Human Health and Ecological Risk Assessment

258 Durocher Street
Ottawa, Ontario

Prepared for: Ottawa Humane Society

Report: PE6934-RA.01
August 6, 2025

EXECUTIVE SUMMARY

Paterson Group Inc. (Paterson) conducted a human health and ecological risk assessment (RA) for the property with the municipal address 258 Durocher Street in Ottawa, Ontario (the 'RA Property').

Previous investigations at the RA Property identified the presence of arsenic, benzo[a]pyrene, and petroleum hydrocarbons (PHC F2) in soil at concentrations exceeding applicable Table 3 Site Condition Standards (SCS).

For due diligence purposes, the property owner, Ottawa Humane Society, retained Paterson to prepare a risk assessment to quantify potential risks to future workers and identify risk management measures (RMM) that might be used to minimize potential exposure to contaminants in soil at the site.

The RA was prepared pursuant to guidance from the Ontario Ministry of the Environment, Conservation and Parks (MECP) and has employed the same standards, assumptions, models, and calculations as those used in RAs prepared under O. Reg. 153/04 (as amended) – Records of Site Condition (RSC), made under the *Environmental Protection Act*; however, the RA is not intended to support an RSC submission at this time.

Contaminants of concern (COC) in soil evaluated in the RA were identified by screening maximum measured concentrations of soil and groundwater parameters against MECP Table 3 Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition for industrial/commercial/community property use and coarse textured soil. Arsenic, benzo[a]pyrene, and PHC F2 in soil were identified as COCs and carried forward for assessment in the RA.

Receptors that were assessed in the human health risk assessment (HHRA) included (i) adult indoor workers, (ii) adult construction workers, (iii) adult outdoor workers, (iv) visitors/patrons, and (v) trespassers. Exposure pathways that were considered in the HHRA include (i) direct (dermal) contact with soil; (ii) incidental ingestion of soil; (iii) inhalation of soil particles in outdoor air; (iv) inhalation of vapours in indoor air; (v) inhalation of vapours in outdoor air; and (vi) inhalation of vapours in trench air.

The main findings of the HHRA were as follows:

- ❑ Soil oral/dermal pathways: Construction workers are at risk from dermal contact and incidental ingestion of arsenic in soil in a trench. Outdoor workers are at risk from dermal contact and incidental ingestion of arsenic and benzo[a]pyrene in soil.
    - Outdoor workers – Outdoor workers are potentially exposed to soil contaminants via incidental ingestion and dermal contact with soil during outdoor work activities (e.g., landscaping). Calculated risk levels exceeded acceptable values for arsenic, benzo[a]pyrene, and the sum of all carcinogenic polycyclic aromatic hydrocarbons (PAH).

   - Construction workers – Construction workers are potentially exposed to soil contaminants via incidental ingestion and dermal contact with subsurface soil in a trench or excavation. Calculated risk levels exceeded acceptable values for arsenic.
   - Contamination at the RA Property is not widespread and concentrations are only marginally greater than soil standards. Arsenic and benzo[a]pyrene impacts were found at depths of more than 0.3 m in areas of the site that is currently covered by a continuous asphalt surface that blocks direct contact with underlying soil. As such, these contaminants pose negligible risk to outdoor workers under current land use conditions.
- Soil inhalation pathways: None of the human receptors are at risk from inhalation of vapours in indoor air or outdoor air.

The ecological risk assessment (ERA) evaluated risks to ecological receptors including plants, soil invertebrates, mammals, birds, and aquatic receptors. Exposure pathways evaluated included (i) root uptake from soil; (ii) dermal contact with soil; (iii) ingestion of soil; (iv) foliar deposition of soil particles and uptake by plants; (v) foliar uptake of vapours by plants; (vi) inhalation of soil particles by wildlife receptors; (vii) inhalation of vapours by wildlife receptors; (viii) ingestion of vegetation, soil invertebrates, and/or prey that accumulated COCs from soil; and (ix) leaching to groundwater followed by migration and discharge to surface water.

The main findings of the ERA were as follows:

- PHC F2 in soil poses a theoretical risk to terrestrial plants that make contact with contaminated soil. Considering that PHC F2 impacts were found in only one sample across the site and was present at a depth that is inaccessible to plant roots and burrowing soil invertebrates, PHC F2 is considered to pose negligible risk to plants or soil invertebrates. Other COCs do not pose a risk to plants.
- No COCs pose any risk to terrestrial wildlife.
- Concentrations of soil contaminants at the site were less than S-GW3 values considered to be protective of aquatic life in the nearest water body (Rideau River). Therefore, risks from soil contaminants to off-site aquatic receptors via leaching and groundwater discharge are considered to be negligible.

Risk management measures (RMM) are recommended to ensure that source-to-receptor exposure pathways are minimized or blocked. The following RMM are recommended:

- Maintenance of existing surface barriers consisting of hard cap barriers (building foundation, concrete/asphalt, interlock pavement) and soil cap barriers (landscaped areas) to prevent direct contact with contaminants in underlying soil by outdoor workers; and

- ❑ Health and Safety Plan for subsurface construction work to minimize exposure to soil contaminants by construction workers in a trench.

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1.0 INTRODUCTION

Paterson Group Inc. (Paterson) was retained by Ottawa Humane Society to conduct a human health and ecological risk assessment (RA) for the property with the municipal address of 258 Durocher 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.

The RA Property is located on the north side of St. Paul Street and bounded by Durocher Street and Desrosier Street to the east and west, respectively. Currently, the property is occupied by a large, single-storey institutional building that is vacant but was previously used for religious purposes by the Kingdom Hall of Jehovah's Witnesses, Riverside Congregation.

Previous investigations at the RA Property identified the presence of several parameters in soil at concentrations exceeding applicable Ontario Ministry of the Environment, Conservation and Parks (MECP) Table 3 Site Condition Standards (SCS).

It is understood that the Ottawa Humane Society is considering using the property for housing animals for adoption, which is considered to be commercial land use. As the current land use is institutional, the intended land use is not more sensitive than the current land use and there is no requirement for a Record of Site Condition (RSC) under Ontario Regulation 153/04 (as amended) – Records of Site Condition, made under the *Environmental Protection Act*. However, for due diligence purposes, the property owner, Ottawa Humane Society, retained Paterson to prepare a risk assessment to quantify potential risks to employees and volunteers and to identify risk management measures (RMM) to minimize potential exposure to contaminants in soil at the site. The RA will not be used to support an RSC and will not be submitted for review to the Ontario 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.

1.1 Risk Assessment Objectives and Approach

The objectives of the RA were to:

- ❑ Complete a due diligence risk assessment for the property located at 258 Durocher Street, Ottawa, Ontario;
- ❑ Quantitatively or qualitatively assess the risk from exposure to contaminants of concern (COC) in soil at the RA Property to the human and ecological receptors that may use the property based on future commercial land use;
- ❑ Develop risk-based concentrations for COCs in soil at the RA Property; and

- Where unacceptable risks are identified to either human or ecological receptors, propose risk management measures (RMM) to mitigate risks associated with COCs present in soil 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 proposed future land use for the RA Property. The last stage of the RA consisted of calculating risks and developing risk-based concentrations for all COCs that were screened into the RA. Where risks to human or ecological receptors were identified, RM measures to ameliorate or eliminate risks were provided.

2.0 SITE CHARACTERIZATION

2.1 Property Information

The RA Property is located on the north side of St. Paul Street and bounded by Durocher Street and Desrosier Street in the City of Ottawa, Ontario (Figure 1). The RA Property consists of a single parcel with the municipal address 258 Derocher Street. Property details are provided in Table 2-1.

Table 2-1: Site Identification Information	
Civic Address	258 Durocher Street, Ottawa, Ontario
Current/Future Land Use	Institutional; proposed commercial
Latitude & Longitude Coordinates	45° 26' 8" N; 75° 39' 58" W (WGS 1984)
Legal Description	LT 1, BLK C, PL 45 , LT 2, BLK C, PL 45, LT 3, BLK C, PL 45, PT LT 4, BLK C, PL 45, PT LT 14, BLK C, PL 45, LT 15, BLK C, PL 45, LT 16, BLK C, PL 45, LT 17, BLK C, PL 45 (SOMETIMES KNOWN AS PLAN 113 GL) AS IN V28957, V28959 & V28960; VANIER/GLOUCESTER
Site Area	4,500 m^2 (approximately)

The RA Property currently is occupied by a vacant single-storey building with a basement level. The building is constructed with a concrete block foundation with an exterior finish in red brick and a flat tar and gravel style roof. The northern half of the RA Property exists as an asphaltic concrete paved parking lot associated with the building. There are no other buildings or structures on the property with the exception of a concrete pad-mounted transformer situated on the south exterior wall of the building.

The neighbouring lands within the study area consist of residential and commercial properties. The RA Property is bounded on three sides by municipal roadways and on the northwest side by residential dwellings. The properties to the north and east of the RA Property are used for residential land uses; properties to the south of the RA Property are a mix of residential and commercial land uses. Based on the availability of municipal services, no drinking water wells are expected to be present within the study area.

2.2 Past Land Uses

According to historical research, the RA property was initially developed prior to 1909 for residential purposes on the northern side and commercial purposes on the southern side of the property, with increased commercial/industrial use until the late 1960s. A manufacturer of aluminum sash and a possible automotive repair garage, woodshed, and a couple of office buildings were identified on the northern, central and southern portions of the site. In the early 1970s, the RA Property was redeveloped with the present-day building that was used by Canada Post from the mid-1970s to 2010. In 2013, the RA Property was acquired by the Kingdom Hall of Jehovah's Witnesses, Riverside Congregation and used as a place of religious gathering until 2019. Since 2019, the RA Property has not been used to congregate for religious purposes.

Surrounding lands historically have been used for residential to the north and east of the RA Property with commercial land use to the south and along Montreal Road. A former tannery and coal storage shed were identified on the neighbouring properties to the southwest. Several other off-site land uses such as retail fuel outlets and garages were identified on properties within the study area.

2.3 Previous Investigations

The property with municipal address 258 Durocher Street has been the subject of previous site investigations. The risk assessment relied on the following reports:

1. Paterson Group Inc. (2022) Phase I - Environmental Site Assessment, 258 Durocher Street, Ottawa, Ontario. Prepared for WestUrban Developments Ltd. PE5641-1. July 21, 2022.
2. Paterson Group Inc. (2022) Phase II - Environmental Site Assessment, 258 Durocher Street, Ottawa, Ontario. Prepared for WestUrban Developments Ltd. PE5641-1. August 31, 2022.
3. Exp Services Inc. (2022) Supplemental Phase II Environmental Site Assessment, 258 Durocher Street, Ottawa, Ontario. Prepared for Watch Tower Bible & Tract Society of Canada. OTT-22020118-A0. October 4, 2022.

2.3.1 Paterson 2022 Phase One Environmental Site Assessment

Paterson completed a Phase One Environmental Site Assessment (ESA) for the RA Property. The purpose of the Phase One ESA was to research the past and current use of the site and neighbouring properties and to identify any environmental concerns with the potential to have impacted the property.

The RA Property was formerly addressed 141 to 153 St. Paul Street and 240/242 to 258 Durocher Street. According to historical research, the first developed use of the RA Property was considered to be mixed-use (commercial and residential) sometime before 1909. In 1932, the St. Paul Street portion of the property (formerly addressed as 141 to 153 St. Paul Street) was listed under private individuals until 1955/56. From 1961 to 1968 the properties were listed under private individuals and commercial retailers (firearms and domestic ice service). The Durocher Street portion of the property, formerly addressed 240 to 258 Durocher Street, was listed under Aluminum

Windows and Sash at 240 Durocher Street from 1953 to 1961, while the remaining properties along the western side of Durocher Street, addressed 246 to 258 Durocher Street, were listed under several private individuals from 1951 to 1961.

From 1961 to 1967, the property was used for residential and commercial retail purposes (fruit/produce store). In the early 1970s, the property was redeveloped with the present-day building that was used by Canada Post until 2010. The Kingdom Hall of Jehovah's Witnesses, Riverside Congregation acquired the property to use as a place of worship from 2013 to 2019. The interior of the main level was renovated to create an auditorium (or nave) for the religious community to congregate.

Based on the historical review, several potentially contaminating activities (PCA) were identified on the RA Property or on nearby properties, including metal fabrication, a former on-site automotive repair garage, and an off-site tannery and coal shed. Six areas of potential contamination (APECs) were identified:

- ❑ APEC 1: Former industrial use (manufacturer of aluminum sash);
- ❑ APEC 2: Fill material of unknown quality;
- ❑ APEC 3: Presence of a concrete pad-mounted transformer;
- ❑ APEC 4: Former automotive repair garage;
- ❑ APEC 5: Application of road salt;
- ❑ APEC 6: Former industrial sites (tannery and coal shed).

Based on the APECs identified, the following contaminants of potential concern (CPCs) in soil and/or groundwater were identified:

- ❑ Volatile Organic Compounds (VOCs);
- ❑ Petroleum Hydrocarbons (PHC F1-F4);
- ❑ Polycyclic Aromatic Hydrocarbons (PAHs);
- ❑ Metals including arsenic, antimony, and selenium;
- ❑ Mercury and hexavalent chromium (Cr VI);
- ❑ Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC).

2.3.2 Paterson 2022 Phase Two Environmental Site Assessment

Paterson completed a Phase Two ESA in April and June 2022 to investigate soil and groundwater quality at the site potentially affected by the APECs previously identified.

The field investigation consisted of the drilling of six (6) boreholes across the site (BH1-22 through BH6-22). All six boreholes were completed as groundwater monitoring wells.

The soil profile encountered generally consisted of an asphalt pavement or topsoil followed by a granular material, underlain by a fill material consisting of sandy silt with some crushed stone, clay and traces of organics, followed by a shaley glacial till, overlying shale bedrock. The boreholes were terminated at a maximum depth of 6.38 metres below the ground surface (mbgs). Soil samples were obtained from the boreholes and screened using vapour measurements along with visual and olfactory observations. A petroleum odour was noted in the field at BH1-22.

Based on the screening results in combination with sample depth and location, ten (10) soil samples and a duplicate were submitted for laboratory analysis of VOCs including BTEX parameters (benzene, toluene, ethylbenzene, xylenes), PHC F1–F4, PAHs, polychlorinated biphenyls (PCBs), and/or metals including mercury and hexavalent chromium.

Paterson compared analytical results to Ontario MECP Table 3 Full Depth Generic Site Condition Standards (SCS) in a Non-Potable Ground Water Condition from the April 15, 2011 *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act* (MOE 2011b) assuming future residential land use and coarse textured soil. Concentrations of PHC F2 and F3, metals (cobalt and molybdenum), and PAHs (benzo[a]anthracene, benzo[a]pyrene, and fluoranthene) in excess of the selected MECP Table 3 residential standards were identified in soil samples BH1-22-SS4 and BH6-22-AU1/SS2. Paterson considered cobalt and molybdenum to be naturally occurring elements.

Groundwater samples from all six monitoring wells were recovered and analyzed for VOCs including BTEX, PHC F1–F4, and/or PAHs. No free-phase product was observed on the groundwater at any of the monitoring well locations during the groundwater sampling events in April and June of 2022. With the exception of chloroform, all parameter concentrations were less than laboratory detection limits. The chloroform was deemed to be the result of municipal water used for coring bedrock and therefore was not considered a contaminant of concern.

2.3.3 EXP Services Inc. 2022 Phase Two Environmental Site Assessment

EXP Services Inc. (EXP) completed a Phase Two ESA for the RA Property in 2022. The objective of the supplemental Phase Two ESA investigation was to refine estimated remediation costs provided in the Paterson Phase Two ESA by collecting and submitting additional soil samples for laboratory analyses.

The supplemental Phase Two ESA consisted of advancing a total of nine (9) boreholes (BH1 through BH9) to delineate the quality of fill on the property. Soil stratigraphy consisted of 0.1 m to 0.2 m thick layer of crushed stone, underneath which was sand with some gravel to a maximum depth of 1.4 mbgs. At BH3 and BH7, there was approximately 0.3 m of silty topsoil overlying 0.9 m of sand with some gravel fill material, overlying glacial till consisting of sand and gravel, with some silty and clay. Drilling refusal on inferred bedrock was found between 1.68 and 2.29 mbgs.

EXP submitted 14 soil samples plus two field duplicate samples for laboratory analysis of PHC F1–F4, BTEX, PAHs, metals, and/or sodium adsorption ratio (SAR). Concentrations of BTEX, PHC F1–F4, and PAHs in the analyzed soil samples were less than MECP Table 3 SCS (residential land use, coarse textured soil). Concentrations of arsenic, cobalt, molybdenum, nickel, thallium, and SAR in one or more soil samples exceeded Table 3 SCS.

2.4 Physical Setting

2.4.1 Topography and Surface Water Drainage

The RA Property is occupied by a vacant single-storey building that was last used for religious gatherings. The RA Property is situated in a residential area with commercial land use to the south along Montreal Road. The majority of the RA Property is covered in an asphaltic concrete pavement structure with some landscaped areas along the perimeter of the property. The site topography slopes slightly towards the west, while the regional topography slopes down in a westerly direction towards the Rideau River. Site drainage consists of infiltration on the landscaped areas and sheet flow on the asphalt paved concrete areas to catch basins along Desrosiers and St. Paul Street.

The closest water body is the Rideau River, which flows to the north approximately 350 m west of the site. There are no areas of natural significance located in the vicinity of the RA Property.

No drinking water wells are located on the RA Property. The site and surrounding properties are serviced by municipal potable water and sewer services. No private water supply wells are located in the study area.

2.4.2 Geology

Intrusive investigations conducted at the site revealed an asphaltic concrete structure or topsoil, followed by a granular fill and/or crushed stone beneath the concrete structure or a fill material consisting of silty sand to sandy silt with some crushed stone and traces of clay, underlain by shaley till, followed by shale bedrock. Bedrock was encountered at approximately 2.03 to 3.07 m below the ground surface.

2.4.3 Hydrogeology

Groundwater at the RA Property was encountered within the in the till layer and the bedrock during the groundwater sampling events in April and June 2022. This unit is interpreted to function as the shallow aquifer on the RA Property.

Groundwater levels were measured during the groundwater sampling events on 14 April 2022 and 24 June 2022 using an electronic water level meter. Groundwater levels during April ranged from approximately 2.07 to 2.64 mbgs. Groundwater levels during June ranged from approximately 2.58 to 3.15 mbgs.

Based on the contour mapping, groundwater beneath the RA Property appears to flow in a westerly direction. An average horizontal hydraulic gradient of approximately 0.03 m/m was calculated.

2.5 Identification of Contaminants of Concern

COCs were identified by comparing maximum measured concentrations to the applicable Site Condition Standards (SCS) established by Ontario MECP in the April 15, 2011 document, "Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act*" (MOE 2011b).

The applicable standards were identified based on the following considerations:

- ❑ The full depth option is a more conservative approach.
- ❑ The future land use will be commercial.
- ❑ The RA Property, and all other properties located, in whole or in part, within 250 m of the boundaries of the property, are supplied by a municipal drinking water system, as defined in the *Safe Drinking Water Act*, 2002, and there are no wells installed for the extraction of groundwater. The RA Property is not located in an area designated in the municipal official plan as a well-head protection area or other designation identified by the municipality for the protection of groundwater.
- ❑ The predominant soil type is coarse-grained soil.
- ❑ Section 41 of the Regulation (Environmentally Sensitive Areas) does not apply to the site. No environmentally sensitive areas were identified in the vicinity of the RA Property. Additionally, soil pH was within the limits specified by MECP (5–9 in surface soil; 5-11 in subsurface soil).

- Section 43.1 of the regulation does not apply to the site, as the RA Property is not a shallow soil property (whereby more than one-third of the property has less than 2 m of overburden).

Based on the above considerations, the appropriate standards were determined to be the Table 3 Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition assuming industrial/commercial/community land use and coarse textured soil.

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.

2.5.1 Contaminants of Concern in Soil

Contaminants of concern in groundwater were determined by screening the maximum measured concentrations of chemical parameters against applicable Table 3 SCS for commercial land use. The screening of soil parameters is summarized in Table 2-2.

Table 2-2: Identification of Contaminants of Concern in Soil

Parameter	Maximum concentration (µg/g)	Table 3 SCS [a] (µg/g)	COC	Rationale
Metals and Inorganics				
Antimony	1.6	40	No	Max. < Table 3 SCS
Arsenic	**27.3**	18	Yes	Max. > Table 3 SCS
Barium	137	670	No	Max. < Table 3 SCS
Beryllium	1.2	8	No	Max. < Table 3 SCS
Boron (Total)	8.4	120	No	Max. < Table 3 SCS
Boron (Hot Water Soluble)	0.09	2	No	Max. < Table 3 SCS
Cadmium	1.2	1.9	No	Max. < Table 3 SCS
Chromium VI	<0.2	8	No	RDL < Table 3 SCS
Chromium (Total)	29	160	No	Max. < Table 3 SCS
Cobalt	43	80	No	Max. < Table 3 SCS
Copper	80	230	No	Max. < Table 3 SCS
Lead	115	120	No	Max. < Table 3 SCS
Mercury	0.188	3.9	No	Max. < Table 3 SCS
Molybdenum	16	40	No	Max. < Table 3 SCS
Nickel	161	270	No	Max. < Table 3 SCS
Selenium	2	5.5	No	Max. < Table 3 SCS
Silver	<0.3	40	No	RDL < Table 3 SCS
Thallium	2.9	3.3	No	Max. < Table 3 SCS

Table 2-2: Identification of Contaminants of Concern in Soil

Parameter	Maximum concentration (µg/g)	Table 3 SCS [a] (µg/g)	COC	Rationale
Uranium	6.6	33	No	Max. < Table 3 SCS
Vanadium	49	86	No	Max. < Table 3 SCS
Zinc	236	340	No	Max. < Table 3 SCS
Sodium adsorption ratio (unitless)	5.36	12	No	Max. < 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	<0.2	68	No	RDL < Table 3 SCS
Xylenes	0.25	26	No	Max. < Table 3 SCS
PHC F1	16	55	No	Max. < Table 3 SCS
PHC F2	**520**	230	Yes	Max. > Table 3 SCS
PHC F3	397	1,700	No	Max. < Table 3 SCS
PHC F4	58	3,300	No	Max. < Table 3 SCS
Volatile Organic Chemicals				
Acetone	<0.5	16	No	RDL < Table 3 SCS
Bromodichloromethane	<0.05	18	No	RDL < Table 3 SCS
Bromoform	<0.05	0.61	No	RDL < Table 3 SCS
Bromomethane	<0.05	0.05	No	RDL < Table 3 SCS
Carbon Tetrachloride	<0.05	0.21	No	RDL < Table 3 SCS
Chlorobenzene	<0.05	2.4	No	RDL < Table 3 SCS
Chloroform	<0.05	0.47	No	RDL < Table 3 SCS
Dibromochloromethane	<0.05	13	No	RDL < Table 3 SCS
Dichlorodifluoromethane	<0.05	16	No	RDL < Table 3 SCS
1,2-Dichlorobenzene	<0.05	6.8	No	RDL < Table 3 SCS
1,3-Dichlorobenzene	<0.05	9.6	No	RDL < Table 3 SCS
1,4-Dichlorobenzene	<0.05	0.2	No	RDL < Table 3 SCS
1,1-Dichloroethane	<0.05	17	No	RDL < Table 3 SCS
1,2-Dichloroethane	<0.05	0.05	No	RDL < Table 3 SCS
1,1-Dichloroethylene	<0.05	0.064	No	RDL < Table 3 SCS
1,2-cis-Dichloroethylene	<0.05	55	No	RDL < Table 3 SCS
1,2-trans-Dichloroethylene	<0.05	1.3	No	RDL < Table 3 SCS
1,2-Dichloropropane	<0.05	0.16	No	RDL < Table 3 SCS
1,3-Dichloropropene	<0.05	0.18	No	RDL < Table 3 SCS
Ethylene dibromide	<0.05	0.05	No	RDL < Table 3 SCS
(n)-Hexane	<0.05	46	No	RDL < Table 3 SCS
Methyl Ethyl Ketone	<0.5	70	No	RDL < Table 3 SCS
Methyl Isobutyl Ketone	<0.5	31	No	RDL < Table 3 SCS
Methyl tert-Butyl Ether (MTBE)	<0.05	11	No	RDL < Table 3 SCS
Methylene Chloride	<0.05	1.6	No	RDL < Table 3 SCS
Styrene	<0.05	34	No	RDL < Table 3 SCS
1,1,1,2-Tetrachloroethane	<0.05	0.087	No	RDL < Table 3 SCS
1,1,2,2-Tetrachloroethane	<0.05	0.05	No	RDL < Table 3 SCS
Tetrachloroethylene	<0.05	4.5	No	RDL < Table 3 SCS
1,1,1-Trichloroethane	<0.05	6.1	No	RDL < Table 3 SCS

Table 2-2: Identification of Contaminants of Concern in Soil				
Parameter	**Maximum concentration (µg/g)**	**Table 3 SCS [a] (µg/g)**	**COC**	**Rationale**
1,1,2-Trichloroethane	<0.05	0.05	No	RDL < Table 3 SCS
Trichloroethylene	<0.05	0.91	No	RDL < Table 3 SCS
Trichlorofluoromethane	<0.05	4	No	RDL < Table 3 SCS
Vinyl Chloride	<0.02	0.032	No	RDL < Table 3 SCS
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	0.09	96	No	Max. < Table 3 SCS
Acenaphthylene	<0.05	0.15	No	RDL < Table 3 SCS
Anthracene	0.23	0.67	No	Max. < Table 3 SCS
Benz[a]anthracene	0.64	0.96	No	Max. < Table 3 SCS
Benzo[a]pyrene	**0.65**	0.3	Yes	Max. > Table 3 SCS
Benzo[b]fluoranthene	0.63	0.96	No	Max. < Table 3 SCS
Benzo[g,h,i]perylene	0.31	9.6	No	Max. < Table 3 SCS
Benzo[k]fluoranthene	0.34	0.96	No	Max. < Table 3 SCS
Chrysene	0.77	9.6	No	Max. < Table 3 SCS
Dibenz[a,h]anthracene	0.05	0.1	No	Max. < Table 3 SCS
Fluoranthene	1.43	9.6	No	Max. < Table 3 SCS
Fluorene	0.1	62	No	Max. < Table 3 SCS
Indeno[1,2,3-cd]pyrene	0.29	0.76	No	Max. < Table 3 SCS
Methylnaphthalene 1-, 2-	<0.05	76	No	RDL < Table 3 SCS
Naphthalene	<0.05	9.6	No	RDL < Table 3 SCS
Phenanthrene	1.05	12	No	Max. < Table 3 SCS
Pyrene	1.16	96	No	Max. < Table 3 SCS
Polychlorinated Biphenyls				
Total PCBs	<0.05	1.1	No	RDL < Table 3 SCS

[a] Table 3 Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition, industrial/commercial/community land use, coarse textured soil (MOE 2011).
COC – Contaminant of concern; RDL – Reported detection limit; SCS – Site Condition Standard

The following soil parameters were identified as COCs and were carried forward in the RA for further evaluation:

- Arsenic;
- Benzo[a]pyrene; and
- PHC F2.

2.5.2 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 screening of groundwater is summarized in Table 2-3.

Table 2-3: Identification of Contaminants of Concern in Groundwater				
Parameter	**Maximum concentration (µg/L)**	**Table 3 SCS [a] (µg/L)**	**COC**	**Rationale**
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
PHC F1	<25	750	No	RDL < Table 3 SCS
PHC F2	<100	150	No	RDL < Table 3 SCS
PHC F3	<100	500	No	RDL < Table 3 SCS
PHC F4	<100	500	No	RDL < Table 3 SCS
Volatile Organic Chemicals				
Acetone	<5	130,000	No	RDL < Table 3 SCS
Bromodichloromethane	<0.5	85,000	No	RDL < 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
Chloroform	**3.8**	2.4	No	Not a COC [b]
Dibromochloromethane	<0.5	82,000	No	RDL < Table 3 SCS
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	<1	51	No	RDL < Table 3 SCS
Methyl Ethyl Ketone	<5	470,000	No	RDL < Table 3 SCS
Methyl Isobutyl Ketone	<5	140,000	No	RDL < Table 3 SCS
Methyl tert-Butyl Ether	<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	<0.5	1.6	No	RDL < 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
Vinyl Chloride	<0.5	0.5	No	RDL < Table 3 SCS

Table 2-3: Identification of Contaminants of Concern in Groundwater				
Parameter	Maximum concentration (µg/L)	Table 3 SCS [a] (µg/L)	COC	Rationale
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	<0.05	600	No	RDL < Table 3 SCS
Acenaphthylene	<0.05	1.8	No	RDL < Table 3 SCS
Anthracene	<0.01	2.4	No	RDL < Table 3 SCS
Benz[a]anthracene	<0.01	4.7	No	RDL < Table 3 SCS
Benzo[a]pyrene	<0.01	0.81	No	RDL < Table 3 SCS
Benzo[b]fluoranthene	<0.05	0.75	No	RDL < Table 3 SCS
Benzo[g,h,i]perylene	<0.05	0.2	No	RDL < Table 3 SCS
Benzo[k]fluoranthene	<0.05	0.4	No	RDL < Table 3 SCS
Chrysene	<0.05	1	No	RDL < Table 3 SCS
Dibenz[a,h]anthracene	<0.05	0.52	No	RDL < Table 3 SCS
Fluoranthene	<0.01	130	No	RDL < Table 3 SCS
Fluorene	<0.05	400	No	RDL < Table 3 SCS
Indeno[1,2,3-cd]pyrene	<0.05	0.2	No	RDL < Table 3 SCS
Methlynaphthalene, 1-(2-)	<0.1	1800	No	RDL < Table 3 SCS
Naphthalene	<0.05	1400	No	RDL < Table 3 SCS
Phenanthrene	<0.05	580	No	RDL < Table 3 SCS
Pyrene	<0.01	68	No	RDL < Table 3 SCS

[a] Table 3 Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition, coarse textured soil (MOE 2011)
[b] Chloroform concentrations exceeding Table 3 SCS in groundwater samples were attributed to the use of municipal water during coring.
COC – Contaminant of concern; RDL – Reported detection limit; SCS – Site Condition Standard

No groundwater COCs were identified based on the screening against Table 3 SCS.

2.5.3 Sampling Summary

Paterson has evaluated the Phase Two ESA investigations completed for the site and is of the opinion 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 and ecological receptors.

Paterson and EXP have conducted subsurface investigations at the RA Property to evaluate the potential contaminants that might be found as a result of historic activities and other PCAs. Six APECs related to the previous industrial land use were described for the site. The potential COCs identified were metals, PAHs, VOCs, BTEX, PHCs, and PCBs. The Phase Two ESA work program included investigation of the environmental quality of soil and groundwater at the site, specifically for the COCs previously identified. The locations of the boreholes and monitoring wells were selected to assess and delineate potential and/or confirmed impacts on the site.

Given the relatively small size of the property and the number of samples collected, there is high confidence that the maximum concentrations of COCs were acquired in the soil and groundwater sampling program. A total of 23 soil samples were analyzed for metals and metalloids; 21 samples were analyzed for PAHs; 21 samples were analyzed for BTEX and PHCs; and four samples were analyzed for VOCs. Groundwater samples were analyzed for VOCs, BTEX, and PHCs in six locations and for PAHs in three locations. Two rounds of groundwater samples were included in the RA data set.

All laboratory analysis completed in the Phase Two ESA were completed at a laboratory accredited by the Standards Council of Canada. The laboratory Certificates of Analysis are attached in the Phase Two ESA report. All the certificates of analysis provided per Sub-section 47(2)(b) in the Phase Two ESA are deemed to comply with Sub-section 47(3), and a Certificate of Analysis was received for each sample submitted.

Overall, the RA Property is considered to be satisfactorily characterized with respect to contaminant sources for the purposes of meeting the objectives of the RA investigation.

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 through the use of reasonable estimated maximum (REM) estimates for each parameter screened into the RA. The REM estimate was calculated as the maximum measured concentration plus 20%.

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., U.S. EPA) that stepwise identifies, characterizes, and integrates the elements of risk.

3.1 Problem Formulation

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

3.1.1 Human Health Conceptual Site Model

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

Subsurface investigations at the RA Property identified the presence of arsenic, benzo[a]pyrene, and PHC F2 in soil at concentrations exceeding Table 3 SCS.

Environmental transport pathways relevant to the site include: (i) entrainment of soil particles in outdoor air; (ii) volatilization from surface soil to outdoor air; (iii) volatilization from subsurface soil into air in a trench; and (iv) vapour intrusion from soil into a commercial building.

Receptors that were assessed in the HHRA include (i) adult indoor workers; (ii) adult construction workers, (iii) adult outdoor workers, (iv) visitors (all ages); and (v) trespassers. Receptors are discussed in detail in Section 3.2.1.

Exposure pathways that were evaluated in the HHRA include: (i) incidental ingestion of soil; (ii) direct (dermal) contact with soil; (iii) inhalation of soil particulates in outdoor air; (iv) inhalation of volatile soil contaminants in soil in outdoor air; (v) inhalation of volatile soil contaminants in soil in a trench or excavation; and (vi) vapour intrusion of volatile soil contaminants into a commercial building. Exposure pathways are discussed in detail in Section 3.2.2.

3.1.2 Identification of COCs for HHRA

A total of three VOCs were identified as COCs in soil by comparing maximum detected concentrations to MECP Table 3 SCS (as summarized above in Section 2.5.1). Parameters evaluated quantitatively in the HHRA were identified by screening REM concentrations of COCs against relevant Table 3 component values for contact and inhalation pathways (where available). Component values were selected from the Table of Drivers in the latest MECP Modified Generic Risk Assessment (MGRA) model and incorporate the MECP latest toxicity reference values (TRVs; July 2024). COCs for which the REM concentration exceeded a component value were carried forward for further evaluation in the HHRA. COCs with no component values for a specific pathway also were carried forward in the HHRA.

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

- S-GW1 – Soil values that are protective of ingestion of drinking water; although the property is serviced by municipal drinking water and therefore groundwater at the property is non-potable, soil was screened against S-GW1 values to identify COCs requiring evaluation of direct contact and ingestion pathways for construction workers.
- S2 – Soil ingestion/dermal contact pathways under a lower-frequency, lower-intensity scenario for surface soil at a property with commercial/industrial/ community land use;
- S3 – Soil ingestion/dermal contact pathways under a low-frequency, high-intensity human health exposure scenario that is protective of a worker exposed to sub-surface soils (e.g., construction worker);
- 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 is shown in Table 3-1.

Table 3-1: Screening of Soil COCs for HHRA

COC	Maximum conc. (µg/g)	REM conc. (µg/g)	Contact			Inhalation	
			S-GW1 (µg/g)	S2 (µg/g)	S3 (µg/g)	S-IA (µg/g)	S-OA (µg/g)
Arsenic	27.3	32.76	–	**0.2**	**7.4**	–	–
Benzo[a]pyrene	0.65	0.78	6.6	**0.7**	17	5,400	68
PHC F2	520	624	4,300	22,000	48,000	**380**	25,000

Bold – component value exceeded by REM concentration.

With respect to the soil screening, the following is noted:

- Arsenic and benzo[a]pyrene concentrations exceeded S2 values protective of direct contact and ingestion pathways under a commercial setting. These COCs were carried forward for evaluation of risks to outdoor workers potentially exposed to soil during outdoor work (e.g., landscaping).

- The concentration of arsenic exceeded the S3 component value protective of direct contact in a subsurface environment. Arsenic was carried forward for evaluation of risks to construction workers in a trench or excavation.
- The concentration of PHC F2 exceeded the S-IA component value protective of inhalation pathways in a commercial building. PHC F2 was carried forward for evaluation of risks from inhalation of indoor air. As there are no soil component values protective of inhalation of outdoor air or trench air, PHC F2 was also evaluated for risk to outdoor workers and construction workers via inhalation of outdoor air and trench air, respectively.

3.2 Exposure Assessment

3.2.1 Receptor Characteristics

3.2.1.1 Indoor Workers

Indoor worker characteristics are summarized in Table 3-2. Default values recommended by MECP for a long-term indoor worker were used for the following:

- Body weight;
- Exposure frequency and duration; and
- Averaging periods.

The greatest potential source of exposure to COCs for indoor workers is inhaling soil vapours that have migrated to the indoor environment. Indoor workers will have negligible exposure to soil since they are inside a building; therefore, soil contact pathways (incidental ingestion, dermal contact, inhalation of particulates) were not assessed.

Table 3-2: Indoor Worker Characteristics and Exposure Parameters

Characteristic		Units	Typical adult	Reference
Body weight		kg	70.7	MOE (2011)
Intake rates	Inhalation	m^3/hour	0.692	Health Canada (2021)
Time Indoors		hours/day	9.8	MOE (2011)
		days/year	250	MOE (2011)
Exposure duration		years	56	MOE (2011)
Averaging period	Non-carcinogens	years	56	MOE (2011)
	Carcinogens	years	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 soil vapours in trench air, and direct contact (ingestion and dermal contact) with soil in a trench. The extent to which construction/utility work may occur at the site is unknown, but standard HHRA practice is to typically 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 3-3. 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 (MOE 2011a) and is deemed reasonably conservative.

Table 3-3: 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	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 soil vapours in outdoor air. 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 "long-term outdoor worker" were used for all applicable parameters.

Table 3-4: Outdoor 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	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 Visitors and Patrons

Visitors/patrons of all age groups may visit the RA Property. The greatest potential source of exposure to COCs for visitors and patrons is inhaling 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 indoor worker who is present for the entire workday. Therefore, the results for indoor workers (i.e., the calculated human health-based values) will be protective of visitors/patrons. On this basis, visitors/patrons were not quantitatively assessed in the remaining sections of the HHRA.

3.2.1.5 Trespassers

People may trespass at the site. Exposure pathways for such receptors are limited to inhalation of soil vapours in outdoor air. Default exposure frequency values are not provided by MECP for such receptors, but their exposure is assumed to be infrequent and for short durations (e.g., one hour/day), likely much less than that of an outdoor worker. Therefore, the results for outdoor workers (i.e., the calculated human health effects-based values) were assumed to be health-protective of trespassers. On this basis, trespassers were not quantitatively assessed in the HHRA.

3.2.2 Pathway Analysis

3.2.2.1 Soil Ingestion and Dermal Contact

The equations used to quantitatively estimate exposure to groundwater COCs are presented in Appendix B1. The applicability of these pathways at this site is summarized in Table 3-5.

Table 3-5: Exposure Pathway Summary – Soil

Pathway	Receptor	Assessment	Rationale	Exposure frequency and duration
Incidental ingestion, dermal contact, and particulate inhalation (ingested)	Indoor worker	None	No soil contact; works indoors	–
	Outdoor worker	Quantitative	Potential contact with soil through outdoor work; S2 component value exceeded	195 days/year, 56 years
	Construction worker	Quantitative	Extensive soil contact through construction work; S3 component value exceeded	195 days/year, 1.5 years
	Patrons/ visitors	Qualitative	No soil contact; most time is spent indoors	–
	Trespassers	Qualitative	Soil exposure much less than workers	–

3.2.2.2 Vapour Inhalation Pathways

The equations used to quantitatively estimate exposure to soil COCs via vapour inhalation pathways are presented in Appendix B1. The applicability of these pathways at this site is summarized in Table 3-6.

Table 3-6: Exposure Pathway Summary – Vapours

Source	Receptor	Assessment	Rationale	Exposure frequency and duration
Vapour inhalation (soil source)	Indoor worker	Quantitative (indoor air)	Pathway of concern and component values were exceeded	9.8 hours/day, 250 days/year, 56 years
	Outdoor worker	Quantitative (outdoor air)	Assessed to be conservative	9.8 hours/day, 195 days/year, 56 years
	Construction worker	Quantitative (trench air)	Assessed to be conservative	9.8 hours/day, 50 days/year, 1.5 years
	Patrons/ visitors	Qualitative (indoor air)	Receptor will have less exposure than workers	–
	Trespassers	Qualitative (outdoor air)	Receptor will have less exposure than workers	–

Indoor vapour modelling was considered for the following scenarios:

1. **Generic commercial building with a basement** – Generic default values as defined by MECP were used for all building parameters, including dimensions (20 m length, 15 m width, 3.0 m mixing zone height). Soil contamination was modelled at 191.25 cm below grade (basement extends to 161.25 cm, plus slab thickness of 11.25 cm, plus 29.9 cm of gravel crush, plus 0.1 cm of clean fill under the gravel crush for functionality of the model). Vapour modelling output is provided in Appendix B3.

2. **Site-specific commercial building with a basement** – The existing building was modelled using dimensions 34 m length by 38 m width. Default MECP values were

assumed for other model inputs, including 3.0 m mixing zone height and 11.25 cm slab thickness. Soil contamination was modelled at 191.25 cm below grade (basement extends to 161.25 cm, plus slab thickness of 11.25 cm, plus 29.9 cm of gravel crush, plus 0.1 cm of clean fill under the gravel crush for functionality of the model). Vapour modelling output is provided in Appendix B3.

3.2.2.3 Negligible Exposure Pathways

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 and 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 Exposure Estimates

Exposure estimates were calculated using standard models and equations (refer to Appendix B1). For direct contact exposure pathways, exposure estimates were calculated as average daily does (ADD) summing contributions from dermal contact and incidental ingestion exposure pathways. These summed values were compared to TRVs in the risk characterization phase. For soil inhalation pathways, total inhalation concentrations were calculated by summing contributions from soil particulate inhalation (the fraction inhaled and retained in the lungs) and vapour inhalation. Summed concentrations were compared to exposure limits (TRVs) in the risk characterization.

Benzo[a]pyrene belongs to a group of chemicals called PAHs that cause both non-carcinogenic and carcinogenic effects. Typically, non-carcinogenic risks are assessed individually for each PAH but carcinogenic risks are assessed for all 13 carcinogenic PAHs, regardless of whether they were screened in as COCs. Cancer risks are assessed using Toxic Equivalence Factors (TEF) based on the potency of each PAH relative to benzo[a]pyrene. Benzo[a]pyrene equivalent concentrations for each individual carcinogenic PAH were summed to determine the total carcinogenic TEF. For inhalation pathways, the benzo[a]pyrene equivalent concentrations were summed for the volatile carcinogenic PAHs only: acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, and pyrene.

Toxicological reference values for PHCs are based on the various aliphatic and aromatic sub-fractions within each of the four fractions. Therefore, for risks to be assessed, exposure assessment calculations had to convert environmental PHC F2 fraction concentrations to sub-fraction concentrations.

Exposure estimates are presented in the following tables:

- ❑ Soil COC oral/dermal contact – Table 3-7;
- ❑ Soil COC vapour inhalation – Table 3-8.

Details of exposure estimate results, including doses from specific exposure pathways, are provided in Appendix B3.

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

COC	Soil ingestion (mg/kg-day)	Dermal contact (mg/kg-day)	Soil particulate ingestion (mg/kg-day)	Total soil oral/dermal dose (mg/kg-day)
Outdoor worker				
Arsenic	1.24E-05	5.05E-06	5.09E-07	1.79E-05
Benzo[a]pyrene	5.89E-07	5.21E-07	1.21E-08	1.12E-06
Sum carcinogenic PAH	8.33E-07	7.37E-07	1.72E-08	1.59E-06
Construction worker				
Arsenic	1.24E-05	5.05E-06	5.09E-07	1.79E-05
Benzo[a]pyrene	5.89E-07	5.21E-07	1.21E-08	1.12E-06
Sum carcinogenic PAH	8.33E-07	7.37E-07	1.72E-08	1.59E-06

Table 3-8: Exposure Estimates – Inhalation

COC		Soil particulate conc. (mg/m^3)	Trench vapour conc. (mg/m^3)	Outdoor air conc. (mg/m^3)	Indoor air conc. (mg/m^3)	Total inhaled conc. (mg/m^3)
Indoor worker – Generic commercial building						
Arsenic		NA	NA	NA	–	–
Benzo[a]pyrene		NA	NA	NA	–	–
Sum carcinogenic PAH		NA	NA	NA	6.61E-09	6.61E-09
PHC F2	Aliphatic C>10-C12	NA	NA	NA	3.31E-03	3.31E-03
	Aliphatic C>12-C16	NA	NA	NA	1.59E-02	1.59E-02
	Aromatic C>10-C12	NA	NA	NA	2.56E-03	2.56E-03
	Aromatic C>12-C16	NA	NA	NA	3.38E-03	3.38E-03
Indoor worker – Site-specific building						
Arsenic		NA	NA	NA	–	–
Benzo[a]pyrene		NA	NA	NA	–	–
Sum carcinogenic PAH		NA	NA	NA	1.65E-09	1.65E-09
PHC F2	Aliphatic C>10-C12	NA	NA	NA	8.16E-04	8.16E-04
	Aliphatic C>12-C16	NA	NA	NA	3.78E-03	3.78E-03
	Aromatic C>10-C12	NA	NA	NA	6.31E-04	6.31E-04
	Aromatic C>12-C16	NA	NA	NA	8.13E-04	8.13E-04

Table 3-8: Exposure Estimates – Inhalation						
COC		**Soil particulate conc. (mg/m³)**	**Trench vapour conc. (mg/m³)**	**Outdoor air conc. (mg/m³)**	**Indoor air conc. (mg/m³)**	**Total inhaled conc. (mg/m³)**
Outdoor worker						
Arsenic		7.64E-07	NA	-	NA	7.64E-07
Benzo[a]pyrene		1.82E-08	NA	-	NA	1.82E-08
Sum carcinogenic PAH		2.57E-08	NA	6.61E-11	NA	2.58E-08
PHC F2	Aliphatic C>10-C12	5.24E-06	NA	3.03E-03	NA	3.03E-03
	Aliphatic C>12-C16	6.40E-06	NA	1.73E-03	NA	1.74E-03
	Aromatic C>10-C12	1.31E-06	NA	2.24E-04	NA	2.25E-04
	Aromatic C>12-C16	1.60E-06	NA	5.20E-05	NA	5.36E-05
Construction worker						
Arsenic		7.64E-07	-	-	NA	7.64E-07
Benzo[a]pyrene		1.82E-08	-	-	NA	1.82E-08
Sum carcinogenic PAH		2.57E-08	2.17E-09	6.61E-11	NA	2.80E-08
PHC F2	Aliphatic C>10-C12	5.24E-06	2.11E-03	3.03E-03	NA	5.14E-03
	Aliphatic C>12-C16	6.40E-06	1.21E-03	1.73E-03	NA	2.94E-03
	Aromatic C>10-C12	1.31E-06	1.81E-04	2.24E-04	NA	4.06E-04
	Aromatic C>12-C16	1.60E-06	9.64E-05	5.20E-05	NA	1.50E-04

NA – Not applicable (incomplete pathway)

3.2.3.1 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 dealt with include the following.

Soil 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 soil 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 soil in a trench was assessed, even though it is expected 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 soil 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.

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.

All the COCs in this HHRA have the potential to cause adverse health effects unrelated to cancer. Arsenic and PAHs are considered carcinogens. None of the COCs are 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 U.S. EPA sources) or, if not available, other recognized regulatory jurisdictions. The MECP's latest TRVs (July 2024) were employed in the RA.

3.3.2.1 Threshold-Acting Chemicals

A TRV for a threshold-acting chemical is typically expressed as a tolerable daily intake (TDI), a reference dose (RfD), a tolerable concentration (TC), or a reference concentration (RfC):

- ❑ The TDI is often used to describe a daily intake of a substance over a lifetime that is considered to be without appreciable health risk.
- ❑ The RfD is often used as an analog to the TDI but is specific to direct contact (ingestion and dermal). The RfD is as an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL (No-Observed Adverse Effect Level), LOAEL (Lowest-Observed Adverse Effect Level), or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used.
- ❑ The TC is often used to describe the airborne concentration of a substance that is considered to be without appreciable health risk.
- ❑ The RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used.

The TRVs used to assess non-cancer hazard in the HHRA are provided in Appendix B2.

3.3.2.2 Non-Threshold-Acting Chemicals

A TRV for a non-threshold-acting chemical is typically expressed as a cancer slope factor (CSF) or a unit risk factor (URF):

- ❑ 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. This estimate, usually expressed in units of proportion (of a population) affected per mg/kg-day, is generally reserved for use in the low-dose region of the dose-response relationship, that is, for exposures corresponding to risks less than 1 in 100. CSFs are generally derived using mathematical models that, in most cases, extrapolate results from animal studies conducted at high doses to low doses that may occur in human populations. This approach assumes that a threshold for the carcinogenic low dose response does not exist and that some risk is associated with any dose of the chemical. It should also be noted that for many compounds carcinogenicity has only been demonstrated in experimental animal models. Slope factors for each compound are derived for the most sensitive or affected organ or system (the target) in the studied species. In cases where only animal data are available, it is generally assumed that the target organ or system would be the same for a human subject. For strictly airborne concentrations where exposure occurs through inhalation, unit risk may be used to describe the risk associated with carcinogenicity.
- ❑ The URF is the upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 mg/m^3 in air; e.g., if the IUR was 2 x 10^{-3} per mg/m^3, then an individual continually exposed to 1 mg/m^3 would have a risk of developing cancer of 0.002 (0.2%); another way of interpreting it is if 1,000 people were continually exposed to 1 mg/m^3, then two excess cases of cancer would be expected.

The TRVs used to assess cancer risk in the HHRA are provided in Appendix B2.

3.3.2.3 Developmental Toxicants

Developmental toxicity is accounted for in the Exposure Assessment by excluding pro-rating factors. As previously stated, none of the COCs in this RA are classified as developmental toxicants.

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.

TRVs incorporate uncertainty factors to address the following sources of uncertainty:

- The expected differences in responsiveness between humans and animals; for example, chemicals may be assumed to be human carcinogens based on animal studies even when there is limited or no available evidence that the chemical is a human carcinogen. Such chemicals may not actually be carcinogenic in humans and therefore overestimate the potential risk levels. Candidates for long-term carcinogenicity studies in laboratory animals are typically selected based on preliminary evidence that indicates a potential concern. Included are results of short-term mutagenicity studies, chemical class considerations, or presence of structural elements that are similar to those present on known carcinogens. While many high priority chemicals have been studied, not all chemicals have undergone testing for carcinogenesis and as a result, some chemicals that have not been tested may actually be carcinogenic and therefore could pose a cancer risk. However, the toxicity data applied herein are based on the current state of the science regarding potential health effects caused by chemical exposure and therefore are appropriate.
- CSFs and URFs are derived from study data on animals dosed with high concentrations and therefore may not be applicable to the evaluation of low concentration exposures. High doses of chemicals may overwhelm the detoxification or excretion capabilities of an organism and allow the chemical to impact the target cells and therefore result in an overestimation of the risk and provide lower, more conservative PSSs. In cases where chemicals are activated to carcinogens by metabolism, tumor incidence may not increase at higher dose levels because the responsible metabolic pathway becomes saturated. The impact of this response on derived CSFs and URFs is unclear because derivation of CSFs and URFs involves fitting experimental data to a dose-response model and linearly extrapolating the curve through the origin. The slope of this linear portion of the curve is used to derive CSFs and URFs. As such, the impact of saturation at high doses on the extrapolated linear low-dose portion of the dose-response curve is uncertain.
- Variability among individuals within the human population.
- Extrapolation from a LOAEL to a NOAEL.
- Extrapolation from a sub-chronic to chronic exposure.
- 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 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 (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.

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 B3. 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).

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

- 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 B3. 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:

- Soil oral/dermal pathways (Table 3-9):
  - Indoor workers – Indoor workers are not at risk from direct contact pathways; exposure via direct contact with soil is assumed to be negligible for these receptors.
  - Outdoor workers – ILCR values exceeded 10^{-6} for arsenic, benzo[a]-pyrene, and the sum of all carcinogenic PAHs; outdoor workers are potentially at risk from incidental ingestion and dermal contact with soil.
  - Construction workers – The ILCR for arsenic exceeded 10^{-6}; construction workers are potentially at risk from incidental ingestion and dermal contact with soil.
- Soil inhalation pathways (Table 3-10) – Hazard quotients and ILCR values for all COCs were less than target values.

Table 3-9: Risk Results – Oral/Dermal Contact

COC	Non-cancer hazard			Cancer risk		
	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
Outdoor workers						
Arsenic	1.79E-05	3.0E-04	6.0E-02	1.79E-05	9.5E+00	**1.7E-04**
Benzo[a]pyrene	1.12E-06	3.0E-04	3.7E-03	1.12E-06	1.0E+00	**1.1E-06**
Sum carcinogenic PAHs	1.59E-06	-	-	1.59E-06	1.0E+00	**1.6E-06**
Construction workers						
Arsenic	1.79E-05	3.0E-04	6.0E-02	4.80E-07	9.5E+00	**4.6E-06**
Benzo[a]pyrene	1.12E-06	5.0E-03	2.3E-04	3.01E-08	1.0E+00	3.0E-08
Sum carcinogenic PAHs	1.59E-06	-	-	4.25E-08	1.0E+00	4.3E-08

Table 3-10: Risk Results – Inhalation

COC	Non-cancer hazard			Cancer risk		
	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
Indoor worker – Generic commercial building						
Arsenic	-	1.5E-05	-	-	1.5E-01	-
Benzo[a]pyrene	-	2.0E-06	-	-	6.0E-01	-
Sum carcinogenic PAHs	6.61E-09	-	-	6.61E-09	6.0E-01	4.0E-09
PHC F2	-	-	4.9E-02	-	-	-
Aliphatic C>10-C12	3.31E-03	1.0E+00	3.3E-03	3.31E-03	-	-
Aliphatic C>12-C16	1.59E-02	1.0E+00	1.6E-02	1.59E-02	-	-
Aromatic C>10-C12	2.56E-03	2.0E-01	1.3E-02	2.56E-03	-	-

Table 3-10: Risk Results – Inhalation						
	Non-cancer hazard			**Cancer risk**		
COC	**Total inhaled conc. (mg/m³)**	**Inhalation TRV (mg/m³)**	**HQ**	**Amortized inhaled conc. (mg/m³)**	**Inhalation TRV (mg/m³)⁻¹**	**ILCR**
Aromatic C>12-C16	3.38E-03	2.0E-01	1.7E-02	3.38E-03	-	-
Indoor worker – Site-specific building						
Arsenic	-	1.5E-05	-	-	1.5E-01	-
Benzo[a]pyrene	-	2.0E-06	-	-	6.0E-01	-
Sum carcinogenic PAHs	1.65E-09	-	-	1.65E-09	6.0E-01	9.9E-10
PHC F2	-	-	1.2E-02	-	-	-
Aliphatic C>10-C12	8.16E-04	1.0E+00	8.2E-04	8.16E-04	-	-
Aliphatic C>12-C16	3.78E-03	1.0E+00	3.8E-03	3.78E-03	-	-
Aromatic C>10-C12	6.31E-04	2.0E-01	3.2E-03	6.31E-04	-	-
Aromatic C>12-C16	8.13E-04	2.0E-01	4.1E-03	8.13E-04	-	-
Outdoor worker						
Arsenic	7.64E-07	1.5E-05	5.1E-02	7.64E-07	1.5E-01	1.2E-07
Benzo[a]pyrene	1.82E-08	2.0E-06	9.1E-03	1.82E-08	6.0E-01	1.1E-08
Sum carcinogenic PAHs	2.58E-08	-	-	2.58E-08	6.0E-01	1.6E-08
PHC F2	-	-	6.2E-03	-	-	-
Aliphatic C>10-C12	3.03E-03	1.0E+00	3.0E-03	3.03E-03	-	-
Aliphatic C>12-C16	1.74E-03	1.0E+00	1.7E-03	1.74E-03	-	-
Aromatic C>10-C12	2.25E-04	2.0E-01	1.1E-03	2.25E-04	-	-
Aromatic C>12-C16	5.36E-05	2.0E-01	2.7E-04	5.36E-05	-	-
Construction worker						
Arsenic	7.64E-07	1.5E-05	5.1E-02	2.05E-08	1.5E-01	3.1E-09
Benzo[a]pyrene	1.82E-08	2.0E-06	9.1E-03	4.87E-10	6.0E-01	2.9E-10
Sum carcinogenic PAHs	2.80E-08	-	-	7.49E-10	6.0E-01	4.5E-10
PHC F2	-	-	1.1E-02	-	-	-
Aliphatic C>10-C12	5.14E-03	1.0E+00	5.1E-03	1.38E-04	-	-
Aliphatic C>12-C16	2.94E-03	1.0E+00	2.9E-03	7.88E-05	-	-
Aromatic C>10-C12	4.06E-04	2.0E-01	2.0E-03	1.09E-05	-	-
Aromatic C>12-C16	1.50E-04	2.0E-01	7.5E-04	4.02E-06	-	-

3.4.1.1 Required Risk Reduction and Human Health Effects-Based Values

A summary of the HHRA quantitative assessment is presented in Table 3-11.

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, based on a source allocation factor (SAF) of 0.2 or 20%; for PHCs, the SAF is 0.5. Risk reduction factors were calculated as:

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

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

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

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

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

Risk management (RM) measures are needed to accomplish the necessary risk reductions. RM measures are presented in Section 5. A graphical depiction of the human health conceptual site model with RM implemented to block critical exposure pathways is presented in Figure 4.

Table 3-11: Risk Based Concentrations for Human Health

COC	REM soil conc. (µg/g)	Risk-based concentrations				Minimum risk-based conc. (µg/g)	RM req'd
		Oral/ dermal exposure (µg/g)	Inhalation exposure				
			Outdoor air (µg/g)	Indoor air (µg/g)	Trench air (µg/g)		
Indoor Workers – Generic Commercial Building							
Arsenic	32.76	NA	NA	–	NA	–	No
Benzo[a]pyrene	0.78	NA	NA	–	NA	–	No
Sum carcinogenic PAHs	1.10	NA	NA	–	NA	–	No
PHC F2	624	NA	NA	6,380	NA	6,380	No
Indoor Workers – Site-specific Building							
Arsenic	32.76	NA	NA	–	NA	–	No
Benzo[a]pyrene	0.78	NA	NA	–	NA	–	No
Sum carcinogenic PAHs	1.10	NA	NA	–	NA	–	No
PHC F2	624	NA	NA	26,400	NA	26,400	No
Outdoor Workers							
Arsenic	32.76	**0.192**	129	NA	NA	**0.20** [a]	**Yes**
Benzo[a]pyrene	0.78	**0.695**	17.1	NA	NA	**0.7** [a]	**Yes**
Sum carcinogenic PAHs	1.10	**0.695**	71.3	NA	NA	**0.7** [a]	**Yes**
PHC F2	624	–	50,600	NA	NA	50,600	No
Construction Workers							
Arsenic	32.76	**7.18**	129	NA	–	**7.4** [a]	**Yes**
Benzo[a]pyrene	0.78	–	17.1	NA	–	17.1	No
Sum carcinogenic PAHs	1.10	–	71.3	NA	31,600	71.3	No
PHC F2	624	–	50,600	NA	28,700	28,700	No

[a] Component value identified where risk-based value is less than component value.
NA – Not applicable

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.

3.4.2.2 Receptors Assessed Qualitatively

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

- Visitors and patrons represent people who may visit the commercial operation at the site. These receptors were not evaluated quantitatively because risks to these receptors are assumed to be conservatively represented by potential risks to staff who work at the site (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 visitors.
- Trespassers represent people from the surrounding community (e.g., teens) who may visit the site for reasons unrelated to it's intended purpose. Their greatest potential source of exposure to COCs is outdoor contact with soil. Their exposure is assumed to be infrequent and over a short-term timeframe. Risks to construction workers and outdoor workers are assumed to be conservatively representative of potential risks to the most highly exposed trespassers. Health standards protective of construction workers and outdoor workers are also considered to provide adequate protection for trespassers.

3.4.3 Summary of Risks to Human Health

Hazard quotients for arsenic and benzo[a]pyrene in soil were greater than one for the outdoor worker and construction worker exposed to soil via direct contact pathways. These results suggest that prolonged, intense exposure to contaminated soil by landscape workers or construction workers in a trench may result in adverse health effects. However, as noted previously, risks were calculated using a number of very conservative assumptions to ensure risks were not underestimated; i.e., the RA was designed to evaluate worst-case exposure scenarios. It is important to recognize that a risk assessment is desk exercise only, and that calculated risk estimates (hazard quotients, ILCRs) that exceed acceptable limits do not necessarily translate into adverse impacts for current or future occupants.

At this site, arsenic and benzo[a]pyrene impacts were limited to one soil sample each. Arsenic exceeding the Table 3 SCS was found in soil from sample BH5-S3 from at depth of 1.2–2.0 mbgs. Arsenic concentrations in the other 22 soil samples analyzed for metals were less than the soil standard. Similarly, benzo[a]pyrene impacts were present in sample BH6-22-AU1/SS2 collected from a depth of 0.3–1.37 mbgs, but not in any of the other 20 soil samples analyzed for PAHs. Contamination at the RA Property is not widespread and concentrations are only marginally greater than soil standards. In the case of arsenic, there is some evidence that the maximum concentration reported is naturally occurring: sample BH5-S3 was collected from the native glacial till stratum and the arsenic concentration in a sample from the overlying fill material did not exceed the Table 3 SCS.

Given that arsenic and benzo[a]pyrene impacts were found at depths of more than 0.3 m, these contaminants pose negligible risk to outdoor workers under current land use conditions. Samples with arsenic and benzo[a]pyrene impacts were collected from the centre of the site that is currently covered by an impervious asphalt surface that prevents direct contact with underlying soil. As such, maintenance of this hard surface is recommended to ensure the continued protection of outdoor workers. No additional measures are necessary to address risks to outdoor workers under existing conditions.

Risks to construction workers that may be exposed to subsurface soil in a trench or excavation may be managed using an occupational health and safety plan (HSP) to ensure workers use appropriate equipment to prevent direct contact with potentially contaminated soil.

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 was 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 Johnson & Ettinger model. 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* (US EPA 2004). Overall, the use of J&E model 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 Site Model

The ecological CSM summarizes the contaminant transport pathways relevant to ecological receptors, exposure pathways, and receptors. The CSM is presented in graphical form in Figure 5.

Subsurface investigations at the RA Property identified the presence of arsenic, benzo[a]pyrene, and PHC F2 in soil at concentrations greater than Table 3 SCS.

Contaminants in soil are subject to several environmental transport pathways:

- Volatilization to atmosphere – Volatile parameters may volatilize 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 leach from soil to groundwater and undergo subsurface transport, potentially discharging to a down-gradient surface water body. The MECP refers to this exposure pathway as the GW3 pathway.
- Degradation – Organic chemicals can be degraded over time by both abiotic and biotic pathways.

The nearest water body to the site is the Rideau River, located approximately 350 m west of the RA Property. The river is assumed to provide suitable habitat for a variety of aquatic receptors, including aquatic plants, aquatic invertebrates, amphibians, and fish. The potential discharge of contaminated groundwater to the Rideau River 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;
- Soil invertebrates, represented by earthworms;
- Mammals: herbivorous meadow vole, insectivorous short-tailed shrew; and
- Birds: herbivorous red-winged blackbird; insectivorous American woodcock.

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 pathway:

- ❑ 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.
- ❑ Direct/dermal contact – Soil invertebrates are potentially exposed to COCs 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 COCs in soil via ingestion of soil during foraging.
- ❑ Ingestion of food/prey – Mammals and birds are exposed to COCs 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 via leaching 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 COCs for ERA

In Section 2.5, COCs in soil were identified based on comparison to Table 3 SCS. To identify those requiring further examination in the ERA, REM concentrations of COCs in soil were screened against several ecological component values:

- 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 arsenic. 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 arsenic via the S-GW3 pathway is considered to be negligible. Metals such as arsenic have poor aqueous solubility and tend to bind strongly to soil particles, exhibiting low mobility in groundwater. This is supported by the absence of any metals in groundwater exceeding GW3 values. Because the distance from the RA Property to the nearest water body (350 m) is greater than the default value assumed in the generic model, site-specific S-GW3 values were calculated using the Ministry's MGRA model, which includes the Domenico 2-D transport model for estimating concentrations of parameters discharging to a water body at a specified distance from the RA property.

The secondary screening of COCs is presented in Table 4-1.

Table 4-1: Screening of Soil COCs for ERA

COC	REM concentration (µg/g)	Plants & soil organisms (µg/g)	Mammals & birds (µg/g)	S-GW3 Table 3 S-GW3 (µg/g)	S-GW3 Site-specific S-GW3 (350m) (µg/g)
Arsenic	32.76	40	330	NV	NV
Benzo[a]pyrene	0.78	72	46,000	3.80E+13	2.87E+14
PHC F2	624	**260**	**NV**	**230**	1,730

NV – No value

The following COCs were evaluated quantitatively in the ERA:

- PHC F2 – Root uptake/direct contact (plants and soil organisms); ingestion (mammals and birds).

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.

A search of the Ontario National Heritage Information Center (NHIC) online database was conducted to identify threatened and endangered species within a 1-km^2 area (grid 18VR4731) 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). 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.
- Skillet Clubtail – The skillet clubtail (*Gomphorus venticosus*) is listed under Species at Risk in Ontario (SARO) as *Threatened*. The skillet clubtail is a dragonfly found in medium to slow-running mesotrophic waters with fine substrate, usually having a significant component of silt and/or clay. The preferred habitat in Canada is the Saint John River in New Brunswick. As the site does not include any surface water bodies, no habitat for the skillet clubtail exists at the site.
- Chimney Swift – The chimney swift (*Chaetura pelagica*) is listed as *Threatened* by COSEWIC and SARO. The chimney swift is a medium-sized (12-14 cm long; 21 g) bird that breeds in central and eastern Canada and overwinters in South

America. Swifts are aerial insectivores, foraging over a variety of habitats, including cities, towns, and villages, as well as various natural landscapes. The chimney swift preys mostly on beetles, true bugs, caddisflies, mayflies, crane flies, wasps, ants, and bees. The chimney swift utilizes either natural or anthropogenic chimneys, vacant or derelict buildings for roosting and breeding. A vertical cavity with an interior surface that is porous but stable, and to which swifts can cling and attach their nests, is required. Suitable chimneys are those with an opening diameter greater than 28.5 cm and a rough interior surface. As there are several older houses potentially with chimneys in the vicinity of the RA Property, the presence of the chimney swift at the site cannot be excluded; e.g., chimney swift may forage for aerial insects at the site.

- Least Bittern – The least bittern (*Ixobrychus exilis*) is listed as *Threatened* by COSEWIC and SARO. The least bittern 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; no such habitat exists at the RA Property.

The potential for chimney swifts to forage at the RA Property cannot be excluded. Chimney swifts that forage at the site may be exposed to soil COCs via ingestion of invertebrates that accumulate contaminants from soil. To address the potential for chimney swifts to be exposed to contaminants in soil at the site, a surrogate avian insectivore species (American woodcock) was included as a VEC in the ERA. The American woodcock was evaluated instead of the chimney swift because the natural history of the bird (e.g., diet, ingestion rates, etc.) is well known.

4.2.2 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;

- Birds: herbivorous red-winged blackbird, insectivorous American woodcock;
- Aquatic plant community;
- Aquatic invertebrate community;
- Amphibian community; and
- Fish community.

Descriptions of VECs are provided below.

4.2.2.1 Terrestrial Plants

The site supports typical urban landscaping 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 MECP guidance, 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.

4.2.2.2 Soil Invertebrates

Soil at the site 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.

4.2.2.3 Meadow Vole

Portions of the site may be suitable for supporting small herbivorous mammals. Of the mammals that may be present, 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).

4.2.2.4 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).

4.2.2.5 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.

4.2.2.6 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.

4.2.2.7 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.

4.2.2.8 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. 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.

4.2.2.9 Amphibians

The nearest water body to the site is 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.

4.2.2.10 Fish

Fish may be potentially affected by contaminants in surface water. Because there are numerous fishes that may be potentially impacted by contaminants, 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.

4.2.3 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);
- ❑ Survival, growth, and reproduction of bird populations (American woodcock, red-winged blackbird); 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. For wildlife, measurement endpoints are usually defined as some low-effect threshold concentration such as a LOAEL, derived from laboratory studies using oral exposures in a sensitive test species representative of small mammals and birds. The LOAEL is documented as the lowest concentration at which a relevant adverse effect (e.g., diminished growth or fewer offspring) was demonstrated in a study using appropriate exposure conditions. 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 consisted of benchmark concentrations derived from multiple endpoints (e.g., 25th percentile of effect concentration 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).

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/contact (from soil);
- Foliar uptake of vapours;
- Direct/dermal contact (with soil);
- Ingestion of soil;
- Ingestion of food/prey;
- Inhalation of soil; and
- Inhalation of vapours.

Potentially complete exposure pathways for off-site receptors included:

- Foliar uptake of vapours;
- Inhalation of soil;
- Inhalation of vapours;
- 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.

Summaries of major exposure pathways for on-site receptors are provided below.

4.3.1.1 Root Uptake from Soil

In general, plants may be exposed to chemicals via root uptake or foliar uptake. Root uptake is the primary route of exposure for contaminants in soil. Root contact and uptake of COCs from soil is assumed to be a complete exposure pathway for terrestrial plants.

For root uptake to occur, roots must make contact with contaminants. Therefore, rooting depth is a major factor limiting uptake. Although rooting depth varies among different plant species and according to soil properties (e.g., mechanical resistance, aeration, fertility, moisture), relatively few plant species have rooting depths greater than 1 m, and in most natural ecosystems the majority of root mass is contained in the upper 0.5 m depth (Suter *et al.* 2000). In temperate zones, even large, mature trees do not typically have tap root systems extending to great depths. A large data set of root dimensions on windthrown trees (Gasson and Cutler 1990) revealed 90 to 99% of root mass was contained within the upper 1 m. For the purposes of the risk assessment, however, it was assumed that root contact/uptake from soil is a complete exposure pathway regardless of soil depth; i.e., a full-depth approach was used, consistent with MECP expectations for an RA conducted under O. Reg 153/04.

Root uptake of organic chemicals is determined partly by soil characteristics (e.g., pH, clay and organic matter content/type, and moisture content), and partly by the selective absorption from soil solution by the root. In general, uptake into plants is considered a minor pathway of exposure for PHC constituents, due to limited aqueous solubility (CCME 2008). Nevertheless, PHCs can inhibit plant growth and development through effects on root systems.

4.3.1.2 Foliar Deposition and Uptake

Volatile COCs such as PHC F2 in soil may volatilize and migrate to outdoor air. Terrestrial plants may take up contaminants from outdoor air via foliar uptake. Foliar uptake is limited to atmospheric contaminants (i.e., those released into the air from incineration, etc.) and those that volatilize from shallow soil strata. Compared to root uptake, foliar uptake is considered a minor exposure pathway for most chemicals. Risks from foliar uptake were evaluated using a qualitative approach.

4.3.1.3 Direct Contact with Soil

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.

The feeding and burrowing habits of earthworms determine their exposure to chemicals in soil and litter. For the purposes of the risk assessment, it was assumed that root contact/uptake is a complete exposure pathway regardless of soil depth; i.e., a full-depth approach was used.

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.

4.3.1.4 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 voles 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.

4.3.1.5 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. Although some PHC constituents have chemical properties that allow uptake by plants, significant accumulation of these chemicals at concentrations greater than ambient concentrations in soil rarely occurs, possibly because the rhizosphere is a zone of enhanced biological activity which increases the rate of degradation of these compounds (Chaineau *et al*. 1997). PHCs are considered to have a low likelihood of uptake by terrestrial plants. Uptake and accumulation of PHC by animals also is minimal. PHC mixtures are easily metabolized and/or eliminated in most invertebrate and vertebrate animals. Like other eukaryotes, earthworms possess the multifunction oxidase systems required to oxidize aliphatic hydrocarbons, as well as cytochrome P450 enzymes required to metabolize aromatic hydrocarbons (Dhainaut and Scaps 2001). However, there is evidence that earthworm species vary considerably in their capacity to absorb and degrade xenobiotics (Gilman and Vardanis 1974) likely due to earthworm species having divergent affinity for and activity towards different chemicals (Stenerson *et al*. 1992). As a result, tissue concentrations of PHCs are expected to remain very low, and mammalian and avian receptors that consume earthworms, as well as higher-order carnivores that consume small mammals and birds, will not receive significant levels of exposure through food chain pathways. Consistent with the approach defined by the CCME, it was assumed that "*consumption of either plants or other* *animals (as opposed to soil ingestion) does not tend to constitute the major component of exposure for PHC in wildlife and livestock populations"* (CCME 2008).

4.3.1.6 Soil Inhalation

Entrainment of surface soil by wind can result in airborne contaminants that may be inhaled by wildlife. As entrained soil may be transferred to off-site properties, both on-site and off-site wildlife may be exposed to soil contaminants via this pathway. 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.

4.3.1.7 Vapour Inhalation

Wildlife 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. Risks from foliar inhalation pathways were evaluated using a qualitative approach.

4.3.1.8 Exposure of Aquatic Receptors

Aquatic receptors may be exposed to COCs in surface water via several uptake pathways, including foliar uptake, root uptake, dermal contact, uptake across the gills, ingestion of water, and ingestion of food. The secondary screening determined that no COCs at the site exceeded S-GW3 values and therefore exposure of off0site aquatic receptors is considered to be negligible.

4.3.2 Exposure Estimates

PHC F2 was the only soil COC requiring quantitative evaluation in the ERA. Exposure estimates are provided for (i) terrestrial plants and soil invertebrates and (ii) wildlife receptors. At this site, risks from groundwater COCs were evaluated using a qualitative approach (ERA screening) and therefore no exposure estimates were calculated.

For terrestrial plants and soil invertebrates that are only exposed to PHC F2 in soil via root uptake or direct contact, exposure estimates typically are represented by the estimated maximum soil concentrations (REM). For wildlife, exposure estimates are presented as weight-normalized daily doses.

4.3.2.1 Terrestrial Plants and Soil Invertebrates

Because plants and soil invertebrates are essentially immobile, exposure of an individual to contaminants cannot be averaged or integrated among areas of the property with higher and lower concentrations. Some fraction of individuals in a population at a site are potentially exposed to the highest concentrations of COCs. Therefore, the exposure estimate for these receptors was based on the REM (maximum plus 20%) concentrations of PHC F2 in soil (624 µg/g).

4.3.2.2 Wildlife Receptors

In general, wildlife are potentially exposed to soil COCs via several pathways, with ingestion of soil and food items being the primary exposure route. The ecological conceptual exposure model identified accumulation of COCs in plants and soil invertebrates as a potential exposure pathway. Average daily doses (ADD) received by mammals and birds were calculated for PHC F2 using the following equation:

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

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

At this site, the only soil COC evaluated quantitatively was PHC F2, which is assumed to have negligible accumulation in vegetation, soil invertebrates, or prey animals. Therefore, at this site, uptake was calculated based on soil ingestion only.

REM concentrations of COCs in soil were used in exposure calculations for wildlife. As wildlife are potentially capable of amortizing exposure from areas of low and high COC concentrations, the use of maxima resulted in conservative estimates of exposure that are likely greater than those actually received by wildlife.

Body weight and soil consumption rates 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 2011a). Exposure factors for wildlife VECs are summarized in Table 4-2.

Table 4-2: Exposure Factors for Ecological Receptors		
Receptor	**Body weight (kg)**	**Soil ingestion rate (kg/d)**
Meadow vole	0.044	1.80E-05
Short-tailed shrew	0.015	1.87E-04
Red-winged blackbird	0.064	0.00109
American woodcock	0.198	0.0025

Exposure estimates (ADD) for terrestrial wildlife receptors are presented in Table 4-3.

Table 4-3: Exposure Estimates for Ecological Receptors	
Receptor	**Average daily dose (mg/kg/day)**
Meadow vole	0.255
Short-tailed shrew	7.78
Red-winged blackbird	10.6
American woodcock	7.88

4.3.3 Uncertainty

It is recognized that some residual uncertainty in exposure analysis always remains due to constraints of the data (i.e., sampling provides only an estimate of actual contaminant concentrations). Because no modelling 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 the exposure assessment was addressed by using conservative estimates of exposure based on maximum concentrations plus 20% during the ecological screening to ensure risks were not underestimated as a result of other uncertainties.

The level of uncertainty in the exposure estimates for terrestrial wildlife receptors is considered acceptable. Estimated doses from the ingestion pathway are strongly dependent 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. Soil ingestion rates for the woodcock and the shrew were estimates calculated by the MECP based on the rate of ingestion of earthworms; soil ingestion rates may be overestimated for individuals that consume a greater proportion of other invertebrates (e.g., beetles, arthropods, etc.) that tend to have less soil adhered to them.

No adjustments to the dose calculations were made for bioavailability; i.e., the fraction of a chemical absorbed by the digestive system of the receptor and available to interact with biological tissues. Some chemicals have low bioavailability and are poorly absorbed in the GI tract; others are readily taken up. For the purposes of the RA, 100% bioavailability was assumed; therefore, doses were overestimated for chemicals with low bioavailability.

4.4 Hazard Assessment

A quantitative evaluation of risks from COCs in soil was performed for the following VECs:

- Plants and soil organisms;
- Mammals and birds.

4.4.1 Toxicity Reference Values

PHC F2 was the only COC requiring quantitative evaluation in the ERA. The F2 fraction is defined by CCME (2008) as the range including compounds with equivalent carbon numbers >10 through 16, and includes the following subfractions: C>10-C12 aliphatic, C>12-C16 aliphatic, C>10-C12 aromatic and C>12-C16 aromatic. By weight, this fraction consists of 80% aliphatics and 20% aromatics.

4.4.1.1 Plants and Soil Invertebrates

The TRV for the F2 fraction in plants and soil invertebrates was based on data reported by the CCME in the development of the Canada Wide Standard for Petroleum Hydrocarbons (CCME 2008a). The CCME considered both laboratory data and field data when identifying the standard. The standard is based on the 50th percentile of threshold effects data (LC/IC20/25) from growth-based endpoints in terrestrial plants (alfalfa, northern wheatgrass, and barley) and invertebrate species (*O. folsomi* and *E. andrei*). Endpoints in plants included various measures of growth, including shoot length/weight, root length/weight, and whole plant weight. Endpoints in invertebrates included several chronic endpoints based on survival, growth, and reproduction. The 50th percentile for all effects was estimated to be 260 mg/kg ("initial realized"). This value was adopted as the benchmark for both plants and soil invertebrates.

4.4.1.2 Mammals

The mammalian TRV for PHC F2 is derived from a study of health effects in cattle (Stober 1962) cited by CCME in the development of the Canada Wise Standards for PHCs (CCME 2008). Stober exposed cattle to crude oil via food and reported a threshold value equivalent to 210 mg/kg/d when adjusted to a weight-normalized daily dose. The threshold value was based on an unbounded LOAEL for behavioural, blood chemistry, and liver function endpoints, all of which were reversible within eight to ten days following exposure. The portion attributable to the F2 fraction (based on the standard composition assumed by CCME) was 44.73 mg/kg/day.

4.4.1.3 Birds

Insufficient data are available for the derivation of avian TRVs for PHC fractions.

4.4.2 Uncertainty

MECP does not provide mammalian TRVs for PHCs. The TRV for PHC F2 was adopted from values recommended for use at Federal Contaminated Sites Action Plan (FCSAP) sites provided by Environment and Climate Change Canada (ECCC) in Module 7 of the *Ecological Risk Assessment Guidance* (ECCC 2021). The TRV for the F2 fraction was based on an unbounded LOAEL for behavioural responses, blood chemistry, and liver functioning endpoints in cattle exposed to crude oil via food (Stober 1962). ECCC (2021) noted several limitations of the TRV:

- ❑ The TRV is based on potentially overly conservative endpoints that were also observed to be reversible in the underlying toxicological study.
- ❑ The TRV was based on a single study with very small sample size (one cow). Therefore, it is not possible to quantify the magnitude of effect associated with this TRV.
- ❑ It is also not possible to quantify uncertainty associated with this TRV, in terms of natural range in biological responses to PHC exposure between different cows, or between different types of mammals.
- ❑ Additionally, Stober (1962) could not determine if the observed endpoints were necessarily due to toxicity through PHC exposure, or from malnutrition; given the option, cows would choose non-contaminated food over contaminated food, and cows with access to only contaminated food would choose not to eat.

Given these limitations, ECCC gave the TRVs for PHCs a grade of “C”, recommending both values as a default TRV, but with substantial inconsistencies with FCSAP TRV guidance, and low degree of confidence in its overall suitability as a default for federal contaminated sites. Considering the test conditions under which the TRVs were developed, the use of the TRVs likely results in an overestimation of the risk to mammals.

Overall, the uncertainty in the hazard assessment was considered to be acceptable for meeting the objectives of the ERA.

4.5 Risk Characterization

Risks to ecological receptors, as represented by terrestrial plants, soil invertebrates, meadow vole, short-tailed shrew, red-winged blackbird, and American woodcock, were assessed using a quantitative approach, where possible. Risks were assessed in the absence of RM measures. A qualitative assessment of risk was conducted for birds, for which no TRV could be identified.

4.5.1 Quantitative Interpretation of Ecological Risks

Hazard quotients (HQ) or 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:

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

Exposure ratios were interpreted as follows: if the ER was less than one, no unacceptable risks to ecological receptors were expected, because concentrations were below levels known to cause adverse effects. Conversely, if the ER exceeded one, it was inferred that adverse effects to individuals were possible.

Given a certain magnitude and type of effect associated with a particular TRV or assessment endpoint, inferences about potential effects can be made. For example, if the level of exposure exceeds a TRV based on a 25% reduction in a growth-based endpoint (ER > 1), it can be inferred that one possible outcome may be diminished growth of individuals, potentially (but not necessarily) leading to a reduction in population abundance of that receptor. However, exceeding an ER of 1 does not necessarily mean adverse effects will occur; rather, it suggests that we have less confidence that adverse effects will not occur.

4.5.1.1 Terrestrial Plants and Soil Invertebrates

Terrestrial plants and soil invertebrates are potentially exposed to PHC F2 in soil via direct contact pathways (root uptake and dermal contact). The exposure estimate for plants and soil invertebrates was based on the REM concentration of PHC F2. The exposure ratios for PHC F2 was greater than one:

$$\text{Exposure ratio} = \frac{624\ \mu g/g}{150\ \mu g/g} = 4.2$$

It may be inferred from this result that survival, growth, and reproduction of plants and soil organisms may be inhibited by PHC F2 in soil at the site if available for uptake/contact.

PHC F2 was found in one soil sample only: BH1-22-SS4, collected from a depth of 2.29–2.89 mbgs and located on the north side of the property in an area of the site covered by asphaltic concrete. All other soil samples, including those collected from the soil surface and depths less than 1 mbgs, reported PHC F2 concentrations less than Table 3 SCS. Sample BH1-22-SS4 was collected from native glacial till consisting of dense, black silty sand to sandy silt with clay and shale fragments. Volatile organic levels from the photoionization detector (PID) were elevated significantly relative to soil in shallower samples from this borehole. The absence of elevated PID readings in shallow samples and the presence of shale in sample SS4 suggests that PHC F2 in this sample may be naturally elevated rather than as a result of anthropogenic contamination. Shale in the Ottawa area is known to exhibit elevated hydrocarbon concentrations.

Considering that PHC F2 impacts were found in only one sample across the site and was present at a depth that is inaccessible to plants and soil invertebrates, PHC F2 is considered to pose negligible risk to these ecological receptors. At a minimum depth of 2.3 mbgs, contaminated soil is not accessible by plant roots or by burrowing invertebrates. Therefore, the risk to plants and soil invertebrates from PHC F2 is negligible.

4.5.1.2 Wildlife

Mammalian and avian receptors are potentially exposed to PHC F2 in soil via ingestion of soil. Exposure ratios for the herbivorous meadow vole and insectivorous shrew were less than one (Table 4-4) suggesting that risks to mammals from PHC F2 in soil are negligible. No exposure ratios were calculated for avian receptors.

Table 4-4: Risk Estimates for Ecological Receptors

Receptor	Average daily dose (mg/kg/day)	Toxicity reference value (mg/kg/day)	Exposure ratio
Meadow vole	0.255	44.73	0.0057
Short-tailed shrew	7.78		0.17
Red-winged blackbird	10.6	NV	NV
American woodcock	7.88		NV

NV – No value

4.5.2 Qualitative Interpretation of Ecological Risks

A qualitative evaluation of ecological risks is provided for:

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

3. Receptors without TRVs.

4.5.2.1 Negligible Exposure Pathways

Foliar Deposition

Foliar uptake is limited to atmospheric contaminants (i.e., those released into the air from incineration, etc.) and those that volatilize and are released from shallow soil into ambient air. 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 negligible.

Vapour Inhalation

Wildlife may be exposed to volatile COCs via inhalation. Exposure levels from inhalation are minimal, as dilution in outdoor air prior to uptake typically results in negligible concentrations available for uptake. Therefore, the risk to wildlife from exposure via inhalation of VOCs is considered to be negligible.

4.5.2.2 COCs Screened Against Component Values

A qualitative evaluation (Section 4.1) was conducted by screening REM concentrations of COCs against MECP component values. The REM concentrations of arsenic and benzo[a]pyrene were less than component values for plants and soil invertebrates and for mammals and birds, indicating that negligible risk exists for these receptors. REM concentrations of all three COCs were less than site-specific S-GW3 values, indicating that risks to off-site aquatic receptors also are negligible.

4.5.2.3 Receptors without TRVs

An avian TRV for PHC F2 was not identified. In general, there are fewer toxicological studies of birds than mammals, there are few avian studies of PHCs, and there are essentially no studies of avian toxicity using the CCME fractions of PHCs. Therefore, an avian TRV for PHC F2 could not be identified.

In a review of toxicological data for a variety of terrestrial species, Kapustka (2004) noted that for hydrocarbon compounds for which both avian and mammalian toxicological data were available, mammals were always more sensitive than birds.

Therefore, it is reasonable to assume that the mammalian TRV for PHC F2 may provide adequate protection for birds. The average daily doses received by both the red-winged blackbird (10.6 mg/kg/day) and the American woodcock (7.88 mg/kg/day) were less than the mammalian TRV for PHC F2 (44.73 mg/kg/day). Based on this comparison, it is reasonable to conclude that PHC F2 likely poses no unacceptable risks to birds exposed to contaminated soil. It is also worth noting that the PHC F2 impacts were found at a depth inaccessible to wildlife receptors and therefore the exposure pathway is currently incomplete.

4.5.3 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 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. As no groundwater COCs were identified and soil impacts were at depths considered to be inaccessible to plants via root uptake, direct contact and ingestion exposure pathways are incomplete for terrestrial ecological receptors.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This RA evaluated risks to human and ecological receptors representative of current conditions with the existing building and commercial land use. The RA was intended to support the identification of risk management measures (RMM) that might be necessary to protect the health of residents and other receptors under the current use scenario.

As noted previously, the RA was designed to evaluate worst-case exposure scenarios. This is a conservative approach intended to ensure that risks are not underestimated. It is important to recognize that a risk assessment is desk exercise only, and that calculated risk estimates (hazard quotients, ILCRs, exposure ratios) that exceed acceptable limits do not necessarily translate into adverse impacts for current or future human or ecological receptors.

5.1 Conclusions

5.1.1 Risks to Human Health

The main findings of the HHRA were as follows:

- Soil oral/dermal pathways:
  - Indoor workers – Indoor workers are not at risk from direct contact pathways; exposure via direct contact with soil is assumed to be negligible for these receptors.
  - Outdoor workers – ILCR values exceeded 10^{-6} for arsenic, benzo[a]pyrene, and the sum of all carcinogenic PAHs for incidental ingestion and dermal contact pathways.
  - Construction workers – The ILCR for arsenic exceeded 10^{-6} for incidental ingestion and dermal contact pathways.
- Soil inhalation pathways – Hazard quotients and ILCR values for all COCs were less than target values; human receptors are not at risk from inhalation pathways.

A summary of the risks to human health are presented in Table 5-1.

Table 5-1: Summary of Risk/Hazard Results for Human Receptors

Source	Pathway	Receptor	Endpoint	Risk
Soil	Incidental ingestion and dermal contact	Indoor workers	All pathways	No risk (no exposure to soil)
		Outdoor workers	Non-cancer	No risk
			Cancer	Arsenic, benzo[a]pyrene, PAHs
		Construction workers	Non-cancer	No risk
			Cancer	Arsenic
	Vapour & particulate inhalation	All receptors	All endpoints	No risk
Ground-water	Drinking water ingestion	All receptors	All endpoints	No risk (no groundwater COCs)
	Incidental ingestion and dermal contact	Construction worker	All endpoints	No risk (no groundwater COCs)
	Vapour inhalation	All receptors	All endpoints	No risk (no groundwater COCs)

Given that arsenic and benzo[a]pyrene impacts were found at depths of more than 0.3 m, these contaminants pose negligible risk to outdoor workers under current land use conditions. Samples with arsenic and benzo[a]pyrene impacts were collected from the centre of the site that is currently covered by an impervious asphalt surface that blocks direct contact with underlying soil. As such, no additional measures are necessary to address risks to outdoor workers under existing conditions.

Risks to construction workers that may be exposed to subsurface soil in a trench or excavation may be managed using an occupational health and safety plan (HSP) to ensure workers use appropriate equipment to prevent direct contact with potentially contaminated soil.

5.1.2 Risks to the Environment

The main findings of the ERA were as follows:

- ❑ The exposure ratio for PHC F2 was greater than one for terrestrial plants and soil invertebrates. Considering that PHC F2 impacts were found in only one sample across the site and was present at a depth that is inaccessible to plant roots and burrowing soil invertebrates, PHC F2 is considered to pose negligible risk to plants or soil invertebrates.
- ❑ Exposure ratios for PHC F2 for mammalian receptors were less than one, suggesting that PHC F2 in soil poses negligible risk for mammalian wildlife. No exposure ratio was calculated for birds, but a qualitative comparison of doses predicted for birds and the mammalian TRV suggests risks are negligible for avian receptors as well. PHC F2 impacts were found at a depth inaccessible to wildlife receptors and therefore the exposure pathway is currently incomplete.
- ❑ Concentrations of soil contaminants at the site were less than S-GW3 values considered to be protective of aquatic life in the nearest water body (Rideau

River). Therefore, risks to off-site aquatic receptors via leaching and groundwater discharge are negligible.

A summary of ecological risk estimates is provided in Table 5-2.

Table 5-2: Summary of Risk/Hazard Results for Ecological Receptors

Source	Pathway	Receptor	Risk
Soil	Root uptake	Terrestrial plants	PHC F2 (negligible risk)
	Foliar uptake	Terrestrial plants	No risk
	Direct contact	Soil invertebrates	PHC F2 (negligible risk)
	Ingestion	Meadow vole	No risk
		Short-tailed shrew	No risk
		Red-winged blackbird	No risk
		American woodcock	No risk
	Inhalation	Wildlife	No risk
	S-GW3	Aquatic receptors	No risk
Groundwater	Root uptake	Terrestrial plants	No risk (no groundwater COCs)
	Inhalation	Wildlife receptors	No risk (no groundwater COCs)
	GW3	Aquatic receptors	No risk (no groundwater COCs)

5.2 Recommended Risk Management Measures

Theoretical risks were identified for outdoor workers and construction workers from direct contact/ingestion of soil impacted by arsenic and benzo[a]pyrene.

Risk management measures (RMM) are recommended to ensure that relevant source-to-receptor exposure pathways are minimized/mitigated/blocked. The RMMs must be capable of providing the required level of risk reduction. Effects-based concentrations and required risk reduction factors are provided in Table 5-3.

Table 5-3: Summary of Required Risk Reductions

Exposure pathway	Receptor	COC	Soil REM (µg/g)	Minimum effects-based value (µg/g)	Risk reduction factor
Oral/dermal contact	Outdoor workers	Arsenic	32.76	0.2	164
		Benzo[a]pyrene	0.78	0.7	1.1
		Sum PAHs	1.1	0.7	1.6
	Construction workers	Arsenic	32.76	7.4	4.4

Recommended RMM are listed in Table 5-4. The objectives of the RMM are to render the risks/hazards to acceptable levels, primarily by blocking or eliminating exposure pathways or reducing exposure concentrations. Implementation of the RMM at the RA Property will ensure risks to human health are negligible.

Table 5-4: Risk Management Measures

Risk Management Measure	Applicable pathways of exposure	Discussion/rationale
Surface Barrier		
Maintenance of hard cap surface barrier over soil impacts	Outdoor workers: Direct contact (incidental ingestion, dermal contact)	Existing asphalt surface in areas with soil impacts should be maintained. This RMM provides nearly 100% risk reduction as exposure pathway is inoperable.
Health and Safety Plan		
Health and Safety Plan for construction workers	Construction workers: Direct contact (incidental ingestion or dermal contact) with soil in a trench	The use of personal protective equipment (PPE) mitigates exposure through direct contact (incidental ingestion or dermal contact) with soil in a trench setting.

Details on the recommended RMM are provided below.

5.2.1 Surface Barrier

Surface barrier systems include soft caps such as uncontaminated soil or hard caps (i.e. concrete or asphalt, landscaping pavers, and/or other constructed hard cap features including buildings), intended to address direct contact pathways. An intact surface barrier effectively blocks exposure by direct contact pathways (dermal contact, ingestion, root uptake) for both human and ecological receptors. With a surface barrier in place, risks to human health and the environment are negligible.

Currently, existing asphalt and concrete pavers cover much of the RA Property, including locations with underlying contaminated soil. Maintenance of existing hard cap barriers at the RA Property will provide effective protection from direct contact exposure pathways.

If existing hard cap barriers are altered or damaged such that cover is discontinuous or absent in areas overlying known contaminated soil, barriers should be reinstalled at the earliest opportunity with a hard cap or soft cap barrier. The barriers should incorporate the following design features:

- ❑ Fill Cap Barriers – The fill cap barriers must be at least 0.5 m (50 cm) 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. The 0.5 m soil cap thickness is suggested to be consistent with the Ministry's RMMs outlined in the Approved MGRA Model (MECP, 2016; November 1, 2016 version). In areas where deep-rooting trees are to be placed, there is a need to provide clean soil to a depth and width of two times the root ball. The fill cap is overlain by topsoil or planting media as required to establish growth of plants/grasses, or other landscape or other landscape ornaments.

- Hard Cap Barriers – Hard cap barriers that will be installed must include non-soil surface treatments such as asphalt, concrete or concrete pavers, stone pavers, brick or aggregate, and may include the footprint of a building (i.e., walls over the footings and the floor slabs), in addition to concrete walkways. The hard cap layers must 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 and include the building foundation or building floor slab meeting these specifications.

The fill caps or hard caps should cover areas of the RA Property where COCs are present above the human and ecological risk-based standards found within 0.5 m of the surface. It is recommended that buried infrastructure/utilities be covered with clean soil or granular materials. A light-duty geotextile or other measure (red/yellow warning/safety tape, etc.) should be placed over top of the infrastructure to demarcate its location.

5.2.2 Health and Safety Plan

A health and safety plan (HSP) should be prepared and implemented by a Competent Person as defined under the *Ontario Health and Safety Act* for any excavation which may extend to depths intersecting impacted soil at the site to protect construction workers or other individuals from exposure to direct contact with soil. The HSP should be specific to the planned excavation and must consider the COCs at the site and make provision for occupational hygiene, personal protective equipment, contingency measures, and documentation.

Personal Protective Equipment (PPE) is required to shield or isolate individuals from the chemical hazards posed by contaminants at a site. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. In addition to safety equipment normally required for excavation works, workers should be equipped with:

- Tyvek coveralls;
- PVC or latex gloves;
- Disposable overboots;
- Light-duty dust mask.

The contractor should provide hand washing stations on site, which shall be used by all workers prior to smoking, drinking or eating, or leaving the site following work completed within a trench setting.

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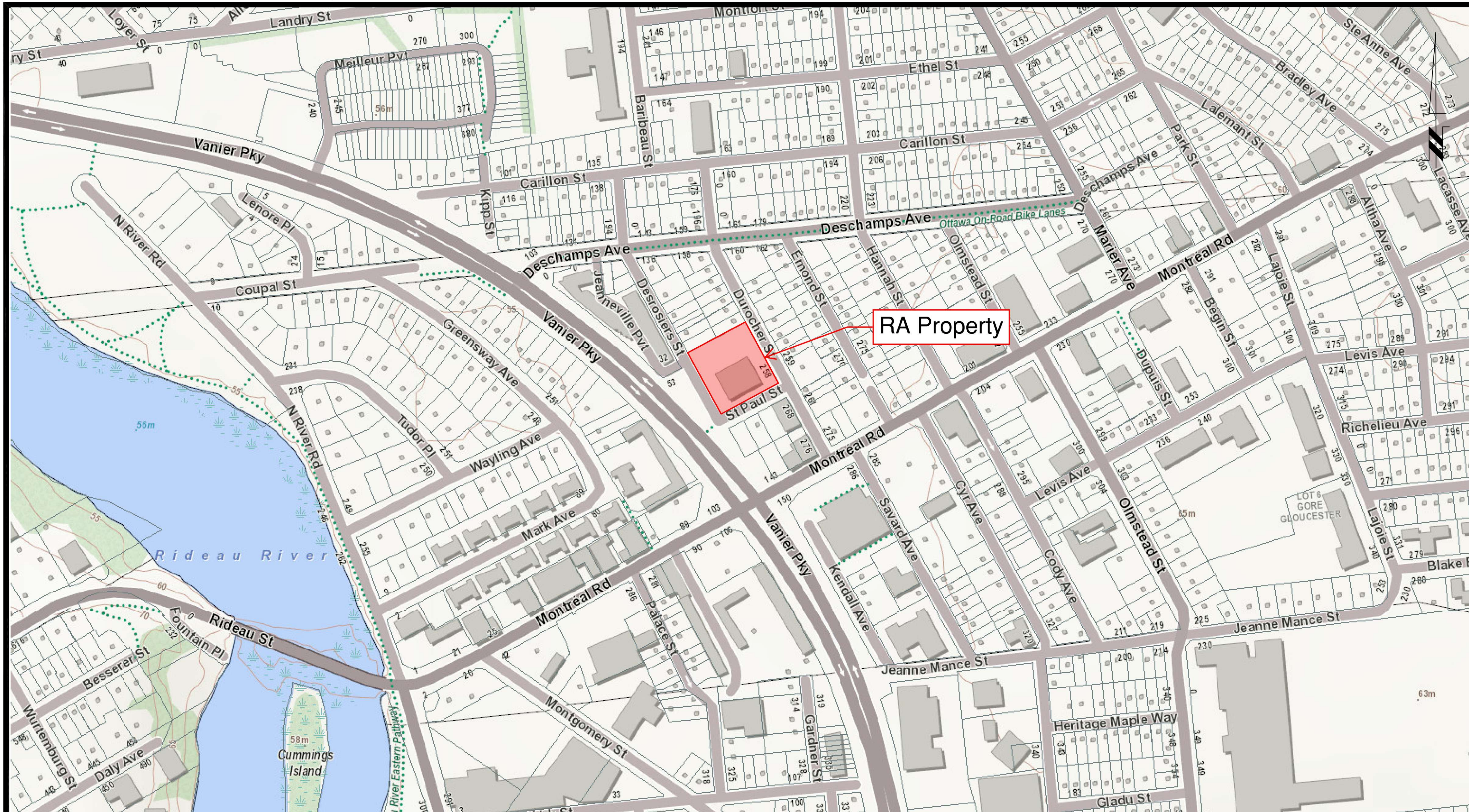

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HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
258 DUROCHER STREET
OTTAWA ONTARIO

Title:
SITE LOCATION

Scale:	N.T.S.	Date:	07/2025
Drawn by:	CM	Report No.:	PE6934-RA.01
Checked by:	MSD	Dwg. No.:	PE6934-FIG.01
Approved by:	MSD	Revision No.:	

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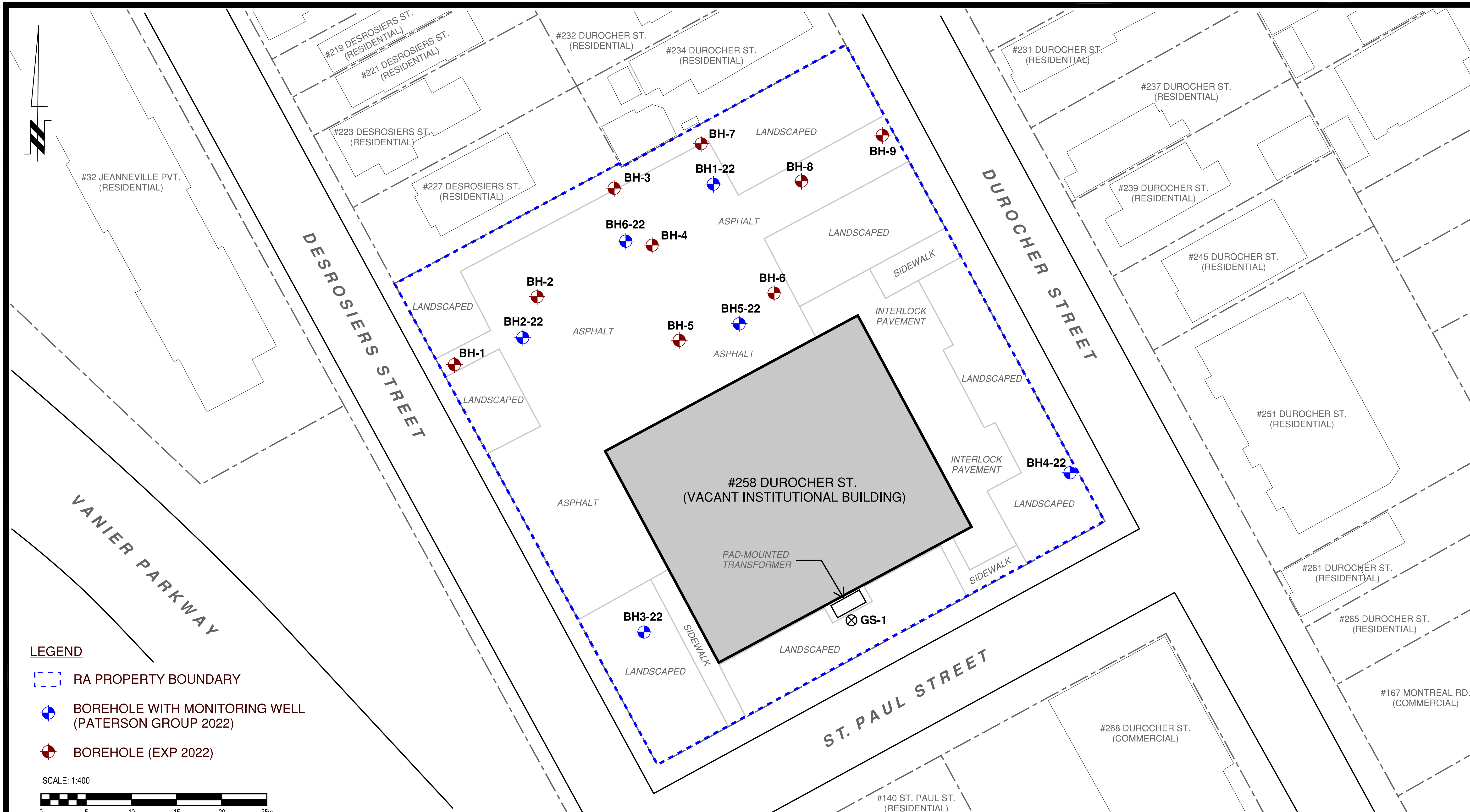

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Title:
SITE LAYOUT AND SAMPLING LOCATIONS

Scale:	1:400	Date:	07/2025
Drawn by:	CM	Report No.:	PE6934-RA.01
Checked by:	MSD	Dwg. No.:	PE6934-FIG.02
Approved by:	MSD	Revision No.:	

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Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site: Construction worker	On-Site: Outdoor worker	On-Site: Indoor worker	On-Site: Patron	On-Site: Resident	On-Site: Visitor	On-Site: Trespasser	Off-Site: Construction worker	Off-Site: Outdoor worker	Off-Site: Indoor worker	Off-Site: Community member
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

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Title: **HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL**

Scale: N.T.S.	Date: 07/2025
Drawn by: CM	Report No.: PE6934-RA.01
Checked by: MSD	Dwg. No.: PE6934-FIG.03
Approved by: MSD	Revision No.:

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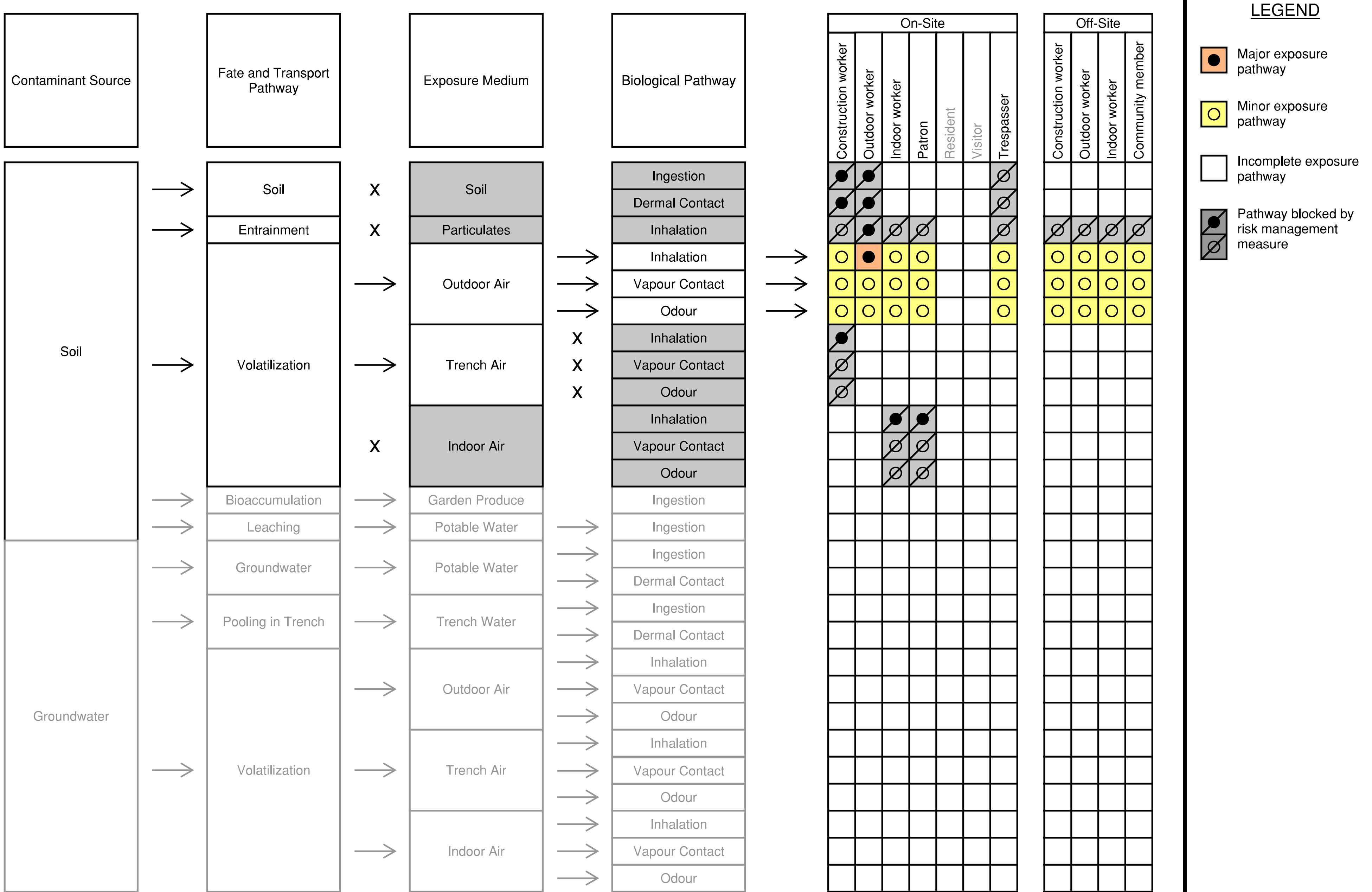

PATERSON GROUP
9 AURIGA DRIVE
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K2E 7T9
TEL: (613) 226-7381

OTTAWA HUMANE SOCIETY
HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
258 DUROCHER STREET
OTTAWA, ONTARIO

Title:
HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL (RM)

Scale: N.T.S.	Date: 07/2025
Drawn by: CM	Report No.: PE6934-RA.01
Checked by: MSD	Dwg. No.: PE6934-FIG.04
Approved by: MSD	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 biota
Soil	Soil	Soil	Root Uptake	●										
Soil	Soil	Soil	Dermal Contact		●	○	○							
Soil	Soil	Soil	Ingestion			●	●							
Soil	Entrainment	Particulates	Foliar Deposition	○					○					○
Soil	Entrainment	Particulates	Inhalation			○	○				○	○		
Soil	Bioaccumulation	Terrestrial Biota	Ingestion			●	●							
Soil	Volatilization	Outdoor Air	Foliar Uptake	○					○					○
Soil	Volatilization	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 Invertebrates	Ingestion								○	○		○
Groundwater	Groundwater	Groundwater	Root Uptake											
Groundwater	Volatilization	Outdoor Air	Foliar Uptake											
Groundwater	Volatilization	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 invertebrates	Ingestion											
Sediment	Sediment	Indoor Air	Root Uptake											
Sediment	Sediment	Indoor Air	Contact											
Sediment	Sediment	Aquatic invertebrates	Ingestion											

LEGEND

● Major exposure pathway

○ Minor exposure pathway

Incomplete exposure pathway

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HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
258 DUROCHER STREET
OTTAWA, ONTARIO

Title: **ECOLOGICAL CONCEPTUAL EXPOSURE MODEL**

Scale: N.T.S.	Date: 07/2025
Drawn by: CM	Report No.: PE6934-RA.01
Checked by: MSD	Dwg. No.: PE6934-FIG.05
Approved by: MSD	Revision No.:

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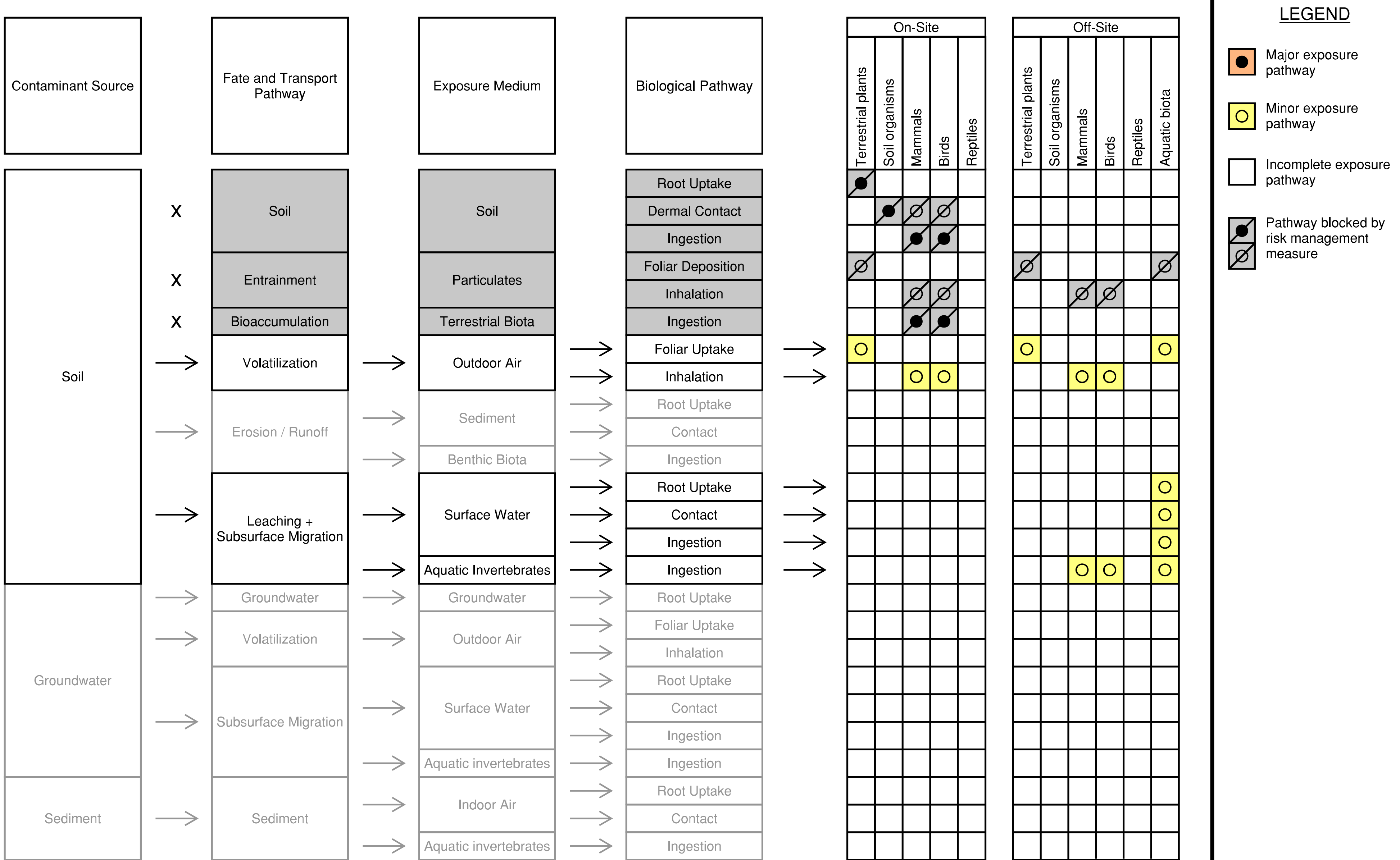

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HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT
258 DUROCHER STREET
OTTAWA, ONTARIO

Title:
ECOLOGICAL CONCEPTUAL EXPOSURE MODEL (RM)

Scale: N.T.S.	Date: 07/2025
Drawn by: CM	Report No.: PE6934-RA.01
Checked by: MSD	Dwg. No.: PE6934-FIG.06
Approved by: MSD	Revision No.:

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APPENDIX A

Analytical Data Summary

Table A1: Soil Analytical Data

PATERSON GROUP

							Table 3		*Location:*	BH1-22			BH2-22	BH3-22	G1	BH4-22
							I/C/C	No. samples exceed	*Sample ID:*	BH1-22-SS2	BH1-22-SS4	DUP	BH2-22-AU1	BH3-22-SS2	G1	BH4-22-AU1
		No. samples			Max.	Max. for		exceed	*Date:*	8-Apr-2022	8-Apr-2022	8-Apr-2022	8-Apr-2022	8-Apr-2022	17-Jun-2022	17-Jun-2022
Parameter	Units	analyzed	Min. RDL	Max. RDL	detected	screening	Coarse	Table 3	*Depth (m):*	0.76-1.45	2.29-2.89		0.2-0.3	0.76-1.37	0-0.3	0-0.68
Sodium Adsorption Ratio	–	16			5.36	5.36	12									
pH	–	2											7.9	7.04		
Antimony	µg/g	23	0.5	1	1.6	1.6	40			<1.0	<1.0		<1.0	<1.0		<1.0
Arsenic	µg/g	23	0.5	1	**27.3**	**27.3**	18	1		5.1	9.2		9.2	10.7		2.4
Barium	µg/g	23	1	1	137	137	670			37.1	86.8		81.2	67.9		69.2
Beryllium	µg/g	23	0.2	0.5	1.2	1.2	8			0.5	1.2		1	0.7		<0.5
Boron (Total)	µg/g	23	0.5	5	8.4	8.4	120			5	7.7		6.7	5.3		<5.0
Boron (Hot Water Soluble)	µg/g	16	0.02	0.02	0.09	0.09	2									
Cadmium	µg/g	23	0.5	0.5	1.2	1.2	1.9			<0.5	1		0.8	<0.5		0.5
Chromium VI	µg/g	17	0.2	0.2		<0.2	8				<0.2					
Chromium (Total)	µg/g	23	1	5	29	29	160			15.2	24.3		22.5	20.1		16
Cobalt	µg/g	23	1	1	43	43	80			10.6	23		17.8	12.1		4.6
Copper	µg/g	23	1	5	80	80	230			21.3	48.5		47.9	32.5		13.8
Lead	µg/g	23	1	5	115	115	120			11.2	15.3		57	45.2		22.8
Mercury	µg/g	17	0.005	0.1	0.188	0.188	3.9				<0.1					
Molybdenum	µg/g	23	1	1	16	16	40			3.1	8		6.5	5		<1.0
Nickel	µg/g	23	1	5	161	161	270			31.6	75.1		60.2	38.5		10.2
Selenium	µg/g	23	0.5	1	2	2	5.5			<1.0	2		<1.0	<1.0		<1.0
Silver	µg/g	23	0.2	0.3		<0.3	40			<0.3	<0.3		<0.3	<0.3		<0.3
Thallium	µg/g	23	0.1	1	2.9	2.9	3.3			<1.0	1		<1.0	<1.0		<1.0
Uranium	µg/g	23	0.1	1	6.6	6.6	33			1.2	2.9		2.2	2.1		<1.0
Vanadium	µg/g	23	1	10	49	49	86			24.9	41.7		36.6	30.4		23.1
Zinc	µg/g	23	3	20	236	236	340			36.2	107		117	96.4		43.6
Acetone	µg/g	4	0.5	0.5		<0.5	16				<0.50	<0.50				
Bromodichloromethane	µg/g	4	0.05	0.05		<0.05	18				<0.05	<0.05				
Bromoform	µg/g	4	0.05	0.05		<0.05	0.61				<0.05	<0.05				
Bromomethane	µg/g	4	0.05	0.05		<0.05	0.05				<0.05	<0.05				
Carbon Tetrachloride	µg/g	4	0.05	0.05		<0.05	0.21				<0.05	<0.05				
Chlorobenzene	µg/g	4	0.05	0.05		<0.05	2.4				<0.05	<0.05				
Chloroform	µg/g	4	0.05	0.05		<0.05	0.47				<0.05	<0.05				
Dibromochloromethane	µg/g	4	0.05	0.05		<0.05	13				<0.05	<0.05				
Dichlorodifluoromethane	µg/g	4	0.05	0.05		<0.05	16				<0.05	<0.05				
1,2-Dichlorobenzene	µg/g	4	0.05	0.05		<0.05	6.8				<0.05	<0.05				
1,3-Dichlorobenzene	µg/g	4	0.05	0.05		<0.05	9.6				<0.05	<0.05				
1,4-Dichlorobenzene	µg/g	4	0.05	0.05		<0.05	0.2				<0.05	<0.05				
1,1-Dichloroethane	µg/g	4	0.05	0.05		<0.05	17				<0.05	<0.05				
1,2-Dichloroethane	µg/g	4	0.05	0.05		<0.05	0.05				<0.05	<0.05				
1,1-Dichloroethylene	µg/g	4	0.05	0.05		<0.05	0.064				<0.05	<0.05				
1,2-cis-Dichloroethylene	µg/g	4	0.05	0.05		<0.05	55				<0.05	<0.05				
1,2-trans-Dichloroethylene	µg/g	4	0.05	0.05		<0.05	1.3				<0.05	<0.05				
1,2-Dichloropropane	µg/g	4	0.05	0.05		<0.05	0.16				<0.05	<0.05				
1,3-Dichloropropene	µg/g	4	0.05	0.05		<0.05	0.18				<0.05	<0.05				
Ethylene dibromide	µg/g	4	0.05	0.05		<0.05	0.05				<0.05	<0.05				
(n)-Hexane	µg/g	4	0.05	0.05		<0.05	46				<0.05	<0.05				
Methyl Ethyl Ketone	µg/g	4	0.5	0.5		<0.5	70				<0.5	<0.5				

Table A1: Soil Analytical Data

PATERSON GROUP

Parameter	Units	No. samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 I/C/C Coarse	No. samples exceed Table 3	Location:	BH1-22			BH2-22	BH3-22	G1	BH4-22
									Sample ID:	BH1-22-SS2	BH1-22-SS4	DUP	BH2-22-AU1	BH3-22-SS2	G1	BH4-22-AU1
									Date:	8-Apr-2022	8-Apr-2022	8-Apr-2022	8-Apr-2022	8-Apr-2022	17-Jun-2022	17-Jun-2022
									Depth (m):	0.76-1.45	2.29-2.89		0.2-0.3	0.76-1.37	0-0.3	0-0.68
Methyl Isobutyl Ketone	µg/g	4	0.5	0.5		<0.5	31				<0.5	<0.5				
Methyl tert-Butyl Ether (MTBE)	µg/g	4	0.05	0.05		<0.05	11				<0.05	<0.05				
Methylene Chloride	µg/g	4	0.05	0.05		<0.05	1.6				<0.05	<0.05				
Styrene	µg/g	4	0.05	0.05		<0.05	34				<0.05	<0.05				
1,1,1,2-Tetrachloroethane	µg/g	4	0.05	0.05		<0.05	0.087				<0.05	<0.05				
1,1,2,2-Tetrachloroethane	µg/g	4	0.05	0.05		<0.05	0.05				<0.05	<0.05				
Tetrachloroethylene	µg/g	4	0.05	0.05		<0.05	4.5				<0.05	<0.05				
1,1,1-Trichloroethane	µg/g	4	0.05	0.05		<0.05	6.1				<0.05	<0.05				
1,1,2-Trichloroethane	µg/g	4	0.05	0.05		<0.05	0.05				<0.05	<0.05				
Trichloroethylene	µg/g	4	0.05	0.05		<0.05	0.91				<0.05	<0.05				
Trichlorofluoromethane	µg/g	4	0.05	0.05		<0.05	4				<0.05	<0.05				
Vinyl Chloride	µg/g	4	0.02	0.02		<0.02	0.032				<0.02	<0.02				
Benzene	µg/g	21	0.02	0.02		<0.02	0.32				<0.02	<0.02			<0.02	
Ethylbenzene	µg/g	21	0.05	0.05		<0.05	9.5				<0.05	<0.05			<0.05	
Toluene	µg/g	21	0.05	0.2	0.06	<0.2	68				0.06	<0.05			<0.05	
Xylene Mixture	µg/g	21	0.05	0.03	0.25	0.25	26				0.25	0.19			<0.05	
PHC F1	µg/g	20	7	10	16	16	55				16				<7	
PHC F2	µg/g	20	4	5	**520**	**520**	230	1			**520**				<4	
PHC F3	µg/g	20	8	10	397	397	1700				397				19	
PHC F4	µg/g	20	6	10	58	58	3300				<6				<6	
Acenaphthene	µg/g	21	0.02	0.05	0.09	0.09	96			<0.02			<0.02	<0.02		<0.02
Acenaphthylene	µg/g	21	0.02	0.05		<0.05	0.15			<0.02			<0.02	<0.02		<0.02
Anthracene	µg/g	21	0.02	0.05	0.23	0.23	0.67			<0.02			0.03	0.04		0.12
Benz[a]anthracene	µg/g	21	0.02	0.05	0.64	0.64	0.96			<0.02			0.09	0.1		0.08
Benzo[a]pyrene	µg/g	21	0.02	0.05	**0.65**	**0.65**	0.3	1		<0.02			0.1	0.09		0.08
Benzo[b]fluoranthene	µg/g	21	0.02	0.05	0.63	0.63	0.96			<0.02			0.1	0.11		0.09
Benzo[g,h,i]perylene	µg/g	21	0.02	0.05	0.31	0.31	9.6			<0.02			0.06	0.06		0.04
Benzo[k]fluoranthene	µg/g	21	0.02	0.05	0.34	0.34	0.96			<0.02			0.05	0.06		0.04
Chrysene	µg/g	21	0.02	0.05	0.77	0.77	9.6			<0.02			0.1	0.11		0.1
Dibenz[a,h]anthracene	µg/g	21	0.02	0.05	0.05	0.05	0.1			<0.02			<0.02	<0.02		<0.02
Fluoranthene	µg/g	21	0.02	0.05	1.43	1.43	9.6			<0.02			0.21	0.24		0.16
Fluorene	µg/g	21	0.02	0.05	0.1	0.1	62			<0.02			<0.02	<0.02		<0.02
Indeno[1,2,3-cd]pyrene	µg/g	21	0.02	0.05	0.29	0.29	0.76			<0.02			0.06	0.05		0.03
Methylnaphthalene 1-, 2-	µg/g	21	0.04	0.05		<0.05	76			<0.04			<0.04	<0.04		<0.04
Naphthalene	µg/g	21	0.01	0.05	0.04	<0.05	9.6			<0.01			<0.01	0.01		<0.01
Phenanthrene	µg/g	21	0.02	0.05	1.05	1.05	12			<0.02			0.14	0.15		0.11
Pyrene	µg/g	21	0.02	0.05	1.16	1.16	96			<0.02			0.2	0.19		0.13
Polychlorinated Biphenyls	µg/g	1	0.05	0.05		<0.05	1.1								<0.05	

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Table A1: Soil Analytical Data

Parameter	Units	BH5-22		BH6-22		BH1	BH2		BH3	BH4			BH5	
		BH5-22-AU1	BH5-22-SS3	BH6-22-AU1/SS2	BH6-22-SS3	BH1-S2	BH2-S1	BH2-S4	BH3-S2	BH4-S2	DUP2	BH4-S4	BH5-S1	BH5-S3
		17-Jun-2022	17-Jun-2022	17-Jun-2022	17-Jun-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022
		0.3-0.6	1.52-2.13	0.3-1.37	1.52-2.13	0.6-1.2	0-0.6	1.8-2.3	0.6-1.2	0.6-1.2		1.8-2.2	0-0.6	1.2-2.0
Sodium Adsorption Ratio	–					2.93	4.33	5.36	0.401	3.37	3.98	4.24	3.41	1.25
pH	–													
Antimony	µg/g	<1.0		<1.0		1.1	<0.5	0.7	<0.5	<0.5	<0.5	0.9	<0.5	1.6
Arsenic	µg/g	4.8		11.7		13.3	4.4	9.8	6.2	6.5	5.3	14.1	6.5	**27.3**
Barium	µg/g	59		62.6		88	47	74	103	52	46	137	61	75
Beryllium	µg/g	0.5		0.06		1	0.3	1.2	0.6	0.4	0.4	1	0.7	1.1
Boron (Total)	µg/g	5.7		5.6		5.8	3.8	7.3	5.4	4.7	5.7	7.5	6.1	7
Boron (Hot Water Soluble)	µg/g					0.06	<0.02	0.06	0.09	0.03	0.03	0.05	0.04	0.06
Cadmium	µg/g	<0.5		<0.5		1	<0.5	0.9	<0.5	<0.5	<0.5	0.6	<0.5	0.7
Chromium VI	µg/g					<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium (Total)	µg/g	18.4		21.2		26	17	26	22	18	15	24	19	24
Cobalt	µg/g	7.4		9.4		25	7	25	12	9	9	29	12	43
Copper	µg/g	19.3		24		57	20	62	25	23	24	66	33	80
Lead	µg/g	24.2		28.3		115	21	19	38	33	32	23	93	40
Mercury	µg/g					0.188	0.033	0.078	0.159	0.064	0.061	0.087	0.086	0.139
Molybdenum	µg/g	2.1		2.8		12	3	10	5	3	3	11	3	16
Nickel	µg/g	22.6		29		70	24	99	28	28	30	98	40	161
Selenium	µg/g	<1.0		<1.0		1.6	0.7	1.4	0.7	0.7	0.7	1.3	0.9	1.8
Silver	µg/g	<0.3		<0.3		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	<1.0		<1.0		0.7	<0.1	1	0.4	0.3	0.3	0.9	0.4	2.9
Uranium	µg/g	<1.0		1		6.6	1.2	2.8	1.1	1	1	3.1	1.5	4.3
Vanadium	µg/g	26		28		42	23	49	28	26	25	38	31	40
Zinc	µg/g	44.4		104		236	54	103	68	56	57	89	62	90
Acetone	µg/g		<0.50		<0.50									
Bromodichloromethane	µg/g		<0.05		<0.05									
Bromoform	µg/g		<0.05		<0.05									
Bromomethane	µg/g		<0.05		<0.05									
Carbon Tetrachloride	µg/g		<0.05		<0.05									
Chlorobenzene	µg/g		<0.05		<0.05									
Chloroform	µg/g		<0.05		<0.05									
Dibromochloromethane	µg/g		<0.05		<0.05									
Dichlorodifluoromethane	µg/g		<0.05		<0.05									
1,2-Dichlorobenzene	µg/g		<0.05		<0.05									
1,3-Dichlorobenzene	µg/g		<0.05		<0.05									
1,4-Dichlorobenzene	µg/g		<0.05		<0.05									
1,1-Dichloroethane	µg/g		<0.05		<0.05									
1,2-Dichloroethane	µg/g		<0.05		<0.05									
1,1-Dichloroethylene	µg/g		<0.05		<0.05									
1,2-cis-Dichloroethylene	µg/g		<0.05		<0.05									
1,2-trans-Dichloroethylene	µg/g		<0.05		<0.05									
1,2-Dichloropropane	µg/g		<0.05		<0.05									
1,3-Dichloropropene	µg/g		<0.05		<0.05									
Ethylene dibromide	µg/g		<0.05		<0.05									
(n)-Hexane	µg/g		<0.05		<0.05									
Methyl Ethyl Ketone	µg/g		<0.5		<0.5									

Table A1: Soil Analytical Data

PATERSON GROUP

Parameter	Units	BH5-22		BH6-22		BH1	BH2		BH3	BH4			BH5	
		BH5-22-AU1	BH5-22-SS3	BH6-22-AU1/SS2	BH6-22-SS3	BH1-S2	BH2-S1	BH2-S4	BH3-S2	BH4-S2	DUP2	BH4-S4	BH5-S1	BH5-S3
		17-Jun-2022	17-Jun-2022	17-Jun-2022	17-Jun-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022
		0.3-0.6	1.52-2.13	0.3-1.37	1.52-2.13	0.6-1.2	0-0.6	1.8-2.3	0.6-1.2	0.6-1.2		1.8-2.2	0-0.6	1.2-2.0
Methyl Isobutyl Ketone	µg/g		<0.5		<0.5									
Methyl tert-Butyl Ether (MTBE)	µg/g		<0.05		<0.05									
Methylene Chloride	µg/g		<0.05		<0.05									
Styrene	µg/g		<0.05		<0.05									
1,1,1,2-Tetrachloroethane	µg/g		<0.05		<0.05									
1,1,2,2-Tetrachloroethane	µg/g		<0.05		<0.05									
Tetrachloroethylene	µg/g		<0.05		<0.05									
1,1,1-Trichloroethane	µg/g		<0.05		<0.05									
1,1,2-Trichloroethane	µg/g		<0.05		<0.05									
Trichloroethylene	µg/g		<0.05		<0.05									
Trichlorofluoromethane	µg/g		<0.05		<0.05									
Vinyl Chloride	µg/g		<0.02		<0.02									
Benzene	µg/g		<0.02		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ethylbenzene	µg/g		<0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	µg/g		<0.05		<0.05	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Xylene Mixture	µg/g		<0.05		<0.05	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PHC F1	µg/g		<7		<7	<10	<10	<10	<10	<10	<10	<10	<10	<10
PHC F2	µg/g		16		15	14	<5	31	<5	<5	<5	73	<5	13
PHC F3	µg/g		38		20	23	<10	42	<10	21	19	64	16	31
PHC F4	µg/g		12		15	<10	<10	<10	<10	12	13	58	<10	<10
Acenaphthene	µg/g			0.09		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	µg/g			<0.02		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Anthracene	µg/g			0.23		<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	0.05	<0.05
Benz[a]anthracene	µg/g			0.64		<0.05	0.06	<0.05	<0.05	0.24	0.1	<0.05	0.15	<0.05
Benzo[a]pyrene	µg/g			**0.65**		<0.05	<0.05	<0.05	<0.05	0.22	0.08	<0.05	0.13	<0.05
Benzo[b]fluoranthene	µg/g			0.63		<0.05	0.06	<0.05	<0.05	0.29	0.11	<0.05	0.18	<0.05
Benzo[g,h,i]perylene	µg/g			0.31		<0.05	<0.05	<0.05	<0.05	0.13	<0.05	<0.05	0.09	<0.05
Benzo[k]fluoranthene	µg/g			0.34		<0.05	<0.05	<0.05	<0.05	0.11	<0.05	<0.05	0.06	<0.05
Chrysene	µg/g			0.77		<0.05	0.05	<0.05	<0.05	0.25	0.09	<0.05	0.16	<0.05
Dibenz[a,h]anthracene	µg/g			0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fluoranthene	µg/g			1.43		<0.05	0.09	<0.05	<0.05	0.53	0.21	<0.05	0.32	<0.05
Fluorene	µg/g			0.1		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno[1,2,3-cd]pyrene	µg/g			0.29		<0.05	<0.05	<0.05	<0.05	0.16	0.06	<0.05	0.1	<0.05
Methylnaphthalene 1-, 2-	µg/g			<0.04		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Naphthalene	µg/g			0.04		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phenanthrene	µg/g			1.05		<0.05	<0.05	<0.05	<0.05	0.31	0.15	<0.05	0.24	<0.05
Pyrene	µg/g			1.16		<0.05	0.08	<0.05	<0.05	0.44	0.17	<0.05	0.27	<0.05
Polychlorinated Biphenyls	µg/g													

Table A1: Soil Analytical Data

Parameter	Units	BH6	BH7		BH8			BH9
		BH6-S2	BH7-S2	BH7-S4	BH8-S2	BH8-S3	DUP1	BH9-S2
		7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022
		0.6-1.2	0.6-1.2	1.8-.2.1	0.6-1.2	1.2-1.8		0.6-1.2
Sodium Adsorption Ratio	–	2.09	1.02	0.975	5.11	2.64	3.58	2.86
pH	–							
Antimony	µg/g	0.8	<0.5	0.8	0.7	0.8	0.7	<0.5
Arsenic	µg/g	11.7	6.1	10	10.3	12	12	7.6
Barium	µg/g	77	59	84	68	68	68	112
Beryllium	µg/g	1	0.5	1	0.8	1	1	0.7
Boron (Total)	µg/g	8.2	5.7	6.7	6.4	7.4	8	8.4
Boron (Hot Water Soluble)	µg/g	0.09	0.06	0.05	0.05	0.06	0.06	0.08
Cadmium	µg/g	1.1	<0.5	1.2	<0.5	0.9	0.7	<0.5
Chromium VI	µg/g	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium (Total)	µg/g	25	18	23	23	24	24	29
Cobalt	µg/g	29	10	34	23	31	27	16
Copper	µg/g	78	24	73	52	67	67	38
Lead	µg/g	23	27	20	34	20	21	19
Mercury	µg/g	0.119	0.053	0.087	0.109	0.076	0.076	0.078
Molybdenum	µg/g	12	3	13	8	10	10	5
Nickel	µg/g	99	32	105	69	98	94	55
Selenium	µg/g	1.4	0.7	1.5	1.1	1.1	1.2	1
Silver	µg/g	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	1.3	0.3	1.7	0.3	1.4	1.2	0.5
Uranium	µg/g	4.4	1	2.7	2.5	2.6	2.6	1.5
Vanadium	µg/g	43	26	41	35	38	39	37
Zinc	µg/g	146	51	149	87	118	107	72
Acetone	µg/g							
Bromodichloromethane	µg/g							
Bromoform	µg/g							
Bromomethane	µg/g							
Carbon Tetrachloride	µg/g							
Chlorobenzene	µg/g							
Chloroform	µg/g							
Dibromochloromethane	µg/g							
Dichlorodifluoromethane	µg/g							
1,2-Dichlorobenzene	µg/g							
1,3-Dichlorobenzene	µg/g							
1,4-Dichlorobenzene	µg/g							
1,1-Dichloroethane	µg/g							
1,2-Dichloroethane	µg/g							
1,1-Dichloroethylene	µg/g							
1,2-cis-Dichloroethylene	µg/g							
1,2-trans-Dichloroethylene	µg/g							
1,2-Dichloropropane	µg/g							
1,3-Dichloropropene	µg/g							
Ethylene dibromide	µg/g							
(n)-Hexane	µg/g							
Methyl Ethyl Ketone	µg/g							

Table A1: Soil Analytical Data

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Parameter	Units	BH6	BH7		BH8			BH9
		BH6-S2	BH7-S2	BH7-S4	BH8-S2	BH8-S3	DUP1	BH9-S2
		7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022	7-Sep-2022
		0.6-1.2	0.6-1.2	1.8-.2.1	0.6-1.2	1.2-1.8		0.6-1.2
Methyl Isobutyl Ketone	µg/g							
Methyl tert-Butyl Ether (MTBE)	µg/g							
Methylene Chloride	µg/g							
Styrene	µg/g							
1,1,1,2-Tetrachloroethane	µg/g							
1,1,2,2-Tetrachloroethane	µg/g							
Tetrachloroethylene	µg/g							
1,1,1-Trichloroethane	µg/g							
1,1,2-Trichloroethane	µg/g							
Trichloroethylene	µg/g							
Trichlorofluoromethane	µg/g							
Vinyl Chloride	µg/g							
Benzene	µg/g	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Ethylbenzene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Toluene	µg/g	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Xylene Mixture	µg/g	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
PHC F1	µg/g	<10	<10	<10	<10	<10	<10	<10
PHC F2	µg/g	22	5	55	18	44	32	<5
PHC F3	µg/g	39	15	56	27	63	47	<10
PHC F4	µg/g	<10	<10	<10	<10	<10	<10	<10
Acenaphthene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Anthracene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benz[a]anthracene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo[a]pyrene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo[b]fluoranthene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo[g,h,i]perylene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo[k]fluoranthene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chrysene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dibenz[a,h]anthracene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fluoranthene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fluorene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno[1,2,3-cd]pyrene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Methylnaphthalene 1-, 2-	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Naphthalene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phenanthrene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Pyrene	µg/g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Polychlorinated Biphenyls	µg/g							

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Table A2: Groundwater Analytical Data

Parameter	Units	No. samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 Coarse	No. samples exceed Table 3	*Location:*	BH1-22	BH2-22	BH3-22		BH4-22		BH5-22	BH6-22
									Sample ID:	BH1-22-GW 2217201-01	BH2-22-GW 2217201-02	BH3-22-GW 2217201-03	DUP 2217201-04	BH4-22-GW1 2227104-01	Dup BH4-102 2227104-02	BH5-22-GW1 2227104-03	BH6-22-GW1 2227104-04
									Date:	14-Apr-2022	14-Apr-2022	14-Apr-2022	14-Apr-2022	24-Jun-2022	24-Jun-2022	24-Jun-2022	24-Jun-2022
Acetone	µg/L	8	5	5		<5	130000			<5	<5	<5	<5	<5	<5	<5	<5
Bromodichloromethane	µg/L	8	0.5	0.5		<0.5	85000			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bromoform	µg/L	8	0.5	0.5		<0.5	380			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bromomethane	µg/L	8	0.5	0.5		<0.5	5.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon Tetrachloride	µg/L	8	0.2	0.2		<0.2	0.79			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorobenzene	µg/L	8	0.5	0.5		<0.5	630			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	µg/L	8	0.5	0.5	**3.8**	**3.8**	2.4	2		<0.5	<0.5	<0.5	<0.5	**3.8**	**3.6**	<0.5	0.5
Dibromochloromethane	µg/L	8	0.5	0.5		<0.5	82000			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dichlorodifluoromethane	µg/L	8	1	1		<1	4400			<1	<1	<1	<1	<1	<1	<1	<1
1,2-Dichlorobenzene	µg/L	8	0.5	0.5		<0.5	4600			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,3-Dichlorobenzene	µg/L	8	0.5	0.5		<0.5	9600			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,4-Dichlorobenzene	µg/L	8	0.5	0.5		<0.5	8			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1-Dichloroethane	µg/L	8	0.5	0.5		<0.5	320			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,2-Dichloroethane	µg/L	8	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1-Dichloroethylene	µg/L	8	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,2-cis-Dichloroethylene	µg/L	8	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,2-trans-Dichloroethylene	µg/L	8	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,2-Dichloropropane	µg/L	8	0.5	0.5		<0.5	16			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,3-Dichloropropene	µg/L	8	0.5	0.5		<0.5	5.2			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylene dibromide	µg/L	8	0.2	0.2		<0.2	0.25			<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
(n)-Hexane	µg/L	8	1	1		<1	51			<1	<1	<1	<1	<1	<1	<1	<1
Methyl Ethyl Ketone	µg/L	8	5	5		<5	470000			<5	<5	<5	<5	<5	<5	<5	<5
Methyl Isobutyl Ketone	µg/L	8	5	5		<5	140000			<5	<5	<5	<5	<5	<5	<5	<5
Methyl tert-Butyl Ether (MTBE)	µg/L	8	2	2		<2	190			<2	<2	<2	<2	<2	<2	<2	<2
Methylene Chloride	µg/L	8	5	5		<5	610			<5	<5	<5	<5	<5	<5	<5	<5
Styrene	µg/L	8	0.5	0.5		<0.5	1300			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,1,2-Tetrachloroethane	µg/L	8	0.5	0.5		<0.5	3.3			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2,2-Tetrachloroethane	µg/L	8	0.5	0.5		<0.5	3.2			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Tetrachloroethylene	µg/L	8	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,1-Trichloroethane	µg/L	8	0.5	0.5		<0.5	640			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2-Trichloroethane	µg/L	8	0.5	0.5		<0.5	4.7			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethylene	µg/L	8	0.5	0.5		<0.5	1.6			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Trichlorofluoromethane	µg/L	8	1	1		<1	2500			<1	<1	<1	<1	<1	<1	<1	<1
Vinyl Chloride	µg/L	8	0.5	0.5		<0.5	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzene	µg/L	8	0.5	0.5		<0.5	44			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	µg/L	8	0.5	0.5		<0.5	2300			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	µg/L	8	0.5	0.5		<0.5	18000			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylene Mixture	µg/L	8	0.5	0.5		<0.5	4200			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
PHC F1	µg/L	6	25	25		<25	750			<25	<25	<25		<25		<25	<25
PHC F2	µg/L	6	100	100		<100	150			<100	<100	<100		<100		<100	<100
PHC F3	µg/L	6	100	100		<100	500			<100	<100	<100		<100		<100	<100
PHC F4	µg/L	6	100	100		<100	500			<100	<100	<100		<100		<100	<100
Acenaphthene	µg/L	3	0.05	0.05		<0.05	600			<0.05	<0.05	<0.05					
Acenaphthylene	µg/L	3	0.05	0.05		<0.05	1.8			<0.05	<0.05	<0.05					
Anthracene	µg/L	3	0.01	0.01		<0.01	2.4			<0.01	<0.01	<0.01					

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Table A2: Groundwater Analytical Data

Parameter	Units	No. samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 Coarse	No. samples exceed Table 3	*Location:*	BH1-22	BH2-22	BH3-22		BH4-22		BH5-22	BH6-22
									Sample ID:	BH1-22-GW 2217201-01	BH2-22-GW 2217201-02	BH3-22-GW 2217201-03	DUP 2217201-04	BH4-22-GW1 2227104-01	Dup BH4-102 2227104-02	BH5-22-GW1 2227104-03	BH6-22-GW1 2227104-04
									Date:	14-Apr-2022	14-Apr-2022	14-Apr-2022	14-Apr-2022	24-Jun-2022	24-Jun-2022	24-Jun-2022	24-Jun-2022
Benz[a]anthracene	µg/L	3	0.01	0.01		<0.01	4.7			<0.01	<0.01	<0.01					
Benzo[a]pyrene	µg/L	3	0.01	0.01		<0.01	0.81			<0.01	<0.01	<0.01					
Benzo[b]fluoranthene	µg/L	3	0.05	0.05		<0.05	0.75			<0.05	<0.05	<0.05					
Benzo[g,h,i]perylene	µg/L	3	0.05	0.05		<0.05	0.2			<0.05	<0.05	<0.05					
Benzo[k]fluoranthene	µg/L	3	0.05	0.05		<0.05	0.4			<0.05	<0.05	<0.05					
Chrysene	µg/L	3	0.05	0.05		<0.05	1			<0.05	<0.05	<0.05					
Dibenz[a,h]anthracene	µg/L	3	0.05	0.05		<0.05	0.52			<0.05	<0.05	<0.05					
Fluoranthene	µg/L	3	0.01	0.01		<0.01	130			<0.01	<0.01	<0.01					
Fluorene	µg/L	3	0.05	0.05		<0.05	400			<0.05	<0.05	<0.05					
Indeno[1,2,3-cd]pyrene	µg/L	3	0.05	0.05		<0.05	0.2			<0.05	<0.05	<0.05					
Methlynaphthalene, 1- & 2-	µg/L	3	0.1	0.1		<0.1	1800			<0.1	<0.1	<0.1					
Naphthalene	µg/L	3	0.05	0.05		<0.05	1400			<0.05	<0.05	<0.05					
Phenanthrene	µg/L	3	0.05	0.05		<0.05	580			<0.05	<0.05	<0.05					
Pyrene	µg/L	3	0.01	0.01		<0.01	68			<0.01	<0.01	<0.01					

APPENDIX B

Human Health Risk Assessment Supporting Information

APPENDIX B1

Human Health Exposure Calculations

Soil Direct Contact & Ingestion Pathways:

Soil Ingestion

Incidental soil ingestion is an exposure pathway that is relevant for receptors that are assumed to spend significant time outdoors, including residents, outdoor workers, and construction workers. The average daily dose (ADD) from incidental soil ingestion was calculated using the following formula:

$$ADD_{S-Ing} = \frac{C_{soil}\ IR_{soil}\ RAF_{S-ora}}{BW} \times \frac{Days}{365}$$

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

PATERSON GROUP

Soil Direct Contact & Ingestion Pathways:

Soil Dermal Contact

Soil dermal contact is an exposure pathway that is relevant for receptors that are assumed to spend significant time outdoors, including residents, outdoor workers, and construction workers. The ADD from soil dermal contact was calculated using the following formula:

$$ADD_{S-Dermal} = \frac{C_{soil} \cdot SA \cdot R_{adhe} \quad \cdot RAF_{S-oral}}{BW} \times \frac{Days}{365}$$

where: $ADD_{S\text{-}Der}$ = Average daily dose due to dermal contact (mg/kg/day);
C_{soil} = Concentration of COC in soil (mg/kg);
SA = Skin surface area (cm^2);
R_{adher} = Rate of soil adherence ($kg/cm^2/d$);
$RAF_{S\text{-}oral}$ = Relative absorption factor (soil, dermal);
BW = Body weight (kg);
Days = Days per year exposed.

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Soil Direct Contact & Ingestion Pathways:

Soil Particulate Inhalation

The dose received from inhalation of soil particulates in outdoor air was calculated using formulae from Massachusetts Department of Environmental Protection (MassDEP 2008). Risk from particulates inhaled by receptors is a function of the size distribution of particulates at a site. Concentrations of particulates are expressed in units of concentration (µg/m^3) for a specific particle size; thus, PM_{10} represents the concentration (in µg/m^3) of particulates less than or equal to 10 µm in diameter. Doses are typically standardized according to the 10-micron particle size.

Inhaled particulates can contribute to the dose received by receptors in two ways:

1. A fraction of particulates (typically smaller particulates, i.e., PM_{10}) may be deposited and retained in the alveolar regions of the lungs.
2. A fraction of particulates (both large and small) are removed from the respiratory tract (e.g., by coughing) and are ingested.

MassDEP made the following assumptions regarding these fractions:

- 100% of respirable particulate mass is equal to or less than 30 microns in diameter (≤ PM_{30});
- 50% of total respiratory particulate mass is equal to or less than 10 microns in diameter (≤ PM_{10});
- 100% of inhaled particulates greater than 10 microns but less than or equal to 30 microns are swallowed; and
- 50% of inhaled particulates equal to or less than 10 microns are swallowed, and the remaining 50% enter the lungs.

Based on the above, the effective exposure concentration of respirable particulates for the gastro-intestinal (GI) system is 1.5 times the concentration of PM_{10}, while that for the lungs is 0.5 times the concentration of PM_{10}. To be consistent with the retained lung fraction assumed by MECP (MOE 2011), these values were adjusted to 0.6 x PM_{10} inhaled and 1.4 x PM_{10} ingested.

The dose for the fraction of COCs inhaled and retained in the lungs was calculated using the following formula:

$$\mathrm{ADD_{S-Part-Inhal}} = \frac{[\mathrm{PM_{10}}] \cdot 0.6 \cdot \mathrm{C_{soil}} \cdot \mathrm{IR_{air}} \cdot \mathrm{RAF_{S-inhal}}}{\mathrm{BW}} \times \frac{\mathrm{Hours}}{24} \times \frac{\mathrm{Days}}{365}$$

where: $ADD_{S\text{-}Part\text{-}Inhal}$ = Average daily dose from inhaled particulates (mg/kg/d);
$[PM_{10}]$ = Concentration of PM_{10} in air (100 mg/m^3);
C_{soil} = COC concentration in soil (mg/kd)
IR_{air} = Inhalation rate (m^3/day);
$RAF_{S\text{-}Inhal}$ = Relative absorption factor for inhalation exposure;
BW = Body weight (kg).

According to MassDEP calculations, the fraction entering the lungs is summed with concentrations from volatile COCs and contributes to the overall inhalation concentration. The dose (in mg/kd/day) is converted to an equivalent air concentration assuming an inhalation rate of 20 m^3/day and a body weight of 70 kg:

$$C_{S-Part-Inhal}\left(\frac{mg}{m^3}\right) = ADD_{S-Part-Inhal}\left(\frac{mg}{kg \cdot day}\right) \times 70\ kg \div 20\,\frac{m^3}{day}$$

The dose for the fraction of COCs inhaled and ingested was calculated using the following formula:

$$ADD_{S-Part-Inhal-GI} = \frac{[PM_{10}] \cdot 1.4\ C_{soil} \cdot IR_{air} \cdot RAF_{S-Oral}}{BW} \times \frac{Hours}{24} \times \frac{Days}{365}$$

where: $ADD_{S\text{-}Part\text{-}Inhal\text{-}GI}$ = Average daily dose from inhaled particulates ingested (mg/kg/d);
$[PM_{10}]$ = Concentration of PM_{10} in air (100 mg/m^3);
C_{soil} = COC concentration in soil (mg/kd)
IR_{air} = Inhalation rate (m^3/day);
$RAF_{S\text{-}Oral}$ = Relative absorption factor for soil ingestion;
BW = Body weight (kg).

The ADD for particulates inhaled but ultimately ingested were summed with doses from soil ingestion and dermal exposure pathways.

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/m³);
C_{soil} = Concentration in soil (µg/g);
VF = Volatilization factor (g/m³);
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/m³);
C_{gw} = Concentration in groundwater (µg/L);
VF = Volatilization factor (L/m³);
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/m³);
W = Width of contamination source (m);
B = Soil bulk density (g/cm³);
U_{air} = Mean annual wind speed (cm/sec);
∂_{air} = Mixing zone height of breathing zone for outdoor model (cm);
$D_{eff\text{-}soil}$ = Effective molecular diffusion coefficient for vadose zone soil (cm²/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:

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

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 (J&E) 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.

Indoor vapour modelling was modelled using the following buildings:

1. Generic commercial building with a basement – Generic default values as defined by MECP were used for all building parameters, including dimensions (20 m length, 15 m width, 3.0 m mixing zone height). Soil contamination was modelled at 191.25 cm below grade (basement extends to 161.25 cm, plus slab thickness of 11.25 cm, plus 29.9 cm of gravel crush, plus 0.1 cm of clean fill under the gravel crush for functionality of the model).

2. Site-specific commercial building with a basement – The existing building was modelled using dimensions 34 m length by 38 m width. Default MECP values were assumed for other model inputs, including 3.0 m mixing zone height and 11.25 cm slab thickness. Soil contamination was modelled at 191.25 cm below grade (basement extends to 161.25 cm, plus slab thickness of 11.25 cm, plus 29.9 cm of gravel crush, plus 0.1 cm of clean fill under the gravel crush for functionality of the model).

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APPENDIX B2

Human Health Toxicity Reference Values

Arsenic

Oral Tolerable Daily Intake: 0.0003 mg/kg/day

The Ministry's oral chronic TDI for arsenic was last updated in 2017. Three TDIs are provided, including a Reference Dose (RfD) of 0.0003 mg/kg/day that was developed by the US EPA and listed on IRIS (US EPA 1991). The US EPA RfD is based on studies by Tseng *et al.* (1968) and Tseng (1977) in which effects from chronic oral exposure in humans were examined. The critical endpoints were dermal hyperpigmentation/keratosis and vascular complications. US EPA converted the NOAEL of 0.009 mg/L in drinking water to a dose of 0.0008 mg/kg/day and applied a total UF of 3 to arrive at the RfD.

Inhalation Tolerable Concentration: 1.5×10^{-5} mg/m^3

The Ministry's inhalation chronic TC was last updated in 2017; no value was identified at this time. MOE (2011) recommended a TRV of 3.0×10^{-5} mg/m^3 based on a chronic Reference Exposure Level (REL) developed by CalEPA (2000). The REL for arsenic was revised to 1.5×10^{-5} mg/m^3 in 2014. It is based on neurological effects in people exposed to arsenic in drinking water. An oral LOAEL of 2.27 µg/day (Tsai *et al.* 2003; Wasserman *et al.* 2004) was converted to an inhalation value of 0.46 µg/m^3 by assuming an inhalation rate of 9.9 m^3/day and an absorption rate of 50%. CalEPA applied a total uncertainty factor of 30 (3 for use of a LOAEL, 10 for inter-individual variation) to arrive at its REL.

Oral Cancer Slope Factor: 9.5 (mg/kg/day)$^{-1}$

The Ministry's cancer slope factor for arsenic was last updated in 2017. MECP endorses the use of an oral non-threshold TRV of 9.5 (mg/kg-day)$^{-1}$ that was developed by CalEPA in setting its public health goal for arsenic in drinking water (OEHHA 2004). It is based on the incidence of lung and bladder cancer (OEHHA 2004).

Inhalation Unit Risk: 0.15 (mg/m^3)$^{-1}$

The Ministry's non-threshold inhalation TRV for arsenic was last updated in 2017. The recommended inhalation non-threshold TRV is 0.15 (mg/m^3)$^{-1}$, developed by the Texas Commission on Environmental Quality (TCEQ 2012). TCEQ set its unit risk factor based on multiple epidemiological studies examining lung cancer mortality rates and survival probabilities (Enterline *et al.* 1995; Lubin *et al.* 2000; Lubin *et al.* 2008; Järup and Pershagen 1989 as cited in TCEQ 2012).

Benzo[a]pyrene

Oral Tolerable Daily Intake: 0.0003 mg/kg/day

The Ministry's oral chronic TDI for benzo[a]pyrene was last updated in 2018. MECP recommends use of the US EPA (2017) Reference Dose of 0.0003 mg/kg/day, which is based on developmental neurobehavioural changes in rats (Chen *et al.* 2012). MECP has indicated that although the critical effect is developmental in nature, the TRV does not require restrictions on pro-rating.

Subchronic Tolerable Daily Intake: 0.005 mg/kg/day

The Ministry's subchronic chronic TDI for benzo[a]pyrene was last updated in 2018. MECP recommends a value modified from the California EPA Public Health Goal (PHG) for drinking water (OEHHA 2010). CalEPA's reference dose for non-cancer effects was based on renal toxicity in F344 rats given 0, 5, 50 or 100 mg/kg benzo[a]pyrene in the diet for up to 90 days (Knuckles *et al.* 2001). Increased tubular casts were observed in the male kidney at all doses (5 mg/kg or greater) and the occurrence of the abnormalities appeared to be dose-dependent. The LOAEL of 5 mg/kg/day was adjusted by MECP using a total UF of 1,000 (10 for extrapolation from a LOAEL to a NOAEL, 10 for interspecies extrapolation, and 10 for variability among humans) to derive the subchronic TDI.

Inhalation Tolerable Concentration: 2.0×10^{-6} mg/m^3

The Ministry's inhalation chronic TC was last updated in 2018. MECP recommends use of the US EPA (2017) Reference Concentration of 2×10^{-6} mg/kg/day, which is based on decreased embryo/fetal survival in rats (Archibong *et al.* 2002). MECP has indicated that although the critical effect is developmental in nature, the TRV does not require restrictions on pro-rating.

Oral Cancer Slope Factor: 1.0 (mg/kg/day)$^{-1}$

The Ministry's cancer slope factor for benzo[a]pyrene was last updated in 2018. MECP recommends use of a slope factor of 1 (mg/kg/day)$^{-1}$ derived by US EPA (2017) based on forestomach, esophagus, tongue, and larynx tumors in female B6C3F1 mice (Kroese *et al.* 2001; Beland and Culp 1998). US EPA states that this slope factor is "*the highest value (most sensitive) among a range of slope factors derived*."

Inhalation Unit Risk: 0.6 (mg/m^3)$^{-1}$

The Ministry's non-threshold inhalation TRV for benzo[a]pyrene was last updated in 2018. MECP recommends use of the US EPA (2017) unit risk factor of 0.6 (mg/m^3)$^{-1}$ derived by US EPA (2017) and based on squamous cell neoplasia in the larynx, pharynx, trachea, nasal cavity, esophagus, and forestomach in male hamsters exposed via inhalation of benzo[a]pyrene adsorbed onto sodium chloride aerosols (Thyssen *et al.* 1981).

PHCs – Aliphatic C>8-C10, C>10-C12, C>12-C16

Oral Tolerable Daily Intake: 0.1 mg/kg/day

The Ministry's oral chronic TDI for aliphatic hydrocarbons in the C8-C16 range was last updated in 2011. The oral TRV was derived by the Total Petroleum Hydrocarbon Working Group (Edwards *et al.* 1997) using route-to-route extrapolation from an inhalation TRV based on hepatic and hematologic changes in laboratory animals after exposure to petroleum streams and JP-8 (Phillips and Egan 1984; 1981; Mattie *et al.* 1991).

Subchronic Tolerable Daily Intake: 1 mg/kg/day

The Ministry's oral subchronic TDI for aliphatic hydrocarbons in the C8-C16 range was last updated in 2011. The subchronic TDI is based on the same studies showing hepatic and hematologic changes in laboratory animals (Phillips and Egan 1984; 1981; Mattie *et al.* 1991) used to derive the chronic TDI for this fraction. MECP adjusted the chronic TDI of 0.1 mg/kg/day by a factor of 10 to derive the subchronic TDI.

Inhalation Tolerable Concentration: 1 mg/m^3

The Ministry's inhalation chronic TC for aliphatic hydrocarbons in the C8-C16 range was last updated in 2011. MOE (2011) recommends the TRVs developed by the Total Petroleum Hydrocarbon Working Group (Edwards *et al.* 1997) and adopted by CCME (2008). The inhalation TRV is based on hepatic and hematologic changes in lab animals after exposure to petroleum streams and JP-8 (Phillips and Egan 1984; 1981; Mattie *et al.* 1991; Mattie *et al.* 1995).

Oral Cancer Slope Factor: None selected

The Ministry's cancer slope factor was last updated in 2011. No value was selected at this time.

Inhalation Unit Risk: None selected

The Ministry's non-threshold inhalation TRV was last updated in 2011. No value was selected at this time.

PHCs – Aromatic C>8-C10, C>10-C12, C>12-C16

Oral Tolerable Daily Intake: 0.04 mg/kg/day

The Ministry's oral chronic TDI for aromatic hydrocarbons in the C8–C16 range was last updated in 2011. The oral TRV was derived by the Total Petroleum Hydrocarbon Working Group (Edwards *et al.* 1997) and adopted by CCME (2008). The oral TRV was based on decreased body weight in laboratory animals and developed using a weight of evidence approach based on reference doses for nine available surrogate chemicals including cumene, naphthalene, fluoranthene, and fluorene (Cushman *et al.* 1995; Plasterer *et al.* 1985; Shopp *et al.* 1984; BCL 1980a; b; US EPA 1989). The TPH working group reviewed LOAEL/NOAELs for available individual compounds and mixtures and determined that the oral RfD of 0.04 mg/kg/day would be an appropriate fraction-specific RfD for the C9–C16 carbon range. Most of the available RfDs for individual compounds in this fraction were approximately 0.04 mg/kg/day.

Inhalation Tolerable Concentration: 0.2 mg/m^3

The Ministry's inhalation chronic TC for aromatic hydrocarbons in the C8–C16 range was last updated in 2011. MOE (2011) recommends the TRVs developed by the Total Petroleum Hydrocarbon Working Group (Edwards *et al.* 1997) and adopted by CCME (2008). The inhalation TRV was based on decreased body weight in laboratory animals exposed to high flash aromatic naphtha that was used as surrogate compound (Douglas *et al.* 1993; Clark *et al.* 1989).

Oral Cancer Slope Factor: None selected

The Ministry's cancer slope factor was last updated in 2011. No value was selected at this time.

Inhalation Unit Risk: None selected

The Ministry's non-threshold inhalation TRV was last updated in 2011. No value was selected at this time.

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APPENDIX B3

Human Health Risk Tables

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Table B3-1: Human Health COC Screening - Soil

Soil COC	Maximum soil concentration (µg/g)	REM soil concentration (µg/g)	S-GW1 Leaching Potable Coarse (µg/g)	S2 Contact (I/C/C) (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)	Free phase threshold Coarse (µg/g)
Arsenic	27.3	32.76	–	**2.0E-01**	**7.4E+00**	–	–	–	–	1.2E+04
Acenaphthene	0.09	0.108	1.5E+02	7.0E+02	2.6E+04	2.1E+02	2.4E+03	1.8E+04	1.0E+02	2.8E+03
Acenaphthylene	0.05	0.06	1.7E+01	7.0E+01	2.6E+03	1.2E+01	1.8E+02	–	–	2.9E+03
Anthracene	0.23	0.276	5.1E+01	7.0E+01	2.6E+03	2.8E+02	9.5E+02	–	–	2.7E+03
Benz[a]anthracene	0.64	0.768	1.9E+02	7.0E+00	2.6E+02	1.8E+03	6.0E+02	–	–	7.7E+03
Benzo[a]pyrene	0.65	0.78	6.6E+00	**7.0E-01**	1.7E+01	5.4E+03	6.8E+01	–	–	7.7E+03
Benzo[b]fluoranthene	0.63	0.756	6.7E+01	7.0E+00	2.6E+02	1.5E+05	3.8E+03	–	–	7.7E+03
Benzo[g,h,i]perylene	0.31	0.372	2.2E+03	7.0E+01	2.6E+03	–	–	–	–	7.7E+03
Benzo[k]fluoranthene	0.34	0.408	6.6E+01	7.0E+00	2.6E+02	1.8E+05	3.8E+03	–	–	7.7E+03
Chrysene	0.77	0.924	2.0E+01	7.0E+01	2.6E+03	5.0E+04	1.2E+04	–	–	7.7E+03
Dibenz[a,h]anthracene	0.05	0.06	2.2E+01	7.0E-01	2.6E+01	8.8E+05	7.9E+02	–	–	7.7E+03
Fluoranthene	1.43	1.716	1.8E+02	7.0E+01	2.6E+03	6.7E+03	4.5E+03	–	–	7.7E+03
Fluorene	0.1	0.12	1.1E+03	5.6E+03	5.6E+04	–	–	–	–	2.8E+03
Indeno[1,2,3-cd]pyrene	0.29	0.348	2.2E+02	7.0E+00	2.6E+02	1.2E+06	7.3E+03	–	–	7.7E+03
Methylnaphthalene, 2-(1-)	0.05	0.06	3.0E+01	5.6E+02	5.6E+02	–	–	1.6E+02	9.9E-01	3.6E+03
Naphthalene	0.05	0.06	9.3E+01	2.8E+03	2.8E+04	9.6E+00	2.7E+02	7.1E+02	4.5E+00	2.8E+03
Phenanthrene	1.05	1.26	1.7E+01	–	–	–	–	–	–	2.3E+03
Pyrene	1.16	1.392	1.7E+03	7.0E+02	2.6E+04	5.1E+04	4.1E+04	–	–	7.7E+03
Total carcinogenic PAHs	0.919	1.10	–	–	–	–	–	–	–	–
PHC F2	520	624	4.3E+03	2.2E+04	4.8E+04	**3.8E+02**	2.5E+04	–	–	2.7E+03

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Table B3-2: Human 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
Drinking water intake rate	L/d	2.3	2.1	–	–	–	–
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 B3-3: Outdoor/Trench Vapour Exposure Model Parameters

Category	Parameter	Symbol	Unit	Value
Outdoor Vapour Modelling Inputs	Depth below grade to contaminated soil	L_S	cm	30
	Depth below grade to contaminated GW	L_{gw}	cm	0
	Soil type for the outdoor model			Sand
	Outdoor Model: Capillary zone thickness	h_c	cm	0.025
	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	0.075
	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	Β	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	Β	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 B3-4: Trench/Outdoor Air Vapour Concentrations - Soil Source

COC	Soil properties							Trench air (soil source)		Outdoor air (soil source)					
	Enthalpy of vaporization at average groundwater temperature (cal/mol)	Henry's law constant at average groundwater temperature (atm-m^3/mol)	Henry's law constant at average groundwater temperature (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)	diffusivity above water table (for trench air modelling) D_{ws}^{eff}	diffusivity above water table (for outdoor air modelling) D_{ws}^{eff}	$VF_{S\text{-}TA}$ ([mg/m^3]/[mg/kg])	Trench vapour concentration (soil source) (µg/m^3)	$VF_{S\text{-}OA}$ (CM-1a) ([mg/m^3]/[mg/kg])	$VF_{S\text{-}OA}$ (CM-1b) ([mg/m^3]/[mg/kg])	$VF_{S\text{-}OA}$ (CM-3a) ([mg/m^3]/[mg/kg])	$VF_{S\text{-}OA}$ (CM-3b) ([mg/m^3]/[mg/kg])	Outdoor Vapour Concentration (surface soil source) (µg/m^3)	Outdoor Vapour Concentration (subsurface soil source) (µg/m^3)
Arsenic															
Acenaphthene	1.61E+04	7.07E-05	2.99E-03	6.81E-03	4.58E-04	1.83E+01	1.53E-03	7.81E-06	8.43E-04	2.87E-06	1.28E-04	3.36E-07	1.28E-04	3.10E-04	3.63E-05
Acenaphthylene	1.61E+04	4.86E-05	2.05E-03	7.10E-03	5.50E-04	1.74E+01	1.79E-03	6.61E-06	3.96E-04	2.43E-06	1.28E-04	2.41E-07	1.28E-04	1.46E-04	1.44E-05
Anthracene	1.83E+04	1.91E-05	8.06E-04	5.24E-03	9.13E-04	1.14E-06	2.40E-03	2.07E-06	5.72E-04	7.62E-07	1.28E-04	2.37E-08	1.28E-04	2.10E-04	6.54E-06
Benz[a]anthracene	2.30E+04	3.12E-06	1.32E-04	8.27E-03	5.34E-03	6.66E-06	7.27E-03	3.60E-07	2.77E-04	1.32E-07	1.28E-04	7.15E-10	1.28E-04	1.02E-04	5.49E-07
Benzo[a]pyrene															
Benzo[b]fluoranthene															
Benzo[g,h,i]perylene															
Benzo[k]fluoranthene															
Chrysene															
Dibenz[a,h]anthracene															
Fluoranthene															
Fluorene	1.62E+04	3.72E-05	1.57E-03	5.87E-03	6.00E-04	1.96E-03	1.84E-03	3.88E-06	4.66E-04	1.43E-06	1.28E-04	8.30E-08	1.28E-04	1.71E-04	9.96E-06
Indeno[1,2,3-cd]pyrene															
Methylnaphthalene, 2-(1-)	1.62E+04	2.01E-04	8.51E-03	7.76E-03	3.75E-04	2.59E-03	1.31E-03	2.02E-05	1.21E-03	7.42E-06	1.28E-04	2.24E-06	1.28E-04	4.45E-04	1.35E-04
Naphthalene	1.29E+04	2.07E-04	8.74E-03	9.54E-03	4.41E-04	3.18E-03	1.55E-03	2.62E-05	1.57E-03	9.64E-06	1.28E-04	3.79E-06	1.28E-04	5.79E-04	2.28E-04
Phenanthrene	1.83E+04	1.45E-05	6.14E-04	5.39E-03	1.11E-03	1.80E-03	2.74E-03	1.82E-06	2.29E-03	6.68E-07	1.28E-04	1.82E-08	1.28E-04	8.42E-04	2.30E-05
Pyrene	2.07E+04	3.54E-06	1.50E-04	4.42E-03	3.72E-03	1.47E-03	4.22E-03	4.78E-07	6.66E-04	1.76E-07	1.28E-04	1.26E-09	1.28E-04	2.45E-04	1.75E-06
Total Carcinogenic PAHs									3.89E-05					1.43E-05	3.03E-07
PHC F2															
Aliphatic C>10-C12	1.30E+04	1.37E+00	5.79E+01	8.08E-03	3.20E-04	2.69E-03	1.14E-03	1.68E-04	3.77E+01	6.18E-05	1.28E-04	1.56E-04	1.28E-04	1.39E+01	2.88E+01
Aliphatic C>12-C16	1.56E+04	5.10E+00	2.16E+02	8.08E-03	3.20E-04	2.69E-03	1.14E-03	7.86E-05	2.16E+01	2.89E-05	1.28E-04	3.40E-05	1.28E-04	7.93E+00	9.34E+00
Aromatic C>10-C12	1.29E+04	1.61E-03	6.83E-02	8.08E-03	3.27E-04	2.69E-03	1.17E-03	5.76E-05	3.23E+00	2.12E-05	1.28E-04	1.83E-05	1.28E-04	1.19E+00	1.03E+00
Aromatic C>12-C16	1.56E+04	5.22E-04	2.21E-02	8.08E-03	3.40E-04	2.69E-03	1.21E-03	2.51E-05	1.72E+00	9.23E-06	1.28E-04	3.47E-06	1.28E-04	6.33E-01	2.38E-01

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Table B3-5: J&E Vapour Intrusion Model Soil Properties

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 B3-6: J&E Vapour Intrusion Model Input Parameters

Category	Site Characteristic	Symbol	Units	Value	Value
Land Use	Land use		–	Commercial	Commercial
Building	Type of Building		–	Commercial Building-with-Basement	Site Building-with-Basement
	Length		cm	2,000	3,400
	Width		cm	1,500	3,800
	Height (of mixing zone)		cm	300	300
	Slab Thickness	Lcrack	cm	11.25	11.25
	Depth below grade to bottom of floor	L_F	cm	161.25	161.25
	Crack depth below grade	$X_{crack\ or\ Zcrack}$	cm	161.25	161.25
	Crack Width	w	cm	0.1	0.1
	Pressure Differential, Building - Soil	Δp	g/cm-sec2	20	20
	Air Exchange Rate	ER	1/hour	1	1
	Flow rate of soil vapour into building (or leave blank)	Q_{SOIL}	L/min	9.80	9.80
	Floor-wall seam perimeter	X_{crack}	cm	7,000	14,400
	Building ventilation rate	$Q_{building}$	cm^3/s	2.50E+05	1.08E+06
	Area of enclosed space below grade	A_B	cm^2	4.13E+06	1.52E+07
	Crack-to-total area ratio	η	–	1.70E-04	9.45E-05
J&E soil inputs	Depth below grade to top of contaminated soil	zsoil or L_t	cm	30	30
	Depth to contaminated soil used in indoor model	zsoil or L_t	cm	191.25	191.25
	Soil Source-bldg. separation	L_T	cm	30	30
	Soil Stratum A - Thickness	h_A	cm	161.25	161.25
	Soil Stratum B - Thickness (Soil model)	h_B	cm	29.90	29.90
	Soil Stratum C - Thickness (Soil model)	h_C	cm	0.10	0.10
	MECP Source Depletion Multiplier (SDM) Applied	SDM	unitless	Yes	Yes
	Depth below grade to bottom of contaminated soil	L_b	cm	0	0

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Table B3-7: Source Depletion Multiplier Calculations

COC	C_{soil} (µg/g)	Soil Bulk Density (g/cm^3)	Volume of source zone (cm^3)	Site Building-with-Basement												
				Length of building (cm)	Width of building (cm)	Depth of building below grade (cm)	Volume of excavated soil (cm^3)	Volume of source zone (adjusted) (cm^3)	Initial mass (g)	Initial $C_{indoor\ air}$ (µg/m^3)	Volume of building (m^3)	Air exchange rate (hour^{-1})	Mass remaining (1 week) (g)	Half-life (years)	Source Depletion Multiplier	Final $C_{indoor\ air}$ (µg/m^3)
Arsenic																
Acenaphthene	0.108	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	2.770467418	7.78E-04	3,876	1	2.8	72.66	1.0	7.42E-04
Acenaphthylene	0.06	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	1.539148565	2.97E-04	3,876	1	1.5	105.67	1.0	2.88E-04
Anthracene	0.276	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	7.080083401	1.60E-04	3,876	1	7.1	905.44	1.0	1.59E-04
Benz[a]anthracene	0.768	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	19.70110164	6.50E-06	3,876	1	19.7	61,855.32	1.0	6.50E-06
Benzo[a]pyrene																
Benzo[b]fluoranthene																
Benzo[g,h,i]perylene																
Benzo[k]fluoranthene																
Chrysene																
Dibenz[a,h]anthracene																
Fluoranthene																
Fluorene	0.12	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	3.078297131	2.45E-04	3,876	1	3.1	255.85	1.0	2.42E-04
Indeno[1,2,3-cd]pyrene																
Methylnaphthalene, 2-(1-)	0.06	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	1.539148565	2.54E-03	3,876	1	1.5	12.37	1.3	1.92E-03
Naphthalene	0.06	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	1.539148565	4.24E-03	3,876	1	1.5	7.40	1.6	2.65E-03
Phenanthrene	1.26	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	32.32211987	5.45E-04	3,876	1	32.3	1,210.12	1.0	5.43E-04
Pyrene	1.392	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	35.70824672	4.37E-05	3,876	1	35.7	16,669.91	1.0	4.37E-05
Total Carcinogenic PAHs																
PHC F2																
Aliphatic C>10-C12	224.64	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	5762.572229	2.92E+02	3,876	1	5,572.6	0.40	100.0	2.92E+00
Aliphatic C>12-C16	274.56	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	7043.143836	2.43E+01	3,876	1	7,027.3	5.90	1.8	1.35E+01
Aromatic C>10-C12	56.16	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	1440.643057	2.26E+01	3,876	1	1,425.9	1.30	10.0	2.26E+00
Aromatic C>12-C16	68.64	1.66	3.38E+08	1,299	1,299	191.15	3.23E+08	1.55E+07	1760.785959	4.48E+00	3,876	1	1,757.9	8.01	1.5	2.91E+00

Table B3-8: Vapour Intrusion Model - Soil Source - Commercial Building with Basement

COC	REM soil concentration (µg/g)	REM soil concentration (µg/kg)	Initial soil concentration used C_R (µg/kg)	Enthalpy of vapour at average soil temperature ΔHv,TS (cal/mol)	Henry's law constant at average soil temperature H_{TS} (atm-m³/mol)	Henry's law constant at average soil temperature H'_{TS} (unitless)	Vapour viscosity at average soil temperature μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient D^{eff}_A (cm²/s)	Stratum B effective diffusion coefficient D^{eff}_B (cm²/s)	Stratum C effective diffusion coefficient D^{eff}_C (cm²/s)	Total overall effective diffusion coefficient D^{eff}_T (cm²/s)	Diffusion path length L_d (cm)
Acenaphthene	0.108	108	108	1.61E+04	7.07E-05	2.99E-03	1.77E-04	6.81E-03	1.14E-02	6.81E-03	1.14E-02	3.00E+01
Acenaphthylene	0.06	60	60	1.61E+04	4.86E-05	2.05E-03	1.77E-04	7.10E-03	1.19E-02	7.10E-03	1.19E-02	3.00E+01
Anthracene	0.276	276	276	1.83E+04	1.91E-05	8.06E-04	1.77E-04	5.24E-03	8.80E-03	5.24E-03	8.78E-03	3.00E+01
Benz[a]anthracene	0.768	768	768	2.30E+04	3.12E-06	1.32E-04	1.77E-04	8.27E-03	1.39E-02	8.27E-03	1.38E-02	3.00E+01
Benzo[a]pyrene	0.78											
Benzo[b]fluoranthene	0.756											
Benzo[g,h,i]perylene	0.372											
Benzo[k]fluoranthene	0.408											
Chrysene	0.924											
Dibenz[a,h]anthracene	0.06											
Fluoranthene	1.716											
Fluorene	0.12	120	120	1.62E+04	3.72E-05	1.57E-03	1.77E-04	5.87E-03	9.86E-03	5.87E-03	9.84E-03	3.00E+01
Indeno[1,2,3-cd]pyrene	0.348											
Methylnaphthalene, 2-(1-)	0.06	60	60	1.62E+04	2.01E-04	8.51E-03	1.77E-04	7.76E-03	1.30E-02	7.76E-03	1.30E-02	3.00E+01
Naphthalene	0.06	60	60	1.29E+04	2.07E-04	8.74E-03	1.77E-04	9.54E-03	1.60E-02	9.54E-03	1.60E-02	3.00E+01
Phenanthrene	1.26	1,260	1,260	1.83E+04	1.45E-05	6.14E-04	1.77E-04	5.39E-03	9.05E-03	5.39E-03	9.03E-03	3.00E+01
Pyrene	1.392	1,392	1,392	2.07E+04	3.54E-06	1.50E-04	1.77E-04	4.42E-03	7.39E-03	4.42E-03	7.37E-03	3.00E+01
Total Carcinogenic PAHs	1.10298											
PHC F2	624	624,000	0.00E+00									
Aliphatic C>10-C12	224.64	224,640	85,786	1.30E+04	1.37E+00	5.79E+01	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01
Aliphatic C>12-C16	274.56	274,560	38,122	1.56E+04	5.10E+00	2.16E+02	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01
Aromatic C>10-C12	56.16	56,160	56,160	1.29E+04	1.61E-03	6.83E-02	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01
Aromatic C>12-C16	68.64	68,640	68,640	1.56E+04	5.22E-04	2.21E-02	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01

COC	Convection path length L_p (cm)	Soil-water partition coefficient K_d (cm³/g)	Crack radius r_{crack} (cm)	Average vapour flow rate into building Q_{soil} (cm³/s)	Crack effective diffusion coefficient D^{crack} (cm²/s)	Area of crack A_{crack} (cm²)	Exponent of equivalent foundation Peclet number $\exp(Pe^f)$ (unitless)	Soil source vapour concentration C_{source} (µg/m³)	Infinite source indoor attenuation coefficient α (unitless)	Bio-Attenuation Factor BAF (unitless)	Indoor building conc. (no source depletion) REM $C_{building}$ (µg/m³)	Source Depletion Multiplier SDM (unitless)	Indoor building conc. (with source depletion) REM $C_{building}$ (µg/m³)	Indoor building conc. (for risk calcs): Indoor building conc. (with source depletion) (µg/m³)
Acenaphthene	1.61E+02	6.12E+01	1.00E-01	1.63E+02	6.81E-03	7.00E+02	3.02E+167	5.27E+00	5.92E-04	1.00E+00	3.12E-03	1.05E+00	2.98E-03	2.98E-03
Acenaphthylene	1.61E+02	6.12E+01	1.00E-01	1.63E+02	7.10E-03	7.00E+02	4.01E+160	2.01E+00	5.94E-04	1.00E+00	1.20E-03	1.03E+00	1.16E-03	1.16E-03
Anthracene	1.61E+02	2.04E+02	1.00E-01	1.63E+02	5.24E-03	7.00E+02	3.05E+217	1.09E+00	5.76E-04	1.00E+00	6.27E-04	1.00E+00	6.25E-04	6.25E-04
Benz[a]anthracene	1.61E+02	2.31E+03	1.00E-01	1.63E+02	8.27E-03	7.00E+02	6.13E+137	4.38E-02	6.02E-04	1.00E+00	2.64E-05	1.00E+00	2.64E-05	2.64E-05
Benzo[a]pyrene														
Benzo[b]fluoranthene														
Benzo[g,h,i]perylene														
Benzo[k]fluoranthene														
Chrysene														
Dibenz[a,h]anthracene														
Fluoranthene														
Fluorene	1.61E+02	1.13E+02	1.00E-01	1.63E+02	5.87E-03	7.00E+02	1.59E+194	1.67E+00	5.83E-04	1.00E+00	9.74E-04	1.01E+00	9.62E-04	9.62E-04
Indeno[1,2,3-cd]pyrene														
Methylnaphthalene, 2-(1-)	1.61E+02	2.98E+01	1.00E-01	1.63E+02	7.76E-03	7.00E+02	8.13E+146	1.71E+01	5.99E-04	1.00E+00	1.03E-02	1.30E+00	7.89E-03	7.89E-03
Naphthalene	1.61E+02	1.84E+01	1.00E-01	1.63E+02	9.54E-03	7.00E+02	3.32E+119	2.85E+01	6.08E-04	1.00E+00	1.73E-02	1.56E+00	1.11E-02	1.11E-02
Phenanthrene	1.61E+02	2.08E+02	1.00E-01	1.63E+02	5.39E-03	7.00E+02	3.70E+211	3.72E+00	5.77E-04	1.00E+00	2.15E-03	1.00E+00	2.14E-03	2.14E-03
Pyrene	1.61E+02	6.94E+02	1.00E-01	1.63E+02	4.42E-03	7.00E+02	1.13E+258	3.01E-01	5.63E-04	1.00E+00	1.69E-04	1.00E+00	1.69E-04	1.69E-04
Total Carcinogenic PAHs											2.42E-05		2.36E-05	2.36E-05
PHC F2														
Aliphatic C>10-C12	1.61E+02	2.51E+03	1.00E-01	1.63E+02	8.08E-03	7.00E+02	1.10E+141	1.97E+06	6.01E-04	1.00E+00	1.18E+03	1.00E+02	1.18E+01	1.18E+01
Aliphatic C>12-C16	1.61E+02	5.01E+04	1.00E-01	1.63E+02	8.08E-03	7.00E+02	1.10E+141	1.64E+05	6.01E-04	1.00E+00	9.86E+01	1.74E+00	5.67E+01	5.67E+01
Aromatic C>10-C12	1.61E+02	2.51E+01	1.00E-01	1.63E+02	8.08E-03	7.00E+02	1.10E+141	1.52E+05	6.01E-04	1.00E+00	9.15E+01	1.00E+01	9.15E+00	9.15E+00
Aromatic C>12-C16	1.61E+02	5.01E+01	1.00E-01	1.63E+02	8.08E-03	7.00E+02	1.09E+141	3.02E+04	6.01E-04	1.00E+00	1.82E+01	1.50E+00	1.21E+01	1.21E+01

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Table B3-9: Vapour Intrusion Model - Soil Source - Site Building with Basement

COC	REM soil concentration (µg/g)	REM soil concentration (µg/kg)	Initial soil concentration used C_R (µg/kg)	Enthalpy of vapour at average soil temperature ΔHv,TS (cal/mol)	Henry's law constant at average soil temperature H_{TS} (atm-m^3/mol)	Henry's law constant at average soil temperature H'_{TS} (unitless)	Vapour viscosity at average soil temperature 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)	Total overall effective diffusion coefficient D^{eff}_T (cm^2/s)	Diffusion path length L_d (cm)	Convection path length L_p (cm)	Soil-water partition coefficient K_d (cm^3/g)	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)	Soil source vapour concentration C_{source} (µg/m^3)	Infinite source indoor attenuation coefficient α (unitless)	Bio-Attenuation Factor BAF (unitless)	Indoor building conc. (no source depletion) REM $C_{building}$ (µg/m^3)	Source Depletion Multiplier SDM (unitless)	Indoor building conc. (with source depletion) REM $C_{building}$ (µg/m^3)	Indoor building conc. (for risk calcs): Indoor building conc. (with source depletion) (µg/m^3)
Arsenic																										
Acenaphthene	0.108	108	108	1.61E+04	7.07E-05	2.99E-03	1.77E-04	6.81E-03	1.14E-02	6.81E-03	1.14E-02	3.00E+01	1.61E+02	6.12E+01	1.00E-01	1.63E+02	6.81E-03	1.44E+03	2.59E+81	5.27E+00	1.48E-04	1.00E+00	7.78E-04	1.05E+00	7.42E-04	7.42E-04
Acenaphthylene	0.06	60	60	1.61E+04	4.86E-05	2.05E-03	1.77E-04	7.10E-03	1.19E-02	7.10E-03	1.19E-02	3.00E+01	1.61E+02	6.12E+01	1.00E-01	1.63E+02	7.10E-03	1.44E+03	1.18E+78	2.01E+00	1.48E-04	1.00E+00	2.97E-04	1.03E+00	2.88E-04	2.88E-04
Anthracene	0.276	276	276	1.83E+04	1.91E-05	8.06E-04	1.77E-04	5.24E-03	8.80E-03	5.24E-03	8.78E-03	3.00E+01	1.61E+02	2.04E+02	1.00E-01	1.63E+02	5.24E-03	1.44E+03	5.27E+105	1.09E+00	1.46E-04	1.00E+00	1.60E-04	1.00E+00	1.59E-04	1.59E-04
Benz[a]anthracene	0.768	768	768	2.30E+04	3.12E-06	1.32E-04	1.77E-04	8.27E-03	1.39E-02	8.27E-03	1.38E-02	3.00E+01	1.61E+02	2.31E+03	1.00E-01	1.63E+02	8.27E-03	1.44E+03	9.55E+66	4.38E-02	1.48E-04	1.00E+00	6.50E-06	1.00E+00	6.50E-06	6.50E-06
Benzo[a]pyrene	0.78	780																								
Benzo[b]fluoranthene	0.756	756																								
Benzo[g,h,i]perylene	0.372	372																								
Benzo[k]fluoranthene	0.408	408																								
Chrysene	0.924	924																								
Dibenz[a,h]anthracene	0.06	60																								
Fluoranthene	1.716	1,716																								
Fluorene	0.12	120	120	1.62E+04	3.72E-05	1.57E-03	1.77E-04	5.87E-03	9.86E-03	5.87E-03	9.84E-03	3.00E+01	1.61E+02	1.13E+02	1.00E-01	1.63E+02	5.87E-03	1.44E+03	2.53E+94	1.67E+00	1.47E-04	1.00E+00	2.45E-04	1.01E+00	2.42E-04	2.42E-04
Indeno[1,2,3-cd]pyrene	0.348	348																								
Methylnaphthalene, 2-(1-)	0.06	60	60	1.62E+04	2.01E-04	8.51E-03	1.77E-04	7.76E-03	1.30E-02	7.76E-03	1.30E-02	3.00E+01	1.61E+02	2.98E+01	1.00E-01	1.63E+02	7.76E-03	1.44E+03	2.60E+71	1.71E+01	1.48E-04	1.00E+00	2.54E-03	1.32E+00	1.92E-03	1.92E-03
Naphthalene	0.06	60	60	1.29E+04	2.07E-04	8.74E-03	1.77E-04	9.54E-03	1.60E-02	9.54E-03	1.60E-02	3.00E+01	1.61E+02	1.84E+01	1.00E-01	1.63E+02	9.54E-03	1.44E+03	1.26E+58	2.85E+01	1.49E-04	1.00E+00	4.24E-03	1.60E+00	2.65E-03	2.65E-03
Phenanthrene	1.26	1,260	1,260	1.83E+04	1.45E-05	6.14E-04	1.77E-04	5.39E-03	9.05E-03	5.39E-03	9.03E-03	3.00E+01	1.61E+02	2.08E+02	1.00E-01	1.63E+02	5.39E-03	1.44E+03	7.00E+102	3.72E+00	1.46E-04	1.00E+00	5.45E-04	1.00E+00	5.43E-04	5.43E-04
Pyrene	1.392	1,392	1,392	2.07E+04	3.54E-06	1.50E-04	1.77E-04	4.42E-03	7.39E-03	4.42E-03	7.37E-03	3.00E+01	1.61E+02	6.94E+02	1.00E-01	1.63E+02	4.42E-03	1.44E+03	2.77E+125	3.01E-01	1.45E-04	1.00E+00	4.37E-05	1.00E+00	4.37E-05	4.37E-05
Total Carcinogenic PAHs	1.10298	1,103																					6.04E-06		5.90E-06	5.90E-06
PHC F2	624	624,000																								
Aliphatic C>10-C12	224.64	224,640	85,786	1.30E+04	1.37E+00	5.79E+01	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01	1.61E+02	2.51E+03	1.00E-01	1.63E+02	8.08E-03	1.44E+03	3.64E+68	1.97E+06	1.48E-04	1.00E+00	2.92E+02	1.00E+02	2.92E+00	2.92E+00
Aliphatic C>12-C16	274.56	274,560	38,122	1.56E+04	5.10E+00	2.16E+02	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01	1.61E+02	5.01E+04	1.00E-01	1.63E+02	8.08E-03	1.44E+03	3.64E+68	1.64E+05	1.48E-04	1.00E+00	2.43E+01	1.80E+00	1.35E+01	1.35E+01
Aromatic C>10-C12	56.16	56,160	56,160	1.29E+04	1.61E-03	6.83E-02	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01	1.61E+02	2.51E+01	1.00E-01	1.63E+02	8.08E-03	1.44E+03	3.64E+68	1.52E+05	1.48E-04	1.00E+00	2.26E+01	1.00E+01	2.26E+00	2.26E+00
Aromatic C>12-C16	68.64	68,640	68,640	1.56E+04	5.22E-04	2.21E-02	1.77E-04	8.08E-03	1.36E-02	8.08E-03	1.36E-02	3.00E+01	1.61E+02	5.01E+01	1.00E-01	1.63E+02	8.08E-03	1.44E+03	3.63E+68	3.02E+04	1.48E-04	1.00E+00	4.48E+00	1.54E+00	2.91E+00	2.91E+00

Table B3-10: Exposure and Risk Calculations - Soil Oral and Dermal Pathways

	Outdoor worker												
	Dose				Non-cancer hazard				Cancer risk				
COC	Soil ingestion dose (mg/kg-day)	Soil dermal contact dose (mg/kg-day)	Soil particulate ingestion (mg/kg/d)	Total soil oral/dermal dose (mg/kg-day)	Threshold oral TRV (mg/kg-day)	Soil oral/dermal HQ	SAF	Risk reduction required	Total amortized soil oral/dermal dose (mg/kg-day)	Non-threshold oral TRV (mg/kg/day)$^{-1}$	Soil oral/dermal ILCR	Risk reduction required	Risk-based concentration (µg/g)
Arsenic	1.24E-05	5.05E-06	5.09E-07	1.79E-05	3.00E-04	5.98E-02	2.00E-01	2.99E-01	1.79E-05	9.50E+00	**1.70E-04**	**1.70E+02**	1.92E-01
Acenaphthene	8.16E-08	7.21E-08	1.68E-09	1.55E-07	2.00E-02	7.77E-06	2.00E-01	3.89E-05	1.55E-07	1.00E-03	1.55E-10	1.55E-04	6.95E+02
Acenaphthylene	4.53E-08	4.01E-08	9.33E-10	8.64E-08	2.00E-02	4.32E-06	2.00E-01	2.16E-05	8.64E-08	1.00E-02	8.64E-10	8.64E-04	6.95E+01
Anthracene	2.09E-07	1.84E-07	4.29E-09	3.97E-07	1.30E-01	3.06E-06	2.00E-01	1.53E-05	3.97E-07	1.00E-02	3.97E-09	3.97E-03	6.95E+01
Benz[a]anthracene	5.80E-07	5.13E-07	1.19E-08	1.11E-06	-	-	-	-	1.11E-06	1.00E-01	1.11E-07	1.11E-01	6.95E+00
Benzo[a]pyrene	5.89E-07	5.21E-07	1.21E-08	1.12E-06	3.00E-04	3.74E-03	2.00E-01	1.87E-02	1.12E-06	1.00E+00	**1.12E-06**	**1.12E+00**	6.95E-01
Benzo[b]fluoranthene	5.71E-07	5.05E-07	1.18E-08	1.09E-06	-	-	-	-	1.09E-06	1.00E-01	1.09E-07	1.09E-01	6.95E+00
Benzo[g,h,i]perylene	2.81E-07	2.48E-07	5.79E-09	5.35E-07	-	-	-	-	5.35E-07	1.00E-02	5.35E-09	5.35E-03	6.95E+01
Benzo[k]fluoranthene	3.08E-07	2.73E-07	6.34E-09	5.87E-07	-	-	-	-	5.87E-07	1.00E-01	5.87E-08	5.87E-02	6.95E+00
Chrysene	6.98E-07	6.17E-07	1.44E-08	1.33E-06	-	-	-	-	1.33E-06	1.00E-02	1.33E-08	1.33E-02	6.95E+01
Dibenz[a,h]anthracene	4.53E-08	4.01E-08	9.33E-10	8.64E-08	-	-	-	-	8.64E-08	1.00E+00	8.64E-08	8.64E-02	6.95E-01
Fluoranthene	1.30E-06	1.15E-06	2.67E-08	2.47E-06	4.00E-02	6.17E-05	2.00E-01	3.09E-04	2.47E-06	1.00E-02	2.47E-08	2.47E-02	6.95E+01
Fluorene	9.07E-08	8.02E-08	1.87E-09	1.73E-07	4.00E-02	4.32E-06	2.00E-01	2.16E-05	1.73E-07	-	-	-	5.56E+03
Indeno[1,2,3-cd]pyrene	2.63E-07	2.32E-07	5.41E-09	5.01E-07	-	-	-	-	5.01E-07	1.00E-01	5.01E-08	5.01E-02	6.95E+00
Methylnaphthalene, 2-(1-)	4.53E-08	4.01E-08	9.33E-10	8.64E-08	4.00E-03	2.16E-05	2.00E-01	1.08E-04	8.64E-08	-	-	-	5.56E+02
Naphthalene	4.53E-08	4.01E-08	9.33E-10	8.64E-08	2.00E-02	4.32E-06	2.00E-01	2.16E-05	8.64E-08	-	-	-	2.78E+03
Phenanthrene	9.52E-07	8.42E-07	1.96E-08	1.81E-06	-	-	-	-	1.81E-06	-	-	-	-
Pyrene	1.05E-06	9.30E-07	2.16E-08	2.00E-06	3.00E-02	6.68E-05	2.00E-01	3.34E-04	2.00E-06	1.00E-03	2.00E-09	2.00E-03	6.95E+02
Total Carcinogenic PAHs	8.33E-07	7.37E-07	1.72E-08	1.59E-06	-	-	-	-	1.59E-06	1.00E+00	**1.59E-06**	**1.59E+00**	6.95E-01

PATERSON GROUP

Table B3-10: Exposure and Risk Calculations - Soil Oral and Dermal Pathways

COC	Construction worker												
	Dose				Non-cancer hazard				Cancer risk				
	Soil ingestion dose (mg/kg-day)	Soil dermal contact dose (mg/kg-day)	Soil particulate ingestion (mg/kg/d)	Total soil oral/dermal dose (mg/kg-day)	Threshold oral TRV (mg/kg-day)	Soil oral/dermal HQ	SAF	Risk reduction required	Total amortized soil oral/dermal dose (mg/kg-day)	Non-threshold oral TRV $(mg/kg/day)^{-1}$	Soil oral/dermal ILCR	Risk reduction required	Risk-based concentration (µg/g)
Arsenic	1.24E-05	5.05E-06	5.09E-07	1.79E-05	3.00E-04	5.98E-02	2.00E-01	2.99E-01	4.80E-07	9.50E+00	**4.56E-06**	**4.56E+00**	7.18E+00
Acenaphthene	8.16E-08	7.21E-08	1.68E-09	1.55E-07	7.00E-02	2.22E-06	2.00E-01	1.11E-05	4.16E-09	1.00E-03	4.16E-12	4.16E-06	9.73E+03
Acenaphthylene	4.53E-08	4.01E-08	9.33E-10	8.64E-08	7.00E-02	1.23E-06	2.00E-01	6.17E-06	2.31E-09	1.00E-02	2.31E-11	2.31E-05	2.59E+03
Anthracene	2.09E-07	1.84E-07	4.29E-09	3.97E-07	4.30E-01	9.24E-07	2.00E-01	4.62E-06	1.06E-08	1.00E-02	1.06E-10	1.06E-04	2.59E+03
Benz[a]anthracene	5.80E-07	5.13E-07	1.19E-08	1.11E-06	-	-	-	-	2.96E-08	1.00E-01	2.96E-09	2.96E-03	2.59E+02
Benzo[a]pyrene	5.89E-07	5.21E-07	1.21E-08	1.12E-06	5.00E-03	2.25E-04	2.00E-01	1.12E-03	3.01E-08	1.00E+00	3.01E-08	3.01E-02	2.59E+01
Benzo[b]fluoranthene	5.71E-07	5.05E-07	1.18E-08	1.09E-06	-	-	-	-	2.91E-08	1.00E-01	2.91E-09	2.91E-03	2.59E+02
Benzo[g,h,i]perylene	2.81E-07	2.48E-07	5.79E-09	5.35E-07	-	-	-	-	1.43E-08	1.00E-02	1.43E-10	1.43E-04	2.59E+03
Benzo[k]fluoranthene	3.08E-07	2.73E-07	6.34E-09	5.87E-07	-	-	-	-	1.57E-08	1.00E-01	1.57E-09	1.57E-03	2.59E+02
Chrysene	6.98E-07	6.17E-07	1.44E-08	1.33E-06	-	-	-	-	3.56E-08	1.00E-02	3.56E-10	3.56E-04	2.59E+03
Dibenz[a,h]anthracene	4.53E-08	4.01E-08	9.33E-10	8.64E-08	-	-	-	-	2.31E-09	1.00E+00	2.31E-09	2.31E-03	2.59E+01
Fluoranthene	1.30E-06	1.15E-06	2.67E-08	2.47E-06	4.00E-01	6.17E-06	2.00E-01	3.09E-05	6.62E-08	1.00E-02	6.62E-10	6.62E-04	2.59E+03
Fluorene	9.07E-08	8.02E-08	1.87E-09	1.73E-07	4.00E-01	4.32E-07	2.00E-01	2.16E-06	4.63E-09	-	-	-	5.56E+04
Indeno[1,2,3-cd]pyrene	2.63E-07	2.32E-07	5.41E-09	5.01E-07	-	-	-	-	1.34E-08	1.00E-01	1.34E-09	1.34E-03	2.59E+02
Methylnaphthalene, 2-(1-)	4.53E-08	4.01E-08	9.33E-10	8.64E-08	4.00E-03	2.16E-05	2.00E-01	1.08E-04	2.31E-09	-	-	-	5.56E+02
Naphthalene	4.53E-08	4.01E-08	9.33E-10	8.64E-08	2.00E-01	4.32E-07	2.00E-01	2.16E-06	2.31E-09	-	-	-	2.78E+04
Phenanthrene	9.52E-07	8.42E-07	1.96E-08	1.81E-06	-	-	-	-	4.86E-08	-	-	-	-
Pyrene	1.05E-06	9.30E-07	2.16E-08	2.00E-06	3.00E-01	6.68E-06	2.00E-01	3.34E-05	5.37E-08	1.00E-03	5.37E-11	5.37E-05	2.59E+04
Total Carcinogenic PAHs	8.33E-07	7.37E-07	1.72E-08	1.59E-06	-	-	-	-	4.25E-08	1.00E+00	4.25E-08	4.25E-02	2.59E+01

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Table B3-11: Exposure and Risk Calculations - Soil Inhalation Pathways

COC	Indoor worker – Commercial Building with Basement: Exposure concentration					Non-cancer hazard				Cancer risk				
	Soil particulate concentration (mg/m^3)	Trench vapour concentration (soil source) (mg/m^3)	Outdoor air concentration (soil source) (mg/m^3)	Indoor air concentration (soil source) (mg/m^3)	Total inhaled concentration (soil source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Soil inhalation HQ	SAF	Risk reduction required	amortized inhaled concentration (soil source) (mg/m^3)	Non-threshold inhalation TRV $(mg/m^3)^{-1}$	Soil inhalation ILCR	Risk reduction required	Risk-based concentration (µg/g)
Arsenic	NA	NA	NA	-	-	1.50E-05	-	2.00E-01	-	-	1.50E-01	-	-	-
Acenaphthene	NA	NA	NA	8.35E-07	8.35E-07	-	-	-	-	8.35E-07	6.00E-04	5.01E-10	5.01E-04	2.16E+02
Acenaphthylene	NA	NA	NA	3.24E-07	3.24E-07	-	-	-	-	3.24E-07	6.00E-03	1.94E-09	1.94E-03	3.09E+01
Anthracene	NA	NA	NA	1.75E-07	1.75E-07	-	-	-	-	1.75E-07	6.00E-03	1.05E-09	1.05E-03	2.63E+02
Benz[a]anthracene	NA	NA	NA	7.37E-09	7.37E-09	-	-	-	-	7.37E-09	6.00E-02	4.42E-10	4.42E-04	1.74E+03
Benzo[a]pyrene	NA	NA	NA	-	-	2.00E-06	-	2.00E-01	-	-	6.00E-01	-	-	-
Benzo[b]fluoranthene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-02	-	-	-
Benzo[g,h,i]perylene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-03	-	-	-
Benzo[k]fluoranthene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-02	-	-	-
Chrysene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-03	-	-	-
Dibenz[a,h]anthracene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-01	-	-	-
Fluoranthene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-03	-	-	-
Fluorene	NA	NA	NA	2.69E-07	2.69E-07	-	-	-	-	2.69E-07	-	-	-	-
Indeno[1,2,3-cd]pyrene	NA	NA	NA	-	-	-	-	-	-	-	6.00E-02	-	-	-
Methylnaphthalene, 2-(1-)	NA	NA	NA	2.21E-06	2.21E-06	-	-	-	-	2.21E-06	-	-	-	-
Naphthalene	NA	NA	NA	3.11E-06	3.11E-06	3.70E-03	8.40E-04	2.00E-01	4.20E-03	3.11E-06	-	-	-	1.43E+01
Phenanthrene	NA	NA	NA	5.99E-07	5.99E-07	-	-	-	-	5.99E-07	-	-	-	-
Pyrene	NA	NA	NA	4.73E-08	4.73E-08	-	-	-	-	4.73E-08	6.00E-04	2.84E-11	2.84E-05	4.90E+04
Total Carcinogenic PAHs	NA	NA	NA	6.61E-09	6.61E-09	-	-	-	-	6.61E-09	6.00E-01	3.97E-09	3.97E-03	2.78E+02
PHC F2	-	-	-	-	-	-	4.89E-02	5.00E-01	9.77E-02	-	-	-	-	6.38E+03
Aliphatic C>10-C12	NA	NA	NA	3.31E-03	3.31E-03	1.00E+00	3.31E-03	5.00E-01	6.62E-03	3.31E-03	-	-	-	3.39E+04
Aliphatic C>12-C16	NA	NA	NA	1.59E-02	1.59E-02	1.00E+00	1.59E-02	5.00E-01	3.17E-02	1.59E-02	-	-	-	8.65E+03
Aromatic C>10-C12	NA	NA	NA	2.56E-03	2.56E-03	2.00E-01	1.28E-02	5.00E-01	2.56E-02	2.56E-03	-	-	-	2.19E+03
Aromatic C>12-C16	NA	NA	NA	3.38E-03	3.38E-03	2.00E-01	1.69E-02	5.00E-01	3.38E-02	3.38E-03	-	-	-	2.03E+03

Table B3-11: Exposure and Risk Calculations - Soil Inhalation Pathways

COC	Indoor worker													
	Site Building with Basement													
	Exposure concentration					Non-cancer hazard				Cancer risk				
	Soil particulate concentration (mg/m^3)	Trench vapour concentration (soil source) (mg/m^3)	Outdoor air concentration (soil source) (mg/m^3)	Indoor air concentration (soil source) (mg/m^3)	Total inhaled concentration (soil source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Soil inhalation HQ	SAF	Risk reduction required	amortized inhaled concentration (soil source) (mg/m^3)	Non-threshold inhalation TRV (mg/m^3)$^{-1}$	Soil inhalation ILCR	Risk reduction required	Risk-based concentration (µg/g)
Arsenic	NA	-	-	-	-	1.50E-05	-	2.00E-01	-	-	1.50E-01	-	-	-
Acenaphthene	NA	NA	NA	2.07E-07	2.07E-07	-	-	-	-	2.07E-07	6.00E-04	1.24E-10	1.24E-04	8.68E+02
Acenaphthylene	NA	NA	NA	8.04E-08	8.04E-08	-	-	-	-	8.04E-08	6.00E-03	4.83E-10	4.83E-04	1.24E+02
Anthracene	NA	NA	NA	4.44E-08	4.44E-08	-	-	-	-	4.44E-08	6.00E-03	2.67E-10	2.67E-04	1.04E+03
Benz[a]anthracene	NA	NA	NA	1.82E-09	1.82E-09	-	-	-	-	1.82E-09	6.00E-02	1.09E-10	1.09E-04	7.04E+03
Benzo[a]pyrene	NA	-	-	-	-	2.00E-06	-	2.00E-01	-	-	6.00E-01	-	-	-
Benzo[b]fluoranthene	NA	-	-	-	-	-	-	-	-	-	6.00E-02	-	-	-
Benzo[g,h,i]perylene	NA	-	-	-	-	-	-	-	-	-	6.00E-03	-	-	-
Benzo[k]fluoranthene	NA	-	-	-	-	-	-	-	-	-	6.00E-02	-	-	-
Chrysene	NA	-	-	-	-	-	-	-	-	-	6.00E-03	-	-	-
Dibenz[a,h]anthracene	NA	-	-	-	-	-	-	-	-	-	6.00E-01	-	-	-
Fluoranthene	NA	-	-	-	-	-	-	-	-	-	6.00E-03	-	-	-
Fluorene	NA	NA	NA	6.77E-08	6.77E-08	-	-	-	-	6.77E-08	-	-	-	-
Indeno[1,2,3-cd]pyrene	NA	-	-	-	-	-	-	-	-	-	6.00E-02	-	-	-
Methylnaphthalene, 2-(1-)	NA	NA	NA	5.36E-07	5.36E-07	-	-	-	-	5.36E-07	-	-	-	-
Naphthalene	NA	NA	NA	7.42E-07	7.42E-07	3.70E-03	2.01E-04	2.00E-01	1.00E-03	7.42E-07	-	-	-	5.98E+01
Phenanthrene	NA	NA	NA	1.52E-07	1.52E-07	-	-	-	-	1.52E-07	-	-	-	-
Pyrene	NA	NA	NA	1.22E-08	1.22E-08	-	-	-	-	1.22E-08	6.00E-04	7.33E-12	7.33E-06	1.90E+05
Total Carcinogenic PAHs	NA	NA	NA	1.65E-09	1.65E-09	-	-	-	-	1.65E-09	6.00E-01	9.90E-10	9.90E-04	1.11E+03
PHC F2	-	-	-	-	-	-	1.18E-02	5.00E-01	2.36E-02	-	-	-	-	2.64E+04
Aliphatic C>10-C12	NA	NA	NA	8.16E-04	8.16E-04	1.00E+00	8.16E-04	5.00E-01	1.63E-03	8.16E-04	-	-	-	1.38E+05
Aliphatic C>12-C16	NA	NA	NA	3.78E-03	3.78E-03	1.00E+00	3.78E-03	5.00E-01	7.56E-03	3.78E-03	-	-	-	3.63E+04
Aromatic C>10-C12	NA	NA	NA	6.31E-04	6.31E-04	2.00E-01	3.16E-03	5.00E-01	6.31E-03	6.31E-04	-	-	-	8.89E+03
Aromatic C>12-C16	NA	NA	NA	8.13E-04	8.13E-04	2.00E-01	4.07E-03	5.00E-01	8.13E-03	8.13E-04	-	-	-	8.44E+03

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Table B3-11: Exposure and Risk Calculations - Soil Inhalation Pathways

	Outdoor worker													
	Exposure concentration					Non-cancer hazard				Cancer risk				
COC	Soil particulate concentration (mg/m^3)	Trench vapour concentration (soil source) (mg/m^3)	Outdoor air concentration (soil source) (mg/m^3)	Indoor air concentration (soil source) (mg/m^3)	Total inhaled concentration (soil source) (mg/m^3)	Threshold inhalation TRV (mg/m^3)	Soil inhalation HQ	SAF	Risk reduction required	amortized inhaled concentration (soil source) (mg/m^3)	Non-threshold inhalation TRV (mg/m^3)$^{-1}$	Soil inhalation ILCR	Risk reduction required	Risk-based concentration (µg/g)
Arsenic	7.64E-07	NA	-	NA	7.64E-07	1.50E-05	5.09E-02	2.00E-01	2.55E-01	7.64E-07	1.50E-01	1.15E-07	1.15E-01	1.29E+02
Acenaphthene	2.52E-09	NA	7.92E-09	NA	1.04E-08	-	-	-	-	1.04E-08	6.00E-04	6.26E-12	6.26E-06	1.72E+04
Acenaphthylene	1.40E-09	NA	3.15E-09	NA	4.55E-09	-	-	-	-	4.55E-09	6.00E-03	2.73E-11	2.73E-05	2.20E+03
Anthracene	6.44E-09	NA	1.43E-09	NA	7.87E-09	-	-	-	-	7.87E-09	6.00E-03	4.72E-11	4.72E-05	5.85E+03
Benz[a]anthracene	1.79E-08	NA	1.20E-10	NA	1.80E-08	-	-	-	-	1.80E-08	6.00E-02	1.08E-09	1.08E-03	7.10E+02
Benzo[a]pyrene	1.82E-08	NA	-	NA	1.82E-08	2.00E-06	9.10E-03	2.00E-01	4.55E-02	1.82E-08	6.00E-01	1.09E-08	1.09E-02	1.71E+01
Benzo[b]fluoranthene	1.76E-08	NA	-	NA	1.76E-08	-	-	-	-	1.76E-08	6.00E-02	1.06E-09	1.06E-03	7.14E+02
Benzo[g,h,i]perylene	8.68E-09	NA	-	NA	8.68E-09	-	-	-	-	8.68E-09	6.00E-03	5.21E-11	5.21E-05	7.14E+03
Benzo[k]fluoranthene	9.52E-09	NA	-	NA	9.52E-09	-	-	-	-	9.52E-09	6.00E-02	5.71E-10	5.71E-04	7.14E+02
Chrysene	2.16E-08	NA	-	NA	2.16E-08	-	-	-	-	2.16E-08	6.00E-03	1.29E-10	1.29E-04	7.14E+03
Dibenz[a,h]anthracene	1.40E-09	NA	-	NA	1.40E-09	-	-	-	-	1.40E-09	6.00E-01	8.40E-10	8.40E-04	7.14E+01
Fluoranthene	4.00E-08	NA	-	NA	4.00E-08	-	-	-	-	4.00E-08	6.00E-03	2.40E-10	2.40E-04	7.14E+03
Fluorene	2.80E-09	NA	2.17E-09	NA	4.97E-09	-	-	-	-	4.97E-09	-	-	-	-
Indeno[1,2,3-cd]pyrene	8.12E-09	NA	-	NA	8.12E-09	-	-	-	-	8.12E-09	6.00E-02	4.87E-10	4.87E-04	7.14E+02
Methylnaphthalene, 2-(1-)	1.40E-09	NA	2.94E-08	NA	3.08E-08	-	-	-	-	3.08E-08	-	-	-	-
Naphthalene	1.40E-09	NA	4.96E-08	NA	5.10E-08	3.70E-03	1.38E-05	2.00E-01	6.90E-05	5.10E-08	-	-	-	8.70E+02
Phenanthrene	2.94E-08	NA	5.01E-09	NA	3.44E-08	-	-	-	-	3.44E-08	-	-	-	-
Pyrene	3.25E-08	NA	3.83E-10	NA	3.29E-08	-	-	-	-	3.29E-08	6.00E-04	1.97E-11	1.97E-05	7.06E+04
Total Carcinogenic PAHs	2.57E-08	NA	6.61E-11	NA	2.58E-08	-	-	-	-	2.58E-08	6.00E-01	1.55E-08	1.55E-02	7.13E+01
PHC F2	-	-	-	-	-	-	6.16E-03	5.00E-01	1.23E-02	-	-	-	-	5.06E+04
Aliphatic C>10-C12	5.24E-06	NA	3.03E-03	NA	3.03E-03	1.00E+00	3.03E-03	5.00E-01	6.06E-03	3.03E-03	-	-	-	3.71E+04
Aliphatic C>12-C16	6.40E-06	NA	1.73E-03	NA	1.74E-03	1.00E+00	1.74E-03	5.00E-01	3.47E-03	1.74E-03	-	-	-	7.91E+04
Aromatic C>10-C12	1.31E-06	NA	2.24E-04	NA	2.25E-04	2.00E-01	1.13E-03	5.00E-01	2.25E-03	2.25E-04	-	-	-	2.49E+04
Aromatic C>12-C16	1.60E-06	NA	5.20E-05	NA	5.36E-05	2.00E-01	2.68E-04	5.00E-01	5.36E-04	5.36E-05	-	-	-	1.28E+05

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Table B3-11: Exposure and Risk Calculations - Soil Inhalation Pathways

COC	Construction worker													
	Exposure concentration					Non-cancer hazard				Cancer risk				
	Soil particulate concentration (mg/m³)	Trench vapour concentration (soil source) (mg/m³)	Outdoor air concentration (soil source) (mg/m³)	Indoor air concentration (soil source) (mg/m³)	Total inhaled concentration (soil source) (mg/m³)	Threshold inhalation TRV (mg/m³)	Soil inhalation HQ	SAF	Risk reduction required	amortized inhaled concentration (soil source) (mg/m³)	Non-threshold inhalation TRV $(mg/m^3)^{-1}$	Soil inhalation ILCR	Risk reduction required	Risk-based concentration (µg/g)
Arsenic	7.64E-07	-	-	NA	7.64E-07	1.50E-05	5.09E-02	2.00E-01	2.55E-01	2.05E-08	1.50E-01	3.07E-09	3.07E-03	1.29E+02
Acenaphthene	2.52E-09	4.72E-08	7.92E-09	NA	5.76E-08	-	-	-	-	1.54E-09	6.00E-04	9.26E-13	9.26E-07	1.17E+05
Acenaphthylene	1.40E-09	2.22E-08	3.15E-09	NA	2.67E-08	-	-	-	-	7.16E-10	6.00E-03	4.30E-12	4.30E-06	1.40E+04
Anthracene	6.44E-09	3.20E-08	1.43E-09	NA	3.99E-08	-	-	-	-	1.07E-09	6.00E-03	6.41E-12	6.41E-06	4.31E+04
Benz[a]anthracene	1.79E-08	1.55E-08	1.20E-10	NA	3.35E-08	-	-	-	-	8.97E-10	6.00E-02	5.38E-11	5.38E-05	1.43E+04
Benzo[a]pyrene	1.82E-08	-	-	NA	1.82E-08	2.00E-06	9.10E-03	2.00E-01	4.55E-02	4.87E-10	6.00E-01	2.92E-10	2.92E-04	1.71E+01
Benzo[b]fluoranthene	1.76E-08	-	-	NA	1.76E-08	-	-	-	-	4.72E-10	6.00E-02	2.83E-11	2.83E-05	2.67E+04
Benzo[g,h,i]perylene	8.68E-09	-	-	NA	8.68E-09	-	-	-	-	2.32E-10	6.00E-03	1.39E-12	1.39E-06	2.67E+05
Benzo[k]fluoranthene	9.52E-09	-	-	NA	9.52E-09	-	-	-	-	2.55E-10	6.00E-02	1.53E-11	1.53E-05	2.67E+04
Chrysene	2.16E-08	-	-	NA	2.16E-08	-	-	-	-	5.77E-10	6.00E-03	3.46E-12	3.46E-06	2.67E+05
Dibenz[a,h]anthracene	1.40E-09	-	-	NA	1.40E-09	-	-	-	-	3.75E-11	6.00E-01	2.25E-11	2.25E-05	2.67E+03
Fluoranthene	4.00E-08	-	-	NA	4.00E-08	-	-	-	-	1.07E-09	6.00E-03	6.43E-12	6.43E-06	2.67E+05
Fluorene	2.80E-09	2.60E-08	2.17E-09	NA	3.10E-08	-	-	-	-	8.31E-10	-	-	-	-
Indeno[1,2,3-cd]pyrene	8.12E-09	-	-	NA	8.12E-09	-	-	-	-	2.17E-10	6.00E-02	1.30E-11	1.30E-05	2.67E+04
Methylnaphthalene, 2-(1-)	1.40E-09	6.77E-08	2.94E-08	NA	9.85E-08	-	-	-	-	2.64E-09	-	-	-	-
Naphthalene	1.40E-09	8.80E-08	4.96E-08	NA	1.39E-07	3.70E-03	3.76E-05	2.00E-01	1.88E-04	3.72E-09	-	-	-	3.19E+02
Phenanthrene	2.94E-08	1.28E-07	5.01E-09	NA	1.63E-07	-	-	-	-	4.35E-09	-	-	-	-
Pyrene	3.25E-08	3.72E-08	3.83E-10	NA	7.01E-08	-	-	-	-	1.88E-09	6.00E-04	1.13E-12	1.13E-06	1.24E+06
Total Carcinogenic PAHs	2.57E-08	2.17E-09	6.61E-11	NA	2.80E-08	-	-	-	-	7.49E-10	6.00E-01	4.49E-10	4.49E-04	2.45E+03
PHC F2	-	-	-	-	-	-	1.09E-02	5.00E-01	2.17E-02	-	-	-	-	2.87E+04
Aliphatic C>10-C12	5.24E-06	2.11E-03	3.03E-03	NA	5.14E-03	1.00E+00	5.14E-03	5.00E-01	1.03E-02	1.38E-04	-	-	-	2.18E+04
Aliphatic C>12-C16	6.40E-06	1.21E-03	1.73E-03	NA	2.94E-03	1.00E+00	2.94E-03	5.00E-01	5.89E-03	7.88E-05	-	-	-	4.66E+04
Aromatic C>10-C12	1.31E-06	1.81E-04	2.24E-04	NA	4.06E-04	2.00E-01	2.03E-03	5.00E-01	4.06E-03	1.09E-05	-	-	-	1.38E+04
Aromatic C>12-C16	1.60E-06	9.64E-05	5.20E-05	NA	1.50E-04	2.00E-01	7.50E-04	5.00E-01	1.50E-03	4.02E-06	-	-	-	4.58E+04

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Table B3-12: Risk Based Concentrations and Property Specific Standards - Soil

		Indoor worker		Outdoor worker				Construction worker												
		Inhalation			Inhalation				Inhalation											
		Indoor air																		
COC	REM soil concentration (µg/g)	Generic commercial building (µg/g)	Site Building with Basement (µg/g)	Oral/Dermal (µg/g)	Particulates (µg/g)	Outdoor Air (µg/g)	All Inhalation Sources (µg/g)	Oral/Dermal (µg/g)	Particulates (µg/g)	Outdoor Air (µg/g)	Trench Air (µg/g)	All Inhalation Sources (µg/g)	Minimum oral/dermal risk based concentration (µg/g)	Minimum inhalation risk based concentration (µg/g)	Minimum Risk Based Concentration Oral/Dermal + Inhalation (µg/g)	Check: Minimum component value check (µg/g)	Final Risk Based Concentration (soil) (µg/g)	RM required	PSS (µg/g)	Basis
Arsenic	32.76	-	-	**1.92E-01**	1.29E+02	-	1.29E+02	**7.18E+00**	1.29E+02	-	-	1.29E+02	**1.92E-01**	1.29E+02	**1.92E-01**	-	**1.92E-01**	**Yes**	32.76	Max. + 20%
Benzo[a]pyrene	0.78	-	-	**6.95E-01**	1.71E+01	-	1.71E+01	-	1.71E+01	-	-	1.71E+01	**6.95E-01**	1.71E+01	**6.95E-01**	-	**6.95E-01**	**Yes**	0.78	Max. + 20%
Total Carcinogenic PAHs	1.10	-	-	**6.95E-01**	7.14E+01	-	7.13E+01	-	2.67E+03	-	3.16E+04	2.45E+03	**6.95E-01**	7.13E+01	**6.95E-01**	-	**6.95E-01**	**Yes**	1.10	Max. + 20%
PHC F2	624	6.38E+03	2.64E+04	-	-	-	5.06E+04	-	-	-	-	2.87E+04	-	6.38E+03	6.38E+03	-	6.38E+03	No	624	Max. + 20%
Aliphatic C>10-C12	224.64	-	-	-	2.14E+07	-	3.71E+04	-	2.14E+07	-	5.32E+04	2.18E+04	-	2.18E+04	2.18E+04	-	2.18E+04	No		
Aliphatic C>12-C16	274.56	-	-	-	2.14E+07	-	7.91E+04	-	2.14E+07	-	1.14E+05	4.66E+04	-	4.66E+04	4.66E+04	-	4.66E+04	No		
Aromatic C>10-C12	56.16	-	-	-	4.29E+06	-	2.49E+04	-	4.29E+06	-	3.11E+04	1.38E+04	-	1.38E+04	1.38E+04	-	1.38E+04	No		
Aromatic C>12-C16	68.64	-	-	-	4.29E+06	-	1.28E+05	-	4.29E+06	-	7.12E+04	4.58E+04	-	4.58E+04	4.58E+04	-	4.58E+04	No		

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Table B3-13: Risk Reduction Factors - Soil

COC	REM soil concentration (µg/g)	Oral/Dermal + Particulate Inhalation		Vapour Inhalation			Overall risk reduction factor (soil)
		Outdoor worker	Construction worker	Site Building with Basement: Indoor workers	Outdoor air: Outdoor workers	Trench air: Construction worker	
Arsenic	32.76	1.70E+02	4.56E+00	-	-	-	1.70E+02
Benzo[a]pyrene	0.78	1.12E+00	-	-	-	-	1.12E+00
Total Carcinogenic PAHs	1.10	1.59E+00	-	-	-	-	1.59E+00
PHC F2	624	-	-	-	-	-	-

APPENDIX C

Ecological Risk Assessment Supporting Information

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.

Soil ingestion rates were the same as those used in the MECP generic model:

- Meadow vole – The soil ingestion rate for the meadow vole (1.8×10^{-5} kg/d) was the same value used by MECP in the generic model. MECP cited Sample and Suter (1994) and the US EPA Wildlife Exposure Handbook (US EPA 1993) as sources for this value.
- Short-tailed shrew – The soil ingestion rate for the shrew (1.87×10^{-4} kg/d) was calculated by MECP (MOE 2011) based on values reported by US EPA (1993). The rate of soil ingestion was assumed to be 13% of the diet (Sample and Suter 1994) on a dry weight basis, which was calculated to be 1.44 g/d using a food ingestion rate of 0.009 kg/d (wet weight) cited by Sample and Suter (1994) based on the average of rates for shrews in captivity fed a diet of larch sawflies (Buckner 1964) and mealworms (Barrett and Stueck 1976) and assuming a moisture content of 84% for earthworms (Sample and Suter 1994).
- Red-winged blackbird – The soil ingestion rate for the red-winged blackbird (1.09×10^{-3} kg/d) was calculated by MECP (MOE 2011). The value was based on soil ingestion rates reported in the US EPA Wildlife Exposure Handbook (US EPA 1993) for similar species.
- American woodcock – The soil ingestion rate for the American woodcock (2.5×10^{-3} kg/d) was calculated by MECP based on values reported by US EPA (1993). The rate of soil ingestion was assumed to be 10.4% of the diet (Sample and Suter 1994) on a dry weight basis, which was calculated to be 24 g/d using a food ingestion rate of 0.15 kg/d (wet weight) cited by Sample and Suter (1994) and assuming a moisture content of 84% for earthworms (Sample and Suter 1994).

The average daily dose (ADD) from soil ingestion was calculated using the following formula:

$$ADD_{Soil} = \frac{C_{soil} \times IR_{soil}}{BW}$$

where: ADD_{Soil} = Average daily dose due to soil ingestion (mg/kg/day);
C_{soil} = Concentration of COC in soil (mg/kg);
IR_{soil} = Soil ingestion rate (kg/day); and
BW = Body weight (kg).

ADDs for soil were summed with ADDs from food sources.

References

Barrett, G.W. and K.L. Stueck (1976) Caloric ingestion rate and assimilation efficiency of the short-tailed shrew, *Blarina brevicauda*. Ohio Journal of Science 76: 25-26.

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Sample, B.E. and G.W. Suter, II (1994) Estimating Exposure of Terrestrial Wildlife to Contaminants, U.S. Department of Energy, Office of Environmental Restoration and Waste Management. ES/ER/TM-125.

US EPA (1993) Wildlife Exposure Factors Handbook. Washington, DC, U.S. Environmental Protection Agency, Office of Research and Development. EPA/600/R-93/187.

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Table C-1: Ecological COC Screening - Soil

COC	Maximum soil concentration (µg/g)	REM concentration (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)	Site-specific S-GW3 (350 m) (Coarse) (µg/g)	Free phase threshold (coarse) (µg/g)
Arsenic	27.3	32.76	4.00E+01	3.30E+02	NV	NV	1.20E+04
Benzo[a]pyrene	0.65	0.78	7.20E+01	4.60E+04	3.80E+13	2.87E+14	7.70E+03
Petroleum Hydrocarbons F2	520	624	**2.60E+02**		**2.30E+02**	1.73E+03	2.70E+03

Table C-2: Ecological Receptor Exposure Parameters

Food item:	Terrestrial plant foliage			Terrestrial plant seeds			Earthworms			Other soil invertebrates			Mammals/birds					
% 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)	Food ingestion rate (dry) (kg/d)	Soil ingestion rate (kg/d)	Body weight (kg)
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	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	3.11E-03	1.87E-04	1.50E-02
Red-winged blackbird	0	0	0	1	9.10E-02	8.25E-02	0	0	0	0	0	0	0	0	0	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	2.40E-02	2.50E-03	1.98E-01

Table C-3: Exposure and Risk Estimates -
Plants and Soil Organisms

	Plants & Soil Organisms		
		Coarse R/P/I	
COC	REM concentration (µg/g)	TRV (µg/g)	Exposure ratio
Petroleum Hydrocarbons F2	624	150	**4.2E+00**

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Table C-4: Exposure and Risk Estimates - Meadow Vole

		Meadow vole												
		Uptake into Vegetation			Uptake into Earthworms				ADD					
COC	REM soil concentration (µg/g)	Soil-to-plant transfer factor/equation	Source	Maximum conc. in vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Maximum conc. in soil invertebrates (mg/kg ww)	Maximum conc. in 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
PHC F2	624	$C_p = 0$	CCME (2008)	0	$C_e = 0$	CCME (2008)		0	2.55E-01	0.00E+00	0.00E+00	2.55E-01	4.47E+01	5.71E-03

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Table C-5: Exposure and Risk Estimates - Short-tailed Shrew

COC	REM soil concentration (µg/g)	Short-tailed Shrew: Uptake into Vegetation: Soil-to-plant transfer factor/equation	Source	Maximum conc. in vegetation (mg/kg dw)	Uptake into Earthworms: Soil-to-invertebrate transfer factor/equation	Source	Maximum conc. in soil invertebrates (mg/kg ww)	Maximum conc. in soil invertebrates (mg/kg dw)	ADD: 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
PHC F2	624	$C_p = 0$	CCME (2008)	0	$C_e = 0$	CCME (2008)		0	7.78E+00	0.00E+00	0.00E+00	7.78E+00	4.47E+01	1.74E-01

Table C-6: Exposure and Risk Estimates - Red-winged Blackbird

		Red-winged Blackbird												
		Uptake into Vegetation			Uptake into Earthworms				ADD					
COC	REM soil concentration (µg/g)	Soil-to-plant transfer factor/equation	Source	Maximum conc. in vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Maximum conc. in soil invertebrates (mg/kg ww)	Maximum conc. in 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
PHC F2	624	$C_p = 0$	CCME (2008)	0	$C_e = 0$	CCME (2008)		0	1.06E+01	0.00E+00	0.00E+00	1.06E+01	NV	-

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Table C-7: Exposure and Risk Estimates - American Woodcock

		American Woodcock												
		Uptake into Vegetation			Uptake into Earthworms				ADD					
COC	REM soil concentration (µg/g)	Soil-to-plant transfer factor/equation	Source	Maximum conc. in vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Maximum conc. in soil invertebrates (mg/kg ww)	Maximum conc. in 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
PHC F2	624	$C_p = 0$	CCME (2008)	0	$C_e = 0$	CCME (2008)		0	7.88E+00	0.00E+00	0.00E+00	7.88E+00	NV	-

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Table C-8: Risk-Based Concentrations - Meadow Vole

	Meadow vole															
		Uptake into Vegetation			Uptake into Earthworms				ADD							
COC	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Maximum conc. in vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Maximum conc. in soil invertebrates (mg/kg ww)	Maximum conc. in 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 concentration (µg/g)
PHC F2	1.09E+05	$C_p = 0$	CCME (2008)	0	$C_e = 0$	CCME (2008)		0	4.47E+01	0.00E+00	0.00E+00	4.47E+01	4.47E+01	1.00E+00	1.09E+05

Table C-9: Risk-Based Concentrations - Short-tailed Shrew

COC	Short-tailed Shrew														
		Uptake into Vegetation			Uptake into Earthworms				ADD						
	Soil conc. (µg/g)	Soil-to-plant transfer factor/equation	Source	Maximum conc. in vegetation (mg/kg dw)	Soil-to-invertebrate transfer factor/equation	Source	Maximum conc. in soil invertebrates (mg/kg ww)	Maximum conc. in 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 concentration (µg/g)
PHC F2	3.59E+03	$C_p = 0$	CCME (2008)	0	$C_e = 0$	CCME (2008)		0	4.47E+01	0.00E+00	0.00E+00	4.47E+01	4.47E+01	1.00E+00	3.59E+03

Table C-10: Risk Based Concentrations
and Property Specific Standards - Soil

COC	Soil REM concentration (µg/g)	Risk Based Concentrations 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)	Minimum risk based concentration (µg/g)	RM required	Risk reduction factor	PSS (µg/g)	Basis
Arsenic	32.76	NA	NA	NA	NA	NA	NA	NA				32.76	Max.+20%
Benzo[a]pyrene	0.78	NA	NA	NA	NA	NA	NA	NA				0.78	Max.+20%
Petroleum Hydrocarbons F2	624	**2.6E+02**	1.1E+05	3.6E+03	5.2E+04				**2.6E+02**	**Yes**	2.40E+00	624	Max.+20%

APPENDIX D

Limitations

Disclaimer and Limitations

1. **Paterson Group Inc.** provided this report for **Ottawa Humane Society** 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.

9. This report is not to be given over to any third party for any purpose whatsoever without the written permission of **Paterson Group Inc.,** our Client, or their representative.

10. **Paterson Group Inc.** reserves all rights in this report, unless specifically agreed to otherwise in writing with **Ottawa Humane Society.**