Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health

ETHYLBENZENE 2004

This fact sheet provides Canadian soil quality guidelines for ethylbenzene for the protection of environmental and human health (Table 1). A supporting scientific document is also available (Environment Canada 2004).

Background Information

Ethylbenzene ($C_2H_5C_6H_5$; CAS 100-41-4) is a monoaromatic hydrocarbon with a significantly high vapour pressure (1.276 kPa at 25°C) and Henry's law constant (669–1001 $Pa{\cdot}m^{-3}{\cdot}mol^{-1}$), and is subject to rapid volatilization. Ethylbenzene also has a high air saturation potential. These characteristics combined with a low flash point (18.0°C) make ethylbenzene highly flammable. The solubility of ethylbenzene in water is relatively low (150 $mg{\cdot}L^{-1}$ at 25°C), but is high enough to be of environmental concern. Ethylbenzene has a moderate octanol–water partition coefficient (log K_{ow} 3.13), indicating a moderate fat solubility and consequently a moderate bioaccumulation potential (Environment Canada 2004).

Toluene, ethylbenzene, and the three xylene isomers (*o*-, *m*-, and *p*-xylene) fall into the broad category of volatile organic compounds that are monoaromatic hydrocarbons composed of an alkyl-substituted benzene ring. These compounds, collectively referred to as TEX, are often studied together with the addition of benzene, because they are all present in gasoline and make up more than 60% of the water soluble fraction (Barbaro et al. 1992).

TEX are products or by-products of petroleum and coal refining. Toluene and xylene are produced as an aromatic mixture with benzene, primarily from catalytic reformate in refineries and secondarily as by-products of olefin manufacture during the cracking of hydrocarbons. Ethylbenzene is primarily produced by the alkylation of benzene with ethylene.

Table 1. Soil quality guidelines for ethylbenzene ($mg{\cdot}kg^{-1}$).*

	Land use and soil texture							
	Agricultural		Residential/ parkland		Commercial		Industrial	
	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Surface								
Guideline[a]	**0.082**	**0.018**[b]	**0.082**	**0.018**[b]	**0.082**	**0.018**[b]	**0.082**	**0.018**[b]
SQG_{HH}	0.082	0.018[b]	0.082	0.018[b]	0.082	0.018[b]	0.082	0.018[b]
SQG_E	55	120	55	120	300	430	300	430
Subsoil								
Guideline[a]	**0.082**	**0.018**[b]	**0.082**	**0.018**[b]	**0.082**	**0.018**[b]	**0.082**	**0.018**[b]
SQG_{HH}	0.082	0.018[b]	0.082	0.018[b]	0.082	0.018[b]	0.082	0.018[b]
SQG_E	110	240	110	240	600	860	600	860

Notes: SQG_E = soil quality guideline for environmental health; SQG_{HH} = soil quality guideline for human health.
* Free-phase formation, a circumstance deemed unacceptable by many jurisdictions, occurs when a substance exceeds its solubility limit in soil water. The concentration at which this occurs is dependent on a number of factors, including soil texture, porosity, and aeration porosity. Under the assumptions used for this guideline, at concentrations greater than 430 $mg{\cdot}kg^{-1}$ soil, formation of free-phase ethylbenzene will likely occur. Contact jurisdiction for guidance.

[a]Data are sufficient and adequate to calculate an SQG_{HH} and an SQG_E. Therefore the soil quality guideline is the lower of the two and represents a fully integrated *de novo* guideline for this land use.

[b]This guideline value may be less than the common limit of detection for ethylbenzene in some jurisdictions. Contact jurisdiction for guidance.

The guidelines in this fact sheet are for general guidance only. Site-specific conditions should be considered in the application of these values. The values may be applied differently in various jurisdictions. Use of some values listed in Table 1 may not be permitted at the generic level in some jurisdictions. For example, use of subsoil values may result in land use restrictions. The reader should consult the appropriate jurisdiction before application of the values.

TEX are widely used as solvents in paints, lacquers, adhesives, inks, and cleaning and degreasing agents and in the production of dyes, perfumes, plastics, pharmaceuticals, and pesticides. TEX also make up a significant fraction of crude petroleum. The typical fractions of ethylbenzene in gasolines used in Ontario are 1.4% in regular unleaded and 1.7% in premium unleaded (OMEE 1993b).

The introduction of TEX into the atmosphere is due largely to incomplete combustion of petroleum fuels from motor vehicles and volatilization of TEX-based solvents and thinners. Other natural sources include volcanic gases, forest fires, and vegetation (Isidorov et al. 1990).

TEX are released to soil and water mainly from leaking of underground petroleum storage tanks and landfill sites, accidents and spills during transportation, pesticide applications, and discharges of industrial and municipal wastes (Johnson et al. 1989; Lesage et al. 1990, 1991; DGAIS 1992).

Data on concentrations of ethylbenzene in soils and sediments are scarce for the Canadian environment. The Ontario Ministry of Environment and Energy has reported that the 98th percentiles of ethylbenzene concentrations in rural and old urban parkland soils not impacted by a local point source of pollution are 0.46–0.50 and 0.40 $\mu g \cdot kg^{-1}$, respectively (OMEE 1993a). No data on the concentrations of ethylbenzene in the atmosphere and in the water are available (Environment Canada 2004).

Environmental Fate and Behaviour in Soil

The major processes that determine the behaviour of TEX in the terrestrial environment are volatilization, sorption, biodegradation, and leaching. TEX do not have hydrolyzable groups, and therefore hydrolysis is not an important transformation pathway. Likewise, TEX are not degraded directly by photolysis (Howard 1990; Mackay et al. 1992). In the atmosphere, however, TEX are degraded with a half-life of 3 h to 1 d by reacting with photochemically produced hydroxyl radicals.

Volatilization is a dominant process determining the fate of TEX in the terrestrial environment (Parker and Jenkins 1986; Jin and O'Connor 1990; Anderson et al. 1991). Volatilization depends on temperature, humidity, sorption, and biodegradation processes in soils (Aurelius and Brown 1987; Ashworth 1988). The relatively high vapour pressures and Henry's law constants of TEX ($>10^{-3}$ $atm \cdot m^3 \cdot mol^{-1}$) make them subject to rapid volatilization from soils with half-lives ranging from 2.2 to 28 d (Howard 1990; Anderson et al. 1991).

Adsorption reduces the mobility of TEX in soils and affects their biotransformation rate. Soil organic matter, especially humic acids, strongly sorb TEX (El-Dib et al. 1978; Schwarzenbach and Westall 1981; Jury et al. 1987; Jin and O'Connor 1990). TEX are also adsorbed on clay minerals such as bentonite, illite, and kaolinite. Adsorption in soil increases with increasing TEX concentrations, with decreasing pH, and with decreasing moisture content (El-Dib et al. 1978; Chiou et al. 1981; English and Loehr 1991; Rutherford and Chiou 1992). Sorption is low in light-textured soils with low organic matter (Garbarini and Lion 1986; English and Loehr 1991).

A variety of soil microorganisms are able to utilize TEX as a source of carbon and degrade them to CO_2 and water. *Pseudomonas* species are the main degrading bacteria in soils, but other species such as *Arthrobacter* have also been reported to degrade TEX (Utkin et al. 1992). Degradation half-lives usually range from 5 to 10 d and are typically <20 d (Grbić-Galić and Vogel 1987; Chiang et al. 1989; Evans et al. 1991a, 1991b; Haag et al. 1991; Mackay et al. 1992). Degradation may occur in aerobic or anaerobic conditions. In aerobic conditions, the oxygen supply in soil is the major controlling factor (Barker et al. 1989; Chiang et al. 1989; Allen 1991). The availability of nutrients, especially nitrogen, also affects the degradation rate. This rate is higher in upper soil horizons and in unsaturated zones due to greater oxygen supply (Kampbell et al. 1987; Miller et al. 1990; Haag et al. 1991; Edwards et al. 1992). Anaerobic degradation is much slower and may be increased by adding nitrates and sulphates to the soil (Evans et al. 1991a, 1991b; Hutchins 1991; Beller et al. 1992; Edwards et al. 1992).

TEX are moderately soluble in water and may move with percolating waters, either in solution or sorbed to dissolved organic matter. In organic soils, TEX leaching is highest in low organic matter and light-texture situations, whereas in mineral soils, it depends on the type of clay and the soil moisture content. Sorption and biodegradation processes reduce TEX mobility in soils.

Bioconcentration

Herman et al. (1991) examined the relationship between K_{ow}, bioconcentration, and toxicity of TEX in algae *(Selenastrum capricornutum)*. A strong positive linear relationship was reported between bioconcentration and K_{ow} ($r^2 = 0.98$) and between bioconcentration and toxicity (EC_{50} for growth reduction) ($r^2 = 0.99$). The sorption rate of these aromatic hydrocarbons by algae was initially rapid and then relatively constant. The 12-h BCF for ethylbenzene, expressed as a logarithm to the base 10, was 2.31. The 8-d EC_{50} was 4.8 $mg \cdot L^{-1}$ for ethylbenzene (Herman et al. 1991).

Although TEX may accumulate in algae (Howard 1990), the relatively low log K_{ow} (<4.0) of TEX indicates that the bioconcentration potential is generally low (WHO 1985; Nielsen and Howe 1991).

Behaviour and Effects in Biota

Soil Microbial Processes

No studies on the effects of ethylbenzene on soil microbial processes were found.

Terrestrial Plants

In an attempt to establish phytotoxic levels of ethylbenzene in soil, Environment Canada conducted seedling emergence tests for both radishes *(Raphanus sativa)* and lettuce (*Lactuca sativa*) in 1995. The lowest concentrations at which adverse effects occurred were 12 and 6 mg ethylbenzene·kg^{-1} soil, resulting in a 25% reduction in seedling emergence for radishes and lettuce, respectively. Although these results were used for deriving provisional soil quality guidelines in 1997, the data were suspect due to problems associated with the recovery of ethylbenzene from soil and the volatility of the compound (Environment Canada 1995).

Using advanced techniques for determining the toxicity of highly volatile compounds, new plant toxicity tests were conducted by ESG International in 2002. Tests conducted with early northern wheatgrass (*Agropyron dasystachyum*) and alfalfa (*Medicago sativa*) examined the effects of ethylbenzene on shoot and root length and dry and wet biomass after 14 days of exposure in both coarse and fine soils. In coarse soils, the most sensitive endpoint for alfalfa was reduction of root length, with an IC_{25} value of 462 mg·kg^{-1},and for northern wheatgrass the most sensitive endpoint was an IC_{25} of 3 mg·kg^{-1} for reduction of root wet mass (ESG 2002). The results for fine soils reported by ESG (2002) were recalculated by Komex (2002) to take into account volatile losses that occur between spiking the sample and introducing the plants 2 hours later. (Similar calculations had already been made by ESG for the data from coarse soils). Therefore, the most sensitive estimated effect concentrations in fine soils for alfalfa and northern wheatgrass were an IC_{25} of 316 mg·kg^{-1} for reduction of root length, and an IC_{25} of 218 mg·kg^{-1} for reduction of root wet mass, respectively (Komex 2002).

Terrestrial Invertebrates

The lowest reported ethylbenzene concentration resulting in adverse effects to soil invertebrates comes from Environment Canada (1995). The earthworm *(Eisenia foetida)* suffered 25% mortality at 113 mg ethylbenzene·kg^{-1} soil. Although this study was used for deriving provisional soil quality guidelines in 1997, the same problems associated with the phytotoxicity tests were encountered (Environment Canada 1995).

Studies commissioned by the CCME in 2001, and using advanced techniques for dealing with volatile compounds, examined the toxicity of ethylbenzene to the collembolan (*Onychiurus folsomi*) and the earthworm (*Eisenia andrei*). In coarse soils, the LC_{25} for collembolans was 576 mg·kg^{-1}, and the NOEC and LOEC for adverse effects in earthworms were 16 and 112 mg·kg^{-1}, respectively (ESG 2002). The results for fine soils reported by ESG (2002) were recalculated by Komex (2002) to take into account volatile losses that occur between spiking the sample and introducing the invertebrates 24 hours later. (Similar calculations had already been made by ESG for the data from the coarse soils.) Therefore, in fine soils the LC_{25} for collembolans was 259 mg·kg^{-1}, and the NOEC and LOEC for adverse effects in earthworms were 16 and 112 mg·kg^{-1}, respectively (Komex 2002).

Livestock and Wildlife

No studies on the effects of ethylbenzene on livestock or wildlife have been reported (Environment Canada 2004). Studies on experimental animals are covered in the next section.

Human and Experimental Animal Health Effects

The uptake of ethylbenzene in animals may occur via many routes, including oral, inhalation, subcutaneous, and dermal (percutaneous) absorption. Ethylbenzene is absorbed and rapidly distributed throughout the animal's body. It is preferentially stored in adipose tissue, but also accumulated in the kidneys, liver, and brain. Excretion through urine is the major route of elimination from the body. Hippuric acid and mandelic acid appear to be the main metabolites (Environment Canada 2004).

In an acute toxicological study, Pyykkö et al. (1987) reported an increase of 50% in the cytochrome P_{450} in the liver of rats and a decrease of 60% in the lungs, but no alterations of the organs were noted. Ethylbenzene has also been shown to reduce brain dopamine levels in both striatal and tuberoinfundibular regions (Romanelli et al. 1986). The changes in brain dopamine levels were found to result from metabolic interferences of ethylbenzene metabolites on the catabolism of dopamine.

Ethylbenzene is a relatively nontoxic compound, with the oral LD_{50} for rats ranging from 3.5 to 4.7 g·kg^{-1} (Wolf et al. 1956). The effects of ethylbenzene inhalation vary from nasal and eye irritation to vertigo, ataxia, and lung edema at concentrations from 1000 to 10 000 ppm (Environment Canada 2004).

Chronic exposure of rats to ethylbenzene showed sporadic incidence of salivation and lacrimation, increase in liver weight, increases in liver-to-body-weight ratios and liver-to-brain-weight ratios, and increases in platelet counts (Cragg et al. 1989). The same authors observed no effects on rabbits exposed to ethylbenzene up to 1610 ppm at which point the animals exhibited a reduced body weight. This study and an earlier one (Elovaara et al. 1985) provided no indication as to whether the organs were undergoing an adaptive or a toxic response.

Ethylbenzene is not considered to be a human carcinogen. A tolerable daily intake for ethylbenzene has not been determined by Health Canada; however, the U.S. Environmental Protection Agency provides a Reference Dose (RfD) of 0.1 $mg \cdot kg^{-1}$ bw per day and a Reference Concentration (RfC) of 1 $mg \cdot m^{-3}$ (USEPA 1991). The oral RfD is based on a study by Wolf et al. (1956) that examined histopathological changes in the kidney and liver of rats exposed to ethylbenzene through gavage. The inhalation RfC is based on studies by Andrew et al. (1981) and Hardin et al. (1981) that examined developmental toxicity of ethylbenzene to rats and rabbits.

Guideline Derivation

Canadian soil quality guidelines are derived for different land uses following the process outlined in CCME (1996a) using different receptors and exposure scenarios for each land use (Table 1). Various modifications to the 1996 protocol that were used in the Canada-wide Standard for Petroleum Hydrocarbons in Soil (CCME 2000) were also applied in the development of these guidelines, including the derivation of guidelines for different soil textures (coarse and fine) and depths (surface soil and subsoil). As defined in the Canada-wide Standard for Petroleum Hydrocarbons, fine-grained soils are those which contain greater than 50% by mass particles less than 75 µm mean diameter (D_{50} < 75 µm). Coarse-grained soils are those which contain greater than 50% by mass particles greater than 75 µm mean diameter (D_{50} > 75 µm). Surface soil refers to the unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for terrestrial plant growth, and can extend as deep as 1.5 m. Subsoil is defined as the unconsolidated regolith material above the water table not subject to soil forming processes; this nominally includes vadose zone materials below 1.5 m depth. Detailed derivations for ethylbenzene soil quality guidelines are provided in Environment Canada (2004).

Soil Quality Guidelines for Environmental Health

Environmental soil quality guidelines (SQG_Es) are based on soil contact using data from toxicity studies on plants and invertebrates. In the case of agricultural land use, soil and food ingestion toxicity data for mammalian and avian species are included. To provide a broader scope of protection, a nutrient and energy cycling check is calculated where data permit. For industrial land use, an off-site migration check is also calculated.

In the case of ethylbenzene, there are sufficient data to derive a guideline value for soil contact with plants and invertebrates (Table 2). A nutrient and energy cycling check was not calculated due to a lack of data. The available dataset was also not sufficient to meet the requirements of the CCME (1996) protocol for calculating the soil and food ingestion guideline; however, the process used to determine tolerable daily intakes for humans was adapted to calculate daily threshold doses for livestock. As bioconcentration of ethylbenzene into livestock fodder is not expected to be significant, a guideline was calculated only for the livestock soil ingestion (and not food ingestion) pathway.

Check values for groundwater have been calculated to determine ethylbenzene soil concentrations that will be protective of freshwater aquatic life and livestock associated with groundwater discharge to surface water. These groundwater check values are not applied in the determination of the SQG_Es, but should be applied on a site-specific basis (Table 2). An off-site migration check was not calculated for ethylbenzene with the rationale that, given the volatility and biodegradability of ethylbenzene, it is unlikely that significant amounts would remain after wind or water transport of soil.

Soil Quality Guidelines for Human Health

Human health soil quality guidelines (SQG_{HH}s) for threshold contaminants are usually derived using a TDI for the most sensitive receptor designated for a land use. In the absence of a TDI from Health Canada for ethylbenzene, the U.S. EPA's RfD for ethylbenzene was used in the calculations. Ingestion and dermal contact guidelines were calculated for all surface soils, but these two pathways were considered not applicable in subsoils, unless the ground is disturbed. Indoor vapour inhalation check values were calculated for both surface soils and subsoils. A groundwater check value was calculated to determine ethylbenzene soil concentrations that will be protective of drinking water.

The SQG_{HH} is the lowest of the human health guidelines and check values, and in the case of ethylbenzene, the

SQG_{HH} for all land uses and soil types is based on the groundwater (drinking water) check (Table 2).

Soil Quality Guidelines for Ethylbenzene

The soil quality guidelines are intended to be protective of both environmental and human health and are taken as the lower of the SQG_{HH} and the SQG_E. Where sufficient data exist for both, the interim soil quality criteria (CCME 1991) can be superseded.

In the case of ethylbenzene, the soil quality guidelines are calculated as the SQG_{HH} for all land uses and soil types. Because there are sufficient data to derive an SQG_{HH} and an SQG_E for each land use, the soil quality guidelines represent fully integrated *de novo* guidelines. The interim soil quality criteria for ethylbenzene (CCME 1991), and the soil quality guidelines for ethylbenzene derived in 1997, are superseded.

CCME (1996b) provides guidance on potential modifications to the final recommended soil quality guideline when setting site-specific objectives.

Table 2a. Soil quality guidelines and check values for ethylbenzene ($mg \cdot kg^{-1}$) in surface soil.

SURFACE SOIL	Land use							
	Agricultural		Residential/ parkland		Commercial		Industrial	
	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Guideline	**0.082[a]**	**0.018[a]**	**0.082[a]**	**0.018[a]**	**0.082[a]**	**0.018[a]**	**0.082[a]**	**0.018[a]**
Human health guidelines/check values								
SQG_{HH}	0.082[b]	0.018[b]	0.082[b]	0.018[b]	0.082[b]	0.018[b]	0.082[b]	0.018[b]
Soil ingestion guideline	10 000	10 000	10 000	10 000	36 000	36 000	620 000	620 000
Soil dermal contact guideline	58 000	58 000	58 000	58 000	210 000	210 000	560 000	560 000
Soil inhalation guideline	NC	NC	NC	NC	NC	NC	NC	NC
Inhalation of indoor air check (basement)	88	1 300	88	1 300	—	—	—	—
Inhalation of indoor air check (slab-on-grade)	55	1 300	55	1 300	630	6 500	630	6 500
Off-site migration check	—	—	—	—	—	—	NC[c]	NC[c]
Groundwater check (drinking water)	0.082	0.018	0.082	0.018	0.082	0.018	0.082	0.018
Produce, meat, and milk check	NC[d]	NC[d]	NC[d]	NC[d]	—	—	—	—
Environmental health guidelines/check values								
SQG_E	55[e]	120[e]	55[f]	120[f]	300[f]	430[f]	300[f]	430[f]
Soil contact guideline	55	120	55	120	300	430	300	430
Soil and food ingestion guideline	910	910	—	—	—	—	—	—
Nutrient and energy cycling check[g]	NC	NC	NC	NC	NC	NC	NC	NC
Off-site migration check	—	—	—	—	—	—	NC[c]	NC[c]
Groundwater check (livestock)	13 000[h]	NC[i]	—	—	—	—	—	—
Groundwater check (aquatic life)	50[j]	NC[i]	50[j]	NC[i]	50[j]	NC[i]	50[j]	NC[i]
Interim soil quality criterion (CCME 1991)	0.1		5		50		50	

Notes: NC = not calculated; ND = not determined; SQG_E = soil quality guideline for environmental health; SQG_{HH} = soil quality guideline for human health. The dash indicates a guideline/check value that is not part of the exposure scenario for this land use and therefore is not calculated.

[a]Data are sufficient and adequate to calculate an SQG_{HH} and an SQG_E. Therefore the soil quality guideline is the lower of the two and represents a fully integrated *de novo* guideline for this land use, derived in accordance with the soil protocol (CCME 1996a). The corresponding interim soil quality criterion (CCME 1991) is superseded by the soil quality guideline.

[b]The SQG_{HH} is the lowest of the human health guidelines and check values.

[c]Given the volatility and biodegradability of ethylbenzene, it is unlikely that significant amounts would remain after wind or water transport of soil, and so this pathway was not evaluated.

[d]This check is intended to protect against chemicals that may bioconcentrate in human food. Ethylbenzene is not expected to exhibit this behaviour, and so this pathway was not evaluated.

[e]The SQG_E for agricultural land uses is based on the lower of the soil contact guideline and the soil and food ingestion guideline.

[f]The SQG_E is based on the soil contact guideline.

[g]Data are insufficient/inadequate to calculate the nutrient and energy cycling check for this land use.

[h]This environmental groundwater check value is provisional because it is not based on the existing Canadian Water Quality Guideline for the protection of livestock watering for ethylbenzene. For details on the derivation, see the scientific supporting document (Environment Canada 2004). This check value is not used in determining the national soil quality guideline, but is provided as a reference for site-specific application.

[i]The environmental groundwater check value has not been determined because calculations show that in 100 years groundwater migration through fine soils will be less than 10 metres. For site-specific calculations where the protection of potable groundwater pathway is active, a hydraulic conductivity of 32 $m \cdot y^{-1}$ should be assumed, if adequate measured data are not available.

[j]This environmental groundwater check value is not used in determining the national soil quality guideline, but is provided as a reference for site-specific application.

Table 2b. Soil quality guidelines and check values for ethylbenzene ($mg \cdot kg^{-1}$) in subsoil.

SUBSOIL	Land use							
	Agricultural		Residential/ parkland		Commercial		Industrial	
	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Guideline	**0.082[a]**	**0.018[a]**	**0.082[a]**	**0.018[a]**	**0.082[a]**	**0.018[a]**	**0.082[a]**	**0.018[a]**
Human health guidelines/check values								
SQG_{HH}	0.082[b]	0.018[b]	0.082[b]	0.018[b]	0.082[b]	0.018[b]	0.082[b]	0.018[b]
Soil ingestion guideline	NC	NC	NC	NC	NC	NC	NC	NC
Soil dermal contact guideline	NC	NC	NC	NC	NC	NC	NC	NC
Soil inhalation guideline	NC	NC	NC	NC	NC	NC	NC	NC
Inhalation of indoor air check (basement)	88	1 300	88	1 300	—	—	—	—
Inhalation of indoor air check (slab-on-grade)	63	1 400	63	1 400	670	6 700	670	6 700
Off-site migration check	—	—	—	—	—	—	NC[c]	NC[c]
Groundwater check (drinking water)	0.082	0.018	0.082	0.018	0.082	0.018	0.082	0.018
Produce, meat, and milk check	NC[d]	NC[d]	NC[d]	NC[d]	—	—	—	—
Environmental health guidelines/check values								
SQG_E	110[e]	240[e]	110[f]	240[f]	600[f]	860[f]	600[f]	860[f]
Soil contact guideline	110	240	110	240	600	860	600	860
Soil and food ingestion guideline	NC	NC	—	—	—	—	—	—
Nutrient and energy cycling check[g]	NC	NC	NC	NC	NC	NC	NC	NC
Off-site migration check	—	—	—	—	—	—	NC[c]	NC[c]
Groundwater check (livestock)	13 000[h]	NC[i]	—	—	—	—	—	—
Groundwater check (aquatic life)	50[j]	NC[i]	50[j]	NC[i]	50[j]	NC[i]	50[j]	NC[i]
Interim soil quality criterion (CCME 1991)	0.1		5		50		50	

Notes: NC = not calculated; ND = not determined; SQG_E = soil quality guideline for environmental health; SQG_{HH} = soil quality guideline for human health. The dash indicates a guideline/check value that is not part of the exposure scenario for this land use and therefore is not calculated.

[a]Data are sufficient and adequate to calculate an SQG_{HH} and an SQG_E. Therefore the soil quality guideline is the lower of the two and represents a fully integrated *de novo* guideline for this land use, derived in accordance with the soil protocol (CCME 1996a). The corresponding interim soil quality criterion (CCME 1991) is superseded by the soil quality guideline.

[b]The SQG_{HH} is the lowest of the human health guidelines and check values.

[c]Given the volatility and biodegradability of ethylbenzene, it is unlikely that significant amounts would remain after wind or water transport of soil, and so this pathway was not evaluated.

[d]This check is intended to protect against chemicals that may bioconcentrate in human food. Ethylbenzene is not expected to exhibit this behaviour, and so this pathway was not evaluated.

[e]The SQG_E for agricultural land uses is based on the lower of the soil contact guideline and the soil and food ingestion guideline.

[f] The SQG_E is based on the soil contact guideline.

[g] Data are insufficient/inadequate to calculate the nutrient and energy cycling check for this land use.

[h] This environmental groundwater check value is provisional because it is not based on the existing Canadian Water Quality Guideline for the protection of livestock watering for ethylbenzene. For details on the derivation, see the scientific supporting document (Environment Canada 2004). This check value is not used in determining the national soil quality guideline, but is provided as a reference for site-specific application.

[i] The environmental groundwater check value has not been determined because calculations show that in 100 years groundwater migration through fine soils will be less than 10 metres. For site-specific calculations where the protection of potable groundwater pathway is active, a hydraulic conductivity of 32 $m \cdot y^{-1}$ should be assumed, if adequate measured data are not available.

[j] This environmental groundwater check value is not used in determining the national soil quality guideline, but is provided as a reference for site-specific application.

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