Rationale Document for Reuse of Excess Soil at Receiving Sites

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1. Introduction

The Ministry of the Environment and Climate Change (MOECC) through engagement with stakeholder experts and Indigenous communities heard the need to develop standards for the reuse of excess soils in Ontario. The MOECC has developed generic tables of Excess Soils Reuse Standards along with associated rules for receiving sites, which would be contained in a document titled "Reuse of Excess Soil at Receiving Sites" and referenced by the *proposed Excess Soil Reuse Regulation.* The standards are just one component of a larger excess soils regulatory proposal being proposed by the MOECC and should be evaluated together. The proposed excess soil reuse standards represent a first phase of standards development and MOECC intends to create additional standards, tools and approaches over time to enable excess soil reuse opportunities (e.g. standards for soil at depth, situations where there are no buildings). The MOECC will continue to work with stakeholders and Indigenous communities to refine the excess soil reuse standards moving forward.

The excess soil reuse standards are intended to address risks associated with chemical impacts in soil and are not meant to address issues of radioactivity, explosive conditions, soil fertility, or geotechnical considerations. The standards do not replace the determination of hazardous and non-hazardous waste, or what is appropriate for lakefilling. The standards are intended to provide users the ability to look-up a table of generic standards to enable the reuse of excess soil at a receiving site. This document provides an overview of the derivation process for the first phase of the excess soil reuse standards, the associated assumptions and placement requirements as well as recommendations for applying these standards, and the actual numerical standards in table format.

While a number of assumptions and exposure pathways used in the development of the existing O.Reg 153/04 brownfields site condition standards are applicable in an excess soil reuse context, certain differences exist, including consideration of larger volumes of impacted soil. These differences require careful consideration and in some cases result in different standards depending on the contaminant and relevant exposure risks. The standards and associated requirements for application are intended to address these differences. The standards have been developed and organized specific to different soil placement categories including, land use, groundwater potability, and soil placement volumes. They provide users a convenient option for determining appropriate soil quality limits by matching receiving sites with the aforementioned categories through a series of look-up tables. This is intended to enable greater utilization of this important soil resource, whilst maintaining the protection of human health and the environment. The standards are developed using generic assumptions to account for the potential exposure risks that one may encounter at any number of different properties in Ontario so as to enable their broad application. Utilization of site specific standard setting approaches is also considered and discussed in this document.

2. Overview of Excess Soil Standard Development

Similar to the brownfield soil standards, excess soil standards were derived through the consideration of a number of component values developed to provide a sensitive human or ecological receptor with an acceptable level of protection from a substance via a specific exposure pathway. Eleven (11) soil component values were considered when deriving the excess soil standards. The lowest of the component values becomes the risk-based standard for a substance. As with the brownfield soil standards, the final excess soil standard is not permitted to be numerically higher than the free phase product formation threshold, or lower than either of the reporting detection limits (RLs) or typical background concentrations found in Ontario.

Components Considered for the Development of Excess Soil Standard

The contaminant pathways considered for the development of excess soil standards are:

1) S1 (Soil for protection of a residential, parkland or institutional (R/P/I) receptor from direct contact (dermal and incidental ingestion) with surface soil). This component is also applied for Agricultural land use.
2) S2 (Soil for protection of an industrial, commercial or community (I/C/C) receptor from direct contact (dermal and incidental ingestion) with surface soil)
3) S3 (Soil for protection of a worker digging in the soil from direct contact (dermal and incidental ingestion) with soil)
4) S-IA (Soil for protection of vapour movement to indoor air and human exposure)
5) S-OA (Soil for protection of vapour movement to outdoor air and human exposure)
6) S-Odour (Soil for protection from excessive odours)
7) S-GW1 (Soil for protection from movement to ground water for drinking water purposes)
8) S-GW2 (Soil for protection from movement to ground water and then vapour migration from ground water to indoor air)
9) S-GW3 (Soil for protection from movement to ground water and then migration to surface water (aquatic life)
10) Plants and Soil Organisms (Soil for protection against adverse effects to plants and soil dwelling organisms)
11) Mammals and Birds (Soil for protection against adverse effects through direct soil contact (ingestion) and food/prey ingestion to mammals and birds)

With the exception of S-GW2, descriptions of the soil component values and pathways can be found in Section 1.3.2 of the MOECC (2011) *Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario.* The S-GW2 pathway was not included in the development of the brownfield soil standards. An explanation of derivation of the S-GW2 component value is presented in Section 3.3 and Appendix I of this document.

Components Not Considered in the Development of Excess Soil Standards

Some of the pathways not considered in the development of brownfield or excess soil standards include the following:

1) Consumption of garden products cultivated at a receiving site
2) Agricultural land use specific exposure scenarios
    - Livestock watering
    - Irrigation water
    - Dust Inhalation

- Consumption of milk or diary product produced at a receiving site
- Consumption of plants or animals cultivated at a receiving site

3) Protection of reptiles and amphibians

A more comprehensive discussion of the human health pathways not considered in soil standard development can be found in Section 2.3.2 of the MOECC (2011) *Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario* rationale document. The regulation proposes additional protections for certain receiving sites e.g., where soil is used as a growing medium for crops.

Differences in the assumptions and derivation processes between excess soil standards and the brownfield soil standards are presented in the following sections of this document.

3. Deviations from Brownfield Standard Development

Consideration of the potential differences between a brownfield redevelopment scenario and an excess soil reuse scenario identified the need for some deviations from the assumptions and inputs used in the development of the brownfield soil standards and in the associated requirements for application of the numerical standards. These differences are discussed in the following sections.

Guiding Principals

The fundamental guiding principle in the development of the excess soil standards and the associated application rules are to promote beneficial reuse of soils as a resource without creating future contaminated sites, and while protecting human and environmental health through targeted acceptable risk levels. Under a brownfield context, a key guiding principle for the development of site condition standards (SCSs) was the cleanup of historical contamination at an individual property. Under this scenario, the SCSs represent risk-based clean down to levels under specific sets of assumptions regarding the size/extent of the impacted area, likely receptors, ground water potability and existing and proposed land uses. Excess soil reuse standards may be used at much larger properties acting as a receiving site for soils coming from one or a number of individual properties, including possibly brownfields. These receiving sites may be in rural areas with no historical anthropogenic impacts, resulting in potential degrading of the ambient condition of a receiving site, which should be considered when using these standards. To the extent possible, the proposed excess soil standards reflect these developmental differences, which are discussed in more detail in the following sections.

Leachate Standards

The ministry has for some “contaminants of potential concern” derived separate leachate standards and provided new Tables (Table E and F of Appendix IV) to accompany the excess soils tables of standards. These newly derived leachate standards provide the ability to more accurately assess and address groundwater contamination risks where the contaminants within the soil are of a potential concern to the receiving site groundwater. A leachate test would be required where a (qualified person) QP determines that there is a likelihood of a “contaminant of potential concern” being present in the excess soil, as listed in Table E and F below. The regulation provides the proposed requirements in greater detail in the section "*Soil Originating from an APEC*". The additional testing provides confirmation that excess soils placed at a receiving site will not lead to unacceptable concentrations within the receiving site groundwater, which may then migrate to drinking water sources or surface water bodies. Within the brownfields redevelopment scenario (under O.Reg 153/04) there is the ability to use groundwater sampling data to confirm the presence of impacts. The regulation would not require groundwater sampling and analysis. Therefore leachate sampling and analysis with comparison to leachate standards would be required by regulation in certain circumstances. Leachate results would act as a surrogate to empirical groundwater data. Leachate standards are only developed where either the leachate pathway is not modelled within the soil standards derivation process, or where a soil standard is set at an analytical reporting limit (RLs).

This additional line of evidence will help to identify potential risks to groundwater and ensure the protection of human health and the environment. It also permits the removal of the related soil to groundwater component value (S-GW1, S-GW2, or S-GW3) from the soil standard, often resulting in a numerically higher soil standard.

Analytical Reporting Limits

Some soil component values derived to protect other media (e.g. groundwater through S-GW1, S-GW2, and S-GW3) are numerically lower than the associated analytical RL in soil (as detailed in the analytical methods for O.Reg 153/04). This generally indicates that the currently available soil sampling and analytical methods may not be able to reliably measure concentration of this magnitude; therefore soil sample analysis results may not adequately assess the potential risks and a leachate test can help to determine if the soil is appropriate for reuse. Where there is a significant difference between the component value and the RL, and where this may lead to that contaminant being a potential concern in terms of groundwater impacts, leachate standards were derived. MOECC is investigating opportunities to identify practical approaches to achieve lower RLs.

Leaching of Inorganics to Groundwater

In addition to the situation described above, leachate analysis would also be required for inorganics. The movement of inorganics from soil to groundwater is not modelled for development of the brownfield standards due to the uncertainty involved in selecting appropriate organic carbon-water partition coefficients for a generic scenario as they are very sensitive to site specific conditions and can range over orders of magnitude. As a result, S-GW1 and S-GW3 component values are not calculated and cannot be used to ensure these pathways are protected. Groundwater component values protective of the drinking water and aquatic life pathways are derived. Brownfield redevelopment also differs in that groundwater sampling can be completed as an additional line of evidence to help determine if leaching is occurring.

Since groundwater sampling and/or monitoring is not required by MOECC as part of proposed excess soil reuse regulation, and movement of inorganics to groundwater is not modelled, leachate standards were derived to offer a better representation of the concentrations within the relevant medium and associated potential risk.

A discussion of Leachate tests and applicable GW1 and GW3 values for the inorganics are available in Appendix IV.

Alternatives to Leachate Testing

As an alternative to completing leachate analysis, set back distances could be utilized at a receiving site. This approach would require a QP to establish a distance setback from one or both a drinking water source, and surface water body. The setback is intended to ensure that contaminants do not reach those receptors at concentrations above the applicable leachate standard. Where a QP has determined that any of the contaminants of potential concern will not reach either a water body or drinking water well at concentrations above the applicable leachate standard, as a result of applying proximity setbacks from any water body or drinking water well, leachate testing would not be required. Where the receiving site is considered to be in a potable groundwater condition then the contaminants of potential concern must not reach the property boundary above the applicable leachate standard.

These kinds of assessments should be performed by a QP. Setbacks should be maintained by the receiving site owner to ensure that these exposure risks do not manifest at some future time. Some additional guidance is provided in Appendix IV.

Volume of Excess Soil

Under a brownfield context, a typical "spill" scenario is modelled as a contaminated soil volume of 13 m by 13 m by 2 m depth (approximately 350 m^3). This source size assumption influences exposure pathways which assume a finite contamination volume with contaminant source which depletes over time (source depletion), and/or employ groundwater transport. Greater volumes of contamination may lead to greater exposure via certain pathways. Greater volumes may also take much longer to deplete and can result in greater exposure risk. The sensitivity of soil standards to soil volume is summarized in Table 1 (see Tables section of document).

Within an excess soil scenario, soil volumes much larger than 350 m^3 are likely to be reused at receiving sites and so standards that account for larger volumes were derived. To ensure the standards are protective of human health and the environment the MOECC considered a range of factors in the derivation of the excess soils standards related to both volume and dimension of the impacted soils. Some uncertainty exists and should be taken into consideration when selecting volume and dimension modelling inputs, as excess soil may be placed in any number of different ways at different receiving sites. To facilitate movement of excess soil to a wide range of different receiving sites, excess soil standards were derived for the following source size scenarios:

- **Small Volume –** applicable for volumes up to 350 m^3. The brownfields O.Reg 153/04 site condition standards (Tables 2-9) which assume a volume ~ 350 m^3 will be applicable at small volume excess soil receiving sites. Brownfield site condition standards will remain unchanged until O. Reg. 153/04 is updated, therefore the updates to key inputs described in Section 3.5 do not apply to the small volume tables at this time.

- **Medium volume –** applicable up to 5000 m^3 being reused at a receiving site. Provided in Appendix III. To effectively assess the impact of soil volume on component values which employ groundwater transport or assume a contamination volume of 5000 m^3 was used to derive these standards.
- **Volume independent –** applicable to any volume of soil being reused at a receiving site. Provided in Appendix III. To effectively eliminate the impact of soil volume on component values which employ groundwater transport or assume a finite contamination volume, assumptions were modified to represent an infinite contaminant volume.

Soil to Groundwater to Indoor Pathway (S-GW2)

The S-GW2 component value is included to protect receptors from exposure to a substance that has leached from soil to groundwater, moved with groundwater, then migrated as a vapour from groundwater to indoor air. Under a brownfield context, the S-GW2 pathway is not included as the S-IA component is generally numerically lower, therefore it would become the resulting standard, ensuring protection of both exposures. The S-GW2 component value is usually numerically higher partly because there is potential for additional vapour attenuation through contaminant leaching and mixing with groundwater before vapours migrate back up to overlying buildings. In addition, the groundwater to indoor air pathway (GW2) can be more directly evaluated through groundwater sampling, which may not be completed when reusing excess soils.

Since impacted soil volumes may be much larger under an excess soil scenario than that assumed in a brownfield scenario, and could result in greater leaching, the S-GW2 pathway is considered a check value to ensure that the soil standard is protective of the vapour intrusion pathway for off-site building structures. Consideration of the S-GW2 pathway is also necessary for scenarios where the S-IA pathway is eliminated (e.g. no buildings) and groundwater monitoring is not required to confirm that concentrations of contaminants in groundwater that may flow off site will be protective of vapour intrusion risks on adjacent properties.

Similar to the brownfield assumption for GW2 component values, it is necessary for the generic standards to prevent a potential scenario wherein groundwater from an I/C/C site at the I/C/C S-GW2 standard flows onto an adjacent R/P/I property and does not meet the R/P/I standard. To protect for this situation, the I/C/C S-GW2 value defaults to the R/P/I S-GW2 value.

The S-GW2 component value is calculated using a partitioning model and vertical migration model coupled with GW2 values to produce soil values that are protective of indoor air quality. Source depletion is considered in the derivation of this component value for the small and medium soil volume tables. A detailed S-GW2 calculation process is presented in Appendix I.

Soil Texture

The generic brownfield SCSs are derived for two soil textures, coarse and medium-fine. Coarse textured soil is considered to be a soil with greater than 50% by mass of particles that are greater than 75 μm or larger in mean diameter. While most direct soil contact human health component values (S1, S2, S3) and ecological component values are independent of soil texture, the remaining component values are sensitive to the soil type in both the vadose zone and saturated zone (capillary fringe).

Table 2 presents the effect of soil type (coarse-textured vs fine/medium textured) on each component value. Generally, coarse-textured soil results in higher vapour transport and partitioning/leaching rates, resulting in more stringent component values.

However, component values for which source depletion is considered may have numerically higher component values for coarse grained soil due to the faster degradation rate for coarse textured soils. Sensitivity analyses indicated that soil standards driven by vapour transport component values (e.g. S-IA, S-OA) are the most sensitive to soil texture.

Under an excess soil scenario, soil disturbance during excavation, transport and deposition may change soil structures, including soil porosity, hydraulic conductivity and vapour permeability. Medium-fine grained excess soil moved to a receiving site may potentially allow increased vapour transport into overlying buildings and/or leaching into groundwater as a result of these disturbances. Therefore, excess soil standards are developed conservatively assuming coarse-textured soil and as such may be applied at a receiving site with either coarse-textured or a medium/fine textured soils.

Where desired, the soil grain size of a receiving site can be evaluated on a case by case basis and may be accounted for as part of site specific standards development.

Changes to Key Inputs

Changes were made to some key input parameters for the derivation of excess soil standards. The changes are detailed in the sections below.

3.1.1. Toxicity Reference Values (TRVs)

The following TRVs have been recently updated in the MOECC 2016 *Approved Model* and as such are used in development of the standards for excess soil:

- The chronic inhalation TRV for TCE was updated from 0.04 mg/m^3 to 0.002 mg/m^3. The new TCE TRV is based on developmental effects, the previous TRV was not.
- The chronic inhalation TRV for tetrachloroethylene (PCE) was updated from 0.25 mg/m^3 to 0.004 mg/m3.
- The chronic inhalation TRVs for ethylbenzene and bromomethane were recently confirmed as non-developmental toxicity and have been updated.
- The oral slope factor for bromoform was changed from 0.0079 to 0.011 (mg/kg-day)$^{-1}$.The inhalation unit risk for bromoform was changed to “none selected” from 0.0011 (mg/m^3)$^{-1}$.
- The oral chronic TRV for chloroform was changed from 0.01 to 0.015 (mg/kg-day). The inhalation unit risk for chloroform was changed to “none selected” from 0.0053 (mg/m^3)$^{-1}$.
- Hazard quotients (HQs) of 0.2 and 0.5 are used for TCE for calculating vapour intrusion component values (S-IA and GW2) for potable and non-potable sites, respectively. Related details are presented in Section 9.1 of the MOECC 2016b User’s Guide.

3.1.2. Updates to Ontario Drinking Water Quality Standards

Several new and revised Ontario Drinking Water Quality Standards (ODWQS) and aesthetic objectives (AO), for chemicals which have site condition standards for soil and groundwater, come into effect in 2017 and 2018, as shown in the following table. The new/updated values have been incorporated into the development of the medium volume and volume independent excess soil standards.

CHEMICAL	NEW ODWQS (mg/L)	OLD ODWQS (mg/L)	NEW ODWQS EFFECTIVE DATE	Comments
Arsenic	0.01	0.025	January 1, 2018	
Benzene	0.001	0.005	January 1, 2017	
Carbon Tetrachloride	0.002	0.005	January 1, 2017	
Ethylbenzene	0.14	NV	July 1, 2017	
Ethylbenzene-AO	0.0016	0.0024	July 1, 2017	
Methyl-t-butyl ether -AO	0.015	0.015	July 1, 2017	Already used as AO based on Canadian DWQS
Selenium	0.05	0.01	July 1, 2017	
Tetrachloroethylene	0.01	0.03	July 1, 2017	
Toluene	0.06	NV	July 1, 2017	Current AO is lower, therefore no change.
Xylenes	0.09	NV	July 1, 2017	
Xylenes -AO	0.02	0.3	July 1, 2017	
Vinyl Chloride	0.001	0.002	January 1, 2017	

4. Using the Tables of Excess Soil Standards

A key objective of the proposed regulation is to ensure that excess soil is only deposited at receiving sites that are appropriate. The determination of appropriateness would be based upon requirements in a site specific instrument, a municipal by-law or an ECA under Part V of the EPA. If such an instrument does not exist, then the determination would be based upon the MOECC standards and associated rules for receiving sites. Schedule C of the regulation includes the proposed requirements associated with receiving sites when using the MOECC excess soil reuse standards.

A site receiving up to 350 m^3 of excess soil would apply the existing brownfields O.Reg 153/04 site condition standards. This means that small volume sites will have the choice to select from a number of existing tables of risk-based standards (Tables 2-9) depending on the characteristics of the receiving site equivalent to what is done as part of brownfields redevelopment under O.Reg 153/04. There is some flexibility proposed in the regulation to allow a QP the discretion to apply that the small volume standards for volumes up to 1000 m^3 (see Schedule C of the regulation). Excess Soil Reuse Standards were also derived for medium soil volume (up to 5000 m^3), and volume independent receiving sites, for both potable (Table 2) and non-potable (Table 3) groundwater scenarios. As discussed in section 3.2 standards for soil leachate have been derived for certain chemicals and must be met in certain situations.

At this time, medium volume and volume independent standards have not been developed for the equivalent of Tables 4-9 (i.e. stratified soil, shallow soils and within 30 m of surface water). The MOECC is considering how to best promote excess soils reuse including the possible development of additional generic tables of excess soil standards and enabling more comprehensive site specific excess soil standards development as discussed in Section 5 of this document.

Selection of Appropriate Table of Standards

When excess soil standards are used, it is important that the correct table be selected based on conditions at the receiving site, and that the key assumptions used to develop the excess soil standards are not violated without careful consideration by a QP. The following sections detail key site conditions that QPs should assess to inform selection of the most appropriate table of excess soil standards for a particular receiving site.

4.1.1. Land Use

Excess soil standards are available for three land use types: agricultural and other, residential/parkland/institutional (R/P/I), and industrial/commercial/community (I/C/C). Non-potable site condition standards were derived for two land use types; R/P/I and I/C/C. Agricultural land is always assumed to be in a potable groundwater condition.

4.1.2. Potable and Non-potable Groundwater Use

Selection of whether potable groundwater conditions apply at a receiving site would be determined in the same way as in O.Reg 153/04. This includes notification of the local municipality, and any upper-tier municipality where non-potable standards are desired and the ability of that municipality to object and compel the use of potable standards.

4.1.3. Soil Volume

The total soil volume to be reused at the receiving site should be no more than 350m^3 for the small volume excess soils standards (with some flexibility up to 1000 m^3 as provided in Schedule C), 5000m^3 for the medium excess soils standards and where soil is above the 5000 m^3 threshold the Volume Independent standards should be used, as outlined in Appendix III. Limitations of the standards are discussed in Section 6 and should be considered when selecting the most appropriate table of excess soils standards. While a number of the standards remain the same irrespective of the volume assumed, for convenience the entire list of contaminants with associated standards is produced in each of the different tables.

Tables of Excess Soils Standards

4.1.4. Table 1 Standards

Table 1 is the same as is found in O.Reg 153/04 contained in the Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, dated April 15, 2011, which can be found here (https://dr6j45jk9xcmk.cloudfront.net/documents/998/3-6-3-sediment-standards-en.pdf). Table 1 provides the "Full Depth Background Site Condition Standards".

Table 1 standards can be helpful when someone would like to confirm that soil not suspected of having any contamination is in fact "clean". Table 1 standards may also be used as a default for sites receiving potentially impacted excess soils, where the available tables of generic excess soils standards do not apply – e.g. the receiving site is different in some significant characteristic than that assumed in the generic standards development. Given that sometimes contaminants may be present at concentrations below available reporting limits (as discussed in section 3.3) when evaluating if soils are in fact unimpacted by anthropogenic sources, it is important to have a good understanding of where the soil originates from. Where investigation indicates potential for the presence of contaminants due to historical potentially contaminated activities, testing and comparison beyond Table 1 (e.g. leachate and/or vapour) can provide additional lines of evidence and in some cases would be required.

The soil standards in Table 1 are intended to represent background conditions derived from the Ontario Typical Range (OTR) values for the land uses indicated and are considered representative of upper limits of typical province-wide background concentrations in soils that are not contaminated by point sources. However, where an OTR value is numerically lower (or not available) than what a laboratory can reliably measure with confidence (as established in O.Reg 153/04) and referred to as the "reporting limit" (RL)) then to be pragmatic the Table 1 value is set at the RL instead of the OTR. Where this happens, it indicates that either:

1) the particular chemical does not occur naturally, and so in the absence of an OTR the Table 1 standard is set at the achievable reporting limit - this ensures that detection demonstrates the likelihood of anthropogenic impacts; or,
2) the chemical may be present in the soil but has been missed by the soil sampling and subsequent analysis.

This latter situation (2) is a limitation for the generic tables of standards including Table 1 in that for soil which has been sourced from areas where a potentially contaminating activity (PCA) has been identified, meeting Table 1 alone may be insufficient to demonstrate that the soil does not contain anthropogenic impacts. If the excess soil has been sourced from an area where historical land use activities may have contaminated the soil, (i.e. the presence of a PCA), then additional lines of evidence (leachate analysis) may be required to determine that the excess soil does not unacceptable levels of risk.

4.1.5. *Small Volume (up to 350 m^3 of soil) - Tables 2-9 from O.Reg 153/04*

The small volume standards are the O.Reg 153/04 site condition standards Tables 2-9. Selection of the appropriate table for a site is based on the same criteria presented in O.Reg 153. These standards are contained in the Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act, dated April 15, 2011 (PIBS # 7382e01), which can be found here (https://dr6j45jk9xcmk.cloudfront.net/documents/998/3-6-3-sediment-standards-en.pdf).

4.1.6. *Medium Volume (up to 5000 m^3) - Tables A (potable) and B (non-potable)*

The medium volume standards are presented in Tables A and B, for potable and non-potable sites, respectively, in Appendix III.

4.1.7. *Volume Independent (applicable to any volume of soil)- Tables C (potable) and D (non-potable)*

Excess soil standards that are independent of soil volume and can be applied to large volumes of soil regardless of the dimensions are presented in Tables C and D, for potable and non-potable sites, respectively, in Appendix III.

4.1.8. *Tables of Leachate Standards*

Leachate standards for the Medium Volume and Volume Independent scenarios as well as for both potable and non-potable ground water use scenarios, which are applied in specified circumstances (as described in section 3.2 and in the Regulation Schedule C), are provided in Tables E and F of Appendix IV.

5. Site Specific Excess Soils Standards Development

Determining acceptable soil quality for a given receiving site may also be achieved through the development of site-specific excess soil standards that better reflect the conditions of that particular receiving site. This kind of site specific assessment often identifies site conditions which may provide for greater protection than what is assumed generically in the tables of generic excess soils standards. Site specific standards will enable greater reuse of excess soils as a resource.

The MOECC is also developing a spreadsheet based tool that will allow for the convenient development of site specific excess soils standards. This “Site Specific Beneficial Reuse Assessment Tool” would allow simple modification of the generic excess soils standards using site specific information. This approach relies on knowledge of the excess soil receiving site, which can significantly change what is deemed to be acceptable soil quality. This tool would also include the ability to reflect more site specific land use characteristics, such as no building development where the soil will be reused or soil being placed at depth.

The tool could also be developed in a way where a user answers a series of relatively simple questions analogous to how someone selects the appropriate generic table of standards (e.g. is the site a shallow soils site, or near a water body etc.) to generate a more tailored table of standards. This approach would have the benefit of permitting a number of different combinations and permutations of standards tables, as opposed to having each of the site characteristics preselected by the MOECC as is done in

Tables 4-9 in O.Reg 153/04. The MOECC will continue to engage stakeholders and Indigenous communities on the merits of this approach vs the generation and publishing of additional generic tables of standards.

It is proposed that the Site Specific Beneficial Reuse Assessment Tool be available for free to users and available at the time the excess soils regulatory requirements come in to force. These site specific options would be enabled explicitly by the regulation. The MOECC is proposing that site specific standards for excess soils receiving sites be developed using the Site Specific Beneficial Reuse Assessment Tool and utilized without the requirement of a provincial review, and may only be used by a QP with expertise in risk assessment.

In addition, other site specific standard development options which do not rely solely on the Site Specific Beneficial Reuse Assessment Tool are being explored. These other site specific standard approaches would only be permitted if governed by a site specific instrument. See Schedule C of the proposed excess soil reuse regulation for proposed rules governing the development of site specific excess soil standards.

6. Additional Considerations When Using Generic Excess Soils Standards

The following sections describe where limitations associated with specific excess soils standards may compel additional consideration and/or requirements to ensure they are applied appropriately.

Special Rules When Applying Excess Soil Reuse Standards

The Regulation includes “special rules” that apply to the Excess Soil Reuse Standards. These rules are intended to help protect agricultural land and *Environmentally Sensitive Areas* from potential impacts. These types of properties may have unique circumstances or receptors which are not accounted for in the derivation of the Excess Soils Reuse Standards and so these special rules are warranted. Some of the rules are also intended to account for anticipated challenges in meeting the standards for sodium and chloride as a result of road salting. Other rules are intended to account for pragmatic constraints anticipated such as when naturally occurring local background conditions may be elevated relative to the excess soil reuse standards. Schedule C of the Regulation lays out these rules in greater detail.

Application of Agricultural Standards

The Agricultural site condition standards do not include consideration of plant uptake of contaminants and the subsequent ingestion by people or livestock. The information available at the time of developing brownfields standards was not sufficient to develop adequate component values for this exposure scenario. Redeveloping brownfields to an agricultural land use is not as likely or as common as the reuse of excess soils at Agricultural properties and so the absence of this exposure scenario becomes more relevant and important for excess soils standards. The ministry will continue to review available science in order to include this exposure scenario.

To account for this limitation, where excess soil is to be used as a growing medium for crops or for pasture that will be consumed, the excess soil must meet Table 1 of O.Reg 153/04 and if from an area of potential contamination, must meet the leachate or mitigation measures as outlined in Schedule C of the proposed excess soil reuse regulation regarding Soil Originating from areas of potential environmental concern (APEC).

In addition, Agricultural standards do not include consideration of soil fertility. Soil fertility is considered as part of good farm practices and general guidance to farmers on importation of excess soil to agricultural properties is available in the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) fact sheet available here: http://www.omafra.gov.on.ca/english/engineer/facts/16-055.htm.

Additional Limitations of Excess Soil Reuse Standards

Below are some additional examples of conditions that can exist at a site and which are not consistent with the assumptions used to develop the generic excess soil standards and which may result in the standards not being appropriate for excess soils reuse at a particular site. The contrary is also true in that site specific conditions may offer greater protection.

It is noted that the presence of any of the below conditions does not necessarily indicate that the excess soil standards are not valid for a given site. This is also true for the brownfields generic site condition standards. The MOECC (2011) *Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario* (Page 16) discusses the conditions which if present at an individual site may warrant the need for additional consideration before applying generic standards.
The following excerpt is taken from the rationale document and provides a brief discussion on this.

> *There are many interrelated parameters and factors that were used in the development of the Generic Site Condition Standards, and in many cases one factor, such as any of those above, can be outweighed by differences in other factors in a manner that, overall, there is sufficient natural protection provided by the site. In addition, it must also be considered that the component that drives the standard may not be affected by the particular limiting condition described above (e.g. a terrestrial ecological driver, but there are high permeable zones in the vadose zone). The QP should consider these types of factors in assessing appropriateness of the use of the Generic Site Condition Standards.*

A summary of the relevant conditions for excess soil reuse standards is provided below.

Impacted Soil Volume and Dimension: Both the small and medium volume tables rely on assumptions of a finite volume and source depletion. The total impacted area at the receiving site, including both excess soil and any existing impacted soil, is estimated and used to select the applicable excess soil standards. It is important to note that if the total impacted zone has a volume or dimensions that are greater than what are assumed in the development of selected excess soil standards, pathways which employ source depletion or groundwater transport (e.g., Soil Odour, S-GW1, S-GW2, S-IA, S-GW3 components of the standards) may not be appropriately protected for. Of particular note is the assumption of a 2m thickness of impacted soil, as a greater thickness may impact the amount of vapour which migrates to indoor air. Should the receiving site be known to already contain impacted soil, consideration should be given to whether or not the addition of additional impacted soils may invalidate some of the assumptions within the Small and/or Medium Volume excess soils standards. Without such knowledge and consideration, it may be more appropriate to use the Volume Independent standards.

Soil with high permeability: if a high permeability zone is present in the vadose zone which provides a direct preferential pathway to the building then the soil properties assumed in the generic Johnson & Ettinger (J&E) modelling to determine the S-IA and S-GW2 components of the standard may not be appropriate.

Groundwater Levels: if the groundwater level is shallower than 3 m below ground surface and/or if the annual average of the capillary fringe of the water table is < 0.8 metres from the outer edge of the gravel crush of the building foundation then the S-GW2 component value may not be protective.

High building susceptibility to soil vapour entry: if site buildings have characteristics that vary significantly from the generic assumptions (e.g. commercial structured with a basement) this could result in enhanced transport of vapour into a building and the S-IA and S-GW2 component values may be non-conservative.

Significant preferential pathways: The development of excess soil standards assumes that preferential pathways (e.g. shallow bed rock, gas under pressure, utility conduits that directly connect the contamination source to the enclosed space of the building, etc.) are not present. If preferential pathways are identified, the S-IA and S-GW2 pathways may be non-conservative

Organic carbon content: if the average organic carbon content (foc) of soil above the water table is <0.002 then more contaminant may be in the water and gas phases than assumed in the excess soil standards.

Continuous source: if there is a continuous source of contamination then the pathways which assume a depleting source (i.e., S-IA, S-GW1, S-GW2, S-GW3, and Soil Odour) in the development of volume specific standards may be non-conservative.

Presence of Exposure Pathway Not Considered for the Development of Excess Soil Standard: If any exposure pathway listed in Section 2.2 is applicable for a given site, the use of the excess soil standards presented may not be protective of that exposure.

7. Attainment of Standards

The MOECC is proposing a departure from the existing compliance requirement from O.Reg 153/04 in which every soil sample must be numerically equal to or lower than the Table 1 standard in order for the soil to be considered Table 1 quality. This new “Attainment Requirement” is intended to account for the natural variability that exists in soil and to account for sample homogeneity and laboratory method precision, thereby providing a better representation of the soil quality. Appendix V provides the approach being proposed and the considerations for using it at excess soils receiving sites.

8. References

Ministry of the Environment and Climate Change (MOECC, formerly known as Ministry of the Environment), 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. (https://www.ontario.ca/document/rationale-development-soil-and-ground-water-standards-use-contaminated-sites-ontario)

MOECC, 2016a. Modified Generic Risk Assessment. (https://files.**ontario**.ca/2016_**modified_generic_risk_assessment_model**.xlsx)

MOECC, 2016b. A Guide to Using the "Approved Model" (November, 2016) When Submitting A Modified Generic Risk Assessment. (https://www.ontario.ca/page/guide-using-approved-model-when-submitting-modified-generic-risk-assessment)

TABLES

Table 1. Sensitivity Analysis of Source Size to Key Component Values

Attenuation Mechanisms		**Source Dimension**		
		Source Length	*Source Width*	*Source Thickness*
S-GW1	*Wellbore Dilution*	✓✓✓ (minimal impact once source area reaches 14,000 m^2)		
	Source Depletion			✓✓* (minimal impact to most of substances once source thickness reaches approximately 10-30 m)
S-GW2	*Aquifer Mixing Cell*	Minimal		
	Source Depletion			✓✓✓ * (minimal impact to most of substances when source thickness is approximately 30 m or higher)
S-GW3	*Aquifer Mixing Cell*	Minimal		
	Lateral mixing	Minimal		
	Surface Water Mixing		✓ (no further impact once source width reaches 65 m)	
S-IA	*Source Depletion*	✓✓✓* (minimal impact to most of substances when source volume is appx. 5,000 - 20,000 m^3)		
S-Nose	*Source Depletion*			✓✓* (minimal impact to most of substances when source depth is 10 - 30 m)
S-OA	*Atmospheric Mixing Cell*	✓✓✓* (ceiling cap is not yet determined; however, this pathway is not driving standards when S-IA is considered)		
	Finite source Jury Vapour Flux			✓✓* (minimal impact to most of substances when source depth is 10 - 30 m)

Notes: √√√: Potential reduction factor of 50x or greater (as compared to generic setting) when source size increases
√√: Potential reduction factor of 10x to 50x (as compared to generic setting) when source size increases
√: Potential reduction factor of 2x to 10x (as compared to generic setting) when source size increases
*: Chemical specific

Table 2 Effect of Soil Types (Coarse-textured vs Fine/Medium Textured) on Different Component Values*

Pathway\Tier2 Input Parameters	**S-IA**	**S-Odour**	**S-Nose**	**S-OA**	**S-GW1**	**S-GW2**	**S-GW3**	**S1-S3**	**Plants & Organisms**	**Birds & Mammals**
Soil Type – vadose zone - (bulk density: 1.70 coarse, 1.40 medium-fine - total porosity: 0.36 coarse, 0.47 medium-fine - water filled porosity: 0.119 coarse, 0.170 medium-fine - soil vapour permeability:1.63E-07/1.78E-07 coarse, 2.30E-09/2.50E-09 medium-fine for RPI/ICC respectively - foc: 0.010 coarse, 0.035 medium-fine	✓✓	✓✓	✓✓	✓✓	✓	✓✓	✓	NA	✓	NA
Vertical recharge rate: **-** vertical recharge rate: 0.28 m/year for coarse, 0.20 m/year for medium-fine	NA	NA	NA	NA	✓	✓	✓	NA	NA	NA
Soil Type – capillary fringe - porosity: 0.375 coarse, 0.399 medium-fine - residual moisture content: 0.053 for coarse and 0.061 for medium-fine	NA	NA	NA	NA	NA	✓✓	NA	NA	NA	NA

Notes: √√: Strong influence, component values are significantly lower for coarse–textured soil, where is applicable

√: Minimal influence, component values are marginally lower (less than 1.2 - 1.5 for most compounds) for coarse-textured soil, where is applicable

APPENDIX I

Development of Soil to Groundwater to Indoor Air (S-GW2) Component Values

Development of Soil to Groundwater to Indoor Air (S-GW2) Component Values

I.1. Background

The Soil to Groundwater to Indoor Air (S-GW2) component is defined as a soil value, protective of exposure from a substance that leaches from soil to groundwater, migrates down-gradient and potentially moves upward to overlying buildings (either on- or off-site). The inclusion of the S-GW2 component in excess soil standards is considered a necessary check for scenarios in which the soil to indoor air (S-IA) component value is eliminated (e.g. no on-site buildings) and/or there is no groundwater monitoring required that would confirm an acceptable protection of groundwater. The conceptual model for the S-GW2 pathway is illustrated in Figure I.1

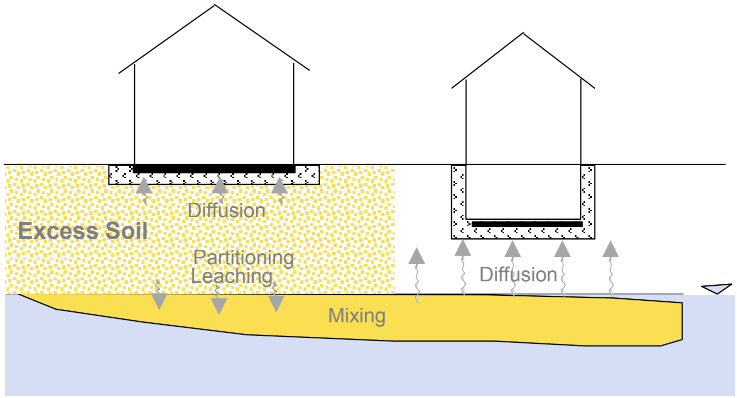

Figure I.1. Conceptual Model for the Soil to Groundwater to Indoor Air (S-GW2) pathway

This appendix presents a derivation approach to determine S-GW2 component values along with some key assumptions and input parameters. Derivation components considered include the following

- A groundwater to vapour partitioning component coupled with the Johnson-Ettinger model for vapour intrusion into buildings is used to back-calculate a groundwater value that is protective of indoor air (GW2). Details on the development of GW2 components are presented in Section 7.6 of the MOE 2011 rationale document.
- A soil to soil leachate partitioning component coupled with a vertical transport model of leachate to the groundwater table and mixing of leachate with groundwater to solve for soil values.
- Source depletion due to mass loss from leaching into groundwater and volatilization into the atmosphere considered to reflect the potential of soil contamination reduced over time.

I.2. Development of Soil to Groundwater to Indoor Air (S-GW2) Component

Recharge through contaminated soil area leaches dissolved substances to an underlying aquifer via a mixing cell and transport down-gradient in groundwater. Volatile substances in the impacted groundwater will then migrate upward to the overlying building structures. Calculation steps consider the following: (1) soil-to-soil leachate partitioning and vertical transport of leachate to the groundwater table and (2) mixing of leachate with groundwater.

I.2.1. Soil To Soil Leachate Partitioning

The soil to soil leachate partitioning includes a three-phase partitioning between substance sorbed to soil, dissolved in leachate and in soil vapour. It is noted that the generic setting (Figure I.1) assumes contaminated soil being located directly above the water table, thus the concentration of a substance in leachate is the same at source and at the water table (therefore, a vertical transport model of leachate to the groundwater table is considered negligible).

The soil concentration is in equilibrium with the soil leachate concentration, determined as below

$$S - GW2 = C_{leachate} \cdot \left(K_{oc} \cdot f_{oc} + \frac{\eta_w + H' \cdot \eta_a}{\rho_b} \right) \qquad \text{(Equation 1)}$$

Where:

S-GW2 = soil to groundwater to indoor air component (µg/g);
$C_{leachate}$ = allowable concentration in leachate at source (mg/L);
K_{oc} = organic carbon-water partition coefficient (cm^3/g);
f_{oc} = fraction organic carbon in soil (dimensionless);
η_w = water-filled porosity (dimensionless);
η_a = air-filled porosity (dimensionless);
H’ = Henry’s Law constant (dimensionless); and,
ρ_b = dry bulk density of the soil (g/cm^3).

I.2.2. Dilution due to Aquifer Mixing Cell

The mixing of leachate with groundwater is based on groundwater velocity, infiltration rate, source length, and mixing zone thickness, shown as below. Please refer to Section 7.6 of the MOE 2011 rationale document for the derivation approach of GW2 component values.

$$C_{leachate} = GW2 \left\{ 1 + \left(\frac{K_h \cdot C \cdot i_h \cdot B}{q_{surface} \cdot L} \right) \right\} \qquad \text{(Equation 2)}$$

where:

$C_{leachate}$ = allowable concentration in leachate at source (ug/L);
GW2 = groundwater to indoor air component value (ug/L);
K_h = horizontal hydraulic conductivity of aquifer (m/s);
i_h = horizontal hydraulic gradient in aquifer (dimensionless);
B = thickness of mixing cell;
$q_{surface}$ = Recharge rate through soil to water table (m/year);
L = Length of source of contaminated soil in direction of groundwater flow (m);

C = Unit conversion (60·60·24·365.25) from meter per second (m/s) to meter per year (m/year).

I. 3. Source Depletion

The development of S-GW2 component values using the approach presented in Section 2 corresponds to an infinite source of contamination; and is thus considered overly protective for scenarios where a source size of contaminated soil is well characterized and limited.

To account for source depletion, if there is no on-going release and a finite source (length x width x height), S-GW2 component values can be adjusted with the consideration of a depletion multiplier (SDM). Source mass depletion is based on the assumption that the soil concentration will deplete over time via mass loss from leaching into groundwater and volatilization to the atmosphere. Key components for determination of a source depletion multiplier are shown as below.

I.3.1. Determination of Initial Mass of Contaminant in Excess Soil

Initial mass of contaminant in excess soil is determined as below

$$Mass\ 1 = \mathrm{S - GW2} \cdot \rho_b \cdot C \cdot V_s \qquad \text{(Equation 3)}$$

where:

Mass 1 = Initial mass of contaminant in source zone (µg);

S-GW2 = soil to groundwater to indoor air component (µg/g);

ρ_b = dry bulk density of the soil (g/cm^3);
V_s = Volume of source zone (m^3); and,

C = Unit conversion (10^6) from cubic centimeter (cm^3) to cubic meter (m^3).

I.3.2. Determination of Contaminant Mass Remaining after One Week of Volatilization to Atmosphere and Leaching to Water Table

As explained in the MOECC (2011) *Rationale for the development of soil and ground water standards for use at contaminated sites in Ontario*, one week was arbitrarily chosen to be sufficiently short to remain a constant removal rate of the exposure concentration rather than one that declines with time. Mass of contaminant in soil theoretically remaining after one week of mass loss due to gas influx to volatilization to atmosphere and leaching to water table at a constant rate is calculated as follows:

$$Mass\ 2 = Mass\ 1 - \left(\frac{C_{leachate} \cdot C_1 \cdot A_S \cdot q_{surface}}{52\left(\frac{week}{year}\right)}\right) - \left(J \cdot A_s \cdot C_2 \cdot \frac{365.25 - frozen\ days}{365.25}\right) \qquad \text{(Equation 4)}$$

where:

Mass 2 = contaminant mass remaining after one week of mass loss due to volatilization to atmosphere and leaching to water table (µg).

$C_{leachate}$ = Allowable concentration in leachate at source (µg/L);

$q_{surface}$ = Recharge rate through soil to water table (m/year);

A_s = Area of contaminated soil (m^2); and,

C_1 = Unit conversion (1000) from litter (L) to cubic meter (m^3).

J = Contaminant flux at the ground surface ($g/cm^2/s$), determine using the Finite Source Jury model (refer to Section 7 of the MOE 2011 rationale document)

C_1 = Unit conversion ($60\cdot60\cdot24\cdot7$) from second (s) to week (week); and,

Frozen day = Number of “frost” days.

I.3.3. Determination of Half-life due to Mass Loss from Volatilization to Atmosphere and Leaching to Water Table

As discussed in the MOE 2011 rationale document, the initial mass (Mass 1) and the mass remaining after one week (Mass 2) are entered into the re-arranged decay equation to generate the effective half-life for this mode of source depletion for each contaminant.

$$t_{1/2} = \frac{-\ln(2)\cdot 1week}{ln\frac{Mass\ 2}{Mass\ 1}\cdot\frac{365.25}{7}} \qquad \text{(Equation 5)}$$

where:

$t_{1/2}$ = half-life for vapour intrusion into building (years).

I.3.4. Determination of Source Depletion Multipliers (SDM)

The SDM is determined as a function of the soil half-life as below

$$SDM = \frac{1}{exp\left(\frac{-ln2\cdot t}{t_{1/2}}\right)} \qquad \text{(Equation 6)}$$

Similar to the development of the S-IA component value, the S-GW2 component value incorporates a time lag (t) between the start of substance depletion and the attainment of the health-based indoor air criteria (HBIAC). The S-GW2 component values are based on initial indoor air concentrations (IAC) that are up to 100-fold greater than the HBIAC. As discussed in MOECC 2011 rationale document, a list of constraints on the potential initial IAC were used, including the following key considerations:

- An initial IAC is expected to continuously decrease to the health-based IAC within the allotted 3 or 5 years, resulting in a SDM of up to 100-fold;

- Incremental lifetime cancer risk from S-IA exposure pathway does not exceed 1×10^{-6}; and,
- A further protection is built in such that the SDM doesn't result in an exceedance of short term effects concentrations (e.g., sub-chronic, developmental), where available.

I.4. References

Ministry of the Environment (MOE, currently known as Ministry of the Environment and Climate Change), 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario (https://www.ontario.ca/document/rationale-development-soil-and-ground-water-standards-use-contaminated-sites-ontario).

APPENDIX II

Consideration of Vapour Intrusion (VI) Assessment in the Development of MOECC Excess Soil Reuse Standards

Considerations of Vapour Intrusion (VI) Assessment in the Development of Excess Soil Standards

II.1. Background

Vapours from volatile organic compounds (VOCs) from contaminated soil and groundwater can migrate into overlying buildings and potentially pose unacceptable risks to building occupants as a result of inhalation of vapours. This VOC migration process is referred to as subsurface vapour intrusion and is considered in the development of Brownfield site condition standards (SCSs) for soil and groundwater as the soil to indoor air (S-IA) and groundwater to indoor air (GW2) components. Generally, if there is no concern about soil data adequacy and site conditions for which key assumptions (e.g. source size) used to develop the SCSs and/or component values may not be valid, the use of S-IA and GW2 are reasonably protective of VOC migration from soil and groundwater to overlying building structures. Alternatively, a vapour intrusion pathway can be assessed through direct measurements of soil vapour and/or other appropriate lines of evidence.

The MOECC has reviewed key assumptions and modelling approaches used to develop the brownfield SCSs in conjunction with consultations from the task working group and jurisdictional review. This work identified two vapour intrusion components (S-IA and S-GW2) as applicable checks to ensure that building occupants are conservatively protected when excess soils are being placed at a receiving site. Other topics covered in this work include preliminary assessment of potential VOC loss to the atmosphere during the soil relocation process and identification of reliable alternates for assessing the vapour intrusion (in replacement of S-IA and/or S-GW2).

The primary objectives of this appendix are to (1) provide a high-level literature review of regulatory directions/recommendations with respect to vapour intrusion, (2) evaluate two key soil components (S-IA and S-GW2) and their underlying assumptions (e.g., source size) as well as implications in development of excess soil standards protective of the vapour intrusion pathway, (3) summarize an literature assessment of the potential of VOC loss during the excess soil relocation process and (4) identification of alternates for addressing the vapour intrusion pathway.

II.2 Jurisdictional Review on Considerations of Vapour Intrusion Assessment in Development of Soil Standard

An initial desktop review was completed with a focus on evaluation of regulatory directions/recommendations with respect to vapour intrusion consideration in development of soil standards for brownfields and in the context of excess soil relocation, where available.

In general, a number of jurisdictions (just to name a few: British Colombia, Massachusetts, New Jersey, US EPA, New York) have not established the concentrations of VOCs in soil at which the potential for vapor intrusion is unlikely to occur; therefore it is suggested that their brownfield soil remediation standards/screening levels should not be utilized in this determination because the standards were not developed for the vapour intrusion pathway. When vapor intrusion is considered a potentially complete exposure pathway at a particular site (e.g. presence of VOCs in the vadose zone adjacent to an occupied structure), it is required/recommended that this pathway is further addressed by direct measurements of soil vapour and/or other appropriate lines of evidence.

In the context of excess soil relocation, it is unclear from reviewed regulatory guidance documents (Mass DEP 2014, NJ DEP 2015, NY DEC 1992) how the vapour intrusion pathway will be addressed. British Columbia (BC MOE 2016) provides some limited discussions, recognizing the potential of VOC loss to the atmosphere through the excess soil relocation process (excavation, transport, deposit, etc.) and identifying some challenges with respect to using soil vapour data collected at the source site to assess the vapour intrusion pathway at the receiving site. It also proposes that "*If the receiving site is to have structures built on relocated soil, then a vapour assessment at the receiving site may be required"*; nevertheless, it was not clear from this review how potential risks, if identified later at the receiving site, will be addressed further and/or mitigated**.**

II.3. Soil to Indoor Air (S-IA) Component

A generic setting for the vapour intrusion pathway assumes that building structures sit directly within the source zone of contaminated soil (or excess soil). A partitioning model coupled with the Johnson-Ettinger model (1991) for vapour intrusion into buildings is used to back calculate a soil concentration that will be protective of indoor air toxicity reference values and odour (referred to herein to as soil to indoor air (S-IA) component value). A source depletion multiplier (SDM) of up to 100-fold (100x) was incorporated into the S-IA component values in order to account for the depletion of a VOC within a finite soil volume over time (MOE 2011).

The S-IA component value is specific to soil texture (coarse and fine/medium) and land use (Residential/Parkland/Institutional and Industrial/Commercial/Community). For a number of VOCs, S-IA components are driving the generic SCSs. To understand the significance of S-IA components to the SCS derivation, a quick exercise was completed to determine soil standards with the exclusion of S-IA component (referred herein to as VI-excluded SCS) and compared with their associated SCS. The comparison exhibits that VI-excluded SCS can be as high as 200 x of SCS (e.g., trichloroethylene (TCE) under Industrial/Commercial/Community scenarios), indicating that if vapour intrusion is deemed insignificant, the soil SCS will increase (less stringent) by a factor of up to 200+, depending on VOCs and site conditions.

II.3.3.1 Source Size and Its Implication for Development of S-IA components

A non-depleting or constant source is often assumed in setting standards, (e.g., a human receptor lives in a constant indoor air concentration for 70 years), and yet a better conceptualization would be to incorporate the declining nature of the source size over time and its implication in exposure with indoor air. Providing there are no on-going releases, the source depletion is attributable to migration of a substance from the source to a receptor.

Conceptually, the mass of the soil volume is greatly depleted in accordance with how much mass of a substance must be lost from the soil in order for a person in the building to be exposed to the contaminant via inhalation of the vapours from the soil. As discussed in the MOE 2011 rationale document, the goal of incorporating source depletion is to better approximate an initial soil concentration that does not exceed the acceptable risk to building occupants caused by a constant source concentration over the entire exposure period, and yet does not result in unacceptable short-term exposure. Below are key considerations in the development of S-IA component values:

- An initial indoor air concentration (IAC) is expected to continuously decrease to the health-based indoor air criteria (HBIAC) within the allotted 3 or 5 years, resulting in a SDM of up to 100x. In other words, the development of S-IA components is based on an initial IAC which is up to 100x higher than the HBIAC.
- Incremental lifetime cancer risk from S-IA exposure pathway does not exceed 1×10^{-6}
- A further protection is built in such that the SDM doesn't result in an exceedance of short term (acute or sub-chronic) or developmental effects concentrations.

Generally, the magnitude of the SDM is dependent on the soil half-life of the substance, which in turn depends on the volatility of the substance, exposure scenarios of critical receptors, source volume, and soil properties. For example, the length of exposure, and hence the risk, is increased with an increasing volume of contaminated soil, thereby resulting in more stringent standards to protect an individual in the building from excessive exposure.

Under a brownfield context, source depletion is based on the assumption of a finite source, a generic size of the modelled contaminated soil "box" being 13 m by 13 m by 2 m (or 338 m^3 in volume) as a typical “spill” scenario in a brownfield site. A sensitivity analysis demonstrated that S-IA component values decrease (up to 100x) with the increase in the source size (from the generic source size of 338 m^3). A minimal impact is reported for most of tested VOCs when the source size reaches a volume of between 5,000 m^3 to 20,000 m^3.

II.3.2. Source Size Range Considered for Assessment of Vapour Intrusion Pathway

Source depletion is based on the assumption of a finite source of contaminated soil which mass is reduced, at the least, at the rate that a VOC migrate into the building, and then leaves the building due to the air exchange rate. And the VOC mitigation generally occurs as a result of different fate and transport mechanisms, including diffusion though the unsaturated zone, biodegradation, and advection into enclosed buildings. While diffusion (and/or biodegradation) tends to be a dominant transport process in the vadose zone, soil vapour advection is often significant in the vicinity of a building foundation, especially when a building is depressurized.

Generally, vapour concentrations decrease with increasing distance from a subsurface vapour source, and eventually dissipate to non-detectable levels. The decrease in vapour concentrations is a function of contamination source size and geometry, soil properties, physical-chemical properties of a VOC, and its possible biological or chemical transformations within the subsurface environment. In approximate terms, vapour intrusion pathway has sufficient natural attenuation to be of negligible concern if the distance between the contamination and buildings of concern (refer herein to as “vapour intrusion inclusion distance”) is greater than:

- 30 m for recalcitrant compounds; and,
- 10 m for compounds that readily biodegrade under aerobic conditions (e.g., petroleum hydrocarbons (PHCs)). Please note that the 10 m distance is based on an on-going assessment of new science and studies on petroleum vapour intrusion and this number may change when our assessment is complete.

The generic setting for the S-IA pathway assumes that building structures sit directly within the source zone and VOC-contaminated soil within the vapour intrusion inclusion distances from building footprint may result in vapour intrusion concerns (referred herein to as zone of vapour intrusion influence); therefore mass loss due to volatilization and transport of VOC into indoor air can be assumed to occur within this zone and incorporated in the development of source deletion multiplier (SDM). It is noted that depending on the size and location of building structures, the zone of vapour intrusion influence may be the same or smaller than the source size. Figure II.1 presents two examples on how to determine the extent of zone of vapour intrusion influence used in the development of source deletion multiplier with the consideration of a residential scenario and a 50m x 50m x 2m volume of excess soil impacted with (1) recalcitrant compounds and (2) PHC compounds.

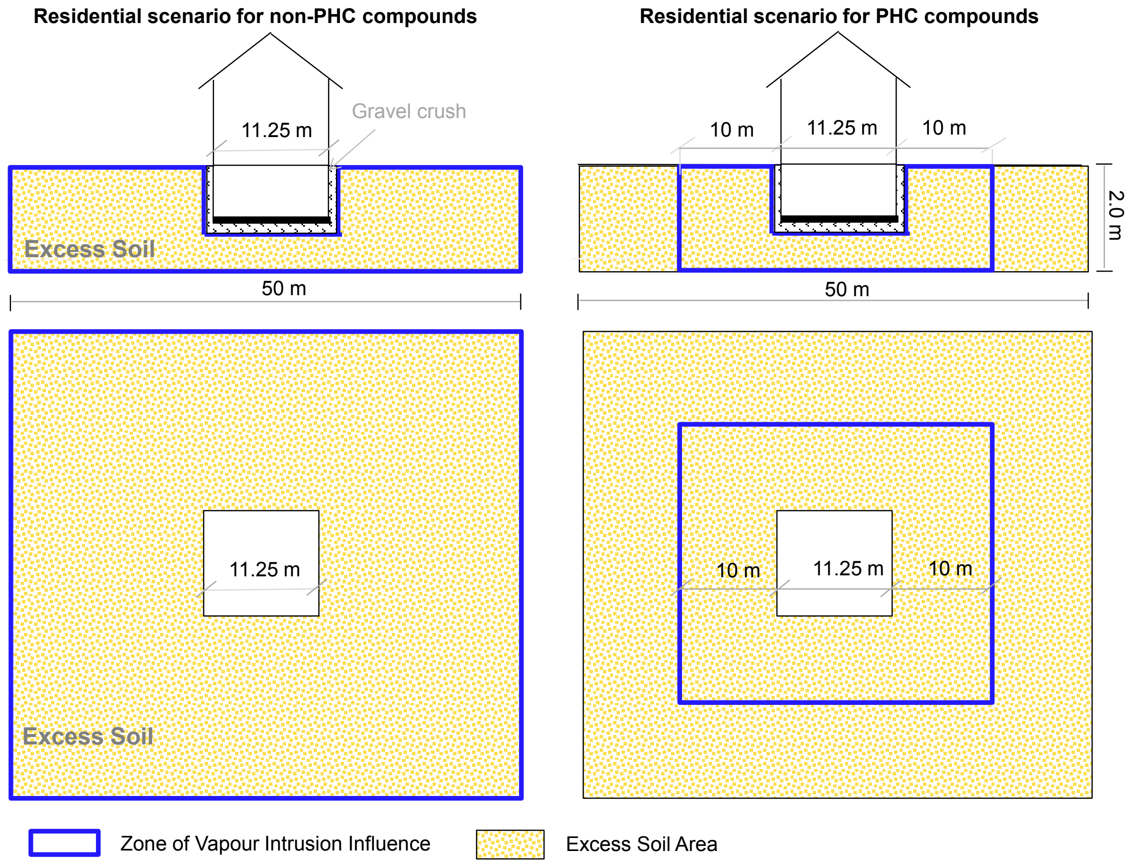

Figure II. 1. Site Plan (Lower) and Cross Sectional (Upper) View of Excess Soil Area and Zone of Vapour Intrusion Influence

II.4. Soil to Groundwater to Indoor Air (S-GW2) Component

The soil to groundwater to indoor air (S-GW2) pathway is not included in the development of the SCSs as this component generally does not drive a soil value to below an S-IA value under brownfield generic settings. However, the consideration of S-GW2 component is necessary for scenarios for which S-IA component is eliminated (e.g. no buildings) and/or there is no groundwater monitoring required to confirm an acceptable protection of groundwater that being potentially flow off-site and below buildings on an adjacent property. Therefore, this pathway is re-introduced as a component value under the excess soil context. More details pertaining to this component can be found in Appendix I

II.5. Potential VOC Loss during Excess Soil Relocation Process

A high-level review on studies pertaining to volatilization of VOC in soil and a screening quantitative assessment was conducted to better understand the volatilization behaviour of VOCs in soil their potential loss to the atmosphere during some key excess soil relocation processes.

Generally, both preliminary literature review and modelling results exhibit that volatilization is likely a predominating process contributing to the potential of VOC loss in soil during the excess soil movement. Nevertheless, this process is complex and its functional dependence on different soil and environmental conditions and soil movement activities appears to be significant and not yet well understood and quantified. Some other key findings are present as follows:

- Volatilization rates appear to decrease significantly when contaminants reside at depth or covered by a layer of soil, even for some reasonably volatile compounds (e.g. benzene, toluene). During the excavation, excavated soil is likely to be transferred in lumps (e.g. buckets), so most of compounds will be potentially contained within the lumps of soil and only those on the surface will volatile to the atmosphere. This VOC containment is likely significant for fine textured soil. In addition, volatilization rate appears to be significant during the excavation and a short period of time after freshly excavated soil is covered by a relatively deep layer of subsequently excavated soil. Thus, a small loss of total VOC in soil might be expected during these activities.
- Although the volatilization rate during the excavation and/or transport may be significant, its contribution to the total VOC loss may be minimal, considering its short activity time. Rather, it would appear that other activities, such as storage, may account for greater VOC loss due to the potential of longer volatilization duration (e.g. weeks or months). However, some H&S mitigation measures (as presented below) applied to prevent the adverse impacts to the surrounding environments may limit and/or reduce the VOC volatilization in excess soil.
- Some health and safety activities (e.g., soil covering) generally implemented during the soil movement process can prevent and/or minimize the occurrence of potential fate and transport mechanisms that may result in VOC loss in soil (e.g., volatilization, abiotic and biotic degradation processes). Some site conditions may also exist that can potentially limit and/or reduce the VOC volatilization rate to the atmosphere, include but not limited to the following:

- Excessive wet soil condition due to precipitation and/or the implementation of H&S mitigation measures (e.g., dust control).
- Freezing condition and/or frozen ground condition during the winter time.
- H&S mitigation activities to ensure an acceptable ambient air quality, including covering contaminated soils with moveable sheeting or uncontaminated soils.

In summary, there are limited literature and a high sensitivity of the model predictions to numerous key variables (e.g. soil and environmental conditions and soil movement activities) to support the consideration of VOC loss in the development of generic excess soil standards. This potential VOC loss, however, may be considered on a case by case basis, if there is a sufficient understanding of case specific soil relocation process (e.g. operation activities, duration, etc.) and site specific conditions.

II.7 References

British Columbia Ministry of the Environment (BC MOE), 2016. Prevention of Site Contamination from Soil Relocation. Intentions paper series.

Massachusetts Department of Environmental Protection (Mass DEP), 2014. Similar Soils Provision Guidance for Identifying When Soil Concentrations at a Receiving Location Are “Not Significantly Lower Than” Managed Soil Concentrations Pursuant to 310 CMR 40.0032(3).

Ministry of the Environment and Climate Change (MOECC, formerly known as the Ministry of the Environment), 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario.

MOECC, 2016. A Guide to Using the “Approved Model” (November, 2016) When Submitting A Modified Generic Risk Assessment

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New Jersey Department of Environmental Protection (NJ DEP), 2015. Fill Material Guidance for SRP Sites.

New York Department of Environmental Conservation (NY DEC), 1992. Petroleum-Contaminated Soil Guidance Policy - STARS #1

APPENDIX III

Proposed Excess Soil Reuse Standards

Small Volume Standards

The small volume standards are the O.Reg 153/04 site condition standards Tables 2-9 and are found in the document *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act*, dated April 15, 2011 (PIBS # 7382e01), which can be found here (https://dr6j45jk9xcmk.cloudfront.net/documents/998/3-6-3-sediment-standards-en.pdf). They are not recreated here.

Medium Volume Standards

TABLE A: PROPOSED Full Depth Excess Soil Reuse Standard in A Potable Ground Water Condition and A Source Size of Less Than 5000m^3

Contaminant	Agricultural and Other Property Use (µg/g)	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Acenaphthene	1.4	1.4	1.4
Acenaphthylene	0.093	0.093	0.093
Acetone	2.6	2.6	2.6
Aldrin	0.05	0.05	0.088
Anthracene	0.11	0.16	0.16
Antimony	7.5 [a]	7.5 [a]	40 [a]
Arsenic	11	18	18
Barium	390 [a]	390 [a]	670 [a]
Benzene	0.02	0.02	0.02
Benz[a]anthracene	0.5	0.5	0.96
Benzo[a]pyrene	0.078	0.3	0.3
Benzo[b]fluoranthene	0.78	0.78	0.96
Benzo[ghi]perylene	6.6	6.6	9.6
Benzo[k]fluoranthene	0.78	0.78	0.96
Beryllium	4 [a]	4 [a]	8 [a]
Biphenyl 1,1'-	0.31	0.31	31
Bis(2-chloroethyl)ether	0.5 [a]	0.5 [a]	0.5 [a]
Bis(2-chloroisopropyl)ether	0.67	0.67	0.81
Bis(2-ethylhexyl)phthalate	5	5	28
Boron (Hot Water Soluble)*	1.5	1.5	2
Boron (total)	120 [a]	120 [a]	120 [a]
Bromodichloromethane	0.1	0.1	0.1
Bromoform	0.16	0.16	0.16
Bromomethane	0.05	0.05	0.05
Cadmium	1	1.2	1.9 [a]
Carbon Tetrachloride	0.05	0.05	0.05
Chlordane	0.05	0.05	0.05
Chloroaniline p-	0.5	0.5	0.5
Chlorobenzene	0.4	0.4	0.4
Chloroform	0.057	0.057	0.16
Chlorophenol, 2-	0.25	0.25	0.25
Chromium Total	160 [a]	160 [a]	160 [a]
Chromium VI	8	8	8
Chrysene	1.3	2.8	2.8
Cobalt	22 [a]	22 [a]	80 [a]
Copper	140 [a]	140 [a]	230 [a]
Cyanide (CN-)	0.051	0.051	0.051
Dibenz[a h]anthracene	0.1	0.1	0.1
Dibromochloromethane	0.16	0.16	0.16
Dichlorobenzene, 1,2-	0.083	0.083	0.083
Dichlorobenzene, 1,3-	1.6	1.6	1.6
Dichlorobenzene, 1,4-	0.05	0.05	0.05

Contaminant	Agricultural and Other Property Use (µg/g)	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Dichlorobenzidine, 3,3'-	1	1	1
Dichlorodifluoromethane	2.6	2.6	2.6
DDD	3.3	3.3	4.6
DDE	0.26	0.26	0.52
DDT	0.078	1.4	1.4
Dichloroethane, 1,1-	0.05	0.05	0.05
Dichloroethane, 1,2-	0.05	0.05	0.05
Dichloroethylene, 1,1-	0.05	0.05	0.063
Dichloroethylene, 1,2-cis-	0.063	0.063	0.063
Dichloroethylene, 1,2-trans-	0.05	0.05	0.063
Dichlorophenol, 2,4-	0.1	0.1	0.1
Dichloropropane, 1,2-	0.05	0.05	0.05
Dichloropropene,1,3-	0.05 [a]	0.05 [a]	0.05 [a]
Dieldrin	0.05	0.05	0.05
Diethyl Phthalate	11 [a]	11 [a]	21 [a]
Dimethylphthalate	17 [a]	17 [a]	34 [a]
Dimethylphenol, 2,4-	2.6	2.6	2.6
Dinitrophenol, 2,4-	2	2	2
Dinitrotoluene, 2,4 & 2,6-	0.5	0.5	0.5
Dioxane, 1,4	0.2	0.51	0.51
Dioxin/Furan (TEQ)	0.000013	0.000013	0.000099
Endosulfan	0.04	0.04	0.075
Endrin	0.04	0.04	0.04
Ethylbenzene	0.051	0.051	0.051
Ethylene dibromide	0.05 [a]	0.05 [a]	0.05 [a]
Fluoranthene	0.69	0.69	1.6
Fluorene	10	10	10
Heptachlor	0.15	0.15	0.19
Heptachlor Epoxide	0.11 [a]	0.11 [a]	0.14 [a]
Hexachlorobenzene	0.19	0.19	0.19
Hexachlorobutadiene	0.01	0.01	0.014
Hexachlorocyclohexane Gamma-	0.01	0.01	0.01
Hexachloroethane	0.01	0.01	0.033
Hexane (n)	2.8	2.8	8.8
Indeno[1 2 3-cd]pyrene	0.38	0.38	0.76
Lead	45	120	120
Mercury	0.25	0.27	2.2
Methoxychlor	0.13	0.13	0.63
Methyl Ethyl Ketone	11	11	11
Methyl Isobutyl Ketone	1.7	1.7	24
Methyl Mercury **	0.0014	0.0014	0.0014
Methyl tert-Butyl Ether (MTBE)	0.05	0.05	0.11
Methylene Chloride	0.1	0.1	0.33
Methlynaphthalene, 2-(1-) ***	0.99	0.99	2
Molybdenum	6.9 [a]	6.9 [a]	40 [a]
Naphthalene	0.59	0.59	6.3
Nickel	100 [a]	100 [a]	270 [a]

Contaminant	Agricultural and Other Property Use (µg/g)	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Pentachlorophenol	0.1	0.1	0.48
Petroleum Hydrocarbons F1****	17	25	25
Petroleum Hydrocarbons F2	10	10	37
Petroleum Hydrocarbons F3	300	300	1300
Petroleum Hydrocarbons F4	2800	2800	3300
Phenanthrene	1.2	1.2	1.2
Phenol	7.6	7.6	7.6
Polychlorinated Biphenyls	0.35	0.35	1.1
Pyrene	16	16	16
Selenium	2.4 [a]	2.4 [a]	5.5 [a]
Silver	20 [a]	20 [a]	40 [a]
Styrene	0.7	0.7	3.2
Tetrachloroethane, 1,1,1,2-	0.05	0.05	0.05
Tetrachloroethane, 1,1,2,2-	0.05 [a]	0.05 [a]	0.05 [a]
Tetrachloroethylene	0.05	0.05	0.063
Thallium	1	1	3.3 [a]
Toluene	0.44	0.44	0.44
Trichlorobenzene, 1,2,4-	0.18	0.18	2.8
Trichloroethane, 1,1,1-	0.38	0.38	1.4
Trichloroethane, 1,1,2-	0.05	0.05	0.05
Trichloroethylene	0.05	0.05	0.05
Trichlorofluoromethane	0.65	0.65	0.65
Trichlorophenol, 2,4,5-	0.62	0.62	0.62
Trichlorophenol, 2,4,6-	0.14	0.14	0.14
Uranium	23 [a]	23 [a]	33 [a]
Vanadium	86	86	86
Vinyl Chloride	0.02	0.02	0.02
Xylene Mixture	0.56	0.56	0.56
Zinc	340 [a]	340 [a]	340 [a]
Electrical Conductivity (mS/cm)	0.7	0.7	1.4
Chloride	N/A	N/A	N/A
Sodium Adsorption Ratio	5	5	12
Sodium	N/A	N/A	N/A

Notes

N/A Not applicable

* The boron standards are for hot water soluble extract for all surface soils. For subsurface soils the standards are for total boron (mixed strong acid digest), since plant protection for soils below the root zone is not a significant concern.

** Analysis for methyl mercury only applies when mercury (total) standard is exceeded

*** The methyl naphthalene standards are applicable to both 1-methyl naphthalene and 2- methyl naphthalene, with the provision that if both are detected the sum of the two must not exceed the standard.

**** F1 fraction does not include BTEX; however, the proponent has the choice as to whether or not to subtract BTEX from the analytical result.

[a] Additional requirement for leachate analysis (please refer to Table E of Appendix IV)

TABLE B: Proposed Full Depth Excess Soil Standards in a Non-Potable Ground Water Condition and A Source Size of Less Than 5000m^3

Contaminant	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Acenaphthene	7.8	45
Acenaphthylene	0.093	0.093
Acetone	2.6	2.6
Aldrin	0.05	0.088
Anthracene	0.16	0.16
Antimony	7.5 [a]	40 [a]
Arsenic	18	18
Barium	390 [a]	670 [a]
Benzene	0.02	0.049
Benz[a]anthracene	0.5	0.96
Benzo[a]pyrene	0.3	0.3
Benzo[b]fluoranthene	0.78	0.96
Benzo[ghi]perylene	6.6	9.6
Benzo[k]fluoranthene	0.78	0.96
Beryllium	4 [a]	8 [a]
Biphenyl 1,1'-	0.31	31
Bis(2-chloroethyl)ether	0.5	0.5
Bis(2-chloroisopropyl)ether	0.67	11
Bis(2-ethylhexyl)phthalate	5	28
Boron (Hot Water Soluble)*	1.5	2
Boron (total)	120 [a]	120 [a]
Bromodichloromethane	8.2	8.2
Bromoform	3.5	3.5
Bromomethane	0.05	0.056
Cadmium	1.2	1.9 [a]
Carbon Tetrachloride	0.05	0.05
Chlordane	0.05	0.05
Chloroaniline p-	0.5	0.5
Chlorobenzene	0.4	0.4
Chloroform	0.057	0.97
Chlorophenol, 2-	1.6	3.1
Chromium Total	160 [a]	160 [a]
Chromium VI	8	8
Chrysene	7	9.6
Cobalt	22 [a]	80 [a]
Copper	140 [a]	230 [a]
Cyanide (CN-)	0.051	0.051
Dibenz[a h]anthracene	0.1	0.1
Dibromochloromethane	7.9	7.9
Dichlorobenzene, 1,2-	3.4	6.8
Dichlorobenzene, 1,3-	4.8	9.6

Contaminant	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Dichlorobenzene, 1,4-	0.05	0.13
Dichlorobenzidine, 3,3'-	1	1
Dichlorodifluoromethane	2.6	2.6
DDD	3.3	4.6
DDE	0.26	0.52
DDT	1.4	1.4
Dichloroethane, 1,1-	0.085	1.5
Dichloroethane, 1,2-	0.05	0.05
Dichloroethylene, 1,1-	0.05	0.064
Dichloroethylene, 1,2-cis-	0.078	1.4
Dichloroethylene, 1,2-trans-	0.05	0.73
Dichlorophenol, 2,4-	1.7	3.4
Dichloropropane, 1,2-	0.05	0.065
Dichloropropene,1,3-	0.05	0.05
Dieldrin	0.05	0.05
Diethyl Phthalate	11 [a]	21 [a]
Dimethylphthalate	17 [a]	34 [a]
Dimethylphenol, 2,4-	64	64
Dinitrophenol, 2,4-	9.6	9.6
Dinitrotoluene, 2,4 & 2,6-	0.92	1.2
Dioxane, 1,4	1.8	1.8
Dioxin/Furan (TEQ)	0.000013	0.000099
Endosulfan	0.04	0.075
Endrin	0.04	0.04
Ethylbenzene	2.1	2.7
Ethylene dibromide	0.05	0.05
Fluoranthene	0.69	9.6
Fluorene	10	10
Heptachlor	0.15	0.19
Heptachlor Epoxide	0.11 [a]	0.14 [a]
Hexachlorobenzene	0.52	0.66
Hexachlorobutadiene	0.01	0.014
Hexachlorocyclohexane Gamma-	0.01	0.01
Hexachloroethane	0.01	0.14
Hexane (n)	2.8	8.8
Indeno[1 2 3-cd]pyrene	0.38	0.76
Lead	120	120
Mercury	0.27	2.2
Methoxychlor	0.13	0.63
Methyl Ethyl Ketone	16	37
Methyl Isobutyl Ketone	1.7	24
Methyl Mercury **	0.0014	0.0014
Methyl tert-Butyl Ether (MTBE)	0.05	0.2
Methylene Chloride	0.1	1.2

Contaminant	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Methlynaphthalene, 2-(1-) ***	0.99	12
Molybdenum	6.9 [a]	40 [a]
Naphthalene	0.59	9.4
Nickel	100 [a]	270 [a]
Pentachlorophenol	0.1	0.48
Petroleum Hydrocarbons F1****	25	25
Petroleum Hydrocarbons F2	10	37
Petroleum Hydrocarbons F3	300	1700
Petroleum Hydrocarbons F4	2800	3300
Phenanthrene	6.2	12
Phenol	7.6	7.6
Polychlorinated Biphenyls	0.35	1.1
Pyrene	78	96
Selenium	2.4 [a]	5.5 [a]
Silver	20 [a]	40 [a]
Styrene	0.7	11
Tetrachloroethane, 1,1,1,2-	0.05	0.05
Tetrachloroethane, 1,1,2,2-	0.05	0.05
Tetrachloroethylene	0.05	0.17
Thallium	1	3.3 [a]
Toluene	2.3	11
Trichlorobenzene, 1,2,4-	0.18	2.8
Trichloroethane, 1,1,1-	0.38	1.6
Trichloroethane, 1,1,2-	0.05	0.05
Trichloroethylene	0.05	0.05
Trichlorofluoromethane	0.65	0.65
Trichlorophenol, 2,4,5-	4.4	4.4
Trichlorophenol, 2,4,6-	0.61	0.61
Uranium	23 [a]	33 [a]
Vanadium	86	86
Vinyl Chloride	0.02	0.02
Xylene Mixture	1.3	4.3
Zinc	340 [a]	340 [a]
Electrical Conductivity (mS/cm)	0.7	1.4
Chloride	N/A	N/A
Sodium Adsorption Ratio	5	12
Sodium	N/A	N/A

Notes

N/A Not applicable

* The boron standards are for hot water soluble extract for all surface soils. For subsurface soils the standards are for total boron (mixed strong acid digest), since plant protection for soils below the root zone is not a significant concern.

** Analysis for methyl mercury only applies when mercury (total) standard is exceeded

*** The methyl naphthalene standards are applicable to both 1-methyl naphthalene and 2- methyl naphthalene, with the provision that if both are detected the sum of the two must not exceed the standard.

**** F1 fraction does not include BTEX; however, the proponent has the choice as to whether or not to subtract BTEX from the analytical result.

[a] Additional requirement for leachate analysis (please refer to Table F of Appendix IV)

Volume Independent Standards

TABLE C: Proposed Full Depth Volume Independent Excess Soil Standards in a Potable Ground Water Condition

Contaminant	Agricultural and Other Property Use (µg/g)	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Acenaphthene	0.25	0.25	0.25
Acenaphthylene	0.093	0.093	0.093
Acetone	0.5	0.5	0.5
Aldrin	0.05	0.05	0.088
Anthracene	0.078	0.16	0.16
Antimony	7.5 [a]	7.5 [a]	40 [a]
Arsenic	11	18	18
Barium	390 [a]	390 [a]	670 [a]
Benzene	0.02	0.02	0.02
Benz[a]anthracene	0.5	0.5	0.96
Benzo[a]pyrene	0.078	0.3	0.3
Benzo[b]fluoranthene	0.78	0.78	0.8
Benzo[ghi]perylene	6.6	6.6	9.6
Benzo[k]fluoranthene	0.78	0.78	0.79
Beryllium	4 [a]	4 [a]	8 [a]
Biphenyl 1,1'-	0.3	0.3	7
Bis(2-chloroethyl)ether	0.5 [a]	0.5 [a]	0.5 [a]
Bis(2-chloroisopropyl)ether	0.5	0.5	0.5
Bis(2-ethylhexyl)phthalate	5	5	9.9
Boron (Hot Water Soluble)*	1.5	1.5	2
Boron (total)	120 [a]	120 [a]	120 [a]
Bromodichloromethane	13 [a]	13 [a]	18 [a]
Bromoform	0.05	0.05	0.05
Bromomethane	0.05 [a]	0.05 [a]	0.05 [a]
Cadmium	1	1.2	1.9 [a]
Carbon Tetrachloride	0.05 [a]	0.05 [a]	0.05 [a]
Chlordane	0.05	0.05	0.05
Chloroaniline p-	20 [a]	20 [a]	40 [a]
Chlorobenzene	0.083	0.083	0.083
Chloroform	0.05	0.05	0.05
Chlorophenol, 2-	0.1	0.1	0.1
Chromium Total	160 [a]	160 [a]	160 [a]
Chromium VI	8	8	8
Chrysene	0.24	2.8	2.8
Cobalt	22 [a]	22 [a]	80 [a]
Copper	140 [a]	140 [a]	230 [a]
Cyanide (CN-)	0.051	0.051	0.051
Dibenz[a h]anthracene	0.1	0.1	0.1
Dibromochloromethane	0.05	0.05	0.05
Dichlorobenzene, 1,2-	0.05	0.05	0.05
Dichlorobenzene, 1,3-	0.26	0.26	0.26
Dichlorobenzene, 1,4-	0.05	0.05	0.05

Contaminant	Agricultural and Other Property Use	Residential/ Parkland/Institutional Property Use	Industrial/ Commercial/Community Property Use
Dichlorobenzidine, 3,3'-	1 [a]	1 [a]	1 [a]
Dichlorodifluoromethane	1.5	1.5	1.5
DDD	3.3	3.3	4.6
DDE	0.26	0.26	0.52
DDT	0.078	1.4	1.4
Dichloroethane, 1,1-	0.05 [a]	0.05 [a]	0.56 [a]
Dichloroethane, 1,2-	0.05 [a]	0.05 [a]	0.05 [a]
Dichloroethylene, 1,1-	0.05 [a]	0.05 [a]	0.057 [a]
Dichloroethylene, 1,2-cis-	0.05 [a]	0.05 [a]	0.55 [a]
Dichloroethylene, 1,2-trans-	0.05 [a]	0.05 [a]	0.1 [a]
Dichlorophenol, 2,4-	0.1	0.1	0.1
Dichloropropane, 1,2-	0.05 [a]	0.05 [a]	0.05 [a]
Dichloropropene,1,3-	0.05 [a]	0.05 [a]	0.05 [a]
Dieldrin	0.05	0.05	0.05
Diethyl Phthalate	11 [a]	11 [a]	21 [a]
Dimethylphthalate	17 [a]	17 [a]	34 [a]
Dimethylphenol, 2,4-	0.43	0.43	0.43
Dinitrophenol, 2,4-	38 [a]	38 [a]	320 [a]
Dinitrotoluene, 2,4 & 2,6-	0.92 [a]	0.92 [a]	1.2 [a]
Dioxane, 1,4	0.2 [a]	1.8 [a]	1.8 [a]
Dioxin/Furan (TEQ)	0.000013	0.000013	0.000022
Endosulfan	0.04	0.04	0.054
Endrin	0.04	0.04	0.04
Ethylbenzene	2.1 [a]	2.1 [a]	34 [a]
Ethylene dibromide	0.05 [a]	0.05 [a]	0.05 [a]
Fluoranthene	0.29	0.56	0.56
Fluorene	7.3	7.3	7.3
Heptachlor	0.15	0.15	0.19
Heptachlor Epoxide	0.11 [a]	0.11 [a]	0.14 [a]
Hexachlorobenzene	0.034	0.034	0.034
Hexachlorobutadiene	0.01	0.01	0.01
Hexachlorocyclohexane Gamma-	0.01	0.01	0.01
Hexachloroethane	0.01	0.01	0.01
Hexane (n)	0.05	0.05	0.46
Indeno[1 2 3-cd]pyrene	0.38	0.38	0.76
Lead	45	120	120
Mercury	0.25	0.27	1.9
Methoxychlor	0.13	0.13	0.45
Methyl Ethyl Ketone	0.5	0.5	0.5
Methyl Isobutyl Ketone	0.53	0.53	0.53
Methyl Mercury **	0.00098	0.00098	0.00098
Methyl tert-Butyl Ether (MTBE)	0.05 [a]	0.05 [a]	0.11 [a]
Methylene Chloride	0.05	0.05	0.05
Methlynaphthalene, 2-(1-) ***	0.35	0.59	0.59
Molybdenum	6.9 [a]	6.9 [a]	40 [a]
Naphthalene	0.59	0.59	1.1
Nickel	100 [a]	100 [a]	270 [a]
Pentachlorophenol	0.1	0.1	0.34

Contaminant	Agricultural and Other Property Use	Residential/ Parkland/Institutional Property Use	Industrial/ Commercial/Community Property Use
Petroleum Hydrocarbons F1****	17	25	25
Petroleum Hydrocarbons F2	10	10	27
Petroleum Hydrocarbons F3	240	240	240
Petroleum Hydrocarbons F4	2800	2800	3300
Phenanthrene	0.21	0.69	0.69
Phenol	2.4	2.4	2.4
Polychlorinated Biphenyls	0.35	0.35	1.1
Pyrene	2.8	2.8	2.8
Selenium	2.4 [a]	2.4 [a]	5.5 [a]
Silver	20 [a]	20 [a]	40 [a]
Styrene	0.5	0.5	0.53
Tetrachloroethane, 1,1,1,2-	0.05	0.05	0.05
Tetrachloroethane, 1,1,2,2-	0.05 [a]	0.05 [a]	0.05 [a]
Tetrachloroethylene	0.05 [a]	0.05 [a]	0.064 [a]
Thallium	1	1	3.3 [a]
Toluene	0.2	0.2	0.2
Trichlorobenzene, 1,2,4-	0.17	0.17	0.51
Trichloroethane, 1,1,1-	0.1	0.1	0.12
Trichloroethane, 1,1,2-	0.05 [a]	0.05 [a]	0.05 [a]
Trichloroethylene	0.05 [a]	0.05 [a]	0.05 [a]
Trichlorofluoromethane	0.17	0.26	0.26
Trichlorophenol, 2,4,5-	0.11	0.11	0.11
Trichlorophenol, 2,4,6-	0.1	0.1	0.1
Uranium	23 [a]	23 [a]	33 [a]
Vanadium	86	86	86
Vinyl Chloride	0.02 [a]	0.02 [a]	0.02 [a]
Xylene Mixture	0.091	0.091	0.091
Zinc	340 [a]	340 [a]	340 [a]
Electrical Conductivity (mS/cm)	0.7	0.7	1.4
Chloride	N/A	N/A	N/A
Sodium Adsorption Ratio	5	5	12
Sodium	N/A	N/A	N/A

Notes

N/A Not applicable

* The boron standards are for hot water soluble extract for all surface soils. For subsurface soils the standards are for total boron (mixed strong acid digest), since plant protection for soils below the root zone is not a significant concern.

** Analysis for methyl mercury only applies when mercury (total) standard is exceeded

*** The methyl naphthalene standards are applicable to both 1-methyl naphthalene and 2- methyl naphthalene, with the provision that if both are detected the sum of the two must not exceed the standard.

**** F1 fraction does not include BTEX; however, the proponent has the choice as to whether or not to subtract BTEX from the analytical result.

[a] Additional requirement for leachate analysis (please refer to Table E of Appendix IV)

TABLE D: PROPOSED Full Depth Volume Independent Excess Soil Standards in a Non-Potable Ground Water Condition

Contaminant	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Acenaphthene	7.8	38
Acenaphthylene	0.093	0.093
Acetone	1.8	1.8
Aldrin	0.05	0.088
Anthracene	0.16	0.16
Antimony	7.5 [a]	40 [a]
Arsenic	18	18
Barium	390 [a]	670 [a]
Benzene	0.02	0.032
Benz[a]anthracene	0.5	0.96
Benzo[a]pyrene	0.3	0.3
Benzo[b]fluoranthene	0.78	0.96
Benzo[ghi]perylene	6.6	9.6
Benzo[k]fluoranthene	0.78	0.96
Beryllium	4 [a]	8 [a]
Biphenyl 1,1'-	0.3	22
Bis(2-chloroethyl)ether	0.5	0.5
Bis(2-chloroisopropyl)ether	0.5	11
Bis(2-ethylhexyl)phthalate	5	28
Boron (Hot Water Soluble)*	1.5	2
Boron (total)	120 [a]	120 [a]
Bromodichloromethane	5.9	5.9
Bromoform	2.5	2.5
Bromomethane	0.05 [a]	0.05 [a]
Cadmium	1.2	1.9 [a]
Carbon Tetrachloride	0.05 [a]	0.05 [a]
Chlordane	0.05	0.05
Chloroaniline p-	0.5	0.5
Chlorobenzene	0.28	0.28
Chloroform	0.05	0.1
Chlorophenol, 2-	1.6	2.4
Chromium Total	160 [a]	160 [a]
Chromium VI	8	8
Chrysene	7	9.6
Cobalt	22 [a]	80 [a]
Copper	140 [a]	230 [a]
Cyanide (CN-)	0.051	0.051
Dibenz[a h]anthracene	0.1	0.1
Dibromochloromethane	5.6	5.6
Dichlorobenzene, 1,2-	3.4	6.8
Dichlorobenzene, 1,3-	4.8	6.9
Dichlorobenzene, 1,4-	0.05	0.05
Dichlorobenzidine, 3,3'-	1	1

Contaminant	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Dichlorodifluoromethane	1.9	1.9
DDD	3.3	4.6
DDE	0.26	0.52
DDT	1.4	1.4
Dichloroethane, 1,1-	0.05	0.15
Dichloroethane, 1,2-	0.05	0.05
Dichloroethylene, 1,1-	0.05	0.05
Dichloroethylene, 1,2-cis-	0.05	0.14
Dichloroethylene, 1,2-trans-	0.05	0.05
Dichlorophenol, 2,4-	1.7	3.4
Dichloropropane, 1,2-	0.05	0.05
Dichloropropene,1,3-	0.05	0.05
Dieldrin	0.05	0.05
Diethyl Phthalate	11 [a]	21 [a]
Dimethylphthalate	17 [a]	34 [a]
Dimethylphenol, 2,4-	46	46
Dinitrophenol, 2,4-	6.8	6.8
Dinitrotoluene, 2,4 & 2,6-	0.92	1.2
Dioxane, 1,4	1.8	1.8
Dioxin/Furan (TEQ)	0.000013	0.000099
Endosulfan	0.04	0.054
Endrin	0.04	0.04
Ethylbenzene	1.9	1.9
Ethylene dibromide	0.05 [a]	0.05 [a]
Fluoranthene	0.69	9.6
Fluorene	7.3	7.3
Heptachlor	0.15	0.19
Heptachlor Epoxide	0.11 [a]	0.14 [a]
Hexachlorobenzene	0.52	0.66
Hexachlorobutadiene	0.01	0.01
Hexachlorocyclohexane Gamma-	0.01	0.01
Hexachloroethane	0.01	0.13
Hexane (n)	0.05	0.46
Indeno[1 2 3-cd]pyrene	0.38	0.76
Lead	120	120
Mercury	0.27	1.9
Methoxychlor	0.13	0.45
Methyl Ethyl Ketone	14	27
Methyl Isobutyl Ketone	0.89	17
Methyl Mercury **	0.00098	0.00098
Methyl tert-Butyl Ether (MTBE)	0.05	0.05
Methylene Chloride	0.059	0.2
Methlynaphthalene, 2-(1-) ***	0.92	8.9
Molybdenum	6.9 [a]	40 [a]
Naphthalene	0.59	9.4
Nickel	100 [a]	270 [a]
Pentachlorophenol	0.1	0.34

Contaminant	Residential/ Parkland/Institutional Property Use (µg/g)	Industrial/ Commercial/Community Property Use (µg/g)
Petroleum Hydrocarbons F1****	25	25
Petroleum Hydrocarbons F2	10	27
Petroleum Hydrocarbons F3	300	1700
Petroleum Hydrocarbons F4	2800	3300
Phenanthrene	6.2	12
Phenol	5.4	5.4
Polychlorinated Biphenyls	0.35	1.1
Pyrene	78	96
Selenium	2.4 [a]	5.5 [a]
Silver	20 [a]	40 [a]
Styrene	0.5	6.9
Tetrachloroethane, 1,1,1,2-	0.05	0.05
Tetrachloroethane, 1,1,2,2-	0.05	0.05
Tetrachloroethylene	0.05	0.05
Thallium	1	3.3 [a]
Toluene	0.99	7.9
Trichlorobenzene, 1,2,4-	0.17	1.3
Trichloroethane, 1,1,1-	0.1	0.4
Trichloroethane, 1,1,2-	0.05	0.05
Trichloroethylene	0.05 [a]	0.05 [a]
Trichlorofluoromethane	0.46	0.46
Trichlorophenol, 2,4,5-	3.2	3.2
Trichlorophenol, 2,4,6-	0.44	0.44
Uranium	23 [a]	33 [a]
Vanadium	86	86
Vinyl Chloride	0.02 [a]	0.02 [a]
Xylene Mixture	0.84	3.1
Zinc	340 [a]	340 [a]
Electrical Conductivity (mS/cm)	0.7	1.4
Chloride	N/A	N/A
Sodium Adsorption Ratio	5	12
Sodium	N/A	N/A

Notes

N/A Not applicable

* The boron standards are for hot water soluble extract for all surface soils. For subsurface soils the standards are for total boron (mixed strong acid digest), since plant protection for soils below the root zone is not a significant concern.

** Analysis for methyl mercury only applies when mercury (total) standard is exceeded

*** The methyl naphthalene standards are applicable to both 1-methyl naphthalene and 2- methyl naphthalene, with the provision that if both are detected the sum of the two must not exceed the standard.

**** F1 fraction does not include BTEX; however, the proponent has the choice as to whether or not to subtract BTEX from the analytical result.

[a] Additional requirement for leachate analysis (please refer to Table F of Appendix IV).

APPENDIX IV

Requirements for Leachate Testing

Requirements for Leachate Testing

VI.1. Introduction

One of the objectives of the excess soil standards was that groundwater monitoring at receiving sites would not be required. However, this may leave exposure pathways that involve the movement of inorganics from soil to groundwater unaccounted for as we do not have reliable organic carbon-water partition coefficients (Koc) to assess this transport mechanism. Therefore, leachate analysis was identified as a potential alternate method of assessing whether GW1 and GW3 component values for inorganics would be met at a site.

The following must be completed as proposed in the regulation.

- If inorganics (i.e. metals) are a contaminant of concern, soil samples must be collected and submitted for leachate analysis.
- If the risk based soil value for that soil to groundwater pathways (S-GW1, S-GW2, and S-GW3) is significantly lower than the achievable soil reporting limit, soil samples must be collected and submitted for leachate analysis (refer to Section 3 of the document for additional details).

The results of the leachate analysis would then be compared to leachate standards which are derived using the lowest of groundwater pathways of concern (GW1, GW2, and GW3, where applicable). Leachate standards are also checked against the reporting limits (RLs)/background concentrations and the standard that is below the RLs will be adjusted up to the RLs and background concentrations. Leachate standards, where appropriate, are listed in Tables E and F of this appendix. The derivation approach for these groundwater components are presented in MOE (2011) rationale document, briefly provided below:

- GW1 component values are the same as those under the brownfield site condition standards. GW1 would only be applicable where the potable soil standards are applicable.
- GW2 component values are derived using a partitioning model coupled with the Johnson-Ettinger (2011) model (or default attenuation factor, where appropriate) to back-calculate a groundwater value from the water table based on acceptable indoor air concentrations for health and odour. GW2 would be only derived for volatile compounds.
- GW3 component values are derived using default dilution factors (from 2 to 10, depending on the volume of impacted soil) to back-calculate a groundwater concentration from aquatic protection values with 30 metres back from the surface water body.

If the results of the leachate assessment do not meet these values, there is the potential for impact to the drinking water and aquatic life pathways.

Where appropriate, proactive risk management at the receiving site may also be permissible instead of required leachate testing. Examples include excess soils brought to sites with a sufficient setback distance from drinking water wells or surface water bodies.

IV.2. Selection of Leachate Test

The applicability of any leachate test results to a specific site is dependent on how closely the leachate extraction method mimics site conditions. There is currently no single test that is appropriate for all scenarios. A brief discussion of a few of the more common tests is provided below.

IV.3. Types of Leachate Tests

There are two main types of leachate tests: 1) single extraction/batch tests (also called "static" tests) and 2) multiple extraction/flow around and flow-through tests (also called "dynamic" tests). Single extraction tests use a specific amount of extractant with a specific amount of soil for a specific time. The extractant is removed at the end of the test and analyzed. Single extraction tests assume that equilibrium is reached by the end of the test, if equilibrium is not reached, results may under predict leaching behaviour. Multiple extraction tests renew or replace the extractant during testing and these tests can be used to assess leaching conditions over time.

Results of a leachate test depend on three main parameters of the test; the pH of extractant, the particle size of the soil sample, and the liquid to solid ratio. By varying one of these components and completing multiple batch extractions on a single sample, the effect of each parameter can be assessed. US EPA Methods 1313 and 1316 are designed to assess pH and liquid to solid ratio, respectively.

The Toxicity Characteristic Leachate Procedure (TCLP, US EPA Method 1311) and Synthetic Precipitation Leachate Procedure (SPLP, US EPA Method 1312) are single batch tests. Both tests require particles size reduction to a maximum particle size of 9.5 mm, use a 20:1 liquid to solid ratio, and rotate the sample for 18 hrs. The main difference is the type of extractant used. The TCLP is used largely for characterizing waste materials for landfill disposal (i.e. using an organic acid), whereas the SPLP is used for estimating the leachate potential for soils, taking into consideration the acidity of the rainfall (i.e. using sulphuric acid and nitric acid, the two main acid producing constituents of precipitation). Because both tests evaluate leaching at a single pH, results may over or under-estimate the leaching potential of some metals. The QP should consider this information when selecting the leachate test and document this appropriately.

IV.4. References

Ministry of the Environment (MOE, currently known as Ministry of the Environment and Climate Change), 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario.

TABLE E: Leachate Standards Required for a Potable Ground Water Condition

Contaminant of Potential Concern	**TABLE A: Full Depth Excess Soil Standards in A Potable Ground Water Condition and A Source Size of Less Than $5000 m^3$**			**TABLE C: Full Depth Volume Independent Excess Soil Standards in a Potable Ground Water Condition**		
	Agricultural and Other Property Use (µg/L)	Residential/ Parkland/ Institutional Property Use (µg/L)	Industrial/ Commercial/ Community Property Use (µg/L)	Agricultural and Other Property Use (µg/L)	Residential/ Parkland/ Institutional Property Use (µg/L)	Industrial/ Commercial/ Community Property Use (µg/L)
Antimony	6	6	6	6	6	6
Barium	1000	1000	1000	1000	1000	1000
Beryllium	4	4	4	4	4	4
Bis(2-chloroethyl)ether	5	5	5	5	5	5
Boron (total)	5000	5000	5000	5000	5000	5000
Bromodichloromethane	-	-	-	16	16	16
Bromomethane	-	-	-	0.89	0.89	0.89
Cadmium	-	-	0.55	-	-	0.5
Carbon Tetrachloride	-	-	-	0.79	0.79	0.79
Chloroaniline p-	-	-	-	10	10	10
Chromium Total	50	50	50	50	50	50
Cobalt	3	3	3	3	3	3
Copper	18	18	18	14	14	14
Dichlorobenzidine, 3,3'-	-	-	-	0.5	0.5	0.5
Dichloroethane, 1,1-	-	-	-	5	5	5
Dichloroethane, 1,2-	-	-	-	1.6	1.6	1.6
Dichloroethylene, 1,1-	-	-	-	1.6	1.6	1.6
Dichloroethylene, 1,2-cis-	-	-	-	1.6	1.6	1.6
Dichloroethylene, 1,2-trans-	-	-	-	1.6	1.6	1.6
Dichloropropane, 1,2-	-	-	-	5	5	5
Dichloropropene,1,3-	0.5	0.5	0.5	0.5	0.5	0.5
Diethyl Phthalate	7.8	7.8	7.8	6	6	6
Dimethylphthalate	7.8	7.8	7.8	6	6	6
Dinitrophenol, 2,4-	-	-	-	10	10	10

Contaminant of Potential Concern	TABLE A: Full Depth Excess Soil Standards in A Potable Ground Water Condition and A Source Size of Less Than 5000m^3			TABLE C: Full Depth Volume Independent Excess Soil Standards in a Potable Ground Water Condition		
	Agricultural and Other Property Use (µg/L)	Residential/ Parkland/ Institutional Property Use (µg/L)	Industrial/ Commercial/ Community Property Use (µg/L)	Agricultural and Other Property Use (µg/L)	Residential/ Parkland/ Institutional Property Use (µg/L)	Industrial/ Commercial/ Community Property Use (µg/L)
Dinitrotoluene, 2,4 & 2,6-	-	-	-	5	5	5
Dioxane, 1,4	-	-	-	50	50	50
Ethylbenzene	-	-	-	1.6	1.6	1.6
Ethylene dibromide	0.2	0.2	0.2	0.2	0.2	0.2
Heptachlor Epoxide	0.01	0.01	0.01	0.01	0.01	0.01
Methyl tert-Butyl Ether (MTBE)	-	-	-	15	15	15
Molybdenum	70	70	70	70	70	70
Nickel	100	100	100	78	78	78
Selenium	13	13	13	10	10	10
Silver	0.31	0.31	0.31	0.3	0.3	0.3
Tetrachloroethane, 1,1,2,2-	1	1	1	1	1	1
Tetrachloroethylene	-	-	-	1.6	1.6	1.6
Thallium	-	-	2	-	-	2
Trichloroethane, 1,1,2-	-	-	-	4.7	4.7	4.7
Trichloroethylene	-	-	-	1.5	1.5	1.5
Uranium	20	20	20	20	20	20
Vinyl Chloride	-	-	-	0.5	0.5	0.5
Zinc	230	230	230	180	180	180

Notes - Not applicable

TABLE F: Leachate Standards Required for a Non-Potable Ground Water Condition

Contaminant of Potential Concern	**TABLE B: Full Depth Excess Soil Standards in A Non-Potable Ground Water Condition and A Source Size of Less Than 5000m^3**		**TABLE D: Full Depth Volume Independent Excess Soil Standards in a Non-Potable Ground Water Condition**	
	Residential/ Parkland/ Institutional Property Use (µg/L)	Industrial/ Commercial/ Community Property Use (µg/L)	Residential/ Parkland/ Institutional Property Use (µg/L)	Industrial/ Commercial/ Community Property Use (µg/L)
Antimony	4200	4200	3200	3200
Barium	6000	6000	4600	4600
Beryllium	14	14	11	11
Boron (total)	9200	9200	7100	7100
Bromomethane	-	-	5.8	5.8
Cadmium	-	0.55	-	0.5
Carbon Tetrachloride	-	-	0.79	0.79
Chromium Total	170	170	130	130
Cobalt	14	14	10	10
Copper	18	18	14	14
Diethyl Phthalate	7.8	7.8	6	6
Dimethylphthalate	7.8	7.8	6	6
Ethylene dibromide	-	-	0.25	0.25
Heptachlor Epoxide	0.01	0.01	0.01	0.01
Molybdenum	1900	1900	1500	1500
Nickel	100	100	78	78
Selenium	13	13	10	10
Silver	0.31	0.31	0.3	0.3
Thallium	-	100	-	80
Trichloroethylene	-	-	1.5	1.5
Uranium	2	2	2	2
Vinyl Chloride	-	-	0.5	0.5
Zinc	230	230	180	180

Notes - Not applicable

APPENDIX V

Attainment of Table 1 Standards

Attainment of Table 1 Standards

V.1. Purpose

The purpose of this document is to propose a procedure to demonstrate compliance with the Ontario Typical Range (OTR) standards often referred to as the "Table 1" or "Background" standards. The MOECC is proposing a departure from the existing compliance requirement from O.Reg 153/04 in which every soil sample must be numerically equal to or lower than the Table 1 standard in order for the soil to be considered Table 1 quality. This new "Attainment Requirement" is intended to account for the natural variability that exists in soil and to acknowledge that laboratory analyses are not precise, thereby providing a better representation of the soil quality. The MOECC is considering the application of this approach beyond Table 1 to other excess soil reuse tables, however this is not discussed in this document and will require additional consideration in terms of how this could align with brownfields redevelopment.

V.2. Background

The current O.Reg 153/04 approach to meeting the background Table 1 standards is if one soil sample exceeds a Table 1 standard for any parameter by any magnitude, the soil does not meet the standard. It has been the Ministry's experience over the past number of years that proponents have identified situations where soils may not meet Table 1 standards at sites they considered to be unimpacted sites. Knowing how the OTR data set was collected and then used to develop the Table 1 standards provides an understanding of how the proposed Attainment Requirement may be of value in addressing this issue.

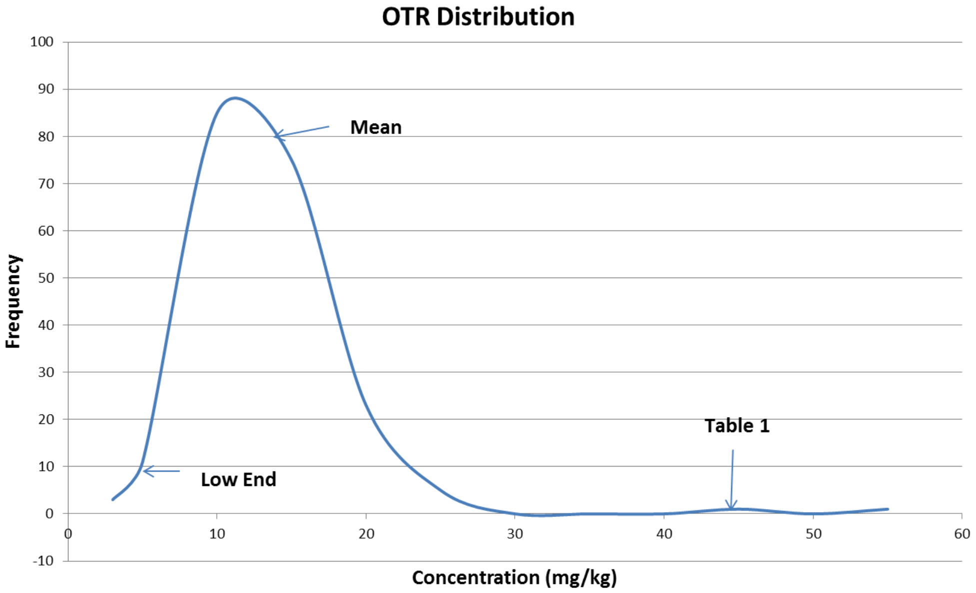
The Table 1 standards were developed from the OTR data collection program for soils. The program involved the collection of samples of unimpacted surface soil from around the province. The Table 1 standards are a statistical estimate of the upper levels (roughly 98% of unimpacted soils in Ontario will be below the OTR number for a specific substance) of provincial background concentrations (see Figure V.1).

Due to the number of soil samples collected from different land uses across Ontario, the confidence level (1-α) for the confidence limits around the OTR_{98} (97.5th percentile of the data) on which Table 1 is based is often 90% or lower for the chemical parameters analyzed. For this reason, there is a chance that a few samples at the upper tail may exceed Table 1 standards. The users of Table 1 do not take into consideration the confidence limits around the OTR_{98} when comparing their data to the standard.

The OTR data that were used to develop the Table 1 standards are the average of two or three composite soil samples collected from each OTR site across the province. Composite samples themselves are averages of discrete samples. In contrast, users of Table 1 almost always collect discrete soil samples for analysis and compare those results to Table 1 standards.

The proposed attainment requirements are intended to help to address the differences in how the OTR standards were developed and how soil quality data is commonly evaluated. Additional detail on the derivation procedures used to establish the Table 1 standards are presented in documents prepared by the Ministry of the Environment and Climate Change [MOE 2011, MEE 1993].

Figure V.1 – OTR Distribution –For Illustration Purposes Only



V.3. Proposed Attainment Requirements

As explained in section 2 above, the current approach can be described as a single point of compliance. The proposed approach deviates from the current approach in that a volume of soil may still be considered Table 1 quality even though a single soil sample does not meet the Table 1 standard. It is proposed that for a given volume of soil to be deemed Table 1 quality, the following Attainment Requirements would need to be met:

1. The 90th percentile of the data set (90% of the samples) is less than the Table 1 standard under the Ministry's Soil, Ground Water and Sediment Standards;
2. No single sample within the data set exceeds the applicable ceiling value as documented in Table 1 of Appendix VI; and,
3. The Upper 95th% upper confidence limit of the mean (UCLM) concentration of the samples must be less than the Table 1 standard under the Ministry's Soil, Ground Water and Sediment Standards.

It is also proposed that a minimum of twenty (20) soil samples is required to use this compliance method, which is intended to ensure proper representation of the soils and strong statistical results. A greater number of samples would be warranted as soil volumes increase to ensure the soil has been characterized adequately. An increased number of samples will lead to greater statistical confidence in the data set and will increase the likelihood that the 95th% UCLM will meet the Table 1 standard. If the sample set contains less than 20 samples, single point compliance continues to be an option (status quo - no single sample result numerically higher than Table 1 standard).

Requirement #1 is intended to, through the use of a statistical approach, account for natural variability in situ and in laboratory analysis yet ensure that the overall soil quality meets the Table 1 standard (would permit some soil (10%) to be higher than the standard). Requirement #2 is intended to both help identify unique populations (which may indicate areas of impact), and to ensure that any volume of soil does not pose unacceptable risks to human health and the environment. Requirement #3 is intended to provide some certainty that the overall soil quality is meeting the standards, and that the statistics used to demonstrate this are supported with a comparable data set – i.e. do not indicate a large variance in the data illustrating the possibility of poor representation of true soil quality, or unique populations.

Table 1 Standards and Corresponding Ceiling Values for Attainment Requirement #2

Ceiling values have been developed to:

1. Protect human health and the environment; and,
2. Ensure that the soils which are determined to meet Table 1 using this approach could reasonably be considered to be naturally occurring in Ontario.

Ceiling values remain the same as Table 1 standards when:

1. OTR's were not developed (Table 1 set at analytical reporting limit (RL)), or
2. OTR is set at the RL as the OTR samples were undetected or detected at levels being less than RLs.

Where neither of the above apply, a ceiling value may be generated based on the Table 1 value multiplied by a factor of 2 (considered to be a reasonable estimate of the variability within Table 1 values that account for sample homogeneity, laboratory method precision).

In addition the ceiling values are not permitted to exceed an upper risk threshold.

This approach results in the Table 1 ceiling values presented at the end of this Appendix.

V.4. Other Considerations for Using this Approach

It should be recognized that any volume of soil that has concentrations above applicable brownfields standards may result in the failure to meet brownfields standards for the filing of a Record of Site Condition under O.Reg 153/04 in the area where this soil is placed at a receiving site. The ministry is considering the application of this approach at O.Reg 153/04 Record of Site Condition (RSC) properties; however this will not completely eliminate this concern. Should the soil representing the upper end of the concentration distribution (i.e. the soil above Table 1 but below the ceiling limit) be reused primarily in an area of a receiving site which at some future time became a single residential home (subject to an RSC filing) then the target risk levels for the generic standards may not be maintained at that residential property. This may lead to the need for additional management and/or clean-up of that residential property in order to file a RSC. These factors should be considered when reusing soil that has relied upon this approach at receiving properties.

The user should be familiar with statistical methods and/or consult with someone having this expertise when evaluating the excess soils data set. The QP may wish to utilize a statistical software package such as ProUCL (free software available from US EPA here: https://www.epa.gov/land-research/proucl-software) or equivalent to generate statistical results. For example, there are several methods available for calculating the 95% UCLM for different population distributions and the resulting values could be significantly different. Therefore, it is very important to select the most appropriate method that reflects the appropriate distribution. This is an example of an area where software such as ProUCL can be an excellent resource as it takes into consideration the data distribution, sample size, skewedness and percentage of non-detect values in the data set.

When presented with soil sample data it is important to first consider the distribution of the data set as it can identify valuable information in terms of soil quality, as well as informing the best approach for developing the statistics used when evaluating whether the Attainment Requirements have been met. An examination of the data set may indicate that it is either normally distributed or non-normally distributed, which each compel different statistical tests in order to be representative of the excess soil. This may be because there is an area of the property containing impacted soil which has significantly different concentrations than the rest of the property. Varying concentrations may also be found when sampling at different soil depths – e.g. some samples are taken at the soil surface (e.g. top 1.5m) and other samples from depth (e.g. below 1.5m) and soil types. Where these situations occur, an evaluation of the data set by someone competent in statistical approaches using statistical software such as ProUCL will lead to more defensible conclusions and may help to drive excess soil management decisions. For example, the removal and disposal of a particular volume, of soil that may be impacted as represented by a few data points (e.g. an area or "hotspot" on the site where a spill occurred that comes across statistically as a unique population), may permit the remaining volume of soil to meet the Attainment Requirements (less variability in the UCLM, and elimination of measurements above the permitted ceiling value). Alternatively, the data may be separated in to two distinct populations and managed differently as soil that is deemed to be Table 1 quality and soil that is some other quality (e.g. Tables 2 or 3).

The user should be aware of the limitations of the statistical approaches and use their judgement and expertise to best represent the soil being evaluated and to ensure soil which would not reasonably be considered to be naturally occurring is not treated as Table 1 soil. These Attainment Requirements are intended as an option for users and is intended to account for the natural variability that exists in soil and to acknowledge that laboratory analyses are not precise, thereby providing a better representation of the soil quality.

V.5. References

Ministry of the Environment (MOE, currently known as Ministry of the Environment and Climate Change), 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario https://www.ontario.ca/document/rationale-development-soil-and-ground-water-standards-use-contaminated-sites-ontario

Ministry of Environment and Energy (MEE, currently known as Ministry of the Environment and Climate Change), 1993. Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags and Snow. https://archive.org/details/ontariotypicalra00torouoft

Table 1 Proposed Standards and Ceiling Values

Contaminant	Residential/ Parkland/Institutional/ Industrial/Commercial/ Community Property Use (µg/g)	Ceilling Values (µg/g)
Acenaphthene	0.072	0.14
Acenaphthylene	0.093	0.19
Acetone	0.5	0.5
Aldrin	0.05	0.05
Anthracene	0.16	0.32
Antimony	1.3	2.6
Arsenic	18	35
Barium	220	430
Benzene	0.02	0.02
Benz[a]anthracene	0.36	0.72
Benzo[a]pyrene	0.3	0.6
Benzo[b]fluoranthene	0.47	0.94
Benzo[ghi]perylene	0.68	1.4
Benzo[k]fluoranthene	0.48	0.97
Beryllium	2.5	5
Biphenyl 1,1'-	0.05	0.05
Bis(2-chloroethyl)ether	0.5	0.5
Bis(2-chloroisopropyl)ether	0.5	0.5
Bis(2-ethylhexyl)phthalate	5	5
Boron (Hot Water Soluble)*	NA	NA
Boron (total)	36	72
Bromodichloromethane	0.05	0.05
Bromoform	0.05	0.05
Bromomethane	0.05	0.05
Cadmium	1.2	2.4
Carbon Tetrachloride	0.05	0.05
Chlordane	0.05	0.05
Chloroaniline p-	0.5	0.5
Chlorobenzene	0.05	0.05
Chloroform	0.05	0.05
Chlorophenol, 2-	0.1	0.1
Chromium Total	70	140
Chromium VI	0.66	1.3
Chrysene	2.8	5.5
Cobalt	21	42
Copper	92	180
Cyanide (CN-)	0.051	0.1
Dibenz[a h]anthracene	0.1	0.1
Dibromochloromethane	0.05	0.05
Dichlorobenzene, 1,2-	0.05	0.05
Dichlorobenzene, 1,3-	0.05	0.05

Contaminant	Residential/ Parkland/Institutional/ Industrial/Commercial/ Community Property Use (µg/g)	Ceilling Values (µg/g)
Dichlorobenzene, 1,4-	0.05	0.05
Dichlorobenzidine, 3,3'-	1	1
Dichlorodifluoromethane	0.05	0.05
DDD	0.05	0.05
DDE	0.05	0.05
DDT	1.4	2.8
Dichloroethane, 1,1-	0.05	0.05
Dichloroethane, 1,2-	0.05	0.05
Dichloroethylene, 1,1-	0.05	0.05
Dichloroethylene, 1,2-cis-	0.05	0.05
Dichloroethylene, 1,2-trans-	0.05	0.05
Dichlorophenol, 2,4-	0.1	0.1
Dichloropropane, 1,2-	0.05	0.05
Dichloropropene,1,3-	0.05	0.05
Dieldrin	0.05	0.05
Diethyl Phthalate	0.5	0.5
Dimethylphthalate	0.5	0.5
Dimethylphenol, 2,4-	0.2	0.2
Dinitrophenol, 2,4-	2	2
Dinitrotoluene, 2,4 & 2,6-	0.5	0.5
Dioxane, 1,4	0.2	0.2
Dioxin/Furan (TEQ)	0.000007	0.000014
Endosulfan	0.04	0.04
Endrin	0.04	0.04
Ethylbenzene	0.05	0.05
Ethylene dibromide	0.05	0.05
Fluoranthene	0.56	1.1
Fluorene	0.12	0.23
Heptachlor	0.05	0.05
Heptachlor Epoxide	0.05	0.05
Hexachlorobenzene	0.01	0.01
Hexachlorobutadiene	0.01	0.01
Hexachlorocyclohexane Gamma-	0.01	0.01
Hexachloroethane	0.01	0.01
Hexane (n)	0.05	0.05
Indeno[1 2 3-cd]pyrene	0.23	0.46
Lead	120	250
Mercury	0.27	0.53
Methoxychlor	0.05	0.05
Methyl Ethyl Ketone	0.5	0.5
Methyl Isobutyl Ketone	0.5	0.5
Methyl Mercury **	NV	NV

Contaminant	Residential/ Parkland/Institutional/ Industrial/Commercial/ Community Property Use (µg/g)	Ceilling Values (µg/g)
Methyl tert-Butyl Ether (MTBE)	0.05	0.05
Methylene Chloride	0.05	0.05
Methlynaphthalene, 2-(1-) ***	0.59	1.2
Molybdenum	2	2
Naphthalene	0.09	0.18
Nickel	82	160
Pentachlorophenol	0.1	0.1
Petroleum Hydrocarbons F1****	25	50
Petroleum Hydrocarbons F2	10	10
Petroleum Hydrocarbons F3	240	480
Petroleum Hydrocarbons F4	120	240
Phenanthrene	0.69	1.4
Phenol	0.5	0.5
Polychlorinated Biphenyls	0.3	0.3
Pyrene	1	2.1
Selenium	1.5	3.1
Silver	0.5	0.5
Styrene	0.05	0.05
Tetrachloroethane, 1,1,1,2-	0.05	0.05
Tetrachloroethane, 1,1,2,2-	0.05	0.05
Tetrachloroethylene	0.05	0.05
Thallium	1	1
Toluene	0.2	0.2
Trichlorobenzene, 1,2,4-	0.05	0.05
Trichloroethane, 1,1,1-	0.05	0.05
Trichloroethane, 1,1,2-	0.05	0.05
Trichloroethylene	0.05	0.05
Trichlorofluoromethane	0.25	0.51
Trichlorophenol, 2,4,5-	0.1	0.1
Trichlorophenol, 2,4,6-	0.1	0.1
Uranium	2.8	5.5
Vanadium	86	170
Vinyl Chloride	0.02	0.02
Xylene Mixture	0.05	0.05
Zinc	290	590
Electrical Conductivity (mS/cm)	0.57	0.57
Chloride	NA	NA
Sodium Adsorption Ratio	2.4	2.4
Sodium	NA	NA

Notes

N/V= No value derived. N/A = Not applicable

* The boron standards are for hot water soluble extract for all surface soils. For subsurface soils the standards are for total boron (mixed strong acid digest), since plant protection for soils below the root zone is not a significant concern.

** Analysis for methyl mercury only applies when mercury (total) standard is exceeded

*** The methyl naphthalene standards are applicable to both 1-methyl naphthalene and 2- methyl naphthalene, with the provision that if both are detected the sum of the two must not exceed the standard.

**** F1 fraction does not include BTEX; however, the proponent has the choice as to whether or not to subtract BTEX from the analytical result.