Effective date: November 1, 2017 Version 2 DRAFT

Vapour Investigation and Remediation

Introduction

Regulatory context

This document provides guidance to qualified professionals for the investigation, characterization, and remediation of vapour at sites in British Columbia (B.C.). It is the responsibility of the site owner or operator to retain a qualified professional with demonstrable experience, as required by Section 63 of the Contaminated Sites Regulation (the Regulation), to ensure that vapour is properly characterized and, if necessary, remediated in accordance with Ministry protocols, procedures, and guidance.

Document organization

This document is divided into sections involving the following three activities (Figure 1):

1. identifying site use, areas of potential environmental concern (APECs), and potential contaminants of concern (PCOCs);
2. characterizing vapour contamination; and
3. remediating vapour contamination.

Supplementary notes and references complete the document. The terms used in this guidance are listed in the ministry Procedure 8, "Definitions and Acronyms for Contaminated Sites".

1. Identifying site use, APECs, and PCOCs

Prior to undertaking an investigation of vapour conditions at a site, a preliminary site investigation (PSI) should be conducted to identify site use, areas of potential environmental concern (APECs), and potential contaminants of concern (PCOCs). See Technical Guidance 10, "Guidance for a Stage 1 Preliminary Site Investigation". Vapour PCOCs include all substances that are:

a) associated with activities listed in Schedule 2 of the Regulation carried out on or near the site, and
b) listed in Schedule 3.3 of the Regulation.

When selecting PCOCs for dry cleaning, waste oil, diesel, or gasoline APECs, the ministry recommends following Soil Vapour Advice and Practical Guidelines – Stage 1 developed by the Contaminated Sites Approved Professional (CSAP). Site use is determined in accordance with Section 12 (2.2) of the Regulation and footnotes 5, 6, 7, 8 and 9 of Schedule 3.3.

Where PSI findings indicate the presence of PCOCs at a site, a detailed site investigation (DSI) will need to be conducted in accordance with Technical Guidance 11, "Guidance for a Stage 2 Preliminary Site Investigation and Detailed Site Investigation".

At this stage a well-developed conceptual site model based on soil and groundwater data will be critical to properly evaluating soil vapour impacts to indoor and outdoor air.

Regarding footnotes 5 and 6 of Schedule 3.3, vapour that passes vertically from water through soil to the breathing zone is deemed to arise from soil. Thus, for example, where vapour arises from groundwater, passes through soil, and enters a commercial building at the surface of a commercial land use site, the site use is commercial and the vapour is deemed to arise from soil, not water.

Refining the list of vapour PCOCs

Once sufficient soil, sediment, and water data have been obtained for each APEC, gasoline and diesel substances may be removed from the PCOC list provided the following requirements are met:

a) substance concentrations are clearly demonstrated to be less than the detection limit[1] in soil, sediment, and water on the site;

b) substance concentrations are clearly demonstrated to be less than the detection limit or likely less than the detection limit in soil, sediment, and water near the site; and

c) there is no other evidence (e.g., odours, staining) suggesting the presence of the substance in soil, sediment, or water.

This refinement step applies only to the gasoline and diesel component substances listed in Table 1 below. The ministry supports this refinement step because gasoline and diesel substances with no identifiable vapour source in soil, sediment, or water pose a negligible vapour risk to human health.

If, after applying this vapour PCOC refinement step, there are no longer any vapour PCOCs for a given APEC, then vapour at that APEC is considered not contaminated and characterization of vapour contamination at that APEC is not required.

Table 1. Substances for which vapour PCOC refinement is permitted

Substance	Chemical Abstract Service #
benzene	71-43-2
butadiene, 1,3-	106-99-0
dibromoethane, 1,2-	106-93-4
dichloroethane, 1,2-	107-06-2
n-decane	124-18-5
ethylbenzene	100-41-4
isopropylbenzene	98-82-8
MTBE	1634-04-4
methylcyclohexane	108-87-2
n-hexane	110-54-3
naphthalene	91-20-3
trimethylbenzene, 1,3,5-	108-67-8
trimethylbenzene, 1,2,4-	95-63-6
toluene	108-88-3
xylenes, total	1330-20-7
VPHv	-

How far should one look for vapour contamination?

The ministry considers buildings and outdoor areas which are more than 30 m laterally (10 m for aerobically degradable substances) away from detectable vapour substance concentrations in soil, sediment, and water to have a low potential for vapour intrusion. Thus, for the purpose of characterizing vapour contamination, it is assumed that current and potential future buildings and outdoor areas that lie more than 30 m laterally from all detectable substance concentrations in vapour are free of vapour contamination, except where:

a) a preferential pathway connects detectable substances in soil, sediment, or water to the building or outdoor area;

b) vapour is moving under pressure;

c) there is continuous, low permeability cover between the detectable substances

[1] The detection limit is that reported by a Canadian Association for Laboratory Accreditation (CALA) certified laboratory using analytical methods specified in a Director's protocol or alternate methods acceptable to Director.

in soil, sediment, or water and the building or outdoor area; or

d) the vapour plume is potentially expanding.

Chapter 5 in Soil Vapour Advice and Practical Guidelines – Stage 1 contains more information on these precluding conditions. When characterizing soil vapour contamination on adjacent parcels, particular attention must be paid to the location of any preferential flow pathways—these have the potential to carry vapour contamination far from the site. In addition, the selection of vapour attenuation factors must be based on the current and reasonable potential future land use and configuration of buildings (e.g., location and foundation depth of buildings), as per Section 12 (5) of the Regulation.

Gasoline and diesel substances lateral exclusion distance

At sites where "biologically active soil" is present, buildings that are more than 10 m (laterally) away from detectable concentrations of aerobically biodegradable substances, are considered to have a low potential for vapour intrusion. Aerobically biodegradable substances are considered to be those gasoline and diesel component substances listed in Table 1, with the exception of 1,2-dibromoethane and 1,2-dichloroethane.

2. Characterizing vapour contamination

Vapour contamination exists if the concentration of any substance in vapour that is associated with a soil, sediment, or water source exceeds its numerical vapour standard listed in Schedule 3.3 in the breathing zone.

What is the breathing zone?

The breathing zone is any area where humans can come into direct contact with contaminated vapour. For the purpose of characterizing vapour contamination, this includes indoor and outdoor locations on source and affected parcels that exist at the time of site assessment or that have a reasonable potential to exist after site assessment and/or site redevelopment is complete.

Estimating vapour substance concentrations in the breathing zone

Characterizing vapour contamination means determining, for each vapour PCOC, whether there are any exceedances of numerical vapour standards in the breathing zone, and if so, delineating the entire extent of vapour substances exceeding standards.

To estimate the concentrations of vapour substances in the breathing zone, the following approaches can be used:

Approach A - Estimation based on subsurface and/or sub-slab vapour measurements

Collect subsurface and/or sub-slab vapour samples, analyze the samples for vapour PCOCs, and apply appropriate ministry vapour attenuation factors (see Protocol 22, "Application of Vapour Attenuation Factors to Characterize Vapour Contamination") to the analytical results to estimate the concentrations of vapour substances in the breathing zone. Note, use of site-specific vapour attenuation factors is only permitted under risk assessment.

Approach B - Direct vapour measurement

Collect indoor, crawlspace, and/or outdoor vapour samples and analyze the samples for vapour PCOCs. Use the analytical results as a direct estimate of the concentrations of vapour substances in the breathing zone.

Approach C - Estimation based on soil and/or groundwater measurements

Collect soil and groundwater samples from the site and analyze the samples for vapour PCOCs. Use the partitioning equations in Exhibit 2 of Health Canada's Federal Contaminated Risk Assessment in Canada: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites [see Reference 1] to estimate, from the soil

and groundwater data, the concentrations of vapour substances in subsurface vapour. Then apply appropriate ministry vapour attenuation factors in Protocol 22 to the estimated concentrations of vapour substances in subsurface vapour to estimate the concentrations of vapour substances in the breathing zone.

Notes on Approach C

- The option to estimate substance concentrations in subsurface vapour from substance concentrations in soil and groundwater is intended as a cost-saving characterization approach (a) where soil and water is well characterized, substance concentrations in soil and water are low, and vapour contamination is unlikely, or (b) where the vapour source will be removed from the site regardless of the outcome of the vapour assessment. Use of this modelling approach in other situations is not recommended.
- The estimation of substance concentrations in subsurface vapour from measured substance concentrations in soil is not recommended as a sole characterization approach for substances with a liquid specific gravity greater than one because these substances can be present in the form of dense nonaqueous phase liquids (DNAPLs). DNAPLs are often difficult to identify and delineate, so vapour arising from DNAPLs will also be difficult to characterize through modelling alone.
- If vapour substance concentrations are estimated in the breathing zone using both vapour data (i.e., Approach A or B) and soil and groundwater data (i.e., Approach C), preference should be given to the estimates derived using vapour data. Also, if the estimates from vapour data and soil/groundwater data are widely different, provide valid, scientific rationale for the disparity.

Vapour sampling and analysis

The following references provide guidance on vapour sampling and analysis. :

- Chapter 7, Chapter 8, and appended checklists therein of CCME's Guidance Manual for Environmental Site Characterisation in Support of Human Health Risk Assessment. Volumes 1-3; and
- Science Advisory Board's Guidance on Site Characterization for Evaluation of Soil Vapour Intrusion into Buildings.

In circumstances of conflicting guidance, the CCME Guidance Manual should be followed.

Qualified professionals carrying out or interpreting the results of vapour investigations should have a detailed understanding of the guidance provided in these references before proceeding with vapour sampling and analysis.

While the above referenced guidance documents from CCME and the Science Advisory Board are thorough, they may not be sufficiently comprehensive for a particular site's circumstances. The following references, listed in order of ministry preference, provide supplementary guidance on vapour sampling and analysis:

- CSAP Society Soil Vapour Advice and Practical Guidelines. This document is particularly helpful for sites with shallow vapour sources;
- California EPA vapour intrusion guidance and response to public comments;
- ASTM standard practice for vapour assessment [see Reference 2];
- ITRC vapour intrusion guidance;
- Washington State DOE vapour intrusion guidance;
- Oregon State DEQ vapour intrusion guidance; and
- US EPA OSWER vapour intrusion guidance.

Please take note of the following when collecting and interpreting vapour data:

a) It is up to the qualified professional to determine how many vapour sampling events are required to capture the worst-case concentrations expected in the

breathing zone for a particular site. Vapour data collected from multiple seasons and years is desirable. However, the results of one round of vapour sampling could be sufficient if accompanied by strong scientific arguments, a well characterized vapour source, and the results of a defensible vapour model which supports the vapour sampling results.

b) Qualified professionals need to indicate, with supporting documentation, whether or not the substance concentration in vapour is at steady-state or decreasing at the location where the vapour sample was taken. Refer to Reference 3 for guidance.

c) Indoor, crawlspace, and subslab samples will only be valid for the building from which they were collected unless sufficient documentation is provided to support the case that the results are also valid for other buildings.

d) In some situations, subsurface vapour collected from uncovered or partially covered areas of a site will not be representative of vapour concentrations beneath adjacent buildings or beneath a building erected above the sampling site in the future. For details, see Section 7.4.2, Table 7-1, and Figures 7-1 and 7-2 of CCME's Guidance Manual for Environmental Site Characterisation in Support of Human Health Risk Assessment. Volumes 1-3.

Vapour migration
If, during site investigation or independent remediation, one or more substances has migrated (or is likely to have migrated) to a neighbouring property and is causing (or is likely to cause) contamination of that property, notification of contaminant migration must be provided in accordance with sections 57 and 60.1 of the Regulation.

3. Remediating vapour contamination

Under Section 16 of the Regulation, a site may be remediated to either the numerical or risk-based standards.

Source reduction or removal

Where a site is remediated to numerical standards, the site would be eligible for a Certificate of Compliance based on numerical vapour standards when it is demonstrated through confirmatory sampling and analysis that the concentration of each vapour substance is either less than its numerical vapour standard in in the breathing zone or, for the gasoline and diesel components listed in Table 1, less than the detection limits in soil, sediment, and water (as detailed in Section 1 of this document).

Risk assessment

Where a site is remediated using risk assessment, the site would be eligible for a Certificate of Compliance based on risk-based standards for vapours when it is demonstrated that the risks associated with exposure to all vapour contaminants do not exceed the risk-based standards under Section 18 of the Regulation.

See Technical Guidance 7, "Supplemental Guidance for Risk Assessments" for general guidance on vapour risk assessment and References 1 and 4 for more detailed guidance on vapour risk assessment. In addition, note that alternative vapour assessment approaches are acceptable under risk assessment provided they are supported by written defensible scientific rationale.

Risk management

Risk management of vapour contamination—e.g., installation of an engineered system or barrier designed to prevent subsurface vapour from entering a building in concentrations that exceed the Regulation's numerical or risk-based standards—is also an acceptable remedial option for contaminated sites. Risk management

to control vapour intrusion risk is considered to be an engineering control and qualifies as a risk control for vapour exposure. Therefore sites using risk management are only eligible for risk based contaminated sites legal instruments. For guidance on the design, installation, monitoring, and maintenance of vapour management systems, refer to external sources, including the following documents:

- California EPA vapour mitigation advisory
- ASTM guidance for the application of engineering controls.

Where risk management other than reliance on mechanical ventilation systems is implemented, the following documentation must be submitted to the ministry before a risk-based Certificate of Compliance can be issued:

a) a statement of the goals and objectives of the vapour management system;
b) a detailed description of the selected vapour management system including figures and calculations (this documentation must be signed and stamped by a professional engineer);
c) a letter of assurance from a professional engineer which 1) confirms that the system has been installed as designed, and 2) describes the quality assurance/quality control tests conducted to confirm that the system operates as designed (e.g., smoke test of the liner system; tests of blowers, gauges, alarms; air quality sampling and/or pressure measurements); and
d) a performance verification plan, and a contingency plan for the system.

Until all the above documents are submitted, the site will only be eligible for an Approval in Principle. Note that requirements a) and b), above, must be submitted to the ministry before an Approval in Principle is issued.

Risk management using mechanical ventilation

Mechanical ventilation systems that are relied upon to increase air exchange rates, or decrease vapour intrusion rates in buildings (e.g., use of the parkade attenuation adjustment divisor (PAAD) from Protocol 22) are considered to be engineering controls, and qualify as risk controls for vapour exposure.

Where risk management via mechanical ventilation is implemented, the following must be included with the application for a risk-based Certificate of Compliance:

a) a statement of the goals and objectives of the ventilation system;
b) a description of the ventilation system accompanied by a signed and sealed statement of assurance confirming that the system will achieve its design objectives.

A recommendation for a Certificate of Compliance based on risk-based standards for vapours where vapour contamination is risk-managed via mechanical ventilation may be made by a Numerical Standards Approved Professional.

Supplementary notes

Where vapour assessment guidance is lacking or considered inappropriate, qualified professionals should exercise defensible and documented professional judgement.

For purposes of soil relocation, source site owners are responsible for ensuring that vapours in soil to be relocated meet the applicable soil vapour use standards at the receiving site.

For more information, please direct inquiries to site@gov.bc.ca.

References

1. Health Canada (2010). Federal Contaminated Risk Assessment in Canada: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites. Available by request from cs-sc@hc-sc.gc.ca.

2. ASTM International (2008). Standard Practice for Assessment of Vapor Intrusion into Structures on Property Involved in Real Estate Transactions. American Society for Testing and Materials E2600-08.

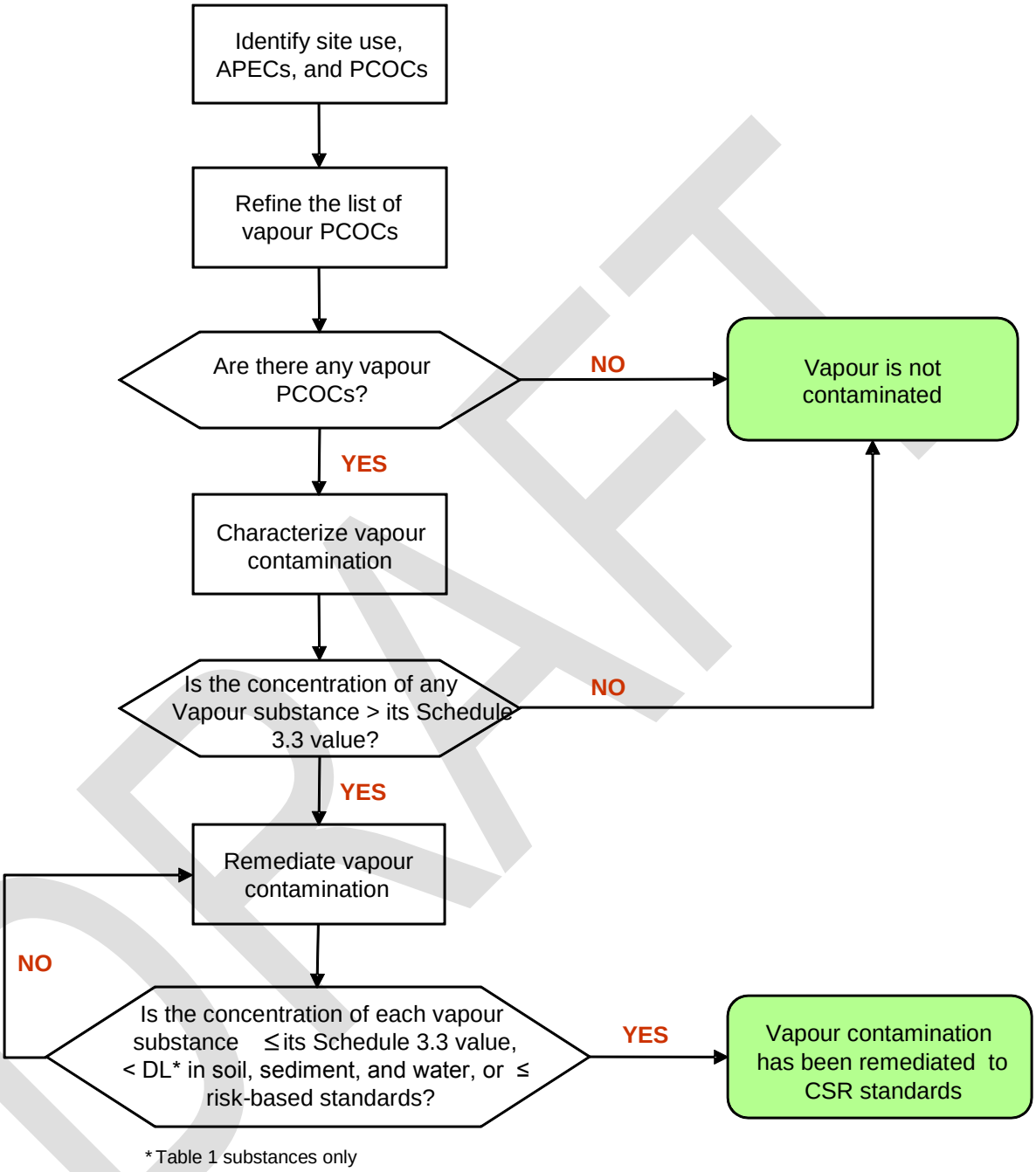
3. Johnson PC, Kemblowski MW, and Johnson RL (1999). Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces: Site-Specific Alternatives to Generic Estimates. Journal of Soil Contamination 8(3): 389–421.

4. Health Canada (Unpublished). Federal Contaminated Site Risk Assessment in Canada Part IV: Spreadsheet Tool for Human Health Preliminary Quantitative Risk Assessment (PQRA). Contaminated Sites Division, Safe Environments Directorate, Health Canada, Ottawa. Available by request from cs-sc@hc-sc.gc.ca

Revision History

Approved Date	Effective Date	Version and Notes
n/a	September 2010	1.0
tbd	November 1, 2017	2.0 Stage 10 amendment implementation

Figure 1. Vapour assessment flowchart



PCOC: potential contaminant of concern
APEC: area of potential environmental concern
DL: detection limit
CSR: Contaminated Sites Regulation
Schedule 3.3: Schedule 3.3 of the CSR, in force Nov. 1, 2017