2005 Review of Canada-Wide Standards for Petroleum Hydrocarbons in Soil:

Report of the Model Parameter Advisory (MPA) Sub Group

March 2006

Acknowledgement

We would like to thank all the members of the Model Parameter Advisory Sub Group for their contribution to this effort, including participation in numerous conference calls and a day-long face-to-face meeting, as well as countless hours spent reviewing documentation and meeting minutes in advance of the conference calls.

Norman Sawatsky, CCME SQGTG
Warren Kindzierski, Chair

Executive Summary

The Model Parameter Advisory (MPA) Sub Group was formed to review information and develop recommendations and advice for the CCME Soil Quality Guidelines Task Group with respect to model parameters and approaches used in the soil vapour and groundwater transport models for petroleum hydrocarbon contaminants in soil.

The MPA Sub Group conducted ten teleconference meetings and held one day-long meeting in Calgary, AB between August 2005 and February 2006. These meetings resulted in a number of recommendations being put forward to the CCME Soil Quality Guidelines Task Group. These recommendations are presented below with further rationale provided in the body of this report:

On use of the Johnson & Ettinger vapour transport model:

1 The full form of the Johnson & Ettinger vapour transport model should be used to represent both coarse and fine-textured soil for the Canada Wide Standard for Petroleum Hydrocarbons.

On changes to the Johnson & Ettinger vapour intrusion model for Tier 1 evaluations:

2 A combination of model parameter modifications are put forward, as summarized in Table ES-1.

3 An Adjustment Factor of 10 should be used in the model.

4 A minimum distance of 30 cm should continue to be used for diffusional path length.

5 The following soil vapour permeability values should be used: $5(10^{-8})$ cm^2 for coarse-grained soils, and 10^{-9} cm^2 for fine-grained soils.

6 The current approach of using a soil temperature of 21°C and Henry's Law constants upon which to base partitioning properties of PHC sub-fractions should continue to be used.

7 A value of 360 cm should be used to represent 2-storey slab-on-grade residential building height as opposed to 488 cm.

8 The following air exchange rates should be used: 0.5 ach for a residential building, and 0.9 for commercial buildings.

9 Dry soil of the same texture as that underlying a building should be used to represent the conditions of soil residing in foundation cracks for fine- and coarse-grained cases.

10 The following total soil porosity values should be used: 0.47 cm^3/cm^3 for fine-grained soils, and 0.36 cm^3/cm^3 for coarse-grained soils.

11 The current default values for building length, building width, and crack surface area (A_{cr}) should continue to be used; and basement wall area should be included in the calculation of building area (A_B).

Table ES-1 Listing of MPA Sub Group Recommendations on vapour intrusion model parameter modifications.

Exposure scenario: / **Model Parameter**	Residential coarse soils case	Residential fine soils case	Commercial coarse soils case	Commercial fine soils case
Use of Adjustment Factor of 10:	Yes	Yes	Yes	Yes
Diffusional path length modification:	no modification recommended (remains at 30 cm)	no modification recommended (remains at 30 cm)	no modification recommended (remains at 30 cm)	no modification recommended (remains at 30 cm)
Vapour permeability modification:	change from 10^{-8} to $5(10^{-8})$ cm^2	apply at Tier 1 (value remains at 10^{-9} cm^2)	change from 10^{-8} to $5(10^{-8})$ cm^2	apply at Tier 1 (value remains at 10^{-9} cm^2)
Soil temperature modification:	no modification recommended (remains at 21°C)	no modification recommended (remains at 21°C)	no modification recommended (remains at 21°C)	no modification recommended (remains at 21°C)
Building height modification	change from 488 to 360 cm	change from 488 to 360 cm	no modification recommended (remains at 300 cm height)	no modification recommended (remains at 300 cm height)
Air exchange modification:	change from 1 to 0.5 ach	change from 1 to 0.5 ach	change from 2 to 0.9 ach	change from 2 to 0.9 ach
Modification of moisture content of soil residing in foundation cracks	change from coarse soil to assuming dry soil of the same texture as that underlying the building	change from coarse soil to assuming dry soil of the same texture as that underlying the building	change from coarse soil to assuming dry soil of the same texture as that underlying the building	change from coarse soil to assuming dry soil of the same texture as that underlying the building
Modification of total soil porosity	change from 0.4 to 0.36 cm^3/cm^3	change from 0.3 to 0.47 cm^3/cm^3	change from 0.4 to 0.36 cm^3/cm^3	change from 0.3 to 0.47 cm^3/cm^3
Modification of building surface area, crack surface area, and A_{cr}/A_b ratio	no modifications recommended for these building parameters	no modifications recommended for these building parameters	no modifications recommended for these building parameters	no modifications recommended for these building parameters
Implications:	Re-calculated F1, F2 guidelines similar to current guidelines.	Re-calculated F1, F2 guidelines ~40% lower than current guidelines. However, ecological pathway will still drive the Tier 1 analysis.	Re-calculated F1, F2 guidelines similar to current guidelines.	Re-calculated F1 guideline similar to current guideline. Re-calculated F2 guideline ~10% lower than current guideline. However, ecological pathway will still drive the Tier 1 analysis.

On changes to the groundwater model for Tier 1 evaluations:

12 Solubility limits and Raoult's Law may be appropriate to implement for Tier 2 or Tier 3 evaluation, but they should not be used in developing Tier 1 groundwater guidelines.

13 A 10-m width as opposed to the current default of 30 m should be used for groundwater source width.

14 The current model assumption of a 0-m distance offset should continue to be used for the distance to a potable water receptor.

15 The current model assumption of a 10-m distance offset should continue to be used for the distance to surface water.

16 An offset distance of 0 m (opposed to 10 m) should be used for the distance to livestock watering.

17 The livestock RfC for crude oil should be revised from 23 mg/L to 230 mg/L, resulting in daily threshold exposure doses (DTEDs) of 53 mg/L and 49 mg/L for F1 and F2, respectively.

18 A calculated mixing zone thickness should be used for both the potable water and ecological pathways.

19 While no changes should be made at Tier 1 to deal with multiple layers to represent groundwater aquifers, users should be allowed to define unsaturated zone and saturated zone conditions separately to reflect actual conditions at a contaminated site in Tier 2 evaluations.

20 The following values should be used for saturated hydraulic conductivity of fine-grained soils: 3.2 m/yr for protection of the freshwater life pathway, 32 m/yr for the drinking water pathway, and 32 m/y for the livestock watering pathway.

21 Consistent assumptions should be used for all model parameters for the aquatic life, drinking (potable) water, and livestock watering pathways except for: (i) hydraulic conductivity for the potable water and livestock watering pathways – which should be adjusted to 32 m/y to reflect aquifer properties required to support potable water wells and livestock dugouts, and (ii) the offset for aquatic life receptors – which should be maintained at 10 m.

22 A working group should be struck to review all aspects of the groundwater model recommended in the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. The review should include aspects of: i) simplicity, reliability, and versatility of the model currently being employed by CCME, ii) assumptions inherent to the model, and iii) appropriate parameterization to ensure accurate, reliable, and conservative estimates of risk when applied to typical sites in Canada.

On miscellaneous issues:

23 A table of soil vapour screening level values should be developed or adopted for Tier 2 and Tier 3 evaluations only. These values should be based on the source of contamination located at least 1 m below a building foundation.

24 A protocol for soil vapour sampling should be developed to support screening level values for Tier 2 and Tier 3 evaluations.

25 Absence of measurable concentrations of soil contamination at lateral distances greater than 30 m from existing or potential future buildings should be sufficient to discount the vapour transport pathway during Tier 2 or 3 evaluations, unless there are precluding factors such as a low permeability surface or significant preferential migration pathways between the contaminant source and receptor location.

26 A depleting contamination source should not be incorporated into the CWS.

27 Exposure to airborne soil particles containing PHCs are not considered important at PHC-contaminated sites.

28 There is no need to further consider fractured clay till conditions as part of the CWS guidance.

29 Not enough information is available to develop a guideline to protect buried infrastructure based on the current science.

30 There is no need to consider explosive hazards in the development of separate guidelines as part of the CWS guidance.

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1.0 Introduction

The Canadian Council of Ministers of the Environment (CCME) is the major intergovernmental forum in Canada for discussion and joint action on environmental issues of national concern. The 14 member governments work as partners in developing nationally consistent environmental standards and practices.

The Canada-Wide Standards (CWS) for Petroleum Hydrocarbons (PHC) in Soil ("the Standard") was established pursuant to the 1998 Canada-wide Accord on Environmental Harmonization of the Canadian Council of Ministers of the Environment (CCME) and its Canada-wide Environmental Standards Sub-Agreement. The PHC CWS is a remediation standard that specifies the environmental endpoints and assessment procedures necessary to address releases of PHC in the soil and subsurface environment. The Standard is based on an application of risk analysis that identifies acceptable concentrations of each PHC fraction in soil in consideration of exposure pathways and protection goals for receptors (humans, plants, animals) applicable for each land use.

The PHC CWS was endorsed by Ministers of Environment (with the exception of Quebec) in May 2001. A commitment was made to review additional scientific, technical and economic analysis to reduce information gaps and uncertainties and allow revisions in 2005. Since that time, a CCME Soil Quality Guidelines Working Group ("the Working Group") requested and reviewed information from stakeholders regarding concerns with the current CCME PHC CWS. The Working Group identified priorities and nominated those priorities to the CCME Soil Quality Guidelines Task Group (SQGTG). The SQGTG agreed on final areas of review of the PHC CWS. A review of the parameters in soil vapour and groundwater transport models for petroleum hydrocarbon contaminants in soil was identified as an area to be considered for revisions.

Mandate of MPA Sub Group –The mandate of the Model Parameter Advisory Sub Group was to develop recommendations and advise the CCME Soil Quality Guidelines Task Group with respect to updating model parameters and methods applied in the soil vapour and groundwater transport models for Petroleum Hydrocarbon contaminants in soil. The sub group was also to review information and make recommendations with respect to appropriate guidance for protection from explosive hazards and contaminant migration into buried water lines.

Specific activities undertaken by the Sub Group included:

- Reviewing relevant information submitted to CCME with respect to contaminant transport model parameters, explosive hazards, and effects on buried infrastructure.
- Obtaining and reviewing additional information directly relevant to submissions that were made to CCME.
- Developing scope and directing research/review activities undertaken to complete the task.

- Examining relevant policy and protocol decisions that were developed for the CCME Soil Quality Guidelines for Petroleum Hydrocarbons in Soils.
- Determining if there were relevant and significant technical or policy changes since development of the CCME Soil Quality Guidelines for Petroleum Hydrocarbons in Soils that may result in substantial changes to the current guidelines.
- Developing updated recommendations and rationale for vapour intrusion, groundwater, explosive hazard and effects to waterlines.
- Investigating the potential for use of soil vapour screening levels in the vapour intrusion pathway and appropriate mechanisms for implementation in keeping with defined protocol and policy decisions.

The Sub Group reported to the CCME Soil Quality Guidelines Task Group about its activities and work progress by providing meeting minutes on a regular and timely basis. Membership of the Sub Group is provided in Appendix A.

2.0 Recommendations

Vapour Transport Issues

2.1 Use of full form of Johnson & Ettinger vapour transport model to represent coarse and fine textured soil.

1 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use the full form of the Johnson & Ettinger vapour transport model (Johnson and Ettinger, 1991) to represent both coarse and fine-textured soil for the Canada Wide Standard for Petroleum Hydrocarbons.

Rationale – Information discussed by the MPA Sub Group support that the full form of the model is more defensible from a technical standpoint than applying the individual components of the model (advection and diffusion) separately, and offers flexibility in applying site-specific data for contaminated sites at the Tier 2/3 level. If input parameters are used that are characteristic of advection or diffusion-dominated flow, these will automatically cause the model to behave like the simplified forms of the model. Therefore, there is no need to use the simplified version of the equation at tier 1.

2.2 Proceeding on changes to Johnson & Ettinger vapour intrusion model for a combination of parameter modifications.

2 **Final Sub Group Recommendation** – The Sub Group reached agreement on recommending a combination of vapour intrusion model parameter modifications. These modifications are illustrated in Table 1 and elaborated upon in subsequent points below. Table 2 provides a comparison between Tier 1 values based on recommendations in this report and Tier 1 values established in 2001. Table 3 provides complete listing of key building and site parameters, recommended values for 2001, for the draft 2005 CCME *Protocol for the derivation of Human Health and Soil Quality Guidelines* (2005 draft Protocol) and recommendations by the subgroup.

Where recommendations have differed from the 2001 review but agree with the 2005 draft Protocol, it was assumed that there is limited need to elaborate as these parameters were reviewed and accepted by CCME during this revision. Where there is significant departure from the 2005 draft Protocol, additional explanation is given.

2.3 Incorporation of an Adjustment Factor in the Johnson & Ettinger vapour intrusion model.

3 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use an Adjustment Factor of 10 in the Johnson & Ettinger vapour intrusion model.

Rationale – The Sub Group reviewed submissions of data on measured PHC vapour concentrations for coarse soil. This included information presented in Health Canada's submission "Soil Vapour Intrusion Guidance for Health Canada Screening Level Risk Assessment" (Golder, 2004) and CPPI empirical site data on measured PHC vapour concentrations for coarse soils (Appendix B). These data were compared to predicted vapour concentrations using the Johnson & Ettinger vapour intrusion model using default assumptions for model parameters.

This comparison tended to show "predicted/observed" F1 vapour concentration ratios consistently greater than 100. Furthermore, relatively rapid attenuation of PHC vapours – likely augmented by biodegradation – has been observed in several studies; this attenuation is greater than that predicted by the presently applied model (which does not account for biodegradation). Although there was discussion about the appropriate range of values that might be associated with the predicted/observed range as well as site conditions that might influence this value, it was felt that a modifier of 10 could be conservatively applied to all observations.

Modifications to input values were considered for a number of parameters in the Johnson & Ettinger vapour intrusion model that are supported by recent scientific literature. However, these modifications result in even less attenuation than that already being observed compared to observed site data at actual petroleum hydrocarbon contaminated sites.

On the other hand, modifications to other selected model parameters – e.g. equilibrium partitioning relationships and biodegradation – were not considered because of an inability to understand how best to modify these types relationships in the model due to limitations in science. Therefore, use of the adjustment factor is intended to strike a balance between modifications to selected parameters inputs for which scientific information exists and an inability to modify other input parameters due to limitations in science.

Literature information compiled as part of the Sub Group's activities is not contrary to the option of incorporating an adjustment factor into the model to balance the effect of increased conservatism that will occur as a result of changes to parameter input values. This approach is also consistent with the New Jersey Department of Environmental Protection (NJDEP, 2005). NJDEP recently incorporated similar factors for vapour transport of PHCs.

The conditions for use of an adjustment factor for deriving Tier 1 guidelines need to be described and provided as part of the CWS. It is understood that the process would defer to a Tier 2/3 approach if these condition were not met at a site. The adjustment factor would apply only to soil guidelines (not to soil vapour guidelines at this time), and only for PHCs. It was noted that supporting empirical evidence for this adjustment factor was based dominantly on measurements for pretroleum hydrocarbons and BTEX (benzene, toluene, ethylbenzene and xylene) compounds.

It is recommended that the adjustment factor can also be used in Tier 2 modifications of Tier 1 values. This is consistent with the literature observations.

2.4 Diffusional path length.

4 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG continue to use the minimum distance of 30 cm for diffusional path length (L_t).

Rationale – The Sub Group discussed using 100 cm as the minimum distance for the diffusional path length as an alternative to the current default of 30 cm. It has been suggested that when L_t is less than 100 cm, the vapour intrusion model becomes increasingly uncertain. Therefore, Tier 2/3 analysis is preferable for short distances

Feedback from N. Sawatsky attendance at the SQGTG meeting in Whitehorse in November 2005 indicated that the SQGTG saw implementation issues with changing the diffusional path length from 30 cm to 100 cm. A. Walter indicated that industry did not have issues with the current default of 30 cm.

From a scientific point-of-view a 100-cm diffusional path length is more defensible for application of the Johnson and Ettinger vapour intrusion model. However, the issue of avoiding implementation issues associated with having more sites treated as Tier 2/3 cases and the fact that industry did not have issues with the current default of 30 cm are reasons for maintaining the minimum distance of 30 cm. Guidelines calculated using a 30 cm path length will be slightly more conservative than values calculated using a 100 cm path length.

2.5 Soil vapour permeability.

5 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use the following soil vapour permeability values for fine- and coarse-grained soils:

- $5(10^{-8})$ cm^2 for coarse-grained soils
- 10^{-9} cm^2 for fine-grained soils

Rationale – The MPA subgroup reviewed relevant submissions to the SQGTG. With respect to coarse-grained soils, the resulting soil gas infiltration rate (Q_{soil}) is about 5 L/min using a soil vapour permeability of $5(10^{-8})$ cm^2 and changes to other model parameters. This value seemed to be more in line with the rate of vapour intrusion into buildings based on the literature survey from Health Canada's submission, "Soil Vapour

Intrusion Guidance for Health Canada Screening Level Risk Assessment" (Golder, 2004). In addition, these changes were more in line with empirical α values compiled in the Golder report and the range for $Q_{soil}/Q_{building}$ recommended by Johnson (2002 and 2005).

With respect to fine-grained soils, the Sub Group discussed the merits of using 10^{-9} or 10^{-10} cm^2 to represent vapour permeability at the Tier 1 level. The resulting guideline using either value is greater than that derived for the ecological pathway. The implication is that the ecological pathway will drive the Tier 1 analysis regardless of the value used to represent vapour permeability for the fine-grained soils case.

As a general rule, uncertainties will always be associated with using theoretical models to derive media guidelines for public health purposes. The subgroup discussed the potential for higher vapour permeabilities to exist in fine grained soils due to fractured flow and due to potential for the coarser textured subcategories in the fine grained category to have naturally higher average permeabilities. In this situation the higher of the vapour permeability values (10^{-9} cm^2) is recommended for the fine-grained soils case for the purpose of guideline development.

2.6 Soil temperature below buildings.

6 **Final Sub Group Recommendation** – The current CCME approach uses a soil temperature of 21°C and Henry's Law constants upon which partitioning properties of PHCs using are based. It is recommended that Henry's Law constants for PHC sub-fractions continue to use a soil temperature of 21°C.

Rationale – The current Henry's Law constants values are calculated from solubility and vapour pressure values for PHC sub-fractions, which are in turn derived by correlating data reflecting a range of temperatures from 10°C to 25°C. N. Sawatsky presented University of Alberta theoretical modelling results, "Temperature gradient calculations in soil to determine an appropriate Henry's Law Constant for use in the J & E Model for Canadian Sites (CCME contract 376-2006) that examined temperature attenuation below a concrete slab. These results indicate that attenuation of soil temperature up to 1 m below a concrete slab is, at most, a few degrees C.

This is consistent with that observed by a Greek study (Mihalakakou et al., 1995) and research by I. Hers at University of British Columbia. As sub-slab temperatures are likely only a few degrees lower than building temperatures, and given the uncertainties in the assumed Henry's Law constants, a temperature adjustment does not appear to be warranted at this time.

2.7 Two-storey residential building height.

7 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use a value of 360 cm (1 ½ stories) for a 2-storey slab-on-grade residential building height as opposed to the default of 488 cm.

Rationale – This assumption is intended to be consistent with the US EPA (2003) *User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings* and to account for differences in air exchange between different stories; empirical data indicate that chemical concentrations resulting from vapour intrusion are likely to be lower on the 2nd storey of a building due to incomplete mixing. This is also consistent with recommended ranges for specific parameters that were included in the review (see section 2.5).

2.8 Building air exchange rate.

8 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use a value of 0.5 ach for a residential building and 0.9 for commercial buildings.

Rationale – The value of 0.5 ach for a residential building is more consistent with long-term air exchange rate values indicated from scientific literature for Canadian and northern US conditions. With respect to air exchange rate for commercial buildings, the current Tier 1 default model assumption for building air exchange in a commercial setting is 2 ach. A range of 0.75 to 1 ach was discussed by the Sub Group with the intent of adopting a single value within this range.

The range of 0.75 to 1 ach is more consistent with recent commercial building ventilation data from the US Environmental Protection Agency Building Assessment Survey and Evaluation (BASE) Study as reported by NIST (2004). As a result, a mid-point value of 0.875 ach (rounded up to 0.9 ach) is recommended.

2.9 Moisture content of soil residing in foundation cracks.

9 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG assume dry soil (i.e. $m/c = 0$) of the same texture as that underlying the building be used to represent the conditions of soil residing in foundation cracks for the fine- and coarse-grained cases.

Rationale – The 2001 Tier 1 standards are based on a set diffusivity in cracks of 0.00454 cm^2/s, equal to the diffusivity calculated at that time for coarse soils. However, proposed soil properties result in a higher calculated diffusivity in fine soils; therefore, it is recommended that soil in the cracks be assumed to be the same as the soil beneath the building.

I. Mitchell of the MPA Sub Group undertook a series of calculations to investigate the effect of soil moisture content (*m/c*) in foundation cracks on derivation of the standard for the fine- and coarse-grained soil cases. These calculations examined foundation crack *m/c* being the same as *m/c* of the underlying soil (current default assumption) and assuming dry soils (i.e. *m/c* = 0) occupying foundation cracks.

For coarse-grained soils, results indicated that an assumption of soil *m/c* in foundation cracks being the same as *m/c* of the underlying soil has no noticeable influence on the resulting standard because it is an advection-dominated situation. For fine-grained soils, results indicated that an assumption of soil *m/c* in foundation cracks being the same as *m/c* of the underlying soil substantially increases the fine-grained soil guidelines. This effect is larger at lower soil vapour permeability (i.e. where diffusive flow becomes more dominant).

The Sub Group believes that soil *m/c* values of foundation cracks likely range somewhere between the condition of dry soils and that of the underlying soils in actual situations. However, validating this is next to impossible. As a general rule, uncertainties will always be associated with using theoretical models to derive media standards for public health purposes. In this situation the lower of the moisture content values (i.e. dry soil conditions) is slightly more conservative and therefore recommended to represent the conditions of fine- and coarse-grained soils residing in foundation cracks for the purpose of guideline development.

2.10 Total soil porosity.

10 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use the following values for fine- and coarse-grained soils:

- 0.47 cm^3/cm^3 for fine-grained soils
- 0.36 cm^3/cm^3 for coarse-grained soils

Rationale – These default values are more consistent with inter-relationships between porosities, specific gravities, and bulk densities. In addition, these values are consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*.

2.11 Building surface area (A_b), crack surface area (A_{cr}).

11 **Final Sub Group Recommendation** – The Sub Group sees no reason to depart from current model assumptions for building length/width and crack area. The basement wall area should be included in the estimation of A_b.

Rationale – These parameters are not highly influential model parameters and a review of the default values still indicates that the numbers are reflective of the appropriate default land use. Including the basement wall area in the calculation of A_b is consistent with the current draft of the CCME protocol and other regulatory jurisdictions, and does not affect the Tier 1 guidelines since the slab-on-grade scenarios govern.

Table 1 Listing of MPA Sub Group Recommendations on vapour intrusion model parameter modifications.

Exposure scenario: / **Model Parameter**	Residential coarse soils case	Residential fine soils case	Commercial coarse soils case	Commercial fine soils case
Use of Adjustment Factor of 10:	Yes	Yes	Yes	Yes
Diffusional path length modification:	no modification recommended (remains at 30 cm)	no modification recommended (remains at 30 cm)	no modification recommended (remains at 30 cm)	no modification recommended (remains at 30 cm)
Vapour permeability modification:	change from 10^{-8} to $5(10^{-8})$ cm^2	apply at Tier 1 (value remains at 10^{-9} cm^2)	change from 10^{-8} to $5(10^{-8})$ cm^2	apply at Tier 1 (value remains at 10^{-9} cm^2)
Soil temperature modification:	no modification recommended (remains at 21°C)	no modification recommended (remains at 21°C)	no modification recommended (remains at 21°C)	no modification recommended (remains at 21°C)
Building height modification	change from 488 to 360 cm	change from 488 to 360 cm	no modification recommended (remains at 300 cm height)	no modification recommended (remains at 300 cm height)
Air exchange modification:	change from 1 to 0.5 ach	change from 1 to 0.5 ach	change from 2 to 0.9 ach	change from 2 to 0.9 ach
Modification of moisture content of soil residing in foundation cracks	change from coarse soil to assuming dry soil of the same texture as that underlying the building	change from coarse soil to assuming dry soil of the same texture as that underlying the building	change from coarse soil to assuming dry soil of the same texture as that underlying the building	change from coarse soil to assuming dry soil of the same texture as that underlying the building
Modification of total soil porosity	change from 0.4 to 0.36 cm^3/cm^3	change from 0.3 to 0.47 cm^3/cm^3	change from 0.4 to 0.36 cm^3/cm^3	change from 0.3 to 0.47 cm^3/cm^3
Modification of building surface area, crack surface area, and A_{cr}/A_b ratio	no modifications recommended for these building parameters	no modifications recommended for these building parameters	no modifications recommended for these building parameters	no modifications recommended for these building parameters
Implications:	Re-calculated F1, F2 guidelines similar to current guidelines.	Re-calculated F1, F2 guidelines ~40% lower than current guidelines. However, ecological pathway will still drive the Tier 1 analysis.	Re-calculated F1, F2 guidelines similar to current guidelines.	Re-calculated F1 guideline similar to current guideline. Re-calculated F2 guideline ~10% lower than current guideline. However, ecological pathway will still drive the Tier 1 analysis.

Table 2. Comparison of vapour inhalation guidelines for 2001 and based on recommendations in the MPA report.

Scenario	Year	Coarse Soils		Fine Soils	
		F1	F2	F1	F2
Residential	2001	30	150	940	5200
	2006	30	150	610	3100
	%change	0	0	-35%	-40%
Commercial	2001	310	1700	4600	25000
	2006	320	1700	4600	23000
	%change	+3%	0	0	-8%

Notes:

- calculated objectives do not consider any proposed changes from other advisory groups
- all calcualated objectives are in units of mg/kg unless otherwise specified
- total porosity now calculated from bulk density
- full version of J&E model applied for both coarse and fine soils
- vapour permeability set at 5×10^{-8} cm^2 for coarse soils and 1×10^{-9} cm^2 for fine soils
- changes to various building parameters
- incorporation of adjustment factor of 10

Table 3. Summary of Key Soil Parameters recommended by the Model Parameters Technical Advisory Subgroup compared with the parameters used in 2001 and those proposed in the 2005 draft Protocol.

PARAMETER	COARSE SOILS			FINE SOILS		
	2001	**Revised Protocol**	**Proposed**	**2001**	**Revised Protocol**	**Proposed**
Bulk Density (g/cm^3)	1.7	1.7	1.7	1.4	1.4	1.4
Total Porosity	0.4	0.36	0.36	0.3	0.47	0.47
Soil Water-filled Porosity	0.119	0.119	0.119	0.168	0.168	0.168
Soil Air-filled Porosity	0.281	0.241	0.241	0.132	0.302	0.302
Crack Diffusivity	0.00454	NS[b]	0.0128[c]	0.00454	NS[b]	0.0183[c]
Organic Carbon Content (g/g)	0.005	0.005	0.005	0.005	0.005	0.005
Soil Temperature (^oC)	21	21	21	21	21	21
Vapour Permeability (cm^2)	$1x10^{-8}$	$1x10^{-8}$	$5x10^{-8}$	NA	$1x10^{-10}$	$1x10^{-9}$
Hydraulic Conductivity (m/y)						
potable water	320	320	320	32	32	32
freshwater life	320	320	320	0.32	32	3.2
livestock watering	320	320	320	0.32	32	32
Recharge (m/y)	0.28	0.28	0.28	0.20	0.20	0.20
Effective Mixing Depth (m)	2[a]	calculated	calculated	2[a]	calculated	calculated
Hydraulic Gradient	0.05	0.028	0.05	0.05	0.028	0.05

a – calculated for freshwater life and livestock watering pathways
b – assumed to be the same as underlying soil
c – calculated based on underlying soil properties

Groundwater Transport Issues

Final Sub Group Recommendations – Final subgroup recommendations are consistent with the 2005 draft Protocol. Recommendations are listed in table 2. Due to some changes that were recommended in 2005 and not reflected in the 2001 PHC review, there are differences between the recommended groundwater criteria for the report. A comparison between the 2001 values and calculated values based on the MPA subgroup recommendations can be found in Appendix C. In addition, the Soil Quality Task Group recommended that the subgroup revisit the hydraulic gradient and recalculate the groundwater values using a 0.028 gradient. The resultant changes in the guidelines are listed in the memorandum attached in Appendix C.

2.12 Use of Raoult's Law and Solubility Limits in developing groundwater guidelines.

12 **Final Sub Group Recommendation** – Raoult's Law and solubility limits may be appropriate to implement at Tier 2 or Tier 3. However, the Sub Group has recommended against incorporating solubility limits and Raoult's Law in developing Tier 1 groundwater guidelines.

Rationale – Complexities (and reduced calculation transparency) involved in undertaking partitioning calculations where multiple petroleum hydrocarbon substances are involved is the main reason for recommending against adopting solubility limits and Raoult's Law in developing Tier 1 groundwater guidelines. Also, the influence of solubility limits and Raoult's Law is only significant at relatively high PHC concentrations, and as a result these concepts have only a small effect on the governing Tier 1 guidelines.

2.13 Groundwater source width.

13 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use 10-m width as opposed to the current default of 30 m for groundwater source width.

Rationale – This value is consistent with the assumed source width specified in the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*, and this model assumption has no effect on derivation of Tier 1 groundwater guidelines. Use of a 30 m source width with a 10 m source length implies that the guidelines are based on a 300 m^2 source area, but since source length is a sensitive parameter and source width is not, the current (2001) default dimensions are non-conservative.

2.14 Distance to potable water receptor.

14 **Final Sub Group Recommendation** – The MPA Sub Group sees no reason to depart from the current model assumption of a 0-m distance for this parameter.

Rationale – The Sub Group believes that an offset would lead to potential land use restrictions and mechanisms are in place at Tier 2 to allow for an offset distance.

2.15 Distance to surface water.

15 **Final Sub Group Recommendation** – The MPA Sub Group sees no reason to depart from the current model assumption of a 10-m distance for this parameter.

Rationale – This value is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*, and surface water body locations are considered to be fixed, with distances less than 10 m being addressed at Tier 2 or Tier 3.

2.16 Distance to livestock watering.

16 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use an offset of 0 m as opposed to the default of 10 m for this parameter.

Rationale – This value is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. In addition an offset would lead to potential land use restrictions.

17 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the livestock RfC for crude oil be adjusted from 23 mg/L to 230 mg/L, resulting in daily threshold exposure doses (DTEDs) of 53 mg/L and 49 mg/L for F1 and F2, respectively.

Rationale – The current daily threshold exposure dose values appear to have been miscalculated. When the subgroup examined information presented in section 4.3.3 of the scientific rationale and in particular, calculations presented on pages 4-140 and 4-141, there appeared to be a factor of 10 error in the calculation. The MPA subgroup recommends that this calculation be corrected.

2.17 Mixing zone thickness.

18 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use a calculated mixing zone thickness for both the potable water and ecological pathways.

Rationale – This approach is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*, and results in greater internal consistency in the Standard. The calculated mixing depths (using current model parameters) are 0.47 m for coarse soils and 2.2 m for fine soils (compared to a fixed value of 2 m used historically for the potable water pathway), resulting in a slight increase in the values for the protection of potable water for fine soils, and a moderate decrease in these values for coarse soils.

Note: This recommendation will result in the same model being used for environment Freshwater Aquatic Life (FWAL) and Drinking Water (DW) calculations. It requires recalculation of the Tier 1 Drinking Water guidelines based on a change in the mixing zone depth calculation. With this change, the equations for DF3, the third dilution factor for aquatic life and the dilution factor for soil to groundwater migration for drinking water will become the same.

2.18 Single/multiple layers to represent groundwater aquifer.

19 Final Sub Group Recommendation – The MPA Sub Group does not recommend changes to the Tier 1 tables. However, the MPA Sub Group recommends that the CCME SQGTG allow users to define unsaturated zone and saturated zone conditions separately to reflect actual conditions at a contaminated site in the Tier 2 guidance. In addition, the Sub Group has also recommended that the decay constant equation in the groundwater model should be changed to $L_{us} = 0.6931/t_{1/2us}$ and $L_s = 0.6931/t_{1/2s}$. Specifically, this involves removing the terms related to groundwater depth and frost-free days, and correcting a typographical error in CWS Scientific Rationale document.

Rationale – Allowing users to define unsaturated zone and saturated zone conditions separately to reflect actual conditions at a contaminated site is more consistent with intended objectives of a Tier 2 evaluation. That is to say, CWS guidance allows Tier 2 levels to be determined by adjusting Tier 1 values using site-specific values for certain parameters determined as part of a more detailed site assessment – in this case to include defining unsaturated zone and saturated zone conditions separately. It was further noted that in many cases, the physical properties of geological deposits above an aquifer of concern are not reflected in the physical properties for the aquifer of concern.

With respect to the decay constant equation, removing the terms related to groundwater depth and frost-free days in the equation is intended to simplify the relationship for evaluation of unsaturated zone solute transport.

2.19 Saturated hydraulic conductivity for fine-grained soil.

20 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use the following values for saturated hydraulic conductivity of fine-textured soils:

- 3.2 m/yr for protection of the freshwater life pathway
- 32 m/yr for the drinking water pathway
- 32 m/y for the livestock watering pathway

Rationale – The recommendation for the freshwater life pathway is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. In addition, this value is more representative and protective of the range of fine-grained soils encountered in Canada than the previous value of 0.32 m/y.

The recommendation for the drinking water pathway is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. In addition, this value represents the minimum desirable hydraulic conductivity for domestic water use.

With respect to the livestock watering pathway, data reviewed by the Sub Group indicate that lower hydraulic conductivities do not appear to provide sufficient water to a dugout without surface water input. In addition, preliminary model calculations indicate that the anticipated dilution by surface water at lower hydraulic conductivities would likely result in guideline values similar to those calculated at 32 m/y.

2.20 Consistency in groundwater model parameter assumptions for aquatic and drinking water receptors.

21 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG use consistent assumptions for all model parameters for the aquatic life, drinking (potable) water, and livestock watering pathways except for:

- hydraulic conductivity for the potable water and livestock watering pathways should be adjusted to 32 m/y for fine soils to reflect aquifer properties required to support potable water wells and livestock dugouts, as opposed to the recommended default value of 3.2 m/y for fine soils.
- the offset for aquatic life receptors should be maintained at 10 m

Rationale – In the case of hydraulic conductivities, this recommendation is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*, and it reflects the desired minimum hydraulic conductivity in a potable aquifer.

In the case of the offset for aquatic life receptors, this recommendation is consistent with the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*.

2.21 Revision to the CCME protocol value for hydraulic gradient

22 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG strike a working group that will review all aspects of the groundwater model recommended in the *CCME 2005 Draft Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines*. The review of the model should include aspects of: i) simplicity, reliability, and versatility of the model currently being employed by CCME, ii) assumptions inherent to the model, and iii) an appropriate suite of parameters that when examined together, ensure accurate, reliable, and conservative estimates of risk when applied to typical sites in Canada.

Rationale – The Sub Group recognizes that hydraulic gradient is an important parameter in groundwater modelling and it is important to ensure that appropriate and documented decisions are made with respect to this parameter. Furthermore, the Sub Group recognizes that there is a lack of documentation for the proposed hydraulic gradient default value of 0.028 contained in the 1996 protocol or 0.05 contained in the *CCME Canada-wide Standards for Petroleum Hydrocarbons in Soil*. Finally, the Sub Group recognizes in a qualitative sense that these values may not adequately and conservatively describe "typical" sites nationally.

At this time, the MPA Sub Group is wrapping up discussions and preparing final recommendations to the CCME SQGTG. The MPA Sub Group recognizes time constraints that the CCME SQGTG is under in preparing final revisions to the Canada Wide Standard and that the original timelines proposed have not been met. While parameters contained in the groundwater model were considered for review by the MPA Sub Group, review of the model was not part of the terms of reference. In addition, only a few elements of groundwater modelling were identified as priorities for review and the issue of hydraulic gradient was not one of them.

The MPA Sub Group recognizes that there are a number of simplifying assumptions built into the groundwater model to ensure that the model can be easily applied. While these assumptions are necessary, the potential impact of the assumptions cannot always be easily quantified. It is therefore, advisable to investigate all input parameters in the model as a group to ensure that all parameters, when working together, can reliably and conservatively predict reaction at field sites on a national scale. MPA Sub Group therefore recommends that the issue of hydraulic gradient be investigated on a broader scale that will include all aspects of the groundwater model to ensure that the modelling endpoints achieved are reliable relative to risks in the environment.

Miscellaneous Issues

2.22 Development of soil vapour screening level guidance.

23 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG develop or adopt a table of soil vapour screening level values for Tier 2 and Tier 3 based on the source of contamination located at least 1 m below a building foundation. Tier 2 or 3 implementation is recommended at this point due to:

- The need for a protocol for soil vapour screening that should be part of guideline implementation.
- The temporal and spatial variability that is associated with vapour measurements and the additional flexibility that Tier 2 or 3 gives relative to site specific monitoring programs that can be developed to meet the needs of a given site condition.
- Differences in monitoring needs and tabular values that would be associated with below slab or at source vapour screening measurements and the difficulty this presents in establishing standard protocols at this time.

24 **Final Sub Group Recommendation** – The MPA Sub Group recommends that the CCME SQGTG develop or adopt a protocol for soil vapour sampling to support screening level values for Tier 2 and Tier 3 application.

Rationale – Reasons for not applying soil vapour screening level values for Tier 1 are similar to those in section 2.21.2 and include,

- The need for a protocol for soil vapour screening that should be part of guideline implementation.
- The temporal and spatial variability that is associated with vapour measurements and the additional flexibility that Tier 2 or 3 gives relative to site specific monitoring programs that can be developed to meet the needs of a given site condition.
- Differences in monitoring needs and tabular values that would be associated with below slab or at source vapour screening measurements and the difficulty this presents in establishing clear and simple Tier 1 guidance and look up tables.

<u>Note</u>: A check should be made with respect to attenuation factors derived from the calculated table soil vapour screening values and corresponding indoor air concentrations to ensure that these factors are consistent with the attenuation factors derived for the soil-to-indoor-air pathway.
<u>Note</u>: CPPI strongly supports the development of soil vapour screening level values for Tier 1, 2, and 3 applications.

2.23 Lateral migration of contaminants.

25 **Final Sub Group Recommendation** – The MPA Sub Group recommends that absence of measurable concentrations of soil contamination at lateral distances greater than 30 m from existing or potential future buildings is sufficient to discount the vapour transport pathway at Tier 2 or 3, based on recommendations from Health Canada and US EPA, unless there are precluding factors such as a low permeability surface or significant preferential migration pathways between the contaminant source and receptor location.

Rationale – Empirical data and modelling studies indicate that the vapour intrusion pathway is in most cases unlikely to affect receptors located a large lateral distance from the contaminant source; US EPA (2003) and the "Soil Vapour Intrusion Guidance for Health Canada Screening Level Risk Assessment" (Golder, 2004) both recommend a distance of approximately 30 m for excluding this pathway. Recent data suggest that 30 m may be conservative for PHC, and it may be acceptable to reduce this distance on a site-specific basis with adequate supporting data.

Note: It was pointed out by committee members that for hydrocarbons, the actual offset distance needed to exclude the vapour inhalation pathway may be lower than 30 meters. However, difficulties are acknowledged to exist at this time in understanding whether distances less than 30 m may also be sufficient to discount the vapour transport pathway due to limited field data.

2.24 Consideration of depleting contamination source.

26 **Final Sub Group Position** – The MPA Sub Group does not believe that a depleting contamination source should be incorporated into the CWS.

Rationale – The impact of this issue is not relevant because:

- The CWS PHC deals with non-carcinogenic substances only and is not based on lifetime, incremental risk.
- Tier 1 does not allow for a depleting source assumption. This assumption should be considered at Tier 3 where mechanisms are available to consider a depleting source.
- Development of soil vapour guidance for Tier 2 and 3 is recommended and vapour monitoring can appropriately deal with a depleting source.

2.25 Assumptions for receptor characteristics and exposure to airborne soil particles.

27 **Final Sub Group Position** – Exposure to airborne soil particles containing PHCs are not considered important at PHC-contaminated sites.

Rationale – Screening calculations presented to the Sub Group show that results of airborne soil particle exposures are less important than other pathways used to derive Tier 1 guidelines with respect to exposure to PHCs.

2.26 Consideration of fractured clay till conditions as part of CWS guidance.

28 **Final Sub Group Position** – The MPA Sub Group does not believe that a need exists to further consider fractured clay till conditions as part of CWS guidance.

Rationale – Provisions already exist in CWS guidance to address this issue. The CWS guidance has a minimum data requirement for a PHC CWS site assessment to include descriptions of stratigraphy and properties of surficial materials. The guidance further indicates… "*Of particular importance are the uniformity of the soil texture and the presence of any depositional or structural features, such as lenses or fissures that could influence the fate and transport of PHC in the subsurface*."

2.27 Consideration of buried infrastructure in development of CWS guidance.

29 **Final Sub Group Position** – The MPA Sub Group believes that not enough information is available to warrant developing a guideline to protect buried infrastructure based on the current science.

<u>Note</u>: Additional text should be provided in the CWS guidance… "*The integrity of buried infrastructure should also be considered during site assessments. Where available, guidance from regulatory organizations or pipeline manufacturers on best practices for construction of infrastructure through petroleum hydrocarbon impacted zones should be consulted, although it is acknowledged that there is relatively little clear and consistent guidance on this matter available at present.*"

Rationale – Provisions already exist in CWS guidance to guide contaminated site professionals in addressing this issue. The CWS guidance states that… "*General site features which should be noted prior to conducting a subsurface investigation include locations and depths of underground utilities, which may act as preferential contaminant migration pathways*."

2.28 Consideration of explosive hazards in development of separate guidelines.

30 **Final Sub Group Position** – The MPA Sub Group does not believe that a need exists to explicitly consider explosive hazards in development of separate guidelines.

Rationale – Screening calculations were performed to illustrate guidelines for an open trench/construction worker explosive hazard exposure scenario. Results of these calculations indicate current Tier 1 guidelines are protective of this type of explosive hazard situation. Therefore it is not necessary to consider explosive hazards in development of separate guidelines. Information on the screening calculation is given in the Memorandum attached in appendix D.

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Appendix A – Model Parameter Advisory Sub Group Membership

Chris Rowat	Health Canada, Edmonton, AB
Meghan Roushorne	Health Canada, Burnaby, BC
Joan La Rue-van Es	Manitoba Conservation, Winnipeg, MB
Raymond Morin	New Brunswick Department of Environment and Local Government, Fredericton, NB
Heather Valsangkar	New Brunswick Department of Environment and Local Government, Fredericton, NB
Dennis Stefani	Calgary Health Region, Calgary, AB
Andrea Walter	Petro-Canada, Calgary, AB
John Czechowski	Shell Canada Ltd., Calgary, AB
Ian Hers	Golder Associates Ltd., Burnaby, BC
Debra Hopkins	Golder Associates Ltd., Calgary, AB
Miles Tindal	Axiom Environmental Inc., Calgary, AB
Ian Mitchell	Meridian Environmental Inc., Calgary, AB
Dave Williams	Meridian Environmental Inc., Calgary, AB
Norman Sawatsky	CCME SQGTG representative, Alberta Environment, Edmonton, AB
Joelle Hatton	Recorder, Alberta Environment, Edmonton, AB
Warren Kindzierski	Chair, WBK & Associates Inc., St Albert, AB

Appendix B – Field Soil Vapour Measurement Data Submitted by CPPI.

SOIL VS SOIL VAPOUR COMPARISONS (CPPI DATA)

Location	Summary					Former Bulk V	S Ontario
Vapour Well ID	**Mean**	**Median**	**Minimum**	**Maximum**	**10th percentile**		
Depth to Contamination (m)						1.8	1.5
Depth to Vapour Probe (m)						1.5 to 2	1.5
Vapour probe at source?						Y	Y
						0	0
F1 in Soil (mg/kg)	956.96429	220	0.25	7300	8.275	1089	7300
Predicted F1 in Vapour @ source (mg/m3)	1141658.4	262460	298.25	8708900	9872.075	1299177	8708900
Measured F1 in Vapour (mg/m3)	2138.6215	27.05	0.0005	13500	1.3	27.1	9200
Predicted/Measured	37529879	7941.498	8.5214286	524920000	74.652879	4.79E+04	9.47E+02
Log Predicted/Measured	3.7996316	3.893655	0.9305124	8.7200931	1.6837892	4.68E+00	2.98E+00
F2 in Soil (mg/kg)	2110.5	2110.5	2000	2221	2022.1	2221	2000
Predicted F2 in Vapour @ source (mg/m3)	92862	92862	88000	97724	88972.4	97724	88000
Measured F2 in Vapour (mg/m3)	41.08	41.08	2.16	80	9.944	2.16	80
Predicted/Measured	23171.296	23171.296	1100	45242.593	5514.2593	4.52E+04	1.10E+03
Log Predicted/Measured	3.8484701	3.8484701	3.0413927	4.6555475	3.2028082	4.66E+00	3.04E+00

Location	C, ON	C, ON	C, ON	C, ON	C, ON	C, ON	C, ON	C, ON	C, ON	C, ON	K3, ON	K3, ON
Vapour Well ID	GP-201	GP-202	GP-205	GP-2	GP-5	GP-11	GP-102	GP-103	GP-104	GP-105	GP-101	GP-102
Depth to Contamination (m)	1.5 to 2.1	0.8 to 1.4	1.5 to 2.1	0.8 to 1.4	1.5 to 2.1	1.5 to 2.1	1.5 to 2.1	1.5 to 2.1	0.8 to 1.4	1.5 to 2.1	1.5 to 1.8	1.5 to 1.8
Depth to Vapour Probe (m)	1.6	1.2	1.6	0.8	1.5 to 2.4	1.5 to 2.4	1.5 to 2.4	1.5 to 2.4	1.5 to 2.4	1.6	1.5	1.5
Vapour probe at source?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	0	0	0	0	0	0	0	0	0.5	0	0	
F1 in Soil (mg/kg)	310	0.25	220	84	2100	1500	220	310	0.25	210	27	27
Predicted F1 in Vapour @ source (mg/m3)	369830	298.25	262460	100212	2505300	1789500	262460	369830	298.25	250530	32211	32211
Measured F1 in Vapour (mg/m3)	56	11	0.0005	66	13500	7010	1	2.6	35	27	2	3
Predicted/Measured	6.60E+03	2.71E+01	5.25E+08	1.52E+03	1.86E+02	2.55E+02	2.62E+05	1.42E+05	8.52E+00	9.28E+03	1.61E+04	1.07E+04
Log Predicted/Measured	3.82E+00	1.43E+00	8.72E+00	3.18E+00	2.27E+00	2.41E+00	5.42E+00	5.15E+00	9.31E-01	3.97E+00	4.21E+00	4.03E+00

(grey shading) - measured concentration was less than analytical detection limit; set at detection limit for calculations

Appendix C – Comparison of groundwater pathway Tier 1 values in 2001 with those calculated based on recommendations in this report.

Note: these calculated objectives do not consider any proposed changes from other advisory groups

Protection of Potable Groundwater

Year	Coarse Soils		Fine Soils	
	F1	F2	F1	F2
2001	860	1200	180	250
2006	250	350	190	260
%change	-71%	-71%	+6%	+4%

Notes:

- Use of calculated groundwater mixing depth

Protection of Groundwater for Aquatic Life

Year	Coarse Soils		Fine Soils	
	F1	F2	F1	F2
2001	230	150	NA	NA
2006	380	200	RES	RES
%change	+65%	+33%	NA	NA

Notes:

- Removal of depth-related term from decay constant equation

Protection of Groundwater for Livestock Watering

Year	Coarse Soils		Fine Soils	
	F1	F2	F1	F2
2001	9000	4000	NA	NA
2006	4700	15000	3600	11000
%change	-48%	+275%	new	new

Notes:

- Published 2001 values incorrect
- Distance to receptor adjusted to 0
- K_H set to 32 m/y for fine soils

Correction of reference concentration used to derive DTEDs

MEMORANDUM

To: Model Parameters Advisory Sub-Group Date: February 8, 2008

From: Ian Mitchell and David Williams

RE: Hydraulic Gradient and Hydraulic Conductivity

The hydraulic gradient (i) and saturated hydraulic conductivity (K_H) are key parameters for the groundwater transport model used to develop soil guidelines for the protection of potable water, aquatic life and livestock watering. These parameters are closely linked, and are always used together in the model in the form of the Darcy velocity (V), which is the product of the saturated hydraulic conductivity and hydraulic gradient.

The Soil Quality Guidelines Task Group (SQGTG) has proposed applying a hydraulic gradient of 0.028 for the revised soil guidelines protocol, as well as a saturated hydraulic conductivity of 32 m/y for all fine-grained soil scenarios. These values differ from those which have been used by the Model Parameters Advisory (MPA) Sub-Group during their review of the Canada-Wide Standard for Petroleum Hydrocarbons in Soil. The following tables and text summarize the implications for guideline values of carrying these parameter values over to the Standard.

Protection of Potable Groundwater

The effects of Darcy velocity are relatively small on the protection of potable groundwater pathway if calculated mixing depths are used, since the effects on dilution and mixing depth to some extent counterbalance each other.

	K_H (m/y)	**i**	**V (m/y)**	**F1 guideline (mg/kg)**	**F2 guideline (mg/kg)**
Coarse Soils					
2001 standard	320	0.05	16	860	1200
Current MPA parameter values[a]	320	0.05	16	250	350
SQGTG values[a]	320	0.028	8.96	230	320
Fine Soils					
2001 standard	32	0.05	1.6	180	250
Current MPA parameter values[a]	32	0.05	1.6	190	260
SQGTG values[a]	32	0.028	0.896	170	230

a – includes effects of other parameter value changes proposed by MPA

Protection of Livestock Watering

Much like the protection of potable water, changing the Darcy velocity has relatively small effects on the livestock watering pathway with the proposed elimination of the offset distance for this pathway.

	K_H (m/y)	i	V (m/y)	F1 guideline (mg/kg)	F2 guideline (mg/kg)
Coarse Soils					
2001 standard	320	0.05	16	9000	4000
Current MPA parameter values[a]	320	0.05	16	4700	15000
SQGTG values[a]	320	0.028	8.96	4300	14000
Fine Soils					
2001 standard	32	0.05	1.6	NA	NA
Current MPA parameter values[a]	32	0.05	1.6	3600	11000
SQGTG values[a]	32	0.028	0.896	3200	10000

a – includes effects of other parameter value changes proposed by MPA

Protection of Aquatic Life

Changing the Darcy velocity has a very large effect on the coarse soil guidelines for the protection of aquatic life due to the 10 m offset. The model predicts that several years are needed for PHC constituents to be transported 10 m using default model parameters. If the Darcy velocity is reduced, for example, by a factor of 2, the transport time is doubled. This increased transport time is potentially several times the assumed biodegradation half-life, resulting in much higher soil guidelines.

For fine-textured soils, none of the proposed parameter combinations lead to soil guidelines less than 30,000 mg/kg (RES).

	K_H (m/y)	i	V (m/y)	F1 guideline (mg/kg)	F2 guideline (mg/kg)
Coarse Soils					
2001 standard	320	0.05	16	230	150
Current MPA parameter values[a]	320	0.05	16	380	200
SQGTG values[a]	320	0.028	8.96	1800	600
Fine Soils					
2001 standard	32	0.05	1.6	NA	NA
Current MPA parameter values[a]	3.2	0.05	0.16	RES	RES
SQGTG values[a]	32	0.028	0.896	RES	RES
SQGTG K_H only[a]	32	0.05	1.6	RES	RES

a – includes effects of other parameter value changes proposed by MPA

Appendix D – Calculation of risk associated with explosive hazard and risk to workers in a trench.

MERIDIAN ENVIRONMENTAL INC.

MEMORANDUM

To: Model Parameters Advisory Sub-Group Date: February 8, 2008

From: Ian Mitchell and David Williams

RE: Vapour Migration into Trenches/Explosive Hazards

In order to ensure that the Tier 1 soil quality guidelines are protective of workers in trenches (e.g. utility workers) and explosive hazards, modelling of vapour intrusion into trenches was undertaken using a method published by the Virginia Department of Environmental Quality (VDEQ, 2005).

The Virginia model uses two separate calculation approaches:

- For situations where the contamination is not in contact with a trench, an equilibrium equation is used; this equation is the same as the diffusive transport through a bare dirt floor component of the Johnson & Ettinger (1991) model.
- For situations where contaminated groundwater enters the trench, liquid-phase and gas-phase transfer coefficients are estimated from chemical properties and used to predict the rate of entry of the chemical into the trench.

If the trench is wider than it is deep (which would include trenches with 45^{o} sloped sidewalls), unrestricted air exchange between the trench and the atmosphere is expected and VDEQ recommend an air exchange rate of 360/h based on average wind speeds and an assumed trench depth of 4.6 m. For trenches which have a depth greater than the trench width, gas exchange with the atmosphere is limited, and VDEQ recommend an air exchange rate of 2/h based on typical commercial buildings. Both of these assumed air exchange rates are highly uncertain.

Modelling herein was conducted by calculating the PHC subfraction concentrations in soil gas (for the first modelling approach) and water (for the second modelling approach) based on the standard equilibrium partitioning relationship, assuming that the F1 and F2 concentrations in soil are equal to the commercial soil quality guidelines, excluding protection of groundwater pathways (i.e. the lower of the vapour inhalation and ecological soil contact guidelines). The attenuation factors and predicted F1 and F2 concentrations in a hypothetical trench were then calculated, based on the input parameters summarized in Table 1. Chemical properties for the PHC subfractions were obtained from the PHC CWS Scientific Rationale, except molecular weight, which was obtained from the TPHCWG documents.

Results of the calculations are summarized in Table 2. For the scenarios where the trench width exceeded the depth, which would reflect most excavations that workers would spend substantial amounts of time in, the predicted F1 and F2 concentrations in the trench are less than the typical occupational exposure limit for gasoline, and generally less than the commercial target air concentrations (the concentration which would lead to a hazard index of 0.5 with a commercial exposure scenario); therefore the commercial soil quality guidelines appear to be protective of this scenario. F1 and F2 concentrations are higher than the target air concentrations when the trench depth exceeds the width, in some cases approaching or exceeding occupational exposure limits; in most cases workers would not be expected to spend as much time in these excavations, however.

The lower explosive limit of gasoline is approximately 1.4% or 14,000 ppmv. Assuming an average molecular weight of 80 g/mol, this is equivalent to a concentration of approximately 46,000 mg/m^3. The predicted concentrations in the trenches are far below the lower explosive limit. The calculations for a trench with depth exceeding width may be a reasonable approximation for utility corridors, indicating that the commercial soil quality guidelines appear to be protective of explosive hazards in underground utilities.

It should be noted that, as shown in Table 2, higher F1 concentrations were predicted to occur when the contamination is 30 cm from the trench than when contaminated groundwater enters the trench, even though the calculations for groundwater in the trench are meant to represent a worst-case scenario. This is an artefact of the separate modelling approaches used for each scenario. The first modelling approach (used for the 30 cm separation) may not be appropriate for small separation distances; in this approach, the predicted concentration is inversely proportional to the separation distance, resulting in predicted chemical concentrations in the trench approaching infinity as the separation distance approaches 0.

TABLE 1
MODEL INPUT PARAMETERS

PARAMETER	VALUE
Length of Trench (m)	2.4
Width of Trench (m)	1
Mixing Height (m)	1
Fraction of Floor Exposed	1
Distance from Contamination to Trench (m)	0.3[a]
Air Exchange Rate (exchanges/h)	360 or 2[b]
Coarse Soil Properties	
Bulk Density (g/cm^3)	1.7
Moisture-Filled Porosity	0.241
Vapour-Filled Porosity	0.119
Fine Soil Properties	
Bulk Density (g/cm^3)	1.4
Moisture-Filled Porosity	0.168
Vapour-Filled Porosity	0.302

a – applied only for the first calculation method
b – 360 when width > depth; 2 when depth > width

TABLE 2
PREDICTED PHC CONCENTRATIONS IN TRENCHES
(mg/m^3)

Scenario	Coarse Soils		Fine Soils	
	F1	F2	F1	F2
Width > Depth, Distance = 30 cm	4.9	0.38	9.8	0.92
Width > Depth, Distance = 0	1.3	0.84	2.2	1.7
Depth > Width, Distance = 30 cm	870	69	1800	170
Depth > Width, Distance = 0	230	150	400	300
Target Commercial Air Concentration[a]	8.2	1.6	7.7	1.6

a – calculated using inverse mass-weighted average, based on PHC composition in vapour phase and subfraction reference concentrations, with commercial exposure factor of 0.275 and allocation factor of 0.5.

Notes:
Lower explosive limit of gasoline is 14,000 ppm, or approximately 46,000 mg/m^3
ACGIH TWA for gasoline is 300 ppm, or approximately 990 mg/m^3
No adjustment factor applied to calculations; it may be reasonable to apply the adjustment factor of 10 to the 30 cm calculations.