

## Protocol 22: Application of Vapour Attenuation Factors to Characterize Vapour Contamination

May 2018

Stakeholder Comments / Recommendations	Ministry Response(s)
Section 3.0 Should specify AAD's are unitless for consistency with the rest of the sections.	The units for Attenuation Adjustment Divisors (AAD) have been corrected in the final version of the Protocol.
Section 3.1 Contact with the slab only for parkades built to the 2012 BC Building Codes or later. Would be interested to know what characteristics of the code are driving this and whether it is possible to make these assumptions for older parkades if they meet the characteristics.	This may be considered in future policy revisions.
Table 1 Why are parkade AFs the same as residential indoor air? Exposure scenario can't be the same (people spend much less time in a parkade vs in their homes).	The attenuation factors (AF) for parkades were adopted to be the same as the most conservative set of AFs available, which is for residential, until such a time as AFs can be calculated specific to parkades (intended in future updates).
Need to collect moisture content - additional cost and analytical.	The ministry acknowledges the need for the collection of moisture content results to support vapour investigations. This parameter is routinely provided with soil analyses so it is not anticipated to involve an additional cost.
Need non-detect vapours for 2 m or 5 m, what is this based on?	There is no need for vapour concentrations to be below analytical detection limits, rather concentrations in "clean biologically active soil" must be below detection limits.
What is "biologically active"?	Biologically active refers to soil with characteristics supportive of a robust biological (bacterial) community. Biologically active soil is defined in Procedure 8 "Definitions and Acronyms for Contaminated Sites".
80% of surrounding area to what extent? Property line? Won't be applicable for any densely developed area (i.e. lower mainland).	This may be considered in future policy revisions.
Can the BAAD be applied without a VAF (PAAD/LAAD specified no)?	No, section 4.1.1 of Protocol 22 states on "The biodegradation attenuation adjustment divisor (BAAD) can only be used for the aerobically biodegradable gasoline and diesel substances listed in Table 2 in conjunction with a Table 1 vertical AF".
Can only apply to subslab samples, typically don't collect if possible, nuisance to building occupants. What about future developments?	The ability to use a parkade attenuation adjustment divisor (PAAD) is limited as described.
PAAD use is only specified for risk-based closures. Is there an ability to apply to numerical if appropriate municipal administrative control is in place (i.e. zoning or development plans that require developments have underground parking). There are other controls like this allowed in numerical submissions (No DW wells, slab on grade development). TG4 refers to mechanical ventilation system as eligible for numerical C of C.	No, the use of a PAAD constitutes reliance on an engineered system to control vapour concentrations in a parkade. This constitutes risk management for the vapour pathway, making the site eligible for a risk-based instrument only. TG4 does not indicate that mechanical ventilation systems are eligible for a numerical Certificate of Compliance (CoC), but rather they are eligible for a risk-based CoC and that recommendation can be made by a numerical AP (provided no detailed risk assessment arguments are used).
Use LAAD only when concentrations <10x standards?	Yes. The intent of the lateral attenuation adjustment divisor (LAAD) is to provide relief when substantial site investigation and delineation effort has

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	been conducted, yet a minor (<10X) predicted exceedance of vapour standards has been found at the plume boundary. Experience indicates that when the breathing zone under assessment is laterally separated from the sample location, the additional step-out sample would most likely be below the standard.
Is it reasonable not to laterally attenuate vapours at distances 15-30 m away if exceedances are shallow?	For shallow exceedances, lateral attenuation adjustment is available at distances of 15-30m provided the conditions for use of the LAAD are met.
It specified that point of application of LAAD must be beyond the source of contamination i.e. at the boundary of <u>detectable</u> concentrations in soil and groundwater. Why detectable? Is the expectation to delineate to detectable or exceeding – this is may require additional samples and limit application.	The intent of the LAAD is to provide relief when substantial site investigation and delineation effort has been conducted, yet a minor (<10X) predicted exceedance of vapour standards has been found at the plume boundary. Experience indicates that when the breathing zone under assessment is laterally separated from the sample location, the additional step-out sample would most likely be below the standard.
Can vapour contamination exist if substances are present in vapour that are not associated with a soil, sediment or water source?	Vapour contamination could be detectable on a site due to ambient air or anthropogenic influences. However, for select prescribed substances, if the vapour contamination is determined to not have arisen from soil, sediment or water from a contaminated site, then it is possible it maynot be considered as vapour contamination.
Section 4.0 Why has 2012 been chosen as the Building Code to which parkades must conform in order to be exempted from the shallow groundwater/active pumping precluding conditions? Could older parkades be exempted if confirmed by a qualified professional to meet current codes?	This may be considered in future policy revisions. The authors of the PAAD expressed concern with its application to older buildings that may not have been built in accordance with the assumptions of the PAAD, therefore it's application was limited to recent construction. Language has been amended to indicate equivalent or better than the 2012 BC Building Code.
Section 4.0 Why is a maximum 1 m distance from source specified for vapour data to which the BAAD can be applied?	The 1m distanceallows for aerobic degradation. Sampling close to the source is to ensure samples subjected to the BAAD are not collected above the zone in which biodegradation is anticipated to occur.
Section 4.0 In the definition of "biologically active soil", must all Schedule 3.3 concentrations be non-detectable, or only those identified as PCOCs?	All Schedule 3.3 substances must be non-detect as some substances can be transformed into other substances by the degradation process.
Section 4.0 Why is Table 2 in draft Protocol 22 not consistent with Table 1 of TG4, since all substances in the latter are considered aerobically biodegradable except 1,2-dibromomethane and 1,2-dichloroethane?	Table 1 of TG4 and Table 2 of P22 have been adjusted to align with the ministry's intent to provide relief on substances which are known to aerobically biodegrade. The reference for this topic is ITRC Petroleum Vapor Intrusion (PVI) Guidance (Appendix I) found in the references of Protocol 22.
Section 4.0 If application of LAAD is limited to 10 times the vapour standard, then what is purpose of presenting values > 10 in Table 3A for lateral offset distances of 15 to 30 m?	The ministry considered truncating the values in Table 3A to 10; however, the values as calculated give practitioners all of the known information on this topic at this point in time.
Section 4.0 Does the requirement of a stable or decreasing contaminant plume, for the application of LAADs, also include	The statements in TG4 and P22 relating to a stable and decreasing plume applies to all media including vapours.

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the vapour plume?	
Section 4.0 Why are no LAADs specified for samples collected < 1 m depth, when depths <1 m are included for vertical VAFs in Table 1 of P22?	<p>P22 has been revised to include <math>\leq 1.0</math> m vertical depth.</p> <p>The calculation performed to derive the LAAD was based on a comparison of vertical attenuation factors from Table 2 of TG-4 (V.1.0). The LAAD calculation was limited to VAFs that were generated using the Johnson &amp; Ettinger model. Incorporation of the sub-slab VAF was determined to be inappropriate due to the fact that it was derived via an alternative method.</p>
Should the list of references also include all the references included in TG4, for consistency between documents?	No, the list of references for TG24 and P22 follow the ministry's standard reference format.
Section 4.0 For two years, UDI has recommended that the Ministry allow for horizontal attenuation factors in the vapour standards, so we are pleased that they have been incorporated into <i>Protocol 22 (Application of Vapour Attenuation Factors to Characterize Vapour Contamination)</i> . Other attenuation factors allowed for are also generally supported.	The ministry appreciates the comment.
Section 4.0 Derivation of the 50x lower attenuation factor – this factor was based on a 1 m distance from building to soil vapour measurement point and use of the J&E model for a parking garage scenario. In the high density residential report (reference #11), the assumptions for inputs to the model are summarized in Section 9.4.1.2 (Table 8) and summary 9.4.1.2.3 notes that the 50x factor is the ratio of TG 4 attenuation factor ( $2.8e-3$ ) for RL at 1m to the median modelled attenuation factor for the parking garage scenario also at 1 m vertical separation. Depths greater than 1 m were not considered. Commercial land (CL) use was not considered in the calculations and not certain what factor would apply. In addition, a subslab scenario would affect this ratio and therefore the 50x factor. We note that the PAAF is only applied to the sub-slab attenuation factor. It is less clear how to translate this approach to sub-slab given that it is based on empirical data rather than derived from J&E model. However, given the significant increase in attenuation factor from 1 m ( $2.8E-03$ ) to sub-slab ( $2E-02$ ) it is likely that the 50X factor would also be protective for sub-slab data. The data gaps are estimation of RL factors for depths greater than 1 m, estimation of CL factors and checking of adjustment of sub-slab attenuation factor.	The contents of this comment are under consideration for future updates to vapour policy.
Section 2 The protocol indicates if concentrations exceed the	Numerical standards, natural background concentrations, and site specific

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<p>Schedule 3.3 standard, then the site is considered to be contaminated for vapours and must be remediated. Are risk-based standards an option or is this addressed under remediation.</p>	<p>numerical standards are applicable for defining the presence and extent of contamination at a site. If contamination is present, demonstrating compliance with risk based standards would be one of the remedial options available.</p>
<p>Section 4.0 Since the application of AAF are defined separately and each apply to the alphas (based on vertical VAFs in Table 1) and refer back to equations in Section 4.0, it is not clear whether or not they can be combined. For example, can alpha be divided by PAAF and BAAF? The second paragraph in Section 4.0 implies that can be done; the following paragraph suggests one AAF.</p>	<p>One or more AADs can be used in conjunction with a VAF as described in Section 4.0.</p>
<p>Section 4.0 “Biologically active soil must not contain detectable concentrations of substances from Schedule 3.3. The following geologic materials do not qualify as biologically active: coarse sand and gravel with low silt, clay and organic matter content, and a low moisture content that is less than two percent dry weight; fractured, faulted, or jointed consolidated rock; or consolidated rock with solution channels (i.e., karst) [reference [10] 2015 US EPA document]. Soil samples must be collected and analyzed for soil moisture, which must be greater than two percent by dry weight to indicate a biologically active soil.”– The ITRC PVI guidance infers biologically active or “relatively clean” soil as containing sufficient oxygen for biodegradation. The California Low Threat Policy defines a bioattenuation zone as a continuous zone that provides a separation of at least 30 feet both laterally and vertically between the LNAPL in soil and the foundation of existing or potential buildings, and Total TPH (TPH-g and TPH-d combined) are less than 100 mg/kg throughout the entire lateral and vertical extent of the bioattenuation zone. Another approach is to estimate a soil saturation concentration that is indicative of the presence of a LNAPL source with the rationale being that when no residual contamination is present there are unlikely to be oxygen limitations. The report U.S. Environmental Protection Agency (EPA). 2013a. Evaluation of Empirical Data to Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds. Office of Underground Storage Tanks, Washington, D.C. EPA-510-R-13-001. January. Currently available online at: <a href="http://www.epa.gov/oust/cat/pvi/PVI_Database_Report.pdf">http://www.epa.gov/oust/cat/pvi/PVI_Database_Report.pdf</a></p>	<p>The ministry has provided clarification in Protocol 22. The ministry’s position is that the requirement for non-detectable contamination is appropriate for defining biologically active soil.</p> <p>The intent is to ensure adequate capture of contamination. It is acknowledged that the soil moisture content limit would be infrequently encountered in BC; however, it is possible to encounter the limite at dry locations in some seasons so the ministry feels it is best to include it as adopted from the US EPA 2015 reference.</p>

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<p>prepared by Golder Associates and RTI International derived an estimated TPH concentration of 250 mg/kg as indicative of potential residual LNAPL. A criteria based on non-detect concentrations is too conservative. The precluding factors based on soil lithology are not considered relevant given that there are many examples of biologically active soils for these soil lithologies. The precluding factor based on soil moisture content is considered applicable but would be infrequently encountered in BC.</p>	
<p>Section 4.1.1 It is noted that ...underlies the entire extent of the breathing zone under evaluation." Will there be some guidance on how to establish this? How many soil samples per area will be required to demonstrate the extent of biologically active soil? How will samples be obtained near or below existing buildings?</p>	<p>The ministry would expect a Conceptual Site Model and site investigation information to be used by a qualified professional to ascertain that biologically active soil is present to provide the biodegradation process necessary to attenuate the contamination.</p>
<p>Section 4.1.1 "There must be no substantive surface cap at the site. Specifically, paved or other low permeability surfaces cannot represent more than 80% of the area surrounding the building." This requirement was part of Health Canada guidance but we no longer believe that this is necessary given that there will be gas transport through concrete and asphalt both the bulk material and cracks. Particularly given that only 10X reduction factor is allowed for (i.e., as opposed to pathway exclusion), a precluding factor for surface cover is not considered warranted. If a vertical exclusion factor approach were to be fully adopted in BC, a possible precluding factor for large buildings should be considered.</p>	<p>The contents of this comment are under consideration for future updates to vapour policy.</p>
<p>Section 4.1.1 Conditions for BAAF: Bullet item 4 implies oxygen availability is considered as a contributing factor. Are there other oxygen limiting conditions such as peat or permafrost?</p>	<p>The contents of this comment are under consideration for future updates to vapour policy.</p>
<p>In our opinion, Table 2 substances should be expanded to include naphthalene, 1,3,5-trimethylbenzene, 1,2,4-trimethylbenzene, n-decane, naphthalene, methylcyclohexane and isopropylbenzene (cumene) based on biodegradation rate constants published in ITRC Petroleum Vapor Intrusion (PVI) Guidance (Appendix I). The inclusion of substances such as hexane and naphthalene for application of BAAF is supported by the empirical data in US EPA (2013).</p>	<p>Agreed. Table 1 of Technical Guidance 4 and Table 2 of Protocol 22 have been adjusted for substances which are known to aerobically biodegrade. The reference for this topic is ITRC Petroleum Vapor Intrusion (PVI) Guidance (Appendix I).</p>

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Page 6 Footnote 2: the moisture content is indicated by % dry weight; We note that laboratories commonly report in % wet weight and that this is not always noted on the reports.	The ministry consulted the BC Environmental Laboratory Technical Advisory Committee and they can confirm that laboratories commonly report percent dry weight for soil analyses.
Section 4.2.1 There is requirement that application of PAAF requires that site be managed under CSR risk-based standards. Application of PAAF assumes standard building conditions that would be no different than standards applied for example to commercial buildings. Therefore it is recommended that numeric standards apply.	Reliance on the mechanical ventilation system, which is the basis for the PAAD, is reliance on an engineered control to manage vapour intrusion risk into a parkade. This reliance on an engineered system to manage vapour intrusion risk constitutes risk management for vapours, and therefore a risk-based instrument is appropriate.
Section 4.3.1 Some of these factors exceed the 10x requirement (Table 3A), but perhaps ok.	The ministry considered truncating the values in Table 3A to 10; however, the values as calculated give practitioners all of the known information on this topic at this point in time
Reference #10: check date/year, document is dated October 2011	This has been corrected in the final version of the Protocol.
<p>Section 3.1 Use of the Table 1 vertical VAFs for vapour characterization is not permitted if either of the following conditions apply:</p> <p>a. Groundwater is in contact with the foundation slab at any time of the year, or there is active pumping or drawdown of groundwater at the site, <b>with the exception of parkades built to 2012 or later BC Building Codes.</b></p> <p>Under the City of Vancouver Building Bylaw 10908, council has adopted the 2012 British Columbia Building Code with <b>additional requirements and revisions specific to Vancouver</b>: <a href="http://vancouver.ca/your-government/vancouver-building-bylaw.aspx">http://vancouver.ca/your-government/vancouver-building-bylaw.aspx</a>. As such, the Vancouver building bylaw is separate from the 2012 BC Building Code.</p> <p>Could you confirm that we will be able to apply VAFs in the City of Vancouver using its own building codes? I understand that this is a small technicality, but I would like to make sure there are no legal issues that would arise from using a different building code.</p>	The final version of the protocol was revised to indicate that 'equivalent or better' to the 2012 or later BC Building Codes is acceptable.