdoor Air	Inhalation											
Soil	Volatilization	Outdoor Air	Vapour Contact											
Soil	Volatilization	Outdoor Air	Odour											
Soil	Volatilization	Trench Air	Inhalation											
Soil	Volatilization	Trench Air	Vapour Contact											
Soil	Volatilization	Trench Air	Odour											
Soil	Volatilization	Indoor Air	Inhalation											
Soil	Volatilization	Indoor Air	Vapour Contact											
Soil	Volatilization	Indoor Air	Odour											
Soil	Bioaccumulation	Garden Produce	Ingestion											
Soil	Leaching	Potable Water	Ingestion											
Groundwater	Groundwater	Potable Water	Ingestion											
Groundwater	Groundwater	Potable Water	Dermal Contact											
Groundwater	Pooling in Trench	Trench Water	Ingestion	●										
Groundwater	Pooling in Trench	Trench Water	Dermal Contact	●										
Groundwater	Volatilization	Outdoor Air	Inhalation	●	●	○	○				○	○		○
Groundwater	Volatilization	Outdoor Air	Vapour Contact	○	○	○	○				○	○		○
Groundwater	Volatilization	Outdoor Air	Odour	○	○	○	○				○	○		○
Groundwater	Volatilization	Trench Air	Inhalation	●										
Groundwater	Volatilization	Trench Air	Vapour Contact	○										
Groundwater	Volatilization	Trench Air	Odour	○										
Groundwater	Volatilization	Indoor Air	Inhalation			●	○							
Groundwater	Volatilization	Indoor Air	Vapour Contact			○	○							
Groundwater	Volatilization	Indoor Air	Odour			○	○							

Legend:
- ● Major exposure pathway
- ○ Minor exposure pathway
- (blank) Incomplete exposure pathway

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HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
1518, 1524, 1526 STITTSVILLE MAIN STREET
OTTAWA ONTARIO

Title:

HUMAN HEALTH CONCEPTUAL SITE MODEL

Scale:	N.T.S.	Date:	08/2024
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Checked by:	MB	Dwg. No.:	PE4767-FIG.03
Approved by:	MB	Revision No.:	

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Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site: Const. Worker	On-Site: Outdoor Worker	On-Site: Indoor Worker	On-Site: Patron	On-Site: Resident	On-Site: Res. Visitor	On-Site: Trespasser	Off-Site: Const. Worker	Off-Site: Outdoor Worker	Off-Site: Indoor Worker	Off-Site: Community Mem.
Soil	Soil	Soil	Ingestion	○	○									
Soil	Soil	Soil	Dermal Contact	○	○									
Soil	Entrainment	Particulates	Inhalation	○	○						○	○		○
Soil	Volatilization	Outdoor Air	Inhalation											
Soil	Volatilization	Outdoor Air	Vapour Contact											
Soil	Volatilization	Outdoor Air	Odour											
Soil	Volatilization	Trench Air	Inhalation											
Soil	Volatilization	Trench Air	Vapour Contact											
Soil	Volatilization	Trench Air	Odour											
Soil	Volatilization	Indoor Air	Inhalation											
Soil	Volatilization	Indoor Air	Vapour Contact											
Soil	Volatilization	Indoor Air	Odour											
Soil	Bioaccumulation	Garden Produce	Ingestion											
Soil	Leaching	Potable Water	Ingestion											
Groundwater	Groundwater	Potable Water	Ingestion											
Groundwater	Groundwater	Potable Water	Dermal Contact											
Groundwater	Pooling in Trench	Trench Water	Ingestion	●										
Groundwater	Pooling in Trench	Trench Water	Dermal Contact	●										
Groundwater	Volatilization	Outdoor Air	Inhalation	●	●	○	○				○	○		○
Groundwater	Volatilization	Outdoor Air	Vapour Contact	○	○	○	○				○	○		○
Groundwater	Volatilization	Outdoor Air	Odour	○	○	○	○				○	○		○
Groundwater	Volatilization	Trench Air	Inhalation	●										
Groundwater	Volatilization	Trench Air	Vapour Contact	○										
Groundwater	Volatilization	Trench Air	Odour	○										
Groundwater	Volatilization	Indoor Air	Inhalation			●	○							
Groundwater	Volatilization	Indoor Air	Vapour Contact			○	○							
Groundwater	Volatilization	Indoor Air	Odour			○	○							

Legend:
- ● Major exposure pathway
- ○ Minor exposure pathway
- Incomplete exposure pathway
- Pathway blocked (risk management measure)

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NO.	REVISIONS	DATE	INITIAL

INVERNESS HOMES
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
1518, 1524, 1526 STITTSVILLE MAIN STREET
OTTAWA ONTARIO

Title:
HUMAN HEALTH CONCEPTUAL SITE MODEL with RMM

Scale:	N.T.S.	Date:	08/2024
Drawn by:	CM	Report No.:	PE4767-RA
Checked by:	MB	Dwg. No.:	PE4767-FIG.04
Approved by:	MB	Revision No.:	

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Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site Receptors: Terrestrial plants	On-Site: Soil organisms	On-Site: Mammals	On-Site: Birds	On-Site: Reptiles	Off-Site Receptors: Terrestrial plants	Off-Site: Soil organisms	Off-Site: Mammals	Off-Site: Birds	Off-Site: Reptiles	Off-Site: Aquatic Receptors
Soil	Soil	Soil	Root Uptake	●										
			Dermal Contact		●	O	O							
			Ingestion			●	●							
	Bioaccumulation	Terrestrial Biota	Ingestion			●	●							
	Entrainment	Particulates in Outdoor Air	Foliar Deposition	O					O					O
			Inhalation			O	O				O	O		
	Volatilization	Vapours in Outdoor Air	Foliar Uptake											
			Inhalation											
	Erosion/runoff	Sediment	Root Uptake											
			Contact											
		Benthic Biota	Ingestion											
	Leaching & Subsurface Migration	Surface Water	Root Uptake											O
			Contact											O
			Ingestion											O
		Aquatic invert.	Ingestion											O
	Groundwater	Groundwater	Root Uptake											
Groundwater	Volatilization	Vapours in Outdoor Air	Foliar Uptake	O					O					O
			Inhalation			O	O				O	O		
	Subsurface Migration	Surface Water	Root Uptake											O
			Contact											O
			Ingestion											O
		Aquatic invert.	Ingestion											O
Sediment	Sediment	Sediment	Root Uptake											
			Contact											
		Benthic Biota	Ingestion											

Legend:
● Major exposure pathway
O Minor exposure pathway
(blank) Incomplete exposure pathway (not evaluated)

PATERSON GROUP
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NO.	REVISIONS	DATE	INITIAL

INVERNESS HOMES
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
1518, 1524, 1526 STITTSVILLE MAIN STREET
OTTAWA ONTARIO

Title:
ECOLOGICAL CONCEPTUAL SITE MODEL

Scale:	N.T.S.	Date:	08/2024
Drawn by:	CM	Report No.:	PE4767-RA
Checked by:	MB	Dwg. No.:	PE4767-FIG.05
Approved by:	MB	Revision No.:	

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Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site: Terrestrial plants	On-Site: Soil organisms	On-Site: Mammals	On-Site: Birds	On-Site: Reptiles	Off-Site: Terrestrial plants	Off-Site: Soil organisms	Off-Site: Mammals	Off-Site: Birds	Off-Site: Reptiles	Off-Site: Aquatic Receptors
Soil	Soil	Soil	Root Uptake	●										
Soil	Soil	Soil	Dermal Contact		●	○	○							
Soil	Soil	Soil	Ingestion			●	●							
Soil	Bioaccumulation	Terrestrial Biota	Ingestion			●	●							
Soil	Entrainment	Particulates in Outdoor Air	Foliar Deposition	○					○					○
Soil	Entrainment	Particulates in Outdoor Air	Inhalation			○	○				○	○		
Soil	Volatilization	Vapours in Outdoor Air	Foliar Uptake											
Soil	Volatilization	Vapours in Outdoor Air	Inhalation											
Soil	Erosion/runoff	Sediment	Root Uptake											
Soil	Erosion/runoff	Sediment	Contact											
Soil	Erosion/runoff	Benthic Biota	Ingestion											
Soil	Leaching & Subsurface Migration	Surface Water	Root Uptake											○
Soil	Leaching & Subsurface Migration	Surface Water	Contact											○
Soil	Leaching & Subsurface Migration	Surface Water	Ingestion											○
Soil	Leaching & Subsurface Migration	Aquatic invert.	Ingestion											○
Groundwater	Groundwater	Groundwater	Root Uptake											
Groundwater	Volatilization	Vapours in Outdoor Air	Foliar Uptake	○					○					○
Groundwater	Volatilization	Vapours in Outdoor Air	Inhalation			○	○				○	○		
Groundwater	Subsurface Migration	Surface Water	Root Uptake											○
Groundwater	Subsurface Migration	Surface Water	Contact											○
Groundwater	Subsurface Migration	Surface Water	Ingestion											○
Groundwater	Subsurface Migration	Aquatic invert.	Ingestion											○
Sediment	Sediment	Sediment	Root Uptake											
Sediment	Sediment	Sediment	Contact											
Sediment	Sediment	Benthic Biota	Ingestion											

Legend:
- ● Major exposure pathway
- ○ Minor exposure pathway
- Incomplete exposure pathway (not evaluated)
- ● Pathway blocked (risk management measure)

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INVERNESS HOMES
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1518, 1524, 1526 STITTSVILLE MAIN STREET
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Title:
ECOLOGICAL CONCEPTUAL SITE MODEL with RMM

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APPENDIX A

Risk Assessor Qualifications

PATERSON GROUP

solution oriented engineering

Christopher Marwood, Ph.D., QP$_{RA}$
Senior Risk Assessor

Dr. Marwood is an environmental consultant specializing in human health and ecological risk assessment and providing expert advice on toxicology issues at contaminated sites. He has a wide range of experience with different approaches to risk assessment of chemicals and other stressors, including distributional analysis and probabilistic techniques, and has completed risk assessments for federal, provincial, and regional agencies and over 50 risk assessments in support of Records of Site Condition in Ontario. He also brings expertise in the fields of environmental chemistry, aquatic and terrestrial ecotoxicology, toxicity testing methods, environmental effects monitoring, and biodiversity assessment. As a former university professor, Dr. Marwood oversaw research programs examining biochemical mechanisms of toxicity, development of novel methods of assessing contaminant exposure in ecological risk assessments, and evaluation of the performance of biomarkers in mesocosm and field studies with aquatic organisms. He has also provided his expertise to various regulatory agencies in the U.S. and Canada for the development or review of risk assessment strategies and programs. Dr. Marwood has taught undergraduate courses in ecological sciences and graduate-level courses in toxicology, ecological risk assessment, and field methods in ecology and environmental science, and has contributed to the body of knowledge in this area in peer-reviewed literature.

EDUCATION
B.Sc. 1994, Biology, University of Waterloo, Waterloo, ON
Ph.D. 1999, Environmental Biology, University of Guelph, Guelph, ON

YEARS OF EXPERIENCE
With Paterson: <1
Total: 20+

OFFICE LOCATION
9 Auriga Drive, Ottawa, Ontario, K2E 7T9

PROFESSIONAL EXPERIENCE
2023 to present, Senior Risk Assessor, Paterson Group Inc., Ottawa, Ontario
- Responsible for development of risk assessment practice.
- Conduct human health and ecological risk assessment for brownfields under Ontario Regulation 153/04.

2010 to 2023, Senior Risk Assessor, NovaTox Inc., Guelph, Ontario
- QP$_{RA}$ supervising risk assessments under O. Reg. 153/04.
- Prepared human health and ecological risk assessments for brownfields properties.
- Conducted due diligence human health and ecological risk assessments for commercial and industrial sites, federal properties under FCSAP, and military bases under multi-year standing offer agreements.
- Prepared risk management plans and development of site-specific remedial targets.
- Biodiversity assessments, wildlife exposure assessment, environmental assessment under MMER.

2009 to 2010, Supervising Health Scientist, ChemRisk Canada Co., Guelph, Ontario
- Ecological risk assessor and project manager for Canadian office of ChemRisk.
- Responsible for all aspects of project management and business development.
- Oversaw ecotoxicological investigations into ecotoxicity of tire particles; managed and interpreted toxicity identification/evaluation programs; primary author on journal publications.
- Prepared ERAs for brownfields properties under O. Reg. 153/04.

- Conducted ecological risk assessments for federal-owned properties and military sites.

2005 to 2009, Senior Risk Assessor, AMEC Earth and Environmental, Ottawa, Ontario

- Ecological risk assessor for Canada projects; provided ecotoxicological support for multiple offices.
- Designated QPRA; Conducted ecological risk assessments under O. Reg. 153/04 for Ontario project sites.
- Prepared risk assessments for provincial and federal government properties; oversaw environmental sampling and analysis programs.
- Provided support for environmental assessments for mining projects under MMER; development of risk-based effluent limits; evaluation of effects in benthic macroinvertebrate communities and fish populations.
- Expert advice for government risk-based initiatives.

2002 to 2005: Assistant Professor, University of California Santa Barbara, Donald Bren School of Environmental Science and Management

- Tenure-track research & teaching professor.
- Oversaw laboratory- and field-based research programs focusing on development of toxicological markers in wildlife and phototoxicity in aquatic systems.
- Managed laboratory with on-going Masters and Doctorate student research programs.
- Supervised Master's students research group projects.
- Taught Masters-level courses: Ecotoxicology; Ecological Risk Assessment; Environmental Field Methods; Biological Community Survey and Analysis.
- Published research findings in professional journals.
- Responsible for grant applications and management of finances.
- Served on various UCSB committees and boards of professional societies.

2000 to 2002: Post-doctoral Fellow, Miami University, Oxford, Ohio

- Research and teaching fellow.
- Conducted lab and field-based research into biomarkers of toxicity in rainbow trout; conducted survey of UV light transmission in subalpine lakes in Sierra Nevada mountains.
- Taught undergraduate Ecology lecture course.

SELECT PROJECT EXPERIENCE

Brownfields Risk Assessment (Records of Site Condition)

- Risk Assessment to Support a Record of Site Condition for 28 High Street, Carleton Place, Ontario (IDS 7020-CKSJWH). December 2023.
- Risk Assessment to Support a Record of Site Condition for 3-33 Selkirk Street and 2 Montreal Road, Ottawa, Ontario (IDS 1611-CJNJGE) – Senior Risk Assessor. November 2023.
- Risk Assessment to Support a Record of Site Condition for 1171 Newmarket Street, Ottawa, Ontario (IDS 2010-BNUJCE) – Ecological Risk Assessor. October 2023.
- Risk Assessment to Support a Record of Site Condition for 55 & 65 Ellerslie Avenue, Toronto, Ontario (IDS 1815-B7MNC7) – Ecological Risk Assessor. July 2023.
- Risk Assessment to Support a Record of Site Condition for 20 Shirk Place, Kitchener, Ontario (IDS 3653-BUYLHP) – Ecological Risk Assessor. July 2023.
- Risk Assessment to Support a Record of Site Condition for 65 Heward Avenue, Toronto, Ontario (IDS 1530-937J3U) – Ecological Risk Assessor. May 2023.
- Risk Assessment to Support a Record of Site Condition for 819 Bank Street, Ottawa, Ontario (IDS 4108-BFJNNV) – Ecological Risk Assessor. May 2023.
- Risk Assessment to Support a Record of Site Condition for Parts 5, 6, 7, 8, 9, and 10 of Block X on Plan 3001 Leaside, Part of 815-845 Eglinton Avenue East (Leaside East Conveyance), Toronto, Ontario (IDS 7654-C3MGUN) – Ecological Risk Assessor. April 2023.
- Risk Assessment to Support a Record of Site Condition for Part 11, Part of Block X on Plan 3001 Leaside, Part of 815-845 Eglinton Avenue East, Toronto, Ontario (IDS 6626-C2GLKK) – Ecological Risk Assessor. April 2023.
- Risk Assessment to Support a Record of Site Condition for Part of Former Pittsburg Quarry, 998 Highway 15, Kingston, Ontario (IDS 0421-CGYSCE) – Senior Risk Assessor. January 2023.
- Risk Assessment to Support a Record of Site Condition for Part of 700 Gardiners Road, Kingston, Ontario (IDS 6272-BXQGPS) – Senior Risk Assessor. November 2022.
- Risk Assessment to Support a Record of Site Condition for 180 Groh Avenue, Cambridge, Ontario (IDS 4232-CAZHLQ) – Ecological Risk Assessor. October 2022.
- Risk Assessment to Support a Record of Site Condition for 170-180 Coleman Street, Belleville, Ontario

(IDS 1036-BVNLPE) – Ecological Risk Assessor. September 2022.
- Risk Assessment to Support a Record of Site Condition for 350 Montgomery Street, Ottawa, Ontario (IDS 0681-C8TM7S). July 2022.
- Risk Assessment to Support a Record of Site Condition for 168-180 Colborne Street West, Brantford, Ontario (IDS 4725-CAZJY6). January 2022.
- Risk Assessment to Support a Record of Site Condition for 19 West Street North, Fenelon Falls, Ontario (IDS 0676-C23GWV) – Ecological Risk Assessor. October 2021.
- Risk Assessment to Support a Record of Site Condition for 425 Rea Street South, Timmins, Ontario (IDS 1317-9UJRXQ). January 2020.
- Risk Assessment to Support a Record of Site Condition for 2270-2280, 2296 Eglinton Avenue West and 6 Sanderstead Avenue, Toronto, Ontario (IDS 7488-9RFUSB). January 2020.
- Risk Assessment to Support a Record of Site Condition for 908 & 920 Yonge Street, Toronto, Ontario (IDS 6640-AZ9TCB) – Ecological Risk Assessor. September 2019.
- Risk Assessment to Support a Record of Site Condition for 0 and 19 Western Battery Road, Toronto, Ontario (IDS 8326-AT6V2F and 3064-ASRQ6U) – Ecological Risk Assessor. July 2019.
- Risk Assessment to Support a Record of Site Condition for 400-440 Strasburg Road, Kitchener, Ontario (IDS 0440-86VJBN) – Ecological Risk Assessor. May 2019.
- Risk Assessment to Support a Record of Site Condition for 1311-1315 Queen Street East and 62½ Laing Street, Toronto, Ontario (IDS 7523-A5ASAB) – Ecological Risk Assessor. February 2019.
- Risk Assessment to Support a Record of Site Condition for 135 West Street, Orillia, Ontario (IDS 4381-8TNNJE) – Ecological Risk Assessor. January 2019.
- Risk Assessment to Support a Record of Site Condition for 37 Mill Street, Mississippi Mills (Almonte), Ontario (IDS 4373-A4MJQF) – Ecological Risk Assessor, Technical Reviewer. November 2018.
- Risk Assessment to Support a Record of Site Condition for 200 Industrial Parkway, Aurora, Ontario (IDS 5123-9GYLTL) – Ecological Risk Assessor. November 2018.
- Risk Assessment to Support a Record of Site Condition for Jacob's Trail Phase 2, St. Jacobs, Ontario (IDS 6150-9AEQVU) – Ecological Risk Assessor. October 2017.
- Risk Assessment to Support a Record of Site Condition for 26 Charles Street, Kitchener, Ontario (IDS 1653-9CLL75) – Ecological Risk Assessor. November 2016.
- Risk Assessment to Support a Record of Site Condition for 322-336 King Street East, Hamilton, Ontario (IDS 8827-93LPL9) – Ecological Risk Assessor. August 2016.
- Risk Assessment to Support a Record of Site Condition for 475 Speedvale Avenue East, Guelph, Ontario (IDS 4133-94GK8V) – Ecological Risk Assessor. August 2016.
- Risk Assessment to Support a Record of Site Condition for 1541 Merivale Road, Ottawa, Ontario (IDS 5207-9GXPKM) – Ecological Risk Assessor. July 2016.
- Risk Assessment to Support a Record of Site Condition for 89-93 Ontario Street South, Kitchener, Ontario (IDS 5287-97YNM8) – Ecological Risk Assessor. June 2015.
- Risk Assessment to Support a Record of Site Condition for 1044 Ministry Road, Blind River, Ontario (IDS 4608-94HTFV) – Ecological Risk Assessor. April 2015.
- Risk Assessment to Support a Record of Site Condition for 127 George Street, Peterborough, Ontario (IDS 7668-8NWS3G) – Ecological Risk Assessor. January 2015.
- Risk Assessment to Support a Record of Site Condition for 818, 820 and 824 Victoria Street North, Kitchener, Ontario (IDS 0488-9GUSQT) – Ecological Risk Assessor. January 2015.
- Risk Assessment to Support a Record of Site Condition for 18-20 Vansittart Avenue, Woodstock, Ontario (IDS 3214-9CJJDX) – Ecological Risk Assessor. November 2014.
- Risk Assessment to Support a Record of Site Condition for 3091 Appleby Line, Burlington, Ontario (IDS 0570-8LGS2W) – Ecological Risk Assessor. October 2014.
- Risk Assessment to Support a Record of Site Condition for 2-4 Union Street, Toronto, Ontario (IDS 2861-855NW8) – Ecological Risk Assessor. August 2014.
- Risk Assessment to Support a Record of Site Condition for 606 Beech Street West, Whitby, Ontario (IDS 0754-8AGMDH) – Ecological Risk Assessor. October 2013.
- Risk Assessment to Support a Record of Site Condition for 2055-2057 Danforth Avenue, Toronto, Ontario (IDS 0773-99UHE9) – Ecological Risk Assessor. July 2013.
- Risk Assessment to Support a Record of Site Condition for 14 Algoma Street, Toronto, Ontario (IDS 5521-89WMQF) – Ecological Risk Assessor. December 2012.
- Risk Assessment in Support of a Record of Site Condition, 51-75 Bradford Street, Barrie, Ontario (IDS 4730-823K2U) – Ecological Risk Assessor. October 2012.

- Risk Assessment to Support a Record of Site Condition for 298 Lawrence Avenue, Kitchener, Ontario (IDS 8823-893NG8) – Ecological Risk Assessor. August 2012.
- Risk Assessment to Support a Record of Site Condition for 200 Weber Street North, Waterloo, Ontario (IDS 1880-8AKREJ) – Ecological Risk Assessor. August 2012.
- Risk Assessment to Support a Record of Site Condition for the Phoenix Advanced Exploration Project, Red Lake, Ontario (IDS 6185-86G4Q) – Ecological Risk Assessor. March 2011.
- Risk Assessment in Support of a Record of Site Condition, 301 Front Street, Toronto, Ontario (IDS 2450-7YWLND) – Ecological Risk Assessor. October 2010.
- Risk Assessment in Support of a Record of Site Condition, 300 West Hunt Club Road, Ottawa, Ontario (IDS 0508-6X6LPZ) – Ecological Risk Assessor. September 2009.
- Risk Assessment in Support of a Record of Site Condition, 19 Waterman Avenue, Toronto, Ontario (IDS 6348-79JTFC) – Ecological Risk Assessor. July 2009.
- Risk Assessment in Support of a Record of Site Condition, 344 Glendale Avenue, St. Catherines, Ontario (IDS 2064-7G4MVT) – Ecological Risk Assessor. May 2009.
- Risk Assessment to Support a Record of Site Condition, 140 West River Street, Paris, Ontario (IDS 2646-79JSDD) – Ecological Risk Assessor. October 2008.
- Risk Assessment in Support of a Record of Site Condition, Woodbine Avenue and 14th Avenue, Markham, Ontario (IDS 7531-73RK47) – Ecological Risk Assessor. April 2008.
- Risk Assessment in Support of a Record of Site Condition, 15 Lake Street, Grimsby, Ontario (IDS 4658-6U7MWG) – Ecological Risk Assessor. February 2008.
- Risk Assessment to Support a Record of Site Condition, 80 Willow Street, Paris, Ontario (IDS 1223-78BK3H) – Ecological Risk Assessor. July 2008.
- Risk Assessment in Support of a Record of Site Condition, 41 Oliver Street, Hamilton, Ontario (IDS 2535-6R7KMC) – Ecological Risk Assessor. May 2008.
- Risk Assessment in Support of a Record of Site Condition, 76-86 Dalhousie Street, Brantford, Ontario (IDS 7648-6XYZPWB) – Ecological Risk Assessor. July 2007.
- Risk Assessment to Support a Record of Site Condition, 210-240 Canarctic Drive, North York, Ontario (IDS 8744-6FQHJD) – Human Health and Ecological Risk Assessor. September 2006.

Other Risk Assessment

- Preliminary Quantitative Risk Assessment and Screening Level Ecological Risk Assessment, St. Clair National Wildlife Area, Lambton County, Ontario – Ecological Risk Assessor. March 2024.
- Owen Sound Harbour 2023 Risk Management Implementation Report, Owen Sound, Ontario – Senior Reviewer. February 2024.
- Preliminary Quantitative Risk Assessment and Screening Level Ecological Risk Assessment, Long Point National Wildlife Area, Port Rowan, Ontario – Ecological Risk Assessor. January 2024.
- Ecological Risk Assessment: Red River, Manitoba Hydro Sutherland Facility, Winnipeg, Manitoba – Ecological Risk Assessor. December 2023.
- Terrestrial Ecological Risk Assessment for Riverbank Lands, Manitoba Hydro Sutherland Facility, Winnipeg, Manitoba – Ecological Risk Assessor. December 2023.
- Human Health and Ecological Risk Assessment, Former Domtar Mill Site, Cornwall, Ontario – Project Manager, Ecological Risk Assessor. October 2023.
- Traditional Foods Assessment Study Design, Rowan Project, Red Lake, Ontario – Senior Risk Assessor. October 2023.
- Development of Risk-Based Standards, 35 Hayward Avenue, Kitchener, Ontario – Ecological Risk Assessor. October 2023.
- Site Specific Effluent Limits for Seymour Project, Armstrong, Ontario – Senior Ecotoxicologist. June 2023.
- Detailed Quantitative Risk Assessment, CFB Esquimalt, Aldergrove, British Columbia – Ecological Risk Assessor. March 2023.
- Detailed Quantitative Risk Assessment, Matsqui Property, CFB Esquimalt, British Columbia – Ecological Risk Assessor. March 2023.
- Phase III Environmental Site Assessment Supplemental Site Investigations – PIN 614538, Transport Canada, Pickering, Ontario – Senior Reviewer. January 2023.
- Detailed Quantitative Risk Assessment, Heals Rifle Range, Saanich, British Columbia – Lead Risk Assessor. November 2022.
- Detailed Quantitative Human Health and Ecological Risk Assessment, Water Treatment Plant Site, Bunibonibee Cree Nation, Manitoba – Ecological Risk Assessor. October 2022.
- Human Health and Ecological Risk Assessment, 620 King Street West, Hamilton, Ontario – Ecological

Risk Assessor. August 2022.

- Cape Ray Gold Project Environmental Impact Statement (Section 21), Cape Ray, Newfoundland and Labrador – Ecological Risk Assessor. June 2022.
- Preliminary Quantitative Risk Assessment, NCC Property Asset #743, 20 Laurier Street, Gatineau, Quebec – Ecological Risk Assessor. February 2022.
- Human Health and Ecological Risk Assessment, Part of 450 Montreal Road, Ottawa, Ontario – Ecological Risk Assessor. October 2021.
- Human Health and Ecological Risk Assessment, 1317 Wellington Street West, Ottawa, Ontario – Project Manager and Ecological Risk Assessor. April 2021.
- Environmental Risk Assessment, Lagoon and Landfill Areas, Whiteshell Laboratories, Pinawa, Manitoba – Lead Ecological Risk Assessor and NovaTox Project Leader. March 2021.
- Human Health and Ecological Risk Assessment for 3463 Thomas Street, Innisfil, Ontario – Ecological Risk Assessor. December 2020.
- Human Health and Ecological Risk Assessment for Enchanted Harbour Marina, Candle Lake, Saskatchewan – Ecological Risk Assessor. November 2020.
- Human Health and Ecological Risk Assessment for 1450 Cornwall Street, Regina, Saskatchewan – Ecological Risk Assessor. June 2020.
- Human Health and Ecological Risk Assessment for 1820 Midland Avenue, Toronto, Ontario – Ecological Risk Assessor. June 2020.
- Review of Potential Ecotoxicity of Resolute Forest Products Wood Ash, Thunder Bay, Ontario– Ecological Risk Assessor. May 2020.
- Human Health and Ecological Risk Assessment, 3052 Elmcreek Road, Mississauga, Ontario – Ecological Risk Assessor. April 2020.
- Human Health and Ecological Risk Assessment for Holt Asphalt Plant, 4772 Mount Albert Road, East Gwillimbury, Ontario – Ecological Risk Assessor. March 2020.
- Human Health and Ecological Risk Assessment for 55 Triller Avenue, Toronto, Ontario – Ecological Risk Assessor. October 2019.
- Human Health and Ecological Risk Assessment for 25 Curity Avenue, Toronto, Ontario – Ecological Risk Assessor. August 2019.
- Human Health and Ecological Risk Assessment for 415 Madison Street, Winnipeg, Manitoba – Ecological Risk Assessor. August 2019.
- Human Health and Ecological Risk Assessment, Burnhamdale Park, Mississauga, Ontario – Ecological Risk Assessor. July 2019.
- Aquatic Exposure Pathway Analysis, 801 57th Street, Saskatoon, Saskatchewan – Ecological Risk Assessor. May 2019.
- Human Health and Ecological Risk Assessment and Development of Site Specific Target Levels for Town of Gravelbourg Landfill, Saskatchewan – Ecological Risk Assessor. April 2019.
- Human Health and Ecological Risk Assessment for Ontario Ministry of Natural Resource and Forestry Camp #19, Lac Seul, Ontario – Ecological Risk Assessor. June 2018.
- Human Health and Ecological Risk Assessment, Former Ministry of Natural Resources Fire Base Kenogamisis Lake, Municipality of Greenstone, Ontario – Ecological Risk Assessor. May 2018.
- Human Health and Ecological Risk Assessment for 117 Wakooma Street, Saskatoon, Saskatchewan – Ecological Risk Assessor. May 2018.
- Human Health and Ecological Risk Assessment for 619 8th Street East, Saskatoon, Saskatchewan – Ecological Risk Assessor. May 2018.
- Preliminary Quantitative Human Health Risk Assessment and Screening Level Ecological Risk Assessment, Canadian Forces Ammunition Depot, Angus, Ontario – Ecological Risk Assessor. November 2017.
- Detailed Quantitative Risk Assessment, Pickering Lands Site PIN 614576, Pickering, Ontario – Ecological Risk Assessor. March 2017.
- Screening Level Ecological Risk Assessment, Site 441-C20, Collins Bay Institution, Kingston, Ontario – Ecological Risk Assessor. March 2017.
- Ecological Risk Assessment, Sir Lionel Chevrier Building, Cornwall, Ontario – Ecological Risk Assessor. March 2017.
- Detailed Quantitative Risk Assessment, Fire Fighter Training Area #1, CFB Borden, Ontario – Ecological Risk Assessor. June 2016.
- Preliminary Quantitative Ecological Risk Assessment, Mohawk Island National Wildlife Area, Haldimand,

Ontario – Ecological Risk Assessor. March 2016.
- Preliminary Quantitative Risk Assessment, Domestic Waste Landfill #4 and Flamethrower Training Area, CFB Borden, Ontario – Ecological Risk Assessor. March 2016.
- Detailed Quantitative Risk Assessment, Former RV Compound, 22 Wing North Bay, Ontario – Ecological Risk Assessor. March 2015.
- Preliminary Quantitative Risk Assessment, Sewage Sludge Ponds #1, CFB Borden, Ontario – Ecological Risk Assessor. March 2015.
- Preliminary Quantitative Ecological Risk Assessment, Wood Hobby Shop, 22 Wing North Bay, Ontario – Ecological Risk Assessor. November 2014.
- Site Specific Risk Assessment, Northern Ontario Hydrometric Stations – Ecological Risk Assessor. March 2014.
- Detailed Quantitative Risk Assessment, Former Central Heating Plant, 22 Wing North Bay, Ontario – Ecological Risk Assessor. February 2014.
- Human Health and Ecological Risk Assessment for Former Woodstock General Hospital – Ecological Risk Assessor. April 2013.
- Detailed Quantitative Risk Assessment, Sudbury Armoury – Ecological Risk Assessor. March 2013.
- Detailed Quantitative Risk Assessment, Wheeled Vehicle Hangar Area, CFB Borden, Ontario – Ecological Risk Assessor. January 2013.
- Detailed Quantitative Risk Assessment, Hangar Line Complex, CFB Borden, Ontario – Ecological Risk Assessor. November 2012.
- Preliminary Quantitative Human Health and Ecological Risk Assessment, Vehicle Refueling Facility #1, CFB Borden, Ontario – Ecological Risk Assessor. October 2012.
- Human Health and Ecological Risk Assessment, Infrastructure Ontario – Senior Reviewer. September 2012.
- Human Health and Ecological Risk Assessment, City of Mississauga, Ontario – Ecological Risk Assessor. December 2011.
- Preliminary Quantitative Ecological Risk Assessment, Public Works and Government Services Canada – Ecological Risk Assessor. March 2011.
- Risk Assessment and Site-Specific Water Quality Objectives for Red Lake Flowpath, Campbell Complex Tailings Management Area, Goldcorp, Balmertown, Ontario – Ecological Risk Assessor. February 2011.
- Ecological Risk Assessment, City of Mississauga – Ecological Risk Assessor. February 2011.
- Assessment of Risk to Humans and the Environment from Phoenix Advanced Exploration Project, Rubicon Minerals, Red Lake, Ontario – Ecotoxicologist. January 2011.
- Screening Level Ecological Risk Assessment, Ontario Realty Corporation, St. Thomas, Ontario – Ecological Risk Assessor. January 2011.
- Screening Level Ecological Risk Assessment, City of Mississauga, Ontario – Ecological Risk Assessor. February 2010.
- Alexander Lake Quantitative Ecological Risk Assessment, Defence Construction Canada, Halifax, Nova Scotia – Ecological Risk Assessor. August 2009.
- Screening Level Ecological Risk Assessment, Commercial Property, Caledon, Ontario – Project Manager and Ecological Risk Assessor. April 2009.
- Land East of East White Hills Road Ecological Risk Assessment, PWGSC, St. John's, Newfoundland and Labrador – Ecological Risk Assessor. April 2009.
- PQRA & Screening Level Ecological Risk Assessment, Atlantic Cool Climate Crop Research Centre, St. John's, Newfoundland and Labrador – Ecological Risk Assessor. March 2009.
- Quantitative Ecological Risk Assessment, Grand Falls Armoury, Grand Falls-Windsor, Newfoundland and Labrador – Ecological Risk Assessor. March 2009.
- Ecological Risk Assessment, Building 107, 9 Wing Gander, Newfoundland and Labrador – Ecological Risk Assessor. February 2009.
- Ecological Risk Assessment for Cambrai Range, Makinsons, Newfoundland and Labrador – Ecological Risk Assessor. October 2008.
- Preliminary Quantitative Ecological Risk Assessment, Three Nations Creek, Xstrata Copper, Timmins, Ontario – Ecological Risk Assessor. July 2008.
- Ferryland Head Light Station Screening Ecological Risk Assessment, Ferryhead, Newfoundland and Labrador – Ecological Risk Assessor. February 2008.
- Cadegan Brook Screening Level Ecological Risk Assessment, Sydney, Nova Scotia – Ecological Risk Assessor. February 2008.

- Quantitative Ecological Risk Assessment and Final Remedial Action Plan for Sites at CFAD Bedford, CFB Halifax, Nova Scotia – Ecological Risk Assessor. November 2007.
- Scotchtown Summit Ecological Risk Assessment, Sydney, Nova Scotia – Senior Reviewer and Ecological Risk Assessor. October 2007.
- Screening Level Ecological Risk Assessment of Former Bait Depot Property, Rencontre, Newfoundland and Labrador – Ecological Risk Assessor. August 2007.
- Buchans Mine Closure Ecological Risk Assessment, Abitibi Consolidated, Buchans, Newfoundland and Labrador – Ecological Risk Assessor. April 2007.
- Risk Assessments of Small Craft Harbours, PWGSC, Newfoundland and Labrador – Ecological Risk Assessor. March 2007.
- Ecological Risk Assessment, Port Union, Newfoundland and Labrador – Ecological Risk Assessor. February 2007.
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APPENDIX B

Analytical Data

PATERSON GROUP

Table B1: Soil Analytical Data

Parameter	Units	Number samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 I/C/C Coarse	Number samples exceed Table 3	Location:													
									Sample ID:	BH1-SS1	BH4-SS8	BH1-SS7	BH2-SS2	BH2-SS6	BH1-20-SS8	BH3-20-SS2	BH3-20-SS7	DUP1	BH4-20-SS2	BH1-22-SS2	BH1-22-SS7	BH2-22-SS5
									Date:	11/09/2011	11/09/2011	06/03/2019	06/03/2019	06/03/2019	07/22/2020	07/22/2020	07/22/2020	07/22/2020	07/23/2020	06/16/2022	06/16/2022	06/16/2022
									Depth (m):													
Antimony	µg/g	6	1	1		<1	40						<1.0			<1.0			<1.0	<1.0	<1.0	<1.0
Arsenic	µg/g	6	1	1	5.8	5.8	18						2.1			3.2			5.8	1.8	1.3	1.7
Barium	µg/g	6	1	1	198	198	670						51.3			198			185	14	8.3	11.7
Beryllium	µg/g	6	0.5	0.5		<0.5	8						<0.5			<0.5			<0.5	<0.5	<0.5	<0.5
Boron (Total)	µg/g	6	5	5	10.3	10.3	120						5			10.3			10.1	<5.0	<5.0	<5.0
Cadmium	µg/g	6	0.5	0.5		<0.5	1.9						<0.5			<0.5			<0.5	<0.5	<0.5	<0.5
Chromium VI	µg/g	2	0.2	0.2		<0.2	8									<0.2			<0.2			
Chromium (Total)	µg/g	6	5	5	22.9	22.9	160						11.6			14.3			22.9	8.8	6.4	9.2
Cobalt	µg/g	6	1	1	5.8	5.8	80						3			5.8			5.6	5.5	3.7	5.4
Copper	µg/g	6	5	5	43.3	43.3	230						15.9			12.4			43.3	12.2	9.3	11.7
Lead	µg/g	6	1	1	**268**	**268**	120	1					61.3			13.1			**268**	3.6	2.5	2.8
Mercury	µg/g	2	0.1	0.1	0.5	0.5	3.9									<0.1			0.5			
Molybdenum	µg/g	6	1	1		<1	40						<1.0			<1.0			<1.0	<1.0	<1.0	<1.0
Nickel	µg/g	6	5	5	13.1	13.1	270						5.6			13.1			11.6	8	<5.0	6.7
Selenium	µg/g	6	1	1		<1	5.5						<1.0			<1.0			<1.0	<1.0	<1.0	<1.0
Silver	µg/g	6	0.3	0.3	0.3	0.3	40						<0.3			<0.3			0.3	<0.3	<0.3	<0.3
Thallium	µg/g	6	1	1		<1	3.3						<1.0			<1.0			<1.0	<1.0	<1.0	<1.0
Uranium	µg/g	6	1	1		<1	33						<1.0			<1.0			<1.0	<1.0	<1.0	<1.0
Vanadium	µg/g	6	10	10	27.5	27.5	86						12.5			21.4			23.9	22.3	16.1	27.5
Zinc	µg/g	6	20	20	236	236	340						82.9			<20.0			236	<20.0	<20.0	<20.0
Acetone	µg/g	9	5	5		<5	16				<0.5	<0.5		<0.5	<0.5		<0.5	<0.5		<0.5	<0.5	<0.5
Bromodichloromethane	µg/g	9	0.5	0.5		<0.5	18				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Bromoform	µg/g	9	0.5	0.5		<0.5	0.61				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Bromomethane	µg/g	9	0.5	0.5		<0.5	0.05				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Carbon Tetrachloride	µg/g	9	0.2	0.2		<0.2	0.21				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Chlorobenzene	µg/g	9	0.5	0.5		<0.5	2.4				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Chloroethane	µg/g	1	0.05	0.05		<0.05					<0.05											
Chloroform	µg/g	9	0.5	0.5		<0.5	0.47				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Chloromethane	µg/g	1	0.05	0.05		<0.05					<0.2											
Dibromochloromethane	µg/g	9	0.5	0.5		<0.5	13				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Dichlorodifluoromethane	µg/g	9	1	1		<1	16				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,2-Dichlorobenzene	µg/g	9	0.5	0.5		<0.5	6.8				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,3-Dichlorobenzene	µg/g	9	0.5	0.5		<0.5	9.6				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,4-Dichlorobenzene	µg/g	9	0.5	0.5		<0.5	0.2				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,1-Dichloroethane	µg/g	9	0.5	0.5		<0.5	17				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,2-Dichloroethane	µg/g	9	0.5	0.5		<0.5	0.05				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,1-Dichloroethylene	µg/g	9	0.5	0.5		<0.5	0.064				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,2-cis-Dichloroethylene	µg/g	9	0.5	0.5		<0.5	55				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,2-trans-Dichloroethylene	µg/g	9	0.5	0.5		<0.5	1.3				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,2-Dichloropropane	µg/g	9	0.5	0.5		<0.5	0.16				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,3-Dichloropropene	µg/g	9	0.5	0.5		<0.5	0.18				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Ethylene dibromide	µg/g	9	0.2	0.2		<0.2	0.05				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
(n)-Hexane	µg/g	9	1	1		<1	46				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Methyl Ethyl Ketone	µg/g	9	5	5		<5	70				<0.5	<0.5		<0.5	<0.5		<0.5	<0.5		<0.5	<0.5	<0.5
Methyl Isobutyl Ketone	µg/g	9	5	5		<5	31				<0.5	<0.5		<0.5	<0.5		<0.5	<0.5		<0.5	<0.5	<0.5
Methyl tert-Butyl Ether (MTBE)	µg/g	9	2	2		<2	11				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Methylene Chloride	µg/g	9	5	5		<5	1.6				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Styrene	µg/g	9	0.5	0.5		<0.5	34				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,1,1,2-Tetrachloroethane	µg/g	9	0.5	0.5		<0.5	0.087				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,1,2,2-Tetrachloroethane	µg/g	9	0.5	0.5		<0.5	0.05				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Tetrachloroethylene	µg/g	9	0.5	0.5	1.01	1.01	4.5				0.09	1.01		<0.05	0.25		<0.05	<0.05		<0.05	<0.05	<0.05
1,2,4-Trichlorobenzene	µg/g	4	0.05	0.05		<0.05	3.2				<0.05									<0.05	<0.05	<0.05

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Table B1: Soil Analytical Data

Parameter	Units	Number samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 I/C/C Coarse	Number samples exceed Table 3	Location:													
									Sample ID:	BH1-SS1	BH4-SS8	BH1-SS7	BH2-SS2	BH2-SS6	BH1-20-SS8	BH3-20-SS2	BH3-20-SS7	DUP1	BH4-20-SS2	BH1-22-SS2	BH1-22-SS7	BH2-22-SS5
									Date:	11/09/2011	11/09/2011	06/03/2019	06/03/2019	06/03/2019	07/22/2020	07/22/2020	07/22/2020	07/22/2020	07/23/2020	06/16/2022	06/16/2022	06/16/2022
									Depth (m):													
1,1,1-Trichloroethane	µg/g	9	0.5	0.5		<0.5	6.1				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
1,1,2-Trichloroethane	µg/g	9	0.5	0.5		<0.5	0.05				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Trichloroethylene	µg/g	9	0.5	0.5		<0.5	0.91				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Trichlorofluoromethane	µg/g	9	1	1		<1	4				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Vinyl Chloride	µg/g	9	0.5	0.5		<0.5	0.032				<0.02	<0.02		<0.02	<0.02		<0.02	<0.02		<0.02	<0.02	<0.02
Benzene	µg/g	9	0.02	0.02		<0.02	0.32				<0.02	<0.02		<0.02	<0.02		<0.02	<0.02		<0.02	<0.02	<0.02
Ethylbenzene	µg/g	9	0.05	0.05		<0.05	9.5				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Toluene	µg/g	9	0.05	0.05		<0.05	68				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
Xylene Mixture	µg/g	9	0.05	0.05		<0.05	26				<0.05	<0.05		<0.05	<0.05		<0.05	<0.05		<0.05	<0.05	<0.05
PHC F1	µg/g	3	7	7		<7	55													<7	<7	<7
PHC F2	µg/g	3	4	4		<4	230													<4	<4	<4
PHC F3	µg/g	3	8	8		<8	1700													<8	<8	<8
PHC F4	µg/g	3	6	6		<6	3300													<6	<6	<6
Acenaphthene	µg/g	3	0.02	0.02		<0.02	96			<0.02						<0.02			<0.02			
Acenaphthylene	µg/g	3	0.02	0.02	0.07	0.07	0.15			<0.02						<0.02			0.07			
Anthracene	µg/g	3	0.02	0.02	0.04	0.04	0.67			<0.02						<0.02			0.04			
Benz[a]anthracene	µg/g	3	0.02	0.02	0.12	0.12	0.96			0.02						<0.02			0.12			
Benzo[a]pyrene	µg/g	3	0.02	0.02	0.17	0.17	0.3			<0.02						<0.02			0.17			
Benzo[b]fluoranthene	µg/g	3	0.02	0.02	0.25	0.25	0.96			0.03						<0.02			0.25			
Benzo[g,h,i]perylene	µg/g	3	0.02	0.02	0.17	0.17	9.6			<0.02						<0.02			0.17			
Benzo[k]fluoranthene	µg/g	3	0.02	0.02	0.12	0.12	0.96			<0.02						<0.02			0.12			
Chrysene	µg/g	3	0.02	0.02	0.13	0.13	9.6			0.02						<0.02			0.13			
Dibenz[a,h]anthracene	µg/g	3	0.02	0.02	0.05	0.05	0.1			<0.02						<0.02			0.05			
Fluoranthene	µg/g	3	0.02	0.02	0.24	0.24	9.6			0.03						<0.02			0.24			
Fluorene	µg/g	3	0.02	0.02		<0.02	62			<0.02						<0.02			<0.02			
Indeno[1,2,3-cd]pyrene	µg/g	3	0.02	0.02	0.15	0.15	0.76			<0.02						<0.02			0.15			
Methylnaphthalene 1-, 2-	µg/g	3	0.04	0.04		<0.04	76			<0.04						<0.04			<0.04			
Naphthalene	µg/g	3	0.01	0.01		<0.01	9.6			<0.02						<0.01			<0.01			
Phenanthrene	µg/g	3	0.02	0.02	0.09	0.09	12			<0.02						<0.02			0.09			
Pyrene	µg/g	3	0.02	0.02	0.2	0.2	96			0.04						<0.02			0.2			
1,1'-Biphenyl	µg/g	1	0.03	0.03		<0.03	52			<0.02												

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Table B2: Groundwater Analytical Data

Parameter	Units	Number samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 Coarse	Number samples exceed Table 3	Location:	BH2-11			BH1-19			BH2-19				BH1-20		BH3-20	BH1-22	
									Sample ID:	MW1-GW1	BH2-G1	BH2-102-GW	BH1-GW1	BH1-GW2	BH1-GW3	BH2-GW1	BH2-GW2	BH2-GW1	BH2-19-GW2	BH1-20-GW1	BH1-20-GW	BH3-20-GW1	BH1-22-GW	BH1-22-GW
									Date:	10/25/2019	7/22/2020	06/20/2022	06/11/2019	06/20/2019	06/20/2019	06/11/2019	06/20/2019	10/11/2019	8/06/2020	08/06/2020	11/04/2022	08/06/2020	06/20/2022	06/05/2023
Antimony	µg/L	1	0.1	0.1		<0.1	20000										<0.5							
Arsenic	µg/L	1	0.5	0.5		<0.5	1900										<1							
Barium	µg/L	1	1	1	114	114	29000										114							
Beryllium	µg/L	1	1	1		<1	67										<0.5							
Boron	µg/L	1	0.5	0.5	101	101	45000										101							
Cadmium	µg/L	1	10	10		<10	2.7										<0.1							
Chromium (Total)	µg/L	1	0.1	0.1		<0.1	810										<1							
Chromium VI	µg/L	1	1	1		<1	140										<10							
Cobalt	µg/L	1	10	10		<10	66										<0.5							
Copper	µg/L	1	0.5	0.5		<0.5	87										<0.5							
Lead	µg/L	1	0.5	0.5		<0.5	25										<0.1							
Mercury	µg/L	1	0.1	0.1		<0.1	0.29										<0.1							
Molybdenum	µg/L	1	0.5	0.5	1.5	1.5	9200										1.5							
Nickel	µg/L	1	1	1		<1	490										<1							
Selenium	µg/L	1	1	1		<1	63										<1							
Silver	µg/L	1	0.1	0.1		<0.1	1.5										<0.1							
Sodium	µg/L	1	200	200	94500	94500	2300000										94500							
Thallium	µg/L	1	0.1	0.1		<0.1	510										<0.1							
Uranium	µg/L	1	0.1	0.1	3.4	3.4	420										3.4							
Vanadium	µg/L	1	0.5	0.5		<0.5	250										<0.5							
Zinc	µg/L	1	5	5	6	6	1100										6							
Acetone	µg/L	17	5	5		<5	130000			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0
Bromodichloromethane	µg/L	17	0.3	0.5	3	3	85000			3	<0.5	<0.5	<0.5	<0.5	<0.3	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Bromoform	µg/L	17	0.4	0.5		<0.5	380			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Bromomethane	µg/L	17	0.5	0.5		<0.5	5.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	µg/L	17	0.2	0.2		<0.2	0.79			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2
Chlorobenzene	µg/L	17	0.5	0.5		<0.5	630			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Chloroethane	µg/L	2	0.2	1		<1									<0.2			<1.0						
Chloroform	µg/L	17	0.5	0.5	**28.1**	**28.1**	2.4	3		**28.1**	**17.5**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	**5.4**	<0.5	<0.5	<0.5
Chloromethane	µg/L	1	3	3		<3												<3.0						
Dibromochloromethane	µg/L	17	0.3	0.5		<0.5	82000			<0.5	<0.5	<0.5	<0.5	<0.5	<0.3	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Dichlorodifluoromethane	µg/L	17	0.5	1		<1	4400			<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
1,2-Dichlorobenzene	µg/L	17	0.4	0.5		<0.5	4600			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,3-Dichlorobenzene	µg/L	17	0.4	0.5		<0.5	9600			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,4-Dichlorobenzene	µg/L	17	0.4	0.5		<0.5	8			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,1-Dichloroethane	µg/L	17	0.4	0.5		<0.5	320			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,2-Dichloroethane	µg/L	17	0.2	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.2	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,1-Dichloroethylene	µg/L	17	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,2-cis-Dichloroethylene	µg/L	17	0.4	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,2-trans-Dichloroethylene	µg/L	17	0.4	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,2-Dichloropropane	µg/L	17	0.5	0.5		<0.5	16			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,3-Dichloropropene	µg/L	16	0.5	0.5		<0.5	5.2			<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Ethylene dibromide	µg/L	17	0.2	0.2		<0.2	0.25			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2
(n)-Hexane	µg/L	17	1	5		<5	51			<1.0	<1.0	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
Methyl Ethyl Ketone	µg/L	17	5	10		<10	470000			<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0
Methyl Butyl Ketone	µg/L	1	10	10		<10												<10						
Methyl Isobutyl Ketone	µg/L	15	5	10		<10	140000			<5.0	<5.0	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0		<5.0	<5.0	<5.0	<5.0	
Methyl tert-Butyl Ether (MTBE)	µg/L	17	2	2		<2	190			<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0		<2.0	<2.0	<2.0	<2.0	<2.0
Methylene Chloride	µg/L	17	4	5		<5	610			<5.0	<5.0	<5.0	<5.0	<5.0	<4.0	<5.0	<5.0	<5.0		<5.0	<5.0	<5.0	<5.0	<5.0
Styrene	µg/L	17	0.5	0.5		<0.5	1300			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,1,1,2-Tetrachloroethane	µg/L	17	0.5	0.5		<0.5	3.3			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2,2-Tetrachloroethane	µg/L	17	0.5	0.5		<0.5	3.2			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5

Table B2: Groundwater Analytical Data

Parameter	Units	Number samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 Coarse	Number samples exceed Table 3	*Location:*	BH2-11			BH1-19			BH2-19				BH1-20		BH3-20	BH1-22	
									Sample ID:	MW1-GW1	BH2-G1	BH2-102-GW	BH1-GW1	BH1-GW2	BH1-GW3	BH2-GW1	BH2-GW2	BH2-GW1	BH2-19-GW2	BH1-20-GW1	BH1-20-GW	BH3-20-GW1	BH1-22-GW	BH1-22-GW
									Date:	10/25/2019	7/22/2020	06/20/2022	06/11/2019	06/20/2019	06/20/2019	06/11/2019	06/20/2019	10/11/2019	8/06/2020	08/06/2020	11/04/2022	08/06/2020	06/20/2022	06/05/2023
Tetrachloroethylene	µg/L	17	0.3	0.5	**57.1**	**57.1**	1.6	10		**9.6**	**3.7**	**11**	<0.5	<0.5	<0.3	<0.5	<0.5	<0.5		**40.3**	**57.1**	**3.5**	**1.4**	**4.2**
1,1,1-Trichloroethane	µg/L	17	0.4	0.5		<0.5	640			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2-Trichloroethane	µg/L	17	0.4	0.5		<0.5	4.7			<0.5	<0.5	<0.5	<0.5	<0.5	<0.4	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethylene	µg/L	17	0.3	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.3	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Trichlorofluoromethane	µg/L	17	0.5	1		<1	2500			<1.0	<1.0	<1.0	<1.0	<1.0	<0.5	<1.0	<1.0	<1.0		<1.0	<1.0	<1.0	<1.0	<1.0
1,3,5-Trimethylbenzene	µg/L	2	0.3	0.5		<0.5									<0.3			<0.5						
Vinyl Chloride	µg/L	17	0.2	0.5		<0.5	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.2	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Benzene	µg/L	17	0.5	0.5		<0.5	44			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	µg/L	17	0.5	0.5		<0.5	2300			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	µg/L	17	0.5	0.5		<0.5	18000			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5
Xylene Mixture	µg/L	17	0.5	0.5		<0.5	4200			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5

PATERSON GROUP

Table B2: Groundwater Analytical Data

Parameter	Units		BH2-22	
		DUP 06/05/2023	BH2-22-GW 06/20/2022	BH2-22-GW 11/04/2022
Antimony	µg/L			
Arsenic	µg/L			
Barium	µg/L			
Beryllium	µg/L			
Boron	µg/L			
Cadmium	µg/L			
Chromium (Total)	µg/L			
Chromium VI	µg/L			
Cobalt	µg/L			
Copper	µg/L			
Lead	µg/L			
Mercury	µg/L			
Molybdenum	µg/L			
Nickel	µg/L			
Selenium	µg/L			
Silver	µg/L			
Sodium	µg/L			
Thallium	µg/L			
Uranium	µg/L			
Vanadium	µg/L			
Zinc	µg/L			
Acetone	µg/L	<5.0	<5.0	<5.0
Bromodichloromethane	µg/L	<0.5	<0.5	<0.5
Bromoform	µg/L	<0.5	<0.5	<0.5
Bromomethane	µg/L	<0.5	<0.5	<0.5
Carbon Tetrachloride	µg/L	<0.2	<0.2	<0.2
Chlorobenzene	µg/L	<0.5	<0.5	<0.5
Chloroethane	µg/L			
Chloroform	µg/L	<0.5	<0.5	<0.5
Chloromethane	µg/L			
Dibromochloromethane	µg/L	<0.5	<0.5	<0.5
Dichlorodifluoromethane	µg/L	<1.0	<1.0	<1.0
1,2-Dichlorobenzene	µg/L	<0.5	<0.5	<0.5
1,3-Dichlorobenzene	µg/L	<0.5	<0.5	<0.5
1,4-Dichlorobenzene	µg/L	<0.5	<0.5	<0.5
1,1-Dichloroethane	µg/L	<0.5	<0.5	<0.5
1,2-Dichloroethane	µg/L	<0.5	<0.5	<0.5
1,1-Dichloroethylene	µg/L	<0.5	<0.5	<0.5
1,2-cis-Dichloroethylene	µg/L	<0.5	<0.5	<0.5
1,2-trans-Dichloroethylene	µg/L	<0.5	<0.5	<0.5
1,2-Dichloropropane	µg/L	<0.5	<0.5	<0.5
1,3-Dichloropropene	µg/L	<0.5	<0.5	<0.5
Ethylene dibromide	µg/L	<0.2	<0.2	<0.2
(n)-Hexane	µg/L	<1.0	<1.0	<1.0
Methyl Ethyl Ketone	µg/L	<5.0	<5.0	<5.0
Methyl Butyl Ketone	µg/L			
Methyl Isobutyl Ketone	µg/L		<5.0	<5.0
Methyl tert-Butyl Ether (MTBE)	µg/L	<2.0	<2.0	<2.0
Methylene Chloride	µg/L	<5.0	<5.0	<5.0
Styrene	µg/L	<0.5	<0.5	<0.5
1,1,1,2-Tetrachloroethane	µg/L	<0.5	<0.5	<0.5
1,1,2,2-Tetrachloroethane	µg/L	<0.5	<0.5	<0.5

Table B2: Groundwater Analytical Data

Parameter	Units		BH2-22	
		DUP	BH2-22-GW	BH2-22-GW
		06/05/2023	06/20/2022	11/04/2022
Tetrachloroethylene	µg/L	**4.1**	**10.8**	**19.7**
1,1,1-Trichloroethane	µg/L	<0.5	<0.5	<0.5
1,1,2-Trichloroethane	µg/L	<0.5	<0.5	<0.5
Trichloroethylene	µg/L	<0.5	<0.5	<0.5
Trichlorofluoromethane	µg/L	<1.0	<1.0	<1.0
1,3,5-Trimethylbenzene	µg/L			
Vinyl Chloride	µg/L	<0.5	<0.5	<0.5
Benzene	µg/L	<0.5	<0.5	<0.5
Ethylbenzene	µg/L	<0.5	<0.5	<0.5
Toluene	µg/L	<0.5	<0.5	<0.5
Xylene Mixture	µg/L	<0.5	<0.5	<0.5

APPENDIX C

HHRA Supporting Information

Groundwater Direct Contact & Ingestion Pathways:

Groundwater Ingestion

Groundwater ingestion is a relevant exposure pathway for residents and indoor workers at properties where drinking water is sourced from groundwater. Incidental groundwater ingestion is an exposure pathway that is relevant for construction workers that may be exposed to groundwater that accumulates in an open trench. The average daily dose (ADD) from groundwater ingestion (non-carcinogenic dose) was calculated using the following formula:

$$ADD_{GW-Ing} = \frac{C_{gw} \cdot IR_{gw} \cdot RAF_{GW-oral}}{BW} \times \frac{Days}{365}$$

where: $ADD_{GW\text{-}Ing}$ = Average daily dose due to groundwater ingestion (mg/kg/day);
C_{gw} = Concentration of COC in groundwater (mg/L);
IR_{gw} = Groundwater ingestion rate (kg/day);
$RAF_{GW\text{-}oral}$ = Relative absorption factor (groundwater, oral exposure);
BW = Body weight (kg);
Days = Days per year exposed.

Groundwater Direct Contact & Ingestion Pathways:

Groundwater Dermal Contact

Groundwater contact is a relevant exposure pathway for residents and indoor workers that use that water is sourced from groundwater for bathing, washing hands, etc. Groundwater dermal contact is also an important exposure pathway for construction workers that may be exposed to groundwater that accumulates in an open trench. The average daily dose (ADD) from groundwater dermal contact was calculated using the following formula from US EPA's *Risk Assessment Guidance for Superfund* (RAGS) Part E (US EPA 2004):

$$ADD_{GW-Der} = \frac{DA_{event} \cdot EV \cdot SA}{BW} \times \frac{Days}{365}$$

where: $ADD_{GW\text{-}Der}$ = Average daily dose due to groundwater dermal contact (mg/kg/day);
DA_{event} = Dose absorbed per event (mg/cm^2-event);
EV = Event frequency (events/day);
SA = Skin surface area (cm^2);
BW = Body weight (kg);
Days = Days per year exposed.

The amount of contaminant absorbed per square cm of skin during a single exposure event ($DA_{event)}$ is a function of (i) skin characteristics, (ii) chemical properties, and (iii) the length of time skin is in contact with groundwater (e.g., whether or not the contact time is greater than the time required for the chemical to reach steady state in the skin of the receptor). In short-term exposure events in trenches, the duration of an exposure event for a construction worker will be less than the time required for the chemical to reach steady state in the skin. This means that concentrations of chemicals in skin do not reach steady state, and uptake is governed only by the rate of diffusion through the stratum corneum.

DA_{event} for inorganic COCs was calculated using the following equation (US EPA 2004):

$$\mathrm{DA_{event}} = \mathrm{C_{gw}} \cdot \mathrm{K_p} \cdot \mathrm{t_{event}} \cdot \mathrm{CF}$$

where: DA_{event} = Dose absorbed per event (mg/cm^2-event);
C_{gw} = COC concentration in groundwater (µg/L);
K_P = Dermal permeability coefficient of COC in water (cm/h);
t_{event} = Time in contact with groundwater (h/event);
CF = Conversion factor (0.001 mg/µg).

DA_{event} for organic COCs was calculated using the following equation (US EPA 2004):

$$\mathrm{DA_{event}} = \mathrm{C_{gw}} \cdot \mathrm{K_p} \cdot \mathrm{CF1} \cdot \mathrm{CF2} \cdot 2\mathrm{FA}\sqrt{\frac{6\,\tau_{\mathrm{event}} \cdot \mathrm{t_{event}}}{\pi}}$$

where: FA = Fraction absorbed;
τ_{event} = Lag time for chemical to diffuse through stratum corneum (h/event).

The dermal permeability coefficient representing the extent to which a chemical can diffuse across the stratum corneum was calculated as:

$$K_p = 10^{(-2.80 + 0.66\ \log K_{OW} - 0.0056\ mw)}$$

where: K_{OW} = Octanol-water partition coefficient (unitless);
mw = Molecular weight of chemical (g/mol).

The time required for the diffusion rate across a membrane to reach 95% of the steady-state value is approximately 2.4 times the lag time. The lag time (τ) of each chemical was calculated using the following equation:

$$\tau_{event} = 0.105 \times 10^{(0.0056\ mw)}$$

Outdoor Air and Trench Vapour Exposure Pathways

Inhalation of vapours sourced from soil or groundwater in outdoor air or in a trench is a relevant exposure pathway for outdoor workers (outdoor air) and construction workers (trench air). Air concentrations were estimated using volatilization factors (VF) for various scenarios. All equations were obtained from the *Atlantic Canada Partners in Risk-Based Corrective Action Implementation Group* (Atlantic PIRI 2003).

Air concentrations of COCs from a soil source were calculated using the following equation:

$$C_{air} = C_{soil} \cdot VF \times \frac{Hours}{24} \times \frac{Days}{365}$$

where: C_{air} = Concentration in air (µg/m^3);
C_{soil} = Concentration in soil (µg/g);
VF = Volatilization factor (g/m^3);
Hours = Hours per day exposed to vapours (h);
Days = Days per year exposed to vapours (d).

Air concentrations of COCs from a groundwater source were calculated using the following equation:

$$C_{air} = C_{gw} \cdot VF \times \frac{Hours}{24} \times \frac{Days}{365}$$

where: C_{air} = Concentration in air (µg/m^3);
C_{gw} = Concentration in groundwater (µg/L);
VF = Volatilization factor (L/m^3);
Hours = Hours per day exposed to vapours (h);
Days = Days per year exposed to vapours (d).

The VF for soil to outdoor air was calculated assuming a surface contamination source using equations from Atlantic PIRI (2003). Atlantic PIRI provides two equations for calculating the volatilization factor that provide different results depending on the molecular diffusivity of the contaminant:

$$VF_{S-OA} = \left[\frac{2 \cdot W \cdot B}{U_{air} \cdot \delta_{air}}\right] \sqrt{\frac{D_{soil}^{eff} \cdot H}{\pi \cdot t(\theta_{water} + k_{OC} \cdot f_{OC} \cdot B + \theta_{air} \cdot H)}} \times (10^3)$$

and

$$VF_{S-OA} = \left[\frac{W \cdot B \cdot d}{U_{air} \cdot \delta_{air} \cdot t}\right] \times (10^3)$$

where: VF_{S-OA} = Volatilization factor for soil-to-outdoor air (kg/m^3);
W = Width of contamination source (m);
B = Soil bulk density (g/cm^3);
U_{air} = Mean annual wind speed (cm/sec);
∂_{air} = Mixing zone height of breathing zone for outdoor model (cm);
$D_{eff-soil}$ = Effective molecular diffusion coefficient for vadose zone soil (cm^2/sec);
H = Henry's Law coefficient (unitless);
t = Averaging time for flux (s);

θ_{water} = Water-filled soil porosity, vadose zone (unitless);
K_{oc} = Organic carbon-water sorption coefficient (cm^3-water/g-carbon);
f_{oc} = Fraction organic carbon;
θ_{air} = Air-filled soil porosity, vadose zone (unitless).

The result producing the smallest $VF_{S\text{-}OA}$ value from the above equations was used to calculate the outdoor air concentration, per guidance from Atlantic PIRI (2003).

The effective molecular diffusion coefficient for vadose zone soil was calculated as:

$$D_{soil}^{eff} = \frac{D_{air} \cdot \theta_{air}^{3.33}}{\theta_{total}^{2}} + \frac{D_{water} \cdot \theta_{air}^{3.33}}{H \cdot \theta_{total}^{2}}$$

where: D_{air} = Molecular diffusion constant in air (cm^2/sec);
θ_{total} = Total soil porosity (unitless);
D_{water} = Molecular diffusion constant in water (cm^2/sec).

The VF for soil to trench air was calculated using the following equation:

$$VF_{S-TA} = \left[\frac{2(W_{tr} \cdot L_{tr} \cdot 2L_{tr} \cdot D_{tr} + 2W_{tr} \cdot D_{tr})\ B}{V_{tr} \cdot AXR}\right] \sqrt{\frac{D_{soil}^{eff} \cdot H}{\pi \cdot t(\theta_{water} + k_{OC} \cdot f_{OC} \cdot B + \theta_{air} \cdot H)}} \times (10^3)$$

where: W_{tr} = Width of trench (cm);
L_{tr} = Length of trench (cm) (breathing zone for trench model);
D_{tr} = Depth of trench (cm) (mixing zone height for trench model);
V_{tr} = Volume of trench (cm^3);
AXR = Air exchange rate (1/sec).

The air exchange rate was calculated as:

$$AXR = \frac{(U \cdot F \cdot L \cdot D)}{V_{tr}}$$

The VF for groundwater to outdoor air was calculated using the following equation:

$$VF_{GW-OA} = \frac{H}{1 + \left[\frac{U_{air} \cdot \delta_{air} \cdot L_{gw}}{D_{gw}^{eff} \cdot W}\right]} \times (10^3)$$

where: L_{gw} = Depth below grade to groundwater contamination (cm);
$D_{eff\text{-}gw}$ = Effective molecular diffusion coefficient above groundwater table (cm^2/sec).

The effective molecular diffusion coefficient above the groundwater table was calculated as:

$$D_{gw}^{eff} = \left(h_{cap} + h_{vad}\right)\left[\frac{h_{cap}}{D_{cap}^{eff}} + \frac{h_{vad}}{D_{vad}^{eff}}\right]^{-1}$$

where: h_{cap} = Thickness of capillary zone (cm);
h_{vad} = Thickness of vadose zone (cm);
$D_{eff\text{-}cap}$ = Effective molecular diffusion coefficient for capillary zone soil (cm^2/sec);
$D_{eff\text{-}vad}$ = Effective molecular diffusion coefficient for vadose zone soil (cm^2/sec).

The VF for groundwater to trench air was calculated using the following equation:

$$VF_{GW-T} = \frac{H}{1 + \left[\frac{U_{air} \cdot F_{tr} \cdot \delta_{air} \cdot L_{tr-g}}{D_{gw}^{eff} \cdot W}\right]} \times (10^3)$$

where: F_{tr} = Fraction of mean annual wind speed that occurs in trench (unitless).

Indoor Air Vapour Exposure Pathways

Inhalation of vapours sourced from soil or groundwater in indoor air is a relevant exposure pathway for indoor workers and residents. Indoor air concentrations were estimated using the Johnson & Ettinger subsurface vapour intrusion model (Johnson and Ettinger 1991). The model calculates the concentration of vapours at the contaminant source (soil or groundwater), then converts this maximum source vapour concentration to a reduced indoor vapour concentration by accounting for the attenuation that occurs as the vapour diffuses through soil, undergoes advective transport through cracks or other permeable areas of the building foundation, and is ultimately diluted by indoor air and normal building ventilation processes.

Indoor vapour concentrations predicted by the J&E model are pro-rated for a receptor's exposure frequency and duration. The effective concentration is calculated using the following equation:

$$C_{effective} = C_{indoor} \times \frac{Hours}{24} \times \frac{Days}{365}$$

where: C_{indoor} = COC concentration in indoor air (µg/m3);
Hours = Hours per day exposed to vapours (h);
Days = Days per year exposed (d).

Indoor air concentrations from a soil source are calculated using the following equation:

$$C_{indoor} = C_{soil} \times \frac{H \cdot B \cdot CF1}{\theta_{water} + (K_{OC} \cdot f_{OC})\,B + H \cdot \theta_{air}} \times \alpha \times BAF \times \frac{1}{SDM}$$

where: CF1 = Conversion factor (10^6 cm^3/m^3);
α = Attenuation factor (unitless);
BAF = Bio-attenuation factor (unitless);
SDM = Source depletion multiplier (unitless).

Indoor air concentrations from a groundwater source are calculated using the following equation:

$$C_{indoor} = C_{gw} \times H \times CF2 \times \alpha \times BAF$$

where: CF2 = Conversion factor (1,000 L/m^3).

The attenuation factor, alpha, is calculated using the following equation:

$$\alpha = \frac{\left(\frac{D_T A_B}{Q_{building} L_T}\right) \times \exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)}{\exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right) + \frac{D_T A_B}{Q_{building} L_T} + \frac{D_T A_B}{Q_{soil} L_T} \times \left[\exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right) - 1\right]}$$

where: L_T = Distance from building to source of contamination (cm);
L_{crack} = Thickness of floor/building foundation/concrete slab (cm);
A_B = Area of the building below grade (cm^2);
A_{crack} = Area of total cracks in building below grade (cm^2);
D_T = Diffusion coefficient for soil (cm^2/sec);
D_{crack} = Diffusion coefficient for floor/cracks (cm^2/sec);

Q_{soil} = Flow rate of soil vapour into the building (cm^3/s);
$Q_{building}$ = Flow rate of outdoor air into the building (cm^3/sec).

Ontario MECP allows for the application of a bio-attenuation factor (BAF) to account for biodegradation of certain contaminants (naphthalene, BTEX, PHC F1/F2, hexane) as they migrate through aerobic soil. For soil vapour modelling, if there is at least 1 m of clean fill between the soil contamination and the underside of the crushed gravel layer under the building, then a BAF of 0.1 can be applied. If there is at least 3 m of clean fill, then the BAF can be 0.01. For groundwater vapour modelling, if there is at least 0.74 m of unsaturated clean fill (vadose zone soil) between the top of the saturated capillary zone and the underside of the crushed gravel layer under the building, then a BAF of 0.1 can be applied. If there is at least 3 m of unsaturated clean fill, then the BAF can be 0.01.

Ontario MECP allows for the application of a source depletion multiplier (SDM) to adjust indoor air concentrations based on the depletion of a finite contaminant source in soil due to volatilization. SDMs used in the model were calculated in a manner consistent with those used by MECP in the generic model:

- ❑ Maximum SDM of 100 for contaminants with a half-life ≤0.4515 years;
- ❑ Exponential decay equation for contaminants with half-lives between >0.4515 years and <0.905 years;
- ❑ SDM of 10 for contaminants with half-lives between 0.905 years and <1.505 years; and
- ❑ Exponential decay equation for contaminants with half-lives ≥1.505 years.

The mass of contaminant remaining takes into account the initial mass in a volume of soil in 13 m by 13 m by 2 m, minus the volume of soil excavated to allow placement of a building, and the mass of contaminant that remains after one week of depletion/volatilization. The one-week half-life is subsequently extrapolated to an annual half-life.

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Table C1: Soil COC Screening

Soil COC	Maximum soil conc. (ug/g)	REM conc. (ug/g) (µg/g)	S-GW1 Leaching Potable Coarse (µg/g)	S2 Contact (commercial) (µg/g)	S3 Contact (subsurface) (µg/g)	S-IA Indoor air I/C/C Coarse (µg/g)	S-OA Outdoor air Coarse (µg/g)	S-Odour IA Odour I/C/C Coarse (µg/g)	Nose Direct odour Coarse (µg/g)	S-GW3 Leaching Coarse (µg/g)	Free phase threshold Coarse (µg/g)
Lead	268	321.6	NA	4.2E+02	4.2E+02	–	–	–	–	–	2.4E+04
Mercury	0.5	0.6	NA	6.7E+01	6.7E+02	3.9E+00	3.6E+01	–	–	1.2E+14	3.4E+04
Tetrachloroethylene	1.01	1.212	NA	5.2E+02	2.0E+04	4.5E+00	1.9E+02	1.5E+03	6.1E+01	1.8E+01	3.7E+03

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Table C2: Groundwater COC Screening

Groundwater COC	Maximum groundwater conc. (µg/L)	REM conc. (µg/L)	GW1 Potable (µg/L)	GW1-Odour Direct odour (µg/L)	GW2 I/C/C Coarse (µg/L)	GW2-Odour I/C/C Coarse (µg/L)	1/2-Solubility Limit (µg/L)
Tetrachloroethylene	57.1	68.52	NA	NA	**3.0E+01**	6.6E+06	1.0E+05
VC (future)	6.41	6.41	NA	NA	**3.0E+00**	4.4E+07	4.4E+06

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Table C3: Receptor Exposure Parameters

Receptor Characteristic	Units	Workers					
		Indoor worker	Pregnant indoor worker	Outdoor worker	Pregnant outdoor worker	Construction worker	Pregnant construction worker
Body weight	kg	70.7	63.1	70.7	63.1	70.7	63.1
Skin surface area	cm^2	4,343	3988	3,400	3090	3,400	3090
Soil adherence rate	$mg/cm^2/d$	0.07	0.07	0.2	0.2	0.2	0.2
Soil ingestion rate	mg/d	50	50	100	100	100	100
	kg/d	5.0E-05	5.0E-05	1.0E-04	1.0E-04	1.0E-04	1.0E-04
Garden produce ingestion rate (no garden)	g/kg/d	–	–	–	–	–	–
	kg/d	–	–	–	–	–	–
Drinking water intake rate	L/d	0	0	–	–	–	–
Incidental groundwater ingestion rate	L/d	–	–	–	–	0.23	0.23
Inhalation rate	m^3/h	0.692	0.692	1.5	1.5	1.5	1.5
PM_{10} concentration	$\mu g/m^3$	–	–	100	100	100	100
Time Indoors	h/d	9.8	24	–	–	–	–
	d/wk	5	7	–	–	–	–
	wks/y	50	52	–	–	–	–
	d/y	250	365	–	–	–	–
Time Outdoors	h/d	–	–	9.8	24	9.8	24
	d/wk	–	–	5	7	5	7
	wks/y	–	–	39	52	39	52
	d/y	–	–	195	365	195	365
Time in Trench	hr/event	–	–	–	–	0.006	0.006
	events/day	–	–	–	–	10	10
	d/y	–	–	–	–	50	365
Exposure Duration	y	56	56	56	56	1.5	1.5
Averaging period (non-canc)	y	56	56	56	56	1.5	1.5
Averaging period (canc)	y	56	56	56	56	56	56

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Table C4: Outdoor/Trench Vapour Model Input

Category	Parameter	Symbol	Unit	Value
Outdoor Vapour Modelling Inputs	Depth below grade to contaminated soil	L_S	cm	0.1
	Depth below grade to contaminated GW	L_{gw}	cm	5
	Soil type for the outdoor model			Sand
	Outdoor Model: Capillary zone thickness	h_c	cm	1.125
	Outdoor Model: Capillary zone total porosity	n_{CZ}	cm^3/cm^3	0.375
	Outdoor Model: Capillary zone water-filled porosity	$\theta_{w,cz}$	cm^3/cm^3	0.253
	Outdoor Model: Capillary zone air-filled porosity	$\theta_{a,cz}$	cm^3/cm^3	0.122
	Outdoor Model: Vadose zone thickness	h_v	cm	3.375
	Outdoor Model: Vadose zone total porosity	E_t	cm^3/cm^3	0.375
	Outdoor Model: Vadose zone water-filled porosity	Θ_{ws}	cm^3/cm^3	0.054
	Outdoor Model: Vadose zone air-filled porosity	Θ_{as}	cm^3/cm^3	0.321
	Soil fraction organic carbon	ƒoc	–	0.005
	Soil bulk density	B	g/cm^3	1.66
	Mean annual wind speed	U	cm/s	410
	Width of contaminant source (max = "breathing zone")	W_c	cm	1,000
	Mixing zone height = Height of "breathing zone"	δ_{AIR}	cm	200
	Depth (thickness) of contaminated soil (default value)	D_c	cm	200
	Averaging time for flux	t	s	31,536,000
Trench Vapour Modelling Inputs	Depth below trench to contaminated soil		cm	0
	Depth below trench to contaminated GW	$L_{tr\text{-}gw}$	cm	1
	Soil type for the trench model			Sand
	Trench Model: Capillary zone thickness	h_c	cm	0.250
	Trench Model: Capillary zone total porosity	n_{CZ}	cm^3/cm^3	0.375
	Trench Model: Capillary zone water-filled porosity	$\theta_{w,cz}$	cm^3/cm^3	0.253
	Trench Model: Capillary zone air-filled porosity	$\theta_{a,cz}$	cm^3/cm^3	0.122
	Trench Model: Vadose zone thickness	h_v	cm	0.750
	Trench Model: Vadose zone total porosity	E_t	cm^3/cm^3	0.375
	Trench Model: Vadose zone water-filled porosity	Θ_{ws}	cm^3/cm^3	0.054
	Trench Model: Vadose zone air-filled porosity	Θ_{as}	cm^3/cm^3	0.321
	Soil fraction organic carbon	ƒoc	–	0.005
	Soil bulk density	B	g/cm^3	1.66
	Mean annual wind speed	U	cm/s	410
	Fraction of total wind speed that occurs in trench	F_t	–	0.25
	Air exchange rate in trench = (UxFxLxD)/V_{trench}	AXR	s^{-1}	0.51250
	Width of contaminant source (max = "breathing zone")	W_c	cm	1,000
	Trench length	L_{tr}	cm	1,000
	Trench width	W_{tr}	cm	200
	Trench depth (mixing zone height, "breathing zone")	$D_{tr} = \delta_{AIR}$	cm	200
	Trench volume	V_{tr}	cm^3	40,000,000
	Averaging time for flux	t	s	31,536,000

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Table C5: Outdoor/Trench Vapour Model Output

	Soil properties							Trench - GW		Outdoor air - GW	
COC	Enthalpy of vaporization at ave. GW temperature (cal/mol)	Henry's law constant at ave. GW temp. (atm-m3/mol)	Henry's law constant at ave. GW temp. (unitless)	Effective diffusivity in vadose zone soil D_s^{eff} (cm^2/s)	Effective diffusivity in capillary zone soil D_{cap}^{eff} (cm^2/s)	Effective diffusivity above water table (for trench air modelling) D_{ws}^{eff} (cm^2/s)	Effective diffusivity above water table (for outdoor air modelling) D_{ws}^{eff} (cm^2/s)	VF_{GW-TA} ($[mg/m^3]/[mg/L]$)	Trench Vapour Conc (GW source) (ug/m3)	VF_{GW-OA} ($[mg/m^3]/[mg/L]$)	Outdoor Vapour Conc (GW source) (ug/m3)
Tetrachloroethylene	9.50E+03	1.01E-02	4.29E-01	1.16E-02	4.62E-04	1.65E-03	1.65E-03	5.84E-02	4.00E+00	3.24E-03	2.22E-01
VC (future)	4.94E+03	2.09E-02	8.83E-01	1.71E-02	6.79E-04	2.43E-03	2.43E-03	1.35E-01	8.65E-01	7.50E-03	4.81E-02

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Table C6: Soil Parameters

Category	Parameter	Symbol	Unit	Value
J&E Soil Stratum A Parameters	Stratum A SCS soil type			Sand
	Stratum A soil total porosity	n^A	–	0.375
	Stratum A water filled porosity	θ_W^A	cm^3/cm^3	0.054
	Stratum A soil air-filled porosity	θ_a^A	cm^3/cm^3	0.321
	Stratum A soil dry bulk density	ρ_b^A	g/cm^3	1.66
	Stratum A soil organic carbon fraction	f_{OC}^A	–	0.005
	User defined stratum A soil vapour permeability	k_V	cm^2	
	Stratum A effective total fluid saturation	S_{te}	cm^3/cm^3	0.003
	Stratum A soil intrinsic permeability	k_i	cm^2	1.00E-07
	Stratum A soil relative air permeability	k_{rg}	cm^2	0.998
	Stratum A soil effective vapour permeability	k_v	cm^2	9.99E-08
J&E Soil Stratum B Parameters	Stratum B SCS soil type			Gravel Crush
	Stratum B soil total porosity	n^B	–	0.400
	Stratum B water filled porosity	θ_W^B	cm^3/cm^3	0.010
	Stratum B soil air-filled porosity	θ_a^B	cm^3/cm^3	0.390
	Stratum B soil dry bulk density	ρ_b^B	g/cm^3	1.60
	Stratum B soil organic carbon fraction	f_{OC}^B	–	0.000
J&E Soil Stratum C Parameters	Stratum C SCS soil type			Sand
	Stratum C soil total porosity	n^C	–	0.375
	Stratum C water filled porosity	θ_W^C	cm^3/cm^3	0.054
	Stratum C soil air-filled porosity	θ_a^C	cm^3/cm^3	0.321
	Stratum C soil dry bulk density	ρ_b^C	g/cm^3	1.66
	Stratum C soil organic carbon fraction	f_{OC}^C		0.005
J&E Miscellaneous Parameters	Soil/Groundwater temperature		^oC	15
	Exposure duration		y	56
	Exposure duration	τ	s	1.77E+09
	Conversion factor	C	cm^3-kg/m^3-g	1,000

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Table C7: Vapour Intrusion Model Input Parameters

Category	Site Characteristic	Symbol	Units	Value	Value	Value
Water Potability	Potability of groundwater		–	Non-Potable		
Land Use	Land use		–	Commercial	Commercial	Commercial
	Produce garden		–	No		
Building	Type of Building		–	Commercial Slab-on-Grade	Site Slab-on-Grade	Site Slab-on-Grade
	Length		cm	2,000	2,176	1,147
	Width		cm	1,500	1,738	603
	Height (of mixing zone)		cm	300	366	366
	Slab Thickness	Lcrack	cm	11.25	11.25	11.25
	Depth below grade to bottom of floor	L_F	cm	11.25	11.25	11.25
	Crack depth below grade	$X_{crack\ or\ Zcrack}$	cm	11.25	11.25	11.25
	Crack Width	w	cm	0.1	0.1	0.1
	Pressure Differential, Building - Soil	Δp	g/cm-sec2	20	20	20
	Air Exchange Rate	ER	1/hour	1	1	1
	Flow rate of soil vapour into building (or leave blank)	Q_{SOIL}	L/min	9.80	9.80	9.80
	Floor-wall seam perimeter	X_{crack}	cm	7,000	7,828	3,500
	Building ventilation rate	$Q_{building}$	cm^3/s	2.50E+05	3.84E+05	7.03E+04
	Area of enclosed space below grade	A_B	cm^2	3.00E+06	3.78E+06	6.92E+05
	Crack-to-total area ratio	η	–	2.33E-04	2.07E-04	5.06E-04
J&E soil inputs	Depth below grade to top of contaminated soil	zsoil or L_t	cm	0.1	0.1	0.1
	Depth to contaminated soil used in indoor model	zsoil or L_t	cm	41.25	41.25	41.25
	Soil Source-bldg. separation	L_T	cm	30	30	30
	Soil Stratum A - Thickness	h_A	cm	11.25	11.25	11.25
	Soil Stratum B - Thickness (Soil model)	h_B	cm	29.90	29.90	29.90
	Soil Stratum C - Thickness (Soil model)	h_C	cm	0.10	0.10	0.10
	MECP Source Depletion Multiplier (SDM) Applied	SDM	unitless	No	No	No
	Depth below grade to bottom of contaminated soil	L_b	cm	0	0	0
J&E groundwater inputs	Depth below grade to contaminated GW	zgw or L_{WT}	cm	450.00	450.00	450.00
	Depth to contaminated GW used in indoor model	zgw or L_{WT}	cm	450.00	450.00	450.00
	GW Source-bldg. separation	L_T	cm	438.75	438.75	438.75
	Soil Stratum A - Thickness	h_A	cm	11.25	11.25	11.25
	Soil Stratum B - Thickness (GW model)	h_B	cm	29.90	29.90	29.90
	Soil Stratum C - Thickness (GW model)	h_C	cm	408.85	408.85	408.85
	Soil stratum directly above water table	–	–	C	C	C
	SCS soil type directly above water table	–	–	Sand	Sand	Sand
	Capillary zone thickness	L_{CZ}	cm	17.045	17.045	17.045
	Capillary zone total porosity	n_{CZ}	cm^3/cm^3	0.375	0.375	0.375
	Capillary zone water-filled porosity	$\theta_{w,cz}$	cm^3/cm^3	0.253	0.253	0.253
	Capillary zone air-filled porosity	$\theta_{a,cz}$	cm^3/cm^3	0.122	0.122	0.122

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Table C8: Vapour Intrusion - Groundwater Source - Commercial Building Slab-on-Grade

COC	Max. ground-water conc. (µg/L)	REM (µg/L)	Enthalpy of vaporization at average groundwater temperature ΔHv,TS (cal/mol)	Henry's law constant at average groundwater temp. H_{TS} (atm-m^3/mol)	Henry's law constant at average groundwater temp. H'_{TS} (unitless)	Vapour viscosity at average soil temp. μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient D^{eff}_{A} (cm^2/s)	Stratum B effective diffusion coefficient D^{eff}_{B} (cm^2/s)	Stratum C effective diffusion coefficient D^{eff}_{C} (cm^2/s)	Capillary zone effective diffusion coefficient D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient D^{eff}_{T} (cm^2/s)	Diffusion path length L_d (cm)	Convection path length L_p (cm)	Crack radius r_{crack} (cm)	Average vapour flow rate into building Q_{soil} (cm^3/s)	Crack effective diffusion coefficient D^{crack} (cm^2/s)	Area of crack A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number exp(Pe^f) (unitless)	Groundwater source vapour conc. C_{source} (µg/m^3)	Infinite source indoor attenuation coefficient α (unitless)	Default attenuation factor α (unitless)	Bio-Attenuation Factor BAF (unitless)	Indoor building concentration REM $C_{building}$ (µg/m^3)
Tetrachloroethylene	57.1	68.52	9.50E+03	1.01E-02	4.29E-01	1.77E-04	1.16E-02	1.96E-02	1.16E-02	4.62E-04	6.09E-03	4.39E+02	1.13E+01	1.00E-01	1.63E+02	1.16E-02	7.00E+02	8.81E+97	2.94E+04	1.33E-04		1.00E+00	3.90E+00
VC (future)	6.41	6.41	4.94E+03	2.09E-02	8.83E-01	1.77E-04	1.71E-02	2.88E-02	1.71E-02	6.79E-04	8.95E-03	4.39E+02	1.13E+01	1.00E-01	1.63E+02	1.71E-02	7.00E+02	3.38E+66	5.66E+03	1.78E-04		1.00E+00	1.01E+00

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Table C9: Vapour Intrusion - Groundwater Source - Site Building - Restaurant

COC	Max. ground-water conc. (µg/L)	REM (µg/L)	Enthalpy of vaporization at average groundwater temperature ΔHv,TS (cal/mol)	Henry's law constant at average groundwater temp. H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at average groundwater temp. H'_{TS} (unitless)	Vapour viscosity at average soil temp. μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient D^{eff}_{A} (cm^2/s)	Stratum B effective diffusion coefficient D^{eff}_{B} (cm^2/s)	Stratum C effective diffusion coefficient D^{eff}_{C} (cm^2/s)	Capillary zone effective diffusion coefficient D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient D^{eff}_{T} (cm^2/s)	Diffusion path length L_d (cm)	Convection path length L_p (cm)	Crack radius r_{crack} (cm)	Average vapour flow rate into building Q_{soil} (cm^3/s)	Crack effective diffusion coefficient D^{crack} (cm^2/s)	Area of crack A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number $exp(Pe^f)$ (unitless)	Groundwater source vapour conc. C_{source} ($\mu g/m^3$)	Infinite source indoor attenuation coefficient α (unitless)	Default attenuation factor α (unitless)	Bio-Attenuation Factor BAF (unitless)	Indoor building concentration REM $C_{building}$ ($\mu g/m^3$)
Tetrachloroethylene	57.1	68.52	9.50E+03	1.01E-02	4.29E-01	1.77E-04	1.16E-02	1.96E-02	1.16E-02	4.62E-04	6.09E-03	4.39E+02	1.13E+01	1.00E-01	1.63E+02	1.16E-02	7.83E+02	3.84E+87	2.94E+04	1.03E-04		1.00E+00	3.04E+00
VC (future)	6.41	6.41	4.94E+03	2.09E-02	8.83E-01	1.77E-04	1.71E-02	2.88E-02	1.71E-02	6.79E-04	8.95E-03	4.39E+02	1.13E+01	1.00E-01	1.63E+02	1.71E-02	7.83E+02	3.10E+59	5.66E+03	1.36E-04		1.00E+00	7.72E-01

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Table C10: Vapour Intrusion - Groundwater Source - Site Building - Retail/Office

COC	Max. ground-water conc. (µg/L)	REM (µg/L)	Enthalpy of vaporization at average groundwater temperature ΔHv,TS (cal/mol)	Henry's law constant at average groundwater temp. H_{TS} (atm-m^3/mol)	Henry's law constant at average groundwater temp. H'_{TS} (unitless)	Vapour viscosity at average soil temp. μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient D^{eff}_{A} (cm^2/s)	Stratum B effective diffusion coefficient D^{eff}_{B} (cm^2/s)	Stratum C effective diffusion coefficient D^{eff}_{C} (cm^2/s)	Capillary zone effective diffusion coefficient D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient D^{eff}_{T} (cm^2/s)	Diffusion path length L_d (cm)	Convection path length L_p (cm)	Crack radius r_{crack} (cm)	Average vapour flow rate into building Q_{soil} (cm^3/s)	Crack effective diffusion coefficient D^{crack} (cm^2/s)	Area of crack A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number exp(Pe^f) (unitless)	Groundwater source vapour conc. C_{source} (µg/m^3)	Infinite source indoor attenuation coefficient α (unitless)	Default attenuation factor α (unitless)	Bio-Attenuation Factor BAF (unitless)	Indoor building concentration REM $C_{building}$ (µg/m^3)
Tetrachloroethylene	57.1	68.52	9.50E+03	1.01E-02	4.29E-01	1.77E-04	1.16E-02	1.96E-02	1.16E-02	4.62E-04	6.09E-03	4.39E+02	1.13E+01	1.00E-01	1.63E+02	1.16E-02	3.50E+02	7.76E+195	2.94E+04	1.29E-04		1.00E+00	3.79E+00
VC (future)	6.41	6.41	4.94E+03	2.09E-02	8.83E-01	1.77E-04	1.71E-02	2.88E-02	1.71E-02	6.79E-04	8.95E-03	4.39E+02	1.13E+01	1.00E-01	1.63E+02	1.71E-02	3.50E+02	1.14E+133	5.66E+03	1.85E-04		1.00E+00	1.05E+00

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Table C11: Exposure and Risk Calculations - Groundwater Oral and Dermal Pathways

	Construction worker											
COC	Groundwater ingestion dose (mg/kg-day)	Groundwater dermal contact dose (mg/kg-day)	Total groundwater oral/dermal dose (mg/kg-day)	Threshold oral TRV (mg/kg-day)	Groundwater oral/dermal HQ	SAF	Risk reduction required	Total amortized groundwter oral/dermal dose (mg/kg-day)	Non-threshold oral TRV $(mg/kg/d)^{-1}$	Groundwater oral/dermal ILCR	Risk reduction required	Risk-based groundwater concentration (ug/L)
Tetrachloroethylene	3.05E-05	2.99E-05	6.04E-05	6.00E-03	1.01E-02	2.00E-01	5.03E-02	1.62E-06	2.10E-03	3.40E-09	3.40E-03	1.36E+03
VC (future)	2.86E-06	3.64E-07	3.22E-06	3.00E-03	1.07E-03	2.00E-01	5.37E-03	8.63E-08	1.40E+00	1.21E-07	1.21E-01	5.31E+01

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Table C12: Exposure and Risk Calculations - Groundwater Inhalation Pathways

COC	Indoor worker - Commercial Slab-on-Grade												
	Trench vapour concentration (groundwater source) (mg/m^3)	Outdoor air concentration (groundwater source) (mg/m^3)	Indoor air concentration (groundwater source) (mg/m^3)	Total vapour concentration (groundwater source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Groundwater inhalation HQ	SAF	Risk reduction required	Total amortized inhaled concentration (groundwater source) (mg/m^3)	Non-threshold inhalation TRV ($(mg/m^3)^{-1}$)	Groundwater inhalation ILCR	Risk reduction required	Risk-based groundwater concentration (ug/L)
Tetrachloroethylene	NA	NA	1.09E-03	1.09E-03	4.00E-02	2.73E-02	2.00E-01	1.36E-01	1.09E-03	2.60E-04	2.84E-07	2.84E-01	2.41E+02
VC (future)	NA	NA	2.82E-04	2.82E-04	1.00E-01	2.82E-03	2.00E-01	1.41E-02	2.82E-04	8.80E-03	**2.48E-06**	**2.48E+00**	2.58E+00

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Table C12: Exposure and Risk Calculations - Groundwater Inhalation Pathways

COC	Indoor worker - Site Building (Restaurant)												
	Trench vapour concentration (groundwater source) (mg/m^3)	Outdoor air concentration (groundwater source) (mg/m^3)	Indoor air concentration (groundwater source) (mg/m^3)	Total vapour concentration (groundwater source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Groundwater inhalation HQ	SAF	Risk reduction required	Total amortized inhaled concentration (groundwater source) (mg/m^3)	Non-threshold inhalation TRV (mg/m^3)$^{-1}$	Groundwater inhalation ILCR	Risk reduction required	Risk-based groundwater concentration (ug/L)
Tetrachloroethylene	NA	NA	8.50E-04	8.50E-04	4.00E-02	2.12E-02	2.00E-01	1.06E-01	8.50E-04	2.60E-04	2.21E-07	2.21E-01	3.10E+02
VC (future)	NA	NA	2.16E-04	2.16E-04	1.00E-01	2.16E-03	2.00E-01	1.08E-02	2.16E-04	8.80E-03	**1.90E-06**	**1.90E+00**	3.37E+00

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Table C12: Exposure and Risk Calculations - Groundwater Inhalation Pathways

	Indoor worker - Site Building (Retail/Office)												
COC	Trench vapour concentration (groundwater source) (mg/m^3)	Outdoor air concentration (groundwater source) (mg/m^3)	Indoor air concentration (groundwater source) (mg/m^3)	Total vapour concentration (groundwater source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Groundwater inhalation HQ	SAF	Risk reduction required	Total amortized inhaled concentration (groundwater source) (mg/m^3)	Non-threshold inhalation TRV (mg/m^3)$^{-1}$	Groundwater inhalation ILCR	Risk reduction required	Risk-based groundwater concentration (ug/L)
Tetrachloroethylene	NA	NA	1.06E-03	1.06E-03	4.00E-02	2.65E-02	2.00E-01	1.33E-01	1.06E-03	2.60E-04	2.76E-07	2.76E-01	2.49E+02
VC (future)	NA	NA	2.93E-04	2.93E-04	1.00E-01	2.93E-03	2.00E-01	1.46E-02	2.93E-04	8.80E-03	**2.57E-06**	**2.57E+00**	2.49E+00

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Table C12: Exposure and Risk Calculations - Groundwater Inhalation Pathways

	Outdoor worker													
COC	Trench vapour concentration (groundwater source) (mg/m^3)	Outdoor air concentration (groundwater source) (mg/m^3)	Indoor air concentration (groundwater source) (mg/m^3)	Total vapour concentration (groundwater source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Groundwater inhalation HQ	SAF	Risk reduction required	Total amortized inhaled concentration (groundwater source) (mg/m^3)	Non-threshold inhalation TRV (mg/m^3)$^{-1}$	Groundwater inhalation ILCR	Risk reduction required	Risk-based groundwater concentration (ug/L)
Tetrachloroethylene	NA	4.85E-05	NA	4.85E-05	4.00E-02	1.21E-03	2.00E-01	6.06E-03	4.85E-05	2.60E-04	1.26E-08	1.26E-02	5.44E+03
VC (future)	NA	1.05E-05	NA	1.05E-05	1.00E-01	1.05E-04	2.00E-01	5.24E-04	1.05E-05	8.80E-03	9.23E-08	9.23E-02	6.95E+01

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Table C12: Exposure and Risk Calculations - Groundwater Inhalation Pathways

	Construction worker												
COC	Trench vapour concentration (groundwater source) (mg/m^3)	Outdoor air concentration (groundwater source) (mg/m^3)	Indoor air concentration (groundwater source) (mg/m^3)	Total vapour concentration (groundwater source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Groundwater inhalation HQ	SAF	Risk reduction required	Total amortized inhaled concentration (groundwater source) (mg/m^3)	Non-threshold inhalation TRV $(mg/m^3)^{-1}$	Groundwater inhalation ILCR	Risk reduction required	Risk-based groundwater concentration (ug/L)
Tetrachloroethylene	2.24E-04	4.85E-05	NA	2.72E-04	4.00E-02	6.81E-03	2.00E-01	3.40E-02	7.29E-06	2.60E-04	1.90E-09	1.90E-03	2.01E+03
VC (future)	4.84E-05	1.05E-05	NA	5.89E-05	1.00E-01	5.89E-04	2.00E-01	2.94E-03	1.58E-06	8.80E-03	1.39E-08	1.39E-02	4.62E+02

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Table C13: Risk-based Groundwater Values and Property Specific Standards

Groundwater COC	Groundwater REM conc. (mg/kg)	Groundwater Risk-based Values – Oral/dermal – Toddler (µg/L)	Oral/dermal – Full-life composite (µg/L)	Oral/dermal – Indoor worker (µg/L)	Oral/dermal – Outdoor worker (µg/L)	Oral/dermal – Construction worker (µg/L)	Minimum oral/dermal risk-based value (µg/L)	Inhalation – Indoor worker On-Site Building Restaurant (µg/L)	Inhalation – Indoor worker On-Site Building Retail/Office (µg/L)	Inhalation – Outdoor worker (µg/L)	Inhalation – Construction worker (µg/L)	Minimum inhalation risk-based value (µg/L)	Minimum risk-based value (µg/g)	RM required	Risk reduction factors – Oral/dermal – Oral/dermal Trench Const. worker	Inhalation – Vapour inhalation On-Site Building Restaurant Indoor worker	Inhalation – Vapour inhalation On-Site Building Retail/Office Indoor worker	Inhalation – Vapour inhalation Oudoor air Outdoor worker	Inhalation – Vapour inhalation Trench Const. worker	Overall risk reduction factor	PSS (µg/L)	Basis
Tetrachloroethylene	68.52	-	-	-	-	1.36E+03	1.36E+03	3.10E+02	2.49E+02	5.44E+03	2.01E+03	**4.98E-01**	**4.98E-01**	**Yes**						1.38E+02	68.52	Max.+20%
VC (future)	6.41	-	-	-	-	5.31E+01	5.31E+01	**3.37E+00**	**2.49E+00**	6.95E+01	4.62E+02	**7.15E-03**	**7.15E-03**	**Yes**		1.90E+00	2.57E+00			8.96E+02	6.41	Max.+20%

APPENDIX D

ERA Supporting Information

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Table D1: Ecological Soil Screening

COC	Maximum soil conc. (µg/g)	REM conc. (µg/g)	Plants & soil org. component I/C/C Coarse (µg/g)	Mammals & birds component I/C/C (µg/g)	S-GW3 component Coarse (µg/g)	Ont Soil Background (µg/g)	Free phase threshold (coarse) (µg/g)	Free phase threshold (fine) (µg/g)
Lead	268	321.6	1.10E+03	**3.20E+01**	NV	1.20E+02	2.40E+04	3.80E+04

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Table D2: Ecological Groundwater Screening

COC	Maximum groundwater conc. (µg/l)	REM conc. (µg/L)	Table 2/3 GW3 (µg/L)	Aquatic Protection Value (µg/l)	Half-solubility limit (µg/l)
Tetrachloroethylene	57.1	68.52	1.10E+04	8.40E+02	1.00E+05
Vinyl chloride (future)	6.41	6.41	4.50E+05	3.56E+04	4.40E+06

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Table D3: Ecological Receptors Exposure Parameters

Food item:	Terrestrial plant foliage			Terrestrial plant seeds			Earthworms			Other soil invertebrates			Mammals/birds			Food ingestion rate (wet) (kg/d)	Food ingestion rate (dry) (kg/d)	Soil ingestion rate (kg/d)	Body weight (kg)
% Moisture:	85%			9.3%			84%			69%			68%						
Receptor	Diet fraction (wet)	IR-wet (kg/d)	IR-dry (kg/d)	Diet fraction (wet)	IR-wet (kg/d)	IR-dry (kg/d)	Diet fraction (wet)	IR-wet (kg/d)	IR-dry (kg/d)	Diet fraction (wet)	IR-wet (kg/d)	IR-dry (kg/d)	Diet fraction (wet)	IR-wet (kg/d)	IR-dry (kg/d)				
Meadow vole	0.9	4.50E-03	6.75E-04	0.05	2.50E-04	2.27E-04	0	0	0	0.05	2.50E-04	7.75E-05	0	0	0	5.00E-03	9.79E-04	1.80E-05	4.40E-02
Short-tailed shrew	0	0	0	0.138	1.24E-03	1.13E-03	0.314	2.83E-03	4.52E-04	0.548	4.93E-03	1.53E-03	0	0	0	9.00E-03	3.11E-03	1.87E-04	1.50E-02
Red fox	0.07	3.01E-02	4.52E-03	0	0	0	0	0	0	0.03	1.29E-02	4.00E-03	0.9	3.87E-01	1.24E-01	4.30E-01	1.32E-01	3.85E-03	4.50E+00
Red-winged blackbird	0	0	0	1	9.10E-02	8.25E-02	0	0	0	0	0	0	0	0	0	9.10E-02	8.25E-02	1.09E-03	6.40E-02
American woodcock	0	0	0	0	0	0	1	1.50E-01	2.40E-02	0	0	0	0	0	0	1.50E-01	2.40E-02	2.50E-03	1.98E-01
Red-tailed hawk	0	0	0	0	0	0	0	0	0	0	0	0	1	9.87E-02	3.16E-02	9.87E-02	3.16E-02	1.80E-03	1.13E+00

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Table D4: Risk Calculations - Plants and Soil Organisms

	Plants & Soil Organisms		
		Coarse R/P/I	
COC	REM conc. (µg/g)	TRV (µg/g)	Exposure ratio
Lead	321.6	2.50E+02	**1.29E+00**

Table D5: Exposure and Risk Calculations - Meadow Vole

COC	REM soil conc. (µg/g)	Meadow vole											
		Source: Vegetation			Source: Soil Invertebrates			ADD				TRV (mg/kg/d)	Exposure ratio
		Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)		
Lead	321.6	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	6.76E+00	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	8.49E+01	1.32E-01	1.39E-01	1.49E-01	4.20E-01	8.00E+01	5.24E-03

Table D6: Risk-based Values - Meadow Vole

COC	Meadow vole													
		Source: Vegetation			Source: Soil Invertebrates			ADD						
	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio	Risk-based soil conc. (µg/g)
Lead	1.37E+05	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	2.02E+02	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	1.12E+04	5.61E+01	4.14E+00	1.98E+01	8.00E+01	8.00E+01	1.00E+00	1.37E+05

Table D7: Exposure and Risk Calculations - Short-tailed Shrew

		Short-tailed Shrew											
		Source: Vegetation			Source: Soil Invertebrates			ADD					
COC	REM soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio
Lead	321.6	$\ln(C_p) = 0.561 \ln(C_s) – 1.328$	U.S. EPA (2005)	6.76E+00	$\ln(C_e) = 0.807 \ln(C_s) – 0.218$	U.S. EPA (2005)	8.49E+01	4.01E+00	5.08E-01	1.12E+01	1.57E+01	8.00E+01	1.97E-01

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Table D8: Risk-based Values - Short-tailed Shrew

COC	Short-tailed Shrew													
		Source: Vegetation			Source: Soil Invertebrates			ADD						
	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio	Risk-based soil conc. (µg/g)
Lead	2.14E+03	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	1.96E+01	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	3.92E+02	2.67E+01	1.47E+00	5.18E+01	8.00E+01	8.00E+01	1.00E+00	2.14E+03

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Table D9: Exposure and Risk Calculations - Red Fox

		Red Fox															
		Source: Vegetation			Source: Soil Invertebrates			Source: Shrew Prey			ADD						
COC	REM soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Soil-to-mammal transfer factor/equation	Source	Conc. mammal tissue (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	Dose from mammal ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio
Lead	321.6	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	6.76E+00	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	8.49E+01	$\ln(C_m) = 0.4422 \ln(C_s) + 0.0761$	Sample et al (1998)	1.39E+01	2.75E-01	6.78E-03	7.54E-02	3.81E-01	7.39E-01	8.00E+01	9.23E-03

Table D10: Risk-based Values - Red Fox

	Red Fox																
		Source: Vegetation			Source: Soil Invertebrates			Source: Shrew Prey			ADD						
COC	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Soil-to-mammal transfer factor/equation	Source	Conc. shrew tissue (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	Dose from mammal ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio	Risk-based soil conc. (µg/g)
Lead	8.06E+04	$\ln(C_p) = 0.561 \ln(C_s) – 1.328$	U.S. EPA (2005)	1.50E+02	$\ln(C_e) = 0.807 \ln(C_s) – 0.218$	U.S. EPA (2005)	7.32E+03	$\ln(C_m) = 0.4422 \ln(C_s) + 0.0761$	Sample et al (1998)	1.59E+02	6.90E+01	1.50E-01	6.51E+00	4.39E+00	8.00E+01	8.00E+01	1.00E+00	8.06E+04

Table D11: Exposure and Risk Calculations - Red-winged Blackbird

COC	REM soil conc. (µg/g)	Red-winged Blackbird											
		Source: Vegetation			Source: Soil Invertebrates			ADD				TRV (mg/kg/d)	Exposure ratio
		Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)		
Lead	321.6	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	6.76E+00	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	8.49E+01	5.48E+00	8.72E+00	0.00E+00	1.42E+01	3.30E+00	**4.30E+00**

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Table D12: Risk-based Values - Red-winged Blackbird

COC	Red-winged Blackbird													
		Source: Vegetation			Source: Soil Invertebrates			ADD						
	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio	Risk-based soil conc. (µg/g)
Lead	3.84E+01	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	2.05E+00	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	1.53E+01	6.54E-01	2.65E+00	0.00E+00	3.30E+00	3.30E+00	1.00E+00	3.84E+01

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Table D13: Exposure and Risk Calculations - American Woodcock

COC	REM soil conc. (µg/g)	American Woodcock											
		Source: Vegetation			Source: Soil Invertebrates			ADD				TRV (mg/kg/d)	Exposure ratio
		Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)		
Lead	321.6	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	6.76E+00	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	8.49E+01	4.06E+00	0.00E+00	1.03E+01	1.43E+01	3.30E+00	**4.35E+00**

Table D14: Risk-based Values - American Woodcock

COC	American Woodcock													
		Source: Vegetation			Source: Soil Invertebrates			ADD						
	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio	Risk-based soil conc. (µg/g)
Lead	5.77E+01	$\ln(C_p) = 0.561 \ln(C_s) – 1.328$	U.S. EPA (2005)	2.58E+00	$\ln(C_e) = 0.807 \ln(C_s) – 0.218$	U.S. EPA (2005)	2.12E+01	7.29E-01	0.00E+00	2.57E+00	3.30E+00	3.30E+00	1.00E+00	5.77E+01

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Table D15: Exposure and Risk Calculations - Red-tailed Hawk

		Red-tailed Hawk															
		Source: Vegetation			Source: Soil Invertebrates			Source: Shrew Prey			ADD						
COC	REM soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Soil-to-mammal transfer factor/equation	Source	Conc. shrew tissue (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	Dose from mammal ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio
Lead	321.6	$\ln(C_p) = 0.561 \ln(C_s) – 1.328$	U.S. EPA (2005)	6.76E+00	$\ln(C_e) = 0.807 \ln(C_s) – 0.218$	U.S. EPA (2005)	8.49E+01	$\ln(C_m) = 0.4422 \ln(C_s) + 0.0761$	Sample et al (1998)	1.39E+01	5.14E-01	0.00E+00	0.00E+00	3.89E-01	9.03E-01	2.80E+01	3.22E-02

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Table D16: Risk-based Values - Red-tailed Hawk

		Red-tailed Hawk																
		Source: Vegetation			Source: Soil Invertebrates			Source: Shrew Prey			ADD							
COC	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Conc. vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Conc. soil invertebrates (mg/kg dw)	Soil-to-mammal transfer factor/equation	Source	Conc. shrew tissue (mg/kg dw)	Dose from soil ingestion (mg/kg/d)	Dose from vegetation ingestion (mg/kg/d)	Dose from soil invertebrate ingestion (mg/kg/d)	Dose from mammal ingestion (mg/kg/d)	ADD total (mg/kg/d)	TRV (mg/kg/d)	Exposure ratio	Risk-based soil conc. (µg/g)
Lead	1.61E+04	$\ln(C_p) = 0.561 \ln(C_s) - 1.328$	U.S. EPA (2005)	6.08E+01	$\ln(C_e) = 0.807 \ln(C_s) - 0.218$	U.S. EPA (2005)	2.00E+03	$\ln(C_m) = 0.4422 \ln(C_s) + 0.0761$	Sample et al (1998)	7.83E+01	2.58E+01	0.00E+00	0.00E+00	2.20E+00	2.80E+01	2.80E+01	1.00E+00	1.61E+04

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Table D17: Risk-based Soil Values and Property Specific Standards

COC	Soil REM conc. (mg/kg)	Risk-based Values							Min. risk-based value (µg/g)	RM required	Risk reduction factor	PSS (µg/g)	Basis
		Plants & soil organisms (µg/g)	Meadow vole (µg/g)	Short-tailed shrew (µg/g)	Red fox (µg/g)	Red-winged blackbird (µg/g)	American woodock (µg/g)	Red-tailed hawk (µg/g)					
Lead	321.6	NA	1.37E+05	2.14E+03	8.06E+04	**3.84E+01**	**5.77E+01**	1.61E+04	**3.84E+01**	**Yes**	**8.37E+00**	3.22E+02	Max.+20%

APPENDIX E

Limitations

Disclaimer and Limitations

1. **Paterson Group Inc.** provided this report for **Inverness Homes Inc.** solely for the purpose stated in this report. Paterson does not accept any responsibility for the use of this report for any other purpose other than as specified and intended for the purpose of obtaining an approved Risk Assessment for the RA/PSC Property, to support an RSC filing through the Ontario Ministry of the Environment, Conservation and Parks.
2. **Paterson Group Inc.** does not have and does not accept, any responsibility or duty of care whether based in negligence or otherwise, in relation to the use of this report in whole or in part by any third party. Any alternate use, including by a third party, or any reliance on or decision made based on this report, are the sole responsibility of the alternative user or third party. **Paterson Group Inc.** does not accept responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.
3. The work performed in the preparation of this RA report and the conclusions presented are subject to the following:
   (a) The Scope of Services;
   (b) Time and Budgetary limitations as described in Contracts with our respective client(s); and
   (c) The Limitations stated herein.
4. No other warranties or representations, either expressed or implied, are made as to the professional services provided, other than that **Paterson Group Inc.** has exercised reasonable skill, care and diligence in accordance with accepted practice and usual standards of thoroughness and competence for the profession of toxicology and environmental risk assessment to assess and evaluate information acquired during the preparation of this report.
5. The conclusions and discussion presented in this report were based, in part, on borehole logs that were obtained through visual observations of the site and attendant structures by our Client. Our conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in our opinion, for direct observation, or by our Client.
6. The site history research provided by our Client included obtaining information from third parties and employees or agents of the owner. No attempt has been made to verify the accuracy of any information provided, unless specifically noted in our report.
7. Because of the limitations referred to above, different environmental conditions from those stated in our report may exist. Should such different conditions be encountered, **Paterson Group Inc.** must be notified in order that it may determine if modifications to the conclusions in the report are necessary.
8. This report is for the sole use of the party to whom it is addressed unless expressly stated otherwise in the report or contract. Any use which any third party makes of the report, in whole or in part, or any reliance thereon or decisions made based on any information or conclusions in the report, is the sole responsibility of such third party. **Paterson Group Inc.** accepts no responsibility whatsoever for damages or loss of any nature or kind suffered by any such third party as a result of actions taken or not taken or decisions made in reliance on the report or anything set out therein.
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