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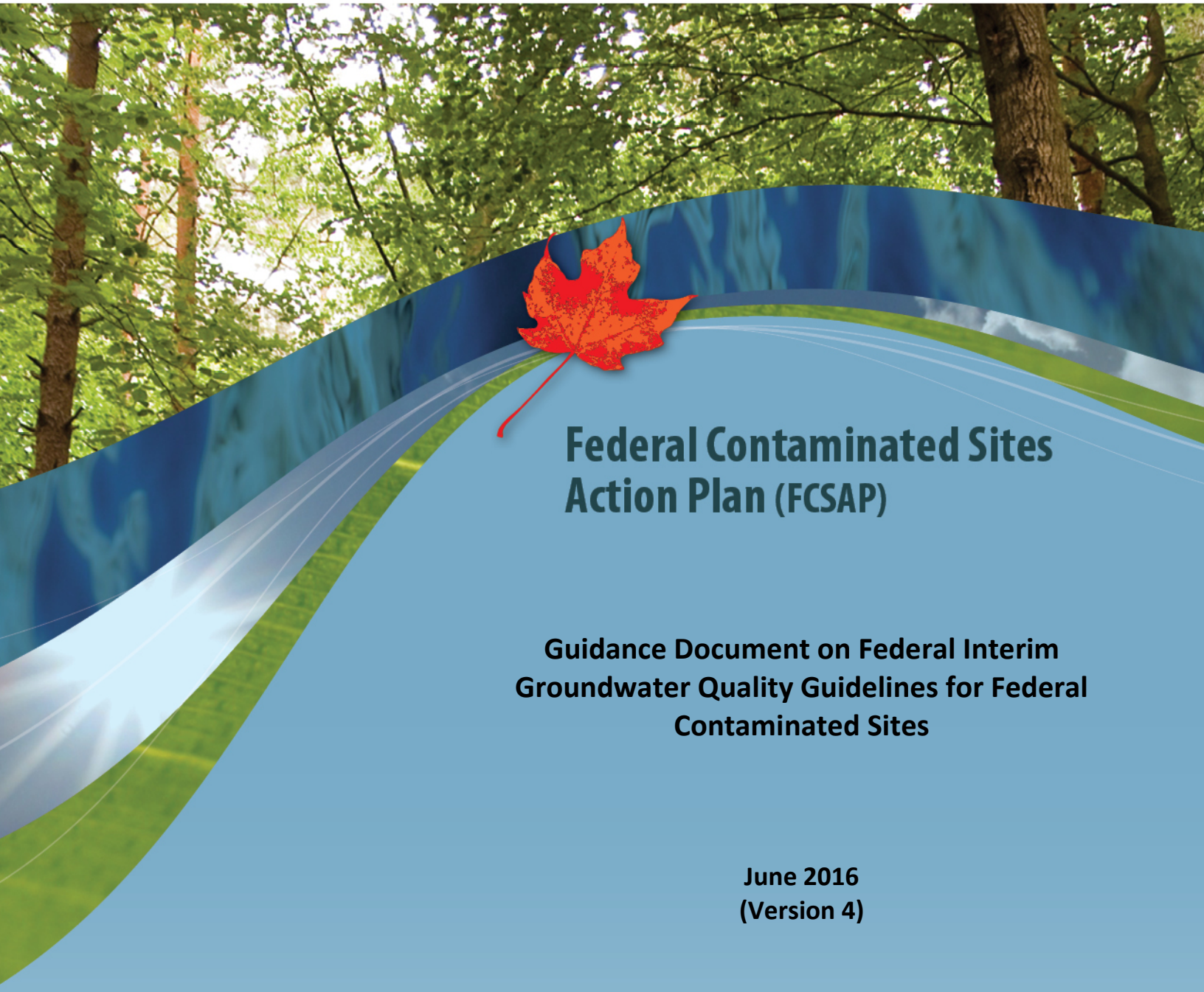

Federal Contaminated Sites Action Plan (FCSAP)

Guidance Document on Federal Interim Groundwater Quality Guidelines for Federal Contaminated Sites

June 2016
(Version 4)

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NOTICE

The Federal Interim Groundwater Guidelines for Federal Contaminated Sites (FIGQG) were established in 2010 to provide a nationally consistent approach for assessing groundwater on federal contaminated sites. However, errors in translation were found in some of the tables and because of this, the English and French versions were removed from the FCSAP Web Portal and IDEA.

Please note that the FIGQGs were not developed de novo, but were instead adopted (and sometimes adapted) from different jurisdictions. For most contaminants the guidelines are adopted from the Alberta Ministry of the Environment. The guidelines for some contaminants are based on guidelines from the Ontario Ministry of the Environment, the BC Contaminated Sites Regulation or the CCME water quality guidelines. CCME is currently developing groundwater quality guidelines and they are expected to be published this fiscal or early next. Therefore, in the interim period before the CCME publishes the new guidelines, an updated FIGQG Memo containing the values that are out of date in this document has been posted and is available on IDEA or from the FCSAP Secretariat. The FIGQG Memo also contains new values for **methanol** and **trichlorfon** not previously reported in the FIGQG document.

Thank you for your understanding,

FCSAP Secretariat

Version History

- May 2010 Version
- Revised November 2012
- Revised March 2014 (Version 2)
- Revised November 2015 (Version 3)
- Revised June 2016 (Version 4)

Preface

The Federal Contaminated Sites Action Plan (FCSAP) was established to help federal departments, agencies and consolidated Crown corporations (referred to as custodians) address federal contaminated sites, so as to reduce environmental and human health risks as well as federal financial environmental liability associated with the higher risk federal contaminated sites.

The Federal Interim Groundwater Quality Guidelines presented in this report were developed to assist federal custodians in assessing, remediating/risk managing federal contaminated sites funded under the FCSAP. Federal custodians are advised to use these interim guidelines as an interim measure until Canadian groundwater quality guidelines are available.

This report was developed based on a study conducted for Environment Canada by Meridian Environmental Inc. to review existing approaches for deriving groundwater quality guidelines used by other jurisdictions in Canada and other countries, and recommended one of them that can be adapted for use at federal contaminated sites. The study was conducted under the guidance of an Environment Canada working group of experts, and reviewed by the Expert Support Science Department of Health Canada and Fisheries and Oceans.

An update of the May 2010 version of this guidance document is required as it contains a number of groundwater guidelines that were calculated based on *The Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Site in Ontario* (2009) developed by the Ontario Ministry of the Environment. These guidelines have been revised since then. In addition, comments were solicited from custodians and consultants based on their experiences in applying the May 2010 version of the Federal Interim Groundwater Quality Guidelines at their contaminated sites. These comments were considered and addressed where appropriate in the current version of the guidelines.

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OVERVIEW OF CHANGES MADE SINCE THE MAY 2010 VERSION OF THE GUIDANCE DOCUMENT ON FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES FOR FEDERAL CONTAMINATED SITES (FIGQGS)

- Clarified that the 2012 update supersedes the May 2010 version of the this document
- Updated year of publication for guidelines where applicable
- Removed sentence “and in many cases may not discharge to nearby surface water bodies” from 5th paragraph under the “Background on Groundwater” section (Section 2)
- Removed 4th bullet on The Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses as an additional set of guidelines that is relevant for groundwater at federal contaminated sites as these guidelines are already incorporated in Table 1-3 (Section 3)
- Removed 7th bullet on “use of groundwater for human consumption (i.e. drinking water)” as a potential receptors and exposure pathways considered under the FIGQG. The protection of drinking water is addressed separately by the Guidelines for Canadian Drinking Water Quality that should be used in conjunction the FIGQGs (Section 3)
- Added a section on “Guidelines Lower than Detection Limits” as a special considerations on the application of the numerical guidelines (Section 4.3)
- Added a paragraph that clarified situations when the FIGQGs apply to dissolved or total concentrations in groundwater (Section 4.3)
- Revised section on Application on First Nation Lands to state that “For contaminated sites on settlement lands, First Nations (e.g. in Yukon Territory) may have the right to request more stringent standards/guidelines for water quality than those provided in Federal or Territorial laws (Section 4.3)
- Clarified the “Drinking water” section under “Pathways Elimination” that protection of drinking water may also need to be considered if contaminated groundwater may impact surface water used for drinking water supply (Section 5.2)
- Revised “Protection of freshwater/marine life” section under “Pathways Elimination” to provide clarification and guidance on when to eliminate this pathway (Section 5.2)
- Clarified and clearly define “conservative solute” (Section 5.2)
- Added FCSAP Ecological Risk Assessment guidance documents to current list of references relevant while conducting site-specific risk assessments (Section 6)
- Reviewed and updated all FIGQG adopted from Ontario MOEE 1997 to be in line with the newly released OMOEE groundwater guidelines (Appendix A, Table 1-3)
- Revised Appendix B to include models, equations and default model parameters used to calculate Tier 2 guidelines (Appendix B)
- Provided additional guidance for the derivation of Tier 2 adjustment factors (calculated using the Tier 2 model assuming steady-state conditions and no biodegradation, with all other parameters at Tier 1 default values) (B.3 Groundwater Transport)
- Corrections related to corresponding values in the French and English version include revised values as follows:
    - Table 1 – Lowest guideline (Coarse) for 1,1,2,2 –tetrachloroethane should be 0.0032,
    - Table 2 – Soil Organisms Direct Contact (Coarse) for Chloride should be “–“;
    - Table 3 – Lowest guideline (Coarse) for Ethylbenzene should be 11; and
    - Table 3 – Inhalation (Fine) for Chlordane should be 1.7.

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- DDAC (Didecyl dimethyl ammonium chloride) was corrected in the French version from “Clorure de dimethyl (octadecyl) ammonium (DDAC)”
- Revisions for Version 4 include changes to the Notice section that refer to the FIGQG Memo that includes updated values for boron, cadmium, silver, tetrachlroethene (Tetrachloroethylene, Perchloroethylene, PCE), Trichloromethane (Chloroform), methanol, glyphosate, and trichlorfon

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GLOSSARY

Active layer: The soil layer in Northern regions with permafrost that melts in the summer and re-freezes in the fall or winter.

Aquifer: A geologic formation(s) that has the ability to store and/or transmit water, such as to springs. Use of the term is usually restricted to water-bearing formations capable of yielding water in significant quantities sufficient to constitute a usable supply for people's uses.

Background concentration: Representative, naturally occurring level of a contaminant in the environment. Reflects natural geologic variations.
Coarse-grained soil: Soil which contains greater than 50% by mass particles greater than 75 µm mean diameter (D50 > 75 µm).

Confined aquifer: A region of soil or rock below the land surface that is saturated with water. There are impermeable material layers above and below it and it is under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.

Dilution factor: A constant applied to groundwater guidelines to address the decrease in concentration as contaminants are transported to surface water due to dilution.

Ecological receptor: A non-human organism potentially experiencing adverse effects from exposure to contaminated media either directly or indirectly (food chain transfer).

Ecosystem: A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

Fine-grained soil: Soil which contains greater than 50% by mass particles less than 75 µm mean diameter (D50 < 75 µm).

Groundwater: Subsurface water beneath the water table in fully saturated geologic formations.

Hypolentic zone: Transition zone between groundwater and surface water beneath lakes and wetlands.

Hyporheic zone: Transition zone between groundwater and surface water beneath streams and rivers.

Offset distances: A minimum distance from a receptor where guidelines do not apply, due to limitations in transport models or other invalidated guideline assumptions.

Receptor: A receptor is the person or organism exposed to a chemical. For human health risk assessment, it is common to define a critical receptor as the person expected to experience the most severe exposure (due to age, sex, diet, lifestyle, etc.) or most severe effects (due to state of health, genetic disposition, sex, age, etc.) as a result of that exposure.

Recharge: Process which occurs when the water content of the unsaturated zone becomes high enough to cause excess water to percolate downward to the water table, usually as a result of the infiltration of snow melt or rainwater into surface soils. Using a water balance approach, recharge is equal to the total amount of precipitation less the amount of surface runoff and evapotranspiration.

Pore water: The water occupying the space between particles of sediment or soil.

Solubility: The maximum concentration of a chemical that can be dissolved in water when that water is both in contact and at equilibrium with the pure chemical.

Subsurface: Unconsolidated regolith material above the water table not subject to soil forming processes.

Transition zone: The area where groundwater enters a surface water body.

Unconfined aquifer: A region of saturated ground material not overlain by an impermeable or low-permeability layer such as clay, whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall. These systems allow for the draining of pore water and the subsequent movement of air (or water) to fill the spaces vacated by the moving water.

Water table: Depth below which soil is saturated with groundwater.

1 INTRODUCTION

The Federal Contaminated Sites Action Plan (FCSAP) was established in 2005 as a 15-year program with a commitment of $3.5 billion from the Government of Canada. The program helps federal departments, agencies, and consolidated Crown corporations (referred to as custodians) determine if a site is contaminated and, if so, to what extent. Where appropriate, it provides financial assistance to deal with the environmental and human health risks that these sites may pose.

Federal contaminated sites are generally evaluated using the *Canadian Environmental Quality Guidelines* (CEQG) (CCME 1999) developed by the Canadian Council of Ministers of the Environment (CCME). The CEQGs are primarily risk-based numerical guidelines set at levels at which it is believed that unacceptable adverse effects on environmental or human health will not occur. These were developed for various media: water, soil, and sediments, and biological tissue. For some media (e.g. surface water, soil), there is a multi-tier framework that allows for the application of generic numerical guidelines, the modification of guidelines based on site-specific conditions, or the use of site-specific risk assessment. While the *Canadian Soil Quality Guidelines* (CCME 1999) include consideration of the protection of groundwater for organic chemicals, there are currently no Canadian Environmental Quality Guidelines for groundwater. In the absence of national groundwater guidelines, provincial guidelines are sometimes applied at federal contaminated sites, or in other cases, potable water guidelines, and/or surface water quality guidelines are often applied for groundwater – either directly or with an arbitrary adjustment factor. In recognizing the need for a nationally-consistent approach for assessing and managing groundwater at federal contaminated sites, Environment Canada conducted a study to develop a federal approach that would be based on a critical review and evaluation of existing approaches used by other jurisdictions in Canada and in other countries. Meridian Environmental Inc. conducted such a review for Environment Canada, and recommended Federal Interim Groundwater Quality Guidelines (FIGQG), presented in this report, that should be used by custodians to assess, remediate/risk manage contaminated groundwater at federal sites funded under FCSAP. This report was prepared for the FCSAP Secretariat of Environment Canada and is based on the recommendations provided by Meridian Environmental Inc. in their study.

The FIGQG are intended to be used as an interim measure until CEQGs for groundwater are available. This update supersedes the May 2010 version of the FIGQG. A draft CCME protocol for the derivation of groundwater quality guidelines for contaminated sites has recently been developed; once that protocol is finalized, guidelines developed under the CCME protocol would supersede the FIGQG presented herein. Until such time, the FIGQG are to be used in connection with groundwater investigation and remediation activities at federal contaminated sites.

An update of the May 2010 version of this guidance document is required as it contains a number of groundwater guidelines that were calculated based on *The Rationale for the Development of Soil and Groundwater Standards for Use at Contaminated Site in Ontario* (2009) developed by the Ontario Ministry of the Environment. These guidelines have been revised since then. In addition, comments were solicited from custodians and consultants based on their experiences in applying the May 2010 version of the FIGQG at their

contaminated sites. These comments were considered and addressed where appropriate in the current version of the guidelines.

These guidelines are intended as assessment and remediation criteria for contaminated sites, and should not be construed as “pollute up to” levels. The FIGQG follow a tiered framework, consistent with the Canadian Soil Quality Guidelines development through the CCME. The tiers are:

- Tier 1: direct application of the generic numerical guidelines; specifically, application of the lowest guideline for any pathway
- Tier 2: allows for the development of site-specific remediation objectives through the consideration of site-specific conditions, by modifying (within limits) the numerical guidelines based on site-specific conditions and focusing on exposure pathways and receptors that are applicable to the site
- Tier 3: use of site-specific risk assessment to develop Site-Specific Remediation Objectives

The FIGQG presented in this report have been adopted from other jurisdictions, with some modifications, and are based on common risk assessment methods. Quantitative human health and environmental risk assessments involve a number of uncertainties and limitations. As a consequence, the use of the recommendations presented herein may either be overly protective or may not necessarily provide complete protection of human and environmental receptors or prevent damage of property in all circumstances. The generic (i.e. Tier 1) guidelines are not intended for application at all sites without consideration of the sensitivity of the site and its characteristics, as discussed below. However, it is expected that the generic guidelines will be protective of the majority of federal contaminated sites. Sites that are more sensitive than what was assumed for the derivation of the generic guidelines must be assessed at higher tiers; at other sites of lower sensitivity it may be advantageous to proceed to the higher tiers.

This report is organized in six sections. Section 1 provides general background information on the FCSAP program and the FIGQG. Section 2 provides general background on groundwater. Section 3 describes the basis of the FIGQG. Section 4 describes how the generic numerical guidelines (Tier 1) are to be applied and their limitations. Section 5 explains how these Tier 1 guidelines can be modified for site-specific conditions to generate Tier 2 values. Section 6 provides relevant reference guidance documents that can be used to derive site-specific risk assessment guidelines (Tier 3). The FIGQG are provided in Appendix A, for the agricultural, residential/parkland, commercial and industrial land uses. Finally, Appendix B provides the equations and default model parameters that were used to derive the Tier 1 generic numerical guidelines, so that Tier 2 numbers can be derived if required.

2 BACKGROUND ON GROUNDWATER

The term “groundwater”, in its most basic sense, refers to water beneath the ground surface. For purposes of this document, groundwater refers primarily to water beneath the surface of the water table (i.e. in the saturated zone) in either unconsolidated soils (e.g., gravel or sand) or bedrock, including both shallow groundwater and deeper aquifers. Groundwater is part of the hydrologic cycle, and groundwater can be transported to surface water bodies. For

contaminated sites, the most important interaction between groundwater and surface water is direct discharge of groundwater into surface water bodies such as streams, lakes or wetlands. Groundwater may also be discharged to the surface (e.g., spring or seepage) and subsequently reach surface water bodies via surface run-off.

The transition between groundwater and surface water is not a sharp or distinct boundary; rather, there is a dynamic transition zone from groundwater to surface water. This transition zone is considered to be an important component of the surface water ecosystem (US EPA 2008). Transition zones beneath streams and rivers are referred to as hyporheic zones, while those beneath lakes and wetlands are referred to as hypolentic zones (US EPA 2008). The transition zone includes the sediment-water interface and sediment beneath and adjacent to the surface water where surface water conditions may affect groundwater and where surface water biota (particularly invertebrates, larvae and microbial communities) spend at least part of their time. The transition zone plays a major role in nutrient and energy cycling in surface water bodies (Hayashi and Rosenberry 2002), and in some cases has been shown to contribute significantly to the biodegradation of contaminants (US EPA 2008). Since groundwater typically has a more stable temperature than surface water, the transition zone can provide a thermal refuge for fish in summer or winter (Hayashi and Rosenberry 2002). The extent of the transition zone can vary over time; since groundwater and surface water often have very different chemical characteristics, the extent can often be determined from water chemistry (Hayashi and Rosenberry 2002).

Groundwater is also present beneath surface water bodies; for purposes of this document, water beneath the hyporheic zone or beneath the hypolentic zone is considered to be groundwater (i.e. the transition zone is not considered as groundwater).

Water within soil pores in the unsaturated zone is referred to herein as pore water. For purposes of this document, water bodies which support macroscopic life (e.g. fish) in subterranean caverns are not considered to be groundwater, but rather would be potential receptors.

In areas of Northern Canada with permafrost, water may also be present at least part of the year in the active layer (the soil layer that thaws during the summer and re-freezes in the fall or winter). This water is also treated as groundwater for purposes of this document. Some of the exposure pathways evaluated herein may not apply for the active layer; these pathways could be excluded on a site-specific basis. For example, the active layer is unlikely to be used as a source of potable water. Furthermore, permafrost may also thaw near surface water bodies; this thawed permafrost would also be considered as groundwater for purposes of these guidelines.

The term “aquifer” is used to describe a subsurface formation which can produce enough water when tapped by a well to be useful (e.g., as a drinking water source). Water in aquifers can move either through pores or through fractures. In rare cases, particularly in limestone, fractures may be enlarged to form larger channels or caverns. Aquifers can be unconfined, meaning the water table is present within the unit, or confined, meaning a relatively impermeable layer forms the upper boundary of the aquifer.

3 BASIS FOR THE GUIDELINES

The FIGQG have been adopted from other jurisdictions, with some modifications; however,

these guidelines have generally been developed using methods consistent with nationally approved protocols published by CCME, and in particular *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines* (CCME 2006) and the *Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale* and *User Guidance* (CCME 2008a, CCME 2008b). The *Guidelines for Canadian Drinking Water Quality* (Health Canada 2008) and the *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses* (CCME 1999) were applied for the protection of potable water.

In addition to the FIGQG, three other sets of guidelines may be relevant for groundwater at federal contaminated sites:

- The *Guidelines for Canadian Drinking Water Quality* (Health Canada 2010 and available online at http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/index-eng.php) apply for potable water sources; the most recent version of the guidelines should be consulted. While they are intended to be applied at the point of exposure (e.g., tap), it is recommended that, at federal contaminated sites, these guidelines be used when investigating groundwater that could be used as a potable water source. The determination of a particular aquifer as a potable water source is often under provincial jurisdiction. In the absence of Federal guidelines for a particular chemical, applicable provincial guidelines for the protection of potable groundwater should also be applied.

- The *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, summarized in the *Canadian Environmental Quality Guidelines* (CCME 1999 and available online at http://ceqg-rcqe.ccme.ca/) should be applied to the receiving water body, groundwater within 10 m of a surface water body, and to the groundwater-surface water transition zone (as defined in Section 2).

- The *Canadian Sediment Quality Guidelines for the Protection of Aquatic Life*, summarized in the *Canadian Environmental Quality Guidelines* (CCME 1999 and available online at http://ceqg-rcqe.ccme.ca/), should be applied for sediments in the groundwater-surface water transition zone for contaminants that are expected to be associated with sediments. If both pore water and bulk sediment samples are collected for comparison with aquatic life and sediment guidelines respectively, both guidelines should be met.

The FIGQG are based on the consideration of several potential receptors and exposure pathways, including:

- groundwater transport to surface water at least 10 m from the contamination and subsequent exposure of freshwater and marine life
- direct contact of soil organisms with contaminated groundwater
- use of groundwater for irrigation water
- use of groundwater for livestock watering
- groundwater transport to surface water at least 10 m from the contamination and subsequent ingestion by wildlife
- migration of contaminant vapours to indoor air and subsequent inhalation by humans.

The generic guidelines are point estimates of a chemical concentration in groundwater associated with an approximate no- to low- effects level based on toxicological information about the chemical, along with a screening-level evaluation of environmental fate and transport and estimated intake rates, or exposure, by potential receptors. The assumed receptor characteristics and fate models are generally the same as those used to derive *Canadian Soil Quality Guidelines* (CCME 2006). Details on the models used and model input parameters applied for guidelines are provided in Appendix B, so that Tier 2 site-specific modification of the guidelines can be performed.

For inorganic substances, the *Canadian Water Quality guidelines for the Protection of Aquatic Life* are applied directly to groundwater, due to the high level of variability in the behaviour of inorganic substances in groundwater and the lack of biodegradation of these substances. Inorganic substances could alternatively be evaluated on a site-specific basis. Additionally, for many organic substances without appropriate groundwater biodegradation rates defined by CCME or other Canadian regulatory agencies, the groundwater quality guidelines are essentially equal to the water quality guidelines for the protection of aquatic life because dispersion alone does not provide significant dilution over the default distance of 10 m. These substances can also be evaluated on a site-specific basis; it should be stressed that applied biodegradation rates should be based on site-specific data or data that conservatively reflect potentially anaerobic degradation in groundwater (not surface water or aerobic degradation rates).

4 APPLICATION OF THE TIER 1 AND TIER 2 NUMERICAL GUIDELINES

At Tier 1, the generic numerical guidelines are directly applied. It is expected that most sites would be addressed using the generic numerical guidelines. The Tier 1 numerical guidelines are presented in Tables 1 to 3 for the agricultural, residential/parkland, commercial and industrial land uses, respectively.

The Tier 2 approach allows for consideration of site-specific conditions by either modifying (within limits) the guidelines based on site-specific conditions and/or removing exposure pathways that may not be applicable to the site.
The columns in Tables 1 to 3 are as follows:

- Lowest Guideline – the lowest guideline available selected from all exposure pathways for that land use.

The existing exposure pathways are:

- Inhalation – the guideline based on indoor inhalation by humans.

- Soil Organisms: Direct Contact – the guideline for direct contact by plants and soil invertebrates, calculated from a Canadian Soil Quality Guideline for these receptors.

- Freshwater Life – the guideline for the protection of freshwater life in a surface water body at least 10 m from the contamination. For soluble organic chemicals, this value is calculated from the *Canadian Water Quality Guideline for the Protection of Aquatic Life* (freshwater) based on groundwater transport modelling; for other chemicals (e.g.,

inorganics), it is equal to the *Canadian Water Quality Guideline for the Protection of Aquatic Life* (freshwater).

- Marine Life – the guideline for the protection of marine life in a surface water body at least 10 m from the contamination. These values are calculated the same way as the freshwater life values, but using the *Canadian Water Quality Guideline for the Protection of Aquatic Life* (marine).

- Irrigation – the *Canadian Water Quality Guideline for the Protection of Agricultural Water Uses; Irrigation Water* guideline values are used directly.

- Livestock – the *Canadian Water Quality Guideline for the Protection of Agricultural Water Uses; Livestock Watering* guideline values are used directly.

- Wildlife Watering – the guideline for the protection of wildlife watering in surface water at least 10 m from the contamination.

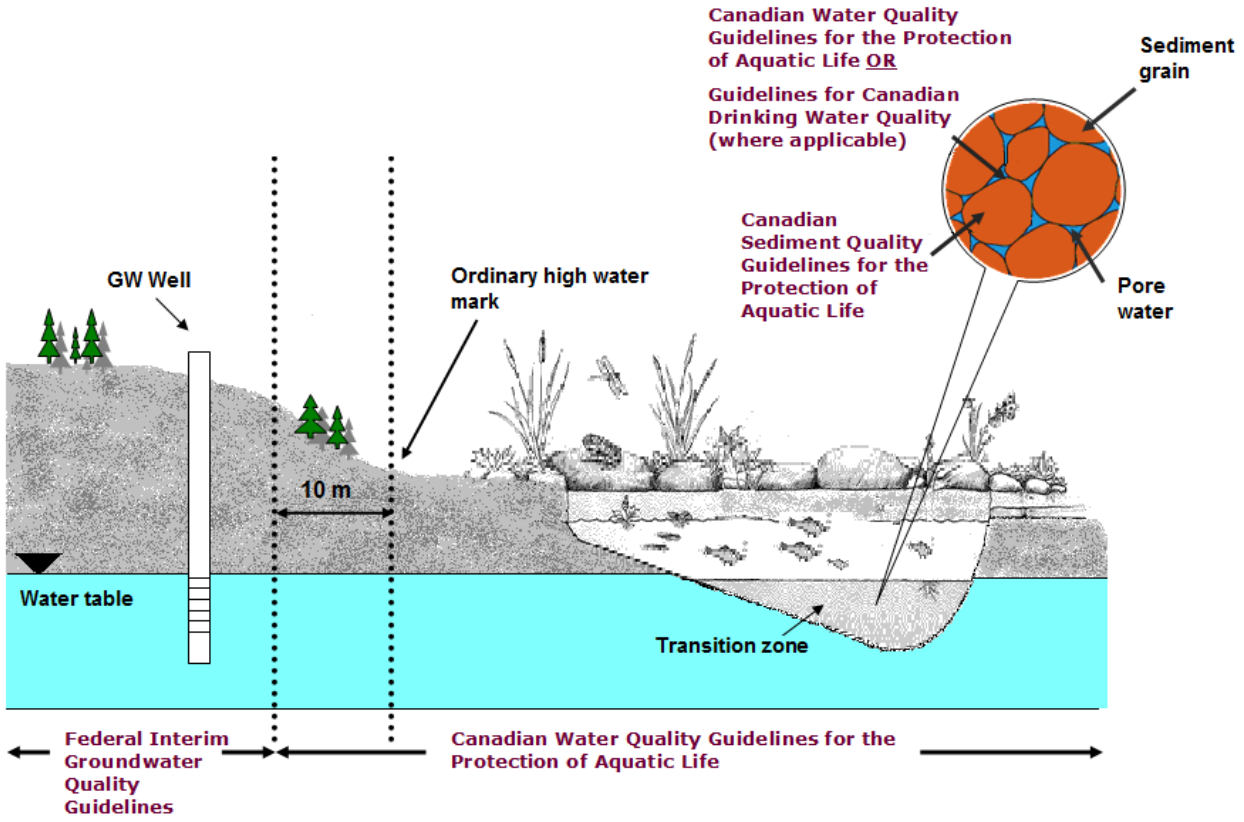
The "lowest guideline" presented in the first two column of Tables 1 to 3 were provided for convenience purposes, and represent the lowest guideline values if all the pathways presented in these tables are present at a site. However, this will often not be the case, and in particular relatively few sites will have both freshwater and marine water bodies nearby; the use of the lowest guideline may therefore result in a guideline that is overly conservative. Further discussion of the applicable pathways is provided in Section 5.2.

It is possible that multiple guidelines will apply at a single location. As a general rule, the following should be applied:

Table 1. Summary of Applicable Groundwater Quality Guidelines

	Federal Interim Groundwater Quality Guidelines	*Canadian **Water** Quality Guidelines for the Protection of Aquatic Life*	*Guidelines for Canadian Drinking Water Quality*	*Canadian **Sediment** Quality Guidelines for the Protection of Aquatic Life*	*Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses*
Groundwater as defined in Section 2 (including the active zone in permafrost areas)	√		√ (where applicable)		√ (where applicable)
Groundwater within 10 m of a water body		√	√ (where applicable)		√ (where applicable)
Groundwater-surface water transition zone		√	√ (where applicable)		√ (where applicable)
Sediment pore water in groundwater-surface water transition zone		√	√ (where applicable)		√ (where applicable)
Sediments in groundwater-surface water transition zone				√ (apply to the sediments)	

The following Figure 1 provides a visual representation of the groundwater and of where the various guidelines would apply near a surface water body.



Note: *Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses* and the *Guidelines for Canadian Drinking Water Quality* may also be applicable where appropriate

Figure 1. Illustration of groundwater cross-section near a surface water body.

4.1 Factors to Consider

In order to apply the numerical Tier 1 and Tier 2 guidelines, the following factors should be considered.

Soil Type Assessment
Groundwater quality guidelines are presented for both coarse (e.g. sand) and fine (e.g. silt or clay) soils. Consistent with *Canadian Soil Quality Guidelines*, coarse soils are defined as having a median particle diameter greater than or equal to 75 µm, while fine soils have a median particle diameter less than 75 µm (CCME 2006). The hydraulic conductivity for coarse soils is typically greater than 33 m/year, while the hydraulic conductivity for fine soils is typically less than 33 m/year.

Groundwater quality guidelines for coarse soils are generally lower than guidelines for fine soils, and therefore the coarse soil guidelines should be applied unless it can be demonstrated that site soils are fine-grained, with no coarse layers which could potentially govern contaminant migration. Even a relatively thin coarse layer in the saturated zone may govern transport towards downgradient receptors such as surface water bodies. Similarly, a layer of coarse soil beneath a building foundation may govern the transport of vapours into the building. There are a few chemicals, however, for which interim guidelines for the protection of soil organisms are lower for fine soils than coarse soils. Therefore, the lower of the guidelines for coarse and fine soils should be applied unless thorough investigation of site stratigraphy has been undertaken, supported by laboratory classification of the soil type, and it can clearly be demonstrated that the chosen soil type is appropriate.

Distance from Surface Water Bodies

As noted above, the groundwater guidelines as presented in Tables 1 to 3 can only be applied if the groundwater is taken at least 10 m away from the receiving water body. *Canadian Water Quality Guidelines for the Protection of Aquatic Life* are applied within 10 m of a surface water body and to the transition zone, particularly the part of the transition zone where aquatic and benthic organisms may reside. The 10 m lateral offset distance should be applied from the ordinary high water mark or edge of the 1 in 100 year flood zone (see Figure 1). For marine water bodies, the point of compliance should be established on a site-specific basis, taking into consideration the maximum expected high tide mark so as to ensure that there is at least a 10 m lateral separation between the contamination and potential habitat for marine aquatic or benthic organisms. Based on historical practices, it is expected that the extent of the transition zone will not be regularly determined at federal contaminated sites, although site-specific determination is recommended.

Water and Land Use Assessment

In order to apply these numerical guidelines, the appropriate land use should be determined. In many jurisdictions, current uses of groundwater as well as potential future uses must also be considered. The same land uses specified for *Canadian Soil Quality Guidelines* (agricultural, residential/parkland, commercial and industrial) are used for groundwater quality guidelines for consistency, because soil and groundwater are generally investigated together. These land uses are defined as follows (CCME 2006):

- *Agricultural*: where the primary land use is growing crops or tending livestock. This also includes agricultural lands that provide habitat for resident and transitory wildlife and native flora.

- *Residential/Parkland*: where the primary activity is residential or recreational activity; parkland is defined as a buffer between areas of residency, and also includes campground areas, but excludes wild lands such as national or provincial parks.

- *Commercial*: where the primary activity is commercial (e.g., shopping mall) and not residential or manufacturing; access to the site is generally not restricted. This does not include zones where food is grown.

- *Industrial*: where the primary activity involves the production, manufacture, or

construction of goods. Access to the site is generally restricted.

Groundwater guidelines are generally less dependent on land use than soil guidelines, because many of the groundwater uses and pathways are independent of human uses of the land. In the event that none of the defined land uses is appropriate for the site, use of the agricultural guidelines is generally conservative.

4.2 Limitations of the Use of the Numerical Guidelines

As discussed above, the numerical guidelines were developed using a specific set of assumptions and models. In some cases, the assumptions used to derive these guidelines may not be protective for particularly sensitive sites. Any of the following conditions may invalidate the assumptions used to develop the FIGQG, and therefore would invalidate the use of the numerical groundwater quality guidelines:

Contaminated groundwater within 10 m of a surface water body
For contaminated groundwater within 10 m of a surface water body, accounting for potential seasonal fluctuations in water and the transition zone, the *Canadian Water Quality Guidelines for the Protection of Aquatic Life* should be applied directly.

Groundwater flow to stagnant water bodies
If contaminated groundwater is discharging into a stagnant water body (a water body without significant outflow), persistent contaminants may be concentrated through evaporation. A site-specific risk assessment is normally required in this scenario.

Fractured bedrock or fractured silt/clay
The transport models used to develop the numerical guidelines assume that contaminant transport occurs through unconsolidated soils. If transport between the contaminant source and receptor (e.g. surface water body) is through fractures instead of unconsolidated soils, either a transport distance of zero should be assumed (i.e. the *Canadian Water Quality Guidelines for the Protection of Aquatic Life* should be applied to groundwater), or a site-specific risk assessment should be conducted.

Very coarse textured soils enhancing transport or high groundwater velocity
Very coarse (e.g. gravel) soils may result in enhanced contaminant transport compared to what was assumed in the derivation of the numerical guidelines. Other scenarios resulting in a high groundwater velocity (e.g. tidal influences close to a marine water body) may also enhance contaminant transport. If the Darcy groundwater velocity exceeds 3×10^{-7} m/s, the groundwater transport modelling conducted for the numerical guidelines may not be protective of nearby surface water bodies; in this case, a site-specific adjustment of the guidelines will likely be necessary. Similarly, if the soil vapour permeability exceeds 6×10^{-8} cm^2, the vapour transport guidelines may need to be adjusted on a site-specific basis.

Contaminated groundwater within 30 cm of a building foundation
The models used to evaluate vapour intrusion are not considered valid if the source of contamination is very close to the building; contaminated groundwater in direct contact with a building in particular is considered to be a high risk situation. In the event that contaminated groundwater is present within 30 cm of a building foundation, a site-specific risk assessment is

normally required.

Earthen Floors or Other Unusual Structural Features
The vapour intrusion model assumes a typical residential or commercial/industrial building with a concrete foundation slab. The presence of a building with an earthen floor within 10 m of groundwater contamination indicates that a site-specific risk assessment is required. Other unusual building features (e.g. unusually low air exchange rate) may need to be addressed in a site-specific risk assessment or site-specific guideline modification.

4.3 Special Considerations on the Application of the Numerical Guidelines

High Natural Background Concentration
In applying the Federal Interim Groundwater Quality Guideline, it is not expected that remediation of a contaminated site would be done to levels below natural background concentrations. However, in some cases where the naturally occurring background concentrations of contaminants are higher than the Federal Interim Groundwater Quality Guideline values, the guideline values may still need to be considered in the development of the risk management approach that would be applied to the site so as to ensure that the site does not continue to pose an unacceptable risk to human health. For example, groundwater in areas with high naturally occurring background chemical concentrations (e.g. arsenic, radon, uranium) may be restricted to non-potable water uses.

Guidelines Lower than Detection Limits
Some groundwater quality guidelines, such as guidelines for the protection of freshwater life for pesticides, may be lower than detection limits normally achieved by analytical laboratories. In most cases these guidelines have been adopted from existing CCME water quality guidelines. The CCME guideline derivation approach does not limit guidelines to concentrations above analytical detection limits; guidelines are set based on the concentrations which may pose a risk to relevant receptors.

Dissolved vs. Total Concentrations
For inorganics, the FIGQG generally apply to dissolved concentrations, and therefore filtration of groundwater samples is required. Appropriate guidance on groundwater sampling methods should be consulted for proper filtration technique. For organic chemicals, filtration is often not possible, particularly for volatile organic chemicals which may be lost to volatilization during the filtration process, and therefore unfiltered groundwater samples are normally used for organic chemicals.

Application on First Nation Lands
For contaminated sites on settlement lands, the First Nation (e.g. in Yukon Territory) may have the right to request more stringent standards/guidelines for water quality than those provided in Federal or Territorial laws.

5 CONSIDERATION OF SITE-SPECIFIC CONDITIONS (FOR TIER 2)

The development of site-specific remediation objectives through consideration of site-specific conditions for deriving Tier 2 groundwater quality guidelines, often referred to as “Tier 2

adjustment", involves the re-calculation of groundwater quality guidelines using the same model and pathways as for the generic guidelines, but adjusting certain stable, readily adjusted parameters in the models or by focusing on the receptors that are applicable to the site to reflect site-specific conditions; or the removal of exposure pathways that are not applicable at a site. These adjustments may be undertaken either for sites where the generic guidelines are not applicable, or for sites where it is believed that site-specific conditions may mitigate exposure for the governing pathway.

5.1 Guidelines Modification based on Site-Specific Conditions

The equations used for site-specific modification of guidelines are presented in Appendix B, along with default model parameters used to derive the generic guidelines. Further guidance on site-specific modification of guidelines, including site characterization requirements, whose parameters can be adjusted, and the adjustment procedures, can be found in the *Alberta Tier 2 Soil and Groundwater Remediation Guidelines* (AESRD 2010b) or Appendices C and D of the *Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: User Guidance* (CCME 2008b) and *Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada* (CCME 1996).

5.2 Pathways Elimination

To determine the groundwater quality guidelines that would be applied to a site, and thus to select the appropriate Tables 1 to 3, the current and intended federal land uses need to be identified first. Pathways that apply to the site would then be identified, considering both the current site conditions and reasonably anticipated future federal uses of the site. In addition, where potable water sources are present in a contaminated site, the *Guidelines for Canadian Drinking Water Quality* (Health Canada 2008) should be applied. The groundwater quality guidelines that apply at the site would be the lowest of the guidelines for all the applicable pathways.

It should be noted that in some circumstances it may be theoretically possible to screen out all pathways for a particular chemical. It is recommended that at least one pathway should be retained unless a site-specific risk assessment can establish an acceptable concentration, taking into consideration additional factors such as potential free-phase product formation and other hazards from the chemical, and the possibility that remaining concentrations could act as a source of further contamination. It is not the intent of these guidelines to allow for unlimited groundwater contamination in the event that all pathways for which guidelines have been calculated can be eliminated at a site.

Drinking water

The protection of drinking water is addressed separately by the *Guidelines for Canadian Drinking Water Quality* (Health Canada 2010). The drinking water guidelines are applied to groundwater that is used as a potable water source or to groundwater defined as a potential potable water source by the province or other agency with jurisdiction over drinking water issues. The protection of drinking water may also need to be considered if contaminated groundwater may impact surface water used for drinking water supply. This pathway can likely

be eliminated for groundwater in the active layer in permafrost areas.

Protection of freshwater/marine life
The protection of freshwater life can be excluded as a consideration for most contaminants if there is no potential for contaminants to reach freshwater surface bodies at concentrations exceeding the surface water quality guidelines. Similarly, marine life guidelines can be excluded if there is no potential for contaminants to reach marine bodies at concentrations above surface water quality guidelines. Potential situations where this may occur include:

- For most contaminants, including petroleum hydrocarbons and metals, if there are no surface water bodies within 500 m then the contaminants are unlikely to reach surface water. Most petroleum hydrocarbon plumes are much less than 500 m and their transport is generally limited by biodegradation. While metals do not biodegrade, the transport times required to travel 500 m are in most cases very long. The 500 m distance should not be automatically applied in very coarse (i.e. gravel) soils.
- For chlorinated solvents, a distance of 500 m will not be protective in all cases; some chlorinated solvent plumes are longer than this. If the plume can be demonstrated to be stable or decreasing (i.e. it is not spreading and concentrations are not increasing) then a distance of 500 m could still be used; if not, a distance of 2000 m may be more appropriate for excluding this pathway.
- For conservative solutes, which are defined as solutes which do not biodegrade and are not significantly retarded (e.g. certain anions such as chloride and fluoride), the plume size is limited primarily by the mass of contamination present at the site. For these contaminants, the protection of aquatic life can be excluded if there are no surface water bodies within 10 km.
- If there are surface water bodies within the above distances, the protection of aquatic life pathways can still be excluded if other lines of evidence such as Tier 2 site-specific groundwater transport modelling demonstrate that, based on the maximum concentrations present at the site and the current plume sizes, contamination would not reach nearby surface water bodies at concentrations exceeding the surface water quality guidelines.
- If site-specific data demonstrate that contaminated groundwater does not have the potential to discharge into a specific water body (i.e. there is no hydrological connection between the contaminated groundwater and the surface water body) then that water body does not need to be considered further.

Irrigation water and livestock watering guidelines
The irrigation water and livestock watering guidelines normally only apply with the agricultural land use. They could be excluded if there is no aquifer suitable for this use, and groundwater contamination is not present within the depth of typical agricultural dugouts (approximately 3-4 m).
Wildlife watering
The wildlife watering guidelines can be excluded if there are no surface water bodies within 500 m of the groundwater contamination, or 10 km for conservative solutes such as chloride. It may also be possible to eliminate this pathway if it can be demonstrated that there is no hydrological connection between the contaminated groundwater and nearby surface water bodies, particularly when addressing contamination in the active layer in permafrost areas.

Vapour intrusion
The vapour intrusion pathway can only be excluded if there are no occupied buildings present at the site and no potential for future occupied buildings within 30 m of the groundwater contamination.

6 SITE-SPECIFIC RISK ASSESSMENT (TIER 3)

The use of site-specific risk assessment to develop site-specific remediation objectives, which are often referred to as "Tier 3", is generally applied where neither Tier 1 nor Tier 2 guidelines apply, or for large and complex sites.

Site-specific risk assessment, may involve the use of different models and assumptions, and generally requires more site-specific data than application of the generic guidelines or site-specific modification of guidelines. Detailed guidance on site-specific risk assessment is beyond the scope of this document; guidance has been published by agencies such as Health Canada, CCME and several international agencies. Particularly relevant documents include:

- *A Framework for Ecological Risk Assessment: General Guidance*. (CCME 1996).
- *A Framework for Ecological Risk Assessment: Technical Appendices*. (CCME 1997).
- *Federal Contaminated Sites Risk Assessment in Canada Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment* (PQRA). (Health Canada 2010, revised 2012).
- *Federal Contaminated Sites Risk Assessment in Canada Part II: Health Canada Toxicological Reference Values* (TRVs). (Health Canada 2010).
- *Federal Contaminated Sites Risk Assessment in Canada Part V: Guidance on Human Health Detailed Quantitative Risk Assessment of Chemicals (DQRA)*. Draft. (Health Canada 2010).
- *A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. (CCME 2006).
- *Guidance on the Site-Specific Application of Water Quality Guidelines in Canada: Procedures for Deriving Numerical Water Quality Objectives*. (CCME 2003).
- *FCSAP Ecological Risk Assessment Guidance*. (Environment Canada 2010 draft).
- *FCSAP Supplemental Guidance for Ecological Risk Assessment. Module A: Toxicity Test Selection and Interpretation.* (Environment Canada 2010 draft).
- *FCSAP Supplemental Guidance for Ecological Risk Assessment. Module B*: *Selection or Development of Site-specific Toxicity Reference Values.* (Environment Canada 2010 draft).
- *FCSAP Supplemental Guidance for Ecological Risk Assessment. Module C: Standardization of Wildlife Receptor Characteristics.* (Environment Canada 2011 draft).

APPENDIX A
FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES

TABLE 1 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR AGRICULTURAL LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2											
			Water Use/Exposure Pathway											
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]		Irriga-tion[j]	Live-stock[j]	Wildlife Watering	
			Soil Type											
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
General and Inorganic Parameters														
pH	6.5-9	6.5-9	-	-	-	-	6.5-9	6.5-9	7-8.7	7-8.7	-	-	-	-
Ammonia	See note e	See note e	-	-	-	-	see note d	see note d	-	-	-	-	-	-
Chloride	100	100	-	-	-	-	120	120	-	-	100	-	-	-
Chlorine	0.002	0.002	-	-	-	-	0.002 [h,i]	0.002 [h,i]	0.003 [h,i]	0.003 [h,i]	-	-	-	-
Cyanide	0.001	0.001	-	-	-	-	0.005	0.005	0.001 [h,i]	0.001 [h,i]	-	-	-	-
Fluoride	0.12	0.12	-	-	-		0.12	0.12	1.5 [h,i]	1.5 [h,i]	1	1	-	-
Nitrate	13	13	-	-	-	-	13	13	16	16	-	-	-	-
Nitrate + Nitrite (as nitrogen)	100	100	-	-	-	-	-	-	-	-	-	100	-	-
Nitrite (as nitrogen)	0.06	0.06	-	-	-	-	0.06	0.06	-	-	-	10	-	-
Sulphate	100	100	-	-	-	-	100 [h,i]	100 [h,i]	-	-	-	1000	-	-
Sulphide (as H_2S)	0.002	0.002	-	-	-	-	0.002	0.002	0.002 [h,i]	0.002 [h,i]	-	-	-	-
Total Dissolved Solids (TDS)	3000	3000	-	-	-	-	-	-	-	-	-	3000	-	-
Metals														
Aluminium	See note e	See note e	-	-	-	-	see note d	see note d	-	-	5	5	-	-
Antimony	2.0	2.0	-	-	-	-	2.0 [f,i]	2.0 [f,i]	-	-	-	-	-	-
Arsenic	0.005	0.005	-	-	-	-	0.005	0.005	0.0125	0.0125	0.1	0.025	-	-
Barium	0.5	0.5	-	-	-	-	2.9 [f,i]	2.9 [f,i]	0.5 [h,i]	0.5 [h,i]	-	-	-	-
Beryllium	0.0053	0.0053	-	-	-	-	0.0053 [h,i]	0.0053 [h,i]	0.1 [h,i]	0.1 [h,i]	0.1	0.1	-	-
Boron	*	*	-	-	-	-	-	-	*	*	*	*	-	-
Cadmium	*	*	-	-	-	-	*	*	*	*	*	*	-	-
Chromium (Total)	See note e	See note e	-	-	-	-	0.0089	0.0089	0.056	0.056	-	0.05	-	-
Cobalt	0.05	0.05	-	-	-	-	-	-	-	-	0.05	1	-	-
Copper	See note e	See note e	-	-	-	-	see note d	see note d	0.002 [h,i]	0.002 [h,i]	0.2	0.5	-	-
Iron	0.3	0.3	-	-	-	-	0.3	0.3	-	-	5	-	-	-
Lead	See note e	See note e	-	-	-	-	see note d	see note d	0.002 [h,i]	0.002 [h,i]	0.2	0.1	-	-
Manganese	0.2	0.2	-	-	-	-	-	-	-	-	0.2	-	-	-
Mercury	See note e	See note e	-	-	-	-	0.000026	0.000026	0.000016	0.000016	-	0.003	-	-
Molybdenum	0.073	0.073	-	-	-	-	0.073	0.073	-	-	-	-	-	-
Nickel	See note e	See note e	-	-	-	-	see note d	see note d	0.083 [h,i]	0.083 [h,i]	0.2	1	-	-
Selenium	0.001	0.001	-	-	-	-	0.001	0.001	0.054 [h,i]	0.054 [h,i]	0.02	0.05	-	-
Silver	*	*	-	-	-	-	*	*	*	*	*	*	-	-
Thallium	0.0008	0.0008	-	-	-	-	0.0008	0.0008	-	-	-	-	-	-

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Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2											
			Water Use/Exposure Pathway											
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]		Irriga-tion[j]	Live-stock[j]	Wildlife Watering	
			Soil Type											
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Titanium	0.1	0.1	-	-	-	-	0.1 [h,i]	0.1 [h,i]	-	-	-	-	-	-
Uranium	0.01	0.01	-	-	-	-	0.015	0.015	-	-	0.01	0.2	-	-
Vanadium	0.1	0.1	-	-	-	-	-	-	-	-	0.1	0.1	-	-
Zinc	0.01	0.01	-	-	-	-	0.03	0.03	0.01 [h,i]	0.01 [h,i]	1	50	-	-
Hydrocarbons														
Benzene	0.088	0.088	2.8	0.14	100	61	33	0.69	9.8	0.2	-	0.088	6.8	0.14
Toluene	4.9	0.083	NGR	74	82	59	NGR	0.083	NGR	8.9	-	4.9	NGR	180
Ethylbenzene	3.2	3.2	NGR	16	42	20	NGR	41	NGR	11	-	3.2	NGR	NGR
Xylenes	13	3.9	80	3.9	21	31	NGR	18	-	-	-	13	NGR	NGR
Styrene	0.072	0.072	90	4.3	-	-	0.072	0.072	-	-	-	-	-	-
F1	6.5	0.81	19	0.81	6.5	7.1	NGR	9.8	-	-	-	53	NGR	NGR
F2	1.8	1.3	NGR	1.5	1.8	1.8	NGR	1.3	-	-	-	NGR	NGR	NGR
Acenaphthene	0.0058	0.0058	NGR	NGR	-	-	0.0058	0.0058	-	-	-	NGR	NGR	NGR
Acenaphthylene	0.046	0.046	-	-	-	-	0.046	0.046	-	-	-	-	-	-
Anthracene	0.000012	0.000012	NGR	NGR	0.025	0.025	0.000012	0.000012	-	-	-	NGR	NGR	NGR
Fluoranthene	0.00004	0.00004	NGR	NGR	0.24	0.24	0.00004	0.00004	-	-	-	NGR	NGR	NGR
Fluorene	0.003	0.003	NGR	NGR	-	-	0.003	0.003	0.012 [h,i]	0.012 [h,i]	-	NGR	NGR	NGR
Methylnaphthalenes	0.18	0.18	35 [f]	6.2 [f]	-	-	0.18 [f,i]	0.18 [f,i]	-	-	-	-	-	-
Naphthalene	0.0011	0.0011	14	0.6	-	-	0.0011	0.0011	0.0014	0.0014	-	NGR	NGR	NGR
Phenanthrene	0.0004	0.0004	-	-	-	-	0.0004	0.0004	-	-	-	NGR	NGR	NGR
Pyrene	0.000025	0.000025	NGR	NGR	-	-	0.000025	0.000025	-	-	-	NGR	NGR	NGR
Benz[a]anthracene [g]	0.000018	0.000018	-	-	-	-	0.000018	0.000018	-	-	-	NGR	NGR	NGR
Benzo[b+j]fluoranthene [g]	0.00048	0.00048	-	-	-	-	0.00048	0.00048	-	-	-	NGR	NGR	NGR
Benzo[k]fluoranthene [g]	0.00048	0.00048	-	-	-	-	0.00048	0.00048	-	-	-	NGR	NGR	NGR
Benzo[g,h,i]perylene [g]	0.00021	0.00017	-	-	-	-	0.00021	0.00017	-	-	-	-	-	-
Benzo[a]pyrene [g]	0.00001	0.00001	-	-	0.0018	0.0018	0.000017	0.000015	0.00001 [h,i]	0.00001 [h,i]	-	NGR	NGR	NGR
Chrysene [g]	0.0001	0.0001	-	-	-	-	0.0014	0.0014	0.0001 [h,i]	0.0001 [h,i]	-	NGR	NGR	NGR
Dibenz[a,h]anthracene [g]	0.00028	0.00026	-	-	-	-	0.00028	0.00026	-	-	-	NGR	NGR	NGR
Indeno[1,2,3-c,d]pyrene [g]	0.00023	0.00021	-	-	-	-	0.00023	0.00021	-	-	-	-	-	-
Halogenated Aliphatics														
Vinyl chloride	0.018	0.0011	0.018	0.0011	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethene	0.68	0.039	0.68	0.039	-	-	-	-	-	-	-	-	-	-
cis-1,2-Dichloroethene	0.017	0.0016	0.017 [f]	0.0016 [f]	-	-	14 [f,i]	14 [f,i]	-	-	-	-	-	-
trans-1,2-Dichloroethene	0.017	0.0016	0.017 [f]	0.0016 [f]	-	-	28 [f,i]	28 [f,i]	-	-	-	-	-	-
Trichloroethene (Trichloroethylene, TCE)	0.05	0.02	0.41	0.02	4.4	5	0.27	0.029	-	-	-	0.05	-	-

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			Water Use/Exposure Pathway											
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]		Irriga-tion[j]	Live-stock[j]	Wildlife Watering	
			Soil Type											
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	*	*	*	*	-	-	*	*	-	-	-	-	-	-
1,1-Dichloroethane	3.1	0.32	3.1[f]	0.32[f]	-	-	260[f,i]	260[f,i]	-	-	-	-	-	-
1,2-Dichloroethane	0.005	0.005	0.17	0.01	-	-	0.1	0.1	-	-	-	0.005	-	-
Dichloromethane (Methylene chloride)	0.05	0.05	61	3.4	-	-	0.098	0.098	-	-	-	0.05	-	-
1,1,1,2-Tetrachloroethane	0.028	0.0033	0.028[f]	0.0033[f]	-	-	2.5[f,i]	2.5[f,i]	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	0.015	0.0032	0.015[f]	0.0032[f]	-	-	3.0[f,i]	3.0[f,i]	-	-	-	-	-	-
1,1,1-Trichloroethane	1.1	0.64	6.7[f]	0.64[f]	-	-	1.1[f,i]	1.1[f,i]	-	-	-	-	-	-
1,1,2-Trichloroethane	0.03	0.0047	0.03[f]	0.0047[f]	-	-	12[f,i]	12[f,i]	-	-	-	-	-	-
Trichloromethane (Chloroform)	*	*	*	*	-	-	*	*	-	-	-	*	-	-
Tetrachloromethane (Carbon tetrachloride)	0.005	0.00056	0.011	0.00056	-	-	0.013	0.013	-	-	-	0.005	-	-
1,2-Dichloropropane	0.14	0.016	0.14[f]	0.016[f]	-	-	7.2[f,i]	7.2[f,i]	-	-	-	-	-	-
1,3-Dichloropropene	0.045	0.0052	0.045[f]	0.0052[f]	-	-	0.31[f,i]	0.31[f,i]	-	-	-	-	-	-
Bromoform	0.77	0.38	0.77[f]	0.38[f]	-	-	3.7[f,i]	3.7[f,i]	-	-	-	-	-	-
Bromomethane	0.056	0.0056	0.056[f]	0.0056[f]	-	-	0.4[f,i]	0.4[f,i]	-	-	-	-	-	-
Bromodichloromethane	8.5	8.5	-	-	-	-	8.5[f,i]	8.5[f,i]	-	-	-	-	-	-
Dibromochloromethane	0.1	0.1	26	1.1	-	-	-	-	-	-	-	0.1	-	-
Ethylene dibromide	0.00083	0.00025	8.3E-4[f]	0.00025[f]	-	-	12[f,i]	12[f,i]	-	-	-	-	-	-
Chlorinated Aromatics														
Chlorobenzene	0.0013	0.0013	0.3	0.014	-	-	0.0013	0.0013	0.025	0.025	-	-	-	-
1,2-Dichlorobenzene	0.0007	0.0007	116	5.4	-	-	0.0007	0.0007	0.042	0.042	-	-	-	-
1,3-Dichlorobenzene	0.042	0.042	-	-	-	-	0.15	0.15	0.042[h,i]	0.042[h,i]	-	-	-	-
1,4-Dichlorobenzene	0.026	0.026	4.6	0.22	-	-	0.026	0.026	-	-	-	-	-	-
1,2,3-Trichlorobenzene	0.008	0.008	0.8	0.032	-	-	0.008	0.008	-	-	-	-	-	-
1,2,4-Trichlorobenzene	0.0054	0.0054	0.71	0.028	-	-	0.024	0.024	0.0054	0.0054	-	-	-	-
1,3,5-Trichlorobenzene	0.38	0.015	0.38	0.015	-	-	-	-	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	NGR	0.14	-	-	0.0018	0.0018	-	-	-	-	-	-
1,2,3,5-Tetrachlorobenzene	0.41	0.017	0.41	0.017	-	-	-	-	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.21	0.0088	0.21	0.0088	-	-	-	-	-	-	-	-	-	-
Pentachlorobenzene	0.006	0.006	NGR	0.038	-	-	0.006	0.006	-	-	-	-	-	-

TABLE 1 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR AGRICULTURAL LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2											
			Water Use/Exposure Pathway											
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]		Irriga-tion[j]	Live-stock[j]	Wildlife Watering	
			Soil Type											
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Hexachlorobenzene	0.00052	0.00052	0.029	0.0012	-	-	-	-	-	-	-	0.00052	-	-
Phenols														
2-Chlorophenol	0.33	0.33	-	-	-	-	0.33 [f,i]	0.33 [f,i]	-	-	-	-	-	-
2,4-Dichlorophenol	0.0002	0.0002	NGR	1500	-	-	0.0002	0.0002	-	-	-	-	-	-
2,4-Dimethylphenol	3.9	3.9	-	-	-	-	3.9 [f,i]	3.9 [f,i]	-	-	-	-	-	-
2,4-Dinitrophenol	1.1	1.1	-	-	-	-	1.1 [f,i]	1.1 [f,i]	-	-	-	-	-	-
Phenol	0.002	0.002	73000	3700	110	150	0.004	0.004	-	-	-	0.002	-	-
2,4,5-Trichlorophenol	0.16	0.16	-	-	-	-	0.16 [f,i]	0.16 [f,i]	-	-	-	-	-	-
2,4,6-Trichlorophenol	0.018	0.018	NGR	54	-	-	0.018	0.018	-	-	-	-	-	-
2,3,4,6-Tetrachlorophenol	0.001	0.001	NGR	NGR	-	-	0.001	0.001	-	-	-	-	-	-
Pentachlorophenol	0.0005	0.0005	NGR	NGR	0.87	0.88	0.0005	0.0005	-	-	-	-	-	-
Pesticides														
Aldicarb	0.00015	0.00015	-	-	-	-	0.001	0.001	0.00015	0.00015	0.055	0.011	-	-
Aldrin	0.003	0.003	-	-	-	-	0.003	0.003	-	-	-	-	-	-
Atrazine and metabolites	0.0018	0.0018	-	-	-	-	0.0018	0.0018	0.01 [h,i]	0.01 [h,i]	0.01	0.005	-	-
Azniphos-methyl	0.00001	0.00001	-	-	-	-	0.00001	0.00001	-	-	-	-	-	-
Bromacil	0.005	0.005	-	-	-	-	0.005	0.005	-	-	-	-	-	-
Bromoxynil	0.00033	0.00033	-	-	-	-	0.005	0.005	-	-	0.00033	0.011	-	-
Captan	0.0013	0.0013	-	-	-	-	0.0013	0.0013	-	-	-	-	-	-
Carbaryl	0.0002	0.0002	-	-	-	-	0.0002	0.0002	0.00032	0.00032	-	1.1	-	-
Carbofuran	0.0018	0.0018	-	-	-	-	0.0018	0.0018	-	-	-	0.045	-	-
Chlordane	0.015	0.015	0.086 [f]	0.058 [f]	-	-	0.015 [f,i]	0.015 [f,i]	-	-	-	-	-	-
Chlorothalonil	0.00018	0.00018	-	-	-	-	0.00018	0.00018	0.00036	0.00036	0.0058	0.17	-	-
Chlorpyrifos	0.000002	0.000002	-	-	-	-	0.0000035	0.0000035	0.000002	0.000002	-	0.024	-	-
Cyanazine	0.0005	0.0005	-	-	-	-	0.002	0.002	-	-	0.0005	0.01	-	-
2,4-D (2,4-Dichlorophenoxyacetic acid) & other phenoxy herbicides	0.004	0.004	-	-	-	-	0.004	0.004	-	-	-	0.1	-	-
DDAC (Didecyl dimethyl ammonium chloride)	0.0015	0.0015	-	-	-	-	0.0015	0.0015	-	-	-	-	-	-
DDT (Dichloro-Diphenyl-Trichloroethane) & metabolites	0.000001	0.000001	-	-	-	-	0.000001	0.000001	-	-	-	0.1	-	-
Deltamethrin	0.0000004	0.0000004	-	-	-	-	0.0000004	0.0000004	-	-	-	-	-	-
Diazinon	0.000003	0.000003	-	-	-	-	0.000003 [h,i]	0.000003 [h,i]	-	-	-	-	-	-
Dicamba	0.000006	0.000006	-	-	-	-	0.01	0.01	-	-	0.000006	0.12	-	-

TABLE 1 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR AGRICULTURAL LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2											
			Water Use/Exposure Pathway											
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]		Irriga-tion[j]	Live-stock[j]	Wildlife Watering	
			Soil Type											
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Dichlofop-methyl	0.00018	0.00018	-	-	-	-	0.0061	0.0061	-	-	0.00018	0.009	-	-
Dieldrin	0.000056	0.000056	-	-	-	-	0.000056	0.000056	-	-	-	-	-	-
Dimethoate	0.003	0.003	-	-	-	-	0.0062	0.0062	-	-	-	0.003	-	-
Dinoseb	0.00005	0.00005	-	-	-	-	0.00005	0.00005	-	-	0.016	0.15	-	-
Endosulfan	0.00002	0.00002	-	-	-	-	0.00003	0.00003	0.00002	0.00002	-	-	-	-
Endrin	0.000036	0.000036	-	-	-	-	0.000036	0.000036	-	-	-	-	-	-
Glyphosate	*	*	-	-	-	-	*	*	-	-	-	*	-	-
Heptachlor epoxide	0.0000038	0.0000038	0.0043	0.00024	-	-	0.0000038	0.0000038	-	-	-	-	-	-
Imidacloprid	0.00023	0.00023	-	-	-	-	0.00023	0.00023	-	-	-	-	-	-
IPBC (3-iodo-2-propynyl butyl carbamate)	0.0019	0.0019	-	-	-	-	0.0019	0.0019	-	-	-	-	-	-
Lindane (γ-hexachlorocyclohexane)	0.00001	0.00001	-	-	-	-	0.00001	0.00001	-	-	-	0.004	-	-
Linuron	0.000071	0.000071	-	-	-	-	0.007	0.007	-	-	0.000071	-	-	-
Malathion	0.0001	0.0001	-	-	-	-	0.0001	0.0001	-	-	-	-	-	-
MCPA	0.000025	0.000025	-	-	-	-	0.0026	0.0026	0.0042	0.0042	0.000025	0.025	-	-
Methoprene	0.00009	0.00009	-	-	-	-	0.00009	0.00009	-	-	-	-	-	-
Methoxychlor	0.00003	0.00003	-	-	-	-	0.00003	0.00003	-	-	-	-	-	-
Metolachlor	0.0078	0.0078	-	-	-	-	0.0078	0.0078	-	-	0.028	0.05	-	-
Metribuzin	0.0005	0.0005	-	-	-	-	0.001	0.001	-	-	0.0005	0.08	-	-
Parathion	0.000013	0.000013	-	-	-	-	0.000013	0.000013	-	-	-	-	-	-
Permethrin	0.000001	0.000001	-	-	-	-	0.000004	0.000004	0.000001	0.000001	-	-	-	-
Picloram	0.029	0.029	-	-	-	-	0.029	0.029	-	-	-	0.19	-	-
Simazine	0.0005	0.0005	-	-	-	-	0.01	0.01	-	-	0.0005	0.01	-	-
Tebuthiuron	0.00027	0.00027	-	-	-	-	0.0016	0.0016	-	-	0.00027	0.13	-	-
Toxaphene	0.0000002	0.0000002	6.4	0.31	-	-	0.0000002	0.0000002	-	-	-	-	-	-
Triallate	0.00024	0.00024	-	-	-	-	0.00024	0.00024	-	-	-	0.23	-	-
Trifluarin	0.0002	0.0002	-	-	-	-	0.0002	0.0002	-	-	-	0.045	-	-
Other Organics														
Acetone	13	13	7700[f]	1800[f]	-	-	13[f,i]	13[f,i]	-	-	-	-	-	-
Acridine	0.00005	0.00005	-	-	-	-	0.00005[h,i]	0.00005[h,i]	-	-	-	-	-	-
Aniline	0.0022	0.0022	1900	87	-	-	0.0022	0.0022	-	-	-	-	-	-
Bis(2-chloroethyl)ether	30	30	2800[f]	810[f]	-	-	30[f,i]	30[f,i]	-	-	-	-	-	-
Bis(2-chloroisopropyl)ether	30	30	1600[f]	400[f]	-	-	30[f,i]	30[f,i]	-	-	-	-	-	-
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	NGR	NGR	-	-	0.016	0.016	-	-	-	-	-	-
Chloroaniline, p-	0.04	0.04	-	-	-	-	0.04[f,i]	0.04[f,i]	-	-	-	-	-	-

TABLE 1 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR AGRICULTURAL LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2											
			Water Use/Exposure Pathway											
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]		Irriga-tion[j]	Live-stock[j]	Wildlife Watering	
			Soil Type											
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**All**	**All**	**Fine**	**Coarse**
Dibutyl phthalate	0.019	0.019	NGR	NGR	-	-	0.019	0.019	-	-	-	-	-	-
di-n-Butyltin	0.00008	0.00008	-	-	-	-	0.00008 [h,i]	0.00008 [h,i]	-	-	-	-	-	-
Diethylphthalate	0.0038	0.0038	-	-	-	-	0.0038 [f,i]	0.0038 [f,i]	-	-	-	-	-	-
Diisopropanolamine	1.6	1.6	-	-	160	160	1.6	1.6	-	-	2	-	-	-
2,4-Dinitrotoluene	0.29	0.29	-	-	-	-	0.29 [f,i]	0.29 [f,i]	-	-	-	-	-	-
Ethylene glycol	190	190	NGR	NGR	9200	16000	190	190	-	-	-	-	-	-
Hexachlorobutadiene	0.0013	0.0013	0.031	0.0013	-	-	0.0013	0.0013	-	-	-	-	-	-
Methyl methacrylate	17	0.84	17	0.84	-	-	-	-	-	-	-	-	-	-
Methyl ethyl ketone	150	150	1700 [f]	470 [f]	-	-	150 [f,i]	150 [f,i]	-	-	-	-	-	-
Methyl isobutyl ketone	58	58	600 [f]	140 [f]	-	-	58 [f,i]	58 [f,i]	-	-	-	-	-	-
Methyl mercury	0.000015	0.000015	-	-	-	-	0.000015 [f,i]	0.000015 [f,i]	-	-	-	-	-	-
MTBE (Methyl tert-butyl ether)	5	0.34	6.1	0.34	-	-	10	10	5	5	-	-	-	-
Monochloramine	0.0005	0.0005					0.0005 [h,i]	0.0005 [h,i]						
Nonylphenol + ethoxylates	0.0007	0.0007	-	-	0.0081	0.0081	0.001	0.001	0.0007	0.0007	-	-	-	-
Propylene glycol	500	500	-	-	-	-	500	500	-	-	-	-	-	-
Quinoline	0.0034	0.0034	-	-	-	-	0.0034 [h,i]	0.0034 [h,i]	-	-	-	-	-	-
Sulfolane	0.5	0.5	-	-	1700	2800	50	50	-	-	0.5	-	-	-
Tributyltin	0.000001	0.000001	-	-	-	-	0.000008	0.000008	0.000001	0.000001	-	0.25	-	-
Triethyltin	0.0004	0.0004	-	-	-	-	0.0004 [h,i]	0.0004 [h,i]	-	-	-	-	-	-
Triphenyltin	0.000022	0.000022	-	-	-	-	0.000022	0.000022	-	-	-	0.8	-	-

a – all values adopted from Alberta Environment (AESRD) (2010a) unless otherwise specified
b – where AESRD (2010a) guideline was not based on the *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Aquatic Life* for freshwater environments (CCME 1999), and a CWQG exists, the groundwater quality guideline was re-calculated based on the CWQG
c – based on *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Aquatic Life* for the marine environments(CCME 1999) and groundwater transport model
d – the freshwater aquatic life guidelines vary depending on water pH, hardness etc. Therefore, see *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (CCME 1999) to determine the appropriate water quality guideline applicable to the site and calculate the groundwater guidelines using formulas provided in Appendix B
e – guideline is the lowest of all applicable pathways
f – adopted from Ontario Ministry of the Environment (OMOE) (2010)
g – for ecological receptors only
h – adopted from BC Contaminated Sites Regulation
i - 10x factor for dilution in surface water was removed from guideline value
j – adopted directly from CCME (1999)
* - Refer to Federal Interim Groundwater Quality Guidelines Memo (2016)
NGR – no guideline required; calculated guideline exceeds solubility limit

TABLE 2 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR RESIDENTIAL/PARKLAND LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
General and Inorganic Parameters										
pH	6.5-9	6.5-9	-	-	-	-	6.5-9	6.5-9	7-8.7	7-8.7
Ammonia	See note e	See note e	-	-	-	-	see note d	see note d	-	-
Chloride	120	120	-	-	-	-	120	120	-	-
Chlorine	0.002	0.002	-	-	-	-	0.002 [h,i]	0.002 [h,i]	0.003 [h,i]	0.003 [h,i]
Cyanide	0.001	0.001	-	-	-	-	0.005	0.005	0.001 [h,i]	0.001 [h,i]
Fluoride	0.12	0.12	-	-	-	-	0.12	0.12	1.5 [h,i]	1.5 [h,i]
Nitrate	13	13	-	-	-	-	13	13	16	16
Nitrite (as nitrogen)	0.06	0.06	-	-	-	-	0.06	0.06	-	-
Sulphate	100	100	-	-	-	-	100 [h,i]	100 [h,i]	-	-
Sulphide (as H_2S)	0.002	0.002	-	-	-	-	0.002	0.002	0.002 [h,i]	0.002 [h,i]
Metals										
Aluminium	See note e	See note e	-	-	-	-	see note d	see note d	-	-
Antimony	2.0	2.0	-	-	-	-	2.0 [f,i]	2.0 [f,i]	-	-
Arsenic	0.005	0.005	-	-	-	-	0.005	0.005	0.0125	0.0125
Barium	0.5	0.5	-	-	-	-	2.9 [f,i]	2.9 [f,i]	0.5 [h,i]	0.5 [h,i]
Beryllium	0.0053	0.0053	-	-	-	-	0.0053 [h,i]	0.0053 [h,i]	0.1 [h,i]	0.1 [h,i]
Boron	*	*	-	-	-	-	-	-	*	*
Cadmium	*	*	-	-	-	-	*	*	*	*
Chromium (Total)	0.0089	0.0089	-	-	-	-	0.0089	0.0089	0.056	0.056
Copper	See note e	See note e	-	-	-	-	see note d	see note d	0.002 [h,i]	0.002 [h,i]
Iron	0.3	0.3	-	-	-	-	0.3	0.3	-	-
Lead	See note e	See note e	-	-	-	-	see note d	see note d	0.002 [h,i]	0.002 [h,i]
Mercury	See note e	See note e	-	-	-	-	0.000026	0.000026	0.000016	0.000016
Molybdenum	0.073	0.073	-	-	-	-	0.073	0.073	-	-
Nickel	See note e	See note e	-	-	-	-	see note d	see note d	0.083 [h,i]	0.083 [h,i]
Selenium	0.001	0.001	-	-	-	-	0.001	0.001	0.054 [h,i]	0.054 [h,i]
Silver	*	*	-	-	-	-	*	*	*	*
Thallium	0.0008	0.0008	-	-	-	-	0.0008	0.0008	-	-
Titanium	0.1	0.1					0.1 [h,i]	0.1 [h,i]		
Uranium	0.015	0.015	-	-	-	-	0.015	0.015	-	-
Zinc	0.01	0.01	-	-	-	-	0.03	0.03	0.01 [h,i]	0.01 [h,i]
Hydrocarbons										
Benzene	2.8	0.14	2.8	0.14	100	61	33	0.69	9.8	0.2
Toluene	82	0.083	NGR	74	82	59	NGR	0.083	NGR	8.9

TABLE 2 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR RESIDENTIAL/PARKLAND LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Ethylbenzene	42	11	NGR	16	42	20	NGR	41	NGR	11
Xylenes	21	3.9	80	3.9	21	31	NGR	18	-	-
Styrene	0.072	0.072	90	4.3	-	-	0.072	0.072	-	-
F1	6.5	0.81	19	0.81	6.5	7.1	NGR	9.8	-	-
F2	1.8	1.3	NGR	1.5	1.8	1.8	NGR	1.3	-	-
Acenaphthene	0.0058	0.0058	NGR	NGR	-	-	0.0058	0.0058	-	-
Acenaphthylene	0.046	0.046	-	-	-	-	0.046	0.046	-	-
Anthracene	0.000012	0.000012	NGR	NGR	0.025	0.025	0.000012	0.000012	-	-
Fluoranthene	0.00004	0.00004	NGR	NGR	0.24	0.24	0.00004	0.00004	-	-
Fluorene	0.003	0.003	NGR	NGR	-	-	0.003	0.003	0.012[h,i]	0.012[h,i]
Methylnaphthalenes	0.18	0.18	35[f]	6.2[f]	-	-	0.18[f,i]	0.18[f,i]	-	-
Naphthalene	0.0011	0.0011	14	0.6	-	-	0.0011	0.0011	0.0014	0.0014
Phenanthrene	0.0004	0.0004	-	-	-	-	0.0004	0.0004	-	-
Pyrene	0.000025	0.000025	NGR	NGR	-	-	0.000025	0.000025	-	-
Benz[a]anthracene[g]	0.000018	0.000018	-	-	-	-	0.000018	0.000018	-	-
Benzo[b+j]fluoranthene[g]	0.00048	0.00048	-	-	-	-	0.00048	0.00048	-	-
Benzo[k]fluoranthene[g]	0.00048	0.00048	-	-	-	-	0.00048	0.00048	-	-
Benzo[g,h,i]perylene[g]	0.00021	0.00017	-	-	-	-	0.00021	0.00017	-	-
Benzo[a]pyrene[g]	0.00001	0.00001	-	-	0.0018	0.0018	0.000017	0.000015	0.00001[h,i]	0.00001[h,i]
Chrysene[g]	0.0001	0.0001	-	-	-	-	0.0014	0.0014	0.0001[h,i]	0.0001[h,i]
Dibenz[a,h]anthracene[g]	0.00028	0.00026	-	-	-	-	0.00028	0.00026	-	-
Indeno[1,2,3-c,d]pyrene[g]	0.00023	0.00021	-	-	-	-	0.00023	0.00021	-	-
Halogenated Aliphatics										
Vinyl chloride	0.018	0.0011	0.018	0.0011	-	-	-	-	-	-
1,1-Dichloroethene	0.68	0.039	0.68	0.039	-	-	-	-	-	-
cis-1,2-Dichloroethene	0.017	0.0016	0.017[f]	0.0016[f]	-	-	18[f,i]	18[f,i]	-	-
trans-1,2-Dichloroethene	0.017	0.0016	0.017[f]	0.0016[f]	-	-	28[f,i]	28[f,i]	-	-
Trichloroethene (Trichloroethylene, TCE)	0.27	0.02	0.41	0.02	4.4	5	0.27	0.029	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	*	*	*	*	-	-	*	*	-	-
1,1-Dichloroethane	3.1	0.32	3.1[f]	0.32[f]	-	-	260[f,i]	260[f,i]	-	-
1,2-Dichloroethane	0.1	0.01	0.17	0.01	-	-	0.1	0.1	-	-
Dichloromethane (Methylene chloride)	0.098	0.098	61	3.4	-	-	0.098	0.098	-	-
1,1,1,2-Tetrachloroethane	0.028	0.0034	0.028[f]	0.0034[f]	-	-	2.5[f,i]	2.5[f,i]	-	-
1,1,2,2-Tetrachloroethane	0.015	0.0032	0.015[f]	0.0032[f]	-	-	3.0[f,i]	3.0[f,i]	-	-

TABLE 2 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR RESIDENTIAL/PARKLAND LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
1,1,1-Trichloroethane	1.1	0.64	6.7[f]	0.64[f]	-	-	1.1[f,i]	1.1[f,i]	-	-
1,1,2-Trichloroethane	0.03	0.0047	0.03[f]	0.0047[f]	-	-	12[f,i]	12[f,i]	-	-
Trichloromethane (Chloroform)	*	*	*	*	-	-	*	*	-	-
Tetrachloromethane (Carbon tetrachloride)	0.011	0.00056	0.011	0.00056	-	-	0.013	0.013	-	-
1,2-Dichloropropane	0.14	0.016	0.14[f]	0.016[f]	-	-	7.2[f,i]	7.2[f,i]	-	-
1,3-Dichloropropene	0.045	0.0052	0.045[f]	0.0052[f]	-	-	0.31[f,i]	0.31[f,i]	-	-
Bromoform	0.77	0.38	0.77[f]	0.38[f]	-	-	3.7[f,i]	3.7[f,i]	-	-
Bromomethane	0.056	0.0056	0.056[f]	0.0056[f]	-	-	0.4[f,i]	0.4[f,i]	-	-
Bromodichloromethane	8.5	8.5	-	-	-	-	8.5[f,i]	8.5[f,i]	-	-
Dibromochloromethane	26	1.1	26	1.1	-	-	-	-	-	-
Ethylene dibromide	0.00083	0.00025	8.3E-4[f]	0.00025[f]	-	-	12[f,i]	12[f,i]	-	-
Chlorinated Aromatics										
Chlorobenzene	0.0013	0.0013	0.3	0.014	-	-	0.0013	0.0013	0.025	0.025
1,2-Dichlorobenzene	0.0007	0.0007	116	5.4	-	-	0.0007	0.0007	0.042	0.042
1,3-Dichlorobenzene	0.042	0.042	-	-	-	-	0.15	0.15	0.042[h,i]	0.042[h,i]
1,4-Dichlorobenzene	0.026	0.026	4.6	0.22	-	-	0.026	0.026	-	-
1,2,3-Trichlorobenzene	0.008	0.008	0.8	0.032	-	-	0.008	0.008	-	-
1,2,4-Trichlorobenzene	0.0054	0.0054	0.71	0.028	-	-	0.024	0.024	0.0054	0.0054
1,3,5-Trichlorobenzene	0.38	0.015	0.38	0.015	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	NGR	0.14	-	-	0.0018	0.0018	-	-
1,2,3,5-Tetrachlorobenzene	0.41	0.017	0.41	0.017	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	0.21	0.0088	0.21	0.0088	-	-	-	-	-	-
Pentachlorobenzene	0.006	0.006	NGR	0.038	-	-	0.006	0.006	-	-
Hexachlorobenzene	0.029	0.0012	0.029	0.0012	-	-	-	-	-	-
Phenols										
2-Chlorophenol	0.33	0.33	-	-	-	-	0.33[f,i]	0.33[f,i]	-	-
2,4-Dichlorophenol	0.0002	0.0002	NGR	1500	-	-	0.0002	0.0002	-	-
2,4-Dimethylphenol	3.9	3.9	-	-	-	-	3.9[f,i]	3.9[f,i]	-	-
2,4-Dinitrophenol	1.1	1.1	-	-	-	-	1.1[f,i]	1.1[f,i]	-	-
Phenol	0.004	0.004	73000	3700	110	150	0.004	0.004	-	-
2,4,5-Trichlorophenol	0.16	0.16	-	-	-	-	0.16[f,i]	0.16[f,i]	-	-
2,4,6-Trichlorophenol	0.018	0.018	NGR	54	-	-	0.018	0.018	-	-
2,3,4,6-Tetrachlorophenol	0.001	0.001	NGR	NGR	-	-	0.001	0.001	-	-

TABLE 2 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR RESIDENTIAL/PARKLAND LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Pentachlorophenol	0.0005	0.0005	NGR	NGR	0.87	0.88	0.0005	0.0005	-	-
Pesticides										
Aldicarb	0.00015	0.00015	-	-	-	-	0.001	0.001	0.00015	0.00015
Aldrin	0.003	0.003	-	-	-	-	0.003	0.003	-	-
Atrazine and metabolites	0.0018	0.0018	-	-	-	-	0.0018	0.0018	0.01 [h,i]	0.01 [h,i]
Azniphos-methyl	0.00001	0.00001	-	-	-	-	0.00001	0.00001	-	-
Bromacil	0.005	0.005	-	-	-	-	0.005	0.005	-	-
Bromoxynil	0.005	0.005	-	-	-	-	0.005	0.005	-	-
Captan	0.0013	0.0013	-	-	-	-	0.0013	0.0013	-	-
Carbaryl	0.0002	0.0002	-	-	-	-	0.0002	0.0002	0.00032	0.00032
Carbofuran	0.0018	0.0018	-	-	-	-	0.0018	0.0018	-	-
Chlordane	0.015	0.015	0.086 [f]	0.058 [f]	-	-	0.015 [f,i]	0.015 [f,i]	-	-
Chlorothalonil	0.00018	0.00018	-	-	-	-	0.00018	0.00018	0.00036	0.00036
Chlorpyrifos	0.000002	0.000002	-	-	-	-	0.0000035	0.0000035	0.000002	0.000002
Cyanazine	0.002	0.002	-	-	-	-	0.002	0.002	-	-
2,4-D (2,4-Dichlorophenoxyacetic acid) & other phenoxy herbicides	0.004	0.004	-	-	-	-	0.004	0.004	-	-
DDAC (Didecyl dimethyl ammonium chloride)	0.0015	0.0015	-	-	-	-	0.0015	0.0015	-	-
DDT (Dichloro-Diphenyl-Trichloroethane) & metabolites	0.000001	0.000001	-	-	-	-	0.000001	0.000001	-	-
Deltamethrin	0.0000004	0.0000004	-	-	-	-	0.0000004	0.0000004	-	-
Diazinon	0.000003	0.000003					0.000003 [h,i]	0.000003 [h,i]		
Dicamba	0.01	0.01	-	-	-	-	0.01	0.01	-	-
Dichlofop-methyl	0.0061	0.0061	-	-	-	-	0.0061	0.0061	-	-
Dieldrin	0.000056	0.000056	-	-	-	-	0.000056	0.000056	-	-
Dimethoate	0.0062	0.0062	-	-	-	-	0.0062	0.0062	-	-
Dinoseb	0.00005	0.00005	-	-	-	-	0.00005	0.00005	-	-
Endosulfan	0.00002	0.00002	-	-	-	-	0.00003	0.00003	0.00002	0.00002
Endrin	0.000036	0.000036	-	-	-	-	0.000036	0.000036	-	-
Glyphosate	*	*	-	-	-	-	*	*	-	-
Heptachlor epoxide	0.0000038	0.0000038	0.0043	0.00024	-	-	0.0000038	0.0000038	-	-
Imidacloprid	0.00023	0.00023	-	-	-	-	0.00023	0.00023	-	-
IPBC (3-iodo-2-propynyl butyl carbamate)	0.0019	0.0019	-	-	-	-	0.0019	0.0019	-	-

TABLE 2 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR RESIDENTIAL/PARKLAND LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Lindane (γ-hexachlorocyclohexane)	0.00001	0.00001	-	-	-	-	0.00001	0.00001	-	-
Linuron	0.007	0.007	-	-	-	-	0.007	0.007	-	-
Malathion	0.0001	0.0001	-	-	-	-	0.0001	0.0001	-	-
MCPA	0.0026	0.0026	-	-	-	-	0.0026	0.0026	0.0042	0.0042
Methoprene	0.00009	0.00009	-	-	-	-	0.00009	0.00009	-	-
Methoxychlor	0.00003	0.00003	-	-	-	-	0.00003	0.00003	-	-
Metolachlor	0.0078	0.0078	-	-	-	-	0.0078	0.0078	-	-
Metribuzin	0.001	0.001	-	-	-	-	0.001	0.001	-	-
Parathion	0.000013	0.000013	-	-	-	-	0.000013	0.000013	-	-
Permethrin	0.000001	0.000001	-	-	-	-	0.000004	0.000004	0.000001	0.000001
Picloram	0.029	0.029	-	-	-	-	0.029	0.029	-	-
Simazine	0.01	0.01	-	-	-	-	0.01	0.01	-	-
Tebuthiuron	0.0016	0.0016	-	-	-	-	0.0016	0.0016	-	-
Toxaphene	0.0000002	0.0000002	6.4	0.31	-	-	0.0000002	0.0000002	-	-
Triallate	0.00024	0.00024	-	-	-	-	0.00024	0.00024	-	-
Trifluarin	0.0002	0.0002	-	-	-	-	0.0002	0.0002	-	-
Other Organics										
Acetone	13	13	7700[f]	1800[f]	-	-	13[f,i]	13[f,i]	-	-
Acridine	0.00005	0.00005	-	-	-	-	0.00005[h,i]	0.00005[h,i]	-	-
Aniline	0.0022	0.0022	1,900	87	-	-	0.0022	0.0022	-	-
Bis(2-chloroethyl)ether	30	30	2800[f]	810[f]	-	-	30[f,i]	30[f,i]	-	-
Bis(2-chloroisopropyl)ether	30	30	1600[f]	400[f]	-	-	30[f,i]	30[f,i]	-	-
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	NGR	NGR	-	-	0.016	0.016	-	-
Chloroaniline, p-	0.04	0.04	-	-	-	-	0.04[f,i]	0.04[f,i]	-	-
Dibutyl phthalate	0.019	0.019	NGR	NGR	-	-	0.019	0.019	-	-
di-n-Butyltin	0.00008	0.00008	-	-	-	-	0.00008[h,i]	0.00008[h,i]	-	-
Diethylphthalate	0.0038	0.0038	-	-	-	-	0.0038[f,i]	0.0038[f,i]	-	-
Diisopropanolamine	1.6	1.6	-	-	160	160	1.6	1.6	-	-
2,4-Dinitrotoluene	0.29	0.29	-	-	-	-	0.29[f,i]	0.29[f,i]	-	-
Ethylene glycol	190	190	NGR	NGR	9200	16000	190	190	-	-
Hexachlorobutadiene	0.0013	0.0013	0.031	0.0013	-	-	0.0013	0.0013	-	-
Methyl methacrylate	17	0.84	17	0.84	-	-	-	-	-	-
Methyl ethyl ketone	150	150	1700[f]	470[f]	-	-	150[f,i]	150[f,i]	-	-
Methyl isobutyl ketone	58	58	600[f]	140[f]	-	-	58[f,i]	58[f,i]	-	-
Methyl mercury	0.000015	0.000015	-	-	-	-	0.000015[f,i]	0.000015[f,i]	-	-
MTBE (Methyl tert-butyl ether)	5	0.34	6.1	0.34	-	-	10	10	5	5

Please refer to NOTICE

TABLE 2 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR RESIDENTIAL/PARKLAND LAND USE[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Monochloramine	0.0005	0.0005	-	-	-	-	0.0005 [h,i]	0.0005 [h,i]	-	-
Nonylphenol + ethoxylates	0.0007	0.0007	-	-	0.0081	0.0081	0.001	0.001	0.0007	0.0007
Propylene glycol	500	500	-	-	-	-	500	500	-	-
Quinoline	0.0034	0.0034	-	-	-	-	0.0034 [h,i]	0.0034 [h,i]	-	-
Sulfolane	50	50	-	-	1700	2800	50	50	-	-
Tributyltin	0.000001	0.000001	-	-	-	-	0.000008	0.000008	0.000001	0.000001
Triethyltin	0.0004	0.0004	-	-	-	-	0.0004 [h,i]	0.0004 [h,i]	-	-
Triphenyltin	0.000022	0.000022	-	-	-	-	0.000022	0.000022	-	-

a – all values adopted from Alberta Environment (AESRD) (2010a) unless otherwise specified
b – where AESRD (2010a) guideline was not based on the *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Aquatic Life* for freshwater environments (CCME 1999), and a CWQG exists, the groundwater quality guideline was re-calculated based on the CWQG
c – based on *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Aquatic Life* for the marine environments(CCME 1999) and groundwater transport model
d – the freshwater aquatic life guidelines vary depending on water pH, hardness etc. Therefore, see *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (CCME 1999) to determine the appropriate water quality guideline applicable to the site and calculate the groundwater guidelines using formulas provided in Appendix B
e – guideline is the lowest of all applicable pathways
f – adopted from Ontario Ministry of the Environment (OMOE) (2009)
g – for ecological receptors only
h – adopted from BC Contaminated Sites Regulation
i - 10x factor for dilution in surface water was removed from guideline value
j – adopted directly from CCME (1999)
* - Refer to Federal Interim Groundwater Quality Guidelines Memo (2016)
NGR – no guideline required; calculated guideline exceeds solubility limit

TABLE 3 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR COMMERCIAL AND INDUSTRIAL LAND USES[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
General and Inorganic Parameters										
pH	6.5-9	6.5-9	-	-	-	-	6.5-9	6.5-9	7-8.7	7-8.7
Ammonia	See note e	See note e	-	-	-	-	see note d	see note d	-	-
Chloride	120	120	-	-	-	-	120	120	-	-
Chlorine	0.002	0.002	-	-	-	-	0.002 [h,i]	0.002 [h,i]	0.003 [h,i]	0.003 [h,i]
Cyanide	0.001	0.001	-	-	-	-	0.005	0.005	0.001 [h,i]	0.001 [h,i]
Fluoride	0.12	0.12	-	-	-	-	0.12	0.12	1.5 [h,i]	1.5 [h,i]
Nitrate	13	13	-	-	-	-	13	13	16	16
Nitrite (as nitrogen)	0.06	0.06	-	-	-	-	0.06	0.06	-	-
Sulphate	100	100	-	-	-	-	100 [h,i]	100 [h,i]	-	-
Sulphide (as H_2S)	0.002	0.002	-	-	-	-	0.002	0.002	0.002 [h,i]	0.002 [h,i]
Metals										
Aluminium	See note e	See note e	-	-	-	-	see note d	see note d	-	-
Antimony	2.0	2.0	-	-	-	-	2.0 [f,i]	2.0 [f,i]	-	-
Arsenic	0.005	0.005	-	-	-	-	0.005	0.005	0.0125	0.0125
Barium	0.5	0.5	-	-	-	-	2.9 [f,i]	2.9 [f,i]	0.5 [h,i]	0.5 [h,i]
Beryllium	0.0053	0.0053	-	-	-	-	0.0053 [h,i]	0.0053 [h,i]	0.1 [h,i]	0.1 [h,i]
Boron	*	*	-	-	-	-	-	-	*	*
Cadmium	*	*	-	-	-	-	*	*	*	*
Chromium (Total)	0.0089	0.0089	-	-	-	-	0.0089	0.0089	0.056	0.056
Copper	See note e	See note e	-	-	-	-	see note d	see note d	0.002 [h,i]	0.002 [h,i]
Iron	0.3	0.3	-	-	-	-	0.3	0.3	-	-
Lead	See note e	See note e	-	-	-	-	see note d	see note d	0.002 [h,i]	0.002 [h,i]
Mercury	See note e	See note e	-	-	-	-	0.000026	0.000026	0.000016	0.000016
Molybdenum	0.073	0.073	-	-	-	-	0.073	0.073	-	-
Nickel	See note e	See note e	-	-	-	-	see note d	see note d	0.083 [h,i]	0.083 [h,i]
Selenium	0.001	0.001	-	-	-	-	0.001	0.001	0.054 [h,i]	0.054 [h,i]
Silver	*	*	-	-	-	-	*	*	*	*
Thallium	0.0008	0.0008	-	-	-	-	0.0008	0.0008	-	-
Titanium	0.1	0.1	-	-	-	-	0.1 [h,i]	0.1 [h,i]	-	-
Uranium	0.015	0.015	-	-	-	-	0.015	0.015	-	-
Zinc	0.01	0.01	-	-	-	-	0.03	0.03	0.01 [h,i]	0.01 [h,i]
Hydrocarbons										
Benzene	19	0.69	19	1.8	540	350	33	0.69	9.8	0.2
Toluene	240	0.083	NGR	NGR	240	200	NGR	0.083	NGR	8.9

TABLE 3 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR COMMERCIAL AND INDUSTRIAL LAND USES[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Ethylbenzene	150	11	NGR	NGR	150	110	NGR	41	NGR	11
Xylenes	74	18	NGR	48	74	120	NGR	18	-	-
Styrene	0.072	0.072	NGR	51	-	-	0.072	0.072	-	-
F1	9.9	9.1	NGR	9.1	9.9	11	NGR	9.8	-	-
F2	3.1	1.3	NGR	17	3.1	3.1	NGR	1.3	-	-
Acenaphthene	0.0058	0.0058	NGR	NGR	-	-	0.0058	0.0058	-	-
Acenaphthylene	0.046	0.046	-	-	-	-	0.046	0.046	-	-
Anthracene	0.000012	0.000012	NGR	NGR	0.32	0.32	0.000012	0.000012	-	-
Fluoranthene	0.00004	0.00004	NGR	NGR	0.86	0.86	0.00004	0.00004	-	-
Fluorene	0.003	0.003	NGR	NGR	-	-	0.003	0.003	-	-
Methylnaphthalenes	0.18	0.18	150[f]	38[f]	-	-	0.18[f,i]	0.18[f,i]	-	-
Naphthalene	0.0011	0.0011	NGR	7	-	-	0.0011	0.0011	0.0014	0.0014
Phenanthrene	0.0004	0.0004	-	-	-	-	0.0004	0.0004	-	-
Pyrene	0.000025	0.000025	NGR	NGR	-	-	0.000025	0.000025	-	-
Benz[a]anthracene [g]	0.000018	0.000018	-	-	-	-	0.000018	0.000018	-	-
Benzo[b+j]fluoranthene [g]	0.00048	0.00048	-	-	-	-	0.00048	0.00048	-	-
Benzo[k]fluoranthene [g]	0.00048	0.00048	-	-	-	-	0.00048	0.00048	-	-
Benzo[g,h,i]perylene [g]	0.00021	0.00017	-	-	-	-	0.00021	0.00017	-	-
Benzo[a]pyrene [g]	0.000017	0.000015	-	-	0.0066	0.0066	0.000017	0.000015	-	-
Chrysene [g]	0.0014	0.0014	-	-	-	-	0.0014	0.0014	-	-
Dibenz[a,h]anthracene [g]	0.00028	0.00026	-	-	-	-	0.00028	0.00026	-	-
Indeno[1,2,3-c,d]pyrene [g]	0.00023	0.00021	-	-	-	-	0.00023	0.00021	-	-
Halogenated Aliphatics										
Vinyl chloride	0.12	0.013	0.12	0.013	-	-	-	-	-	-
1,1-Dichloroethene	4.5	0.49	4.5	0.49	-	-	-	-	-	-
cis-1,2-Dichloroethene	0.23	0.03	0.23[f]	0.03[f]	-	-	18[f,i]	18[f,i]	-	-
trans-1,2-Dichloroethene	0.23	0.03	0.23[f]	0.03[f]	-	-	28[f,i]	28[f,i]	-	-
Trichloroethene (Trichloroethylene, TCE)	0.27	0.029	2.8	0.25	73	83	0.27	0.029	-	-
Tetrachloroethene (Tetrachloroethylene, Perchloroethylene, PCE)	*	*	*	*	-	-	*	*	-	-
1,1-Dichloroethane	44	6.6	44[f]	6.6[f]	-	-	260[f,i]	260[f,i]		
1,2-Dichloroethane	0.1	0.1	1.2	0.13	-	-	0.1	0.1	-	-
Dichloromethane (Methylene chloride)	0.098	0.098	410	43	-	-	0.098	0.098	-	-

TABLE 3 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR COMMERCIAL AND INDUSTRIAL LAND USES[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
1,1,1,2-Tetrachloroethane	0.38	0.066	0.38[f]	0.066[f]	-	-	2.5[f,i]	2.5[f,i]	-	-
1,1,2,2-Tetrachloroethane	0.21	0.063	0.21[f]	0.063[f]	-	-	3.0[f,i]	3.0[f,i]	-	-
1,1,1-Trichloroethane	1.1	1.1	95[f]	13[f]	-	-	1.1[f,i]	1.1[f,i]	-	-
1,1,2-Trichloroethane	0.41	0.091	0.41[f]	0.091[f]	-	-	12[f,i]	12[f,i]	-	-
Trichloromethane (Chloroform)	*	*	*	*	-	-	*	*	-	-
Tetrachloromethane (Carbon tetrachloride)	0.013	0.0068	0.078	0.0068	-	-	0.013	0.013	-	-
1,2-Dichloropropane	2	0.33	2[f]	0.33[f]	-	-	7.2[f,i]	7.2[f,i]	-	-
1,3-Dichloropropene	0.31	0.1	0.61[f]	0.1[f]	-	-	0.31[f,i]	0.31[f,i]	-	-
Bromoform	3.7	3.7	13[f]	8.4[f]	-	-	3.7[f,i]	3.7[f,i]	-	-
Bromomethane	0.23	0.033	0.23[f]	0.033[f]	-	-	0.4[f,i]	0.4[f,i]	-	-
Bromodichloromethane	8.5	8.5	-	-	-	-	8.5[f,i]	8.5[f,i]	-	-
Dibromochloromethane	250	10	250	10	-	-	-	-	-	-
Ethylene dibromide	0.012	0.0051	0.012[f]	0.0051[f]	-	-	12[f,i]	12[f,i]	-	-
Chlorinated Aromatics										
Chlorobenzene	0.0013	0.0013	2.2	0.18	-	-	0.0013	0.0013	0.025	0.025
1,2-Dichlorobenzene	0.0007	0.0007	NGR	64	-	-	0.0007	0.0007	0.042	0.042
1,3-Dichlorobenzene	0.042	0.042	-	-	-	-	0.15	0.15	0.042[h,i]	0.042[h,i]
1,4-Dichlorobenzene	0.026	0.026	32	2.6	-	-	0.026	0.026	-	-
1,2,3-Trichlorobenzene	0.008	0.008	6.9	0.33	-	-	0.008	0.008	-	-
1,2,4-Trichlorobenzene	0.0054	0.0054	6.1	0.29	-	-	0.024	0.024	0.0054	0.0054
1,3,5-Trichlorobenzene	3.3	0.15	3.3	0.15	-	-	-	-	-	-
1,2,3,4-Tetrachlorobenzene	0.0018	0.0018	NGR	NGR	-	-	0.0018	0.0018	-	-
1,2,3,5-Tetrachlorobenzene	NGR	0.16	NGR	0.16	-	-	-	-	-	-
1,2,4,5-Tetrachlorobenzene	NGR	0.08	NGR	0.08	-	-	-	-	-	-
Pentachlorobenzene	0.006	0.006	NGR	0.44	-	-	0.006	0.006	-	-
Hexachlorobenzene	0.21	0.014	0.21	0.014	-	-	-	-	-	-
Phenols										
2-Chlorophenol	0.33	0.33	-	-	-	-	0.33[f,i]	0.33[f,i]	-	-
2,4-Dichlorophenol	0.0002	0.0002	NGR	NGR	-	-	0.0002	0.0002	-	-
2,4-Dimethylphenol	3.9	3.9	-	-	-	-	3.9[f,i]	3.9[f,i]	-	-
2,4-Dinitrophenol	1.1	1.1	-	-	-	-	1.1[f,i]	1.1[f,i]	-	-
Phenol	0.004	0.004	NGR	45000	110	150	0.004	0.004	-	-

TABLE 3 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR COMMERCIAL AND INDUSTRIAL LAND USES[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
2,4,5-Trichlorophenol	0.16	0.16	-	-	-	-	0.16[f,i]	0.16[f,i]	-	-
2,4,6-Trichlorophenol	0.018	0.018	NGR	540	-	-	0.018	0.018	-	-
2,3,4,6-Tetrachlorophenol	0.001	0.001	NGR	NGR	-	-	0.001	0.001	-	-
Pentachlorophenol	0.0005	0.0005	NGR	NGR	2.2	2.2	0.0005	0.0005	-	-
Pesticides										
Aldicarb	0.00015	0.00015	-	-	-	-	0.001	0.001	0.00015	0.00015
Aldrin	0.003	0.003	-	-	-	-	0.003	0.003	-	-
Atrazine and metabolites	0.0018	0.0018	-	-	-	-	0.0018	0.0018	0.01[h,i]	0.01[h,i]
Azniphos-methyl	0.00001	0.00001	-	-	-	-	0.00001	0.00001	-	-
Bromacil	0.005	0.005	-	-	-	-	0.005	0.005	-	-
Bromoxynil	0.005	0.005	-	-	-	-	0.005	0.005	-	-
Captan	0.0013	0.0013	-	-	-	-	0.0013	0.0013	-	-
Carbaryl	0.0002	0.0002	-	-	-	-	0.0002	0.0002	0.00032	0.00032
Carbofuran	0.0018	0.0018	-	-	-	-	0.0018	0.0018	-	-
Chlordane	0.015	0.015	1.7[f]	1.6[f]	-	-	0.015[f,i]	0.015[f,i]	-	-
Chlorothalonil	0.00018	0.00018	-	-	-	-	0.00018	0.00018	0.00036	0.00036
Chlorpyrifos	0.000002	0.000002	-	-	-	-	0.0000035	0.0000035	0.000002	0.000002
Cyanazine	0.002	0.002	-	-	-	-	0.002	0.002	-	-
2,4-D (2,4-Dichlorophenoxyacetic acid) & other phenoxy herbicides	0.004	0.004	-	-	-	-	0.004	0.004	-	-
DDAC (Didecyl dimethyl ammonium chloride)	0.0015	0.0015	-	-	-	-	0.0015	0.0015	-	-
DDT (Dichloro-Diphenyl-Trichloroethane) & metabolites	0.000001	0.000001	-	-	-	-	0.000001	0.000001	-	-
Deltamethrin	0.0000004	0.0000004	-	-	-	-	0.0000004	0.0000004	-	-
Diazinon	0.000003	0.000003					0.000003[h,i]	0.000003[h,i]		
Dicamba	0.01	0.01	-	-	-	-	0.01	0.01	-	-
Dichlofop-methyl	0.0061	0.0061	-	-	-	-	0.0061	0.0061	-	-
Dieldrin	0.000056	0.000056	-	-	-	-	0.000056	0.000056	-	-
Dimethoate	0.0062	0.0062	-	-	-	-	0.0062	0.0062	-	-
Dinoseb	0.00005	0.00005	-	-	-	-	0.00005	0.00005	-	-
Endosulfan	0.00002	0.00002	-	-	-	-	0.00003	0.00003	0.00002	0.00002
Endrin	0.000036	0.000036	-	-	-	-	0.000036	0.000036	-	-
Glyphosate	*	*	-	-	-	-	*	*	-	-

TABLE 3 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR COMMERCIAL AND INDUSTRIAL LAND USES[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Heptachlor epoxide	0.0000038	0.0000038	0.051	0.002	-	-	0.0000038	0.0000038	-	-
Imidacloprid	0.00023	0.00023	-	-	-	-	0.00023	0.00023	-	-
IPBC (3-iodo-2-propynyl butyl carbamate)	0.0019	0.0019	-	-	-	-	0.0019	0.0019	-	-
Lindane (γ-hexachlorocyclohexane)	0.00001	0.00001	-	-	-	-	0.00001	0.00001	-	-
Linuron	0.007	0.007	-	-	-	-	0.007	0.007	-	-
Malathion	0.0001	0.0001	-	-	-	-	0.0001	0.0001	-	-
MCPA	0.0026	0.0026	-	-	-	-	0.0026	0.0026	0.0042	0.0042
Methoprene	0.00009	0.00009	-	-	-	-	0.00009	0.00009	-	-
Methoxychlor	0.00003	0.00003	-	-	-	-	0.00003	0.00003	-	-
Metolachlor	0.0078	0.0078	-	-	-	-	0.0078	0.0078	-	-
Metribuzin	0.001	0.001	-	-	-	-	0.001	0.001	-	-
Parathion	0.000013	0.000013	-	-	-	-	0.000013	0.000013	-	-
Permethrin	0.000001	0.000001	-	-	-	-	0.000004	0.000004	0.000001	0.000001
Picloram	0.029	0.029	-	-	-	-	0.029	0.029	-	-
Simazine	0.01	0.01	-	-	-	-	0.01	0.01	-	-
Tebuthiuron	0.0016	0.0016	-	-	-	-	0.0016	0.0016	-	-
Toxaphene	0.0000002	0.0000002	75	2.9	-	-	0.0000002	0.0000002	-	-
Triallate	0.00024	0.00024	-	-	-	-	0.00024	0.00024	-	-
Trifluarin	0.0002	0.0002	-	-	-	-	0.0002	0.0002	-	-
Other Organics										
Acetone	13	13	1.1E+5[f]	39000[f]	-	-	13[f,i]	13[f,i]	-	-
Acridine	0.00005	0.00005	-	-	-	-	0.00005[h,i]	0.00005[h,i]	-	-
Aniline	0.0022	0.0022	13,000	1,000	-	-	0.0022	0.0022	-	-
Bis(2-chloroethyl)ether	30	30	12000[f]	810[f]	-	-	30[f,i]	30[f,i]	-	-
Bis(2-chloroisopropyl)ether	30	30	7100[f]	400[f]	-	-	30[f,i]	30[f,i]	-	-
Bis(2-ethyl-hexyl)phthalate	0.016	0.016	NGR	NGR	-	-	0.016	0.016	-	-
Chloroaniline, p-	0.04	0.04	-	-	-	-	0.04[f,i]	0.04[f,i]	-	-
Dibutyl phthalate	0.019	0.019	NGR	NGR	-	-	0.019	0.019	-	-
di-n-Butyltin	0.00008	0.00008	-	-	-	-	0.00008[h,i]	0.00008[h,i]	-	-
Diethylphthalate	0.0038	0.0038	-	-	-	-	0.0038[f,i]	0.0038[f,i]	-	-
Diisopropanolamine	1.6	1.6	-	-	160	160	1.6	1.6	-	-
2,4-Dinitrotoluene	0.29	0.29	-	-	-	-	0.29[f,i]	0.29[f,i]	-	-
Ethylene glycol	190	190	NGR	NGR	9200	16000	190	190	-	-
Hexachlorobutadiene	0.0013	0.0013	0.22	0.015	-	-	0.0013	0.0013	-	-

TABLE 3 FEDERAL INTERIM GROUNDWATER QUALITY GUIDELINES
GENERIC GUIDELINES FOR COMMERCIAL AND INDUSTRIAL LAND USES[a] (mg/L)

Note: Guidelines for Canadian Drinking Water Quality (Health Canada, 2010) may also apply
Guidelines may not apply if underlying assumptions are not met (see Section 4.2)

	Tier 1		Tier 2							
			Water Use/Exposure Pathway							
	Lowest Guideline		Inhalation		Soil Organisms Direct Contact		Freshwater Life[b]		Marine Life[c]	
			Soil Type							
Parameters	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**	**Fine**	**Coarse**
Methyl methacrylate	120	10	120	10	-	-	-	-	-	-
Methyl ethyl ketone	150	150	7200[f]	2900[f]	-	-	150[f,i]	150[f,i]	-	-
Methyl isobutyl ketone	58	58	2500[f]	830[f]	-	-	58[f,i]	58[f,i]	-	-
Methyl mercury	0.000015	0.000015	-	-	-	-	0.000015[f,i]	0.000015[f,i]	-	-
MTBE (Methyl tert-butyl ether)	5	4.3	40	4.3	-	-	10	10	5	5
Monochloramine	0.0005	0.0005					0.0005[h,i]	0.0005[h,i]		
Nonylphenol + ethoxylates	0.0007	0.0007	-	-	0.0081	0.0081	0.001	0.001	0.0007	0.0007
Propylene glycol	500	500	-	-	-	-	500	500	-	-
Quinoline	0.0034	0.0034					0.0034[h,i]	0.0034[h,i]		
Sulfolane	50	50	-	-	1700	2800	50	50	-	-
Tributyltin	0.000001	0.000001	-	-	-	-	0.000008	0.000008	0.000001	0.000001
Triethyltin	0.0004	0.0004	-	-	-	-	0.0004[h,i]	0.0004[h,i]	-	-
Triphenyltin	0.000022	0.000022	-	-	-	-	0.000022	0.000022	-	-

a – all values adopted from Alberta Environment (AESRD) (2010a) unless otherwise specified
b – where AESRD (2010a) guideline was not based on the *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Aquatic Life* for freshwater environments (CCME 1999), and a CWQG exists, the groundwater quality guideline was re-calculated based on the CWQG
c – based on *Canadian Water Quality Guidelines* (CWQG) *for the Protection of Aquatic Life* for the marine environments(CCME 1999) and groundwater transport model
d – the freshwater aquatic life guidelines vary depending on water pH, hardness etc. Therefore, see *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (CCME 1999) to determine the appropriate water quality guideline applicable to the site and calculate the groundwater guidelines using formulas provided in Appendix B
e – guideline is the lowest of all applicable pathways
f – adopted from Ontario Ministry of the Environment (OMOE) (2010)
g – for ecological receptors only
h – adopted from BC Contaminated Sites Regulation
i - 10x factor for dilution in surface water was removed from guideline value
j – adopted directly from CCME (1999)
* - Refer to Federal Interim Groundwater Quality Guidelines Memo (2016)
NGR – no guideline required; calculated guideline exceeds solubility limit

APPENDIX B
MODELS, EQUATIONS AND DEFAULT MODEL PARAMETERS USED TO CALCULATE TIER 1 AND TIER 2 GUIDELINES

This appendix provides the equations and default model parameters used to derive most of the generic groundwater guidelines; these same equations and model parameters should be used as the starting point for site-specific modification in the derivation of Tier 2 guidelines. All equations presented herein were adopted from Alberta Environment and Sustainable Resource Development (AESRD) (AESRD 2010a, 2010b) unless otherwise specified.

For more comprehensive guidance on using the models presented herein, including which parameters can be adjusted at Tier 2, appropriate ranges within which these parameters can be adjusted, and data requirements to support Tier 2 adjustment, refer to Appendices C and D of the *Canada-Wide Standard for Petroleum Hydrocarbons in Soil: User Guidance* (CCME, 2008b).

B.1 Human Exposure Pathways

Vapour Inhalation

Groundwater guidelines protective of the indoor infiltration and inhalation pathway were calculated using the equations from the CCME (2006) protocol adapted for groundwater.

Consistent with the approach taken in CCME (2008a), an adjustment factor of 10 is applied in the equations below for petroleum hydrocarbons (including benzene, toluene, ethylbenzene and xylenes), to account for empirical evidence that measured indoor air concentrations are typically lower by at least an order of magnitude than concentrations predicted from the models below. The adjustment factor takes the value of 1 for all other chemicals, reflecting the lack of any empirical data to support such a factor for these chemicals. Default parameter values are summarized in Tables 4 to 8. Separate calculations are made for carcinogens and non-carcinogenic chemicals.

Groundwater Guidelines for Non-Carcinogens

$$GWQG_I = \frac{(TC - C_a) \times SAF \times DF_i \times AF}{H' \times ET \times 10^3}$$

Where:
- $GWQG_I$ = groundwater quality guideline for indoor infiltration (mg/L);
- TC = tolerable concentration (mg/m^3);
- C_a = background air concentration (mg/m^3);
- SAF = allocation factor (dimensionless);
- DF_i = dilution factor from soil gas to indoor air (calculated below);
- AF = adjustment factor (10, hydrocarbons; 1, all other chemicals);
- H’ = dimensionless Henry’s Law Constant (dimensionless);
- ET = exposure term (dimensionless);
- 10^3 = conversion factor from m^3 to L; and,

Groundwater Guidelines for Carcinogens

$$GWQG_I = \frac{RsC \times DF_i \times AF}{H' \times ET \times 10^3}$$

Where: $GWQG_I$= groundwater quality guideline for indoor infiltration (mg/L);
RsC = risk-specific concentration (mg/m^3);
DF_i = dilution factor from soil gas to indoor air (calculated below);
AF = adjustment factor (10, hydrocarbons; 1, all other chemicals);
H' = dimensionless Henry's Law Constant (dimensionless);
ET = exposure term (dimensionless);
10^3 = conversion factor from m^3 to L; and,

Note that in contrast to the CCME (2006) protocol, an exposure term of 0.2747 was used for commercial and industrial land use for carcinogens.

Dilution Factor Calculation

The dilution factor (DF_i) was calculated as follows:

$$DF_i = \frac{1}{\alpha}$$

Where: DF_i = dilution factor from soil gas concentration to indoor air concentration (unitless); and,
α = attenuation coefficient (unitless; see derivation below).

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

where:

α = attenuation coefficient (dimensionless);
D_T^{eff} = effective porous media diffusion coefficient (cm^2/s);
A_B = building area (cm^2);
Q_B = building ventilation rate (cm^3/s);
L_T = distance from contaminant source to foundation (cm);
Q_{soil} = volumetric flow rate of soil gas into the building (cm^3/s);
L_{crack} = thickness of the foundation (cm);
D_{crack} = effective vapour diffusion coefficient through the crack (cm^2/s); and,
A_{crack} = area of cracks through which contaminant vapours enter the building (cm^2).

Calculation of D_T^{eff}:

$$D_T^{eff} \approx D_a \times \left(\frac{\theta_a^{10/3}}{\theta_t^2} \right)$$

Where:

	D_T^{eff}	=	overall effective porous media diffusion coefficient based on vapour-phase concentrations for the region between the source and foundation (cm^2/s);
	D_a	=	diffusion coefficient in air (cm^2/s);
	θ_a	=	soil vapour-filled porosity (dimensionless); and,
	θ_t	=	soil total porosity (dimensionless).

Note that this equation assumes that the dominant form of diffusion is through air and therefore cannot be applied to scenarios where diffusion in water may become a dominant form of the transport equation. Therefore, moisture content must always be set to an unsaturated condition in order to apply this equation.

For Tier 1 and Tier 2 guideline adjustments where more than 1 stratum exists, the calculation of D_T^{eff} must be based on the most conservative stratum in zone of contaminant migration (e.g., the stratum with the highest diffusion coefficient must be used). An exception is allowed for sites where a surficial fine grained deposit exists over a coarse grained deposit. In the event that

1. Sufficient borehole information is provided to support the presence of a continuous fine grained layer over the entire site,
2. Sufficient borehole information is provided to support estimation of the minimum thickness of the fine grained layer and
3. The minimum thickness of the fine grained layer is at least 1 m deeper than the depth of typical excavations at the site in the event of construction and at least 1 m deeper than the maximum depth of basements or potential basements at the site

then the fine grained layer can be applied to the calculation of D_T^{eff}. However, the depth to the contaminant layer or the groundwater cannot be set at a depth greater than the minimum thickness of the layer.

For more detailed site specific risk assessments and in the event that sufficient data is available to determine continuous presence of several layers and minimum and maximum thickness of these layers, it may be possible to estimate the effective diffusion coefficient based on a combination of all layers present at the site. However, this requires a site specific risk assessment and is not allowed for simple model changes at Tier 2.

Where site-specific risk assessments are used, and in the event that there is more than one soil type through which the contaminant must diffuse, D_T^{eff} can be calculated separately for each soil stratum (stratum-specific diffusion coefficients are referred to as D_i^{eff} below) and averaged using the following equation:

$$D_T^{eff} = \frac{L_T}{\sum D_i^{eff} L_i}$$

Where:
- D_T^{eff} = overall effective porous media diffusion coefficient based on vapour-phase concentrations for the region between the source and foundation (cm^2/s);
- D_i^{eff} = effective porous media diffusion coefficient for stratum 'i', calculated as above;
- L_T = distance from contaminant source to foundation (cm); and,
- L_i = thickness of stratum 'i' through which the contaminant travels.

Calculation of D_{crack}:

D_{crack} is calculated in exactly the same way as D_T^{eff}, with the exception that the assumption is made that the soil material in the cracks is dry (CCME, 2006a), and accordingly, the air filled porosity is the same as the total porosity, and the equation becomes:

$$D_{crack} \approx D_a \times \left(\frac{\theta_t^{10/3}}{\theta_t^2} \right)$$

Where:
- D_{crack} = effective porous media diffusion coefficient in floor cracks (cm^2/s);
- D_a = diffusion coefficient in air (cm^2/s);
- θ_t = total porosity for underlying soil (dimensionless).

In this equation, it is always assumed that the soil properties are based on the properties of the soil surrounding the building foundation.

Calculation of Q_B:

$$Q_B = \frac{L_B W_B H_B ACH}{3{,}600}$$

Where:
- Q_B = building ventilation rate (cm^3/s);
- L_B = building length (cm);
- W_B = building width (cm);
- H_B = building height (cm 3);
- ACH = air exchanges per hour (h^{-1}); and,
- 3,600 = conversion factor from hours to seconds.

Calculation of Q_{soil}:

$$Q_{soil} = \frac{2\pi\Delta P k_v X_{crack}}{\mu \, ln\left[\frac{2Z_{crack}}{r_{crack}}\right]}$$

Where Q_{soil} = volumetric flow rate of soil gas into the building (cm^3/s);
ΔP = pressure differential ($g/cm \cdot s^2$);
k_v = soil vapour permeability to vapour flow (cm^2) for soil adjacent to building foundation;
X_{crack} = length of idealized cylinder (cm);
μ = vapour viscosity (0.000173 g/cm·s; CCME, 2006a);
Z_{crack} = distance below grade to idealized cylinder (cm); and,
r_{crack} = radius of idealized cylinder (cm; calculated as A_{crack}/X_{crack}).

B.2 Ecological Exposure Pathways

Direct Contact by Soil organisms

Groundwater guidelines based on direct contact by soil organisms for non-polar organic compounds and salts are based on soil quality guidelines for this pathway:

Non-polar organic compounds

$$GWQG_{DC} = SQG_{DC} \frac{\rho_b}{\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + (H' \times \theta_a)}$$

Where: $GWQG_{DC}$= groundwater remediation guideline protective of direct contact with plants and soil invertebrates in areas of shallow groundwater (mg/L);
SQG_{DC} = soil quality guideline protective of direct contact with plants and soil invertebrates (mg/kg);
ρ_b = dry soil bulk density (g/cm^3);
θ_w = moisture-filled porosity (dimensionless);
K_{oc} = organic carbon partition coefficient (L/kg);
f_{oc} = fraction of organic carbon (g/g);
H' = dimensionless Henry's Law Constant (dimensionless); and,
θ_a = vapour-filled porosity (dimensionless).

Salt Compounds

Salt compounds do not interact significantly with soil organic carbon, are not present to a significant extent in the vapour phase, and are present in pore water or loosely bound to clay mineral surfaces. These guidelines are presented in terms of the electrical conductivity (in

dS/m) of a saturated paste of the soil. The groundwater guideline for this exposure pathway for salts is calculated from the AESRD (2001b) ecological soil contact soil quality guidelines, for coarse and fine soils, using the following equation. It is assumed that the water content of the soil in a saturated paste sample may be approximated by the total porosity of the soil.

$$GWQG_{DC} = SQG_{DC} \frac{1{,}000\rho_b}{\theta t}$$

where:

$GWQG_{DC}$= groundwater remediation objective protective of ecological soil contact in surface soil (μS/cm);
SQG_{DC} = soil quality guideline for salts protective of eco-soil contact (2 dS/m, agricultural and residential; 4 dS/m commercial and industrial);
1,000 = conversion factor from dS/m to μS/cm (dimensionless);
ρ_b = dry soil bulk density (g/cm^3); and,
θ_t = total porosity (dimensionless).

It should be noted that this calculation only applies to the groundwater quality guideline that is calculated for soil-based ecological receptors and cannot be used to screen any other pathways or receptors. It should also be noted that the above calculation only applies to the total ionic concentration in the soil. All pathways and receptors, including soil ecological pathways and receptors, must still be screened for potential effects from exposure of the individual ions that comprise the total electrical conductivity regardless of calculations from this equation.

B.3 Groundwater Transport

Lateral groundwater transport (e.g. to a nearby surface water body) is modelled using a transport model and equations from the CCME (2006) protocol. At this time, transport modelling for inorganic substances is not conducted due to the uncertainties associated with the partitioning of metals between the adsorbed and dissolved phase and the lack of biodegradation of these substances; transport of inorganic substances could be assessed on a site-specific basis where appropriate.

For the protection of aquatic life or wildlife watering, it is assumed that there is a minimum 10 m lateral separation between the point of measurement and the surface water body; this distance can be modified at Tier 2. The model used to calculate the groundwater guidelines for these water uses is simply the lateral transport part of the CCME (2006) model used to calculate the corresponding soil guideline.

The groundwater remediation guideline protective of aquatic life and wildlife watering is calculated using the following equations.

$$GWQG_{GR} = SWQG \times DF4$$

where:

$GWQG_{GR}$= groundwater quality guideline protective of groundwater pathways (mg/kg);
$SWQG_{FL}$= corresponding surface water quality guideline (aquatic life, or

wildlife watering) (mg/L);

DF4 = dilution factor for lateral transport (L/kg).

Assumptions implicit in the model include the following:

- the soil is physically and chemically homogeneous;
- depletion of the contaminant source is not considered (*i.e.*, infinite source mass);
- contaminant is not present as a free phase product;
- groundwater aquifer is unconfined;
- groundwater flow is uniform and steady;
- co-solubility and oxidation/reduction effects are not considered;
- attenuation of the contaminant in the saturated zone is assumed to be one-dimensional with respect to sorption-desorption, dispersion, and biological degradation;
- dispersion in groundwater is assumed to occur in the longitudinal and transverse directions only and diffusion is not considered;
- dilution of the plume by groundwater recharge down-gradient of the source is not included.

Dilution Factor 4

Dilution factor 4 (DF4) from the CCME (2006) model accounts for the processes of dispersion and biodegradation as groundwater travels downgradient from beneath the source of contamination, and is the ratio of the concentration of a chemical in groundwater beneath the source, to the concentration in groundwater at a distance (10 m for generic aquatic life and wildlife watering guidelines) downgradient of the source. For distances less than 10 m, a value of 1 should be used for DF4. Consistent with CCME (2008a,b), the time independent (steady state) version of the equation to calculate DF4 was used:

$$DF4 = \frac{2}{\exp(A) \times [erf(C) - erf(D)]}$$

$$A = \frac{x}{2D_x}\left\{1 - \left(1 + \frac{4L_s D_x}{v}\right)^{1/2}\right\}$$

$$C = \frac{y + Y/2}{2\left(D_y x\right)^{1/2}}$$

$$D = \frac{y - Y/2}{2\left(D_y x\right)^{1/2}}$$

$$L_s = \frac{0.6931}{t_{1/2s}} \times \exp(-0.07d)$$

$$v = \frac{V}{\theta_t R_s}$$

$$R_s = 1 + \frac{\rho_b K_{oc} f_{oc}}{\theta_t}$$

$$D_x = 0.1x$$

$$D_y = 0.01x$$

where:

DF4	=	dilution factor 4 (dimensionless);
erf	=	the error function;
A	=	dimensionless group A (dimensionless);
C	=	dimensionless group C (dimensionless);
D	=	dimensionless group D (dimensionless);
x	=	lateral distance between source and receptor (m);
D_x	=	dispersivity in the direction of groundwater flow (m);
L_s	=	decay constant (1/year);
v	=	velocity of the contaminant (m/year);
y	=	distance to receptor perpendicular to groundwater flow (m);
Y	=	source width (m);
D_y	=	dispersivity perpendicular to the direction of groundwater flow (m);
$t_{1/2s}$	=	decay half-life of contaminant in saturated zone of aquifer (years);
d	=	water table depth (m);
V	=	Darcy velocity in groundwater (m/year);
θ_t	=	total soil porosity (dimensionless) in the aquifer;
R_s	=	retardation factor in saturated zone (dimensionless);
ρ_b	=	dry soil bulk density in the aquifer (g/cm^3);
K_{oc}	=	organic carbon partition coefficient (mL/g); and,
f_{oc}	=	fraction organic carbon (g/g) in the aquifer.

It should be noted that the decay half-life is assumed to be infinite unless a value has been approved by the CCME. Most published half-life data reflect aerobic conditions or surface water/surface soil, and may be unconservative for potentially anaerobic groundwater conditions. Site-specific half-lives may be considered in a site-specific risk assessment.

For screening purposes, a series of distance-based “adjustment factors” have been calculated using the above model, with all inputs set at the default values for Tier 1 with the exception of distance to surface water. These adjustment factors are based on a chemical that does not biodegrade (i.e. decay constant is set to 0); in the absence of biodegradation, the results are independent of most soil properties and chemical properties. The adjustment factors were calculated using the distance at the lower end of each range in the table below (e.g. the factor

for 100-149 m is based on a distance of 100 m). The results are dependent on the plume width, and therefore should not be applied for contaminant plumes that are significantly wider than the Tier 1 default.

These adjustment factors can be applied by multiplying the generic guideline for the protection of aquatic life by the factor for the distance to the nearest surface water body. These factors could also be conservatively applied to biodegrading substances, although use of the full model incorporating biodegradation would result in higher guidelines. For example, the Tier 1 guideline for the protection of freshwater life for naphthalene is 0.0011 mg/L. If the nearest surface water body is at least 250 m away, the guideline could be adjusted by a factor of 8.9, resulting in a Tier 2 guideline for freshwater aquatic life of 0.0011 mg/L x 8.9 = 0.0098 mg/L.

Distance to Surface Water (m)	Adjustment Factor
<50	1
50-74	1.9
75-99	2.75
100-149	3.6
150-199	5.4
200-249	7.1
250-299	8.9
300-349	10.6
350-399	12.4
400-449	14.2
450-499	16
500-1000	17.7

These adjustment factors should only be used at sites where the Tier 1 guidelines could be applied, and are intended to serve as a preliminary screening-level approach for deriving site-specific guidelines for the protection of aquatic life in situations where using the full Tier 2 model may not be warranted. They could be conservatively applied for biodegrading as well as non-biodegrading contaminants, but generally if a chemical has a biodegradation rate then a much higher guideline can be derived using the full model.

B.4 Model Input Parameters

Table 4: Model Input Parameters for Human Receptor Characteristics[a]

Parameter	Symbol	Infant (0 – 6 mo)	Toddler (7 mo - 4 y)	Child (5 – 11 y)	Teen (12 – 19 y)	Adult (20+ y)
Body Weight (kg)	BW	8.2	16.5	32.9	59.7	70.7
Air Inhalation Rate (m^3/d)	IR	2.1	9.3	14.5	15.8	15.8
Water Ingestion Rate (L/d)	WIR	0.3	0.6	0.8	1.0	1.5

a – from CCME 2006

Table 5: Soil and Hydrogeological Model Input Parameters[a]

Parameter	Symbol	Soil Type	
		Coarse-grained	Fine-grained
Saturated Hydraulic Conductivity (m/y)	K_H	320	32
Hydraulic Gradient	i	0.028	0.028
Recharge (Infiltration rate) (m/y)	I	0.28	0.20
Organic Carbon Fraction (g/g)	foc	0.005	0.005
Soil Bulk Density (g/cm3)	ρ_b	1.7	1.4
Water Content (Mw/Ms)	M_W/M_S	0.07	0.12
Total Soil Porosity	n	0.36	0.47
Vapour-Filled Porosity	θ_a	0.241	0.302
Moisture-Filled Porosity	θ_w	0.119	0.168
Soil Vapour Permeability (cm2)	k_v	$6x10^{-8}$	10^{-9}

a – from CCME 2008a

Table 6: Model Input Parameters for Site Characteristics[a]

PARAMETER	SYMBOL	VALUE
Contaminant Source Width (m)	Y	10
Contaminant Source Depth (m)	Z	3
Contaminant Source Length (m)	X	10
Distance to Surface Water (m)	x	10
Distance to Potable Water User (m)	x	0
Distance to Agricultural Water User (m)	x	0
Distance from Groundwater to Building Slab (cm)	L_T	30
Depth to Groundwater (water table) (m)	d	3
Depth of unconfined aquifer (m)	d_a	5

a – from CCME 2006

Table 7: Model Input Parameters for Building [a]

Parameter	Symbol	Residential Basement	Residential Slab-On-Grade	Commercial Slab-On-Grade
Building Length (cm)	L_B	1225	1225	2000
Building Width (cm)	W_B	1225	1225	1500
Building Substructure Area (cm^2)	A_B	$2.7x10^6$	$1.5x10^6$	$3.0x10^6$
Mixing Height (cm)[a]	H_B	360	360	300
Thickness of Building Foundation (cm)	L_{crack}	11.25	11.25	11.25
Depth Below Grade of Foundation (cm)	Z_{crack}	244	11.25	11.25
Area of Crack (cm^2)	A_{crack}	1790	994.5	1846
Length of Idealized Cylinder (cm)	X_{crack}	4900	4900	7000
Air Exchanges per Hour (1/h)	ACH	0.5	0.5	0.9
Pressure Differential ($g/cm\text{-}s^2$)	ΔP	40	40	20

a – from CCME 2008a

Table 8: Model Input Parameters for Livestock and Wildlife Receptor Characteristics[a]

Parameter	Symbol	Unit	Livestock (Cow)	Wildlife (Meadow Vole)
Body Weight	BW	kg	550	0.017
Soil Ingestion Rate	SIR	kg/d	0.747	0.000058
Water Ingestion Rate	WIR	L/d	100	0.00357

a – from AESRD (2010a)

B.5 Chemical-Specific Parameters

A variety of chemical physical-chemical and toxicological parameters are also needed for guideline calculation. The physical-chemical parameters applied to derive the generic guidelines have been summarized in AESRD (2010a) and OMOE (2010). Human toxicological parameters should be based on the latest guidance from Health Canada.

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