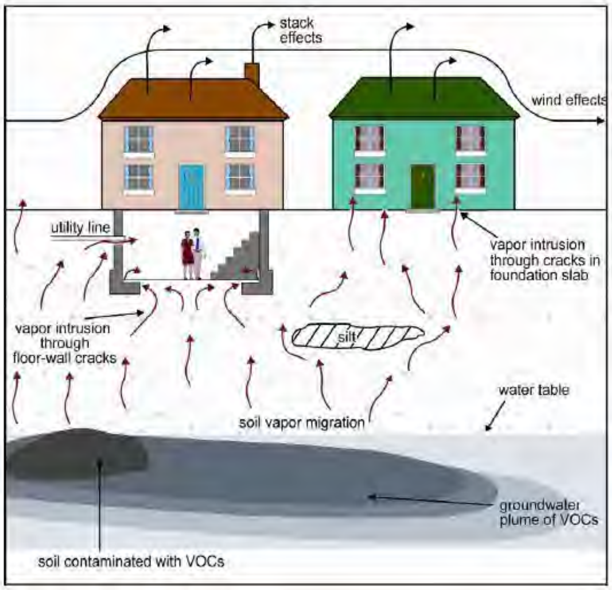
Guidance Document

FOR THE VAPOR INTRUSION PATHWAY

MAY 2013
REMEDIATION AND REDEVELOPMENT DIVISION



Prepared by:

Michigan Department of Environmental Quality
Remediation and Redevelopment Division
525 West Allegan Street
Lansing, Michigan 48933

Protecting Michigan's Environment. Ensuring Michigan's Future.

Norton, Susan (EGLE)

From: MI Dept. of Environment, Great Lakes, and Energy <EGLE@govsubscriptions.michigan.gov>
Sent: Monday, February 26, 2024 2:23 PM
To: Gurnee, Michael (EGLE)
Subject: EGLE RRD updates nonresidential VIAP screening levels in the 2013 VI Guidance: TEST

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EGLE RRD updates nonresidential VIAP screening levels in the 2013 VI Guidance

The Department of Environment, Great Lakes, and Energy, Remediation and Redevelopment Division (RRD) has updated the Appendix D.1 volatilization to indoor air pathway (VIAP) screening levels located in the 2013 Vapor Intrusion Pathway Guidance Document (2013 VI Guidance).

The Appendix D.1 nonresidential VIAP screening levels have been updated to reflect a 12-hour workday exposure time. This exposure time adjustment represents the reasonable maximum exposure estimate from Michigan-specific United States Bureau of Labor survey data.

Careful review of how the building is (or will be) used and zoned is important to determine if a nonresidential exposure scenario is appropriate for the property, facility, or site. Nonresidential VIAP screening levels are developed for healthy adult workers and potential intermittent exposure of adults and children who are customers or visitors to commercial or industrial properties during a portion of the workday. Nonresidential VIAP screening levels are not appropriate for properties where children and other sensitive populations are present on a regular basis (e.g., schools, daycare, hospitals, campgrounds, and recreational areas).

The Appendix C.7 Checklist for Determining if the Volatilization to Indoor Air Pathway Screening Levels Apply has been updated consistent with updates to Appendix D.1. When the VIAP screening levels are not applicable, RRD can assist in the development of applicable Part 201 site-specific volatilization to indoor air criteria (SSVIAC) and Part 213 VIAP site-specific target levels (SSTLs). Requests for assistance can be made using the *SSVIAC or SSTL Questionnaire* available on the RRD Resource Materials webpage.

Alternatively, a person may develop and propose their own Part 201 SSVIAC pursuant to Section 20120b statutory provisions or VIAP SSTLs consistent with the RBCA process as implemented under Part 213.

Questions regarding documentation should be sent to the district project manager where the property, facility, or site is located or the Vapor Intrusion Technical Assistance and Program Support points of contact. For questions regarding the development or use of the VIAP screening levels, please contact Dr. Shane Morrison, RRD VIAP Toxicology and Risk Assessment Specialist, at MorrisonS5@Michigan.gov.

To request this material in an alternative format, contact EGLE-Accessiblity@Michigan.gov or call 800-662-9278.

Norton, Susan (EGLE)

Subject: FW: EGLE RRD recommends reassessment of petroleum vapor intrusion pathway

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From: MI Dept. of Environment, Great Lakes, and Energy <EGLE@govsubscriptions.michigan.gov>
Sent: Tuesday, March 14, 2023 3:02 PM
To: Beukema, Steven (EGLE) <BEUKEMAS@michigan.gov>
Subject: EGLE RRD recommends reassessment of petroleum vapor intrusion pathway

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Remediation and Redevelopment Division recommends reassessment of petroleum vapor intrusion pathway after update to the precluding factors checklists

On January 10, 2023, the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Remediation and Redevelopment Division (RRD) revised the Precluding Factors Assessment Checklists for PVI Separation Distances. The revised Precluding Factors Assessment for the PVI Lateral Inclusion Zone Checklist and the Precluding Factors Assessment for the PVI Vertical Separation Distances Checklist update and clarify the use of both the lateral and vertical distances to appropriately screen out structures and properties from further evaluation of the volatilization to indoor pathway (VIAP) for petroleum releases.

If an Owner or Operator (O/O) previously submitted a Final Assessment Report (FAR) or Closure Report (CR) under Part 213, Leaking Underground Storage Tanks, of the NREPA, and received an insufficient information determination or denial due solely to evaluation of the VIAP, RRD recommends the O/O reevaluate the submittal.

After reevaluation, RRD recommends the O/O revise their FAR or CR to include this updated evaluation and resubmit a revised FAR or CR to the RRD District Office for audit under Part 213 if the following information is true for their submittal:

- the O/O determines that the PVI separation distances would now apply,
- the O/O can demonstrate the VIAP has been adequately evaluated, and

- the O/O can demonstrate any exposure risks will be appropriately addressed as part of the corrective action in the FAR or any exposure risks have been appropriately addressed as part of a corrective action completed for the CR.

Additional information can be found by viewing the webinar Petroleum Vapor Intrusion - Updates to the Lateral Inclusion Zone Checklist and Vertical Separation Checklist.

For questions regarding the Precluding Factors Assessment Checklists for PVI Separation Distances and the VIAP in general, please contact Matt Williams, EGLE, RRD, at 517-881-8641, or Williams13@Michigan.gov.

From: MI Dept. of Environment, Great Lakes, and Energy <EGLE@govsubscriptions.michigan.gov>
Sent: Friday, January 13, 2023 8:51 AM
To:
Subject: EGLE Vapor Intrusion Guidance Document 2023 Addendum

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Petroleum Vapor Intrusion Precluding Factors Checklist Update

The Department of Environment, Great Lakes, and Energy (EGLE), Remediation and Redevelopment Division (RRD) has updated the 2013 Guidance Document for the Vapor Intrusion Pathway (2013 VI Guidance). The update will promote a consistent and informed approach to determine where to characterize and assess risks to human health with the volatilization to indoor air pathway (VIAP) at petroleum release sites. This addendum provides an updated checklist to help determine if certain factors are present at a site that would preclude the use of the Interstate Technology and Regulatory and Council (ITRC) screening process for the VIAP. The screening process presented in the ITRC 2014 Petroleum Vapor Intrusion (PVI) guidance (ITRC PVI guidance[1]) is a means of utilizing soil and groundwater data with lateral and vertical separation distances to screen out properties and/or buildings for the VIAP to reduce unnecessary data collection while remaining protective of human health and the environment. When certain factors are present at a site, the assumptions from the data used in the screening model are no longer valid and preclude the use of ITRC screening distances. When the certain factors are absent, it allows for the establishment of a lateral inclusion zone for assessment and the utilization of vertical separation distances within the lateral inclusion zone.

Lateral Inclusion Zone

The lateral inclusion zone is used in the ITRC PVI screening process to determine whether a building or property is close enough to a petroleum vapor source to warrant an evaluation of the VIAP. A conservative distance of 30-feet from the extent of a vapor source (nonaqueous phase liquids [NAPL], soil contamination, and/or groundwater contamination) may be used in accordance with the ITRC PVI guidance when the conceptual site model supports its use and there are no precluding factors present.

The default lateral inclusion distance of 30 feet is a conservative buffer developed to account for the uncertainty with contaminant stability or with the lateral edge of contamination due to the typical spacing of borings or monitoring wells laterally from the vapor source area. Once the site is fully delineated and well characterized (the extent of the soil contamination, NAPL, and groundwater plume boundary are known and the NAPL body and groundwater plume has been shown to be stable), the vertical screening distances of 5 feet from a dissolved groundwater or a contaminated soil source or 15 feet from NAPL may be applied in the lateral direction, measured from points where target levels are met.

All structures and properties within the lateral inclusion zone must be evaluated for the VIAP. This could include screening out by vertical separation, soil gas sampling, sub-slab sampling, etc. Structures or properties outside of the lateral inclusion zone do not require further evaluation for the VIAP as the lateral inclusion zone is the conservative maximum distance vapors are expected to migrate. The lateral inclusion zone is applied for the entire release and may be used independently of the vertical separation distance. Additional site characterization (e.g., soil gas data) may allow for further reduction of the lateral inclusion zone; however, those approaches are site-specific and not included as part of the ITRC screening process. Additional information and guidance on reducing or developing a site-specific lateral inclusion zone using soil gas data will be provided in the future.

Vertical Separation Distances

The vertical separation distances are applied within the area established as the lateral inclusion zone and therefore cannot be used unless the precluding factors identified for the lateral inclusion zone are absent. The vertical separation distance for dissolved groundwater contamination, soil contamination, and/or NAPL zones may be used on a property-by-property or structure-by-structure basis.

The use of the screening process is not a statutory requirement for compliance with the VIAP under Part 213, Leaking Underground Storage Tanks or Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act,1994 PA 451, as amended. However, if a party is providing a submittal to RRD using the ITRC screening process, the Precluding Factors Assessment for PVI Lateral Inclusion Zone and the Precluding Factors Assessment for PVI Vertical Separation Distance checklists should be used and provided to RRD with the submittal to ensure that a more consistent and efficient review is completed. Training on the use and applications of the checklists is planned for February.

Please contact Nick Swiger, Technical Support Unit Manager, at 231-429-8926 or SwigerN@Michigan.gov, Matthew Williams, Volatilization to Indoor Air Specialist, at 517-881-8641 or WilliamsM13@Michigan.gov, or Dr. Steve Beukema, Part 213 Program Specialist, at 269-547-0125 or BeukemaS@Michigan.gov with any questions.

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[1] ITRC, Petroleum Vapor Intrusion, Fundamentals of Screening, Investigation, and Management dated October 2014. Available at: https://projects.itrcweb.org/PetroleumVI-Guidance/

2021 Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

Michigan Department of Environment, Great Lakes, and Energy sent this bulletin at 03/16/2021 10:00 AM EDT

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2021 Media-Specific Volatilization to Indoor Air

Interim Action Screening Levels

The Department of Environmental, Great Lakes, and Energy (EGLE) Remediation and Redevelopment Division (RRD) has updated the 2013 Guidance Document for the Vapor Intrusion Pathway (2013 VI Guidance) by replacing the previously rescinded Appendix D.3 – Acute Exposures Immediate Response Activity Screening Levels (IRASLs) with Media Specific Volatilization to Indoor Air Interim Action Screening Levels (MSSLs) that have been updated following the December 2020 Toxics Steering Group Report. The references to IRASLs (Immediate Response Action Screening Levels) that remain throughout the 2013 VI Guidance should be interpreted to reference the MSSLs.

The 2013 VI Guidance provides information to department staff and their contractors conducting investigations and remedial or corrective actions at sites with potential vapor intrusion issues. The document is available as a technical reference to assist any person conducting activities to address the volatilization to indoor air pathway.

The MSSLs for soil, shallow groundwater, groundwater, and soil vapor are based on the recommended interim action screening levels identified in the Toxics Steering Group (TSG) Report which provides the toxicological and background information for each hazardous substance. The MSSLs were developed using the best available approaches by incorporating equations and inputs that account for conditions that frequently occur across the state (e.g., shallow groundwater).

The MSSLs are not intended for compliance or for obtaining closure of a release. These interim action screening levels are intended to assist with risk evaluation by 1) determining if potentially unsafe levels of chemicals are present in the environmental media; 2) determining whether interim action to reduce potential exposure is needed; and 3) if interim action is needed, assist in determining how quickly those actions should be completed.

For questions regarding the development and/or use of media specific volatilization to indoor air interim action screening levels, please contact Dr. Shane Morrison, Remediation and Redevelopment Division Toxicologist, at MorrisonS5@Michigan.gov.

EGLE COVID-19 RESPONSE:
For details on EGLE's work during the pandemic, visit our COVID-19 response webpage. Follow state actions and guidelines at Michigan.gov/Coronavirus.

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Friday, September 11, 2020

2020 Volatilization To Indoor Air Pathway Screening Levels

The Department of Environmental, Great Lakes, and Energy Remediation and Redevelopment Division (RRD) developed the 2013 Guidance Document for the Vapor Intrusion Pathway (2013 VI Guidance) to provide information to department staff and their contractors conducting investigations and remedial or corrective actions at sites with potential vapor intrusion issues. The document is available as a technical reference to assist any party conducting activities to address the volatilization to indoor air pathway.

In June 2017, the department rescinded the vapor intrusion screening levels that were included in Appendix D of the 2013 VI Guidance. On June 2, 2020 RRD announced proposed modifications to Appendix D and accepted comments through July 2, 2020. RRD has reviewed the comments received and revised to clarify areas noted by the comments. *A summary of the comments received and RRD's response is available.*

Effective today RRD makes the following modifications to the 2013 VI Guidance:

Replacement of rescinded *Appendix D.1 – Volatilization to Indoor Air Pathway (VIAP) Screening Levels with Residential and Nonresidential VIAP Screening Level Tables*

The VIAP screening levels are provided as a voluntary tool that may be used to determine that site conditions do not present a risk and allow a quick regulatory closure or that site conditions warrant a more site-specific evaluation, at common residential and nonresidential sites. The residential scenario represents a home with a basement and the nonresidential scenario represents an average-sized commercial building with slab-on-grade construction (e.g., gas station convenience store).

The availability of the VIAP screening levels do not affect the ability of a person to use the Part 201 generic cleanup criteria or Part 213 risk-based screening levels when appropriate and applicable, or to develop Part 201 site-specific volatilization to indoor air criteria (SSVIAC) or Part 213 site-specific target levels (SSTLs) under Section 20120b for the department's review and approval. The availability of the screening levels will not change the validity of any SSVIAC or SSTLs that have been previously provided or approved by RRD. These remain valid for the conditions their development was based on and can still be used.

When site conditions are appropriate, these screening levels may be voluntarily proposed for use as Part 201 SSVIAC or Part 213 SSTLs. The use of the screening levels as Part 201

SSVIAC or Part 213 SSTLs requires documentation that the site conditions are appropriate for use. Therefore:

- Any document submitted under Part 201 that relies on the screening levels as SSVIAC including a Baseline Environmental Assessment, Documentation of Due Care Compliance, a Response Activity Plan, No Further Action Report, or any other document that is submitted for department review and approval must include the documentation.

- Any document submitted under Part 213 that relies on the screening levels as SSTLs including a Baseline Environmental Assessment, Documentation of Due Care Compliance, Final Assessment Report, or Closure Report submitted for department review and approval must include the documentation.

The addition of *Appendix C.7 – Checklist for Determining if the Volatilization to Indoor Air Pathway Screening Levels Apply*

A checklist for conditions that are not consistent with the development of the VIAP screening levels has been drafted to evaluate when Part 201 site-specific criteria or Part 213 SSTLs may need to be developed. This checklist will also be available to use to document site conditions are appropriate to voluntarily use of the screening levels as Part 201 SSVIAC or Part 213 SSTLs and may be included with submittals to the department to receive approval.

RRD continues to pursue the development of an on-line calculator that can assist in developing Part 201 SSVIAC or Part 213 SSTLs for scenarios where the screening levels do not apply, or where site conditions can be modified to produce more representative SSVIAC or SSTLs. Until the calculator is available, the department will continue to assist in developing SSVIAC and SSTLs for this pathway. Requests for assistance in their development may be made using the *questionnaire available on the RRD Resource Materials web page*. Alternatively, a person may develop SSVIAC or SSTLs using any of the options available in Section 20120b and submit the necessary information to the department for review and approval.

For questions regarding the development and/or use of the VIAP screening levels, please contact Dr. Shane Morrison, RRD Toxicologist, at morrisons5@michigan.gov, or the VI Technical Assistance and Program Support (TAPS) Points of Contact (POC) for the district where a site is located. Please do not reply to this email.

2013 VI GUIDANCE DOCUMENT MODIFICATIONS

Friday, January 10, 2020

The Michigan Department of Environment, Great Lakes and Energy (EGLE), Remediation and Redevelopment Division (RRD) developed the 2013 Guidance Document for the Vapor Intrusion Pathway (2013 VI Guidance) to provide information to department staff and their contractors conducting investigations and remedial or corrective actions at sites with potential volatilization to indoor air issues. The document is available as a technical reference to assist any party conducting activities to address volatilization to indoor air.

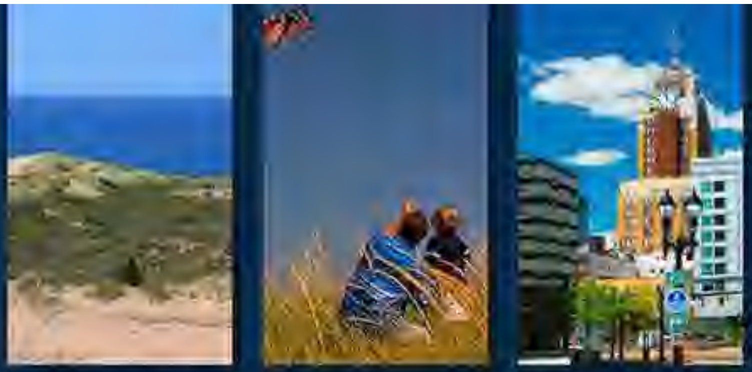
RRD has made the following modifications to the 2013 VI Guidance:

Replacement of rescinded Appendix B.3 – Alternate Approach Considering Biodegradation with the Interstate Technology & Regulatory Council (ITRC) Petroleum Vapor Intrusion (PVI) guidance document, ITRC Technical and Regulatory Guidance Web-Based Document, Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management (PVI-1, 2014), as suitable for a petroleum vapor intrusion assessment pursuant to the relevant statutory provisions. To assist in the use of this document the department has developed a Precluding Factors Assessment for ITRC PVI Separation Distances Checklist. RRD staff will use this checklist when reviewing submittals that propose to rely on the ITRC PVI separation distances.

Questions regarding the use of the ITRC PVI separation distances may be directed to the RRD VI Technical and Program Support (TAPS) Team Coordinator Jay L. Eichberger EichbergerJ@Michigan.gov or 616-446-4043, or Matthew Williams, Volatilization to Indoor Air Specialist, WilliamsM13@Michigan.gov or 517-284-5171 or the VI TAPS Points of Contact (POC) for the district where a site is located.

Modification to Table 5-2: Sampling Density in Commercial Buildings to clarify the expected sample density. There has been consistent reliance on the minimum number of samples without consideration of the building size. Language has been added to the table to clarify the minimum number of samples is only appropriate for a building that meets the minimum of the square footage listed within the table. A sample density less than what is expected from the table may be proposed but must have justification for how it will represent the building conditions.

Questions regarding the use of the department's 2013 VI Guidance may be directed to Matthew Williams, Volatilization to Indoor Air Specialist, WilliamsM13@Michigan.gov or 517-284-5171 or any of the VI TAPS POCs.



MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

Monday, August 07, 2017

The MDEQ and the Michigan Department of Health and Human Services have collaboratively developed recommended interim action screening levels for indoor air. These indoor air screening levels have been developed to assist with the evaluation of volatilization to indoor air risks. The current list includes indoor air screening levels for 29 chemicals identified with a potential to cause adverse human health effects for less than chronic exposures (short-term exposures), or otherwise requiring screening levels to determine if an expedited response is warranted. Additional chemicals will be evaluated and added as required on a project-specific basis.

The indoor air screening levels are intended to assist with risk evaluation by: 1) determining if potentially unsafe levels of chemicals are present in the indoor air; 2) determining whether interim action to reduce potential exposure is needed; and 3) if interim action is needed, assist in determining how quickly those actions should be completed. The indoor air screening levels were developed using the best available toxicological and background information. The Toxics Steering Group's Recommended Interim Action Screening Levels (TSG Report) provides details regarding the basis of the screening level for each chemical.

Media-specific interim response screening levels for soil, groundwater, and soil vapor have also been generated for the 29 chemicals included in the TSG Report. The media-specific screening levels are based on the indoor air screening levels identified in the TSG Report and were developed using conservative assumptions.

The media-specific screening levels are not intended for compliance or for obtaining closure of a release. However, based upon adequate investigation and characterization, further action for these chemicals for volatilization to indoor air may not be necessary if concentrations do not exceed the residential screening levels for soil vapor, soil and shallow groundwater. Typically, an exceedance of a time-sensitive screening level in any media will warrant expedited investigation and possible mitigation. Questions regarding the use of the screening levels for this purpose should be directed to the MDEQ District Office in your area for further assistance.

The TSG Report and resulting recommended interim action screening levels replace Appendix D.3 of the 2013 Guidance Document for the Vapor Intrusion Pathway. Appendix D. 3 - Acute Exposures Immediate Response Activity Screening Levels that were previously removed from the document in October 2016. The references to IRASLs (Immediate Response Action Screening Levels) that remain throughout the guidance document are replaced with the interim action screening levels.

Tuesday, June 20, 2017

The Department of Environmental Quality (DEQ) developed the 2013 Guidance Document for the Vapor Intrusion Pathway (2013 DEQ VI Guidance) to provide information to DEQ staff and their contractors conducting investigations and remedial or corrective actions at sites with potential VI issues. The document is available as a technical reference to assist any party conducting activities to address volatilization to indoor air.

The DEQ has the following modifications to the 2013 DEQ VI Guidance:

1. **Rescission of Screening Values:** The DEQ rescinds Appendix D of the 2013 DEQ VI Guidance. The vapor intrusion screening values provided in Appendix D.1 (i.e., Residential Vapor Intrusion Screening Values) and in Appendix D.2 (i.e., Nonresidential Vapor Intrusion Screening Values) of the 2013 DEQ VI Guidance no longer reflect the DEQ's determination of values that represent the best available information regarding the toxicity and volatilization to indoor air exposure risks posed by the hazardous substances as required by Section 20120b of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Because Appendix D has been rescinded, the values in Appendix D may no longer be utilized to conduct a site-specific evaluation of the volatilization to indoor air pathway (VIAP).

Site-Specific Evaluation: Conditions that must exist in order for the generic criteria to apply are found in the Part 201 Administrative Rules for the generic Groundwater Volatilization to Indoor Air Inhalation Criteria (GVIIC) and the Soil Volatilization to Indoor Air Inhalation Criteria (SVIIC) [R 299.14(2) and R 299.24(2)]. If those conditions are not met and therefore the generic criteria do not apply, a site-specific evaluation of the inhalation risks must be conducted. Details regarding these conditions are contained in Appendix C of the 2013 DEQ VI Guidance Document - Checklist for Determining if Generic Volatilization to Indoor Air Inhalation Criteria Apply. These rules also contain a provision that allows the use of representative soil gas concentrations to demonstrate compliance with criteria for the VIAP [R 299.14(5) and R 299.24(5)]. This evaluation relies upon satisfying site-specific soil gas criteria.

Request for Site Specific Criteria: As noted above, when the generic criteria do not apply or when a person choses to rely upon representative soil gas concentrations to evaluate the VIAP, a person must conduct a site-specific evaluation. The DEQ will assist with the development of site-specific criteria that may be used for the site-specific evaluation. Please contact the appropriate DEQ Remediation and Redevelopment Division District Office for guidance on how to request assistance. Alternatively, a person may generate site-specific criteria and submit the necessary information to the DEQ for review and approval.

2. **Rescission of Alternate Approach Considering Biodegradation:** The DEQ also rescinds Appendix B.3 of the 2013 DEQ VI Guidance – Alternate Approach for Investigating Vapors for Petroleum

Hydrocarbons Considering Biodegradation. In place of this document, the DEQ views the ITRC Technical and Regulatory Guidance Web-Based Document, Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management (PVI-1, 2014) as suitable for a petroleum vapor intrusion assessment pursuant to the relevant statutory provisions.

If you have questions please call the DEQ District Office where your site is located.

From: Shirey, Kathleen (DEQ) <SHIREYK@michigan.gov>
Sent: Friday, October 28, 2016 5:05 PM
To: EGLE-RRD-All <EGLE-RRD-All@michigan.gov>
Subject: Vapor Intrusion Guidance--Appendix D

As many of you are aware, our understanding of the Vapor Intrusion (VI) pathway is rapidly evolving and how to evaluate VI concerns changes as we come to understand how it works better. In the May, 2013 the DEQ Guidance Document for the Vapor Intrusion pathway, Appendix D.3 provided Acute Exposure Immediate Response Activity Screening Levels (IRASLs). With new information that has been developed and in consultation with MDHHS, we have realized that these screening levels are not sufficiently protective of human health. Therefore, Appendix D.3 has been removed from the online version of the VI Guidance document. Please discontinue use of this part of the document. In its place is a statement that the appendix has been removed and further guidance should be requested of the appropriate district office.

We expect to have a table with Acceptable Air Concentrations to replace Appendix D.3 soon. If you receive questions regarding the table and how to evaluate air data before then, please refer to the proposed rules (for use as screening and guidance only, as they are not promulgated rules) and work with your VI Point of Contact. The VI TAPS team will be conferring and working to maintain consistency on the guidance we are providing staff and private parties regarding this very important risk evaluation.

Kathleen Shirey
Acting Assistant Division Chief
Field Operations Chief West
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

STATE OF MICHIGAN
DEQ
DEPARTMENT OF ENVIRONMENTAL QUALITY

GUIDANCE DOCUMENT FOR THE VAPOR INTRUSION PATHWAY

MAY 2013
REMEDIATION AND REDEVELOPMENT DIVISION

The information contained in this document is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This document outlines an approach to demonstrate compliance when the generic criteria under Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and Part 213, Leaking Underground Storage Tanks, of the NREPA, do not apply. Site conditions, contaminants, and geology may require modifications of this approach.

This document was developed to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion (VI) issues in order to promote a consistent, informed, and practical approach for MDEQ staff to follow. By following the process outlined in this document, a party can achieve the performance standards required by Part 201 and Part 213. The process outlined in this document is not the only means by which a party can meet the requirements of Part 201 and Part 213, and is provided as a reference tool and not as a mandatory requirement.

This document is made available as a technical reference that may be informative when conducting work at sites where VI issues are a concern. The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

A policy guidance document cannot establish regulatory requirements for parties outside of the MDEQ. It is explanatory and provides direction to staff, guidance to the regulated community, and consistency in enforcing the NREPA, but does not have the force and effect of law and is not legally binding on the public or the regulated community.

The following is a list of some key stakeholders and parties that have provided valuable input and support into the production of various portions of this guidance document. It is through their voluntary support that this document has been able to be produced. Their support of the MDEQ has been wide ranging from providing comments and suggestions on previous documents, providing solutions or approaches in unique situations, providing the use and access of site data for verification of methodologies and approaches, providing access to published papers and/or presentations, and most importantly by providing access to staff and various equipment to assist in formatting many of the ideas presented in this document.

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AMEC E & I, Inc.
American Petroleum Institute
AMS, Inc.
AQR ColorTec
ARCADIS U.S., Inc.
ATC Associates Inc.
Atlantic Richfield Company
CETCO Lining Technologies
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Environmental Resources Management
Fibertec Environmental Services
Ford Motor Company
Global Remediation Technologies, Inc.
Hamp, Mathews & Associates
Hartman Environmental Geoscience
H&P Mobile Geochemistry, Inc.
Interstate Technology & Regulatory Council (ITRC)
Land Science Technologies
MHE Products
Michigan State Housing Development Authority (MSHDA)
RAM Group of Gannett Fleming, Inc.
Severstal North America, Inc.
Shell Global Solutions
Soil and Materials Engineers, Inc.
TTL Associates, Inc.
URS Corporation
Weston Solutions, Inc.
W. L. Gore & Associates, Inc.

Acronyms and key definitions for terms used in this document:

Acute:	Conditions that have the potential for injury or damage to occur to humans or environmental receptors as a result of an instantaneous or short duration exposure
Acute toxicity:	Ability of a hazardous substance to cause a debilitating or injurious effect in an organism as a result of a single or short-term exposure
AGW_{vi}:	Groundwater concentrations for consideration of an acute exposure for VI
$AGW_{vi\text{-}sump}$:	Groundwater concentrations for consideration of an acute exposure when water is in contact or entering a structure for VI
AIA_{vi}:	Acute indoor air value for VI
Alpha (Alpha Factor or α):	Key parameter in assessing the significance of subsurface VI into indoor air, defined as the concentration of a particular chemical in indoor air divided by its concentration in soil gas at a specified depth beneath the building floor
ASG_{vi}:	Acute soil gas concentrations for VI
ASTM:	ASTM International formerly known as American Society for Testing and Materials
atm-m^3/mole:	Atmosphere meter cubed per mole
bgs:	Below ground surface
CGI:	Combustible gas indicator
Contamination:	Includes hazardous substances that have been released and are present above criteria
Criteria or Criterion:	Includes the cleanup criteria for Part 201 and the Risk-Based Screening Levels (RBSLs) as defined in Part 213 and R 299.5706a(4)
C_{sat}:	Concentrations approach saturation
CSM:	Conceptual site model
ESA:	Environmental Site Assessment
Facility:	Includes “facility” as defined by Part 201 and “site” as defined by Part 213
GC/MS:	Gas chromatograph/mass spectrometry
GVIIC:	Groundwater volatilization to indoor air inhalation criteria
GW_{vi}:	Groundwater concentrations for VI
$GW_{vi\text{-}sump}$:	Groundwater concentrations when water is in contact or entering a structure for VI
HVAC:	Heating, ventilation or air conditioning
IA_{vi}:	Acceptable indoor air value for VI
IBS:	Interior building survey
Indoor Air Inhalation Criteria:	Groundwater volatilization to indoor air inhalation criteria (GVIIC) as defined by R 299.5714 and soil volatilization to indoor air inhalation criteria (SVIIC) as defined by R 299.5724
IRASLs:	Immediate response activity screening levels
J&E Model:	Johnson and Ettinger Model (1991)
LUST:	Leaking underground storage tank
MDEQ:	Michigan Department of Environmental Quality
MEK:	Methyl ethyl ketone also known as 2-butanone
Mitigation:	Proactive remedial actions to reduce risks to receptors
MPE:	Multi-phase extraction
NAPL:	Non-aqueous phase liquid

NFA:	No Further Action
NREPA:	The Natural Resources and Environmental Protection Act, 1994 PA 451, as amended
PAHs:	Polynuclear aromatic hydrocarbons
Part 201:	Part 201, Environmental Remediation, of the NREPA
Part 213:	Part 213, Leaking Underground Storage Tanks, of the NREPA
ppbv	Parts per billion by volume
ppmv	Parts per million by volume
PCE:	Tetrachloroethene also known as perchloroethylene
PEL:	Permissible exposure limit
PID:	Photoionization detector
QA/QC:	Quality assurance/quality control
RAGS:	Risk Assessment Guidance for Superfund
RBSL:	Risk-based screening levels
RECs:	Recommended environmental conditions
REL:	Recommended exposure limit value
Release:	Includes “release” as defined by both Part 201 and Part 213
RRD:	Remediation and Redevelopment Division
Response Action:	Includes “response activity” as defined in Part 201 and “corrective action” as defined in Part 213
S_{vi}:	Concentration in Soil that may pose VI risk
SG_{vi}:	Soil gas concentrations for VI
$SG_{vi\text{-}ss}$:	Soil gas concentrations collecting less than five feet bgs or lowest point of a structure for VI
SIM:	Selected ion monitoring
SMD:	Sub-membrane depressurization
Soil Gas:	Vapor phase compounds occupying the pore spaces of unsaturated soil
SOP:	Standard operating procedures
SSD:	Sub-slab depressurization
Subsurface Migration Route:	Soils in the unsaturated zone through which vapors are transported
SVE:	Soil vapor extraction
SV_{vi}:	Screening values for VI
SVIIC:	Soil volatilization to indoor air inhalation criteria
TCA:	Trichloroethane
TCE:	Trichloroethene
TO-15:	USEPA method for the determination of toxic organic compounds in ambient air
TLV:	Threshold limit value
µg/L:	Micrograms per liter
$\mu g/m^3$:	Micrograms per meter cubed
USEPA:	United States Environmental Protection Agency
USTs:	Underground storage tanks
Vapor Intrusion:	The pathway by which chemicals in soil or groundwater migrate to indoor air
Vapor Intrusion Receptor:	Human occupants of a current or future building
Vapor Intrusion Source:	Contaminated soil, groundwater, or NAPL that have the potential to volatilize and that are sufficiently volatile and toxic to cause a risk
VOCs:	Volatile organic compounds
VSIC:	Volatile soil inhalation criteria

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1.0 Introduction

Part 201, its Administrative Rules, and Part 213 regulate most sites of environmental contamination in Michigan. Under Part 201 and Part 213, a site may always use the generic criteria when they apply, as further detailed in Section 1.3. This document provides technical support, guidance, and a method for assessing risks associated with the VI pathway at sites where the generic criteria do not apply or are not protective. In this document, the MDEQ provides an alternate approach that meets the requirements of Part 201 and Part 213 by developing screening levels that can be used on any site as "site-specific criteria" as established under Part 20120b. An overview and basic flow of the process using these screening levels can be found in flowcharts provided in Appendix A. Appendix B (Supplemental Guidance Information) and Appendix C (Checklists for Evaluating Compliance with Part 201) provide additional supporting materials to assist in this process. Alternate approaches to those identified in this document may be proposed and submitted for review. This may include the use of site-specific attenuation factors (see Section 2.3.1) above what is identified in this document that is supported using site-specific information and data.

Screening levels are discussed in greater detail in Section 2.3 and are provided in Appendix D to further assist in utilizing this approach. The procedures and guidance provided in this document were developed based on a compilation of available information, knowledge, field experience, and general industry practices. **This guidance document is not a statutory requirement** but provides the regulated community and the public information regarding an approach that is consistent with Part 201 and Part 213.

1.1 Intent and Scope of this Document

This document should be used as a reference. Differences may exist between the referenced procedures and what is appropriate due to site-specific conditions. This document does not represent an endorsement of practitioners or products mentioned herein nor does it ensure that this approach is appropriate for all sites. It is imperative that the environmental professional implementing this approach provide adequate justification of the development of any and all site-specific criteria, though it is the intent of this document to assist in that justification.

1.2 Description of the Vapor Intrusion Pathway

Vapor intrusion is an exposure pathway resulting from the migration of volatile chemicals from the subsurface into overlying buildings with human receptors. A VI source, migration route, and a human receptor must be present for the pathway to pose a health risk. In addition, the source of chemicals must be sufficiently volatile and toxic to cause a risk or potential harm to public safety. Vapors are typically generated from a source that may consist of contaminated soil, groundwater, NAPL, or even buried waste materials.

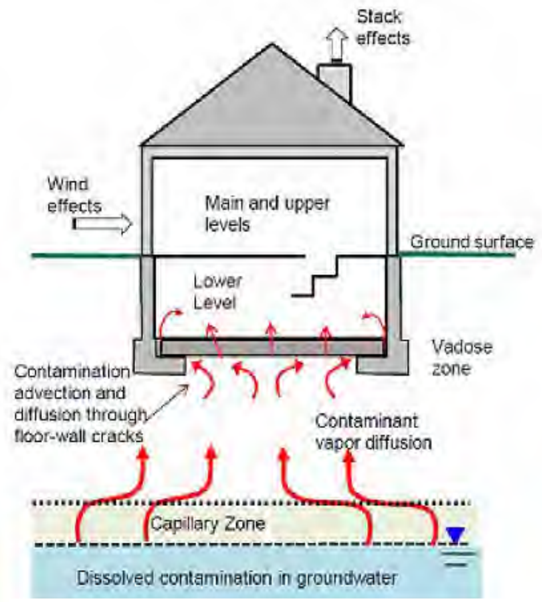

Figure 1-1 – Simplified Model of Vapor Intrusion

Soil Gas and Soil Vapor

In many VI guidance documents, "soil gas" and "soil vapor" are used interchangeably. In this document, "soil gas" refers to the gaseous elements and compounds in the small spaces between particles of soil. Once the gaseous elements or compounds migrate into a structure, they are referred to as "vapor."

Figure 1-1 provides a simplified schematic illustration of the VI pathway for a source of vapors in the groundwater. As shown, VOCs dissolved in groundwater enter into the vapor phase at the boundary between the saturated zone and the vadose zone. These vapor phase compounds can then migrate both vertically or laterally within the subsurface, and move through diffusion or advection into an overlying or adjacent structure. Vapor phase or soil gas migration can occur in any direction due to pressure gradients, variations in soil type, permeability, and moisture content. Pressure gradients influencing soil gas migration can be the result of barometric pressure changes or pressure differences between a building's interior and the subsurface. Such gradients can cause shallow soil gas to enter buildings through foundation cracks, sumps, or other preferential pathways (ITRC, 2007a). Though these are the most obvious and direct paths for vapors to take, it should be noted that there are circumstances where vapors can actually move directly through concrete or other foundation materials.

Vapor intrusion can also be influenced by the advective air movement within a building caused by thermal and air density variations between the building interior and the outside air. This creates vertical airflow through the building (i.e., via the chimney or other openings) and is known as the building stack effect.

1.3 Generic Criteria

The J&E Model is the fate and transport model used by the MDEQ for development of the Part 201 generic GVIIC, SVIIC, and Part 213 RBSLs. These criteria were developed to address human health risks resulting from VOCs volatilizing into the indoor air from the groundwater and soil. The GVIIC and the SVIIC were originally developed in 1998, and the methodology (including the J&E Model inputs and exposure assumptions) and resulting generic criteria were promulgated as part of the 2002 Part 201 Administrative Rules.

The use of generic criteria for analysis of the GVIIC and the SVIIC pathways must be done with caution. A number of assumptions used in the MDEQ's application of the J&E Model are not applicable for all sites; therefore, it is critical to evaluate whether use of the generic criteria is appropriate for assessing the potential risk for VI at a site when actual site conditions stray from the assumptions utilized in the model. To ensure the consideration of critical J&E Model assumptions, Rule 714(2) and 724(2) of the Part 201 Administrative Rules identify conditions when the applicability of the GVIIC and the SVIIC is not appropriate. These conditions are discussed below in more detail and a Checklist for Determining if Generic Volatilization to Indoor Air Inhalation Criteria Apply is contained in Appendix C, to further assist in this analysis.

1.3.1 Construction of Structure

The development of GVIIC and SVIIC include the assumption that the proposed or existing structure is constructed with block or poured concrete walls and floor. Should a structure be equipped with earthen walls and/or floors, the flow of vapors into the structure will occur at a much different rate than what has been assumed in the development of the generic criteria. In these circumstances, the generic criteria do not apply for either the GVIIC [Rule 714(2)(a)] or the SVIIC [Rule 724(2)(a)] pathways, and a site-specific evaluation of indoor inhalation risks shall be conducted.

1.3.2 Presence of Building Sumps

The installation of sumps in building foundations and basements is often required under local building codes to prevent the infiltration of water into the structure. Rules 714(2)(c) for the GVIIC and 724(2)(b) for the SVIIC require a site-specific evaluation to address the VI pathway when a is sump present. The reasoning behind this requirement is that when a sump is present, even in a portion of a building, the sump can create a preferential pathway for vapor migration. Although isolation and/or venting of vapors from the sump to the outdoors may effectively "seal" or "cap" the actual opening in a slab, these measures are not considered adequate to allow for the use of the GVIIC and SVIIC. This is because the development of the generic GVIIC and SVIIC utilize the presence of a continuous concrete foundation that considers a fixed area around the perimeter of the foundation to be available for vapor migration. This fixed area is typically smaller than the actual area occupied by a standard sump.

In addition, the presence of a sump and its associated drainage system may also create pockets of vapor accumulation and areas of preferential vapor flow along fill materials surrounding the drain tiles and produce a "zone of influence". This is particularly true when vented to the outdoors, where subsurface vapors may follow a path of least resistance toward the open sump. These and other factors may or may not cause or contribute to unacceptable VI risk and their effects are not easily quantified or evaluated using a generic application of the J&E Model.

1.3.3 Presence of Shallow Groundwater

Rule 714(2)(b) states that the generic GVIIC are not valid for assessing VI risk at sites where the water table is less than three meters from the ground surface. In these circumstances a generic application of the J&E Model becomes less reliable without the use of site-specific information. This is especially the case as the J&E Model is utilized in situations where the groundwater approaches or is in contact with a buildings foundation. For sites that meet this situation, a site-specific evaluation will need to be performed to adequately assess the VI pathway. This can be accomplished by either using the screening levels provided in this document or by performing a more detailed site-specific evaluation.

1.3.4 Other Limitations of the J&E Model

Other considerations that limit the reliability of GVIIC and SVIIC include, but are not limited to the presence of multiple contaminants at higher levels, as well as the presence or suspected presence of residual or mobile non-aqueous phase liquids (LNAPL, DNAPL, fuels, solvents, etc.) in the subsurface. Additional conditions described by USEPA (2002) when a generic application of the J&E Model may not reliable is provided in the MDEQ's Checklist for Determining if Generic Volatilization to Indoor Air Inhalation Criteria Apply in Appendix C.

1.4 *Site-Specific Evaluation*

A site-specific evaluation of the VI pathway considers and evaluates the actual site conditions rather than using generic assumptions. The approach identified in this document utilizes a direct evaluation of the pathway and is considered appropriate for all sites. It includes:

1. Assessing the potential for VI through the use of screening values developed for both shallow and deep groundwater conditions (Section 3).

2. Utilizing soil gas or sub-slab soil gas sampling results and comparing them to a screening value derived from empirical data as part of a site-specific evaluation (Sections 4 and 5).
3. Assuming that an unacceptable VI risk exists and implementing presumptive remedies to mitigate the potential exposure pathway (Section 6).

In addition to these common methods, the document also identifies soil screening values (to establish whether impacted soil may be a source of vapors) and presents IRASLS to establish site conditions that may warrant quicker response times. Other approaches can be utilized when supported by documentation and appropriate justification. The party conducting the evaluation may utilize the approach outlined in this document without further documentation or evaluation and may, at any time, choose to utilize a different approach or refine the methods identified in this document based on site conditions.

It is a common misconception that performing a site-specific evaluation results in an extensive and cost prohibitive science project. Outside of the use of the soil gas screening levels provided in this document, the most common site-specific approach involves the use of an updated version of the J&E Model that relies on site-specific data. However, because the J&E Model is sensitive to a number of site-specific parameters, using this approach requires data that could be collected, but typically is not collected during the course of an investigation. Specifically, regarding the collection of additional site-specific information the USEPA (2002) states:

> "If the J&E Model is deemed applicable to the site, critical model parameters from site data are needed. We recommend that site-specific information include soil moisture, soil permeability, building ventilation rate, and sub-slab as well as deep vapor concentrations."

In addition, in any approach developed or utilized outside of this document, the method should account for input parameter uncertainty by calibrating the model to the data collected in the field. In support of this, the USEPA (2005) states:

> "Standard approaches for application of models...indicate that a necessary step in model application is calibration of results to field data. In situations where the model is not calibrated to measured indoor air data, and subsequently demonstrated to have predictive capability, the input parameters cannot be assured to represent the properties of the flow system. By performing an uncertainty analysis...a range of potential outputs is revealed to the decision maker."

As there are many limitations and technical considerations when modifying the J&E Model (or other models) with site-specific data, consultation with the MDEQ, RRD, Toxicology Unit is recommended for this or for any time a party proposes development of site-specific criteria using a procedure other than that outlined in this document. Below are factors that may influence any model and should be considered in the development of any site-specific criteria.

1.4.1 Factors Affecting Soil Gas Migration and Vapor Intrusion

Predicting the extent of soil gas contamination from soil or groundwater, as well as the potential for human exposure from VI into buildings, can be complicated by multiple factors. For example, soil gas contaminant plumes may not mimic groundwater contaminant plumes, since different factors affect the migration pattern of water compared to gas. In addition, common building features such as the operation of HVAC systems, the operation of kitchen vents in restaurants, and even elevators in office buildings may induce pressure gradients that result in the migration of vapor-phase contaminants away from a groundwater source of vapors and toward these structures.

Factors that can affect soil gas migration and vapor intrusion generally fall into two categories:

1. Building factors
2. Environmental factors

Examples of building factors are provided in Table 1-1 and several environmental factors are included in Table 1-2. It is important to consider these factors when conducting an investigation of the VI pathway and evaluating its potential effect on the sampling results.

Table 1-1: Building Factors That May Affect Vapor Intrusion

Building Factor	Description
Operation of HVAC systems, fireplaces, and mechanical equipment (e.g., clothes dryers or exhaust fans/vents)	Operation may create a pressure differential between the building or indoor air and the surrounding soil that induces or retards the migration of vapor-phase contaminants toward and into the building.
Heated building	When buildings are closed up and heated, a difference in temperature between the inside and outdoor air induces a stack effect, venting warm air from higher floors to the outside. The VI can be enhanced as the air is replaced in the lower parts of the building.
Air exchange rates	The rate at which outdoor air replenishes indoor air may affect vapor migration into a building as well the indoor air quality. For example, newer construction is typically designed to limit the exchange of air with the outside environment. This may result in the accumulation of vapors within a building.
Foundation type	Earthen floors and fieldstone walls may serve as preferential pathways for VI.
Foundation integrity	Expansion joints or cold joints, wall cracks, or block wall cavities may serve as preferential pathways for VI.
Subsurface features that penetrate the building's foundation	Foundation perforations for subsurface features (e.g., electrical, gas, sewer or water utility pipes, sumps, and drains) may serve as a preferential pathway for VI.

1.4.2 Factors Affecting Indoor Air Quality

Other factors that influence how we evaluate the potential of VI are directly related to the fact that chemicals are a part of our everyday life. Chemicals typically investigated as part of a release are found in common household products, as well as in items we bring into our homes. As such, chemicals that may be part of a release may also be found in the indoor air of homes not affected by VI. This makes the assessment of whether a release is impacting indoor air extremely difficult and in part, is why the MDEQ has a preference for soil gas samples. It is also important to understand that each home is unique and indoor air concentrations in one home may not be similar to another.

Examples of potential sources of volatile chemicals in indoor air are given in Table 1-3.

Table 1-2: Environmental Factors That May Affect Soil Vapor Intrusion

Environmental Factor	Description
Soil conditions	Generally, dry, coarse-grained soils facilitate the migration of subsurface vapors and wet, fine-grained or highly organic soils retard migration.
Volatile chemical/concentrations	The potential for VI generally increases with increasing concentrations of volatile chemicals in groundwater or subsurface soils, as well as with the presence of NAPL. In addition, the type of chemical present (e.g., chlorinated or petroleum) may effect if VI is occurring and the impact that the environmental factors listed within this table actually have on VI.
Source location	The potential for VI generally decreases with increasing distance between the subsurface source(s) of vapor contamination and overlying buildings. For example, the potential for VI associated with contaminated groundwater decreases with increasing depth to groundwater.
Groundwater conditions	Volatile chemicals dissolved in groundwater may off-gas to the vadose zone from the surface of the water table. If contaminated groundwater is overlain by clean water (upper versus lower aquifer systems or significant downward groundwater gradients), then vapor phase migration or partitioning of the volatile chemicals is unlikely. Additionally, fluctuations in the groundwater table may result in contaminant "smear zones." Chemicals on the water table, such as petroleum components, can sorb onto soils within this zone as the water table fluctuates. Sorption of chemicals can influence their gaseous and aqueous phase diffusion in the subsurface and ultimately the rate at which they migrate.
Surface cover or seasonal effects	The surface cover or effects due to seasonal influences (e.g., frost layer, pavement, or buildings) may temporarily or permanently retard the migration of vapors to the surface and allow for greater lateral migration of subsurface vapors. These conditions may also prevent rainfall from reaching subsurface soils, creating relatively dry soils that further increase the potential for soil vapor migration.
Fractures in bedrock and/or tight clay soils	Fractures in both bedrock and clay can facilitate vapor migration (in horizontal and vertical directions) and movement of contaminated groundwater along spaces between fractures. The presence of such fractures can result in an increase in the potential for VI beyond that expected for the bulk, unfractured bedrock or clay matrix.
Underground conduits	Underground conduits (e.g., sewer and utility lines, drains, tree roots, septic systems) can serve as preferential pathways for vapor migration. This is primarily due to the relatively low resistance to flow, relative to the native materials, that result from the highly permeable bedding materials associated with these conduits.
Weather conditions	Wind and barometric pressure changes and thermal differences between air and surrounding soils may induce pressure gradients that affect soil VI.
Biodegradation processes	Depending upon environmental conditions (e.g., soil moisture, oxygen levels, potential measurement of the acidic or alkaline nature of a solution (pH), mineral nutrients, organic compounds, and temperature), the presence of appropriate microbial populations, and the degradability of the volatile chemical of concern, biodegradation in the subsurface may reduce the potential for VI. For example, readily biodegradable chemicals in soil vapor may not migrate a significant distance from a source area while less degradable chemicals may travel farther.

Table 1-3: Alternate Sources of Volatile Chemicals in Indoor Air

Source	Description
Outdoor air	Outdoor sources of pollution can affect indoor air quality due to the exchange of outdoor and indoor air in buildings through natural ventilation, mechanical ventilation, or infiltration. Outdoor sources of volatile compounds include: automobiles, lawn mowers, oil storage tanks, dry cleaners, gasoline stations, industrial facilities, etc.
Attached or underground garages	Volatile chemicals from sources stored in the garage (e.g., automobiles, lawn mowers, oil storage tanks, gasoline containers, etc.) can affect indoor air quality due to the exchange of air between the garage and indoor space.
Off-gassing	Volatile chemicals may off-gas from building materials (e.g., adhesives or caulk), furnishings (e.g., new carpets or furniture), recently dry-cleaned clothing, or areas contaminated by historical use of volatile chemicals in a building (such as floors or walls). Volatile chemicals may also off-gas from contaminated groundwater that infiltrates into the basement (e.g., at a sump) or during the use of contaminated domestic well water (e.g., at a tap or in a shower).
Household products	Household products include, but are not limited to: cleaners, mothballs, cigarette smoke, paints, paint strippers and thinners, air fresheners, lubricants, glues, solvents, pesticides, fuel oil storage, and gasoline storage.
Occupant activities	For example, in nonresidential settings, the use of volatile chemicals in industrial or commercial processes or in products used for building maintenance. In residential settings, the use of products containing volatile chemicals for hobbies (e.g., glues, paints, etc.) or home businesses. People working at industrial or commercial facilities where volatile chemicals are used may bring the chemicals into their home on their clothing.
Indoor emissions	These include, but are not limited to, combustion products from gas, oil, and wood heating systems that are vented outside improperly, as well as emissions from industrial process equipment and operations.

1.5 Investigative Process

The investigative process outlined in this guidance document is designed to be a general how-to guideline for assessing the VI pathway. Although this document identifies a step-wise investigative approach, it is imperative to understand that it is intended to be a generalized framework which describes the various tools utilized for investigating, assessing, completing the data evaluation, and mitigating the VI pathway. Unique or specialized alternative approaches for addressing the VI pathway are provided in Appendix B.

The investigative strategy employed when assessing the VI pathway requires a firm understanding of the desired endpoint (e.g., due diligence for a property transaction, due care assessment, no further action determination, or closure). Often the endpoint, desired outcome, and certainty of the conclusions will dictate the approach utilized and the level of investigation required. The amount of information needed to obtain closure may be very different from what might be needed from a due care perspective, especially if the decision is made to presumptively mitigate. Appendix A provides a series of flowcharts intended to give a *general* overview of the framework and overall approach. Key components associated with each step of a VI investigation have been identified within the flowcharts and provide a general framework to promote a greater understanding of the potential paths and relationships of each step in the process.

2.0 Evaluating the Vapor Intrusion Pathway

The VI pathway is complex and there are various approaches that can be utilized in its evaluation and determining the potential risks. The MDEQ recommends that its staff and contractors utilize the step-wise, risk-based approach identified in the guidance document. This approach emphasizes the use of empirical field data, rather than fate and transport modeling, to assess human health risks. Although this approach is typically used when the generic criteria in Section 20120a do not apply, it can also be utilized as a site-specific approach even when the generic criteria do apply.

The method identified in this document begins by identifying VI sources and then determining if there are (or could be) receptors at risk. If receptors are identified, soil gas concentrations can be evaluated with respect to the identified receptors to determine if a building-specific investigation is required. The VI data are interpreted by developing a CSM, which integrates qualitative and quantitative data sources collected throughout the investigative process.

Note: Throughout this document it refers to the presence of a source of vapors or a vapor source. It is important to understand that a source of vapors may be present in either the vadose zone or in the aquifer.

2.1 Conceptual Site Model

A CSM for VI provides a three-dimensional conceptual understanding of the site by collectively (i.e., not independent of one another) assessing the following:

- Source depth and distance to building (laterally and vertically)
- Geology (including preferential flow paths) between source and building
- Chemical type and concentrations (i.e., source strength)
- Building characteristics (openings, cracks, etc.)
- Receptor characteristics (function of building use)

The collective assessment of the above factors would result in determining if a relevant pathway exists and if so, the type of data collection and collection schedule needed to evaluate the exposure potential. An accurate CSM is necessary to interpret site investigation results, determine whether additional investigation is required, provide support in selecting appropriate remedial actions, and document that site closure criteria have been achieved. A CSM functions both as an interpretation and communication tool used to describe the site conditions and VI pathway for a given site (Figure 2-1).

2.1.1 Developing the Initial Conceptual Site Model

A narrative and visual representation of the actual or predicted relationships between the contaminants at the site and receptors (building occupants) should be developed as part of any CSM. This would reflect any relevant or potential background levels of contamination that may be present or thought to exist. If petroleum hydrocarbons are identified as the only contaminants at the site, the alternate approach provided in Appendix B.3, can be utilized to evaluate the pathway. The CSM should include all of the important features relevant to the characterization of the site and that are thought to influence the VI pathway. An example of the visual representation of a CSM is shown in Figure 2-1.

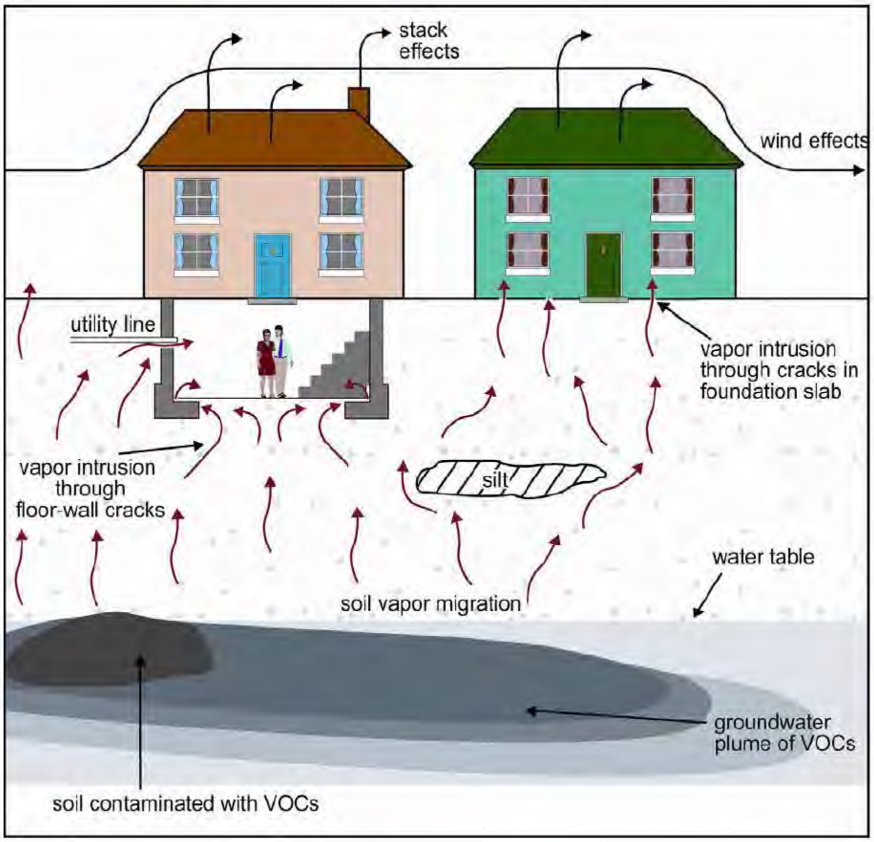

Figure 2-1 – Example of a Preliminary CSM (USEPA, 2008a)

The CSM is typically supported by a narrative and by use of cross-sections, plan-view site figures, and data tables. Cross-sections should identify vapor sources, the interpreted site geology, and receptor locations, as appropriate. Site maps included as part of the CSM should identify the spatial relationships between vapor sources, receptors, sample locations, and known or suspected locations of soil gas and groundwater plumes. The information necessary for developing a CSM can be found in the MDEQ's Checklist for Evaluating a CSM (Appendix C). Additional resources about CSMs are available in the ITRC guidance (ITRC, 2007a) and the USEPA draft guidance (USEPA, 2002).

2.1.2 Building Considerations

As part of the initial Pathway Screening Assessment (Step 1), all known and suspected sources of vapors must be viewed against the physical aspects of the property which includes assessing different building parameters. These physical parameters are not often collected as part of an investigation assessing impacts to groundwater and/or soil. Key building features for consideration include:

1. Underground utilities and process piping:
   - Depths
   - Backfill materials
   - Historical utilities

2. Buildings and structure characteristics:
    - General construction style (e.g., basement, crawlspace, slab on grade)
    - Floor construction and condition (e.g., concrete, dirt, cracks)
    - Depth below grade of lowest floor
    - Building layout (e.g., large and open, small rooms)
    - Height (and number of floors)
    - Sumps or foundation drains
    - Alternate ventilation system
    - Elevator(s) construction

3. Heating, ventilating and air conditioning system in each structure:
    - Type (e.g., forced air, radiant)
    - Equipment location (e.g., basement, crawlspace, utility closet, attic, roof)
    - Source of return air (e.g., inside air, outside air, combination)
    - System design considerations relating to indoor air pressure (e.g., positive pressure may be the case for commercial office buildings)

4. Sub-slab ventilation systems or moisture barriers

Additional and more detailed information on the physical parameters necessary for developing a CSM can be found in the MDEQ's Checklist for Evaluating a CSM (Appendix C) or in the references previously identified in Section 2.1.1.

2.1.3 Updating the CSM

As a site progresses through the Investigation Decision Framework (discussed in Section 2.2 below), the CSM should be augmented and refined to better reflect actual site conditions. Contaminant properties, stratigraphy, hydrogeology, exposure pathways, and potential receptors should be included as they are identified. Refining the CSM may involve a combination of techniques, tools, and sampling results to relay a parties understanding of the subsurface and can include the use of soil, groundwater, soil gas, and/or indoor air samples.

In some cases, the use of additional data may cause the CSM to undergo significant modifications. It is possible that during the course of updating the CSM that a different conclusion, a different solution to an issue, or possibly the need for additional data is identified.

2.2 Investigation Decision Framework

The purpose of a VI investigation is to evaluate whether a relevant VI pathway exists or could exist and, if so, to determine whether there is or may be a risk to receptors in a structure overlying the area. The four major investigation steps are visually identified in the flow charts contained in Appendix A and summarized below. Additional details of each step are discussed in Sections 3 through 6 of this guidance document.

Step 1: Pathway Screening Assessment
Review existing site information (e.g., MDEQ files, county records, Phase I Environmental Site Assessment [ESA]) and previous investigation results for the site; and develop an initial CSM (Section 2.1) for the VI pathway. Development of the CSM should include all available data including site characteristics, to determine if the site must be further investigated for VI (e.g., soil gas sampling) or if VI can be excluded as a

pathway of concern. It should be noted that all data associated with the site should be evaluated collectively, as noted in Section 2.1 above.

Step 2: Soil Gas Investigation
Conduct or complete a soil gas investigation to determine which receptors may be at risk. Use a CSM to assist in the selection of sampling locations and the assessment of risk for determining whether response actions are necessary. A party may need to proceed to Step 3 (Building-Specific Investigation found in Section 5) if proper soil gas samples cannot be collected due to building construction, size of the structure present (or planned), shallow groundwater, the location of the vapor source, or other limiting site conditions. A party may also elect to presumptively conduct a response action as identified in Step 4.

Step 3: Building-Specific Vapor Investigation
Conduct a building-specific vapor investigation to evaluate risks posed to individual receptors which may involve sub-slab soil gas and indoor air sampling. Use a CSM to assist in the selection of sampling locations and the assessment of risk for determining whether response actions are necessary.

Step 4: Response Actions
If necessary, evaluate and implement response actions to address unacceptable VI risks. The term response action is used broadly within this document to refer to corrective or remedial actions including, but not limited to, deed restrictions, mitigation, or presumptive mitigation measures.

In using these steps, it is assumed that a party has performed sufficient evaluation of a site to determine that a site-specific evaluation is necessary. Though this guidance does not establish regulatory requirements for parties, by following the process outlined in this document, a party can achieve the performance standards required by Part 201 and Part 213. This framework is applicable to most VI investigations, regardless of the type of site or the investigation strategies used. At any point during the investigation and when VI risks are identified or suspected, the party proposing the response action may conduct proactive remedial actions to reduce risks to receptors (Step 4, Response Actions).

2.3 Screening Values for the Vapor Intrusion Pathway

As previously discussed in Section 1.3, the MDEQ has developed screening levels that can be used as “site-specific criteria”, in lieu of the generic criteria. Although the MDEQ has identified the use of the screening levels as an option for evaluating the VI pathway, it is important to note that, if desired, the generic criteria can continue to be utilized for sites where the generic assumptions used in the J&E Model are valid.

The SV_{vi} are based on chronic exposure levels and the IRASLs are intended to assist in identifying those conditions that may present an immediate or imminent threat to the public as a result of a release (an acute condition). Both the SV_{vi} and the IRASLs are intended to assist in identifying those conditions that result in unacceptable exposures and can be found in Appendix D. Both the SV_{vi} and the IRASLs are health-based, hazardous substance-specific benchmarks used to evaluate the potential for unacceptable human health risk from inhalation of contaminants in the indoor air environment resulting from VI sources.

Note: The SV$_{vi}$ and IRASLs are generic terms for a group of screening values across multiple media that are utilized to assess the potential for VI.

The terms and nomenclature for the media-specific SV$_{vi}$ and IRASLs for groundwater, soil gas, and sub-slab sampling are described in Table 2-1. The application of screening values in making risk-based decisions is discussed in more detail in Sections 3, 4, and 5.

Table 2-1: Screening Values for the Vapor Intrusion Pathway

Sampling Location	Appropriate Screening Value Vapor Intrusion (SV$_{vi}$)	Immediate Response Activity Screening Levels (IRASLs)
Soil sample	Soil concentration that identified a source of vapors (S$_{vi}$)	- - - - -
Air within the interior space of a building derived from VI sources	Acceptable indoor air value for VI (IA$_{vi}$)	Indoor air values for consideration of an acute exposure for VI (AIA$_{vi}$)
Soil gas collected from the subsurface	Soil gas concentrations for VI (SG$_{vi}$)	Soil gas concentrations for consideration of an acute exposure for VI (ASG$_{vi}$)
Sub-slab soil gas from beneath a building slab	Soil gas concentrations collecting less than five feet bgs or lowest point of a structure (SG$_{vi\text{-}SS}$)	ASG$_{vi}$ – see description above
Groundwater in contact with a structure	Groundwater concentrations when water is in contact or entering a structure for VI (GW$_{vi\text{-}sump}$)	Groundwater concentrations for consideration of an acute exposure when water is in contact or entering a structure for VI (AGW$_{vi\text{-}sump}$)
Groundwater beneath, but not in direct contact with a structure	Groundwater concentrations for VI (GW$_{vi}$)	Groundwater concentrations for consideration of an acute exposure for VI (AGW$_{vi}$)

2.3.1 Screening Values for Vapor

The SV$_{vi}$ screening values for soil gas and sub-slab vapors, identified in Table 2-1, are used for evaluating the risk posed to nearby receptors. In determining these values, it was assumed that 1) contaminant vapor concentrations decrease with distance from vapor sources and 2) contaminant vapor concentrations move upward in the subsurface toward the surface and eventually into buildings.

The vapor attenuation coefficient ("alpha" or α) is a key parameter in assessing the significance of subsurface vapors, the concentrations required for intrusion into indoor air, and in the development of the SV$_{vi}$. The alpha is defined as the concentration of a particular chemical in indoor air divided by its concentration in soil gas at a specified depth beneath the building floor. It is commonly referred to as a numerical constant (unitless) either derived empirically, modeled, or estimated to predict a concentration in soil gas that may cause impacts to indoor air above acceptable health-based indoor air screening levels. The chronic SV$_{vi}$ were established by back calculating from the compound-specific IA$_{vi}$ (as C$_{indoor}$) and use of an attenuation factor or alpha value particular to that media. When using empirically derived data, the alpha can be represented mathematically by:

$$\alpha_{sg} = C_{indoor}/C_{soil\ gas}$$

The MDEQ's α_{sg} and the resulting soil gas and sub-slab SV_{vi} are based on the analysis the USEPA performed on its vapor intrusion database (USEPA, 2008b). That dataset contains multiple sites across the United States with paired soil gas, sub-slab, and indoor air data. Though many states and the USEPA have selected a more conservative value (i.e., results in a lower screening value), the MDEQ has established an attenuation factor of 0.03 for soil gas collected less than five feet bgs and an attenuation factor of 0.003 for deeper soil gas concentrations.

2.3.2 *Screening Values for Groundwater*

Groundwater concentrations for the VI pathway (GW_{vi}) are calculated using both a media-specific attenuation factor (0.001) and the compound-specific Henry's Law Constant. The MDEQ has also provided a concentration for use if the groundwater is in direct contact or entering into a structure ($GW_{vi\text{-}sump}$) and it is assumed that there is no attenuation. This includes situations where impacted groundwater has been identified in a sump or is actually within a structure.

Note: Appropriate VI screening values are based on exposure categories identified in Part 201 Section 324.20120a (i.e., residential and nonresidential).

2.3.3 *Screening Values for Soil*

The MDEQ has developed a screening value for soil (S_{vi}) that may be considered conservative for various site conditions. Establishing the actual conditions when the values are conservative can be a lengthy and intensive process that typically requires the collection of soil gas samples and an evaluation of various lines of evidence. Though soil data are generally not recommended as a stand-alone screening tool for eliminating or identifying the potential for VI, the S_{vi} are established and provided as an initial screening tool to establish a potential source of soil gas within the unsaturated soil column to aid in defining potential sources of vapors that can potentially impact a structure.

2.3.4 *Use of Screening Values*

The SV_{vi} and IRASLs provided within this document are not promulgated values and, therefore, are not binding on the public or the regulated community. These values instead provide a screening value that is known to produce results acceptable to the MDEQ when the generic criteria do not apply.

The SV_{vi} were developed for air, soil gas, and groundwater to represent an acceptable exposure limit that is not expected to cause adverse health effects after a single or short-term exposure to a single hazardous substance. They are intended to be used, in conjunction with an accurate CSM, to evaluate risks posed to receptors when the generic criteria do not apply and may be utilized as site-specific criteria for addressing the VI pathway. In Appendix D, Table D-1 identifies the SV_{vi} for evaluating chronic risks for residential exposure scenarios. The chronic risks for nonresidential exposure assumptions are identified in Table D-2. The IRASLs are also provided in Appendix D, Table D-3. As stated above, the IRASLs are intended for assessing the potential of an acute risk and to assist in identifying conditions that may present an immediate or imminent threat to the public as a result of a release. An acute exposure is generally defined as a single or repeated exposure over a 24-hour period.

Response action decisions are typically based on identifying that a completed exposure pathway exists or could exist. This is supported by the information presented in a CSM and the detection of elevated constituents in subsurface VI samples above the SV_{vi}. Response actions may also be taken when other data sources or site conditions indicate a need to be protective of human health or when a party chooses to implement presumptive corrective measures in lieu of completing a detailed investigation. However, it should be noted that most response actions require some level of investigation to ensure that the design and implementation are protective.

2.4 Field Sampling and Laboratory Analysis

Appendix E contains a standard list of hazardous substances that should be analyzed and reported on during the course of a normal VI investigation (Sections 4 and 5). Compounds currently without an SV_{vi} or IRASL typically do not have sufficient toxicity data to generate a screening value or may not be common compounds of concern for the VI pathway.

Note: For sites in which contaminants not identified in Appendix E are expected to be present, and where those contaminants will meet the definition of a VOC (R 299.5714 and R 299.5724), an assessment of the potential risk from these compounds remains necessary.

2.4.1 Field Sampling

Appendix F contains the MDEQ's SOPs for soil gas and sub-slab soil gas sampling, as well as the MDEQ's procedures for the collection of indoor air samples. These SOPs are written for the MDEQ staff and its contractors and have been made available as a technical reference that may be informative when conducting work at sites where VI issues are of concern.

Soil gas sampling can be conducted using temporary or permanent soil gas monitoring points. However, permanent soil gas monitoring points are recommended when multiple sampling events are necessary. In either case, the annular space around the sample device should be sealed off from the ground surface to prevent infiltration of ambient air. Based on field observations, lithology, field classification of moisture content, and total organic vapor readings should be recorded at each probe location for the depth interval from which the soil gas sample is collected. Organic vapor readings can be obtained using either a flame ionization detector or a PID, as appropriate.

2.4.2 Target Analytes and Analytical Methods

The TO-15 (full scan), a GC/MS method, is the default method used by the MDEQ Laboratory for the analysis of soil gas, sub-slab, and indoor air samples. Samples should be analyzed for the compounds on the Soil Gas Compounds Screening List provided in Appendix E. Alternative analytical methods, like TO-17 and others identified in Table D-3 of the ITRC Toolbox (ITRC, 2007a), may be proposed. However, it is important to note that QA/QC protocols may vary greatly among laboratories and the practices should be reviewed and specified in the work plan prior to data collection. Laboratory QA/QC expectations for VI data are provided in Appendix G.

Similar to soil and groundwater samples, air samples containing elevated concentrations of VOCs can often be subject to dilutions by the laboratory. Laboratory dilutions of a sample or samples for which an insufficient volume of air have been collected, will typically result in higher reporting limits than those specified on the Soil Gas Compounds Screening List (Appendix E). Such situations could be discussed with the MDEQ Specialists to determine if resampling will be necessary or if the diluted results provide the information required. It should be noted that when using the TO-15, there may be some compounds that have laboratory reporting limits that are higher than the compound's SV_{vi}. When this occurs, the TO-15 SIM may be necessary to reach the appropriate detection limits in order to evaluate risk.

Note: It may be possible to reduce the number of compounds in the chemical analysis, if a site has been fully characterized and a health evaluation has been conducted, similar to the Risk Assessment Guidance for Superfund (RAGS) Part A.

It should also be noted that there are several compounds not listed in Appendix E that possess the potential to volatilize from groundwater (R 299.5714) and/or soil (R 299.5724). These compounds have a Henry's Law Constant greater than or equal to 0.00001 atm-m^3/mole but cannot be analyzed using TO-15 or other standard soil gas methods. Examples include (but are not limited to): mercury, polychlorinated biphenyls, and several PAHs. If these compounds are suspected of posing a VI risk, investigators should coordinate with the MDEQ Specialists to determine the appropriate analytical method and sampling procedures.

2.5 Identify Objectives and Strategy

Investigations for VI should be based on clearly defined objectives consistent with site-specific conditions. The type of VI sites can vary widely and include releases from LUSTs, dry cleaners, and VOCs from associated soil contamination; as well as VOC impacted groundwater that may impact multiple receptors, and brownfield sites with proposed new construction or redevelopment (ITRC, 2007b). Site-specific conditions may require different investigation objectives and strategies. Some basic questions that must be considered when identifying the objectives and sampling strategy are identified below:

- *What are the exposure scenarios present?* Analyzing exposure scenarios helps to identify the current and future risks of the pathway and to determine the available screening values. Assessing the potential exposure scenarios aids in designing an investigation to know what and how to sample (e.g., media, depths, parameters, etc.).

- *Are there multiple potential sources of vapors present at a facility?* Within a CSM it is important to identify if there is the potential for multiple sources (on-site and off-site), as this will direct the future site investigation, help to identify acute and potential chronic health issues, explain data variation and results, and identify the need for additional response actions.

- *Is the groundwater impacted above the GW_{vi}?* The presence of contaminants above the screening concentration in groundwater may identify a VI risk for a structure. The CSM must account for preferred pathways including utility lines, sumps, etc.

- *Is the groundwater impacted above the GW_{vi} in contact with or entering a structure?* If groundwater is in contact or entering a structure, the generic criteria are not applicable and it would, in most cases, not be possible to do soil gas sub-slab sampling. This condition can result in a more immediate risk and the need to perform further assessment and possible mitigation.

- *Is there impacted soil in contact with the structure?* When contaminated soils are in contact with a structure, cracks and other foundation penetrations will act as direct conduits for VI. It can result in a risk and the need to perform further assessment and possible mitigation.

- *Is the release from petroleum hydrocarbons?* When the contamination is due to a release of petroleum hydrocarbons, there is a high potential for attenuation of vapors to occur if there is sufficient oxygen present. Different site assessment strategies may be appropriate depending on whether the source is dissolved-phase or LNAPL. Depth to groundwater from a structure may be the driver for dissolved phase sources, rather than the actual groundwater concentration. Further information is available in Appendix B.

- *Could historical site use or processes have resulted in a release, partially or completely from vapors?* Certain processes may cause a direct release of vapors into the subsurface. A release of vapors, wholly or in part, may be a factor in explaining anomalous vapor data results without a corresponding soil and groundwater source observed.

- *What is the size and floor plan of the structures that may be impacted by vapors?* The nature of the structure and its layout has a significant impact on pathways and vapor threshold concentrations. The presence of elevators, sumps, and utility corridors can serve as preferential pathways. Structures with large open spaces (big buildings) may be looked at differently than structures with many small separate offices.

Modifications to the approach outlined in this guidance document may be appropriate with the proper understanding of the site-specific conditions that are present. For instance, it would be inappropriate to collect soil gas samples from greater than five feet below the ground surface if groundwater is present at three feet below the ground surface or if a potential source of vapors is located above the sampling point.

3.0 Step 1: Pathway Screening Assessment

Complete vs. Relevant Pathway

Section 20120a(3) identifies that a pathway must be evaluated and characterized based on whether a pathway is reasonable and relevant and not whether a pathway is complete (i.e., poses a risk at a facility). This evaluation must occur under Part 201, even for properties in which a structure is not present. It is important to note that for the VI pathway it may be possible to complete a site-specific evaluation that documents that conditions at a property do not result in an unacceptable exposure.

Step 1 is a screening level assessment to determine if the VI pathway is relevant. This is accomplished by establishing that there is a source of vapors, a possible migration route, and that potential human receptors exist.

If, during Step 1 or at any other step of the investigation, information points to the potential for imminent health impacts, an emergency assessment and interim response actions including immediate response actions, must be considered in accordance with R 299.5526. Section 3.1 identifies and discusses examples of when a site may need to consider an immediate response and Section 3.2 presents the framework for initial screening at sites where the need for emergency assessment and response is not required.

As with every step of the investigative process, as additional information becomes available, the CSM should be updated to provide a clearer picture of the site conditions.

3.1 Consider the Need for Emergency Assessment and Response

Examples of situations that might require an immediate response include:

- Oil, gas, or chemical infiltration into a basement or sump in a building
- Measured indoor air concentrations near or above the IRASLs
- Uncontrolled potentially flammable or explosive conditions in a building, sewer, or utility conduit
- Chemical odors in an occupied building with or without exposure symptoms to the occupants

The immediate safety of the building occupants is the first priority when an acute or the immediate hazard from VI is suspected. In such cases, call the local fire department by dialing 911 to activate a local response. Local authorities can typically evaluate the conditions quickly and provide an immediate short-term control measure.

Note: Emergency assessment and immediate response actions may be required if imminent health risks are suspected at any point during a VI investigation. To address an imminent VI risk, an interim emergency response action may need to be implemented.

Several sampling techniques may be used to make an immediate decision. Depending on the type of release and which compounds of concern are present, an investigator may use appropriate field screening instruments. In most cases, follow-up indoor air sampling using the TO-15 method will be a necessary activity to determine specific compounds and their concentrations.

The presence of methane resulting from a release should be further evaluated to determine if there are acute hazards present and if there is a need for an immediate or emergency assessment and response. Section 3.3 provides additional information regarding how to evaluate the risk of VI associated with the presence of methane.

3.2 Vapor Intrusion Source and Receptor Evaluation

A critical component of any VI investigation is establishing the extent and area to evaluate. This should begin with a review of existing site records and data, including: historical information like chemical use history, site investigation data, Phase I and Phase II ESA investigations, and other site-specific information. The following sections include a description of how previously collected data can be utilized to establish the area that may represent a potential vapor source. It is important to note that a release may consist of vapors or even be more prevalent in the vapor phase. In these cases, the investigation may need to conduct some initial soil gas sampling, similar to that identified in Section 4, to define the extent of the release.

3.2.1 Identifying Potential Soil Sources of Vapors

Soil data are typically less than ideal for evaluating the potential risk from VI because of the uncertainty associated with using partitioning equations, especially when generic SVIIC (R 299.5724) do not apply. However, as there is usually soil data associated with most sites, having the ability to perform basic screening on the potential for the presence of a VI issue is critical. Therefore, the MDEQ has developed for use a value for soil that may be conservative. As stated above, establishing the actual conditions when the values are conservative can be a lengthy and intensive process that typically requires the collection of soil gas samples and an evaluation of various lines of evidence.

Hartman (Hartman, 2002) reported that calculated soil gas values from soil data may actually overestimate actual soil gas concentrations in the case of hydrocarbons. In most cases, the determination of the health risks cannot be completed without performing a detailed site analysis including the collection of soil gas or sub-slab soil gas samples (Sections 4 and 5). As a result, soil data should be utilized as one part of a line-of-evidence approach. Though not a stand-alone tool, soil data are effective in assisting the delineation of potential vapor sources within the unsaturated soil column (if the release did not include vapors) or to establish sites for further VI assessment.

If the soil concentrations are found to be less than S_{vi} and the soil samples accurately represent and characterize the release and the source of vapors, then the VI pathway does not pose a risk to human health. It must be noted that the ability to document that the site is accurately characterized and that a vapor release has not occurred is critical in making this determination. Single soil samples that do not fully characterize the site would not be sufficient to make this determination.

3.2.2 Identifying Potential Groundwater Sources of Vapors

The GW_{vi} are designed to assist in refining the CSM and to help determine the scope of further investigation. The GW_{vi} represent a concentration at which the VOCs may volatize from the aquifer causing a VI risk to a structure. In some cases the GW_{vi} values may be conservative, for example: sites where the water table is more than 100 feet bgs; sites that contain clays and silts that act as vertical barriers to vapor migration; areas where uncontaminated groundwater is overlying a contaminated groundwater plume; or petroleum sites where biodegradation may be an effective means of addressing VI issues.

Conversely, the GW_{vi} may not be conservative enough at sites with highly permeable soils, for buildings with certain characteristics like dirt floors, or when shallow groundwater is present. In such circumstances, and particularly in cases where groundwater is present in a sump or in contact with a structure, the $GW_{vi\text{-}sump}$ was developed to evaluate groundwater concentrations.

General recommendations to ensure that groundwater samples are appropriate for use in defining the extent of a vapor source in groundwater are as follows:

- *Screen Placement*. Contaminants at the water table, rather than deeper contamination, are responsible for causing potential VI problems. Hence, monitoring wells used to make VI evaluations should be screened across the air-water interface. It is therefore important to make sure that the well screens are not submerged below the water table.

- *Screen Lengths*. Monitoring wells with long well screens, regardless of screen placement, should not be used to make VI evaluations. When sampling long well screens, clean water entering the well screen at depth may dilute the contaminated groundwater near the top of the screen biasing the sampling results and the associated risk determination. Hence, short screen lengths (five feet or less) are preferred for monitoring wells that will be used to make VI evaluations. Longer screens may be warranted under certain geologic conditions or in areas that experience water table fluctuations greater than three feet.

- *Well Installation*. Monitoring wells should be designed and installed to yield representative samples of groundwater conditions. Monitoring wells should have proper filter packs, slot sizes, and annular seals.

- *Well Development*. Monitoring wells should be developed to: create an effective filter pack around the well screen, rectify damage to the formation caused by drilling, optimize hydraulic communication between the formation and well screen, and assist in the restoration of natural water quality of the aquifer near the well.

- *Well Purging*. Prior to sampling, monitoring wells should be adequately purged to remove stagnant casing water from the well that is not representative of aquifer conditions.

- *Well Sampling*. Representative sampling procedures must be utilized which may include the use of low-flow sampling techniques.

When defining the potential extent of a source of vapors in the groundwater, lack of a monitoring network or appropriately collected data does not negate the need to assess the pathway.

Note: Diffusivity for a volatile compound is approximately 10,000 times lower in water than it is in a gaseous phase (i.e., unsaturated soil gas). As a result, uncontaminated groundwater overlying a contaminated groundwater plume can serve as a barrier for the upward migration of contaminant vapors, due to the reduced diffusivity potential. However, these situations should be interpreted using caution because: (a) dissolved VOCs or residual NAPL may be present in the capillary fringe or vadose zone soils associated with historical groundwater fluctuations; and (b) vapors from nearby soil or groundwater contamination may migrate laterally.

3.2.3 Vapor Intrusion Receptor Survey

The purpose of a VI receptor survey is to document the location of current or possible future receptors within a 100-foot radius from vapor sources (Section 3.2.1), defined as the preliminary screening area. A secondary objective should include an evaluation of potential future building exposure scenarios if a structure is not present. The VI receptor survey may need to be extended if preferential pathways (e.g., utility corridors, fractured clays, fractured bedrock, etc.) are identified within the area of potential sources. However, the receptor survey may also be reduced under certain conditions. For example, petroleum-based hydrocarbons are readily degraded to carbon dioxide in the presence of oxygen by ubiquitous soil microbes. In this circumstance, a much smaller separation distance may be appropriate, and is discussed in greater detail in Appendix B.3.

The VI receptor survey represents an integral component of the CSM (Section 2.1 and Appendix C) and must be documented. At a minimum, the VI receptor survey should include a site map of potential receptors and other relevant features with respect to the extent of known vapor sources and information on the type of buildings present, their use, and their construction. Building information and occupancy can be obtained from public records, maps, and available databases and can be verified by field visits, as well as direct contact with the occupants.

3.3 Methane

Methane is not toxic and the principle health and safety concerns are its explosive, flammable, and asphyxiant properties. Since methane is a simple asphyxiant, acting by displacement of oxygen, no threshold limit value (TLV), permissible exposure limit (PEL), or recommended exposure limit value (REL) has been established. However, migrating methane gas can pose serious public health and safety risks, principally fire and explosion.

Note: Methane (chemical formula = CH_4) is the lightest of all hydrocarbons. It is a colorless, odorless, tasteless, flammable gas that is produced as a result of the microbial or thermal alteration of organic matter and is widely distributed in nature. Sources of methane beside wetlands include solid or industrial waste deposits, oil and gas wells, groundwater contamination plumes (especially biodegrading hydrocarbons), and leaking natural gas pipelines.

Under Section 20120a(17) and R 299.5728, the MDEQ has established that the presence of methane (resulting from a release) above 0.52 parts per million in groundwater (the flammability/explosivity screening level) or above 8.4E+6 $\mu g/m^3$ (1.25 percent by volume) in soil gas, represents conditions that must be further evaluated for the presence of acute hazards. The MDEQ has reviewed information about methane in soil and groundwater at several facilities and has determined that these levels are appropriate to protect the public health, safety and welfare because of the acute flammability and explosivity hazards associated with methane when it exceeds these levels.

3.4 Unique Vapor Intrusion Conditions

Vapor Intrusion investigations should be based on clearly defined objectives consistent with site-specific conditions. The approach detailed in Sections 3 through 6 of this document will work for the majority of sites, however, there are unique situations or conditions where this approach may not be appropriate or where a different approach may make more sense. The MDEQ has identified the following scenarios as examples of site-specific conditions that may require different investigation objectives and strategies. More information on ways to address these situations is provided in Appendix B.

3.4.1 Petroleum Underground Storage Tanks

Petroleum products, such as gasoline and diesel, are complex mixtures containing a wide variety of different hydrocarbons. Subsurface sources can include leakage from USTs, fill ports, pipelines, and various pipe fittings. Many hydrocarbons (notably petroleum-based hydrocarbons) are readily degraded to carbon dioxide in the presence of oxygen by ubiquitous soil microbes. Aerobic degradation is a rapid process and frequently occurs in a relatively thin (a few feet thick) zone where the concentrations of oxygen and hydrocarbons are most conducive for microbial processes. The bioattenuation of hydrocarbons can potentially reduce soil gas concentrations and VI by several orders of magnitude. Therefore, the MDEQ has developed an alternate approach to assess bioattenuation and its potential impact on VI into a structure (Appendix B).

3.4.2 Big Building

Because of the nature of large buildings (e.g., larger footprint, higher air exchange, taller ceilings, lack of a basement, thicker slabs of concrete, and occupational activity patterns resulting in lesser exposure), a generic approach to assessing the potential for VI may overestimate the risk to users of the building. As a result, the MDEQ has identified an approach referred to as the "Big Building Model," which provides an alternative methodology for large nonresidential buildings (greater than 4,000 m^2 or 43,000 ft^2) to utilize multiple lines-of-evidence to demonstrate compliance with the volatilization to the indoor air exposure pathway (i.e., VI pathway). The MDEQ approach relies primarily on a paper titled, "Prediction of Indoor Air Quality from Soil-Gas Data at Industrial Buildings" (Eklund and Burrows, 2009). This approach is not valid for all large structures and may not be appropriate for use on the entire structure, especially for smaller enclosed areas like offices and meeting rooms. More information on the application of this approach is detailed in Appendix B.

3.4.3 Volatile Soil Inhalation Criteria

Volatilization of organic compounds from contaminated soil or groundwater into the ambient air represents a potential source of exposure (Radian, 1986). Whether the ambient air pathway needs to be addressed and its possible impact on the human health is dependent on the specifics of the site. However, because of the similarities between the sampling and analysis methodologies, as well as the data collection requirements for the ambient air and vapor intrusion pathways, a brief discussion of the ambient air pathway has been included in this document. In Michigan, under Part 201, the generic cleanup criteria for soil based inhalation of volatile hazardous substance emissions to ambient air are called the VSIC. The MDEQ, RRD has established an approach that, if implemented as described, would demonstrate compliance with the VSIC using ambient air data in accordance with R 299.5726(8). This is done through the collection of ambient air samples within a flux chamber (flux chamber sampling). More information on the application of this approach is detailed in Appendix B.

3.4.4 Facilities with Releases of Hazardous Substances as Vapors

In some cases, the GVIIC and SVIIC are not protective due to facility-specific or contaminant-specific concerns. In situations where these conditions have been identified, additional requirements may be established for response actions [R 299.5532(9)]. Situations that require additional response actions include hazardous substances that have been released via a vapor leak or exist as a subsurface vapor cloud. This may occur at facilities that utilize chemicals, such as methylene chloride, ethanol, TCA, TCE, PCE, acetone, and MEK.

On-site use of such chemicals could result in vapor leaks from the storage tanks and/or associated piping, even in situations where there is no apparent loss of product from the storage system. These vapor leaks (i.e., vapor clouds) may not only result in soil gas contamination, but could ultimately contribute to soil or groundwater contamination. For instance, due to the high vapor pressures and high vapor densities of chlorinated compounds (e.g., PCE and TCE), vapors may emanate from containers or pipes holding these compounds (in either gaseous or liquid phase) which can collect on the floor, penetrate through the slab, and create a zone of contaminated vapor in the vadose zone.

When vapor releases have been confirmed or are suspected at a facility, the collection of soil gas samples in addition to soil and/or groundwater samples will be necessary to adequately evaluate the exposure pathways. In most cases, this will require soil gas samples to be collected from locations alongside or beneath any structures as well as across the facility.

3.4.5 Building with Crawlspaces

Buildings with crawlspaces often require a unique approach if the source of vapors is near the surface. For sources greater than five feet below the surface, soil gas samples collected in accordance with the information provided in Section 4 may provide the information necessary to determine if a risk is present. For sources of vapor less than five feet, the collection methods in most circumstances will have to be modified. In instances when there is restricted access to the crawlspace, indoor air samples may be collected from within the crawlspace (Section 5). Additional samples beyond those identified in Section 5 may be necessary to address potential variability and mixing.

3.4.6 Parcels without Structures

As described in Section 1.2, VI is the migration of volatile chemicals from the subsurface into overlying buildings with human receptors. If there is not a building or structure, VI cannot occur. That being said, because there is not currently a structure on the property, does not necessarily mean that there will not be a structure on the parcel in the future. This is a particularly relevant point in the case of property redevelopment.

For sites without structures, the use of deed restrictions that limit the future construction of buildings or require a vapor assessment (see Appendix H) may eliminate the need to do further evaluation of the VI pathway. However, this approach may be overly conservative and if deed restrictions are not a feasible option or a party wishes to evaluate the possibility for vapors to exist, a VI Investigation could be conducted. How this evaluation is performed, including what type and where samples should be collected, should be based on the CSM (Section 2) and the location of future buildings in relation to the identified sources of vapors. The reliability of the VI evaluation is based on the extent that the conditions and location of the sources of vapors are appropriately characterized and identified.

When groundwater and soil samples are available (when a vapor source is located on a property), a comparison to the $GW_{vi\text{-}sump}$ (groundwater) and S_{vi} (soil concentrations) will provide an indication of the potential or need to further assess the pathway. If the site is adequately characterized and the sampling results are below these screening levels, no further response activities are required. However, in each of these situations, an exceedance of the identified screening levels does not necessary mean that a vapor intrusion risk would present itself in a new structure.

The collection of soil gas samples may be useful in evaluating the potential for vapors to migrate from distant sources. It is recommended that the more restrictive $SG_{vi\text{-}ss}$ values are utilized in the initial evaluation with the understanding that it doesn't necessarily mean that an exceedance confirms a vapor intrusion issue. However, the higher the results are above the screening levels the more likely a VI issue would be present in a newer structure.

3.4.7 Use of MIOSHA for Industrial and Manufacturing Properties

The use of MIOSHA exposure levels to address vapor intrusion is a topic of great interest. Recent amendments to Part 201 in 2012 include provisions for operating facilities subject to the Michigan Occupational Safety and Health Administration (MIOSHA) to achieve compliance for indoor air criteria under Part 201 by complying with MIOSHA standards Sec. 20120a(19). This is limited to manufacturing and industrial facilities covered by the classifications provided by sector 31-33 – manufacturing, of the North American industry classification system, United States, 2012, published by the United States Office of Management and Budget. It also requires the the person to complies with the Michigan occupational safety and health act, 1974 PA 154, MCL 408.1001 to 408.1094, and the rules promulgated under that act applicable to the exposure to the hazardous substance and that the hazardous substance is included in the facility's hazard communication program under section 14a of the Michigan occupational safety and health act, 1974 PA 154, MCL 408.1014a, and the hazard communication rules, R 325.77001 to R 325.77003 of the Michigan administrative code.

Though these provisions allow for the use of the occupational health standards for air contaminants (R 325.51101 to R 325.51108 of the Michigan administrative code) at industrial and manufacturing sites, their use is not appropriate for residential and other nonresidential exposure scenarios that may expose personal that do not fall under the requirements of MIOSHA which includes various sensitive populations. For more information about the use and applicability of MIOSHA on a specific site that does not meet the requirements established under can Sec. 20120a(19) please contact the MDEQ's VI Specialist.

4.0 Step 2: Conducting a Soil Gas Investigation

Once it has been established that the VI Pathway has the potential to pose a risk (Section 3), a soil gas investigation should be performed to assess the risk. It should be noted that soil gas sampling is not always feasible at every site and is dependent on geologic conditions.

This section focuses on the following aspects of soil gas investigations:

- Consideration of investigation objectives and strategies appropriate for different types of sites
- Sampling locations, depths, and procedures
- Use of screening values to evaluate soil gas data within the context of the CSM

4.1 Collecting Representative Soil Gas Samples

The number of soil gas samples needed and the overall investigation strategies for a soil gas investigation will depend upon the geometry (i.e., shape and extent) of the vapor sources, the location of receptors, and the size and complexity of the site, as well as the specific program requirements for which the soil gas investigation is being completed.

Recommended locations for soil gas sampling may include, but are not limited to:

- Immediately above the identified “worst-case” vapor source area or the area of the highest documented concentrations in soil or groundwater
- At identified Recognized Environmental Conditions (RECs) as established by an ASTM E1527-05 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process
- Adjacent to the base of an existing building foundation or basement or within the proposed footprint of a future building
- At points to define the extent of vapors migrating from a suspected source area

In general, it is recommended that soil gas samples should be collected adjacent to specific buildings according to the following depth requirements:

- At least five foot below grade with at least a two foot separation above the water table
- At or near the depth of the basement floor of the building being evaluated (typically to a total depth of eight to ten feet below grade for a residential property)

Structures greater than 2,000 square feet that have a source of vapors present beneath the structure should collect samples in a manner described in Section 5 below. This is especially the case if there are:

- Shallower sources present
- Vapor sources in contact with the structure
- Groundwater located less than five feet below grade (or known to be in contact or entering into the structure)

The effect of precipitation on soil gas samples is generally less of a concern at depths greater than five feet bgs, directly under foundations, or in areas that are significantly covered by an impervious surface cover (ITRC, 2007a). Significant precipitation events can displace shallow soil gas and close off pore space pathways. Therefore, samples should not be collected from depths less than five feet bgs following significant precipitation events, as it may provide an inaccurate representation of soil gas conditions. The effect of significant precipitation can be recognized by observing high vacuum readings, extended sample collection time, and visible moisture droplets within the sampling train during sample collection. Therefore, sampling after a rain event should not be conducted until site conditions return to pre-precipitation conditions.

4.2 Evaluating Soil Gas Data

Soil gas sampling results are used in the context of a well understood CSM to assess the potential risk posed to a receptor in a specific building, especially where the vapor source does not lie in contact with or beneath the structure. A checklist for the MDEQ staff is provided in Appendix C to evaluate the use of soil gas data for determining compliance.

Note: Confusion with Units: One common error that people make with soil-gas programs or data is thinking a ppbv is equivalent to a microgram per liter (µg/L) or a µg/m^3. The units are not equivalent, and the conversion depends on the molecular weight of the compound. Converting between units (e.g., µg/L to µg/m^3, percent to ppmv) can also cause issues (Hartman, 2006).

In general, for sites with similar features and conditions, higher soil gas concentrations are indicative of a higher risk to receptors. The decision framework described below considers levels of risk that are based solely on the comparison of field measured soil gas concentrations to soil gas screening values.

The recommendations for the decision framework are described in Sections 4.2.1 through 4.2.4 and are summarized in Table 4-1. Each level identifies a recommended number of sampling events and the expected outcomes. It is important to note that the described actions and outcomes are based on the expectation that soil gas samples have been collected appropriately, including but not limited to the following methodologies:

- The soil gas samples were collected as close as possible to an existing receptor or within the footprint of future building locations.
- The vapor source present is either at steady state or decreasing in concentration.
- Proper sample collection procedures were performed.
- Full QA/QC procedures were implemented, documented, and verified.
- The vapor samples were analyzed by an approved analytical method (Section 2.4.2).

It should be noted that significant spatial variation (either horizontally or vertically) may be an indication that verification sampling or multiple sampling events over time may be necessary to assess risks more accurately.

4.2.1 Soil Gas Results 10x less than the Soil Gas Screening Levels for Vapor Intrusion

Soil gas concentrations 10x less than their respective SG_{vi} concentrations represent little or no VI risk and as a result, no additional samples are necessary to show that the pathway is not a risk to human health. The samples should undergo a detailed QA/QC procedure in order to document that the samples that are collected are representative of site conditions.

Table 4-1: Soil Gas Concentrations and Expected Outcomes

SG_{vi} Results	Actions	Outcome
With low or no potential source of vapors $[SG_{vi}] < (0.1 * SG_{vi})$ (i.e., 10x less than SG_{vi})	No further sampling is required if samples include QA/QC	Vapors are not present that would pose a risk for the VI pathway
After a remedial action has taken place $[SG_{vi}] < SG_{vi}$ *(i.e., less than SG_{vi})*	A total of three sampling events that include full QA/QC	VI pathway no longer poses a risk
A known source of vapors remains $[SG_{vi}] < SG_{vi}$ *(i.e., less than SG_{vi})*	A total of four sampling events to that include full QA/QC	VI pathway is relevant but does not pose a risk
A source of vapors is present $SG_{vi} < [SG_{vi}] <$ IRASLs *(i.e., greater than SG_{vi}, and less than IRASLs)*	Conduct a building-specific investigation (Section 5)	Assess lines of evidence to determine if mitigation is warranted
A source of vapors is present IRASL $< [SG_{vi}]$ *(i.e., greater than IRASL)*	Conduct a building-specific investigation and an assessment of immediate risk (Section 5)	Immediately conduct presumptive mitigation or immediately assess the risk and evaluate future actions
Definitions: $[SG_{vi}]$ = Measured soil gas concentration, SG_{vi} = Soil gas screening level, IRASL = Immediate Response Activity Screening Level, < = Less Than, > = Greater Than		

4.2.2 Soil Gas Results less than and up to the Soil Gas Screening Levels for Vapor Intrusion

Soil gas concentrations less than and up to their respective SG_{vi} concentrations are addressed in a variety of ways, depending on the specific site situation.

- For sites that have completed a remedial action, a total of **three sampling events** that include a full QA/QC should be performed to assure that the source has been adequately addressed and that seasonal variation has been accounted for. This is consistent with groundwater sampling requirements following completion of a remedial action.
- For sites where a known source of vapors remains and the intent is to show that there is no risk of those vapors causing a VI condition, a total of **four sampling events** that include full QA/QC would be needed to adequately address the seasonal and temporal variability.

It is once again important to note that the samples should undergo a detailed QA/QC procedure in order to document that the samples that are collected are representative of site conditions.

Note: Sub-slab soil gas samples are soil gas samples that are collected less than five feet bgs beneath a structure. For samples collected from less than five feet bgs, the SG_{vi-ss} values are appropriate to use for an evaluation of risk.

4.2.3 Soil Gas Results above the Soil Gas Screening Levels for Vapor Intrusion

Soil gas concentrations that exceed the soil gas screening levels, but are less than their respective IRASL, will likely require further investigation and assessment. The additional assessment work could include; completion of a building survey (Section 5.1), the collection of sub-slab soil gas samples, and possibly confirmation soil gas samples. In some circumstances, it may make sense to forego the additional time and expense associated with further assessment and move directly to presumptive mitigation (Section 6). This is a decision that is project specific and should be made on a case-by-case basis.

4.2.4 Soil Gas Results greater than the Immediate Response Activity Screening Levels

Soil gas concentrations that exceed their compound-specific IRASL indicate a higher VI risk and the potential exists for the occupants to experience an acute exposure. In these situations, an assessment of the immediate risk (Section 5.2) is performed and the need for presumptive mitigation measures (Section 6) evaluated for immediate implementation.

5.0 Step 3: Building-Specific Investigation

Following a soil gas investigation, it may be determined that further assessment is warranted to adequately address the VI pathway or to further determine if the IRASLs are posing an immediate risk. In these circumstances, a building-specific investigation involving the assessment of individual structures may be warranted. The results of a building-specific investigation are used to determine if unacceptable risks exist that require additional response actions.

Building-specific investigations include one or more of the following:

- Conducting an Interior Building Survey (Section 5.1)
- Conducting sub-slab soil gas sampling (Section 5.3) using information obtained from the IBS
- Conducting indoor air sampling if water is present within a structure or an acute risk is being evaluated
- Evaluating the need for response actions throughout each phase of a building-specific investigation

Note: As previously discussed in Section 3.4.6, it is important to understand that even parcels without structures may need to perform some elements of a building specific investigation if it has been determined that further assessment is warranted.

5.1 Interior Building Survey

The IBS consists of two components; a physical building inspection and if warranted, the collection of indoor air samples.

The physical building inspection includes, but is not limited to:

- The collection of information about building use
- Building construction and condition
- Occupancy and floor plan layout
- Potential vapor entry locations
- Other building features that can influence the potential for VI risk

The physical building inspection should be conducted as part of every building-specific investigation involving sub-slab sampling and prior to the collection of any indoor air samples. This is relevant because it is important to evaluate the potential for background air contamination sources within the structure that could impact the results of the indoor air samples. It should be noted that the presence of a potential source in a structure does not eliminate the need to assess the potential migration of vapors into it; it merely helps in determining how the assessment may need to be performed.

The IBS must be completed by an environmental professional, with the approval and assistance of the building owner or other representative, and should include but not be limited to:

- Results of the physical building inspection
- Scale and basic floor plan layout of the structure
- Documentation of the indoor air quality survey (Section 5.5)

A form similar to the MDEQ's Indoor Air Building Survey and Sampling Form (Appendix F.4) should be used to conduct and document the IBS or if an indoor air sample is warranted. The information collected should be included in any document in which the indoor air sampling event is utilized to draw a conclusion.

5.2 Assessment of Immediate Risk

As new information is collected, VI risks are evaluated at each step of the investigation. In many cases, unless a detailed assessment of the site has been conducted, it is difficult to determine if an actual acute exposure has occurred or is occurring. The IRASLs were developed to assist in that determination. Although the actual exceedance of an IRASL does not by itself indicate that an acute exposure has occurred or is occurring, it does provide a line of evidence that indicates its potential to occur. Where an exceedance of an IRASL has been identified, indicating a potential risk due to VI (occupants or building), the initial priority should be the immediate safety of the occupants and an assessment of the risk should occur without delay.

An exceedance of an IRASL, even in the absence of obvious indicators such as odors, physiological symptoms, etc., is an indication that measures to protect building occupants and conduct immediate actions to determine the risk may be needed. Immediate actions would most likely involve conducting an IBS that included the collection of indoor air samples.

In a potential acute/emergency situation, it may not be advisable to wait for laboratory results before making a decision of the risk. In such cases, an investigator may choose to use additional sampling techniques to make an initial acute/emergency decision, until the indoor air samples can be analyzed. These techniques may include the use of a PID, CGI, Draeger tubes, or similar field screening devices to determine whether volatile gases are present at levels that could indicate an immediate risk and/or even a potential explosion hazard in some circumstances.

Note: The immediate safety of the building occupants is the first priority when an acute or immediate hazard from VI is suspected. In such cases, call the local fire department by dialing 911 to activate a local response. Local authorities can typically evaluate the conditions quickly and provide an immediate short-term control measure.

If the assessment identifies that an immediate risk is present, response actions should occur that will effectively prevent, minimize, or mitigate injury to the public [R 299.5526(1)(g)]. This may include immediately implementing presumptive mitigation measure(s) (Section 6) and when necessary, temporary evacuation to protect the public health and safety [R 299.5526(1)(j)].

5.3 Sub-Slab Soil Gas Sampling

Sub-slab soil gas sampling involves the collection of samples directly below a building's foundation. These samples can provide a more direct line of evidence of the risk from VI than soil gas data, as soil gas sampling points may not be located immediately near a building. As a result, sub-slab soil gas sampling can help determine if the VI to indoor air exposure pathway is relevant and if it poses a risk. Indoor air sampling may be conducted concurrently with sub-slab soil gas sampling. However, because of the variation and potential for indoor air samples to be influenced by ambient air sources, decisions regarding potential risk and completion of response actions must be weighted toward the sub-slab soil gas sampling results.

Existing environmental data (e.g., soil gas, groundwater, and soil data), site information, the CSM, and building construction details (e.g., basement, slab-on-grade, or multiple types of foundations, HVAC systems, etc.) must be considered when selecting locations within buildings for sub-slab soil gas sampling points. It is important for the investigator to take into consideration the potential for sub-slab soil gas sampling results to vary both spatially and temporally when planning for and conducting sub-slab soil gas sampling. In general, sub-slab soil gas sample points should include at least one point in a central location away from foundation footings (depending on area). All points should be installed so that the soil gas is collected from within the soil or aggregate immediately below the basement slab or slab-on-grade.

The number or density of soil gas sampling points depends on building size, proximity to sources, the scale of soil and groundwater impacts, heterogeneity in subsurface conditions, and the purpose of the data collection. As a general rule, the greater the heterogeneity in a particular exposure unit, the more samples are required for accurate characterization. Additional samples also may be necessary to reduce uncertainty and can be iterative to increase confidence in vapor plume characterization. See Table 5-1 below for a brief discussion of these factors and their influence on a sampling program.

Table 5-1: Influences on Sampling Density

Factor	Influence on Sampling Program	Rationale
Near Primary Spill/Release Area	Increased Sample Density	Soil contamination, or NAPL can produce heterogeneous contaminant distribution; high concentrations can result in a disproportionately large influence on indoor air quality
Large Scale Site	Reduced Sample Density	Groundwater as the primary VOC source tends to be more homogeneous than soil sources; contaminant concentrations within larger plumes are more spatially uniform
Reconnaissance Sampling Mode	Reduced Sample Density	Lower precision required. Primary objective is to define geographic area of concern, not assess risk/compliance
Geologic Heterogeneity	Increased Sample Density	VI migration rates are sensitive to soil properties, and additional samples are needed to define subsurface variability
Increasing Building Size	Reduced Sample Density	Conditions tend to be more homogenous in larger commonly ventilated spaces.

Table 5-2 identifies a minimum number of sampling points that should be considered in evaluating sub-slab soil gas. The minimum numbers are based on field experience and have demonstrated spatial variability at structures with differing or multiple foundations and may need to be adjusted based on the factors identified in Table 5-1.

The actual number of sub-slab soil gas sample points should be justified and based on the overall aerial extent, number of slabs or multiple levels in contact with the soil (e.g., multiple slabs-on-grade in a large warehouse), and foundation types (e.g., combined basement and slab-on-grade in a residence).

Table 5-2: Sampling Density in Commercial Buildings

Building Size	Sample Density	Minimum Number of Samples
Less than 1,000 ft^2	Not Applicable	2
1,000 ft^2 -10,000 ft^2	3 + one additional sample per 1,500 ft^2 of building over 1,000 ft^2	3
Greater than 10,000 ft^2	9 + one additional sample per 2,500 ft^2 of building over 10,000 ft^2	9
Table modification made for clarity in December 2019		

When evaluating VI potential beneath single-family residences, at least two samples should be collected, regardless of the building size. In general, one of these samples should be collected from beneath the center of the structure and the second from between the center of the structure and the wall nearest the source of contamination. It is understood that the sample locations may need to be adjusted to accommodate the actual site conditions and building layout.

The exchange of air near the margins of building foundations can locally decrease soil and sub-slab soil gas levels. To obtain the most representative results, collect vapor samples at least five feet inside foundation edges. If the contamination is in contact with the structure (i.e., footing, wall, etc.) sampling locations will need to be modified. Additional samples should be collected near utility trenches (i.e., vapor transport) that intersect plumes of contamination.

In the situation where a widespread source area results in the risk of VI to multiple residential properties, it is often difficult to determine where to begin and which properties require the collection of sub-slab soil gas samples. In general, the initial sub-slab sampling focus should be for the following situations:

- Buildings, including residential dwellings, located above or directly adjacent to known or suspected areas of subsurface volatile chemical contamination
- Buildings in which screening with field equipment (e.g., PID, ppbRAE, Jerome Mercury Vapor Analyzer) suggests VI is occurring
- Buildings within known or suspected areas of subsurface volatile chemical contamination that are used or occupied by sensitive populations (e.g., daycare facilities, schools, and nursing homes) should be given special consideration for sub-slab soil gas sampling

Investigations for sub-slab soil gas and/or indoor air contamination should proceed outward in all directions from known or suspected sources, as appropriate, until the nature and full extent of subsurface soil gas contamination has been characterized and all potential and current human exposures have been identified and addressed. In cases where widespread soil gas contamination is present, statistically valid sampling within a representative number of buildings within the study area (rather than all buildings) may be acceptable. Prior to implementation, a statistically based sampling approach can be discussed with the MDEQ specialists as it is important that the approach is based on structures that are similar in construction and condition

5.4 Evaluation of Sub-Slab Soil Gas Results

Sub-slab soil gas results should be used in the context of a well-developed and understood CSM, to assess risks posed to receptors in buildings. The evaluation must consider and use all quantitative and qualitative site investigation results. For risk-based decision making, it is important the investigator use all appropriate lines of evidence collected during the site investigation which should include the spatial and temporal data trends of the site-wide soil gas sources.

A variety of site conditions are discussed in Sections 5.4.1 through 5.4.4 below and are summarized Table 5-3. As identified in Table 5-3 the sub-slab soil gas results may either indicate that a risk from VI does not exist, indicate the necessity to collect additional samples to determine risk, or evaluate the need for mitigation, which may include the need to perform an immediate assessment of risk.

It is important to note that in all of the circumstances discussed below, it is assumed that the sub-slab soil gas samples have been or will be collected in a manner that will take into account the variability associated with such samples. Specifically, these recommendations assume the collection of sub-slab soil gas samples during a period in which the structure is most likely to be influenced by subsurface vapors. This may be in either the heating or the cooling season, depending on the installed heating and cooling systems. Soil gas sample results that vary significantly spatially (either horizontally or vertically) are an indication that verification sampling or multiple sampling events over time may be necessary to assess risks more accurately.

Table 5-3: Sub-Slab Soil Gas Concentrations and Expected Outcomes

SG_{vi-ss} Results	Actions	Outcome
With low or no potential source of vapors $[\mathbf{SG_{vi-ss}}] < (0.1^* SG_{vi-ss})$ *(i.e., 10x less than the SG_{vi-ss})*	No further sampling is required if samples include QA/QC	VI pathway does not pose a risk
After a remedial action has taken place $[\mathbf{SG_{vi-ss}}] < SG_{vi-ss}$ *(i.e., less than SG_{vi-ss})*	A total of three sampling events that include full QA/QC	VI pathway no longer poses a risk
With a known source of vapors to remain $[\mathbf{SG_{vi-ss}}] < SG_{vi-ss}$ *(i.e., less than SG_{vi-ss})*	A total of four sampling events to that include full QA/QC	VI pathway is relevant but does not pose a risk
A source of vapors is present $SG_{vi-ss} < [\mathbf{SG_{vi-ss}}] <$ IRASLs *(i.e., greater than SG_{vi-ss}, but less than IRASLs)*	Presumptively mitigate or Conduct additional assessment to evaluate need to mitigate	Assess lines of evidence to determine if mitigation is necessary after each sampling event
A source of vapors is present IRASL < $[\mathbf{SG_{vi-ss}}]$ *(i.e., greater than IRASL)*	Conduct an assessment of immediate risk	Immediately conduct presumptive mitigation or immediately assess the risk and evaluate future actions
Definitions: $[\mathbf{SG_{vi-ss}}]$= Measured sub-slab soil gas concentration, SG_{vi-ss} = Sub slab soil gas screening level, IRASL = Immediate Response Action Screening Level, < = Less Than, > = Greater Than		

5.4.1 Sub-Slab Soil Gas Results 10x less than the Sub-Slab Soil Gas Screening Levels for Vapor Intrusion

Sub-slab soil gas concentrations 10x less than their respective $SG_{vi\text{-}ss}$ concentrations represent little or no vapor intrusion risk and as a result, no additional samples are necessary to show that the pathway is not a risk. It is important to note that sub-slab soil samples should undergo a detailed QA/QC procedure in order to document that the samples that are collected are representative of site conditions.

5.4.2 Sub-Slab Soil Gas Results less than and up to the Sub-Slab Soil Gas Screening Levels for Vapor Intrusion

Soil gas concentrations less than and up to, their respective $SG_{vi\text{-}ss}$ concentrations are addressed in a variety of ways, depending on the specific site situation.

- For sites that have completed a remedial action, **three additional sampling events** should be performed to assure that the source has been adequately addressed and that seasonal variation has been accounted for. This is consistent with groundwater sampling requirements following completion of a remedial action.
- For sites where a known source of vapors remains and the intent is to show that there is no risk of those vapors causing a vapor intrusion condition, **four additional sampling events** would be needed to adequately address the seasonal and temporal variability.

5.4.3 Sub-Slab Soil Gas Results above the Sub-Slab Soil Gas Screening Levels for Vapor Intrusion

Sub-slab soil gas concentrations that exceed the $SG_{vi\text{-}ss}$, but are less than their respective IRASL (even after one sampling event) are a strong indication of a potential for risk and will likely require further investigation and assessment and/or mitigation.

In some circumstances, it may make sense to forego the additional time and expense associated with further assessment and move directly to presumptive mitigation (Section 6). This is a decision that is project specific and should be made on a case-by-case basis. If concentrations are confirmed through multiple rounds of sampling, the mitigation measures should be implemented as quickly as is practical. The MDEQ recommends an implementation timeframe of six months, however, it is recognized that this is project specific and can vary depending on exposure scenarios, concentrations, building characteristics, and a number of other factors.

5.4.4 Sub-Slab Soil Gas Results greater than the Immediate Response Activity Screening Levels

Sub-slab soil gas concentrations that exceed their compound-specific IRASL indicate a higher VI risk and the potential exists for the occupants to experience an acute exposure. In these situations, an assessment of the immediate risk (Section 5.2) is performed and the need for presumptive mitigation measures (Section 6) evaluated to determine if immediate implementation is warranted.

5.5 Sampling Indoor Air

The MDEQ recommends the collection of indoor air samples only after the evaluation of soil gas, sub-slab soil gas, and other site investigation results indicate the need for an assessment of immediate risk. Indoor air sampling may also be appropriate when odors are present or if groundwater at concentrations above the $GW_{vi\text{-}sump}$ is entering or in contact with the structure and cannot be assessed by either soil gas or sub-slab soil gas samples. Where soil gas or sub-slab soil gas samples cannot be collected, the direct assessment of indoor air sampling may be appropriate.

Residential indoor air samples should be collected over a 24-hour period. Nonresidential indoor air samples should be adjusted to an 8- or 12-hour exposure scenario and require the use of individual, certified clean canisters. During the collection of indoor air samples, the HVAC system should operate under normal conditions. In summer months, windows should be closed to minimize the contribution of ambient air.

Guidelines for the collection of representative indoor air samples include:

- In general, samples should be collected from the lowest habitable level and from each occupied building floor (if warranted)
- Placement of the evacuated canister should be in the breathing zone approximately three to five feet from the floor
- The samples should be collected away from windows or other sources of exterior air leakage
- If direct preferential pathways are identified (e.g., earthen floors, unsealed crawlspaces, sumps), additional indoor air samples should be collected from those areas
- Multiple indoor air sample locations are necessary for multiple foundations, multifamily residential units, and larger commercial or retail buildings

The rate and number of sampling locations should be established by evaluating the building construction as well as the location of the sources. In general the number of samples should be collected at a rate of one indoor air sample per 1,000 ft^2 of open space; however, the number of samples could be adjusted based on the following:

- A smaller number of samples may be appropriate for larger open spaces
- Samples need not be collected from the entire structure and should only be based on the location of the source of vapors
- Sampling locations should reflect where the inhabitants spend their time indoors and be centrally located to be representative of as large an area as possible, so living rooms or family rooms are often the sampling locations of choice
- Avoid locations where dilution air enters the building (e.g., near outside doorways) or where indoor emission sources may be nearby (e.g., utility rooms connecting the house to the garage)

When indoor air sampling is deemed appropriate for evaluation of immediate risk, the MDEQ recommends consecutively collected indoor air sampling events over at least three seasons. For closure, enough sampling events should be performed to account for a statistical evaluation of the data, to assess the site conditions, and to account for seasonal and expected fluctuations. Each sampling event should be documented in a manner similar to that outlined in Appendix F.4.

Results of the indoor air quality survey should be used to identify chemicals that may skew or complicate the interpretation of the indoor air sampling results and to prepare the building for the sampling process by temporarily removing potential background vapor sources. The survey results cannot be used to eliminate any VOCs from consideration. It is recommended that an indoor air quality survey, similar to the MDEQ’s Indoor Air Building Survey and Sampling Form (Appendix F.4) be completed prior to collecting indoor air samples. The results of the survey should be provided to the building owners or occupants with specific instructions to help minimize the potential for indoor air background contamination. All indoor air sampling results should be accompanied by a completed or updated survey which includes a description of modifications that the occupants were requested to make and to what extent they complied.

5.6 Using Multiple Lines of Evidence

The use of VI receptor surveys and screening values to evaluate soil gas, sub-slab soil gas, and indoor air sampling results has been previously addressed. This section discusses other important lines of evidence to consider when interpreting investigation results. The lines of evidence discussed below are important in distinguishing whether compounds detected in the indoor air are derived from VI. Contaminant sources not resulting from VI are referred to as background contaminant sources. Identifying the sources of possible indoor air contamination can be difficult; however, the efforts made to distinguish between VI and background sources represent a critical component of interpreting indoor air results, especially when an assessment of immediate risk is occurring.

5.6.1 Spatial and Temporal Variations of Data Trends

The site-wide spatial distribution of vapor sources and concentration trends, relative to receptor locations, can be important qualitative information regarding risks, especially at larger sites. Information regarding whether vapor sources are stable or attenuating is needed to understand whether sampling results are representative of future conditions near receptors. Such qualitative risk considerations are based on the recognition that actual three-dimensional migration patterns of vapors can be complex and vary spatially and temporally.

> Note: Multiple rounds of sampling are typically required to demonstrate that the VI pathway is not relevant when there is a source of vapor present. The number of sampling events depends on the concentrations detected, location of the source, and the ability to document appropriate sampling procedures, including the use of a tracer gas.

5.6.2 Physical Building Inspection

A physical building inspection (Section 5.1 and Appendix F.4) provides qualitative information regarding the likelihood that subsurface soil gas in close proximity to or beneath a building will enter the building through preferential pathways such as cracks, sumps, earthen floors, drain tiles, utility penetrations, or other openings. Examples of other lines of evidence for risk evaluation include the condition of the building foundation, the long-term integrity of the building structure, and the magnitude of sub-slab concentrations.

Building Influences

It may be discovered that buildings with a specific design feature may be more susceptible to VI and warrant closer attention or proactive mitigation. The building does not necessarily need to be located over the most highly contaminated area.

The presence of obvious preferential pathways along with elevated soil gas and sub-slab results can indicate that a relevant pathway is likely. In such cases, identified entry points should be sealed if possible (Section 6.2.1). Mechanical ventilation systems can influence VI by the amount of ventilation (e.g., air exchanges) provided and how the systems modify the interior building pressure. Though preferential pathways must be evaluated, in most situations a preferential pathway is only likely to be an issue in situations where the pathway is directly in contact with the source material or very high levels of soil gas.

5.6.3 Common Sources for Background Contamination

Many common contaminants are typically found in a release such as solvents and petroleum compounds. They can also be derived from common household products, paints, varnishes, household hobbies, building materials, the use of tobacco products, and chemicals stored in basements or in attached garages. Low levels of several common petroleum compounds and other VOCs are present in outdoor ambient air, especially in urban locations. Nearby point source emissions may also contribute to outdoor ambient air contamination. When outdoor ambient air contaminants are present, they are also likely to be found in the indoor air of buildings at varying levels.

Several studies have been published in recent years on the subject of the background concentration of VOCs in indoor air which document the widespread occurrence of a large number of VOCs that are consistently found in residential indoor air due to background sources rather than from VI (e.g., Folkes and Kurz, 2002; Dawson and McAlary, 2009). The results of such studies emphasize the importance of conducting building surveys and collecting outside ambient air samples as an integral part of all indoor air site investigations. Some of the common causes of indoor and outdoor background contamination originate from the types of sources listed in Table 5-4.

Table 5-4: Common Background Sources of Indoor Air Contaminants

Source Type	Category	Examples
Indoor air background sources	Consumer products	Household cleaners, dry-cleaning chemicals (i.e., PCE), clothing recently dry-cleaned, air fresheners, aerosols, mothballs, scented candles, insect repellents
	Building materials or building sources	Carpets, insulation, paint, varnishes, wood finishing products, polyvinyl chloride (PVC) pipe cleaners and glue, municipal drinking water as a contributor of volatile disinfection products from tap water, contaminated domestic drinking water
	Combustion processes	Smoking, cooking, home heating
	Occupant activities	Craft hobbies, woodworking, home repair activities using glues, paints, solvents, etc.; fuels or chemicals stored in attached garages either in storage containers or equipment
	Commercial or industrial work place chemicals	Can vary widely depending on past and current use
	Residual past chemical use or spills in building	Can vary widely depending on past use
Outdoor ambient air sources	Urban mobile petroleum sources	Cars, trucks, airplanes, boats, construction equipment
	Stationary industrial sources	Nearby chemical or fuel spills, bulk fuel storage or distribution

6.0 Step 4: Response Actions

Response actions for the VI pathway are necessary when there is evidence of a relevant pathway and the risks posed to human health are unacceptable. The term response action is used in this document to refer to all means of mitigating VI risk through remedial actions.

A response action can include one or more of the following measures:

- Remediation of the source of the vapor contamination
- Preventing VI at the receptor using building control technologies
- Controlling VI risks through institutional controls, long-term monitoring, engineering controls, or other long-term risk-management tools

The primary remedial objective is to eliminate risks to receptors; however, the specific remedial actions required to achieve this goal may be site-specific and should be established early during the evaluation of remedial actions and in coordination with the MDEQ project staff. Regulated parties and environmental consultants should consult the specific MDEQ program to determine the programmatic submittal, approval, and other reporting requirements associated with response actions.

The following Sections 6.1 through 6.3 provide supporting information and general recommended practices for response actions most commonly used to eliminate VI risks. However, the MDEQ acknowledges that there may be other acceptable response actions and risk reduction strategies for VI beyond those discussed in this section. Section 6.4 discusses operation and maintenance of constructed remedies and long-term monitoring that may be required to ensure remedial objectives are achieved.

6.1 Source-Area Remediation

Source-area remediation refers to the response actions conducted to address contaminated soil, groundwater, or NAPL that serves as the source for vapors. Examples of source-area remediation include:

- Soil excavation
- SVE
- MPE
- Air sparging
- Groundwater treatment and containment technologies
- In-situ chemical oxidation

Source-area remediation alternatives have varying degrees of effectiveness in addressing immediate VI risks, either due to the length of time to implement the remedy or the time required for the remediation to reduce contaminant levels.

6.2 Building Controls for Vapor Mitigation

Building controls refers to the use of technologies to eliminate the risk associated with relevant VI pathways at a building. Building control technologies may be necessary to rapidly respond to unacceptable risks to receptors in buildings.

The most common building control design and installation recommendations are discussed in Sections 6.2.2 through 6.2.7 and include:

- SSD systems
- SMD systems
- Venting systems for new building construction
- Passive vapor barriers at new building construction
- Building pressurization and ventilation
- Air cleaners (for interim response action)

Note: Mitigation systems can be further classified into two main types: passive and active. Active mitigation systems use mechanical means to redirect subsurface vapors from beneath the structure into the outside atmosphere. Passive mitigation systems reroute the vapors without the use of mechanical means.

6.2.1 Sealing Building Leaks

As previously stated, vapors generated from contaminated soil, groundwater, NAPLs, or buried waste materials can preferentially enter structures through minute cracks in foundations, pipe or utility penetrations through the concrete floor slabs or walls, through foundation drainage, or sump systems. Although gases have actually been shown to be capable of moving through porous concrete, VI is more likely to occur if there are leaks and openings in the building envelope. When this pressure differential exists, even small leaks in the building envelope can encourage VI.

Common building locations where leaks and openings can occur include:

- Foundation and basement wall cracks
- Floor sumps
- Floor drains
- Floor or wall slab joints
- Cinder blocks and mortar joints
- Penetrations from piping, wiring, and ducts

If such entry points are identified for the direct entry of vapors into the structure, the entry points should be sealed by:

- Using VOC resistant caulk or expanding foam to seal openings and cracks
- Repairing damaged concrete slabs
- Covering and sealing areas of exposed earth or pits with VOC resistant materials
- Placing airtight sump covers on existing sumps and venting to the exterior of the structure

Though sealing a building is not a stand-alone measure to mitigate a structure, the implementation of these measures have been shown to increase the effectiveness of many mitigation techniques described below in Sections 6.2.2 through 6.2.5. Sealing of leaks can be especially important when considering the use of active SSDs since building leaks, depending on their location, can reduce their effectiveness. Leaks in building foundations and floor slabs can often be identified during a physical building inspection or by conducting pre-mitigation diagnostic pressure field extension tests.

6.2.2 Sub-Slab Depressurization System

A SSD System is designed to prevent VI into buildings by lowering the air pressure in the soils directly beneath the building's floor slabs relative to indoor air pressure. The typical residential SSD System (Figure 6-1) consists of vertical piping installed into a cavity (known as a suction pit) that is dug below the lower level floor slab. The collected vapors are exhausted to the atmosphere above the building's roof line by using a mechanical means (i.e., a low wattage fan). As used in the MDEQ guidance, the term, SSD implies the use of an active system.

Figure 6-1 - Active sub-slab depressurization system shown on the outside of a home.
From Kansas Department of Health and Environment

A SSD System is considered to be among the most effective VI mitigation strategies for existing buildings and has been documented to achieve vapor concentration reductions of up to 99 percent (USEPA, 1993; Folkes and Kurz, 2002). These systems can be used to mitigate both residential as well as larger commercial/industrial buildings where a concrete slab directly overlies soil.

Key Considerations for a SSD System

- Most widely applied and effective systems for VI control
- Applicable to new and existing construction
- One or two suction pits adequate in most existing single-family homes
- Typically combined with venting layer and passive barrier in new construction
- Performance may be limited by low permeability sub-soils
- May be supplemented with other forms of mitigation, like drain tile, block wall depressurization, or passive barrier systems

Many best management practices developed and documented within the radon mitigation industry for diagnostic testing, design, and installation are applicable to a SSD System designed for VI. There are two main differences that need to be considered. The SSD System must be designed to:

- Have complete coverage of a floor slab or have data that supports the installation of a partial system
- Be able to achieve constant negative pressure in the sub-slab

Guidance discussing the SSD System construction can be found at the following sources: "Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings" (ASTM Standard E2121, 2003); the "Radon Reduction Techniques for Existing Detached Houses – Technical Guidance" (USEPA, 1993), which provides the design considerations for a SSD System in a residential home; and the “Radon Prevention in the Design and Construction of Schools and Other Large Buildings (USEPA, 1994), which provides design considerations for the SSD System designed for larger buildings.

A sub-slab diagnostic test should be conducted prior to installing the SSD System to document the operational design needed to successfully mitigate the building. The primary purpose of sub-slab diagnostic testing is to simulate a completed SSD System in order to determine the number and location of suction pits required to obtain sufficient pressure field extension beneath the slab. Detailed guidelines for conducting a sub-slab diagnostic test can be found in “Radon Reduction Techniques for Existing Detached Houses – Technical Guidance” (USEPA, 1993). A checklist for evaluating the design of a SSD System is provided in Appendix C.


Figure 6-2 - Active sub-membrane depressurization system

6.2.3 Sub-Membrane Depressurization System

The SMD System utilizes a membrane as a surrogate for a slab to allow depressurization of the soil. The SMD System has been demonstrated to be the most effective mitigation method in existing buildings where earthen floors, such as crawlspaces, provide a vapor entry location (USEPA, 1993). An impermeable membrane covers the exposed dirt surface of a crawlspace while the depressurization system withdraws soil gas from beneath the membrane and prevents its intrusion into the space above. A properly installed SMD System can result in vapor concentration reductions of up to 99.5 percent, similar to results found with a SSD System (Folkes and Kurz, 2002). Figure 6-2 illustrates its application.

Like a SSD System, a SMD System typically requires a continuously operated fan to vent vapors from beneath the installed membrane to the atmosphere. Due to the difficulties of sealing the openings and potential for tearing and damage to the membrane, permanently sealing the earthen floor or crawlspaces with a more permanent covering may be a better alternative to the SMD System. Membranes installed must be well maintained to ensure effectiveness and therefore the SMD System may require more long-term maintenance than a SSD System.

Key Considerations for a SMD System

- Most widely applied and effective systems for crawlspace homes
- Applicable to new and existing construction
- Suction field extension (e.g., perforated pipe) may be required for tight soils
- Liners should be sealed to foundation walls and footings
- Liners should be protected against damage where access (e.g., to service furnaces or plumbing) is expected
- Performance may be limited by low-permeability sub-soils
- May be combined with the SSD System, drain tile, and/or block wall systems

6.2.4 Passive Barrier System

A passive barrier system is a combination of one or more synthetic membranes coupled with a passive or active venting system beneath the liner. This system prevents the migration of subsurface vapors into the building by providing a vapor resistant material to prevent the upward migration. The venting system is designed to allow pressure relief and venting of contaminant vapors collected beneath the liner to the atmosphere above the roof line.

Fluid-applied membranes are spray-applied directly to substrates, fabric layers, and building penetrations. These membranes can result in a well adhered and seamless membrane, when installed properly by a contractor who has been trained and approved by the membrane provider. Sheet membrane comes in rolls of varying materials and sizes. However, sheet membranes are rarely employed due to the difficulty in sealing penetrations from subsurface utilities.

Care must be taken during installation of a passive barrier system, as damage will render the barrier ineffective. Small tears, punctures, gaps, or defects in a membrane can create a pathway for vapor entry into buildings, which must in turn be properly sealed. Penetrations through the membrane for utility conduits piping, etc. must also be properly sealed.

Key Considerations for a Passive Barrier System

- Barrier has been evaluated to withstand the vapor concentrations
- Barrier includes a thorough quality control procedure implemented to minimize barrier damage
- Inspect barrier seals at all edges, penetrations, and seams
- Test barrier integrity and performance after installation
- Have contingencies to supplement passive barriers if performance is inadequate

When evaluating the performance and effectiveness of various vapor barrier products, the following factors need to be considered:

- The membrane’s ability to inhibit diffusion or vapor permeation
- The resistance to puncturing and tearing
- The chemical resistance of the membrane

Appropriate testing methods must be incorporated as part of the project’s quality control procedures. The use of a smoke test on a synthetic membrane is an effective method to test for the presence of leaks. A smoke test involves the use of a generator or blower to introduce an inert, nontoxic smoke with sufficient pressure beneath a membrane to visually identify leaks. Appendix C contains a checklist on the key components of the design of a passive barrier system.

6.2.5 Building Pressurization and Ventilation using Heating, Ventilation or Air Conditioning

The HVAC systems in commercial and industrial buildings can help minimize or prevent VI into buildings by providing positive pressure and ventilation. Building pressurization is achieved by having greater air inflow than outflow, resulting in positive pressure differential of the indoor environment relative to the sub-slab environment. This can assist in preventing VI from the subsurface, if this pressure differential between indoor air and the sub-slab environment can be established and maintained for interior spaces.

Because it is extremely hard to document and verify the effectiveness of positive pressure, and it is only possible when the HVAC is in operation, sole use of positive building pressure as a mitigation method is not recommended. However, modification of any HVAC system to maintain a positive pressure within the structure can be a valuable component to supplement any active or passive mitigation system.

Key Considerations of Building Pressurization

- Not generally practical
- Requires relatively "tight" buildings to limit airflow and energy costs
- Typically extremely costly as it requires constant air exchange even when the system is not actively heating or cooling
- May require new or modified HVAC equipment

The HVAC system air exchange rates for buildings undergoing vapor mitigation should be evaluated and compared with industry standards to ensure they are appropriate for the building size and use, sensitive populations, and occupancy rates. Requirements for the HVAC systems, as developed by the American National Standards Institute and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ANSI/ASHRAE Standard 62.2, 2007), are designed to achieve minimum levels of air circulation for occupant health and comfort. These minimum ventilation rates are typically insufficient to address all indoor air risks. Air exchange rates for existing HVACs or other air-exchange systems should be included as part of the physical building inspection conducted for VI investigations and as part of the documentation to support the effectiveness of the HVAC operation (Appendix F). These rates can be obtained from a building operations manager for a commercial or industrial facility or by contacting the equipment manufacturer.

The ability to use the building ventilation systems to address VI in enclosed parking garages is a common question. Environmental VI risks in underground parking garages are typically lower than the risks or concerns posed from carbon monoxide and automobile fuel vapors, which are necessarily addressed through the use of mechanical ventilation. In these situations, a case can often be made that the system installed for the proper ventilation of the garage is sufficient to address the effect of VI and it is therefore unlikely that the additional risks associated with short-term exposure from vapors would be significant. In cases where the structure is near a significant subsurface source of VOC vapors or where the enclosed parking garage is beneath or adjacent to an occupied structure, additional documentation may be required to show that the risk for VI has been adequately addressed. This can be accomplished by demonstrating that the rate of vapors coming into the structure is less than the air exchange rate provided with the ventilation system. The MDEQ recommends that the ventilation rate and design for the structure be documented and included as part of the assessment and evaluation of whether a risk is present.

6.2.6 Indoor Air Cleaners

Indoor air can also be directed to air pollution control equipment (e.g., activated carbon treatment systems) to remove air contaminants from the building interior. It can be an effective interim response action to address immediate risks that have been identified until a longer, more permanent measure can be designed and employed. This technique is dependent on the treatment system's uninterrupted performance to protect receptors. During the use of these short-term interim systems, there must be an indoor air sampling program to confirm the effectiveness of the operation.

Key Considerations of Indoor Air Treatment

- Less effective than other VI control methods
- Expensive to install, operate, and maintain
- Typically generates waste (e.g., spent carbon)

Activated carbon filters are able to remove VOCs in the indoor air to below detection limits for TCE and its daughter products, as well as for hundreds of other chemicals; however, a carbon filter alone may not be effective. When using a carbon filter, a number of factors need to be considered, including: proper operation and maintenance, inadequate airflow, unit size relative to the size of the room being treated, contaminant concentrations, and contaminant distribution. In addition, capital costs, annual operating expenses, and waste disposal concerns can be a drawback to using this technology. Nevertheless, there may be circumstances in which this type of mitigation can be useful, i.e., high water and wet soils.

6.2.7 Other Building Controls used for Mitigation

Several other building control technologies have been used, particularly in the radon mitigation industry, and although less common, may be an option in some situations. In most cases, these additional measures are most appropriate when implemented to supplement the effectiveness of some of the other systems previously discussed.

Block Wall Depressurization

Block wall depressurization is a mitigation technique that mechanically depressurizes the void network within a block wall foundation by drawing air from inside the wall. It uses an electric fan and vents the collected vapors to the outside. As with other depressurization systems, diagnostic testing should be conducted to ensure uniform depressurization can be achieved.

Drain Tile Depressurization

Drain tile depressurization is a mitigation technique that can be used at a building that has perforated drain tile installed along the inside or outside of its foundation. If the drain piping discharges to a sump pit, the negative pressure field should be applied to the sealed sump pit. Alternatively, if the drain piping discharges to an outdoor location, the negative pressure field should be applied to the terminal end.

6.3 Institutional Controls

Institutional controls can provide an administrative or legal control to manage ongoing or future risks, supplement other response actions, and help ensure that potential risks are mitigated. Institutional controls can be used as a component of response actions at remediation sites administered pursuant to Section 20114c of Part 201 to limit unacceptable exposure for either long-term risk management or until site remediation or natural attenuation reduces exposure concentrations to acceptable levels. In situations where response actions may take a considerable amount of time or cannot effectively eliminate long-term VI concerns, institutional controls can help manage long-term risks.

Institutional controls include legally enforceable restrictions and deed restrictions. The recording requirements for instruments filed with Michigan County Register of Deeds offices are contained in Section 1 of the Recording Requirements Act, 1937 PA 103, as amended (Act 103), MCL 565.201 *et seq*. Potential uses for an environmental covenant as a component of a response action to address VI risks include:

- Requiring the use of building controls (either ongoing use or future use) to address VI risks to on-site or off-site properties
- Controlling the type of property use (e.g., residential, commercial/industrial) at a property where VI risks are considered likely

Appendix H contains the instructions for the model Declaration of Restrictive Covenant to be used to place land use or resource use restrictions pursuant to Section 20114c(3) of Part 201.

6.4 Mitigation Verification, Monitoring, and Closure

Remedial verification, monitoring, and closure criteria will vary depending on site-specific conditions and program-specific requirements. Additional guidelines for conducting remedial verification sampling, monitoring, and system maintenance are provided below.

6.4.1 Mitigation Verification

Mitigation systems must be inspected after they are installed and during their use to ensure they are working effectively. Review checklists for mitigation system design have been included in Appendix C and address the need for post installation system verification. This verification typically includes the testing, measurements, and/or documentation necessary to ensure that the system is functioning as designed. If conducted as components of a remedy, building sealing activities and other improvements made to building floors or walls must be inspected and documented to assure that the remedy will achieve reliable results. Information to support that the system is effective can include physical measurements, such as pressure differentials and exhaust gas flow rates, as well as follow-up sub-slab or indoor air sampling.

In some cases, concurrent indoor air and sub-slab vapor sampling may be utilized after a mitigation system is operational to verify system performance and effectiveness. Indoor air sampling is especially warranted if pre-mitigation sampling results confirmed elevated concentrations either in the sub-slab vapor or indoor air.

6.4.2 Part 55, Air Pollution Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

In designing an active mitigation system, the design must consider the requirements of Part 55, including establishing limits on the potential to emit contaminants. Depending on the limits established, a person may need to obtain a permit to install or document any exceptions allowed in R 336.1202, or in R 336.1277 to R 336.1290.

The requirements of R 336.1201(1) to obtain a permit to install do not apply to an emission unit if the conditions under R 336.1290 are met. Sources using this exemption are not required to meet the criteria in Rule 278 and must be able to demonstrate compliance with the various emission limits contained in Rule 290. Requirements for the exemption are detailed in Appendix I.

It should be noted that there are specific requirements that must be met in order for the exemption to be valid. These include:

- A description of the emission unit must be maintained throughout the life of the unit
- Records of material use and calculations identifying the quality, nature, and quantity of the air contaminant emissions must be maintained in sufficient detail to demonstrate that the emissions meet the emission limits outlined in Part 55
- The records must be maintained on file for the most recent two-year period and made available to the MDEQ, Air Quality Division upon request

6.4.3 Operation and Maintenance and Long-Term Monitoring

Long-term maintenance and monitoring may be necessary at a site with an installed mitigation system to ensure the system is operating (active mitigation) and verify that conditions have not changed (passive mitigation). Long-term monitoring plans must be tailored to the design as well as the components of the installed mitigation system. The need for long-term operation, monitoring, and maintenance plans is greater at sites where:

- Long-term monitoring is needed to verify and confirm ongoing remedial effectiveness
- The remedial system requires periodic adjustments and maintenance
- Immediate risks to receptors would result if the system failed or if site conditions changed
- The conditions that would trigger specific contingent responses require ongoing monitoring

At sites with ongoing post-construction and remedial actions, the operation and maintenance plans should clearly specify the following information in accordance with R 299.5538:

- Name, phone number, and address of the person who is responsible for the operation and maintenance
- Operation and maintenance activities and schedule
- A discussion of the critical system's reliability, including options for repair or redundancy
- Design and construction plans
- Equipment diagrams, specifications, operating manuals, and manufacturers' guidelines
- Emergency plan, including emergency contact phone numbers
- A contingency plan that addresses response to failure of any critical system component
- Other information required to determine the adequacy of the operation and maintenance plan

Most mitigation systems will also require the use of a contingency plan, or similar corrective action document, to identify conditions that may trigger the need for additional maintenance, collection of additional data, modifications of monitoring frequency, or other responses to ensure the remedy remains effective. Conditions that might trigger additional responses could be based on monitoring results, facility or system inspections, operational problems of the remedial system, or other information that may indicate that the remedial objectives are not being met.

Note: An operation and monitoring plan is reviewed by the MDEQ as part of a Response Activity Plan under Part 201 or a Final Assessment Report submitted under Part 213.

As appropriate to the facility and in accordance with R 299.5440(2)(a)-(n), monitoring plans or reports associated with monitoring the mitigation system and/or site conditions shall include the following:

- The effectiveness of the response activities in protecting the public health, safety, and welfare and the environment, including a plan and schedule for determining whether the objectives were achieved
- The effectiveness of the response activities in minimizing, mitigating, treating, or removing environmental contamination at a facility
- Location of monitoring points for collection of environmental data

- Environmental media to be monitored such as soil, air, water, sediment, or biota
- Monitoring schedule
- Monitoring methodology, including sample collection procedures
- Substances and conditions to be monitored
- Laboratory methodology, including the name of the laboratory responsible for analysis of monitoring samples, and whether target detection limits were achieved for the monitoring samples. The QA/QC samples that document the accuracy and precision of the monitoring samples shall be made available to the MDEQ on request.
- QA/QC plan
- Data presentation and evaluation plan
- Contingency plan to address ineffective monitoring
- Operation and maintenance plan for monitoring equipment
- An explanation of the way in which monitoring data will be used to demonstrate effectiveness of the response activities
- Other elements required to determine the adequacy of the monitoring plan

6.4.4 2010 Amendments to Part 201

In 2010, Sections 20114a to 20114d of Part 201 were revised to contain a response activity plan submittal and review process. Though Section 20114a expanded the self-implementation provisions of Part 201, there are specific situations that continue to require MDEQ approval, including the use of site-specific criteria as identified in Sections 20120a(2) and 20120b. Appendix D represents values that the MDEQ has reviewed and approved for use as site-specific screening levels when they are used appropriately. Their use, however, does not constitute approval unless, through the submittal of the response activity plan, the MDEQ concurs that they were applied appropriately.

Section 20114b (response activity plan review), subject to Section 14, was amended so that submittal of a response activity plan can include a request for MDEQ approval of one or more aspects of a remedial action. Therefore, response activity plans as they relate to the volatilization to indoor air pathway may result in the submittal and request for approval of a deed restriction, a remedial action, or mitigation system (including a presumptive mitigation system). A post-closure monitoring report would be required under Section 20114c (implemented remedial actions) if there are land use or resource use restrictions.

As specified in Section 20114d (No Further Action Report), upon completion of a remedial action that satisfies applicable cleanup criteria and all other requirements that are applicable to the remedial action, a NFA Report may be submitted for MDEQ review. Though some mitigation systems may qualify for a NFA Report (e.g., a liner with a passive venting system with appropriate property and deed restrictions [Section 6.3]), most active mitigation systems (SSD or SMD) would not, as the remedial action is not complete. It is anticipated that a mitigation system would require a post-closure plan and most systems will also require a post-closure agreement, even those with a liner and a passive venting system (Section 6.2.5).

7.0 References

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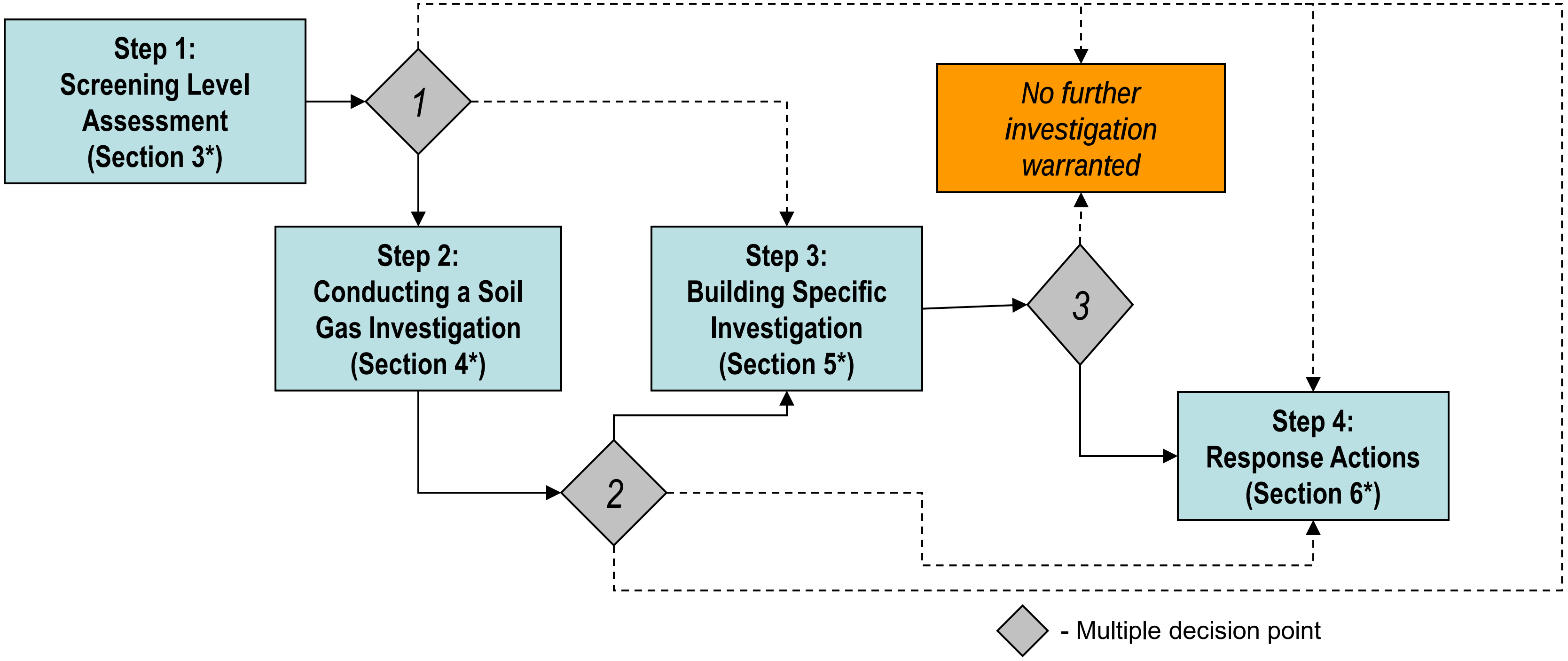
APPENDIX A

Generalized Flowcharts for the Evaluation of the Vapor Intrusion Pathway

Overview of Investigating VI



Step 1:
Screening Level Assessment
(Section 3*)

Step 2:
Conducting a Soil Gas Investigation
(Section 4*)

Step 3:
Building Specific Investigation
(Section 5*)

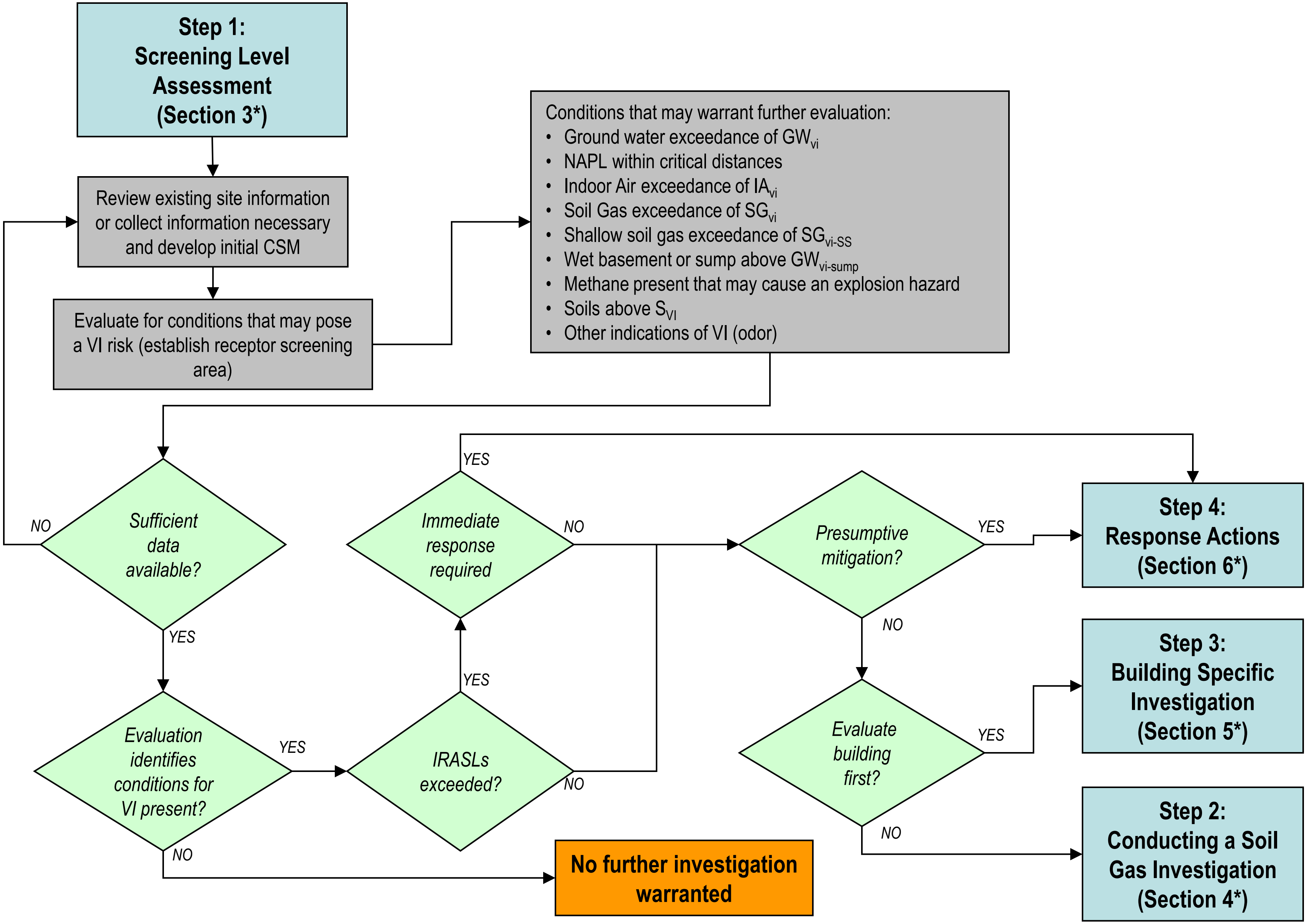
Step 4:
Response Actions
(Section 6*)

No further investigation warranted

◇ - Multiple decision point

←- - - - - Additional options

**Please note: Further details and information on each step and the process involved can be found in the identified Section.*



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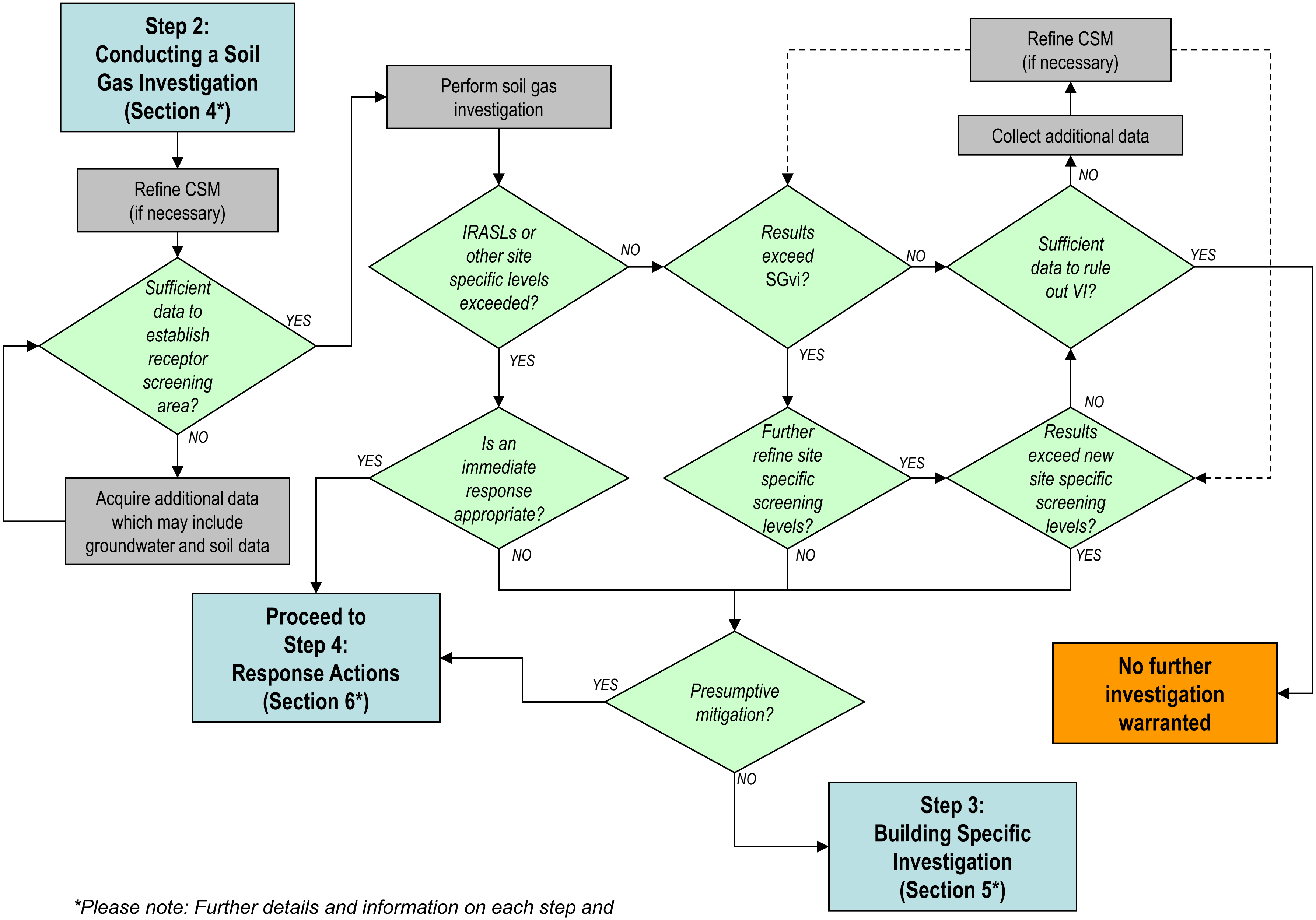
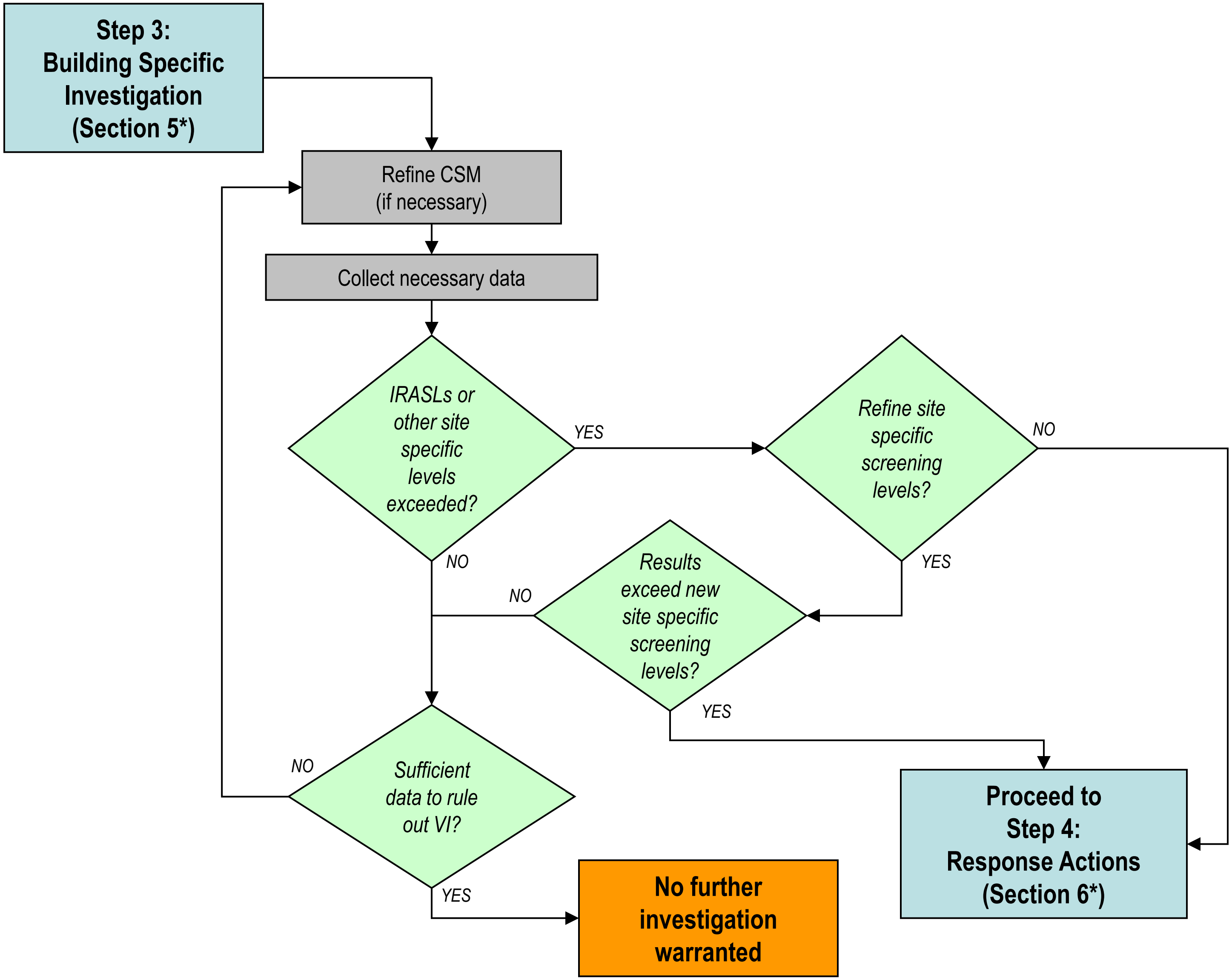


*Please note: Further details and information on each step and the process involved can be found in the identified Section.



*Please note: Further details and information on each step and the process involved can be found in the identified Section.

Appendix B – Supplemental Guidance Information

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APPENDIX B.1

Alternate Approach for Demonstrating Compliance with the Volatilization to Indoor Air Pathway (Big Building Model)

Remediation and Redevelopment Division

ALTERNATE APPROACH FOR DEMONSTRATING COMPLIANCE WITH THE VOLATILZATION TO INDOOR AIR PATHWAY

"Big Building Model"

Original Date of Issuance: January 19, 2012

Revision #: 1 **Revision Date: December 7, 2012**

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A policy guidance document cannot establish regulatory requirements for parties outside of the Michigan Department of Environmental Quality (MDEQ). It is explanatory and provides direction to staff, guidance to the regulated community, and consistency in enforcing the NREPA, but does not have the force and effect of law and is not legally binding on the public or the regulated community.

PLEASE NOTE:

This approach was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide an alternate approach to parties implementing a response action in Michigan. It was created to promote an alternate approach that is consistent with Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). This document is not a statutory requirement, but could be implemented as an alternate approach under R 299.5714(5) and R 299.5724(5).

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document also does not represent an endorsement of practitioners or products mentioned in the document nor does it ensure that this approach is appropriate for all sites. It is imperative that the environmental professional implementing this approach provide adequate justification.

This approach is made available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern. The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the approach was written for MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

Introduction

Because of the nature of large buildings (e.g., larger footprint, higher air exchange, taller ceilings, lack of a basement, thicker slabs of concrete, and occupational activity patterns resulting in less exposure), a generic approach to assessing the potential for vapor intrusion may overestimate the risk to users of the building. Therefore, the MDEQ has identified an approach that is referred to as the "Big Building Model" (BBM) with the intent to provide an alternative methodology for large nonresidential buildings to utilize multiple lines-of-evidence in demonstrating compliance with the volatilization to the indoor air exposure pathway (i.e., vapor intrusion pathway). The MDEQ approach relies primarily on a paper titled, "Prediction of Indoor Air Quality from Soil-Gas Data at Industrial Buildings (Eklund and Burrows, 2009)." The approach has been modified so that it may be utilized to demonstrate compliance with site-specific criteria allowed for under Part 201, including the use of the MDEQ's vapor intrusion screening values (SV_{vi}) as site-specific criteria in situations where the generic cleanup criteria do not apply.

Under Section 20120b, the MDEQ must review and approve all site-specific criteria. For those not approved by the MDEQ prior to the 2010 Amendments, this is now completed through the submittal of a Response Activity Plan.

When relying on soil gas and/or sub-slab soil gas sample data to evaluate the potential for unacceptable human health risks from the volatilization of subsurface contamination to the indoor air (i.e., vapor intrusion), it is common regulatory practice to rely on the maximum soil gas and/or sub-slab soil gas concentrations. This approach is reasonable and often necessary for assessing smaller buildings (less than 5,000 square feet) where a lack of characterization requires the assumption that contamination underlies the entire structure. However, when applied to large nonresidential structures, the use and reliance of the maximum concentration may be overly conservative, especially where localized or discrete areas of contamination have been identified.

1.0 BUILDING CHARACTERISTICS ASSUMED IN GENERIC CRITERIA

When comparing the differences and characteristics between small residential buildings and large nonresidential structures, there are several actual building characteristics that may influence how conservative the use of a maximum sub-slab soil gas concentration is. These include (but are not limited to):

- **Building Footprint** – 4,000 square feet (ft^2) (372 square meters (m^2)) was utilized as the floor space area in the development of the generic groundwater volatilization to indoor air inhalation criteria (GVIIC) and the soil volatilization to indoor air inhalation criteria (SVIIC) (MDEQ, 1998, 2009). However, as identified by Eklund and Burrows (2009), it is not uncommon for large manufacturing and warehouses (i.e., large nonresidential buildings) to have footprints that are greater than 10,500 ft^2 (1,000 m^2). The size of the floor space utilized in developing the Part 201 criteria was originally guided by a report entitled *Commercial Buildings Characteristics 1992* which documents the results of a Commercial Buildings Energy Consumption Survey (CBECS) conducted by the United States Department of Energy (DOE, 1994).

- **Ceiling Height** – Eight feet is the generic commercial building height used in the development of the generic GVIIC and SVIIC (MDEQ, 1998, 2009). It is also the default ceiling height listed in the United States Environmental Protection Agency (USEPA) modeling guidance (USEPA, 2004). However, it is not uncommon for many of the structures addressed by the generic nonresidential criteria (i.e., manufacturing, industrial operations, and warehousing) to exceed interior building heights of 16 feet (NAIOP, 2005). The larger air volume provided by the increased height provides a greater potential mixing, allowing for the potential for dilution of any chemicals that enter the building via vapor intrusion (Eklund and Burrows, 2009).

- **Thickness of Flooring** – Large nonresidential buildings generally have slabs that are thicker than the default standard established by the generic Part 201 criteria (MDEQ, 1998 and 2009) of six inches (15 centimeters (cm)). Eklund and Burrows (2009) identify that these structures often have slabs up to 12 inches (30 cm). With thicker slabs present, differential settling of the underlying soil is less likely to lead to cracking. In addition, any cracks that are present would be less likely to extend through the entire slab thickness thus creating a preferential pathway that would directly connect the indoor space to the pore spaces in the sub-slab fill material.

- **Air Exchange Rates** – Large nonresidential buildings used for manufacturing, industrial operations, and warehousing tend to have higher air exchange rates than single-family homes. Though typical ventilation rates for these nonresidential structures have not been reported, it can be assumed that the rates are equal to or exceed the rates for office buildings, especially for buildings with bay doors and limited insulation (Eklund and Burrows, 2009). In most large nonresidential buildings, areas of natural ventilation (random cracks, interstices, and other unintentional openings in the building envelope) are easily observable.

- **Large Open Areas** – Large nonresidential buildings may have large and continuous open areas (areas without walls or barriers) in order to complete their intended manufacturing or warehouse use. These areas can easily exceed 40,000 ft^2. The greater area of continuous open air allows for a greater potential of mixing for any chemicals that enter the building via vapor intrusion.

2.0 BUILDING CHARACTERISTICS NECESSARY FOR THE USE OF THE BBM

When it is desired to utilize the BBM methodology, certain building characteristics must exist that support the model. These characteristics are as follows:

- Large continuous open areas greater than 4,000 m^2 (43,000 ft^2)
- Ceiling heights greater than 5 m (16 ft)
- Slab-on-grade construction with thicknesses greater than 15 cm (6 inches)
- No dry wells, floor drains, sumps, or other building features are present that would provide a direct conduit to the subsurface are present
- When groundwater is present, concentrations are stable and/or decreasing

When these conditions are not present, it may be possible to provide additional justification for the use of the BBM. However, it should be noted that these situations will be rare and may not be cost efficient to collect the data necessary for the justification.

In addition to the building characteristics identified above, there must also be sufficient site characterization such that potential sources of vapors have been identified and a thorough understanding of the site geology and hydrogeology exists. This includes the expected seasonal variation of the groundwater elevation.

3.0 GENERAL APPROACH TO THE BIG BUILDING MODEL

Consistent with Eklund and Burrows (2009), the MDEQ's recommended approach is to divide the building footprint into a number of grids or zones (z_1, z_2, z_3 through z_n) that are assigned a representative sub-slab soil gas

concentration (C_z) and an area (A_z) that is a portion of the total area (A). The resulting zonal average sub-slab soil gas concentration can be compared directly to a screening concentration such as the MDEQ's screening concetrations for soil gas collected less than five feet bgs or the lowest point of a structure (SG_{vi-ss}).
As discussed in the MDEQ's document titled Guidance Document for the Vapor Intrusion Pathway (MDEQ VI Guidance Document the SG_{vi-ss} were developed using the acceptable indoor air criteria (AIAC) with an attenuation factor (alpha or α_{DEQ}) based on empirical data that a party may use under Part 201 as a site-specific criterion in situations where the generic criteria do not apply.

The zonal average sub-slab soil gas concentration is calculated as identified in Equation 1:

EQUATION 1:

$$C_{subslab} = (\sum C_z A_z)/A$$

As stated in Eklund and Burrows (2009), "The areas should represent a reasonably conservative estimate of the areal extent of the associated sub-slab soil gas concentration." Estimates of zone average concentrations, geometric mean, and maximum reported values may be included for comparison and discussion; however, in most cases enough data will not be collected to allow for a statistical evaluation including a population analysis of each zone.

3.1 Zones

Areas of the structure in which zones for the BBM will be established must be based on an interior structural survey. The structural survey must include the identification of all walls, floor drains, and sumps, and must document that the conditions in Section 2.0 are present. Any variations must be clearly identified in the submitted documentation.

Initial sampling locations within each zone must be biased toward each known or potential source of vapor intrusion as well as along walls or other features outside of the area that are known to contain a source of vapors. Though collecting sub-slab samples on a regular spacing interval and/or grid can be utilized; the larger the spacing utilized, the more difficult it may be to establish discrete zones of sub-slab soil gas concentrations above the SG_{vi-ss}. The MDEQ's experience has identified spacing intervals of 40 to 50 feet provides the optimum distance for the use with the BBM model. Distances further than 80 feet often do not provide the detail necessary and directly impact the BBM's ability to demonstrate that sub-slab soil gas vapors will not impact the indoor air above the AIAC. The smaller the area of higher concentrations, the easier it will be to generate the lines-of-evidence discussed below.

Larger zones may be utilized for use in the BBM by grouping smaller zones with similar sub-slab soil gas results. A geometric mean, 95 percent upper confidence level, or other statistical methods may be possible; however, in most cases there will not be enough data to complete a statistical evaluation that includes a population analysis. If there is not enough data in each zone to complete a statistical evaluation, an average concentration is not appropriate and a maximum concentration must be utilized.

The model must also be run using data collected with the appropriate sampling methods which include the use of the TO-15. Please refer to the MDEQ's Standard Operating Procedure for the collection and analysis of sub-slab soil gas as an approved sampling methodology.

It is important that temporal considerations also be taken into account when establishing sampling locations. For example, as identified by Eklund and Burrows (2009), if a groundwater plume has only reached one end of a building, any sub-slab soil gas measurements may not be predictive of future measurements. It is also necessary to repeat the analysis at select locations to ensure that the results remain consistent due to expected temporal and seasonal variation. In most circumstances, this can be accomplished by three rounds of sub-slab soil gas samples from consecutive quarters that are shown to either be stable or decreasing in concentrations.

Figure 1 shows a representative building with a sampling grid and zones across an open manufacturing area. Figure 2 represents a site where smaller zones are grouped together, using maximum concentrations, to create fewer large zones. This is desirable in that it results in having to run the model for less zones. This approach would be typical for sites where there are multiple sources present.

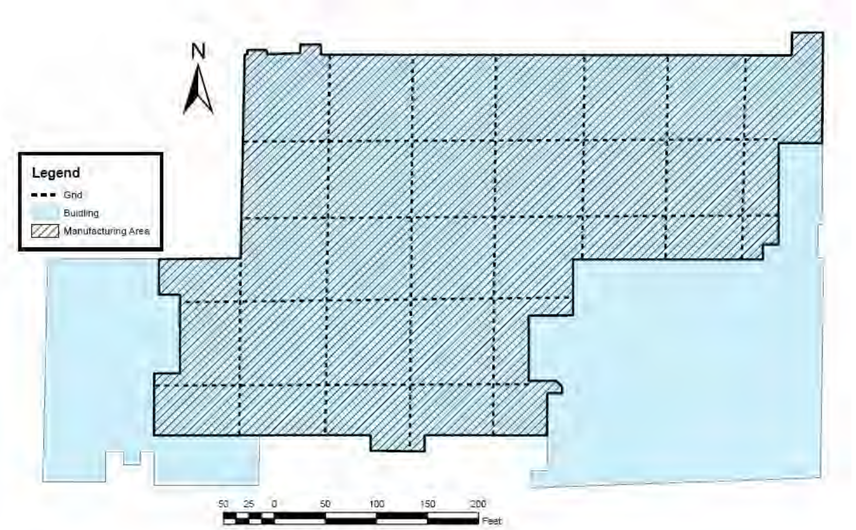

Figure 1 Building with open area and example zones identified.

Figure 2 – Grouping with similar concentrations.

3.2 Demonstrating Compliance With Site-Specific Criteria

Although the term “line-of-evidence” and “weight-of-evidence” is used frequently in assessing the potential for vapor intrusion; there is no consensus on its definition or how it can be applied quantitatively. Each evaluation (risk estimate) will have its own assumptions and associated uncertainties that may not be able to be expressed equivalently. Each line-of-evidence must be evaluated, organized, and explained so that a weight-of evidence evaluation can be made (Suter, 1993). The more the evaluation can be shown to remain protective, as the model inputs exceed the “normal” or “expected” site conditions, the stronger the line-of-evidence supporting the conclusion presented.

The weight of a line-of-evidence is reflected in three general characteristics:

- The weight assigned to each measurement
- The magnitude of response observed in the measurement endpoint
- The concurrence among outcomes of multiple measurements

Utilizing the BBM presented in this approach is not a line-of-evidence that can be supported **until** it can be shown that the site conditions can vary considerably from those identified and the site conditions still remain protective of human health. In essence, the larger the zones that can be utilized (over the identified extent of impact) and the higher the concentrations utilized in each zone (over what was detected in multiple rounds of sampling) that still indicate potential compliance with the $SG_{vi\text{-}ss}$, the stronger the weight-of-evidence.

To provide some general guidance on what conditions provide support and strength to the line-of-evidence if the building conditions established in Section 2.0 are met, the MDEQ has established the following guidelines based on a facility that has performed (or will) perform source removal:

- Extent of the known sources have been identified and delineated.
- Zones are established, are conservative, and at least two times larger in area. Data must not be interpreted between data points unless it can be shown to be overly conservative.
- The model still meets the $SG_{vi\text{-}ss}$ utilizing contamination levels that are at least three times the maximum level of contamination identified.
- No continued use of the contaminant and the source is expected to attenuate over time.
- The modeled area will remain open.

If source removal will not occur, the lines-of-evidence will need to be increased and strengthened. The strength of the evidence presented for the BBM is directly related to how much variation can be accounted for in the model. The less variation possible, the less potential that the BBM would support that a risk cannot occur without further remedial action.

3.3 Calculations

The BBM is analyzed using the following equation:

EQUATION 2:

$$BBM_{conc} = [(Zone1_{max} \times Zone1_{area})+(Zone2_{max} \times Zone2_{area})+(ZoneX_{max} \times ZoneX_{area})]/Area_{TOTAL}$$

Whereas:

BBM_{conc}	– Estimated sub-slab soil gas concentration average
$ZoneX_{max}$	– Maximum concentration identified in Zone X
$ZoneX_{area}$	– Area of Zone X
$Area_{TOTAL}$	– Total area

It is possible to compare the BBM_{conc} to the expected indoor air concentration (BBM_{air}) by multiplying the expected sub-slab soil gas concentration by the attenuation factor (α_{DEQ}). The resulting equation is:

EQUATION 3:

$$BBM_{air} = BBM_{conc} \times \alpha_{DEQ}$$

4.0 BIG BUILDING MODEL EVALUATION SITE - *EXAMPLE*

The following example is based on a site that has a single point of release within the structure. The MDEQ's $SG_{vi\text{-}ss}$ of 540 parts per billion by volume (ppbv) for trichloroethylene (TCE) was utilized as the appropriate site-specific criteria in accordance with Rules 714 and 724 of Part 201. This value represents an acceptable sub-slab soil gas screening concentration appropriate for a nonresidential exposure scenario.

The building is a long, single-story with a footprint of over 72,300 ft^2 of which 13,980 ft^2 are offices and 57,520 ft^2 is part of the manufacturing area. A structural survey and picture documentation confirms that the entire manufacturing area is open and there are no walls or partitions present. An additional 800 ft^2 of space on the manufacturing floor has been removed from consideration from the manufacturing area as that area contains a bathroom and an office area (no contamination, including vapors, has been found beneath either of these structures). Ceiling heights in the manufacturing area are 25 feet. The foundation is slab-on-grade construction that is at least eight inches thick, based on multiple cores. Figure 3 depicts the building.

The site was utilized for manufacturing up until operations ceased in 2007. It contained a former degreasing still and pit (see Figure 3). No other sources of TCE in the open area of the structure were identified. Upon investigation, soils and groundwater were found that contained levels of TCE above Part 201 C_{sat} criteria. In addition, groundwater was less than four feet below the ground surface. Therefore, the Part 201 GVIIC did not apply (see Checklist for Determining if the Generic Volatilization to Indoor Air Inhalation Criteria Apply, Appendix A.1)

The investigation identified sub-slab soil gas concentrations of up to 8,000 ppbv. In order to address the pathway, the company voluntarily performed a source removal around the former degreaser that was located within the structure and extracted groundwater from beneath the floor of the building in a continuing effort to reduce the remaining contaminant mass. Confirmation sampling over multiple sampling events showed that the concentrations of sub-slab soil gas continued to decrease; however, values still continued to exceed the MDEQ's $SG_{vi\text{-}ss}$. Maximum concentrations from the last three events are identified in Table 1 and the sampling locations are identified on Figure 3.

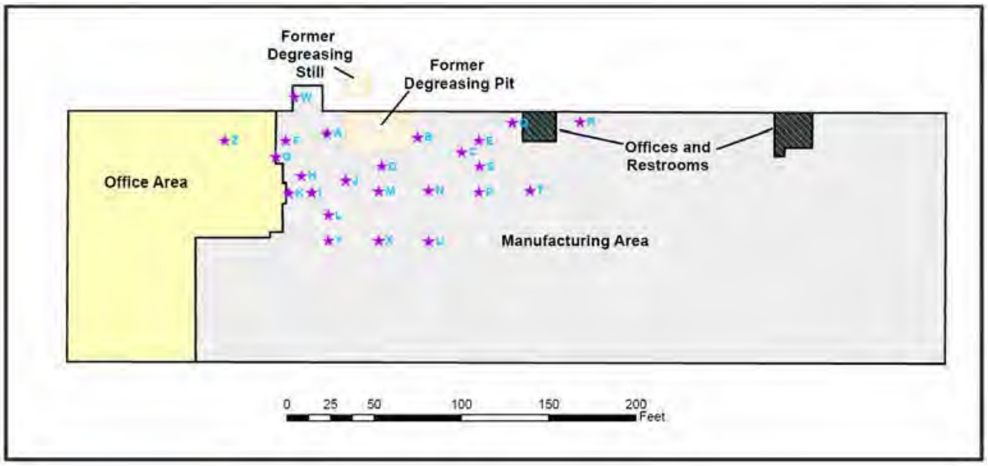

Figure 3 Building Figure

Table 1 Maximum Detected Soil Gas Concentrations For TCE

Point ID	TCE (ppbv)	Point ID	TCE (ppbv)	Point ID	TCE (ppbv)	Point ID	TCE (ppbv)
A	1000	G	ND	M	210	T	2
B	1500	H	290	N	130	U	2
C	580	I	730	P	23	W	260
D	330	J	600	Q	3	X	3
E	130	K	16	R	ND	Y	ND
F	79	L	5	S	140	Z	ND

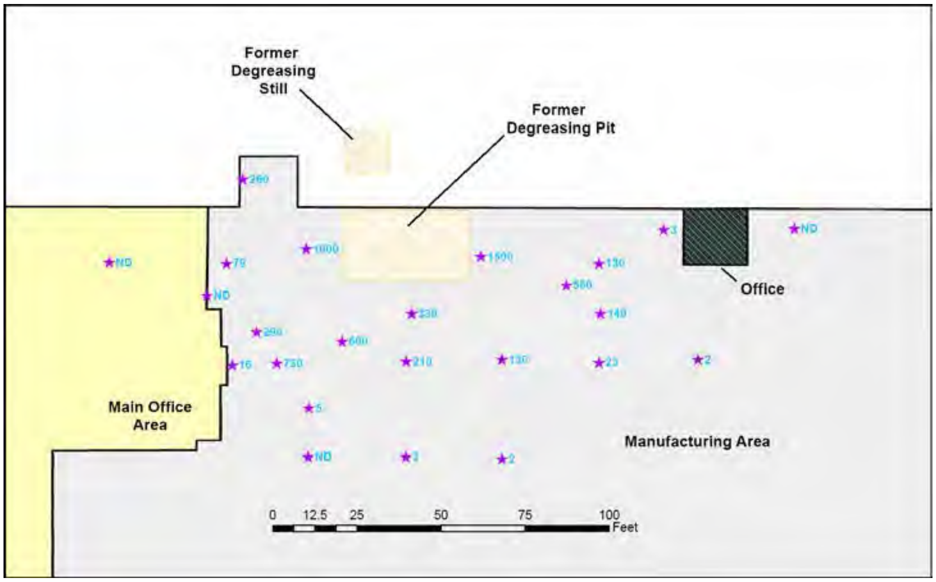

Figure 4 Maximum Concentrations Detected (ppbv of TCE)

The responsible party wished to utilize the BBM to further evaluate the site and determine if further response actions were necessary. Based upon the concentrations identified in Table 1 and Figure 4, the responsible party prepared Figure 5 that identified a contour for the area that remained above the $SG_{vi\text{-}ss}$ nonresidential concentration of 540 ppbv (Figure 6). The map also presented a contour that established concentrations below five ppbv (detection limit of the TO-15 analysis).

Zone 1 was established to represent the areas above the MDEQ's $SG_{vi\text{-}ss}$ of 540 ppbv and was expanded to a point that it contained 79 percent more area than presented in Figure 5. Zone 2 was established to represent a "transition" area between the areas with the sub-slab soil gas concentrations above the MDEQ's $SG_{vi\text{-}ss}$ and the areas where sub-slab soil gas points were analyzed to levels below the detection limit. It also provides an additional zone for modeling.

Final square footage of each area utilized in the BBM was: Zone 1 at 5,425 ft^2; Zone 2 at 4,300 ft^2; and Zone 3 at 47,795 ft^2. Zone 3's square footage was established by:

EQUATION 4:

$$Area_{ZONE3} = Area_{MANU} - (Area_{ZONE1} + Area_{ZONE2})$$

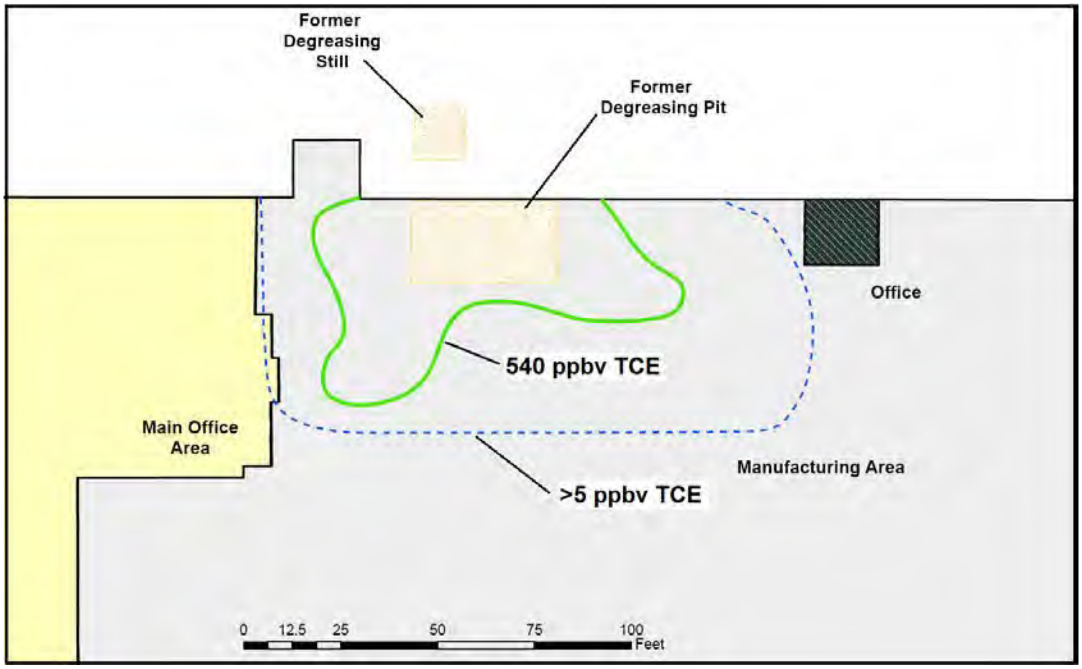

Figure 5 – Contours associated with the MDEQ's $SG_{vi\text{-}ss}$ *value of 540 ppbv for TCE*

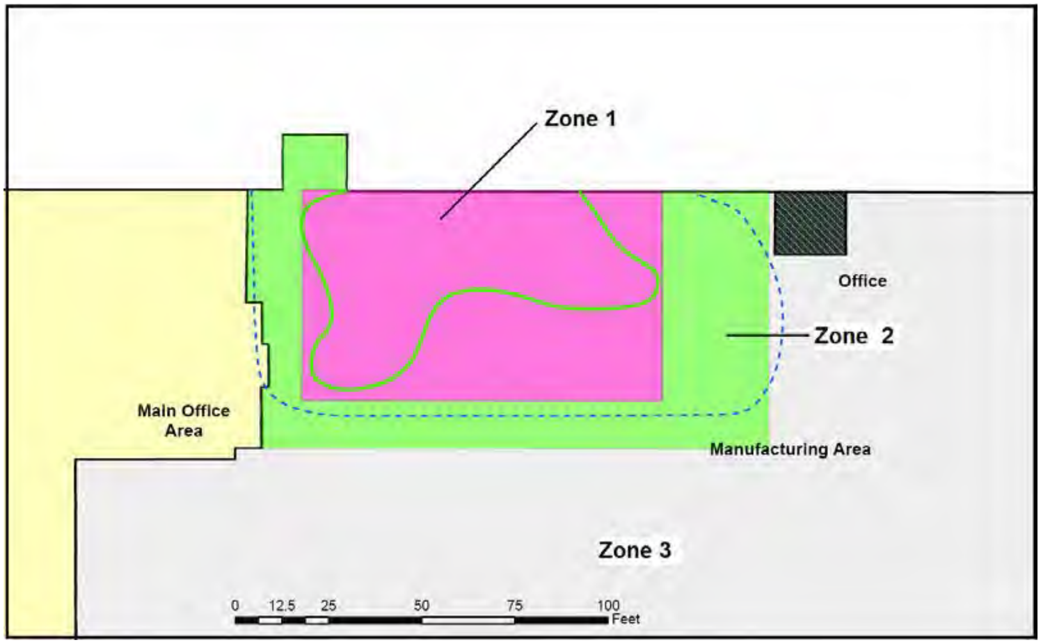

Figure 6 – Establishing the Zones

The inputs for all runs are identified in Table 2. Variations and modifications made for each run of the model are briefly described below. Again, it is important to note that the more the evaluation can be shown to remain protective as the model inputs exceed the "normal" or "expected" site conditions, the stronger is the line-of-evidence supporting the conclusion presented.

Run #1
Base run with expanded areas and maximum concentrations utilized. Even though 540 ppbv was not detected in Zone 2, the concentration is used as it would allow concentrations up to the MDEQ's $SG_{vi\text{-}ss}$ to exist. Zone 3 is run using the detection limit of the method. The BBM results indicate that the expected air concentration (BBM_{air}) for the above parameters would result in an indoor air concentration of 3.7 ppbv which is 60 percent less then the nonresidential AIAC of 11 ppbv.

The BBM in this analysis is conservative based on the following:

- Zone 1 was increased to encompass 79 percent more area than presented by the contour map in Figure 5.
- Zone 1 utilized a maximum concentration of 1,500 ppbv and most of the area did not have concentrations detected at that level.
- Zone 2 utilized the $SG_{vi\text{-}ss}$ for TCE of 540 ppbv even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv even though no source areas are present in the remaining manufacturing area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

Run #2
The maximum concentration in Zone 1 is increased to 300 percent of the maximum detected value. All other zones remain the same. The BBM results indicate that expected air concentration (BBM_{air}) would result in an indoor air concentration of 9.4 ppbv which is 15 percent less then the nonresidential AIAC.

The BBM in this analysis is conservative based on the following:

- The Zone 1 was increased to encompass 79 percent more area than presented by the contour map in Figure 5.
- Zone 1 utilized a concentration of 300 percent of the maximum detected.
- Zone 2 utilized the $SG_{vi\text{-}ss}$ for TCE of 540 ppbv even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv, the method detection limit, even though no source areas are present in the remaining area and sub-slab soil gas concentrations have been successfully defined to below detection levels.
-

- **TABLE 2 – EXAMPLE DATA AND RESULTS TABLE**

	Model Input Variables	*BBM Run #1*	*BBM Run #2*	*BBM Run #3*	*BBM Run #4*
Zone 1 Square Footage (ft^2)	$Zone1_{area}$	5,425	5,425	5,425	10,850
Zone 2 Square Footage (ft^2)	$Zone2_{area}$	4,300	4,300	4,300	8,600
Zone 3 Square Footage (ft^2)	$Zone3_{area}$	47,795	47,795	47,795	38,070
Total Square Footage (ft^2)		57,520	57,520	57,520	57,520
MDEQ Attenuation Factor (subslab)	$A_{subslab}$	0.02	0.02	0.02	0.02
MDEQ $SG_{vi\text{-}ss}$ for TCE (ppbv)	*540*	540	540	540	540
AIAC TCE Nonresidential (ppbv)	11	11	11	11	11
Zone 1 Max Concentration	$Zone1_{max}$	1,500	4,500	4,500	1,500
Zone 2 Max Concentration	$Zone2_{max}$	540	540	1,620	540
Zone 3 Max Concentration	$Zone3_{max}$	5	5	5	5
RESULTS					
BBM Soil Gas Concentration	$\mathbf{BBM_{conc}}$	**186**	**469**	**550**	**367**
Modeled Air Concentration	$\mathbf{BBM_{air}}$	**3.7**	**9.4**	**11.0**	**7.3**

Run #3

Zone 1 concentration remains at 300 percent of the maximum identified concentration. In addition, Zone 2 is increased to 300 percent of its previous value. Zone 3 remains at the detection limit. The BBM results indicate that the expected air concentration (BBM_{air}) would result in an indoor air concentration of 11 ppbv which is the nonresidential AIAC.

The BBM in this analysis is conservative based on the following:

- Zone 1 was increased to encompass 79 percent more area than presented by the contour map in Figure 5.
- Zone 1 utilized a concentration of 300 percent of the maximum detected.
- Zone 2 utilized a concentration of 300 percent of the $SG_{vi\text{-}ss}$ even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv, the method detection limit, even though no source areas are present in the remaining area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

Run #4

Zones 1, 2, and 3 concentrations return to the maximum concentrations identified in Run #1; however, the overall area extent of Zone 1 and Zone 2 is doubled (which results in a decrease in Zone 3). The BBM results indicate that the expected air concentration (BBM_{air}) would result in an indoor air concentration of 7.3 ppbv which is 34 percent less than the nonresidential AIAC.

The BBM in this analysis is conservative based on the following:

- The area in Zone 1 and Zone 2 was increased to encompass double of the area in Run #1.
- Zone 1 utilized a maximum concentration of 1,500 ppbv.
- Zone 2 utilized the $SG_{vi\text{-}ss}$ for TCE of 540 ppbv even though the maximum concentration detected in this zone is less than 140 ppbv.
- Zone 3 utilized a concentration of five ppbv even though no source areas are present in the remaining manufacturing area and sub-slab soil gas concentrations have been successfully defined to below detection levels.

The submittal to the MDEQ included a detailed discussion of the results of the BBM as well as ranges and limitations that were experienced. In addition, the submittal contained the following additional information and supporting lines-of-evidence:

- Multiple sampling rounds were performed with full quality assurance/quality control, showing stable or decreasing concentrations.
- Building does not meet the generic assumptions identified in the generic Part 201 GVIIC and SVIIC.
  - Building area greatly exceeds generic assumptions
  - Building interior height greatly exceeds generic assumption
  - Cement is thicker than the generic assumptions
  - Air exchange rate is greater than identified in the model
- The area of impact is a small percentage of the entire open area.
  - Concentrations of sub-slab soil gas have been defined
  - Multiple rounds of sub-slab soil gas samples have been collected

- Mixing can/will occur
  - Air exchange rate exceeds one per hour
  - Space is large and open with no walls to prevent mixing of indoor air
- Floor has been repaired and sealed
- Deed and use restrictions
  - Deed restriction will prevent subdividing the manufacturing area without further testing and/or installation of a presumptive mitigation system
  - Use of TCE is prohibited
- Source removal has been performed
  - C_{sat} soils were removed and floors replaced with new cement

Other options that may be pursued as part of analyzing the output provided by the model include, but are not limited to:

- Breaking apart the hotter area into multiple zones; however, there is a strong balance between having enough data points in each area and being able to demonstrate that the concentrations represented in the model are conservative.
- Establishing multiple hot spots or sources across the facility (each area must be clearly defined by points containing lower concentrations).
- Selected mitigation of a portion of the manufacturing area – the model would allow for the evaluation of a partial mitigation system with data that is able to document that the system is effectively mitigating vapors from a discrete area.
- Mitigation of selected structures: this approach could be combined with various active or passive mitigation options if it was determined that offices or bathrooms may be at risk.

5.0 PUTTING IT TOGETHER FOR COMPLIANCE

Documentation to complete the line-of-evidence and provide justification that the site conditions are protective for a party's due care obligations or remedial actions will be needed to confirm that this alternate procedure was applied in a manner that provides reliable results .

This documentation should include, but is not limited to, the following information:

- Zoning and a description of the expected future use of the facility
- Foundation and/or floor thickness
- Source of vapors and/or recognized areas of environmental concern (ASTM Phase I)
- Discussion of source removal (if performed)
- Data collection methodology and quality assurance/quality control procedures implemented
- Monitoring data collected
- Detailed explanation on how each of the zones were established
- Pictures documenting the area for which the BBM is being utilized
- Multiple runs of the model with varying inputs
- Discussion of the results and how they document that the approach is conservative and therefore protective
- Provide a discussion of the limitations and assumptions that make the model valid
- Associated maps, figures, and tables

In order for the MDEQ to determine that site-specific criteria intended to be relied upon for remedial action are protective under Sections 20118 and 20120, the party must include the proposed deed restrictions for the property that addresses the following:

- Limit the property's future use to nonresidential, unless a presumptive mitigation system is installed or an evaluation of the potential for vapor intrusion occurs.
- Limit and prevent modifications to the building, including the construction of walls within the area of concern, without evaluating the potential for vapor intrusion or installing a mitigation system.
- Require all future new construction to evaluate the potential for vapor intrusion or install a presumptive vapor mitigation system.

It is also important to note that for a party pursuing this method as a way to document and fulfill its obligations under due care, the entire sample collection procedure outlined above does not necessarily need to be completed prior to acquisition; although, the initial sampling event should at least be conducted and evaluated to ensure that the approach appears to be reasonable and appropriate. The remaining sampling events could be conducted after acquiring the property, if the party's due care plan identifies a contingency plan if future sampling events show that there is a potential for risk or if the model does not achieve the appropriate results.

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APPENDIX B.2

Alternate Approach for Demonstrating Compliance with the Volatilization to Ambient Air Pathway

Remediation and Redevelopment Division

ALTERNATE APPROACH FOR DEMONSTRATING COMPLIANCE WITH THE VOLATILIZATION TO AMBIENT AIR PATHWAY

Original Date of Issuance: January 19, 2012

Revision #: 1 **Revision Date: January 25, 2013**

Written by: **Matthew Williams, Vapor Intrusion Specialist**
Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

A policy guidance document cannot establish regulatory requirements for parties outside of the Michigan Department of Environmental Quality (MDEQ). It is explanatory and provides direction to staff, guidance to the regulated community, and consistency in enforcing the NREPA, but does not have the force and effect of law and is not legally binding on the public or the regulated community.

Special thanks for assistance:
Conestoga-Rovers & Associates
Severstal North America, Inc.
Ford Motor Company
Hamp, Mathews & Associates

PLEASE NOTE:

This approach was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide an alternate approach to parties implementing a response action in Michigan. It was created to promote an alternate approach that is consistent with Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). This document is not a statutory requirement, but could be implemented as an alternate approach under R 299.5714 and R 299.5724.

In general, this document should be used as a reference. Differences may exist between the procedures referenced in this document and what is appropriate under site-specific conditions. This document also does not represent an endorsement of practitioners or products mentioned in the document nor does it ensure that this approach is appropriate for all sites. It is imperative that the environmental professional implementing this approach provide adequate justification of this approach.

This approach is made available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern. The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the approach was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

Alternate Approach for Compliance with VSIC

Volatilization of organic compounds from contaminated soil or groundwater into the ambient air represents a potential source of exposure (Radian, 1986). In Michigan under Part 201, the generic cleanup criteria for soil based on inhalation of volatile hazardous substance emissions to ambient air are called the volatile soil inhalation criteria (VSIC). The VSIC represent the concentrations of a contaminant that can remain in soil at a facility while still protecting people who inhale the ambient air. The concentration of the contaminant in the soil is converted to a concentration in ambient air based on assumptions about the upward flux of the contaminant from the soil surface (and indirectly from the groundwater below the soil) and the use of a dispersion model to estimate the contaminant's concentration in ambient air.

R 299.5726(8) states:

> *A person who is implementing response activity may demonstrate compliance with the generic criteria developed under this rule through the collection and analysis of ambient air samples within the facility boundaries, if the hazardous substance concentration in surficial soil is representative of facility conditions.*

Therefore, the rule requires the collection and analysis of air samples from the site to demonstrate compliance with the VSIC.

In 2009, the Waste and Hazardous Materials Division (WHMD, now known as the Resource Management Division, RMD) of the MDEQ requested the formation of a multi-disciplinary work group to discuss ways to evaluate the VSIC using ambient air samples. The work group, with members representing the MDEQ's RMD, Remediation Division (RD), and the Air Quality Division (AQD) concluded that traditional ambient air monitoring is rarely appropriate or technically feasible for demonstrating compliance with the VSIC.

The work group concluded that given the complexity of ambient air monitoring and the large number of factors that can contribute to data variability (e.g., sampling procedures, equipment, duration, weather, multiple sources, and data interpretation), each application of R 299.5726(8) would entail a time consuming and costly effort to develop a site-specific solution. Therefore, it was determined that most sites will pose significant technical challenges as a result of multiple stationary and mobile air emission sources, varying meteorological (e.g., wind speed, direction, and local influences) and weather conditions (precipitation and temperature), and site activities (e.g., vehicle traffic) that would make it extremely difficult to design and implement a reliable ambient air monitoring program to demonstrate compliance with the VSIC.

Upon consultation with multiple experts, the RD has established the approach identified in this document that, if implemented as described, would demonstrate compliance with the VSIC using ambient air data in accordance with R 299.5726(8). The approach contains three major steps in the evaluation process that consist of:

- Defining zones of similar volatile parameter flux from the subsurface
- Quantifying flux for each zone by flux chamber sample collection
- Using flux as input to dispersion model to estimate relevant receptor concentrations

This is done through the collection of ambient air samples within a flux chamber (flux chamber sampling). Flux chamber sampling addresses many of the concerns and issues identified by the MDEQ work group and provides a direct measurement of volatile organic compound (VOC) emissions from soil to the ambient air at the site. The MDEQ believes that the approach outlined below can be representative of the actual volatilization of organic compounds from contaminated soil into the ambient air if implemented with care.

Although flux chamber sampling is the approach preferred by the MDEQ, other methods for demonstrating compliance under R 299.5726(8) may be proposed with appropriate technical justification.

1.0 GENERAL INFORMATION

1.1 Emission Process

The rate of emissions from contaminated soil is controlled by the diffusion rate of the chemical compound through the air-filled pore spaces of the soil. The exception occurs when the contaminated material is on or very near the ground surface. In these situations, the emission process and rate can be highly influenced by the rate of evaporation. The parameters that affect the evaporation process are basically the properties of the waste itself (e.g., vapor pressure) and those that affect the air-surface interface (e.g., air temperature, humidity, wind speed, surface roughness). In most cases, the background concentration of the contaminant is usually very low and can be assumed to be negligible.

1.2 Flux Chambers

An enclosure or chamber is used to isolate a known area of soil in which the collected vapors are measured over a period of time to measure the direct emissions from a surface. See Figure 1 for a generic representation of a flux chamber. The flux chamber approach provides a direct measurement of the subsurface contaminant flux at the soil-air interface as driven by diffusion and atmospheric conditions, ideally without altering the emission of gases at the surface. The results can be used to evaluate the impact of contaminated soil and other media on ambient air quality. The assessment of soil emissions using flux chambers is usually done in conjunction with sample analysis by Method TO-14A (United States Environmental Protection Agency [USEPA], 1999a) or Method TO-15 (USEPA, 1999b), as appropriate. These methods will yield an analytical detection limit of 0.1 and 0.001 micrograms per liter, respectively, for air in a flux chamber (DTSC, 2004). Other analytical methods may be acceptable and appropriate, depending on the contaminant concentrations expected at the site and the reporting (detection) limits necessary for comparison with criteria.

A Standard Operating Procedure (SOP) for the MDEQ's use of a flux chamber is provided in Attachment D of the MDEQ's document titled *Sample Collection and Evaluation of the Vapor Intrusion to the Indoor Air Pathway when the Generic Criteria Do Not Apply.*

1.3 Soil Flux Chamber Measurements for the Evaluation of Outdoor Air

Flux chamber sampling provides a direct measurement of the rate at which the VOCs are entering outdoor air from the soil. Therefore, if the maximum flux at the surface can be measured with properly collected flux chamber samples, then human exposure to air contaminated with the VOCs from subsurface sources can be estimated using a modeling program (see Section 3.0).

1.4 Establishing Site-Specific Criteria

When using this approach it is imperative that the party include *all of the VOCs associated with the release and the extent of the facility* in the analysis and evaluation of potential risks. This approach will not be valid if only an area or the VOCs present at concentrations exceeding the generic criteria are used. Contributions from all ranges of contamination must be considered.

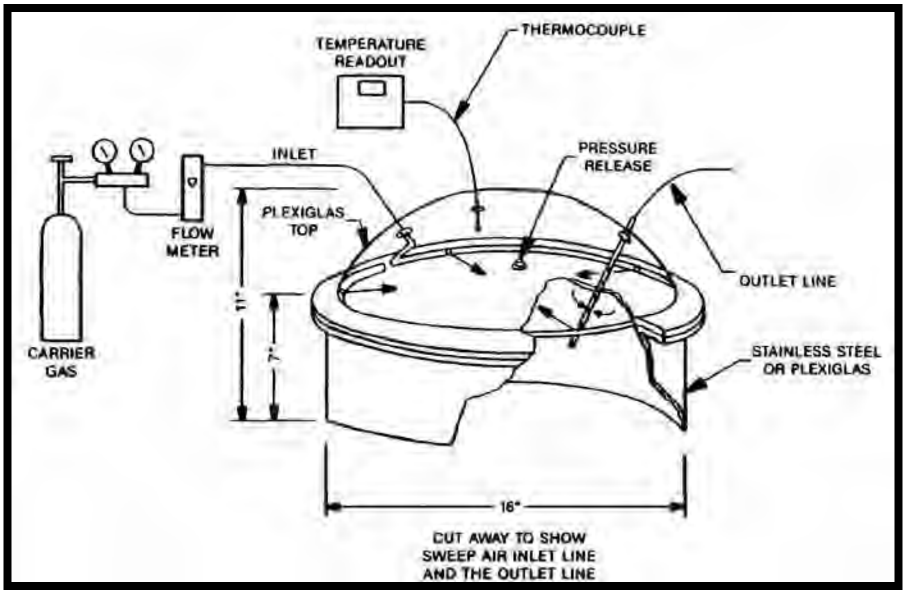

Figure 1 *General flux chamber construction diagram*

2.0 ALTERNATIVE APPROACH FOR DEMONSTRATING COMPLIANCE WITH THE VSIC

In general, the approach consists of the facility (i.e., all areas overlying impacted soil and groundwater) being divided into a number of zones (z_1, z_2, z_3 ... through z_n) and the emission rate for each zone is established. The established emission rates and supporting documentation is then submitted to the AQD by the RD to estimate expected ambient air concentrations at multiple compliance points throughout the facility using AERMOD.

The MDEQ has identified two methods for establishing zones to measure emission rates. One is for smaller (less than 4,000 square meters (m^2)) less complicated sites and the second is for larger (greater than 4,000 m^2) more complicated sites. The method for less complicated sites essentially involves reviewing the geology, topography, soil, and groundwater concentrations to define zones that are similar. With the zones defined you can choose to deploy flux chambers immediately. The method for more complicated sites involves deploying passive soil gas sampling to define areas of similar chemical parameter flux.

2.1 Establishing Zones to Determine Emission Rates Within

When establishing zones at the facility, it is imperative that each zone exhibit similar physical and chemical conditions for key characteristics, including (but not limited to):

- Concentrations of soil and/or groundwater contamination
- Contaminants of concern
- Depths/elevations of contamination
- Ground surface elevation

Zones may be irregular in shape but should be similar in size, unless a smaller zone is established over potential source areas. Smaller areas of potentially higher emission areas may successfully limit the area of higher emission rates to minimize potential areas of contribution to the ambient air in the model.

The following methodology provides a means to divide the facility into separate zones (Z) with an imaginary grid based on the overall areal extent of the facility:

- The extent of the facility is smaller than 4,000 m^2 - divide the facility into at least ten zones with areas not to exceed 200 m^2.
- The facility's areal extent is greater than 4,000 m^2 but smaller than 8,000 m^2 - divide the facility into at least 20 zones with areas not to exceed 400 m^2.
- The facility's areal extent is greater than 8,000 m^2 but smaller than 16,000 m^2 - divide the facility into areas not to exceed five percent of the total overall area.
- The facility's areal extent is greater than 16,000 m^2 - all zones must be smaller than 800 m^2 with no fewer than 20 zones.

Smaller zones and/or grid sizes may be utilized and are recommended as data has shown the ability to use smaller discrete areas is often beneficial during the modeling process.

It is imperative when using this approach that the extent of the contaminant's flux be established at the surface for the entire facility and not just an area that may exceed the generic criteria. Other methods may be acceptable for establishing zones of surface flux. However, many of the alternatives evaluated by the MDEQ are heavily site- or compound-specific. These methods are not described in this guidance document. The approach outlined here can be employed at the majority of sites across Michigan where a potential source of volatilization to ambient air is proposed to remain in place.

Below identifies two different approaches to establishing the emission rates of the zones based on the size of the facility. Each method could be used regardless of size; however, modification of the approach would be necessary.

2.1.1 Facilities Less Than 4,000 Square Meters

For smaller facilities, it can be beneficial and cost effective to go directly to the collection of emission rates. However, the collection of flux chamber samples is labor intensive and the number of flux chambers that can be properly deployed and sampled during a day often limits the size of the sampling program. Based on previous flux chamber sampling performed, the MDEQ has determined that collecting flux chamber samples at more than 15 locations on a facility often become logistically challenging. In such cases, the approach identified in 2.1.2 should be considered.

For small less complicated facilities, zones can be established using site-specific features that could include but are not limited to the following:

- Known subsurface sources of volatile chemical parameters (i.e., leaks from existing or historic process or storage equipment)
- Distribution of volatile chemical parameters in soil
- Distribution of volatile chemical parameters in groundwater
- Groundwater flow direction
- Topography
- Presence of obstructions to volatilization of chemical parameters (i.e., paved surfaces, concrete floor slabs of demolished buildings, engineered caps, etc.)
- Coverage of the lateral extent of the site
- Presence of fill material at ground surface

2.1.2 Facilities Greater Than 4,000 Square Meters

For facilities that contain more than 20 zones, it is often beneficial to first conduct a passive soil gas (PSG) survey with a larger number of measurement locations to group and establish zones with similar flux response levels and then to quantify emission rates in each zone using a smaller number of flux chambers (see Section 2.4). However, the survey must identify the relevant distribution of individual VOCs as opposed to “Total VOCs” or an overall response level.

Passive soil gas methods consist of the burial of an adsorbent into soil near the surface for a period of time (typically five to ten days) and the subsequent retrieval of the adsorbent for measurement. Contaminants “passively” diffuse and adsorb onto the collector over time. The method is easy to deploy and is proven to find areas of contamination (Hartman EPA-OUST Petroleum VI Workshop, 2010).

The use of these passive methods can be an effective tool in understanding the composition of subsurface soil gases and even identify the location of subsurface vapors, especially as it relates to the surficial flux. As most PSG sampling devices require deployment for extended periods of time, the data are less likely to be biased by site conditions that may vary throughout the day such as weather conditions, barometric pressure, or temperature.

2.2 Establishing the Grid Size for Deployment of Passive Soil Gas Samplers

Establishing a grid size for deploying PSG samplers across a site is a difficult balance between being cost effective and being able to provide enough data that discrete zones can accurately be established for modeling that addresses a wide range of emission values.

If PSG samplers are to be deployed, then the grid spacing identified in Section 2.1 can be used. The placement of these samplers should be based on the preexisting site knowledge of contamination and must include placing at least one of the samplers directly over the areas that is thought to contain the highest potential to produce the highest emission rates. It is highly recommended that over the known source areas (or areas of contamination within .5 meters of the surface) a more conservative approach be utilized by reducing the area of each zone by at least 50 percent. The tighter grid spacing over known source areas is highly beneficial in being able to establish smaller zones to input into the model for the areas with potential higher emission rates.

In any situation that the extent of the flux is not found to be decreasing toward the extent of the facility, it may be necessary for additional step-outs to occur.

2.3 Grouping Zones and Emission Rates from the Passive Soil Gas Survey

With known site conditions and the PSG results, it is possible to limit the amount of emission rates that would need to be collected.

This is done by first separating the site into areas with similar site physical and geological characteristics. This separation must occur across the facility based on site conditions (see Section 2.1) and not on response levels of the PSG survey. For instance, if part of the site has had a removal action and clean soil placed on top, it should be separated from areas of the site where a removal has not occurred. It may be beneficial to seek approval of the MDEQ project manager prior to proceeding with the PSG survey in areas with similar site physical and geological characteristics.

Each area can then be further refined and grouped based on the PSG response levels for each contaminant. Each group must then utilize the location of the maximum response level to establish the emission rate to be utilized in AERMOD (see Section 3.0).

With this approach, emission rates can be established across the facility based on the following requirements:

- One emission rate per zone per area
- One emission rate established for every four acres of facility
- A minimum of ten emission rates per sampling event

2.4 Collection of Flux Samples

There are two different types of flux chamber methods:

- **Static-(Closed) Chamber Method**: In this method, contaminants emitted from the soil surface are captured in a closed chamber and the contaminant concentration increases over time until it reaches equilibrium with the soil gas. After this "incubation period," a discrete sample is drawn from the chamber into an evacuated sample container (e.g., a SUMMA canister) and submitted for chemical analysis. Because the length of the incubation period is usually not known in advance, it is necessary to collect a time series of samples from the chamber at several intervals during the sampling event.
- **Dynamic-Chamber Method:** In this method, an inlet gas (sweep gas) is continuously introduced into the chamber during the incubation period and an equivalent amount of the chamber gas is allowed to escape. The system is assumed to reach a steady-state concentration after four or five chamber-residence times, where one residence time equals the chamber volume divided by the sweep-gas flow rate.

An SOP for the dynamic method is provided in Appendix D. Though both methods provide reliable results, the dynamic method is preferred by the MDEQ as there are less decision points to determine if an appropriate sample has been collected.

2.5 Establishing Compliance Points

Evaluation of the model to determine compliance with criteria will be based on compliance points modeled and compared to the appropriate acceptable indoor air criteria (AIACs). The AIACs are appropriate for use to evaluate the risk presented regardless whether a person is indoors or outdoors. Compliance points will be established across the facility based on the following minimum requirements:

- Perimeter of the facility on 100 foot grid spacing
- Closest point of a property with a sensitive population (i.e., school, day care, nursing home, etc.)
- Shallowest contamination present
- Source area

AERMOD will also establish the area of the highest concentration present. If this is different than one of the areas on the facility identified above, an alternative point of compliance will be established and compared to the appropriate AIACs. On any property that is zoned for nonresidential use and the expected use is to remain nonresidential, possibly (through the implementation of institutional controls) the nonresidential air standard will be utilized. All other properties will utilize the residential AIAC unless proper justification can be provided for alternative criteria.

3.0 AERMOD

The AERMOD modeling system replaced the ISCST3 as the preferred recommended model for most regulatory modeling applications, as announced in a November 9, 2005 Federal Register notice, and is listed as such in Appendix A of the USEPA's "Guideline on Air Quality Models," (also published as Appendix W of Title 40 of the Code of Federal Regulations (CFR) Part 51). Detailed information and guidance for the use of AERMOD can be found in the attached MDEQ AQD September 2009 document titled "Air Dispersion Modeling Guidance Document." The information reiterates some of the information found in the attachment; however, it also provides more detailed and specific recommendations and application of the AERMOD in demonstrating compliance with the volatilization to ambient air pathway under Part 201.

The responsible party has the option of conducting their own modeling or having the AQD perform the modeling. In either case, the supporting modeling information listed below must be submitted to the Part 201 project manager for submittal to the AQD to complete the models analysis or for confirmation of the results supplied.

3.1 Evaluating the Results of Model

Utilizing the model prior to the submittal to the MDEQ is a valuable tool for sites that may contain multiple source areas as it allows a responsible party to evaluate various selective response actions across the facility to further assess the potential benefit of a particular remedial action. It must be identified that an exceedance of the AIAC may not present a risk due to some of the conservative nature that is included within this methodology; however, further evaluation of the facility is necessary which could include reducing the area of each zone and/or potential remedial activities being performed.

3.2 Submittal of the Data to the MDEQ

The party is expected to provide all of the information identified below in one submittal. Failure to provide all the information may result in the submittal being returned to the party as insufficient. A CD or DVD should be attached to the report that contains all the necessary digital information including the appropriate tables and figures for processing. All coordinates must be provided in Universal Transverse Mercator (UTM) coordinates that indicate which North American Datum System was used (i.e., NAD 1927 or NAD 1983).

The report should contain a general discussion of the following:

- Site location including street address, city, and county
- General description of the facility and area up to 500 feet beyond the extent of the facility including approved zoning
- Contaminants of concern applicable to the project
- Discussion on how each zone was established and the methodology utilized to establish the representative emission rates with sample calculations
- Other sources of emissions on the facility, whether they are permitted or exempt, sampled emission rates (previous 12 months or maximum concentration identified), and stack heights up to 500 feet beyond the extent of the facility
- Discussion of data collection methodologies and analytical results
- Discussion of building elevations located in the area up to 500 feet beyond the extent of the facility
- Discussion on the quality assurance/quality control performed for the data collected
- Discussion of all sensitive receptors up to 500 feet beyond the extent of the facility
- Discussion of the location of the proposed compliance monitoring points for the model

For every stack with a discharge of VOCs within the facility, the report should contain:

- Name of stack or stack identifier
- Height of stack from ground level (feet or meters)
- Exit temperature of exhaust gas (°Fahrenheit or °Celsius)
- Inside diameter or length and width of stack (feet or meters)
- Exit velocity of exhaust gas (feet or meters per second) or volumetric flow rate (stand cubic feet per meter, cubic meters per second)
- Stack location (UTM or Local)
- Stack orientation (i.e., vertical, horizontal, gooseneck)
- Stack obstructions (rain caps, other)
- Emission rate of each pollutant from this stack (pounds per hour or gallons per second (lbs/hr or g/s))
- The heat content (Btu per cubic foot) and flow rate of the gas out of any installed flares

This information is required whether the applicant or AQD is performing the modeling. For multiple pollutants emitted from multiple stacks, the information may be submitted in a spreadsheet format.

For every zone that is established, a table in the report should contain:

- Zone name or identifier
- Volume of zone
- Coordinates that establish the lateral dimensions of the area by either establishing the coordinates of each corner (if the area is square) or by providing the coordinates every 50 feet around the exterior (and interior if necessary) perimeter
- Emission rate of each pollutant from this area (g/s-square meters)
- Release height if the elevation of the release height is not ground level

For every building that is established, a table in the report should contain:

- Peak roof height from ground level
- Heights of any higher sections (tiers) on main roof
- Building dimensions, length and width
- Building location via Local or UTM coordinates or plot plan

The report should contain the following figures which also should be included as a PDF on the CD or DVD included in the report. All figures must be to scale which is clearly identified.

- Site location map
- Extent of contamination in soil and groundwater above Part 201 criteria
- Site feature map that includes any fence lines, berms, and other public access barriers
- Site feature map that provides the location of all stacks, volumes, and areas being modeled
- Site feature map that identifies the location of all buildings/structures located up to 500 feet beyond the extent of the facility
- Site feature map that locates all sensitive receptors up to 500 feet beyond the extent of the facility (i.e., schools, day cares, nursing homes, hospitals, etc.)
- Flux chamber sample location map (recommended that callout boxes with data are also provided)

All figures must be to scale which is clearly identified.

If the responsible party has been conducting their own modeling and wishes the MDEQ to confirm the results, the following files should be provided:

- Copy of the modeling input files (*.inp, *.dat, *.dta, *.api)
- For AERMOD a copy of the Stage 1 and 3 AERMET input files (*.in1, *.in3)
- For AERMOD a copy of the AERMAP output file (*.rou)
- Copy of the building profile input program (BPIP) file (*.bpi)
- Copy of the modeling output files (not as important as the two first items, but helpful)
- Toxic air contaminant lists/spreadsheets including emission rates, screening levels, and impacts

Tables:

- All PSG sampling results including point name and coordinates
- Flux chamber results including point name and coordinates
- Site contour data tied to the United States Geological Survey elevations (+/- .2 foot)
- Center of all buildings located within the downwash area with building heights provided
- Center of all sensitive receptors located
- Coordinates of the proposed compliance monitoring points

Maps and figures (to scale):

- Entire site features map
- High-resolution aerial photo covering for three kilometers surrounding the project area
- Terrain and other identifiable features in the source area
- All buildings considered in the downwash analysis and plant property boundaries (building sizes and shapes on the map should be drawn to scale)
- Map of the facility clearly delineating the locations of all sources of vapors (groundwater and soil)
- Map of the facility clearly delineating the locations of all emissions
- Map of the zones established for the emission rates

4.0 COMPLAINCE WITH PART 201

If the modeling performed by the AQD demonstrates that the release does not pose a risk, compliance may be obtained by collecting two to three additional rounds of data. The data must be collected during the summer and during periods of little to no rain. If data is shown to be decreasing or stable, compliance may be obtained by a deed restriction of access and preventing any disturbance of the current cover. Installation of a protective barrier may be warranted if the contamination is within six inches of the surface to ensure the long-term protectiveness of the selected remedy.

If modeling has identified the potential for a risk, as identified in Section 3.1, further assessment and/or remedial action may be warranted due to some of the conservative nature that is included within this methodology.

5.0 REFERENCES

Department of Toxic Substances Control (DTSC). 2004. Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.

Hartman, B. 2010. Vapor Intrusion Fundamentals. Webinar. EPA-OUST Petroleum VI Workshop.

Radian Corporation under contract to the United States Environmental Protection Agency. 1986. Measurement of Gaseous Emission Rates from Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide. USEPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, USEPA Contract No. 68-02-3889, Work Assignment 18. Document No. EPA/600/8-86/008. February 1986.

United States Environmental Protection Agency. 1999a. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-14A, Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters With Subsequent Analysis By Gas Chromatography. Center for Environmental Research Information, Office of Research and Development, USEPA, Document No. EPA/625/R-96/010b.

United States Environmental Protection Agency. 1999b. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition, Compendium Method TO-15, Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, USEPA, Document No. EPA/625/R-96/010b.

APPENDIX B.3

Alternate Approach for Investigating Vapors for Petroleum Hydrocarbons Considering Biodegradation

Modified December 16, 2019:

The department has determined the following Interstate Technology & Regulatory Council (ITRC) Petroleum Vapor Intrusion (PVI) guidance document suitable for a petroleum vapor intrusion assessment pursuant to relevant statutory provisions:

ITRC Technical and Regulatory Guidance Web-Based Document, Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management (PVI-1, 2014)

To assist in the use of this document the department has developed two Precluding Factors Assessment for ITRC PVI Vertical and Lateral Separation Distances Checklists. RRD staff will use these checklists when reviewing submittals that propose to rely on the ITRC PVI separation distances.

Precluding Factors Assessment for PVI Lateral Inclusion Zone Checklist

Precluding Factors Assessment for PVI Vertical Separation Distance Checklist

APPENDIX B.4

Approach for Demonstrating Compliance with a Crawlspace

(Currently Under Development)

Appendix C – Checklists for Evaluating Compliance

Table of Contents

APPENDIX C.1

Checklist for Determining if the Generic Volatilization to Indoor Air Inhalation Criteria Apply

APPENDIX C.1

BACKGROUND

Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and the associated Administrative Rules regulate most sites of environmental contamination in Michigan. The Part 201 Administrative Rules establish the generic cleanup criteria for the hazardous substances in vapors emanating from groundwater (R 299.5714) and soil (R 299.5724) to indoor air.

GROUNDWATER

Rule 714(2) identifies conditions for which the generic cleanup criteria for groundwater do not apply and a site-specific evaluation is required. If any of the conditions outlined in Rule 714(2)(a-c) apply, then a site-specific evaluation must be completed.

> Rule 714(2): Except as provided in subrule (1) of this rule, if any of the following conditions exist, the generic cleanup criteria developed pursuant to this rule shall not apply and a site-specific evaluation of indoor air inhalation risks shall be conducted:
> (a) There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.
> (b) The highest water table elevation of a contaminated saturated zone at the facility, considering seasonal variation, is within three meters of the ground surface.
> (c) There is a sump present that is not completely isolated from the surrounding soil by its materials of construction; or there is other direct entry of contaminated groundwater into the basement.

SOIL

Rule 724(2) identifies conditions for which the generic cleanup criteria for soil do not apply and a site-specific evaluation is required. If any of the conditions outlined in Rule 724(2)(a-b) apply, then a site-specific evaluation must be completed.

> Rule 724(2): Except as provided in subrule (1) of this rule, if any of the following conditions exist, the generic cleanup criteria developed pursuant to this rule shall not apply and a site-specific evaluation of indoor air inhalation risks shall be conducted:
> (a) There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.
> (b) There is a sump present that is not completely isolated from the surrounding soil by its materials of construction.

JOHNSON AND ETTINGER MODEL

The United States Environmental Protection Agency (USEPA) has identified a number of conditions under which the application of the Johnson and Ettinger Model is precluded. In accordance with 299.5705 and 299.5706 these conditions could result in concentrations that may not be protective of public health for the vapor intrusion pathway and therefore a site-specific approach should be undertaken.

Conditions include:

1. The actual or suspected presence of residual or free-phase light and dense non-aqueous phase liquids (LNAPL and DNAPL), i.e., fuels, solvents, etc., or smear zones in the subsurface
2. The presence of heterogeneous geologic materials between the vapor source and the building
3. The presence of geologic materials that are fractured, contain macropores, karst, or other preferential pathways
4. Sites where significant lateral flow of vapors occur due to preferential pathways
5. Shallow groundwater in contact with the building foundation
6. Small building air exchange rates (e.g., less than 0.25 building exchanges/hour)
7. Buildings with crawlspace structures or other significant openings to the subsurface (e.g., earthen floors, stone buildings, etc.)
8. Contaminated groundwater sites with large water table fluctuations

APPENDIX C.1
Checklist for Determining if the Generic Volatilization to Indoor Air Inhalation Criteria Apply

The information included in this checklist may be used by staff to determine if the generic criteria apply and a site-specific evaluation is necessary for evaluating hazardous substances in vapors for the volatilization to indoor air pathway.

Site Name: **Site ID:**
Site Address: **County:**

If any of the following apply then a site-specific evaluation in compliance with R 299.5714(5) and R 299.5724(5) is required:

For groundwater:

☐ *There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.*

☐ *The highest water table elevation of a contaminated saturated zone at the facility, considering seasonal variation, is within three meters of the ground surface.*

☐ *There is a sump present that is not completely isolated from the surrounding soil by its materials of construction; or there is other direct entry of contaminated groundwater into the basement.*

For soil:

☐ *There is a structure present or planned to be constructed at the facility which does not have a concrete block or poured concrete floor and walls.*

☐ *There is a sump present that is not completely isolated from the surrounding soil by its materials of construction.*

The USEPA has identified a number of conditions under which the application of the Johnson and Ettinger Model is precluded because these conditions can result in concentrations that may not be protective of public health for the vapor intrusion pathway.

☐ *The actual or suspected presence of free-phase non-aqueous phase liquids (LNAPL; DNAPL; i.e., fuels, solvents, etc.) or smear zones in the subsurface.*

☐ *The presence of heterogeneous geologic materials between the vapor source and the building.*

☐ *The presence of geologic materials that are fractured, contain macropores, karst, or other preferential pathways.*

☐ *Sites where significant lateral flow of vapors occur.*

☐ *Shallow groundwater in contact with the building foundation.*

☐ *Buildings with crawlspace structures or other significant openings to the subsurface (e.g., earthen floors, stone buildings, etc.).*

☐ *Contaminated groundwater sites with large water table fluctuations.*

The other condition identified by the USEPA (e.g., very small building air exchange rates) is not typically investigated during the course of an investigation. The condition, though not included above, should be considered and evaluated if warranted or knowledge indicates a necessity to consider.

APPENDIX C.2

Checklist for Developing a Conceptual Site Model

APPENDIX C.2

Developing a Conceptual Site Model

Developing a conceptual site model (CSM) is an important first step for assessing contaminated sites and the potential for vapor intrusion. Briefly, a CSM is a picture and narrative of the site contamination: how it got there, whether or not it is migrating or degrading, its distribution across the site, who might be exposed to it, and what risk-reduction strategies are most feasible. A CSM development actually begins during the Phase I Environmental Site Assessment with collection and evaluation of site history and reconnaissance information.

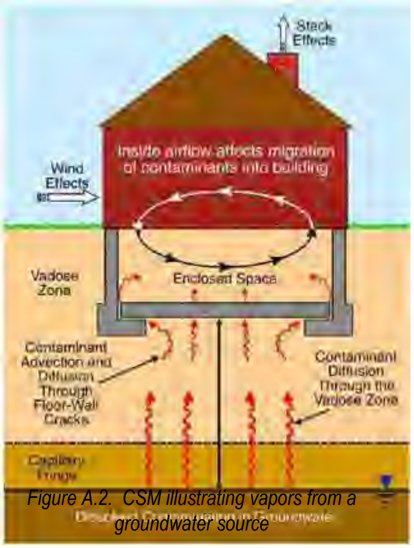

Figure A.2. CSM illustrating vapors from a groundwater source

During subsequent site characterization activities, the CSM can be augmented and refined, as necessary, with site-specific information on source areas, contaminant properties, stratigraphy, hydrogeology, exposure pathways, and potential receptors. Building and refining a thorough CSM may involve a combination of techniques and tools to understand the subsurface, but specifically, investigations for vapor intrusion often include collecting samples of soil, groundwater, soil vapor, and/or indoor air. Investigators may use sampling in combination with predictive models. Constructing a CSM for vapor intrusion requires the integration of important site characteristics to assist in understanding and evaluating the potential impacts that vapor intrusion risks pose to potential receptors.

The purpose for developing a CSM for the vapor intrusion pathway is to assemble a three-dimensional concept of the site that is as comprehensive as possible. This is based on reliable data describing the sources of the contamination, the release/transport mechanisms, the possible subsurface migration routes, the potential receptors, as well as historical uses of the site, cleanup concerns expressed by the community, and future land use plans. All the important features relevant to characterization of a site should be included in a CSM, and any irrelevant ones excluded.

Contents of the Conceptual Site Model

The CSM should present both a narrative and a visual representation of the actual or predicted relationships between the contaminants at the site and receptors (building occupants), as well as reflect any relevant background levels. A basic example of a visual representation is included as Figure A.2.

The CSM should also contain a narrative description that clearly distinguishes what aspects are known or determined and what assumptions have been made in its development. The CSM should also identify conditions that may result in alternate approaches. The CSM provides a conceptual understanding of the potential for exposure to compounds of concern at a site. It is an essential tool to aid management decisions associated with the site and serves as a valuable communication tool both internally with the site team and externally with the community. The CSM is a dynamic tool to be updated as new information becomes available after each stage of investigation. Below is a CSM checklist to assist in the review of this component of the vapor intrusion assessment.

APPENDIX C.2
Checklist for Developing a Conceptual Site Model

The information included in this checklist may be useful for evaluating a site-specific conceptual migration model and ensuring that the model contains the necessary elements. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: **Site ID:**
Site Address: **County:**

1.0 UTILITIES AND PROCESS PIPING

_____ Maps, figures, and cross-sections of the building provide the location and depths of all underground utilities and/or process piping near the soil or groundwater impacts.

2.0 BUILDINGS (RECEPTORS)

_____ Maps identify:
- Existing or proposed buildings
- Vacant parcels
- Property boundaries

_____ Description of the occupancy and use of all properties/buildings

_____ Construction of each structure includes (if applicable):
- General construction style (e.g., basement, crawlspace, slab on grade)
- Floor construction (e.g., concrete, dirt)
- Depth below grade of lowest floor
- Building layout (e.g., large and open, small rooms)
- Height (and number of floors)
- Sumps or foundation drains
- Alternate ventilation system
- Elevator(s)

_____ Heating, ventilation or air conditioning system in each structure is described and includes (if applicable):
- Type (e.g., forced air, radiant)
- Equipment location (e.g., basement, crawlspace, utility closet, attic, roof)
- Source of return air (e.g., inside air, outside air, combination)
- System design considerations relating to indoor air pressure (e.g., positive pressure may be the case for commercial office buildings)

_____ Installed sub-slab ventilation systems or moisture barriers present are described and identified on all building figures

3.0 SOURCE AREA(S)

_____ Description and known history of the release.

_____ Maps and figures identify and show the location of all vapor source(s) in relation to each structure (including the presence, distribution, and composition of any non-aqueous phase liquid at the site).

_____ Cross-sections showing example building, construction styles, and relationship to source of vapors (actual number will vary as appropriate).

_____ Description of the potential migration characteristics (e.g., stable, increasing, decreasing).

4.0 GEOLOGY/HYDROGEOLOGY

_____ Maps, figures, cross-sections, and/or description identify soil lithology and characteristics:

- Heterogeneity/homogeneity of soils and the lithologic units encountered including:
  - Depth and lateral continuity of any confining units that may impede contaminant migration
  - Depth and lateral continuity of any highly transmissive units that may enhance contaminant migration
- Depth of vadose zone, capillary fringe, and phreatic zone including:
  - Any seasonal water table fluctuations
  - Groundwater flow direction
  - Presence of any perched groundwater
  - Note where the water table intersects the well screen interval or the presence of a submerged screen.

_____ Description and location of distinct strata (soil type and moisture content, e.g., moist, wet, dry) and the depth intervals.

_____ Description and location of all fill or non-native materials.

_____ Depth to groundwater identified on all cross-sections.

_____ General groundwater characteristics provided (e.g., seasonal fluctuation, hydraulic gradient).

5.0 SITE CHARACTERISTICS

_____ Map of the site (to scale) showing all paved areas, surface cover, locations of all structures, and ground cover.

_____ Map identifying all potential sources of vapors.

6.0 REFERENCES

Interstate Technology & Regulatory Council. 2007. Vapor Intrusion Pathway: A Practical Guideline, January 2007. Accessed at http://www.itrcweb.org/Documents/VI-1.pdf.

APPENDIX C.3

Checklist for Reviewing
Soil Gas Sampling Protocols
and
Laboratory Data

APPENDIX C.3
Checklist for Reviewing Soil Gas Sampling Protocols and Laboratory Data

The information included in this checklist may be useful for reviewing soil gas data collected outside of a building during the course of an investigation. It is important to understand that data are collected for a variety of purposes and the use of this checklist is only intended for evaluating the use of the data for compliance purposes. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: **Site ID:**
Site Address: **County:**

1.0 SOIL CONDITIONS

_____ Site conditions have not been influenced by precipitation prior to sample collection.
- *The waiting period will be dependent upon soil type, amount of rain, and previous soil moisture content (e.g., longer for clays, longer for heavy rains, shorter for coarse sands, etc.).*
- *Information should be provided showing justification of actual time elapsed between rain and sampling events.*
- *May not be necessary if collected within a structure.*

2.0 SOIL GAS SAMPLE COLLECTION

_____ Points purged before sampling.
- *Gas volume contained in the sampling point and apparatus identified.*
- *Minimum of three volumes was purged from entire sampling system.*
- *Purging rate is less than 200 milliliters per minute (ml/min).*

_____ Samples were collected in a manner that ensures no ambient air infiltration has occurred.
- *Probe is properly constructed and sealed.*
- *Sample collected at less than 200 ml/min.*
- *Points installed at least five feet below ground surface unless site conditions warrant shallower installation (e.g., shallow groundwater).*
- *Tracer gas or other similar quality assurance/quality control protocols utilized.*

_____ Peristaltic or vacuum pumps were not utilized for sample collection.

_____ Sampling point is documented as being in good condition.

_____ Disposable parts were not reused or parts were adequately decontaminated between samples.

_____ Flow controllers and sampling apparatus were not reused.

3.0 SOIL GAS SAMPLE ANALYSIS

_____ Samples analyzed by TO-15.

- *Lab sheets indicate TO-15.*
- *Holding time met.*
- *Tedlar sampling bags are not utilized.*
- *Samples* not shipped *on ice and stored at ambient air temperature.*
- *Chain of Custody review does not identify any issues of concern.*

OR

_____ Information supplied to evaluate analytical methodology utilized.

- *Alternative methods will need to seek approval.*

4.0 ADDITIONAL VERIFICATION OF FIELD METHODS UTILIZED

_____ Copies of the field notes are provided.

_____ Sampling results make sense to the field conditions and concentrations previously identified in soil and groundwater.

_____ Sampling containers were verified as being certified clean from the laboratory.

_____ Utilized Quality Assurance/Quality Control (QA/QC) protocols to verify sampling methodology.

_____ Excessive vacuum is not encountered.

APPENDIX C.4

Checklist for Reviewing
Sub-Slab Sampling Protocols
and
Laboratory Data

APPENDIX C.4
Checklist for Reviewing Sub-Slab Sampling Protocols and Laboratory Data

The information included in this checklist may be useful for reviewing sub-slab soil gas data collected during the course of an investigation. It is important to understand that data are collected for a variety of purposes and the use of this checklist is only intended for evaluating the use of the data for compliance purposes. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: **Site ID:**
Site Address: **County:**

1.0 SUB-SLAB SOIL GAS SAMPLE COLLECTION

_____ Points purged before sampling.
- *Gas volume contained in the sampling point and apparatus identified.*
- *Minimum of three volumes was purged from entire sampling system.*
- *Purging rate is less than 200 milliliters per minute (ml/min).*

_____ Samples were collected in a manner that ensures no ambient air infiltration has occurred.
- *Probe is properly constructed and sealed.*
- *Sample collected at less than 200 ml/min.*
- *Tracer gas or other similar quality assurance/quality control protocols utilized.*

_____ Peristaltic or vacuum pumps were not utilized in the purging or in the sample collection.

_____ Small sample volumes collected.

_____ Disposable parts were not reused or parts were adequately decontaminated between samples.

_____ Flow controllers and sample trains were not reused unless they were adequately decontaminated between samples.

2.0 SUB-SLAB SOIL GAS SAMPLE ANALYSIS

_____ Samples analyzed by TO-15.
- *Lab sheets indicate TO-15.*
- *Holding time met.*
- *Samples* not shipped *on ice and stored at ambient air temperature.*
- *Chain of Custody review does not identify any issues of concern.*

OR

_____ Information supplied to evaluate analytical methodology utilized.
- *Alternative methods will need to seek approval.*

3.0 ADDITIONAL VERIFICATION OF FIELD METHODS UTILIZED

_____ Copies of the field notes.

_____ Sampling results make sense to the field conditions and concentrations previously identified.

_____ Sampling containers were verified as being certified clean from the laboratory and contain a statement from the laboratory.

_____ Utilized industry standard protocols to verify sample was obtained at the screened interval.

_____ Thickness and condition of flooring is documented.

APPENDIX C.5

Checklist for Reviewing the Design of an Active Mitigation System

APPENDIX C.5
Checklist for Reviewing the Design of an Active Mitigation System

The information included in this checklist may be useful for reviewing the design of an active mitigation system. Though it is generally understood that the actual design of the system may vary, many of the design components should be very similar in purpose. The information in this checklist is based on American Society for Testing and Materials (ASTM Standard E2121, 2009). A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name:
Site ID:
Site Address:
County:

1.0 DEFINITIONS

Backdrafting:	A condition where the normal movement of combustion products up a flue (due to the buoyancy of the hot flue gases) is reversed, so that the combustion products enter the building (see *pressure-induced spillage*).
Depressurization:	A negative pressure induced in one area relative to another.
Diagnostic tests:	Procedures used to identify or characterize conditions under, beside, and within buildings that may contribute to radon entry or elevated radon levels or that may provide information regarding the performance of a mitigation system.
Manifold piping:	Piping that collects the flow of soil gas from two or more suction points and delivers that collected soil gas to the vent stack piping. In the case of a single suction point system, there is no manifold piping since the suction point piping connects directly to the vent stack piping. The manifold piping starts where it connects to the suction point piping and ends where it connects to the vent stack piping.
Mitigation system:	Any system or steps designed to reduce concentrations of a contaminant in the indoor air of a building that originates in the subsurface.
Natural draft combustion appliance:	Any fuel burning appliance that relies on a natural convective flow to exhaust combustion products through flues to outside air.
Pressure-field extension:	The distance that a pressure change, created by drawing soil gas through a suction point, extends outward in a sub-slab gas permeable layer, under a membrane, behind a solid wall, or in a hollow wall (see *communication test*).
Pressure-field extension test:	A diagnostic test to evaluate the potential effectiveness of a sub-slab depressurization system by applying a vacuum beneath the slab and measuring, either with a micromanometer or with a heatless smoke device, the extension of the vacuum field.
Pressure-induced spillage:	The unintended flow of combustion gases from an appliance/venting system into a dwelling, primarily as a result of building depressurization (see *backdrafting*).

2.0 GENERAL

_____ Report identifies that the design does not interfere with the normal venting functions for appliances and backdrafting will not occur.

_____ Pressure field extension test (e.g., diagnostic communication test) has been performed.

- *For buildings over 10,000 square feet multiple tests throughout the building are completed.*

_____ Detailed specifications are provided on products utilized including fan, piping, and caulk.

_____ System is designed by a professional engineer with demonstrated experience designing mitigation systems.

_____ Building/Fire Codes: Document states mitigation systems shall be designed and installed to conform to applicable building and fire codes and maintain the function and operation of all existing equipment and building features including doors, windows, access panels, etc.

_____ Discharge Calculations: Estimated calculations for discharge pursuant to Part 55, Air Pollution Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA) and the associated Administrative Rules. Single-family homes are exempt.

3.0 SYSTEM SEALING REQUIREMENTS

Openings that could lessen the effectiveness of the mitigation system are sealed using methods and materials that are permanent and durable.

☐ Cracks and joints:

  _____ Openings and cracks where the slab meets the foundation wall have been addressed.

  _____ Concrete slab (flooring) above the active mitigation system is free of cracks or cracks have been adequately sealed.

  _____ For joints greater than 1⁄2 inch (13 millimeters) in width, a foam backer rod or other comparable filler material should be inserted into the joint before the application of the sealant.

☐ Penetrations:

  _____ Openings around the suction point piping penetrations of the slab have been adequately addressed.

  _____ Vaults, sumps, other large openings, and utility access points in the foundation walls and/or floor slab are sealed using measures that still allow future access.

4.0 SYSTEM MONITORS AND LABELING

_____ Mitigation systems contain mechanisms to monitor performance (airflow or pressure).

_____ Mechanism is simple to read and interpret and is located where it is easily seen or heard.

_____ System provides a visual and/or audible indication of system degradation and failure.

☐ Monitor has reliable power source:

  _____ If powered by house current, it shall be installed on a non-switched circuit and be designed to reset automatically after a power failure. Battery backup for the monitoring system in the event of power failure is recommended.

OR

  _____ If the monitor is battery powered, it shall be equipped with a low-battery power warning feature.

_____ Mechanical system monitors, such as manometer type pressure gauges are clearly marked to indicate the initial pressure readings.

_____ System labels are placed on the mitigation system, the electric service entrance panel, and other prominent locations including the exterior venting locations.

_____ The circuit breaker(s) controlling the circuits on which the mitigation system and system failure warning devices operate are labeled using the word “Vapor Mitigation.” For example, “Vapor Intrusion (VI) System” or if multiple circuits “VI System” and “VI Monitor” as appropriate. No other rooms or appliances should be on the same circuit.

_____ Description of signage and locations are provided.

- *Contain language indicating the mitigation vent that may contain volatile organic compounds.*
- *Figure identifying locations of all signs.*
- *Each roof exhaust point.*
- *Piping run (each individual exhaust line).*
  - *Vertical one per floor.*
  - *Horizontal one per 25 feet.*

_____ For tenants that will be occupying the structure, a notice has been prepared and provided for review.

5.0 PIPING

_____ All pipe joints and connections, both interior and exterior, are permanently sealed.

_____ System piping installed in the interior or on the exterior of a building should be insulated where condensation may occur inside the pipe; and then freeze or block the soil gas exhaust.

_____ Suction point pipes are supported and secured in a permanent manner that prevents their downward movement to the bottom of suction pits, sump pits, or into the soil.

_____ Horizontal piping runs in the mitigation system are sloped to ensure condensation drains downward into the ground beneath the slab.

_____ All vent stack piping is identified as solid, rigid pipe.

_____ For structures less than 2,500 square feet.

- *Exhaust piping not less than three inches (75 millimeters) inside diameter (ID).*
- *Vent stack piping’s ID shall be at least as large as used in the manifold piping.*
- *Manifold piping’s ID shall be as large as used in any suction point.*
- *Manifold piping to which two or more suction points are connected shall be at least four inches. (100 millimeters) ID.*
- *If smaller IDs are proposed, appropriate documentation showing design calculations has been submitted.*

OR

_____ For structures greater than 2,500 square feet.

- *Pipe sizes are identified and justified by field diagnostic measurements and estimated static pressure, air velocity, and rate of airflow measurements.*
- *Piping sizes are justified using the methodologies found in “Industrial Ventilation: A Manual of Standard Practice, 23rd Edition,” or its equivalent.*

6.0 PIPING COMPLETION SPECIFICATIONS

_____ Pipes are completed with a rain cap or wind turbine.

_____ To reduce the risk of vent stack blockage, confirm that the discharge from vent stack pipes is:

- *Vertical and upward, outside the structure, at least ten feet (three meters) above the ground level, above the edge of the roof, and shall also meet the separation requirements below. Whenever practicable, they shall be above the highest roof of the building and above the highest ridge.*
- *Twenty feet (six meters) or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure, if the discharge point is not at least three feet (one meter) above the top of such openings.*
- *Twenty feet (six meters) or more away from any opening, vent, or occupiable spaces of any building (including adjacent structures). Chimney flues shall be considered openings into conditioned or otherwise occupiable space.*
- *For vent stack pipes that penetrate the roof, the point of discharge shall be at least 12 inches (0.3 meters) above the surface of the roof. For vent stack pipes attached to or penetrating the sides of buildings, the point of discharge shall be vertical and a minimum of 12 inches (0.3 meters) above the edge of the roof and in such a position that it can neither be covered with snow or other materials nor be filled with water from the roof or an overflowing gutter.*
- *When a horizontal run of vent stack pipe penetrates the gable end walls, the piping outside the structure shall be routed to a vertical position so that the discharge point meets the requirements described above.*
- *Points of discharge that are not in a direct line of sight from openings into conditioned or otherwise occupiable space because of intervening objects such as dormers, chimneys, windows around the corner, etc., shall meet the separation requirements as stated above.*

7.0 FAN INSTALLATION REQUIREMENTS

_____ Fan sizing calculations are provided that estimate the pressure difference and airflow characteristics under which the system will operate.

Schematics identify:

_____ Fan(s) are to be installed either outside the building or inside the building, outside of occupiable space, and above the conditioned (heated/cooled) spaces of a building.

_____ Fan(s) that are mounted on the exterior of buildings are rated for exterior use or installed within a weather proof protective housing.

_____ Fan(s) are to be connected to the vent pipe using removable couplings or flexible connections that can be tightly secured to both the fan and the vent pipe (facilitate maintenance and future replacement).

_____ Outside air intake vents of fan(s) are screened to prevent the intake of debris. Screens shall be removable to permit cleaning or replacement and building owners shall be informed of the need to periodically replace or clean such screens.

8.0 ADDITIONAL REQUIREMENTS IN THE DESIGN DOCUMENT

_____ Contractor identifies steps to document the effectiveness of the mitigation system. This is typically demonstrated by measuring the pressure differential across the building slab while the VI mitigation system is operating.

_____ Concentrations in the subsurface have been evaluated for the duration and frequency which the system can be out-of-service (including power outages) prior to implementing actions necessary to address the potential risk to the occupants.

_____ Actions are identified to address conditions during periods the system is not operating.

_____ Establish and identify a negative pressure that will be continuously maintained.
- Typically requires higher negative pressure than a radon mitigation system.
- Establish a monitoring program.

_____ Establish a monitoring program for Permit or Permit to Install Exemption pursuant to the Part 55 Rules.

9.0 REFERENCES

ASTM Standard E2121. 2009. Standard Practice for Installing Radon Mitigation Systems in Existing Low-Rise Residential Buildings.

APPENDIX C.6

Checklist for Reviewing the Design of a Passive Mitigation System

APPENDIX C.6
Checklist for Reviewing the Design of a Passive Mitigation System

The information included in this checklist may be useful for reviewing a passive mitigation system. Though it is generally understood that the actual design of the system may vary, many of the design components should be very similar in purpose. A blank is provided before each item to aid in documenting the individual components and where they can be found.

Site Name: **Site ID:**
Site Address: **County:**

1.0 GENERAL

_____ Engineer or design firm is identified and mitigation system is designed by a professional engineer with demonstrated experience designing passive mitigation systems.

_____ Product manufacturer is provided.

_____ Requirements for installation are provided and if required by the manufacturer, the certification for the product applicator.

_____ General site conditions including a conceptual site model are provided.

_____ Concentrations identified at the site are provided including sampling methodology.

_____ All utility and other penetrations are identified on a print.

_____ Surface preparation is identified and includes:

- If applied onto an existing concrete surface it shall be free of any dirt, debris, loose material, release agents, or curing compounds.
- Voids more than 1/4 inch deep and 1/4 inch wide are filled.
- If applied directly on the sub-grade, the sub-grade shall be compacted to a minimum relative compaction of 90 percent or as specified by a civil/geotechnical engineer and the surface prep shall be smooth, uniform, and free of debris and standing water.

_____ Building/Fire Codes: Document states mitigation systems shall be designed and installed to conform to applicable building and fire codes and maintain the function and operation of all existing equipment and building features including doors, windows, access panels, etc.

_____ Drains that perforate the liner must be equipped with a dranjer style drain or dripline to a trap that allows water to flow into sumps and floor drains while sealing out soil gases from the sub-floor area or alternate method is provided.

2.0 LINER DESIGN AND SPECIFICATIONS

_____ Detailed specifications of the liner are provided including transmission rates and/or diffusion coefficients for compounds of interest.

_____ Concentrations in the subsurface have been evaluated for the liner including the required thickness applied and/or overall selection of the product by the engineer or design firm.

_____ Details are provided for areas that require specialized completion including all penetrations and terminations.

_____ Horizontal venting or perforated piping has a minimum in-plane flow rate of 21 gallons per minute per foot per unit width at a hydraulic gradient of 1.0 percent when tested in accordance with the American Society for Testing and Materials D 4716. Greater flow rates may justify greater spacing.

_____ Dewatering has been considered and incorporated into the design.

_____ Horizontal venting (or perforated piping) runs are identified at a maximum rate of one per every 50 feet perpendicular to the length of the run for the expected coverage. Calculations may provide justification for different spacing.

3.0 SYSTEM MONITORS AND LABELING

_____ System labels are placed on the mitigation system and other prominent locations including the exterior venting locations.

_____ Description of signage and locations are provided.

- *Contain language indicating the mitigation vent that may contain volatile organic compounds.*
- *Figure identifying locations of all signs.*
- *Each roof exhaust point.*
- *Piping run (each individual exhaust line).*
  - *Vertical one per floor.*
  - *Horizontal one per 25 feet.*

_____ For tenants that will be occupying the structure, a notice has or will be prepared.

4.0 PIPING

_____ When crossing pipe or pipe sleeves over or under footings or grade beams, document identifies it has been evaluated by an environmental engineer and/or structural engineer for appropriate use and placement materials.

_____ Preliminary piping and routing diagrams including manifolds are provided.

_____ Preliminary horizontal vent locations are identified on a print by the professional engineer.

_____ All pipe joints and connections, both interior and exterior, are permanently sealed.

_____ All exhaust pipes are supported and secured in a permanent manner.

_____ Horizontal piping runs in the mitigation system are sloped or designed to ensure condensation drains downward into the ground beneath the slab.

_____ All vent stack piping is identified as solid, rigid pipe.

_____ Justification of number and location of vent riser locations either based on Table A.6.1 or alternate method provided.

Table A.6.1
Spacing of Perforated Horizontal Piping and Number of Vent Risers

Vent Riser Pipe Diameter (inches)	Number of Vent Risers per Building Footprint Area (Square Feet)
1 1/2	1/1,250 (min of 2 risers)
2	1/2,500 (min of 2 risers)
2 1/2	1/5,000 (min of 3 risers)
3	1/7,500 (min of 4 risers)
4	1/10,000 (min of 4 risers)

Notes:
1) Riser length shall be a maximum of 100 foot measure along solid pipe including bends.
2) Vent risers maximum spacing shall be 100 feet between each.
3) When the application of the spacing and location requirement of this table results in the fractional number of vent risers, any fraction shall be construed as one vent riser.
4) Number of required vent risers shall be determined by the selected riser pipe diameter and the rate of vent riser per building footprint area.

_____ Vertical piping runs terminate in a location that can drain naturally or that can be verified to be free of water or moisture.

_____ For structures less than 2,500 square feet vertical piping is at least:

- *Not less than three inches (75 millimeters) inside diameter (ID).*
- *Vent stack piping's ID shall be at least as large as the largest used in the manifold piping.*
- *Manifold piping's ID shall be at least as large as that used in any suction point.*
- *Manifold piping to which two or more suction points are connected shall be at least four inches (100 millimeters) ID.*
- *If smaller IDs are proposed, appropriate documentation showing design calculations has been submitted.*

OR

_____ For structures greater than 2,500 square feet piping is:

- *Identified and justified by measurements and estimated static pressure, air velocity, and rate of airflow measurements, and head loss calculations based on preliminary exhaust piping design prints.*
- *Documented using the methodologies found in "Industrial Ventilation: A Manual of Standard Practice, 23rd Edition," or its equivalent.*

5.0 PIPING COMPLETION SPECIFICATIONS

(minimums, further distance may be required by exhaust concentrations and primary wind flow direction)

_____ Pipes are completed with a rain cap or wind turbine.

_____ To reduce the risk of vent stack blockage, confirm that the discharge from vent stack pipes is:

- *Vertical and upward, outside the structure, at least ten feet (three meters) above the ground level, above the edge of the roof, and shall also meet the separation requirements below. Whenever practicable, they shall be above the highest roof of the building and above the highest ridge.*
- *Twenty feet (six meters) or more away from any window, door, or other opening into conditioned or otherwise occupiable spaces of the structure, if the discharge point is not at least three feet (one meter) above the top of such openings.*
- *Twenty feet (six meters) or more away from any opening, vent, or occupiable spaces of any building including adjacent structures. Chimney flues shall be considered openings into conditioned or otherwise occupiable space.*
- *For vent stack pipes that penetrate the roof, the point of discharge shall be at least 12 inches (0.3 meters) above the surface of the roof. For vent stack pipes attached to or penetrating the sides of buildings, the point of discharge shall be vertical and a minimum of 12 inches (0.3 meters) above the edge of the roof and in such a position that it can neither be covered with snow or other materials nor be filled with water from the roof or an overflowing gutter.*
- *When a horizontal run of vent stack pipe penetrates the gable end walls, the piping outside the structure shall be routed to a vertical position so that the discharge point meets the requirements described above.*
- *Points of discharge that are not in a direct line of sight from openings into conditioned or otherwise occupiable space because of intervening objects such as dormers, chimneys, windows around the corner, etc., shall meet the separation requirements as stated above.*

6.0 QUALITY ASSURANCE/QUALITY CONTROL INSTALLATION PLAN REQUIREMENTS IDENTIFIED IN THE DESIGN DOCUMENT

_____ Contractor identifies steps to document the effectiveness of the mitigation system.

- Coupon sampling – recommended at one sample per 500 square feet.
- Smoke testing – full coverage is necessary and must be based on the area that it can be confirmed that smoke has migrated to through visual observation.
- On-site installation oversight by the design firm.
- Documentation verifying the installation per project specification and that any areas noted for repair have been completed.
- Estimated quantities of the product to be utilized are provided.

APPENDIX C.7

Checklist for Determining if the Volatilization to Indoor Air Pathway Screening Levels Apply

BACKGROUND

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels (Table 1) are calculated based on unrestricted residential use of a property. The building input parameters assume a residential structure that has a basement with poured concrete floor, block or poured concrete walls, and has less than six floors (i.e., residential high-rise).

Submittals that choose to rely on the unrestricted residential VIAP screening levels (Table 1) as Part 201 site-specific volatilization to indoor air criteria (SSVIAC) or Part 213 VIAP site-specific target levels (SSTLs) must contain documentation that supports the screening levels are appropriate for conditions at the site. The following building construction characteristics are not consistent with the residential VIAP screening levels and therefore the screening levels do not apply when:

- There is not a poured concrete floor, block or poured concrete wall in a basement
- There is a slab-on-grade foundation
- There is a crawl space foundation, with dirt floor or poured concrete slab
- There are six or more floors (including basements)
- There are other building characteristics not consistent with the basic assumptions

The residential shallow groundwater VIAP screening levels (Table 1) apply to a residential structure with a basement when the depth to first encountered groundwater, considering seasonal variation, is 10 feet below ground surface or less. The residential groundwater not in contact VIAP screening levels (Table 1) apply when the depth to first encountered groundwater, considering seasonal variation, is greater than 10 feet below ground surface.

Soil VIAP screening levels were developed using inputs for the United States Department of Agriculture (USDA) soil type of sand and are considered applicable for all other USDA soil types.

The soil vapor VIAP screening levels may be used to evaluate representative sub-slab soil vapor and exterior soil gas data. However, the screening levels are not applicable when the vapor source is shallower than the depth of sample collection and do not account for preferential vapor migration pathways through the vadose zone.

To limit the need for land or resource use restrictions, the unrestricted residential VIAP screening levels may be proposed for structures that do not meet the assumptions provided that the assumptions used to develop the VIAP screening levels would be more protective than the actual conceptual site model and exposure scenario.

Nonresidential VIAP Screening Levels (Table 2) are calculated based on restricted nonresidential use of a property. The building input parameters assume a nonresidential structure that has a poured concrete slab-on-grade and has less than 50,000 ft^2 of continuously open space. The acceptable air concentrations are adjusted to account for a nonresidential 12-hour workday exposure time.

Submittals that choose to rely on the nonresidential VIAP screening levels (Table 2) as Part 201 SSVIAC or Part 213 VIAP SSTLs must contain documentation that supports the screening levels are appropriate for conditions at the site. The following building construction characteristics are not consistent with the nonresidential VIAP screening levels and therefore the values do not apply when:

- The structure has > 50,000 ft^2 of continuously open space with no areas < 50,000 ft^2
- There is a basement
- There is a below grade pit, crawlspace (with dirt floor or poured concrete slab), or elevator shafts that extend below grade such that conditions do not meet the assumptions of a slab-on-grade
- There is a combination of foundation types
- The structure is a former residential structure that is now a nonresidential use
- There are other building characteristics not consistent with the basic assumptions

The nonresidential shallow groundwater VIAP screening levels (Table 2) apply to a nonresidential structure that has less than 50,000 ft^2 of continuously open space with a slab-on-grade when the depth to first encountered groundwater, considering seasonal variation, is five feet below ground surface or less. The nonresidential groundwater not in contact VIAP screening levels (Table 2) apply when the depth of groundwater, considering seasonal variation, is greater than five feet below ground surface.

Soil VIAP screening levels were developed using inputs for the USDA soil type of sand and are considered applicable for all other USDA soil types.

The soil vapor VIAP screening levels may be used to evaluate representative sub-slab soil vapor and exterior soil gas data. However, the screening levels are not applicable when the vapor source is shallower than the depth of sample collection and do not account for preferential vapor migration pathways through the vadose zone.

VOLATILIZATION TO INDOOR AIR PATHWAY SCREENING LEVELS ASSESSMENT

The following checklist will assist in determining if site conditions allow the use of the Volatilization to Indoor Air Pathway (VIAP) Screening Levels or if the development of SSVIAC or VIAP SSTLs is necessary.

Proposed use of the VIAP Screening Levels requires documentation of site conditions that must include:

- Photographs representative of current conditions showing building type (and size for non-residential requests) for structures or as-builts that document the responses on the screening levels checklist (slab-on-grade, basement, etc.).
- Documentation that the depth to shallowest encountered groundwater is representative of site conditions taking variability into account (monitor well logs, soil boring logs, groundwater elevation tables, etc.)

Residential VIAP Screening Levels (Table 1) are calculated based on unrestricted residential use of a property. The building input parameters assume a residential structure with a basement.

Submitter Response	Page Number	Additional Info Needed	Residential VIAP Screening Level Assessment
True ☐ False ☐		☐	There is a poured concrete floor, block or poured concrete wall in a basement. *If false, the structure does not meet the assumptions used to develop the VIAP screening levels and SSVIAC or VIAP SSTLs should be developed.*
True ☐ False ☐		☐	There is only a slab-on-grade foundation. *If true, more representative SSVIAC or VIAP SSTLs could be developed.*
True ☐ False ☐		☐	There is a crawl space foundation, with dirt floor or poured concrete slab. *If true, SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	The structure is a high-rise with six or more floors (including a basement). *If true, more representative SSVIAC or VIAP SSTLs could be developed.*
True ☐ False ☐		☐	There are other building characteristics inconsistent with the residential structure assumptions*. If true, SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	The depth to first encountered groundwater, considering seasonal variation, is ≤ 10 feet. *If true, shallow groundwater VIAP screening levels may be used or SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	The depth to first encountered groundwater, considering seasonal variation, is > 10 feet. *If true, groundwater not in contact VIAP screening levels may be used or SSVIAC or VIAP SSTLs must be developed.*

VOLATILIZATION TO INDOOR AIR PATHWAY SCREENING LEVELS ASSESSMENT

Nonresidential VIAP Screening Levels (Table 2) are calculated based on restricted nonresidential use of a property. The building input parameters assume a nonresidential structure that has a poured concrete slab-on-grade and has less than 50,000 ft^2 of continuously open space. The acceptable air concentrations are adjusted to account for a nonresidential 12-hour workday exposure time.

Submitter Response	Page Number	Additional Info Needed	Nonresidential VIAP Screening Level Assessment
True ☐ False ☐		☐	The structure has areas with > 50,000 ft^2 of continuously open space and no areas < 50,000 ft^2. *If true, more representative SSVIAC or VIAP SSTLs could be developed.*
True ☐ False ☐		☐	There is a basement, below grade pit, crawlspace, elevator shaft or other openings that extend below ground surface such that conditions do not meet the assumptions of a slab-on-grade. *If true, SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	There is a combination of foundation types. *If true, SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	The structure is a former residential structure that is now a nonresidential use. *If true, SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	There are other building characteristics inconsistent with the nonresidential structure assumptions. *If true, SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	The depth to first encountered groundwater, considering seasonal variation, is ≤ 5 feet. *If true, shallow groundwater VIAP screening levels may be used or SSVIAC or VIAP SSTLs must be developed.*
True ☐ False ☐		☐	The depth to first encountered groundwater, considering seasonal variation, is > 5 feet. *If true, groundwater not in contact VIAP screening levels may be used or SSVIAC or VIAP SSTLs must be developed.*

APPENDIX D.1

Volatilization to Indoor Air Pathway (VIAP) Screening Levels

The VIAP screening levels are provided as a voluntary tool that may be used to determine that site conditions do not present a risk and allow a quick regulatory closure or that site conditions warrant a more site-specific evaluation, at common residential and nonresidential sites. The residential scenario represents a home with a basement and the nonresidential scenario represents an average-sized commercial building with slab-on-grade construction (e.g., gas station convenience store).

A person is not required to use the VIAP screening levels, nor are they discouraged from developing a site-specific evaluation that may be more suitable to site conditions.

When site conditions are appropriate, these screening levels may be voluntarily proposed for use as Part 201 site-specific volatilization to indoor air criteria (SSVIAC) or Part 213 VIAP site-specific target levels (SSTLs). The use of the screening levels as Part 201 SSVIAC or Part 213 VIAP SSTLs requires documentation that the site conditions are appropriate for use. Therefore:

Any document submitted under Part 201 that relies on the VIAP screening levels as SSVIAC including a Baseline Environmental Assessment, Documentation of Due Care Compliance, a Response Activity Plan, No Further Action Report, or any other document that is submitted for department review and approval must include the documentation.

Any document submitted under Part 213 that relies on the VIAP screening levels as VIAP SSTLs including a Baseline Environmental Assessment, Documentation of Due Care Compliance, Final Assessment Report, or Closure Report submitted for department review and approval must include the documentation.

Generic Volatilization to Indoor Air Inhalation Criteria

Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, and the associated Administrative Rules establish the generic cleanup criteria for the hazardous substances in vapors emanating from groundwater (R 299.14) and soil (R 299.24) to indoor air. The Part 213 Leaking Underground Storage Tanks program uses the generic cleanup criteria as risk-based corrective action (RBCA) Tier 1 risk-based screening levels (RBSLs).

Appendix C.1 provides the assumptions used in the development of the generic groundwater volatilization to indoor air inhalation criteria (GVIIC) and soil volatilization to indoor air inhalation criteria (SVIIC). This appendix also provides a checklist to assist in determining the applicability of the generic volatilization to indoor air inhalation criteria. The generic GVIIC and SVIIC are derived from data that reflect long-term (chronic) exposures. In some instances, the assumptions used to develop the generic GVIIC and SVIIC may be met at a specific property; however, the presence of hazardous substances that represent less than chronic (i.e., short-term or acute) risk is not assessed with the application of generic GVIIC and SVIIC.

A site-specific VIAP evaluation must be conducted if the generic GVIIC and SVIIC are not applicable, if there are hazardous substances present that have short-term risk concerns, and/or soil gas data (including sub-slab) have been collected. The site-specific evaluation necessitates the development of Part 201 SSVIAC or Part 213 VIAP SSTLs.

Volatilization to Indoor Air Pathway Screening Levels

The VIAP screening levels are values that the department has determined reflect best available information regarding the toxicity and exposure risks posed by the hazardous substances in indoor air. The VIAP screening levels may be used provided it is documented that the conditions assumed in developing the screening levels are met at the site/facility as detailed in the following sections. Appendix C.7 summarizes the assumptions used in the development of the shallow groundwater, groundwater not in contact, soil, and soil vapor VIAP screening levels. This appendix also provides a checklist to assist in determining the applicability of the shallow groundwater, groundwater not in contact, soil, and soil vapor VIAP screening levels. A person may develop and propose their own Part 201 SSVIAC pursuant to Section 20120b statutory provisions or VIAP SSTLs consistent with the RBCA process as implemented under Part 213.

Building Construction

Residential VIAP Screening Levels

Residential shallow groundwater, groundwater not in contact, soil, and soil vapor VIAP screening levels (Table 1) are calculated based on unrestricted residential use of a property. The building input parameters assume a residential structure that has a basement with poured concrete floor, block or poured concrete walls, and has less than six floors (i.e., is not a residential high-rise). Residential VIAP screening levels are intended to address places where people live and/or children or other sensitive populations are present on a regular basis [greater than intermittent].

Residential VIAP screening levels may be appropriate for unique exposure scenarios (e.g., daycares, churches, schools, hospitals, recreational areas); however, a site-specific risk assessment is typically warranted to address these unique exposure scenarios.

Submittals that choose to rely on the residential shallow groundwater, groundwater not in contact, soil, and soil vapor VIAP screening levels (Table 1) as Part 201 SSVIAC or Part 213 VIAP SSTLs must contain documentation that supports the screening levels are appropriate for conditions at the site. The following building construction characteristics are not consistent with the residential VIAP screening levels and therefore the screening levels do not apply when:

- There is not a poured concrete floor, block or poured concrete wall in a basement
- There is a slab-on-grade foundation
- There is a crawl space foundation, with dirt floor or poured concrete slab
- There are six or more floors (including basements)
- There are other building characteristics not consistent with the basic assumptions

A site-specific evaluation is required if the generic criteria are not applicable and residential structures do not meet the assumptions used to develop the VIAP screening levels. To limit the need for land or resource use restrictions, the unrestricted residential VIAP screening levels may be proposed for structures that do not meet the assumptions provided that the assumptions used to develop the VIAP screening levels would be more protective than the actual conceptual site model and exposure scenario.

Nonresidential VIAP Screening Levels

Careful review of how the building is (or will be) used and zoned is important to determine if a nonresidential exposure scenario is appropriate for a current or proposed structure. Nonresidential VIAP screening levels are developed for healthy adult workers and potential intermittent exposure of adults and children who are customers, or visitors to commercial or industrial establishments during a portion of the workday. The acceptable air concentrations are adjusted to account for a nonresidential 12-hour workday exposure time. Nonresidential VIAP screening levels are not appropriate for establishments where children and other sensitive populations are present on a regular basis [greater than intermittent] (e.g., schools, daycares, churches, hospitals, campgrounds, recreational areas).

Nonresidential shallow groundwater, groundwater not in contact, soil, and soil vapor VIAP screening levels (Table 2) are calculated based on restricted nonresidential use of a property. Nonresidential VIAP screening levels were developed to account for all appropriate nonresidential uses may be applied at nonresidential structures that meet the assumptions used to develop the VIAP screening levels.

The building input parameters assume a nonresidential structure that has a poured concrete slab-on-grade and has less than 50,000 ft^2 of continuously open space. The nonresidential building size of less than or greater than (</>) 50,000 ft^2 is based on continuously open space and refers to the structure or portion of the structure that may be subdivided (e.g., offices, breakrooms, etc.). If a single structure contains areas with both </> 50,000 ft^2 of continuously open space, the nonresidential VIAP screening levels representing < 50,000 ft^2 would apply because they represent the most appropriate values to evaluate risk associated with the VIAP in the smaller areas of that structure.

Submittals that choose to rely on the nonresidential VIAP screening levels (Table 2) as Part 201 SSVIAC or Part 213 VIAP SSTLs must contain documentation that supports the screening levels are appropriate for conditions at the site. The following building construction characteristics are not consistent with the nonresidential VIAP screening levels and therefore the screening levels do not apply when:

- The structure has > 50,000 ft^2 of continuously open space with no areas < 50,000 ft^2
- There is a basement
- There is a below grade pit, crawlspace (with dirt floor or poured concrete slab), or elevator shaft that extends below grade such that conditions do not meet the assumptions of a slab-on-grade
- There is a combination of foundation types
- The structure is a former residential structure that is now a nonresidential use
- There are other building characteristics not consistent with the basic assumptions

The following hazardous substances are not adjusted for a 12-hour nonresidential workday exposure time. Methane is not adjusted because the VIAP SLs are based on flame and explosivity risk. Justification for the remaining hazardous substances is provided in the Toxics Steering Group Recommended Interim Action Screening Level report (EGLE 2020).

CAS Number	Hazardous Substance
67641	Acetone
7664417	Ammonia
64175	Ethanol
74828	Methane
108101	4-Methyl-2-pentanone (MIBK)
71238	Propyl alcohol
103651	n-Propylbenzene
108883	Toluene
2303175	Triallate
71556	1,1,1-Trichloroethane

A site-specific evaluation is required if the generic criteria are not applicable and nonresidential structures do not meet the assumptions used to develop the VIAP screening levels.

The exposure scenario for a nonresidential structure with a slab-on-grade and less than 50,000 ft^2 of continuously open space represents the majority of exposure scenarios at sites that requested the department's assistance to develop applicable SSVIAC and VIAP SSTLs since May 2017. The scenario does not represent the most conservative nonresidential VIAP screening levels that could be developed.

Mixed Residential and Nonresidential Use

Properties that have structures where the use of the building consists of mixed residential and nonresidential use are required to evaluate the VIAP using the residential exposure scenario. The use of the residential VIAP screening levels, provided the assumptions listed above are met, would be acceptable to the department. However, a site-specific assessment beyond the scope of this document may be performed that assesses the structure and shows that the residential and nonresidential use areas are separate and distinct and that there is no potential for air exchange or transfer between the two areas.

Groundwater VIAP Screening Levels

Groundwater Separation Distance

Depth to groundwater is a sensitive parameter that determines the groundwater separation distance from a structure. The depth must consider any saturated water zone below the ground surface in which water occupies all or part of the void spaces and is, even seasonally, in the soils or geologic strata. Though the initial depth to groundwater may be estimated through observations, the final depth to groundwater must be established with static water levels using a monitoring well or a piezometer. It is not appropriate to use an average depth to groundwater. Instead, the depth to groundwater below grade should represent the depth of the first encountered groundwater that includes observed seasonal variations and the transient presence of perched groundwater. Based on the soil type (lithology) the capillary zone is calculated and used in establishing the separation distance. The threshold for shallow groundwater determination is different between residential and nonresidential VIAP screening levels due to the presence of basement and slab-on-grade foundations, respectively.

Shallow groundwater VIAP screening levels

The United States Environmental Protection Agency (US EPA) guidance for the Johnson and Ettinger Model (JEM) states that the presence of shallow groundwater within five feet of the building foundation may result in unattenuated or enhanced transport of vapors into buildings (US EPA 2015). The department modified standard equations to develop the VIAP screening levels for shallow groundwater scenarios that frequently occur throughout Michigan.

The residential shallow groundwater VIAP screening levels (Table 1) apply to a residential structure with a basement when the depth to first encountered groundwater, considering seasonal variation, is 10 feet below ground surface or less. The residential groundwater not in contact VIAP screening levels (Table 1) are not applicable when the depth to first encountered groundwater is shallower than 10 feet below ground surface.

The nonresidential shallow groundwater VIAP screening levels (Table 2) apply to a nonresidential structure that has less than 50,000 ft^2 of continuously open space with a slab-on-grade when the depth to first encountered groundwater, considering seasonal variation, is 5 feet below ground surface or less. The nonresidential groundwater not in contact VIAP screening levels (Table 2) are not applicable when the depth of groundwater is shallower than 5 feet below ground surface.

Groundwater Not In Contact VIAP Screening Levels

The groundwater not in contact VIAP screening levels do not use the JEM to calculate a chemical-specific attenuation factor based on groundwater separation distance. Groundwater not in contact VIAP screening levels are instead developed using the recommended vapor attenuation factor of 0.001 (US EPA 2015) when groundwater is not shallow.

The residential groundwater not in contact VIAP screening levels (Table 1) apply to a residential structure with a basement when the depth to first encountered groundwater is greater than 10 feet below ground surface.

The nonresidential groundwater not in contact VIAP screening levels (Table 2) apply to a nonresidential structure that has less than 50,000 ft^2 of continuously open space with a slab-on-grade when the depth to first encountered groundwater is greater than 5 feet below ground.

Part 201 SSVIAC or Part 213 VIAP SSTLs may be developed using chemical-specific attenuation factors from the JEM; however, this approach was not utilized for the development of the groundwater not in contact VIAP screening levels due to the infinite amount of possible groundwater separation distances.

Soil VIAP screening levels

Soil VIAP screening levels were developed using inputs for the United States Department of Agriculture (USDA) soil type of sand and are considered applicable for all other USDA soil types. The USDA soil classification of sand is appropriate to develop VIAP screening levels because it is representative of most areas within Michigan and is the most conservative soil type.

United States Department of Agriculture (USDA) Soil Characterization

Historical soil boring logs were typically recorded using Unified Soil Classification System (USCS); however, the JEM relies on soil parameter inputs based on USDA soil characterization. There is not a direct relationship between the two soil classification systems (ERDC/CRREL 2015). Part 201 SSVIAC or Part 213 VIAP SSTLs may be developed using a USDA soil type other than sand provided that the site soils have been representatively sampled and laboratory sieve and hydrometer testing of the coarsest material was performed. Documentation of appropriate site characterization including characterization of heterogenous soils must be provided for department review and approval to justify use of USDA soil types other than sand.

Soil gas VIAP screening levels

The soil vapor VIAP screening levels may be used to evaluate representative sub-slab soil vapor and exterior soil gas data. However, the VIAP screening levels are not applicable when the vapor source is shallower than the depth of sample collection and do not account for preferential vapor migration pathways through the vadose zone.

Soil vapor VIAP screening levels were developed using the attenuation factor of 0.03 identified as the 95th percentile value from US EPA's vapor intrusion data base (US EPA 2012) as recommended by US EPA (2015). This vapor attenuation factor allows the resulting soil vapor VIAP screening levels to be applied to all depths because diffusion from the vapor source through the vadose zone is not considered. Consequently, the soil vapor value is not affected by soil type. Therefore, consideration should be given to decide whether the extra time and cost associated with representatively sampling and characterizing soil type across a site/facility using USDA methodology is necessary when soil vapor data is being collected to evaluate the VIAP.

Site-Specific Volatilization to Indoor Air Criteria

The VIAP screening levels may be applied to structures that meet the assumptions used during their development; however, these VIAP screening levels do not limit the ability for a person to pursue SSVIAC or VIAP SSTLs that are more representative of site-specific conditions. If a structure does not meet the assumptions identified above for the development of the VIAP screening levels (and the generic GVIIC and SVIIC or RBSLs are not applicable), a site-specific assessment is required.

Option 1: Facility-Specific SSVIAC or VIAP SSTLs Using the Department's VIAP Calculator

The department has assisted the regulated community in developing applicable SSVIAC or VIAP SSTLs since the previous screening levels were rescinded using an internal VIAP calculator tool. The input parameters of the VIAP calculator represent the department's determination of best available information. The department will continue to provide this customer service on a site-specific basis until such time as an online VIAP calculator module is released. A person may request the department's assistance by contacting the appropriate district project manager to complete the *SSVIAC or SSTL Questionnaire* available on the RRD Resource Materials webpage. This site-specific evaluation can account for site-specific geology, groundwater depth, and chemical-specific attenuation factors from the points of compliance using the JEM. Additionally, other building uses, sizes, and foundation types can be evaluated.

Option 2: Proposed SSVIAC Pursuant to Section 20120b or VIAP SSTLs consistent with the RBCA process as implemented under Part 213

A person may pursue development of SSVIAC or VIAP SSTLs using other models, input parameters, and site-specific data using any of the options pursuant to statutory provisions and/or the RBCA process. An alternative approach, including all of the necessary documentation and justification, may be submitted for department review and approval.

References

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Parameter Summary for the Volatilization to Indoor Air Pathway (VIAP) Screening Levels

Unrestricted Residential Screening Levels

Residential structure with basement

- Shallow Groundwater:
  - **Depth below grade ≤ 10 ft**
  - EGLE shallow groundwater α
- Soil: Infinite source
- Vapor: US EPA Default **α= 0.03**

- Groundwater Not In Contact:
  - **Depth below grade > 10 ft**
  - US EPA Default **α= 0.001**
- Soil: Infinite source
- Vapor: US EPA Default **α= 0.03**

Restricted Nonresidential Screening Levels

Nonresidential structure < 50,000 ft^2 of continuous open space with slab-on-grade *Note: Not applicable for former residential now nonresidential use structures.*

- Shallow Groundwater:
  - **Depth below grade ≤ 5 ft**
  - EGLE shallow groundwater α
- Soil: Infinite source
- Vapor: US EPA Default **α= 0.03**

- Groundwater Not In Contact:
  - **Depth below grade > 5 ft**
  - US EPA Default **α= 0.001**
- Soil: Infinite source
- Vapor: US EPA Default **α= 0.03**

Note: Groundwater Not In Contact Scenario aligns with US EPA approach for groundwater vapor intrusion screening levels

Site-Specific Volatilization to Indoor Air Criteria (SSVIAC) and VIAP Site-Specific Target Levels (SSTLs)

Option 1

Site-Specific Using VIAP Calculator

Unrestricted Residential SSVIAC or VIAP SSTLs

- Building: House with basement
- Incorporates:
  - Site geology
  - Actual groundwater depth
  - Johnson and Ettinger model (JEM)

May Be Combined

Restricted SSVIAC or VIAP SSTLs

- Residential and nonresidential
- Building:
  - Other use(s) and sizes
  - Other foundation types
- Incorporates:
  - Site geology
  - Actual groundwater depth
  - JEM

Proposed Part 201 SSVIAC Pursuant to Sec. 20120b or VIAP SSTLs Consistent with the RBCA Process as Implemented Under Part 213

Alternate approaches proposed to RRD for review and approval

Option 1

Potential Models

Model Selection

- Biovapor model
- PVIScreen
- Multi-layer JEM
- Big Building Model
- Other

May Be Combined

Parameter Selection

- Toxicological
- Chemical physical
- Building characteristics
- Other

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

Table 1. Residential shallow groundwater, groundwater not in contact, soil, and soil vapor volatilization to indoor air pathway (VIAP) screening levels. The VIAP screening levels are calculated based on unrestricted residential use. The building construction input parameters include those associated with a residential structure that has a basement and contains less than six floors. The basement must have poured slab and poured or concrete block walls for these VIAP screening levels to be applicable.

The shallow groundwater VIAP screening levels apply when the depth to first encountered groundwater is 10 feet below ground surface or less. The groundwater not in contact VIAP screening levels apply when the depth to first encountered groundwater is greater than 10 feet below ground surface.

The United States Department of Agriculture (USDA) inputs for the soil type of sand and system temperature of 10 °C were used during screening level development.

Refer to the Appendix C.7 checklist for other precluding factors.

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
83329	Acenaphthene	3,900 (S) sol	3,900 (S) sol	2.0E+05 nc	7,300 nc
208968	Acenaphthylene	65 nc	65 (CC) nc	DATA	7,300 nc
75070	Acetaldehyde	190 nc	5,700 nc	34 (M) nc	310 nc
71501	Acetate	NA	NA	NA	NA
64197	Acetic acid	3.6E+06 nc	1.1E+08 nc	6.5E+05 nc	8,700 nc
67641	Acetone	50,000 (FF) st	4.0E+07 (EE) st	2.6E+05 (EE) st	1.0E+06 (EE) st
75058	Acetonitrile	2,800 nc	86,000 nc	620 (M) nc	2,100 nc

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
98862	Acetophenone	8,700 (DD) dev	6.1E+06 (S) (DD) sol	6.2E+05 (DD) dev	1.1E+05 (DD) dev
107028	Acrolein	0.25 (M) nc	7.6 (M) nc	4.6E-02 (M) nc	0.70 nc
79061	Acrylamide	NA	NA	NA	NA
79107	Acrylic acid	1,400 nc	43,000 nc	260 nc	7.0 nc
107131	Acrylonitrile	4.6 ca	140 ca	1.2 (M) ca	12 ca
15972608	Alachlor	NA	NA	NA	NA
116063	Aldicarb	NA	NA	NA	NA
1646884	Aldicarb sulfone	NA	NA	NA	NA
1646873	Aldicarb sulfoxide	NA	NA	NA	NA
309002	Aldrin	0.61 ca	17 (S) sol	520 ca	0.17 ca
7429905	Aluminum	NA	NA	NA	NA
7664417	Ammonia	1,900 (FF) st	1.2E+06 nc	DATA	17,000 nc
994058	t-Amyl methyl ether (TAME)	82 nc	2,400 nc	34 (M) nc	2,200 nc
62533	Aniline	NA	NA	NA	NA
120127	Anthracene	43 (S) sol	43 (S) sol	1.3E+07 nc	35,000 nc
7440360	Antimony	NA	NA	NA	NA
7440382	Arsenic	NA	NA	NA	NA
1332214	Asbestos	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
1912249	Atrazine	NA	NA	NA	NA
103333	Azobenzene	1.8 (M) ca	1.8 (M) (CC) ca	DATA	27 ca
7440393	Barium	NA	NA	NA	NA
71432	Benzene	1.0 ca	28 ca	1.7 (M) ca	110 ca
92875	Benzidine	NA	NA	NA	NA
56553	Benzo(a)anthracene	9.4 (S) (MM) sol	9.4 (S) (MM) sol	1.6E+05 (MM) mut	5.8 (MM) mut
205992	Benzo(b)fluoranthene	NA	NA	NA	NA
207089	Benzo(k)fluoranthene	NA	NA	NA	NA
191242	Benzo(g,h,i)perylene	NA	NA	NA	NA
50328	Benzo(a)pyrene	NA	NA	NA	NA
65850	Benzoic acid	NA	NA	NA	NA
100516	Benzyl alcohol	NA	NA	NA	NA
100447	Benzyl chloride	2.5 (M) ca	75 ca	12 (M) ca	17 ca
7440417	Beryllium	NA	NA	NA	NA
112265	bis(2-Chloroethoxy)ethane	NA	NA	NA	NA
111444	bis-2-Chloroethylether	6.8 ca	200 ca	3.4 (M) ca	2.6 ca
117817	bis(2-Ethylhexyl) phthalate	NA	NA	NA	NA
7440428	Boron	NA	NA	NA	NA
15541454	Bromate	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
108861	Bromobenzene	62 nc	1,800 nc	160 nc	2,100 nc
75274	Bromodichloromethane	1.2 ca	34 ca	0.61 (M) ca	48 ca
75252	Bromoform	89 ca	2,700 ca	45 (M) ca	770 ca
74839	Bromomethane	2.1 (M) nc	55 nc	0.90 (M) nc	350 nc
71363	n-Butanol	98,000 nc	3.0E+06 nc	20,000 nc	12,000 nc
78933	2-Butanone (MEK)	2,600 (DD) dev	4.3E+06 (DD) dev	31,000 (DD) dev	1.7E+05 (DD) dev
123864	n-Butyl acetate	2,900 nc	89,000 nc	1,100 nc	14,000 nc
75650	t-Butyl alcohol	17,000 nc	5.1E+05 nc	3,200 nc	2,500 nc
85687	Butyl benzyl phthalate	NA	NA	NA	NA
104518	n-Butylbenzene	44 nc	1,100 nc	550 nc	7,000 nc
135988	sec-Butylbenzene	270 nc	8,100 nc	3,800 nc	14 nc
98066	t-Butylbenzene	7.7E-02 (M) nc	1.8 nc	0.64 (M) nc	14 nc
7440439	Cadmium	NA	NA	NA	NA
79925	Camphene	4.2 nc	31 nc	14 nc	2,800 nc
105602	Caprolactam	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
63252	Carbaryl	NA	NA	NA	NA
86748	Carbazole	NA	NA	NA	NA
1563662	Carbofuran	NA	NA	NA	NA
75150	Carbon disulfide	92 nc	2,100 nc	52 (M) nc	24,000 nc
56235	Carbon tetrachloride	0.41 (M) ca	7.7 ca	0.31 (M) ca	150 ca
57749	Chlordane	18 (EE) st	56 (S) (EE) sol	13,000 (EE) st	6.7 (EE) st
16887006	Chloride	NA	NA	NA	NA
95512	2-Chloroaniline	NA	NA	NA	NA
106478	4-Chloroaniline	NA	NA	NA	NA
108907	Chlorobenzene	33 nc	940 nc	82 nc	1,700 nc
98668	p-Chlorobenzene sulfonic acid	NA	NA	NA	NA
75683	1-Chloro-1,1-difluoroethane	2,800 nc	32,000 nc	2,400 nc	1.7E+06 nc
75003	Chloroethane	620 nc	15,000 nc	330 nc	1.4E+05 nc
110758	2-Chloroethyl vinyl ether	TX	TX	TX	TX
67663	Chloroform	0.49 (M) ca	14 ca	0.26 (M) ca	37 ca
74873	Chloromethane	15 nc	380 nc	6.9 (M) nc	3,100 nc
59507	4-Chloro-3-methylphenol	NA	NA	NA	NA
91587	beta-Chloronaphthalene	TX	TX	TX	TX

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
95578	2-Chlorophenol	45 (DD) dev	1.1E+05 (DD) dev	12,000 (DD) dev	600 (DD) dev
95498	o-Chlorotoluene	50 nc	1,400 nc	200 nc	2,800 nc
2921882	Chlorpyrifos	NA	NA	NA	NA
16065831	Chromium (III)	NA	NA	NA	NA
18540299	Chromium (VI)	NA	NA	NA	NA
218019	Chrysene	NA	NA	NA	NA
7440484	Cobalt	NA	NA	NA	NA
7440508	Copper	NA	NA	NA	NA
21725462	Cyanazine	NA	NA	NA	NA
74908	Cyanide, Hydrogen	9.0 nc	270 nc	1.8 (M) nc	28 nc
110827	Cyclohexane	290 nc	2,000 nc	320 (M) nc	2.1E+05 nc
108941	Cyclohexanone	2.0E+05 nc	5.9E+06 nc	68,000 nc	24,000 nc
1861321	Dacthal	NA	NA	NA	NA
75990	Dalapon	NA	NA	NA	NA
72548	4-4`-DDD	NA	NA	NA	NA
72559	4-4`-DDE	32 ca	40 (S) sol	39,000 ca	8.7 ca
50293	4-4`-DDT	NA	NA	NA	NA
1163195	Decabromodiphenyl ether	NA	NA	NA	NA
84742	Di-n-butyl phthalate	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
103231	Di(2-ethylhexyl) adipate	NA	NA	NA	NA
117840	Di-n-octyl phthalate	22 (S) sol	22 (S) (CC) sol	DATA	16,000 nc
123422	Diacetone alcohol	2.9E+07 nc	8.8E+08 nc	5.2E+06 nc	83,000 nc
333415	Diazinon	NA	NA	NA	NA
53703	Dibenzo(a,h)anthracene	NA	NA	NA	NA
132649	Dibenzofuran	3,100 (S) sol	3,100 (S) sol	7.1E+06 nc	140 nc
124481	Dibromochloromethane	0.78 (MM) (M) mut	23 (MM) mut	0.40 (MM) (M) mut	14 (MM) mut
96128	Dibromochloropropane	4.5E-04 (MM) (M) mut	4.5E-04 (MM) (M) (CC) mut	DATA	6.2E-02 (MM) mut
74953	Dibromomethane	8.8 nc	260 nc	3.5 (M) nc	140 nc
1918009	Dicamba	NA	NA	NA	NA
95501	1,2-Dichlorobenzene	370 nc	11,000 nc	1,500 nc	10,000 nc
541731	1,3-Dichlorobenzene	2.6 nc	75 nc	10 (M) nc	100 nc
106467	1,4-Dichlorobenzene	5.9 ca	170 ca	23 (M) ca	220 ca
91941	3,3`-Dichlorobenzidine	NA	NA	NA	NA
75718	Dichlorodifluoromethane	13 nc	49 nc	12 (M) nc	11,000 nc
75343	1,1-Dichloroethane	4.7 ca	130 ca	2.6 (M) ca	530 ca

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
107062	1,2-Dichloroethane	1.4 ca	41 ca	0.82 (M) ca	33 ca
75354	1,1-Dichloroethylene	18 nc	330 nc	12 (M) nc	7,000 nc
156592	cis-1,2-Dichloroethylene	3.4 nc	95 nc	2.1 (M) nc	280 nc
156605	trans-1,2-Dichloroethylene	16 nc	390 nc	12 (M) nc	2,800 nc
99309	2,6-Dichloro-4-nitroaniline	NA	NA	NA	NA
120832	2,4-Dichlorophenol	NA	NA	NA	NA
94757	2,4-Dichlorophenoxyacetic acid	NA	NA	NA	NA
78875	1,2-Dichloropropane	2.6 nc	74 nc	2.1 (M) nc	140 nc
542756	1,3-Dichloropropene	3.3 (J) ca	95 (J) ca	3.1 (M) (J) ca	210 (J) ca
62737	Dichlorvos	NA	NA	NA	NA
84617	Dicyclohexyl phthalate	NA	NA	NA	NA
60571	Dieldrin	3.7 ca	110 ca	770 ca	0.18 ca
60297	Diethyl ether	1,200 nc	36,000 nc	350 nc	35,000 nc
84662	Diethyl phthalate	NA	NA	NA	NA
112345	Diethylene glycol monobutyl ether	NA	NA	NA	NA
108203	Diisopropyl ether	36 (DD) dev	13,000 (DD) dev	190 (M) (DD) dev	23,000 (DD) dev

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
108189	Diisopropylamine	3,500 nc	1.1E+05 nc	2,900 nc	7,000 nc
131113	Dimethyl phthalate	NA	NA	NA	NA
127195	N,N-Dimethylacetamide	1.9E+07 nc	5.7E+08 nc	3.8E+06 nc	3,500 nc
121697	N,N-Dimethylaniline	120 ca	3,600 ca	120 ca	71 ca
68122	Dimethylformamide	2.6E+05 nc	7.8E+06 nc	46,000 nc	240 nc
105679	2,4-Dimethylphenol	NA	NA	NA	NA
576261	2,6-Dimethylphenol	NA	NA	NA	NA
95658	3,4-Dimethylphenol	NA	NA	NA	NA
67685	Dimethylsulfoxide	NA	NA	NA	NA
51285	2,4-Dinitrophenol	NA	NA	NA	NA
121142	2,4-Dinitrotoluene	NA	NA	NA	NA
88857	Dinoseb	NA	NA	NA	NA
123911	1,4-Dioxane	1,900 ca	56,000 ca	360 (M) ca	170 ca
85007	Diquat	NA	NA	NA	NA
330541	Diuron	NA	NA	NA	NA
115297	Endosulfan	TX	TX	TX	TX
145733	Endothall	NA	NA	NA	NA
72208	Endrin	NA	NA	NA	NA
106898	Epichlorohydrin	69 nc	2,100 nc	19 (M) nc	35 nc

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
64175	Ethanol	1.0E+05 (FF) st	2.3E+08 (EE) st	1.3E+06 (EE) st	6.3E+05 (EE) st
141786	Ethyl acetate	910 nc	27,000 nc	210 nc	2,400 nc
637923	Ethyl-tert-butyl ether (ETBE)	22 nc	22 (CC) nc	DATA	13,000 nc
100414	Ethylbenzene	2.8 ca	74 ca	12 (M) ca	340 ca
106934	Ethylene dibromide	0.13 ca	3.8 ca	7.4E-02 (M) ca	1.4 ca
107211	Ethylene glycol	NA	NA	NA	NA
111762	Ethylene glycol monobutyl ether	NA	NA	NA	NA
60004	Ethylenediaminetetraacetic acid (EDTA)	NA	NA	NA	NA
206440	Fluoranthene	NA	NA	NA	NA
86737	Fluorene	1,700 (S) sol	1,700 (S) sol	4.7E+05 nc	4,900 nc
7782414	Fluorine (soluble fluoride)	NA	NA	NA	NA
50000	Formaldehyde	3,000 (MM) mut	91,000 (MM) mut	530 (MM) (M) mut	27 (MM) mut
64186	Formic acid	2,500 nc	75,000 nc	440 (M) nc	10 nc
2591868	1-Formylpiperidine	NA	NA	NA	NA
548629	Gentian violet	NA	NA	NA	NA
1071836	Glyphosate	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
76448	Heptachlor	0.25 ca	7.4 ca	3,600 ca	0.65 ca
1024573	Heptachlor epoxide	1.4E-02 ca	1.4E-02 (CC) ca	DATA	0.33 ca
142825	n-Heptane	150 nc	150 (GW) nc	130 nc	1.2E+05 nc
87821	Hexabromobenzene	TX	TX	TX	TX
118741	Hexachlorobenzene (C-66)	0.11 (M) nc	3.1 nc	6.7 (M) nc	1.2 nc
87683	Hexachlorobutadiene (C-46)	0.32 ca	8.2 ca	2.5 (M) ca	39 ca
319846	alpha-Hexachlorocyclohexane	NA	NA	NA	NA
319857	beta-Hexachlorocyclohexane	NA	NA	NA	NA
77474	Hexachlorocyclopentadiene (C-56)	3.0E-02 (M) nc	0.64 (M) nc	0.32 (M) nc	7.0 nc
67721	Hexachloroethane	1.5 (M) ca	43 ca	3.2 (M) ca	85 ca
110543	n-Hexane	29 nc	29 (GW) nc	25 nc	24,000 nc
591786	2-Hexanone	660 nc	20,000 nc	210 (M) nc	1,000 nc
193395	Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA
7439896	Iron	NA	NA	NA	NA
78831	Isobutyl alcohol	4.0E+05 nc	1.2E+07 nc	79,000 nc	52,000 nc
78591	Isophorone	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

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67630	Isopropyl alcohol	53,000 nc	1.6E+06 nc	9,800 nc	7,000 nc
98828	Isopropyl benzene	0.60 (M) ca	15 ca	3.8 (M) ca	81 ca
7439921	Lead	NA	NA	NA	NA
58899	Lindane	NA	NA	NA	NA
7439932	Lithium	NA	NA	NA	NA
7439954	Magnesium	NA	NA	NA	NA
7439965	Manganese	NA	NA	NA	NA
Varies	Mercury (Total)	8.8E-02 nc	2.5 nc	22 (M) nc	10 nc
74828	Methane	10,000 (AA)	10,000 (AA)	DATA	8.4E+06 (GG)
67561	Methanol	1.2E+05 (DD) dev	2.3E+08 (DD) dev	1.4E+06 (DD) dev	6.7E+05 (DD) dev
72435	Methoxychlor	NA	NA	NA	NA
109864	2-Methoxyethanol	8,400 nc	2.5E+05 nc	1,500 nc	38 nc
94746	2-Methyl-4-chlorophenoxyacetic acid	NA	NA	NA	NA
534521	2-Methyl-4,6-dinitrophenol	NA	NA	NA	NA
109024	N-Methyl-morpholine	TX	TX	TX	TX
298000	Methyl parathion	NA	NA	NA	NA
108101	4-Methyl-2-pentanone (MIBK)	200 (FF) st	3.3E+05 (EE) st	3,300 (EE) st	27,000 (EE) st
1634044	Methyl-tert-butyl ether (MTBE)	250 ca	7,400 ca	74 (M) ca	3,300 ca
100618	N-methylaniline	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	Residential Shallow Groundwater µg/L	Residential Groundwater Not In Contact µg/L	Residential Soil µg/kg	Residential Soil Vapor µg/m³
96377	Methylcyclopentane	30 (M) nc	93 nc	29 (M) nc	24,000 nc
101144	4,4`-Methylene-bis-2- chloroaniline (MBOCA)	NA	NA	NA	NA
75092	Methylene chloride	79 (FF) st	8,400 nc	130 nc	21,000 nc
91576	2-Methylnaphthalene	66 nc	2,000 nc	1,700 nc	350 nc
1319773	Methylphenols	NA	NA	NA	NA
95487	2-Methylphenol	NA	NA	NA	NA
51218452	Metolachlor	NA	NA	NA	NA
21087649	Metribuzin	NA	NA	NA	NA
2385855	Mirex	TX	TX	TX	TX
7439987	Molybdenum	NA	NA	NA	NA
91203	Naphthalene	4.2 (M) ca	130 ca	67 (M) ca	25 ca
7440020	Nickel	NA	NA	NA	NA
14797558	Nitrate	NA	NA	NA	NA
14797650	Nitrite	NA	NA	NA	NA
98953	Nitrobenzene	68 ca	2,000 ca	170 (M) ca	21 ca
88755	2-Nitrophenol	0.12 (M) nc	0.12 (M) (CC) nc	DATA	1.7 nc
621647	n-Nitroso-di-n-propylamine	NA	NA	NA	NA
86306	N-Nitrosodiphenylamine	NA	NA	NA	NA
23135220	Oxamyl	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

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88230357	Oxo-hexyl acetate	NA	NA	NA	NA
40487421	Pendimethalin	NA	NA	NA	NA
608935	Pentachlorobenzene	8.6E-03 (M) nc	8.6E-03 (M) (CC) nc	DATA	3.5 nc
82688	Pentachloronitrobenzene	8.5 (M) nc	8.5 (M) (CC) nc	DATA	380 nc
87865	Pentachlorophenol	NA	NA	NA	NA
109660	Pentane	40 (M) nc	40 (M) (GW) nc	36 (M) nc	35,000 nc
109682	2-Pentene	TX	TX	TX	TX
14797730	Perchlorate	NA	NA	NA	NA
335671	Perfluorooctanoic acid	TX	TX	TX	TX
1763231	Perfluorooctane sulfonic acid	NA	NA	NA	NA
85018	Phenanthrene	9.5 nc	290 nc	1,700 nc	3.5 nc
108952	Phenol	NA	NA	NA	NA
57410	Phenytoin	NA	NA	NA	NA
7723140	Phosphorus, White	NA	NA	NA	NA
88993	o-Phthalic acid	NA	NA	NA	NA
85449	Phthalic anhydride	NA	NA	NA	NA
1918021	Picloram	NA	NA	NA	NA
110894	Piperidine	2.9E+06 nc	8.6E+07 nc	2.1E+06 nc	2.4E+05 nc
67774327	Polybrominated biphenyls	NA	NA	NA	NA

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

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1336363	Polychlorinated biphenyls (PCBs)	3.1E-02 (M) (J) ca	3.1E-02 (M) (CC) (J) ca	DATA	8.5 (J) ca
1610180	Prometon	NA	NA	NA	NA
1918167	Propachlor	NA	NA	NA	NA
139402	Propazine	NA	NA	NA	NA
79094	Propionic acid	1.2E+06 nc	3.7E+07 nc	2.2E+05 nc	10,000 nc
71238	Propyl alcohol	9,200 (FF) st	2.2E+07 (EE) st	1.4E+05 (EE) st	83,000 (EE) st
103651	n-Propylbenzene	43 (DD) dev	6,100 (DD) dev	1,800 (DD) dev	33,000 (DD) dev
57556	Propylene glycol	NA	NA	NA	NA
129000	Pyrene	140 (S) sol	140 (S) sol	2.5E+07 nc	3,500 nc
110861	Pyridine	600 nc	18,000 nc	540 nc	120 nc
7782492	Selenium	NA	NA	NA	NA
7440224	Silver	NA	NA	NA	NA
93721	Silvex (2,4,5-TP)	NA	NA	NA	NA
122349	Simazine	NA	NA	NA	NA
17341252	Sodium	NA	NA	NA	NA
26628228	Sodium azide	NA	NA	NA	NA
7647156	Sodium bromide	NA	NA	NA	NA
7440246	Strontium (B,DD)	NA	NA	NA	NA
100425	Styrene	33 ca	960 ca	150 ca	1,500 ca

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

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14808798	Sulfate	NA	NA	NA	NA
126330	Sulfolane	NA	NA	NA	NA
34014181	Tebuthiuron	NA	NA	NA	NA
50585416	2,3,7,8-Tetrabromodibenzo-p-dioxin	NA	NA	NA	NA
95943	1,2,4,5-Tetrachlorobenzene	3.1 nc	91 nc	70 (M) nc	35 nc
1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin	NA	NA	NA	NA
630206	1,1,1,2-Tetrachloroethane	3.1 ca	89 ca	3.2 (M) ca	110 ca
79345	1,1,2,2-Tetrachloroethane	2.4 ca	71 ca	2.7 (M) ca	15 ca
127184	Tetrachloroethylene	1.5 (FF) st	130 (EE) st	6.2 (M) (EE) st	1,400 (EE) st
109999	Tetrahydrofuran	45,000 nc	1.4E+06 nc	13,000 nc	70,000 nc
632224	1,1,3,3-Tetramethylurea	2,700 nc	2,700 (CC) nc	DATA	28 nc
509148	Tetranitromethane	1.7E-02 (M) ca	0.50 (M) ca	7.6E-02 (M) ca	5.6E-02 ca
7440280	Thallium	NA	NA	NA	NA
108883	Toluene	300 (FF) st	41,000 nc	3,700 nc	1.7E+05 nc
106490	p-Toluidine	NA	NA	NA	NA
8001352	Toxaphene	NA	NA	NA	NA
2303175	Triallate	530 (DD) dev	530 (DD) (CC) dev	DATA	6,700 (DD) dev

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

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102829	Tributylamine	170 nc	5,200 nc	3,300 nc	240 nc
87616	1,2,3-Trichlorobenzene	58 nc	1,700 nc	830 nc	940 nc
120821	1,2,4-Trichlorobenzene	3.8 (M) nc	110 nc	53 (M) nc	70 nc
71556	1,1,1-Trichloroethane	180 (FF) st	14,000 (EE) st	450 (EE) st	1.7E+05 (EE) st
79005	1,1,2-Trichloroethane	0.47 (M) nc	14 nc	0.37 (M) nc	7.0 nc
79016	Trichloroethylene	7.3E-02 (M) (DD) dev	10 (DD) dev	0.33 (M) (DD) dev	67 (DD) dev
75694	Trichlorofluoromethane	22 nc	190 nc	19 (M) nc	15,000 nc
95954	2,4,5-Trichlorophenol	NA	NA	NA	NA
88062	2,4,6-Trichlorophenol	NA	NA	NA	NA
96184	1,2,3-Trichloropropane	1.9 nc	57 nc	2.6 (M) nc	10 nc
76131	1,1,2-Trichloro-1,2,2-trifluoroethane	840 nc	2,700 nc	860 nc	6.6E+05 nc
102716	Triethanolamine	NA	NA	NA	NA
112276	Triethylene glycol	NA	NA	NA	NA
88302	3-Trifluoromethyl-4-nitrophenol	NA	NA	NA	NA
1582098	Trifluralin	180 (S) sol	180 (S) (CC) sol	DATA	1.0E+05 nc
540841	2,2,4-Trimethyl pentane	160 nc	160 (GW) nc	130 (M) nc	1.2E+05 nc

Residential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

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107404	2,4,4-Trimethyl-2-pentene	TX	TX	TX	TX
526738	1,2,3-Trimethylbenzene	43 (JT) nc	1,200 (JT) nc	270 (JT) nc	2,100 (JT) nc
95636	1,2,4-Trimethylbenzene	25 (JT) nc	670 (JT) nc	150 (JT) nc	2,100 (JT) nc
108678	1,3,5-Trimethylbenzene	18 (JT) nc	470 (JT) nc	100 (JT) nc	2,100 (JT) nc
115866	Triphenyl phosphate	NA	NA	NA	NA
126727	tris(2,3-Dibromopropyl)phosphate	7.4E-02 (M) ca	7.4E-02 (M) (CC) ca	DATA	1.6 ca
57136	Urea	NA	NA	NA	NA
7440622	Vanadium	NA	NA	NA	NA
108054	Vinyl acetate	690 nc	21,000 nc	160 (M) nc	7,000 nc
75014	Vinyl chloride	0.12 (MM) (M) mut	2.1 (MM) mut	8.2E-02 (MM) (M) mut	54 (MM) mut
1330207	Xylenes	75 (J) nc	2,000 (J) nc	280 (J) nc	7,600 (J) nc
7440666	Zinc	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

Table 2. Nonresidential shallow groundwater, groundwater not in contact, soil, and soil vapor volatilization to indoor air pathway (VIAP) screening levels. The VIAP screening levels are calculated based on restricted nonresidential use. The building construction input parameters includes those associated with a nonresidential structure that has a slab-on-grade and contains portions of the structure that are < 50,000 ft^2 of continuously open space.

The shallow groundwater VIAP screening levels apply when the depth to first encountered groundwater is 5 feet below ground surface or less. The groundwater not in contact VIAP screening levels apply when the depth to first encountered groundwater is greater than 5 feet below ground surface.

The United States Department of Agriculture (USDA) soil type of sand and system temperature of 10 °C were used during screening level development.

The nonresidential acceptable air concentrations are adjusted for 12-hour workday exposures.

Refer to the Appendix C.7 checklist for other precluding factors.

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
83329	Acenaphthene	3,900 (S) sol	3,900 (S) sol	7.2E+06 nc	21,000 nc
208968	Acenaphthylene	1,400 nc	1,400 (CC) nc	DATA	21,000 nc
75070	Acetaldehyde	600 nc	17,000 nc	1,200 (M) nc	920 nc
71501	Acetate	NA	NA	NA	NA
64197	Acetic acid	1.1E+07 nc	3.2E+08 nc	2.3E+07 nc	26,000 nc
67641	Acetone	2.0E+05 (FF) st	4.0E+07 (EE) st	3.1E+06 (EE) st	1.0E+06 (EE) st

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
75058	Acetonitrile	8,700 nc	2.5E+05 nc	22,000 nc	6,100 nc
98862	Acetophenone	72,000 (DD) dev	6.1E+06 (S) (DD) sol	1.5E+07 (C) (DD) dev (8.4E+05)	2.1E+05 (DD) dev
107028	Acrolein	0.81 (M) nc	22 nc	1.6 (M) nc	2.0 nc
79061	Acrylamide	NA	NA	NA	NA
79107	Acrylic acid	4,300 nc	1.3E+05 nc	9,200 nc	20 nc
107131	Acrylonitrile	24 ca	650 ca	67 (M) ca	59 ca
15972608	Alachlor	NA	NA	NA	NA
116063	Aldicarb	NA	NA	NA	NA
1646884	Aldicarb sulfone	NA	NA	NA	NA
1646873	Aldicarb sulfoxide	NA	NA	NA	NA
309002	Aldrin	3.0 ca	17 (S) sol	29,000 ca	0.81 ca
7429905	Aluminum	NA	NA	NA	NA
7664417	Ammonia	4,600 (FF) st	2.7E+06 (EE) st	DATA	40,000 (EE) st
994058	t-Amyl methyl ether (TAME)	430 nc	7,100 nc	1,200 nc	6,300 nc
62533	Aniline	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
120127	Anthracene	43 (S) sol	43 (S) sol	4.4E+08 nc	1.0E+05 nc
7440360	Antimony	NA	NA	NA	NA
7440382	Arsenic	NA	NA	NA	NA
1332214	Asbestos	NA	NA	NA	NA
1912249	Atrazine	NA	NA	NA	NA
103333	Azobenzene	46 ca	46 (CC) ca	DATA	130 ca
7440393	Barium	NA	NA	NA	NA
71432	Benzene	17 ca	130 ca	94 ca	510 ca
92875	Benzidine	NA	NA	NA	NA
56553	Benzo(a)anthracene	9.4 (S) sol	9.4 (S) sol	2.2E+07 ca	66 ca
205992	Benzo(b)fluoranthene	NA	NA	NA	NA
207089	Benzo(k)fluoranthene	NA	NA	NA	NA
191242	Benzo(g,h,i)perylene	NA	NA	NA	NA
50328	Benzo(a)pyrene	NA	NA	NA	NA
65850	Benzoic acid	NA	NA	NA	NA
100516	Benzyl alcohol	NA	NA	NA	NA
100447	Benzyl chloride	14 ca	350 ca	670 ca	80 ca
7440417	Beryllium	NA	NA	NA	NA
112265	bis(2-Chloroethoxy)ethane	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
111444	bis-2-Chloroethylether	33 ca	960 ca	190 ca	12 ca
117817	bis(2-Ethylhexyl) phthalate	NA	NA	NA	NA
7440428	Boron	NA	NA	NA	NA
15541454	Bromate	NA	NA	NA	NA
108861	Bromobenzene	340 nc	5,300 nc	5,600 nc	6,100 nc
75274	Bromodichloromethane	9.9 nc	150 nc	31 (M) nc	200 nc
75252	Bromoform	520 ca	12,000 ca	2,500 ca	3,600 ca
74839	Bromomethane	26 nc	160 nc	32 (M) nc	1,000 nc
71363	n-Butanol	3.0E+05 nc	8.7E+06 nc	7.0E+05 nc	36,000 nc
78933	2-Butanone (MEK)	24,000 (DD) dev	8.7E+06 (DD) dev	7.4E+05 (DD) dev	3.3E+05 (DD) dev
123864	n-Butyl acetate	10,000 nc	2.6E+05 nc	38,000 nc	41,000 nc
75650	t-Butyl alcohol	52,000 nc	1.5E+06 nc	1.1E+05 nc	7,400 nc
85687	Butyl benzyl phthalate	NA	NA	NA	NA
104518	n-Butylbenzene	720 nc	3,100 nc	20,000 nc	20,000 nc
135988	sec-Butylbenzene	790 nc	18,000 (S) sol	1.3E+05 (C) nc (49,000)	41 nc

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
98066	t-Butylbenzene	1.4 nc	5.3 nc	23 (M) nc	41 nc
7440439	Cadmium	NA	NA	NA	NA
79925	Camphene	230 nc	230 (GW) nc	490 nc	8,200 nc
105602	Caprolactam	NA	NA	NA	NA
63252	Carbaryl	NA	NA	NA	NA
86748	Carbazole	NA	NA	NA	NA
1563662	Carbofuran	NA	NA	NA	NA
75150	Carbon disulfide	1,700 nc	6,300 nc	1,800 nc	72,000 nc
56235	Carbon tetrachloride	19 ca	36 ca	17 (M) ca	710 ca
57749	Chlordane	54 (EE) st	56 (S) (EE) sol	4.3E+05 (EE) st	19 (EE) st
16887006	Chloride	NA	NA	NA	NA
95512	2-Chloroaniline	NA	NA	NA	NA
106478	4-Chloroaniline	NA	NA	NA	NA
108907	Chlorobenzene	220 nc	2,800 nc	2,900 nc	5,100 nc
98668	p-Chlorobenzene sulfonic acid	NA	NA	NA	NA
75683	1-Chloro-1,1-difluoroethane	1.3E+05 nc	1.3E+05 (GW) nc	84,000 nc	5.1E+06 nc
75003	Chloroethane	10,000 nc	44,000 nc	12,000 nc	4.1E+05 nc

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
110758	2-Chloroethyl vinyl ether	TX	TX	TX	TX
67663	Chloroform	6.2 ca	65 ca	15 (M) ca	170 ca
74873	Chloromethane	220 nc	1,100 nc	240 (M) nc	9,200 nc
59507	4-Chloro-3-methylphenol	NA	NA	NA	NA
91587	beta-Chloronaphthalene	TX	TX	TX	TX
95578	2-Chlorophenol	370 (DD) dev	2.1E+05 (DD) dev	2.8E+05 (DD) dev	1,200 (DD) dev
95498	o-Chlorotoluene	360 nc	4,200 nc	7,000 nc	8,200 nc
2921882	Chlorpyrifos	NA	NA	NA	NA
16065831	Chromium (III)	NA	NA	NA	NA
18540299	Chromium (VI)	NA	NA	NA	NA
218019	Chrysene	NA	NA	NA	NA
7440484	Cobalt	NA	NA	NA	NA
7440508	Copper	NA	NA	NA	NA
21725462	Cyanazine	NA	NA	NA	NA
74908	Cyanide, Hydrogen	28 nc	800 nc	63 (M) nc	82 nc
110827	Cyclohexane	16,000 nc	16,000 (GW) nc	11,000 nc	6.1E+05 nc
108941	Cyclohexanone	6.0E+05 nc	1.7E+07 nc	2.4E+06 (C) nc (1.7E+06)	72,000 nc
1861321	Dacthal	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m^3
75990	Dalapon	NA	NA	NA	NA
72548	4-4`-DDD	NA	NA	NA	NA
72559	4-4`-DDE	40 (S) sol	40 (S) sol	2.2E+06 ca	41 ca
50293	4-4`-DDT	NA	NA	NA	NA
1163195	Decabromodiphenyl ether	NA	NA	NA	NA
84742	Di-n-butyl phthalate	NA	NA	NA	NA
103231	Di(2-ethylhexyl) adipate	NA	NA	NA	NA
117840	Di-n-octyl phthalate	22 (S) sol	22 (S) (CC) sol	DATA	48,000 nc
123422	Diacetone alcohol	8.8E+07 nc	1.0E+09 (S) sol	1.8E+08 (C) nc (3.5E+07)	2.5E+05 nc
333415	Diazinon	NA	NA	NA	NA
53703	Dibenzo(a,h)anthracene	NA	NA	NA	NA
132649	Dibenzofuran	3,100 (S) sol	3,100 (S) sol	2.5E+08 nc	410 nc
124481	Dibromochloromethane	13 ca	270 ca	55 (M) ca	170 ca
96128	Dibromochloropropane	4.2E-02 (M) ca	4.2E-02 (M) (CC) ca	DATA	0.71 ca
74953	Dibromomethane	36 nc	770 nc	120 (M) nc	410 nc
1918009	Dicamba	NA	NA	NA	NA
95501	1,2-Dichlorobenzene	1,900 nc	32,000 nc	52,000 nc	31,000 nc

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
541731	1,3-Dichlorobenzene	16 nc	220 nc	360 nc	310 nc
106467	1,4-Dichlorobenzene	55 ca	810 ca	1,300 ca	1,000 ca
91941	3,3`-Dichlorobenzidine	NA	NA	NA	NA
75718	Dichlorodifluoromethane	820 nc	820 (GW) nc	440 nc	34,000 nc
75343	1,1-Dichloroethane	80 ca	600 ca	150 ca	2,500 ca
107062	1,2-Dichloroethane	10 ca	190 ca	46 (M) ca	150 ca
75354	1,1-Dichloroethylene	500 nc	970 nc	430 nc	20,000 nc
156592	cis-1,2-Dichloroethylene	28 nc	280 nc	74 nc	820 nc
156605	trans-1,2-Dichloroethylene	230 nc	1,200 nc	420 nc	8,200 nc
99309	2,6-Dichloro-4-nitroaniline	NA	NA	NA	NA
120832	2,4-Dichlorophenol	NA	NA	NA	NA
94757	2,4-Dichlorophenoxyacetic acid	NA	NA	NA	NA
78875	1,2-Dichloropropane	18 nc	220 nc	74 nc	410 nc
542756	1,3-Dichloropropene	39 (J) ca	450 (J) ca	170 (J) ca	1000 (J) ca
62737	Dichlorvos	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
84617	Dicyclohexyl phthalate	NA	NA	NA	NA
60571	Dieldrin	18 ca	200 (S) sol	43,000 ca	0.87 ca
60297	Diethyl ether	6,300 nc	1.1E+05 nc	12,000 nc	1.0E+05 nc
84662	Diethyl phthalate	NA	NA	NA	NA
112345	Diethylene glycol monobutyl ether	NA	NA	NA	NA
108203	Diisopropyl ether	1,400 (DD) dev	26,000 (DD) dev	4,700 (DD) dev	47,000 (DD) dev
108189	Diisopropylamine	11,000 nc	3.1E+05 nc	1.0E+05 nc	20,000 nc
131113	Dimethyl phthalate	NA	NA	NA	NA
127195	N,N-Dimethylacetamide	5.7E+07 nc	1.0E+09 (S) sol	1.4E+08 (C) nc (3.9E+07)	10,000 nc
121697	N,N-Dimethylaniline	580 ca	17,000 ca	6,600 ca	330 ca
68122	Dimethylformamide	7.8E+05 nc	2.3E+07 nc	1.6E+06 nc	720 nc
105679	2,4-Dimethylphenol	NA	NA	NA	NA
576261	2,6-Dimethylphenol	NA	NA	NA	NA
95658	3,4-Dimethylphenol	NA	NA	NA	NA
67685	Dimethylsulfoxide	NA	NA	NA	NA
51285	2,4-Dinitrophenol	NA	NA	NA	NA
121142	2,4-Dinitrotoluene	NA	NA	NA	NA
88857	Dinoseb	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
123911	1,4-Dioxane	9,100 ca	2.7E+05 ca	21,000 ca	800 ca
85007	Diquat	NA	NA	NA	NA
330541	Diuron	NA	NA	NA	NA
115297	Endosulfan	TX	TX	TX	TX
145733	Endothall	NA	NA	NA	NA
72208	Endrin	NA	NA	NA	NA
106898	Epichlorohydrin	210 nc	6,100 nc	660 nc	100 nc
64175	Ethanol	3.1E+05 (FF) st	2.3E+08 (EE) st	1.6E+07 (EE) st	6.3E+05 (EE) st
141786	Ethyl acetate	3,000 nc	81,000 nc	7,300 nc	7,200 nc
637923	Ethyl-tert-butyl ether (ETBE)	1,200 nc	1,200 (CC) nc	DATA	38,000 nc
100414	Ethylbenzene	56 ca	350 ca	680 ca	1,600 ca
106934	Ethylene dibromide	0.78 ca	18 ca	4.2 (M) ca	6.6 ca
107211	Ethylene glycol	NA	NA	NA	NA
111762	Ethylene glycol monobutyl ether	NA	NA	NA	NA
60004	Ethylenediaminetetraacetic acid (EDTA)	NA	NA	NA	NA
206440	Fluoranthene	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
86737	Fluorene	1,700 (S) sol	1,700 (S) sol	1.7E+07 nc	14,000 nc
7782414	Fluorine (soluble fluoride)	NA	NA	NA	NA
50000	Formaldehyde	35,000 ca	1.0E+06 ca	73,000 ca	310 ca
64186	Formic acid	7,600 nc	2.2E+05 nc	16,000 (M) nc	31 nc
2591868	1-Formylpiperidine	NA	NA	NA	NA
548629	Gentian violet	NA	NA	NA	NA
1071836	Glyphosate	NA	NA	NA	NA
76448	Heptachlor	1.3 ca	35 ca	2.0E+05 ca	3.1 ca
1024573	Heptachlor epoxide	0.40 ca	0.40 (CC) ca	DATA	1.5 ca
142825	n-Heptane	3,400 (S) sol	3,400 (S) (GW) sol	4,600 nc	3.6E+05 nc
87821	Hexabromobenzene	TX	TX	TX	TX
118741	Hexachlorobenzene (C-66)	0.42 nc	6.2 (S) sol	240 (M) nc	3.6 nc
87683	Hexachlorobutadiene (C-46)	7.0 ca	38 ca	140 ca	180 ca
319846	alpha-Hexachlorocyclohexane	NA	NA	NA	NA
319857	beta-Hexachlorocyclohexane	NA	NA	NA	NA
77474	Hexachlorocyclopentadiene (C-56)	0.69 (M) nc	1.9 (M) nc	11 (M) nc	20 nc

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
67721	Hexachloroethane	18 ca	200 ca	180 (M) ca	400 ca
110543	n-Hexane	2,000 nc	2,000 (GW) nc	890 nc	72,000 nc
591786	2-Hexanone	2,100 nc	59,000 nc	7,600 nc	3,100 nc
193395	Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA
7439896	Iron	NA	NA	NA	NA
78831	Isobutyl alcohol	1.2E+06 nc	3.5E+07 nc	2.8E+06 nc	1.5E+05 nc
78591	Isophorone	NA	NA	NA	NA
67630	Isopropyl alcohol	1.6E+05 nc	4.8E+06 nc	3.5E+05 nc	20,000 nc
98828	Isopropyl benzene	13 ca	71 ca	210 (M) ca	380 ca
7439921	Lead	NA	NA	NA	NA
58899	Lindane	NA	NA	NA	NA
7439932	Lithium	NA	NA	NA	NA
7439954	Magnesium	NA	NA	NA	NA
7439965	Manganese	NA	NA	NA	NA
Varies	Mercury (Total)	0.61 nc	7.4 nc	790 nc	31 nc
74828	Methane	10,000 (AA)	10,000 (AA)	DATA	8.4E+06 (GG)
67561	Methanol	6.4E+05 (DD) dev	4.7E+08 (DD) dev	3.3E+07 (DD) dev	1.3E+06 (DD) dev

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
72435	Methoxychlor	NA	NA	NA	NA
109864	2-Methoxyethanol	25,000 nc	7.4E+05 nc	53,000 nc	110 nc
94746	2-Methyl-4-chlorophenoxyacetic acid	NA	NA	NA	NA
534521	2-Methyl-4,6-dinitrophenol	NA	NA	NA	NA
109024	N-Methyl-morpholine	TX	TX	TX	TX
298000	Methyl parathion	NA	NA	NA	NA
108101	4-Methyl-2-pentanone (MIBK)	1,400 (FF) st	3.3E+05 (EE) st	40,000 (EE) st	27,000 (EE) st
1634044	Methyl-tert-butyl ether (MTBE)	1,600 ca	35,000 ca	4,200 ca	15,000 ca
100618	N-methylaniline	NA	NA	NA	NA
96377	Methylcyclopentane	1,900 nc	1,900 (GW) nc	1,000 (M) nc	72,000 nc
101144	4,4`-Methylene-bis-2- chloroaniline (MBOCA)	NA	NA	NA	NA
75092	Methylene chloride	2,100 nc	25,000 nc	4,600 nc	61,000 nc
91576	2-Methylnaphthalene	230 nc	5,900 nc	60,000 nc	1,000 nc
1319773	Methylphenols	NA	NA	NA	NA
95487	2-Methylphenol	NA	NA	NA	NA
51218452	Metolachlor	NA	NA	NA	NA
21087649	Metribuzin	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
2385855	Mirex	TX	TX	TX	TX
7439987	Molybdenum	NA	NA	NA	NA
91203	Naphthalene	23 ca	590 ca	3,800 ca	120 ca
7440020	Nickel	NA	NA	NA	NA
14797558	Nitrate	NA	NA	NA	NA
14797650	Nitrite	NA	NA	NA	NA
98953	Nitrobenzene	330 ca	9,600 ca	9,600 ca	100 ca
88755	2-Nitrophenol	1.4 (M) nc	1.4 (M) (CC) nc	DATA	5.1 nc
621647	n-Nitroso-di-n-propylamine	NA	NA	NA	NA
86306	N-Nitrosodiphenylamine	NA	NA	NA	NA
23135220	Oxamyl	NA	NA	NA	NA
88230357	Oxo-hexyl acetate	NA	NA	NA	NA
40487421	Pendimethalin	NA	NA	NA	NA
608935	Pentachlorobenzene	0.36 (M) nc	0.36 (M) (CC) nc	DATA	10 nc
82688	Pentachloronitrobenzene	170 nc	170 (CC) nc	DATA	1,100 nc
87865	Pentachlorophenol	NA	NA	NA	NA
109660	Pentane	2,700 nc	2,700 (GW) nc	1,300 (M) nc	1.0E+05 nc
109682	2-Pentene	TX	TX	TX	TX

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
14797730	Perchlorate	NA	NA	NA	NA
335671	Perfluorooctanoic acid	TX	TX	TX	TX
1763231	Perfluorooctane sulfonic acid	NA	NA	NA	NA
85018	Phenanthrene	29 nc	850 nc	58,000 nc	10 nc
108952	Phenol	NA	NA	NA	NA
57410	Phenytoin	NA	NA	NA	NA
7723140	Phosphorus, White	NA	NA	NA	NA
88993	o-Phthalic acid	NA	NA	NA	NA
85449	Phthalic anhydride	NA	NA	NA	NA
1918021	Picloram	NA	NA	NA	NA
110894	Piperidine	8.7E+06 nc	2.5E+08 nc	7.4E+07 nc	7.2E+05 nc
67774327	Polybrominated biphenyls	NA	NA	NA	NA
1336363	Polychlorinated biphenyls (PCBs)	1.9 (J) ca	1.9 (CC) (J) ca	DATA	40 (J) ca
1610180	Prometon	NA	NA	NA	NA
1918167	Propachlor	NA	NA	NA	NA
139402	Propazine	NA	NA	NA	NA
79094	Propionic acid	3.7E+06 nc	1.1E+08 nc	7.9E+06 nc	31,000 nc
71238	Propyl alcohol	31,000 (FF) st	2.2E+07 (EE) st	1.7E+06 (EE) st	83,000 (EE) st

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
103651	n-Propylbenzene	970 (DD) dev	6,100 (DD) dev	21,000 (DD) dev	33,000 (DD) dev
57556	Propylene glycol	NA	NA	NA	NA
129000	Pyrene	140 (S) sol	140 (S) sol	8.8E+08 nc	10,000 nc
110861	Pyridine	1,800 nc	53,000 nc	19,000 nc	360 nc
7782492	Selenium	NA	NA	NA	NA
7440224	Silver	NA	NA	NA	NA
93721	Silvex (2,4,5-TP)	NA	NA	NA	NA
122349	Simazine	NA	NA	NA	NA
17341252	Sodium	NA	NA	NA	NA
26628228	Sodium azide	NA	NA	NA	NA
7647156	Sodium bromide	NA	NA	NA	NA
7440246	Strontium (B,DD)	NA	NA	NA	NA
100425	Styrene	340 ca	4,500 ca	8,600 ca	7,000 ca
14808798	Sulfate	NA	NA	NA	NA
126330	Sulfolane	NA	NA	NA	NA
34014181	Tebuthiuron	NA	NA	NA	NA
50585416	2,3,7,8-Tetrabromodibenzo-p-dioxin	NA	NA	NA	NA
95943	1,2,4,5-Tetrachlorobenzene	12 nc	270 nc	2,500 nc	100 nc
1746016	2,3,7,8-Tetrachlorodibenzo-p-dioxin	NA	NA	NA	NA

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
630206	1,1,1,2-Tetrachloroethane	29 ca	420 ca	180 ca	540 ca
79345	1,1,2,2-Tetrachloroethane	13 ca	340 ca	150 ca	69 ca
127184	Tetrachloroethylene	70 (FF) st	250 (EE) st	150 (EE) st	2,700 (EE) st
109999	Tetrahydrofuran	1.4E+05 nc	4.0E+06 nc	4.5E+05 nc	2.0E+05 nc
632224	1,1,3,3-Tetramethylurea	31,000 nc	31,000 (CC) nc	DATA	82 nc
509148	Tetranitromethane	8.9E-02 (M) ca	2.4 (M) ca	4.3 (M) ca	0.27 ca
7440280	Thallium	NA	NA	NA	NA
108883	Toluene	6,600 (FF) st	59,000 (EE) st	64,000 (EE) st	2.5E+05 (EE) st
106490	p-Toluidine	NA	NA	NA	NA
8001352	Toxaphene	NA	NA	NA	NA
2303175	Triallate	3,500 (DD) dev	3,500 (DD) (CC) dev	DATA	6,700 (DD) dev
102829	Tributylamine	550 nc	15,000 nc	1.2E+05 nc	720 nc
87616	1,2,3-Trichlorobenzene	250 nc	5,100 nc	29,000 nc	2,800 nc
120821	1,2,4-Trichlorobenzene	17 nc	330 nc	1,900 nc	200 nc

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
71556	1,1,1-Trichloroethane	5,900 (FF) st	19,000 (EE) st	7,500 (EE) st	2.3E+05 (EE) st
79005	1,1,2-Trichloroethane	1.9 nc	41 nc	13 (M) nc	20 nc
79016	Trichloroethylene	3.3 (DD) dev	20 (DD) dev	8.0 (M) (DD) dev	130 (DD) dev
75694	Trichlorofluoromethane	1,100 nc	1,100 (GW) nc	670 nc	45,000 nc
95954	2,4,5-Trichlorophenol	NA	NA	NA	NA
88062	2,4,6-Trichlorophenol	NA	NA	NA	NA
96184	1,2,3-Trichloropropane	6.6 nc	170 nc	91 (M) nc	31 nc
76131	1,1,2-Trichloro-1,2,2-trifluoroethane	53,000 nc	53,000 (GW) nc	30,000 nc	1.9E+06 nc
102716	Triethanolamine	NA	NA	NA	NA
112276	Triethylene glycol	NA	NA	NA	NA
88302	3-Trifluoromethyl-4-nitrophenol	NA	NA	NA	NA
1582098	Trifluralin	180 (S) sol	180 (S) (CC) sol	DATA	3.1E+05 nc
540841	2,2,4-Trimethyl pentane	2,400 (S) sol	2,400 (S) (GW) sol	4,500 nc	3.6E+05 nc
107404	2,4,4-Trimethyl-2-pentene	TX	TX	TX	TX
526738	1,2,3-Trimethylbenzene	300 (JT) nc	3,600 (JT) nc	9,600 (JT) nc	6,100 (JT) nc

Nonresidential Volatilization to Indoor Air Pathway (VIAP) Screening Levels

CAS No.	Hazardous Substance	12-hour Nonresidential Shallow Groundwater µg/L	12-hour Nonresidential Groundwater Not In Contact µg/L	12-hour Nonresidential Soil µg/kg	12-hour Nonresidential Soil Vapor µg/m³
95636	1,2,4-Trimethylbenzene	240 (JT) nc	2,000 (JT) nc	5,200 (JT) nc	6,100 (JT) nc
108678	1,3,5-Trimethylbenzene	220 (JT) nc	1,400 (JT) nc	3,600 (JT) nc	6,100 (JT) nc
115866	Triphenyl phosphate	NA	NA	NA	NA
126727	tris(2,3-Dibromopropyl)phosphate	2.5 (M) ca	2.5 (M) (CC) ca	DATA	7.5 ca
57136	Urea	NA	NA	NA	NA
7440622	Vanadium	NA	NA	NA	NA
108054	Vinyl acetate	2,600 nc	61,000 nc	5,700 nc	20,000 nc
75014	Vinyl chloride	21 ca	36 ca	16 (M) ca	910 ca
1330207	Xylenes	810 (J) nc	5,900 (J) nc	9,900 (J) nc	22,000 (J) nc
7440666	Zinc	NA	NA	NA	NA

FOOTNOTES

- Acceptable Air Values (AAV) endpoint basis used for VIAP screening levels: (**ca**) = Carcinogenetic; (**nc**) = Non-Carcinogenetic; (**dev**) = Developmental; (**mut**) = Mutagenic cancer; (**st**) = Short-term (i.e., less than chronic exposure).
- Footnote **AA**: VIAP groundwater screening levels are not available due to insufficient toxicological data. Dissolved-phase methane in groundwater is not explosive; however, if liberated and allowed to accumulate in an enclosed structure the principle health and safety concerns are explosive, flammable, and asphyxiant properties of gas phase methane. The acceptable groundwater concentration is the flammability and explosivity screening level (**FESL**) is 10,000 µg/L.
- Footnote **C**: The VIAP screening level exceeds the chemical-specific soil saturation screening level (**Csat**). Because this table does not list Csat values both were provided, with the calculated (health-based) value listed first and Csat provided in parenthesis. The person proposing or implementing response activity must document whether additional response activity is required to control non aqueous phase liquid (**NAPL**) to protect against risks associated with NAPL by using methods appropriate for the NAPL present.
- Footnote **CC**: Insufficient chemical-physical input parameters have been identified to allow the development of a VIAP screening level using standard equations. The VIAP screening level for groundwater is developed based solely on the approach that the department uses for shallow groundwater. If groundwater detections are present, soil vapor may be the most appropriate media to evaluate risk posed from the VIAP.
- Footnote **DATA**: Insufficient physical chemical parameters to calculate a VIAP screening level for specified media. If detections are present in specified media, health-based soil vapor value should be used to evaluate risk.
- Footnote **DD**: Hazardous substance causes developmental effects. Residential VIAP screening levels are protective of both prenatal exposure using a pregnant female receptor and postnatal exposure using a child receptor. Nonresidential VIAP screening levels are protective of prenatal exposure using a pregnant female receptor. Prenatal developmental effects may occur after an acute (i.e., short-term) or full-term exposure.
- Footnote **EE**: The acceptable air concentration (**AAC**) for the volatile hazardous substances is not derived using standard equations. The hazardous substance may cause adverse human health effects for less than chronic exposures (i.e., short-term or acute). The AAC for these hazardous substances is the acute or intermediate minimum risk level (MRL) developed by the Agency for Toxic Substances and Disease Registry (ATSDR), a United States Environmental Protection Agency Integrated Risk Information System (IRIS) acute reference concentration, or an acute initial threshold screening level (ITSL) by the EGLE’s Air Quality Division.

- Footnote **FF**: The AAC for the volatile hazardous substances are based on toxicity values that have been identified to have the potential to cause adverse human health effects for less than chronic exposures (i.e. short-term or acute). The short-term exposure for shallow groundwater VIAP screening levels are based on modification of the standard equations by the department to develop applicable shallow groundwater VIAP screening levels.
- Footnote **GG**: VIAP screening levels for soil vapor are not available due to insufficient toxicological data. The soil vapor value addresses the health and safety concerns of explosive, flammable, and asphyxiant properties of gas phase methane. The acceptable soil vapor concentration is derived based on 25% of the lower explosive level (**LEL**) for methane.
- Footnote **GW**: The calculated VIAP screening level for a hazardous substance based upon shallow groundwater is considered protective when it is greater than the calculated value for groundwater.
- Footnote **ID**: Requires further evaluation to determine the appropriate media to sample.
- Footnote **J**: Hazardous substance may be present in several isomer forms. Isomer-specific concentrations must be added together for comparison to criteria.
- Footnote **JT**: Hazardous substance may be present in several isomer forms. The VIAP screening level may be used for the individual isomer provided that it is the sole isomer detected; however, when multiple isomers are detected in a medium, the isomer-specific concentrations must be added together and compared to the most restrictive VIAP screening level of the detected isomers.
- Footnote **M**: The VIAP screening level may be below target detection limits (**TDL**). In accordance with Sec. 20120a(10) when the TDL for a hazardous substance is greater than the developed VIAP screening level, the TDL is used to evaluate the risk posed from the pathway.
- Footnote **MM**: Hazardous substance is a carcinogen with a mutagenic mode of action. The cancer potency values used in calculating VIAP screening levels are modified using age-dependent adjustment factors for those carcinogenic chemicals identified as mutagenic.
- Footnote **NA**: The hazardous substance does not meet the department’s definition of a volatile; therefore, no VIAP screening levels were developed.
- Footnote **S**: Calculated VIAP screening level exceeds the hazardous substance-specific water solubility limit; therefore, the water solubility limit is used to evaluate the risk posed from the pathway. When this occurs the basis for the screening level is noted as “sol”.
- Footnote **TX**: The Remediation and Redevelopment Division Toxicology Unit has not identified an inhalation toxicity value for the hazardous substance at the date of publication of these values.

APPENDIX D.3

Media-Specific Volatilization to Indoor Air Interim Action Screening Levels (MSSLs) for Groundwater, Shallow Groundwater, Soil, and Soil Vapor

The Media-Specific Volatilization to Indoor Air Interim Action Screening Levels (MSSLs) are not intended for compliance decisions (e.g., obtaining closure of a release, facility determination, etc.) and are not appropriate Part 201 site-specific volatilization to indoor air criteria (SSVIAC) or Part 213 site-specific target levels (SSTLs). Compliance decisions for the volatilization to indoor air pathway (VIAP) must be based on applicable generic or site-specific criteria.

The interim action screening levels are intended to assist with risk evaluation by 1) determining if potentially unsafe levels of chemicals are present in environmental media; 2) determining whether interim action to reduce potential exposure is needed; and 3) if interim action is needed, assist in determining how quickly those actions should be completed.

The MSSLs are based on the recommended interim action screening levels for indoor air identified in the December 2020 Toxics Steering Group report (TSG Report): Volatilization to Indoor Air - Recommended Interim Action Screening Levels (RIASLs), Time Sensitive Recommended Interim Action Screening Levels (TS-RIASLs). The TSG Report details the toxicological background information evaluated to develop the indoor air RIASLs for each hazardous substance included in the report.

Response actions should be completed as soon as possible when environmental concentrations exceed MSSLs. Response actions should be completed immediately when environmental concentrations exceed time sensitive MSSLs (TS MSSLs).

Relevant Exposures

- *Residential Media Specific Interim Action Screening Levels*

Residential MSSLs and TS MSSLs are developed to address places where people live and/or children or other sensitive populations are present on a regular basis [greater than intermittent]. Consistent with the TSG Report recommendations, residential MSSLs may be appropriate for unique exposure scenarios (e.g., daycares, churches, schools, doctor's offices, hospitals, recreational areas); however, a site-specific risk assessment is typically warranted to address the unique exposure scenario.

- *Nonresidential Media Specific Interim Action Screening Levels*

Nonresidential MSSLs, 12-hour workday MSSLs ($MSSL_{12}$), and time sensitive $MSSL_{12}$ (TS $MSSL_{12}$) are developed for healthy adult workers and potential intermittent exposure of adults and children who are customers, patrons, or visitors to commercial or industrial establishments during a portion of the workday. Consistent with the TSG Report recommendations, nonresidential interim action screening levels are not appropriate for establishments where children and other sensitive populations are present on a regular basis [greater than intermittent] (e.g., schools, day-care, churches, doctor's offices, hospitals, campgrounds, recreational areas).

Building Construction and Use

- *Residential MSSLs and TS MSSLs*

The building input parameters for residential MSSLs and TS MSSLs assume unrestricted residential use that includes a residential structure that has a basement a poured concrete floor, block or poured concrete walls, and has less than 6 floors (i.e., is not a high-rise apartment).

- *Nonresidential MSSLs and $MSSL_{12}$*

Nonresidential MSSLs and $MSSL_{12}$ assume restricted nonresidential use that includes a former residential structure that has a basement a poured concrete floor, block or poured concrete walls, and has less than 6 floors (i.e., is not a former high-rise apartment).

- *Nonresidential TS $MSSL_{12}$*

Nonresidential TS $MSSL_{12}$ assume restricted nonresidential use that includes a nonresidential structure with < 50,000 ft^2 of continuously open space that has a poured concrete slab-on-grade foundation. It may be appropriate to take expedited response actions at former residential structures when concentrations are less than those identified.

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SOIL		SOIL VAPOR (INCLUDING SUBSLAB)				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL $_{12}$	TS MSSL $_{12}$
		µg/kg	µg/kg	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
67641	**Acetone**	2.6E+05	5.2E+05	1.0E+06	1.0E+06	1.0E+06	1.0E+06	1.0E+06
98862	**Acetophenone**	6.2E+05	1.2E+06 (C) (8.4E+05)	1.1E+05	3.2E+05	1.1E+05	2.1E+05	6.4E+05
7664417	**Ammonia**	DATA	DATA	17,000	40,000	40,000	40,000	40,000
71432	**Benzene**	1.7 (M)	7.9 (M)	110	630	260	510	1,800
78933	**2-Butanone (MEK)**	31,000	62,000	1.7E+05	5.0E+05	1.7E+05	3.3E+05	1.0E+06
56235	**Carbon tetrachloride**	0.31 (M)	1.5 (M)	150	1,500	360	710	7,100
57749	**Chlordane**	13,000	36,000	6.7	6.7	9.3	19	19
108907	**Chlorobenzene**	82	240	1,700	5,200	2,600	5,100	15,000
75003	**Chloroethane**	330	970	1.4E+05	4.2E+05	2.0E+05	4.1E+05	1.2E+06
67663	**Chloroform**	0.26 (M)	1.2 (M)	37	370	87	170	1,700
74873	**Chloromethane**	6.9 (M)	20 (M)	3,100	9,400	4,600	9,200	28,000
95578	**2-Chlorophenol**	12,000	24,000	600	1,800	600	1,200	3,600

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SOIL		SOIL VAPOR (INCLUDING SUBSLAB)				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL 12	TS MSSL 12
		µg/kg	µg/kg	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
541731	**1,3-Dichlorobenzene**	10 (M)	30 (M)	100	310	150	310	920
106467	**1,4-Dichlorobenzene**	23 (M)	110	220	2,200	510	1,000	10,000
75343	**1,1-Dichloroethane**	2.6 (M)	12 (M)	530	5,300	1,200	2,500	25,000
75354	**1,1-Dichloroethylene**	12 (M)	36 (M)	7,000	21,000	10,000	20,000	61,000
156592	**cis-1,2-Dichloroethylene**	2.1 (M)	6.1 (M)	280	830	410	820	2,500
156605	**trans-1,2-Dichloroethylene**	12 (M)	35 (M)	2,800	8,300	4,100	8,200	25,000
78875	**1,2-Dichloropropane**	2.1 (M)	6.2 (M)	140	420	200	410	1,200
108203	**Diisopropyl ether**	190 (M)	390	23,000	70,000	23,000	47,000	1.40E+05
123911	**1,4-Dioxane**	360 (M)	1,700	170	1,700	400	800	8,000
64175	**Ethanol**	1.3E+06	2.7E+06	6.3E+05	6.3E+05	6.3E+05	6.3E+05	6.3E+05
100414	**Ethylbenzene**	12 (M)	57	340	3,400	800	1,600	16,000
110543	**n-Hexane**	25	74	24,000	73,000	36,000	72,000	2.10E+05
Varies	**Mercury (Total)**	22 (M)	66	10	31	15	31	92

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SOIL		SOIL VAPOR (INCLUDING SUBSLAB)				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL[12]	TS MSSL[12]
		µg/kg	µg/kg	µg/m³	µg/m³	µg/m³	µg/m³	µg/m³
67561	**Methanol**	1.4E+06	2.8E+06	6.7E+05	2.0E+06	6.7E+05	1.3E+06	4.0E+06
108101	**4-Methyl-2-pentanone (MIBK)**	3,300	6,600	27,000	27,000	27,000	27,000	27,000
1634044	**Methyl-tert-butyl ether (MTBE)**	74 (M)	350	3,300	33,000	7,700	15,000	1.5E+05
75092	**Methylene chloride**	130	380	21,000	33,000	31,000	61,000	97,000
71238	**Propyl alcohol**	1.4E+05	2.8E+05	83,000	83,000	83,000	83,000	83,000
103651	**n-Propylbenzene**	1,800	3,500	33,000	1.0E+05	33,000	33,000	1.0E+05
127184	**Tetrachloroethylene**	6.2 (M)	12 (M)	1,400	1,400	1,400	2,700	2,700
108883	**Toluene**	3,700	11,000	1.7E+05	2.5E+05	2.5E+05	2.5E+05	2.5E+05
2303175	**Triallate**	DATA	DATA	6,700	20,000	6,700	6,700	20,000
120821	**1,2,4-Trichlorobenzene**	53 (M)	160 (M)	70	210	100	200	610
71556	**1,1,1-Trichloroethane**	450	1,300	1.7E+05	1.7E+05	2.3E+05	2.3E+05	2.3E+05
79016	**Trichloroethylene**	0.33 (M)	0.67 (M)	67	200	67	130	400
526738	**1,2,3-Trimethylbenzene**	270 (JT)	800 (JT)	2,100	6,300	3,100	6,100	18,000

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SOIL		SOIL VAPOR (INCLUDING SUBSLAB)				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL$_{12}$	TS MSSL$_{12}$
		µg/kg	µg/kg	µg/m^3	µg/m^3	µg/m^3	µg/m^3	µg/m^3
95636	**1,2,4-Trimethylbenzene**	150 (JT)	430 (JT)	2,100	6,300	3,100	6,100	18,000
108678	**1,3,5-Trimethylbenzene**	100 (JT)	300 (JT)	2,100	6,300	3,100	6,100	18,000
108054	**Vinyl acetate**	160 (M)	480 (M)	7,000	21,000	10,000	20,000	61,000
75014	**Vinyl chloride**	8.2E-02 (M)	1.4 (M)	54	540	450	910	9,100
1330207	**Xylenes**	280 (J)	830 (J)	7,600 (J)	23,000 (J)	11,000 (J)	22,000 (J)	67,000 (J)

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SHALLOW GROUNDWATER		GROUNDWATER				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL$_{12}$	TS MSSL$_{12}$
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
67641	**Acetone**	50,000	56,000	1.2E+07	1.2E+07	2.5E+07	2.5E+07	1.4E+08
98862	**Acetophenone**	8,700	9,900	6.1E+06 (S)	6.1E+06 (S)	6.1E+06 (S)	6.1E+06 (S)	6.1E+06 (S)
7664417	**Ammonia**	1,900	2,000	2.5E+05	5.7E+05	1.1E+06	1.1E+06	6.7E+06
71432	**Benzene**	1.0	2.7	14	82	66	130	2,600
78933	**2-Butanone (MEK)**	2,600	3,000	1.5E+06	4.6E+06	3.1E+06	6.1E+06	1.0E+08
56235	**Carbon tetrachloride**	0.41 (M)	1.3	5.3	53	25	50	2,700
57749	**Chlordane**	18	26	56 (S)	56 (S)	56 (S)	56 (S)	56 (S)
108907	**Chlorobenzene**	33	51	540	1,600	1,600	3,200	52,000
75003	**Chloroethane**	620	1,100	6,700	20,000	20,000	40,000	6.6E+05
67663	**Chloroform**	0.49 (M)	1.2	7.6	76	36	71	3,900
74873	**Chloromethane**	15	26	160	470	460	910	15,000
95578	**2-Chlorophenol**	45	52	30,000	89,000	59,000	1.20E+05	2.0E+06
541731	**1,3-Dichlorobenzene**	2.6	4.0	52	150	150	300	4,900

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SHALLOW GROUNDWATER		GROUNDWATER				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL$_{12}$	TS MSSL$_{12}$
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
106467	**1,4-Dichlorobenzene**	5.9	15	120	1,200	560	1,100	61,000
75343	**1,1-Dichloroethane**	4.7	12	67	670	320	630	35,000
75354	**1,1-Dichloroethylene**	18	36	170	510	500	1000	16,000
156592	**cis-1,2-Dichloroethylene**	3.4	5.4	48	140	140	280	4,600
156605	**trans-1,2-Dichloroethylene**	16	27	200	600	590	1,200	19,000
78875	**1,2-Dichloropropane**	2.6	4.0	42	130	120	250	4,100
108203	**Diisopropyl ether**	36	65	7,900	24,000	16,000	32,000	5.2E+05
123911	**1,4-Dioxane**	1,900	4,400	14,000	1.4E+05	65,000	1.3E+05	7.4E+06
64175	**Ethanol**	1.0E+05	1.1E+05	5.0E+07	5.0E+07	1.0E+08	1.0E+08	5.9E+08
100414	**Ethylbenzene**	2.8	7.6	45	450	210	420	23,000
110543	**n-Hexane**	29	85	29 (GW)	33	85 (GW)	170 (GW)	6,000
Varies	**Mercury (Total)**	8.8E-02	0.14	1.4	4.3	4.3	8.5	60 (S)
67561	**Methanol**	1.2E+05	1.3E+05	5.0E+07	1.5E+08	9.9E+07	2.0E+08	1.0E+09 (S)

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SHALLOW GROUNDWATER		GROUNDWATER				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL$_{12}$	TS MSSL$_{12}$
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
108101	**4-Methyl-2-pentanone (MIBK)**	200	250	1.6E+05	1.6E+05	3.1E+05	3.1E+05	1.7E+06
1634044	**Methyl-tert-butyl ether (MTBE)**	250	600	4,000	40,000	19,000	38,000	2.1E+06
75092	**Methylene chloride**	79	460	3,900	6,200	11,000	23,000	2.0E+05
71238	**Propyl alcohol**	9,200	10,000	5.3E+06	5.3E+06	1.1E+07	1.1E+07	6.1E+07
103651	**n-Propylbenzene**	43	83	4,100	12,000	8,100	8,100	52,000 (S)
127184	**Tetrachloroethylene**	1.5	3.0	96	96	190	380	2,100
108883	**Toluene**	300	570	23,000	33,000	66,000	66,000	3.6E+05
2303175	**Triallate**	530	660	530	530	660	660	4,000 (S)
120821	**1,2,4-Trichlorobenzene**	3.8 (M)	5.7	95	290	280	560	9,100
71556	**1,1,1-Trichloroethane**	180	500	8,600	8,600	24,000	24,000	1.3E+05
79016	**Trichloroethylene**	7.3E-02 (M)	0.14 (M)	6.1	18	12	24	400
526738	**1,2,3-Trimethylbenzene**	43 (JT)	67 (JT)	800 (JT)	2,400 (JT)	2,300 (JT)	4,700 (JT)	75,000 (S) (JT)
95636	**1,2,4-Trimethylbenzene**	25 (JT)	40 (JT)	440 (JT)	1,300 (JT)	1,300 (JT)	2,600 (JT)	42,000 (JT)

Appendix D.3
Media-Specific Volatilization to Indoor Air Interim Action Screening Levels

CAS #	Hazardous Substance	SHALLOW GROUNDWATER		GROUNDWATER				
		Residential	Nonresidential	Residential		Nonresidential		
		MSSL	MSSL	MSSL	TS MSSL	MSSL	MSSL 12	TS MSSL12
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
108678	**1,3,5-Trimethylbenzene**	18 (JT)	30 (JT)	310 (JT)	940 (JT)	920 (JT)	1,800 (JT)	30,000 (JT)
108054	**Vinyl acetate**	690	1,000	10,000	30,000	30,000	60,000	9.8E+05
75014	**Vinyl chloride**	0.12 (M)	1.4	0.96 (M)	9.6	16	32	1,800
1330207	**Xylenes**	75 (J)	120 (J)	1,200 (J)	3,600 (J)	3,500 (J)	7,100 (J)	1.1E+05 (S) (J)

Appendix D.3
Footnotes

MSSL – Media Specific Volatilization to Indoor Air Interim Action Screening Level

MSSL 12 – Media Specific Volatilization to Indoor Air Interim Action Screening Level adjusted for a nonresidential workday exposure

TS MSSL – Time-Sensitive Media Specific Volatilization to Indoor Air Interim Action Screening Level

TS MSSL 12 – Time-Sensitive Media Specific Volatilization to Indoor Air Interim Action Screening Level adjusted for a nonresidential workday exposure for structures that were not formerly residential houses. It may be appropriate to take expedited response actions at former residential structures when concentrations are less than those identified.

Footnote **C**: The screening level exceeds the chemical-specific soil saturation screening level (Csat). Because this table does not list Csat values both were provided, with the calculated (health-based) value listed first and Csat provided in parenthesis. The person proposing or implementing response activity must document whether additional response activity is required to control non aqueous phase liquid (NAPL) to protect against risks associated with NAPL by using methods appropriate for the NAPL present.

Footnote **DATA**: Insufficient physical chemical parameters to calculate a screening level for specified media.

Footnote **GW**: The calculated value for a hazardous substance based upon shallow groundwater is considered protective when it is greater than the calculated value for groundwater.

Footnote **J**: Hazardous substance may be present in several isomer forms. Isomer-specific concentrations must be added together for comparison to screening level.

Footnote **JT**: Hazardous substance may be present in several isomer forms. Screening levels may be used for the individual isomer provided that it is the sole isomer detected; however, when multiple isomers are detected in a medium, the isomer-specific concentrations must be added together and compared to the most restrictive screening level of the detected isomers.

Footnote **M**: The screening level may be below target detection limits (TDL).

Footnote **S**: Calculated health-based value exceeds the hazardous substance-specific water solubility limit; therefore, the water solubility limit is the screening level.

APPENDIX E

Soil Gas Compounds Screening List

APPENDIX E – Soil Gas Compounds Screening List

Below is a typical list of the compounds detected using the TO-15 Method. While most TO-15 laboratories have very similar analyte lists, there may be minor variations among labs depending on the source of their calibration cylinders. This list can be modified to include site contaminants that are not identified below. For sites that have already been adequately characterized, this list may be reduced considering all contaminants of concern and their degradation products. In addition, each TO-15 analysis is to include the reporting of the top five Tentatively Identified Compounds greater than five parts per billion by volume (ppbv) (reported as micrograms per cubic meters (µg/m$^{3]}$)) that are not attributed to column breakdown, as compared to response of the nearest internal standard.

COMPOUND	CAS No.
Acetone	67-64-1
Benzene	71-43-2
Benzyl chloride	100-44-7
Bromodichloromethane	75-27-4
Bromoform	75-25-2
Bromomethane (Methyl Bromide)	74-83-9
1,3-Butadiene	106-99-0
2-Butanone (Methyl ethyl ketone, MEK)	78-93-3
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroethane (Ethyl chloride)	75-00-3
Chloroform	67-66-3
Chloromethane (Methyl chloride)	74-87-3
Cyclohexane	110-82-7
Dibromochloromethane	124-48-1
1,2-Dibromoethane (Ethylene dibromide)	106-93-4
1,2-Dichlorobenzene	95-50-1
1,3-Dichlorobenzene	541-73-1
1,4-Dichlorobenzene	106-46-7
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethene (DCE)	75-35-4
cis-1,2-Dichloroethene	156-59-2
trans-1,2-Dichloroethene	156-60-5
Dichlorodifluoromethane (Freon 12)	75-71-8
1,2-Dichloropropane	78-87-5
cis-1,3-Dichloropropene	10061-01-5
trans-1,3-Dichloropropene	10061-02-6
Dichlorotetrafluoroethane (Freon 114)	76-14-2
Ethanol	64-17-5
Ethyl acetate	141-78-6
Ethylbenzene	100-41-4
4-Ethyltoluene	622-96-8
n-Heptane	142-82-5
Hexachloro-1,3-butadiene	87-68-3
n-Hexane	110-54-3
4-Methyl-2-pentanone (Methyl isobutyl ketone)	108-10-1
Methylene Chloride (Dichloromethane)	75-09-2

Methyl-tert-butyl ether (MTBE)	1634-04-4
Naphthalene	91-20-3
2-Propanol (isopropyl alcohol)	67-63-0
Propylene (Propene)	115-07-1
Styrene	100-42-5
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene (PCE)	127-18-4
Tetrahydrofuran	109-99-9
Toluene (Methylbenzene)	108-88-3
1,2,4-Trichlorobenzene	120-82-1
1,1,1-Trichloroethane (Methyl chloroform)	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethylene (TCE)	79-01-6
Trichlorofluoromethane (Freon 11)	75-69-4
1,1,2-Trichlorotrifluoroethane (Freon-113)	76-13-1
1,2,4-Trimethylbenzene	95-63-6
1,3,5-Trimethylbenzene	108-67-8
Vinyl chloride	75-01-4
m&p-Xylene	108-38-3
o-Xylene	95-47-6

Appendix F – MDEQ's Standard Operating Procedures

Table of Contents

APPENDIX F.1

Installation of a Soil Gas Probe/Vapor Monitoring Point to Support Vapor Intrusion Investigations

Remediation and Redevelopment Division

Standard Operating Procedure

INSTALLATION OF A SOIL GAS PROBE/VAPOR MONITORING POINT TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

Written by: **Matthew Williams, Vapor Intrusion Specialist**
Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines the generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a Soil Gas Probe/Vapor Monitoring Point. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Soil gas samples collected less than five feet below ground surface must be referenced as shallow soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil gas samples collected at depths greater than five feet below the surface.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

2.0 SAMPLING POINT INSTALLATION

Prior to selecting sample locations, an underground utility search is required. Miss Dig and, if necessary, the local utility companies must be contacted and requested to mark the locations of their underground lines. Each sample location should also be screened in the field with a metal detector or magnetometer to verify that no underground utilities or structures exist.

2.1 Boring Advancement

There are many methods to advance a boring intended to install a soil gas sampling point. It is highly recommended that the methodology utilized have the following characteristics:

- Nominal in diameter (less than three inches is recommended)
- Provide minimal disturbance to the surrounding soil
- Does not inject air or water fluids
- Provides a soil core that can be screened, visibly classified, and if necessary collected for chemical analysis

A hydraulic probe is often utilized to advance a boring utilizing two different sampling devices. Those are:

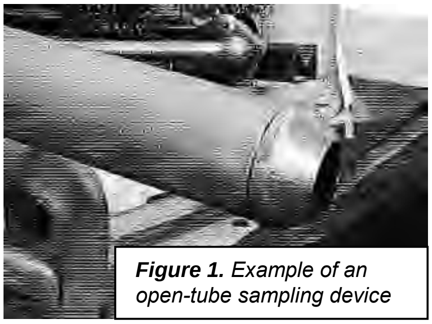

Figure 1. *Example of an open-tube sampling device*

- **Open-tube sampling device** – A direct push sampler for collecting continuous core samples of stable, unconsolidated materials. Although other lengths are available, a standard macro-core sampler (MC5) available from Geoprobe® is available in lengths between 48 and 60 inches with an outside diameter of 2.25 inches (Figure 1). Soil is collected inside a removable liner. Macro-core samplers are readily available and easy to use in most unsaturated soil conditions to at least ten feet below ground surface.

- **Dual-tube sampling system** – Dual-tube sampling systems are efficient methods of collecting continuous soil cores with the added benefit of a cased hole. Dual-tube sampling is beneficial in loose or unstable soils as a casing is advanced that prevents soil samples from falling into the boring (Figure 2).

Figure 2. *Example of a dual-tube sampling device*

Other methods for advancing boring include the use of hand augers, slab bars, and electric hammers. Each methodology has benefits and drawbacks and should be evaluated before a specific use is decided upon. The hydraulic probe methods identified above can be deployed in a wide variety of site conditions that allows the probe to be driven past some dense stratigraphic horizons.

2.2 Soil Gas Well Materials (General List of Materials)

Tubing – Sample probe tubing should be of a small diameter (1/8 to 1/4 inch) and made of materials that will not react or interact with target compounds. The size should also correspond to the size and construction of the sample point. Suggested materials are nylon, Teflon®, polyethylene, copper, polyvinyl chloride (PVC), or stainless steel. The choice of tubing type depends on site-specific considerations, but in general, nylon tubing is preferred as it exhibits lower adsorption rates and is more flexible and easier to work with than stainless steel

Figure 3. *Vapor point examples*

Soil Gas Well Screen – Screens must be less than six inches in length and configured to allow soil gas to enter along the entire length (Figure 3). This typically results in a fine mesh or screen being utilized to prevent dirt or other debris from entering into the sample tubing.

Sand Pack – The grain size of the sand pack should be sized appropriately (i.e., no smaller than the adjacent formation) and installed in a manner to minimize disruption of airflow to the sampling tip.

Bentonite – Bentonite is utilized to form a chemically resilient, low-permeability, flexible seal from above the well screen to the ground surface. In single vapor point well construction, granular bentonite or bentonite crumbles can be utilized. If multiple well screens are to be utilized, then a coated and compressed bentonite pellet or “tablet” must be utilized (1/4 inch) to prevent any bentonite dust from sealing portions of the borehole. It must be noted that adequately sealing soil gas sampling probes is very important to minimize the exchange of atmospheric air with the soil gas and to maximize the representativeness of the sample.

2.3 Soil Gas Well Installation

The following procedure does not account for the advancement of the boring due to the number of available methodologies available; however, it is imperative that for each boring a soil boring log is competed that provides details on the soil conditions and potential contamination encountered. The procedure below starts after the boring has been advanced and may need to be modified based on the boring methodology utilized. Construction details for each point must be documented in a field log.

A. Inspect the borehole to ensure that it has remained open and is free of water to the depth were the well screen is to be placed.
B. Place four to six inches of sand pack on the bottom of the boring.
C. Pre-assemble screen and tubing and lower into borehole in an upright position on top of the sand pack. If the boring is deep and narrow, adding a small inert weight (e.g., nut) may be utilized to facilitate the tube reaching the bottom.
D. Cut the tubing and temporarily terminate the surface end with a Swagelok cap or other fitting to prevent debris from entering into the line.
E. Mark tubing using tape and a ball-point pen to identify the probe location and depth. All marks should be on tags attached to the tubing and not on the tubing itself. Note: Permanent markers must not be used.
F. Place sand pack around the screen and extend the sand pack to six inches above the top of the screen.
G. Confirm the depth to the top of the sand pack.
H. Record all measurements on the field log.
I. Place one foot of dry granular bentonite or bentonite pellets on top of the sand pack.
J. Avoid lateral movement between the tubing and the bentonite as much as possible once a point has been installed.
K. Install bentonite pellets until six inches below the next screen interval and then hydrate with minimal water or one foot from the ground surface ensuring that the bentonite does not bridge during the placement. If an additional vapor point in the same boring is to be installed, return to Step A and repeat.
L. Ensure that the final bentonite seal is at least 2.5 feet thick.
M. Cut the protruding lengths of tubing successively shorter so the deepest sample tube is the longest length and the others progressively shorter. This is helpful if the labels on each tube are lost or illegible upon resampling.
N. Terminate surface ends of tubes with Swagelok caps, valves, or other desired terminations.
O. Complete all required field documentation.
P. Unless soil gas points are to be abandoned the same day they are installed, probes must be properly secured, capped, and completed to prevent infiltration of water or ambient air into the subsurface. For surface completions, the following components may be installed, as necessary:
    1. Fitting for connection to above ground sampling equipment
    2. Protective flush-mounted or above ground well vaults; and/or
    3. Guard posts

Examples of a single depth soil gas probe and a multi-depth or "nested" soil gas probe are shown in Figure 4. Figure 5 shows example pictures of surface completion.

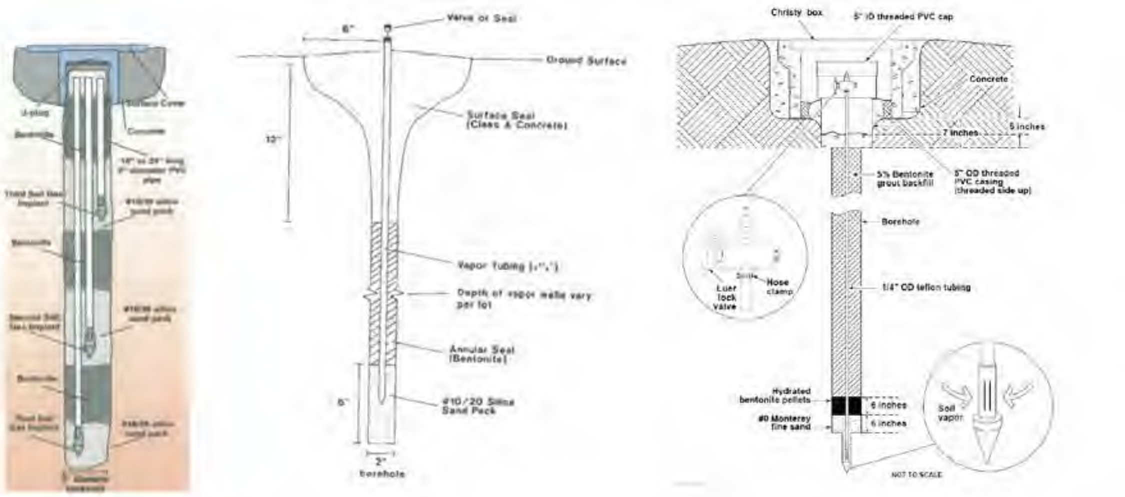

Figure 4. *Examples of complete vapor monitoring points*
[Hartman, 2004 (left and center) and Vonder Haar, S.*, 2000 (right)]*

Figure 5*. Examples of various surface completions for vapor wells. (Hartman, 2004)*

2.4 Soil Gas Well Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified above and that are less than 20 feet in depth may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to original site conditions.

If the tubing cannot be removed, the tubing should be filled with liquid grout and cut off at least one foot below the ground surface. All surface protective covers must be removed and the boring annulus backfilled with uncontaminated native material or grout and returned to as close as possible to original site conditions.

3.0 SOIL BORING LOGS AND VAPOR COMPLETION DIAGRAM

Boring logs and diagrams may be completed utilizing a variety of programs. The following information must be included for every vapor point installed:

- Project information
- Boring location
- Date Installed
- Total depth
- Project personnel including drilling contractor, driller, and geologist
- Drilling method
- Boring diameter
- Soil sampler utilized for lithology
- Sample recovery
- Soil description
- Field screening performed
- Samples sent for analysis
- Unified soil classification system classification
- Boring coordinates (state plane)
- A diagram representing installed sampling point that includes:
    - Surface completion
    - Bentonite seal used
    - Probe and screen construction materials and specifications
    - Depth of all installed materials including screen, bottom of screen, sand pack, tubing, and various bentonite seals

4.0 REFERENCES

Hartman, B., 2004. Vapor Monitoring Wells/Implants Standard Operating Procedures.

Vonder Haar, S., 2000. ERD SOP 1.10: Soil Vapor Surveys - Revision: 4.

Remediation and Redevelopment Division

Standard Operating Procedure

INSTALLATION OF A SUB-SLAB SOIL GAS PROBE/VAPOR MONITORING POINT TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

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1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a sub-slab soil gas probe/vapor monitoring point. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Sub-slab soil gas samples are vapor samples collected within two feet of the floor of the lowest point of the structure and must be referenced as sub-slab soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil samples collected at depths greater than five feet below the surface.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source.

2.0 SAMPLING POINT INSTALLATION

2.1 Boring Advancement

Borings should be through the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified by the SOP (see below) as well as be of sufficient size to penetrate the expected thickness of concrete present.

2.2 Sub-Slab Point Well Materials (General List of Materials)

Tubing:	1/4 inch diameter x 0.35 inch wall thickness stainless steel tubing for implant
Screen (optional):	3 inch stainless steel implant with 1/4 inch stainless steel compression fittings
Misc:	Mini SST ball-valve adapter, rubber shaft plug, top plug, hose barb, ¾" diameter bottle brush, compression fittings
Expendable supplies:	Neat cement, bentonite, or volatile organic compounds (VOC)-free plumbers putty or modeling clay
Surface termination:	Various surface terminations are available and the selection often depends on whether the probes are temporary or permanent and whether they need to be installed flush with the surface. This SOP utilizes products available from AMS, Inc.
Tools:	Shop-Vac® with with HEPA filter (optional) Rotary hammer drill 1 inch x 16 inch x 21 inch SDS max bit 2 inch x 3 inch x 16 inch SDS max core bit 50 cubic centimeter (cc) syringe

2.3 Sub-Slab Vapor Probe Installation Protocol

Figure 1. Hammer Drill

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.

2. Prior to fabrication of the sub-slab vapor probes, use the rotary drill and the **<u>two inch diameter drill bit</u>** to create a shallow (e.g., 1/4 to 1/2 inch in depth) outer hole that **partially** penetrates the slab (Figure 1). This outer hole will allow the protective cap to be flush with the concrete surface.

Figure 2. Inner & Outer Holes

3. Brush the hole with a bottle brush and use the small portable vacuum cleaner to remove cuttings from the outer hole.

4. Use the rotary hammer drill and the **<u>one inch drill bit</u>** to create a smaller diameter "inner" hole through the remainder of the slab and at least 6 inches into the underlying soil to form a void in the sub-slab material. Figure 2 illustrates the appearance of the "inner" and "outer" holes from the surface. Drilling into the sub-slab material will create an open cavity which will prevent obstruction of probes during sampling by small pieces of gravel.

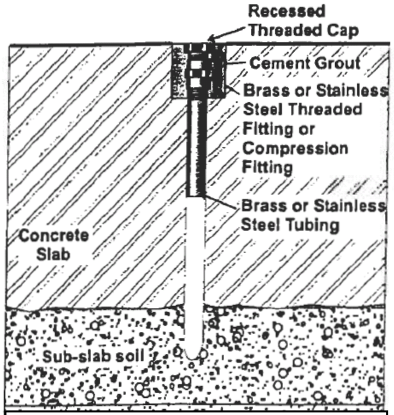

Figure 3. Typical sub-slab vapor probe (shown without a screen)

5. Brush the hole with a bottle brush and use a small portable vacuum cleaner to remove cuttings from the hole. Cuttings should be removed prior to advancing completely through the cement as much as possible. Once through the slab, care should be taken to minimize the amount of vacuum applied beneath the slab.

6. Determine the thickness of the slab and record the measurement.

7. Assemble the vapor point using the basic design of a sub-slab vapor probe illustrated in Figure 3.

Figure 4. Complete Vapor point

8. Place the assembled vapor point (Figure 4) into the hole and ensure the screen, if utilized, extends beyond the concrete and the top of the probe will be completed flush with the slab once the tamper resistant cap is applied, so as not to interfere with day-to-day use of the buildings. Cut tubing if necessary (Figure 5).

9. Confirm the fit of the rubber shaft plug to the sides of the boring. It should be snug and no gaps present. If additional thickness is necessary, VOC-free plumbers putty or modeling clay can be added to the sides of the rubber.

10. Mix quick-drying Portland cement with water to form slurry. Portland cement may expand upon drying. Points installed for a single sampling event may use VOC-free plumbers putty or modeling clay.

Figure 5. Cut tubing

11. Inject the Portland cement with a 50 cc syringe or push into the annular space between the probe and outside of the “outer” hole (Figure 6) until filled (Figure 7). If a tamper-resistant cap is to be used the cement should be left ¼” below the concrete surface.

12. Complete installed vapor point with a plug (Figure 8) or tamper-resistant cap (Figure 9).

13. Allow cement to cure for at least 24 hours prior to sampling. The time may be adjusted if quick-drying cement is utilized.

Figure 6. Seal annular space

Figure 7. Seal complete

Figure 8. Plug

Figure 9. Tamper-resistant cap

2.4 Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to the original site conditions.

If the tubing cannot be removed, the tubing should be cemented in place. All surface protective covers must be removed and returned to as close as possible to original site conditions.

3.0 SOIL BORING LOGS AND VAPOR POINT COMPLETION INFORMATION

Boring logs and diagrams must be completed. A variety of programs may be utilized; however, the following information must be included for every sub-slab vapor point installed:

- Project information
- Boring location
- Date installed
- Total depth
- Thickness of concrete
- Project personnel including drilling contractor, driller, and geologist
- Boring diameter
- Soil description (if identified)
- Field screening performed
- A diagram representing installed sampling point that includes:
    - Surface completion
    - Seal used
    - Probe and screen construction materials and specifications
    - Depth of all installed materials including screen, bottom of screen, sand pack, and tubing

4.0 REFERENCES

Though not specifically referenced, the SOP is based upon the following:

DiGiulio, Dominic. DRAFT Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations. United States Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Ground-Water and Ecosystem Restoration Division, Ada, Oklahoma.

Hartman, B., 2004. Vapor Monitoring Wells/Implants Standard Operating Procedures.

Remediation and Redevelopment Division

Standard Operating Procedure

SAMPLING UTILIZING USEPA METHOD TO-15
VIA
BOTTLE-VAC® TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

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The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for collecting a vapor sample through either a soil gas probe/vapor monitoring point and/or sub-slab monitoring point for the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (USEPA, 1999). Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. Considerations must be given to the types of chemicals of concern, lithology encountered, and the depth of the vapor source. Samples collected deeper than any potential source of vapors may not fully characterize the potential risk and sampling points should never be installed or collected within the zone of saturation.

The Method TO-15 in this procedure has been modified for use with one-liter Bottle-Vac® samplers by Entech Instruments, Inc. Bottle-Vacs® are utilized by the MDEQ's Laboratory in all soil gas sampling applications. Bottle-Vac® has been shown by internal testing performed by the MDEQ Laboratory to be reliable for both holding times and reporting requirements in soil gas sampling applications.

2.0 SOIL GAS COLLECTION

Most vapor wells are installed at relatively shallow depths (less than ten feet below ground surface) so minimum purge volumes and low-volume samples must be performed to minimize potential breakthrough from the surface or between sampling intervals. Tracer/leak gas is necessary to ensure breakthrough does not occur and that a leak does not occur at any fitting above grade. Samples must not be collected after any rain event and until site conditions (including moisture content) return to typical site conditions.

Samples from wells with multiple points installed must not be collected simultaneously and approximately 30 minutes must elapse between each sampled interval which should be documented on the field log. Sample flow rates are not to exceed 200 milliliters per minute (ml/min) to minimize the potential for vacuum extraction of contaminants from the soil phase. Volumes of various tubing sizes are provided in Table 1 in order to aid in calculating purge volumes.

Table 1
Volumes for Select Tubing Sizes

Tubing Size (inches ID)	*Volume/ft. (liters)*
3/16	0.005
1/4	0.010
1/2	0.039

Care must be used during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. Care must also be taken to avoid excessive purging prior to sample collection and prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. The sampling team must avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances) which could potentially cause sample interference in the field.

IMPORTANT SAMPLING NOTES:

- An initial vacuum test must be performed on each point. This is done by attaching a 50-ml syringe and pulling back on a point to ensure that the point is able to provide adequate vapor without obtaining a vacuum. If a point is installed in which the syringe cannot be withdrawn without generating a vacuum, the sampling point may not be valid and may need to be replaced.
- If water droplets are observed in the tubing or in a Bottle-Vac®, the sampling crew must note the presence of water on the sample label and Chain of Custody and recollect the sample.
- Bottle-Vac® must remain out of the sun and not placed on ice or chilled.
- Collected Bottle-Vac® samples must be stored at room temperature and not left in a hot vehicle or freezing vehicle.
- Label all samples with the label provided by the lab using a ballpoint pen. *Do not use a Sharpie*!
- Wash hands or replace sampling gloves between samples to ensure the leak/tracer compound is not on your fingers when connecting fittings.
- Disposable equipment and supplies must not be used for multiple sampling points.
- *Do not write* on boxes provided by the MDEQ Laboratory.
- *Do not remove* the green tape from the flow regulator. Do not adjust; the flow regulator has been calibrated to the correct flow rate of 100 to 200 ml/min.
- The MDEQ provides a dedicated regulator for each sample that is collected. The ID of each regulator should be referenced on the sampling form and any issues reported to the MDEQ Laboratory.

2.1 Soil Gas Collection General List of Materials

The equipment required for soil gas sample collection is as follows:

Tooling and Supplies	**Flow Meters and Detectors:**
• Bottle-Vac® (one per location) • Regulated flow meter assembly set to a maximum of 200 ml/min (one per location) • 1/4 inch tubing (suggested materials are nylon, Teflon® polyethylene, or similar) and assorted fittings • Plastic housing for using tracer gas • 50 ml syringe (for purging) • Camera • Adjustable crescent wrenches, small to medium size, and/or open end combo wrenches 9/16 to 1/2 inch • Scissors/snips to cut tubing • Ballpoint pens • Nitrile gloves • Compound to be used as tracer gas - lab grade helium	• Flow regulator with vacuum gauge. Flow regulators provided by the MDEQ Laboratory are pre-calibrated to a specified flow rate (e.g., 100 ml/min). • Photoionization detector (with appropriate lamp • Helium detector • Methane meter for petroleum sites that is capable of also measuring percent of methane (CH_4), carbon dioxide (CO_2), and oxygen (O_2) • Optional meter to measure %LEL of methane
	Forms: • Chain of Custody forms • Soil gas sample collection log (example attached) • Field notebook

2.2 Soil Gas Tracer Compounds

A leak in the sampling assembly may allow ambient air into the system and dilute the soil gas results (Benton, 2007). Therefore, tracer gases must be utilized during the collection of soil gas samples to verify that the sample collected is from the installed sampling point. The presence of a tracer compound, whether liquid or gaseous, can confirm a leak in the sampling train and the usability of the sample will need to undergo further evaluation.

Careful thought and consideration must be used when choosing a leak check compound as a tracer as each compound utilized can have specific benefits and drawbacks that should be considered. Figure 1 depicts a typical sub-slab sampling setup utilizing helium as a tracer gas. Though other compounds may be utilized, the MDEQ Laboratory has identified a preference for helium.

Helium used as a tracer gas beneath a shroud as shown in Figure 1 allows for the screening of the sampling train in the field. The use of a field meter capable of detecting helium may be able to resolve and correct any leaks by reevaluating the sampling train and retightening all fittings prior to collecting the sample for analysis. If a leak has been detected and is unable to be resolved, the sampling point may need to be decommissioned and a new one installed. Lab grade helium must be utilized to eliminate possible contribution issues as helium available at general merchandise stores may contain secondary contaminants such as benzene (Figure 2).

Understanding the relationship between a leak and the concentration detected of the tracer gas used to check for leaks, the potential for absorption of the tracer gas (i.e., helium) onto sample train tubing, and the potential for interference by the tracer gas compound with VOCs is important in answering the data usability. An ambient air leak up to ten percent may be acceptable if quantitative tracer testing is performed. Otherwise, the soil gas vapor well should be decommissioned if the leak cannot be corrected. Replacement vapor wells should be installed at least five feet from the location where the original vapor well was decommissioned due to a confirmed leak.

Figure 1. *Sampling shroud being pressurized with helium.*

Figure 2. *Use Ultra High Pure (UHP) grade helium to avoid background contaminants.*

2.3 Sample Collection Procedure

***Figure 3**. Sampling equipment.*

1. Allow for subsurface conditions to equilibrate and vapor concentrations to stabilize after vapor point installation:
    - Do not conduct the purge volume test, leak test, and soil gas sampling for at least 45 minutes.
    - Do not conduct the purge volume test, leak test, and soil gas sampling for at least 48 hours after vapor probe installation with augers.
    - Do not conduct the purge volume test, leak test, and soil gas sampling after any rain event until site conditions return to normal.

2. Assemble the aboveground sampling equipment which consists of new connector tubing, a designated regulated flow meter assembly including pressure gauge for each sample, purging equipment, and Bottle-Vac® (Figure 3).

3. Place the completed sampling label on the Bottle-Vac®.

***Figure 4.** Connect sampling line to point.*

***Figure 5**. Connect regulator to sampling line.*

***Figure 6**. Connect regulator assembly to shroud.*

4. Connect the above ground sampling line to the vapor monitoring point (Figure 4).

5. Connect the regulated flow meter assembly to sampling line (Figure 5).

6. Connect the regulated vapor flow meter assembly to the sampling shroud (Figure 6).

7. Calculate volume of air contained within the vapor point and sampling assembly up to the point where the sample will be collected and record on the field sampling form.

8. Check all sampling system connections and fittings for tightness and/or obvious deterioration.

Figure 7

Figure 8

Figure 9

9. Run all sampling lines through the helium shroud and place the enclosure on the ground (Figure 7). It may be appropriate to seal the enclosure to the ground using VOC-free plumbers putty, modeling clay, or hydrated bentonite.

10. Connect the sampling port line to the outside of shroud, making sure that the valve is closed (Figure 8).

11. Connect the helium cylinder to the tracer gas port. Opening the valve on the line from helium to the shroud, begin the flow of helium into the enclosure (Figure 9).

Figure 10

Figure 11

12. Confirm that the enclosure contains helium through the use of the helium detector.

13. Connect a 50 cubic centimeter (cc) syringe to the sampling port line and purge at least three volumes of air from the sampling system (Figure 10). After purging is complete, close the valve to the sampling line, disconnect the syringe, and close valve to the helium cylinder.

14. Calibrate the helium detector and zero for existing site conditions.

15. Connect the helium detector to the sampling port, collect, and record a reading (Figure 11).

16. If helium is detected, return to Step 5 and repeat process until no helium is detected. If a leak is unable to be resolved, the sampling point may need to be decommissioned and a new one installed.

17. Reaffirm that the enclosure contains helium through the use of the helium detector. If helium is not detected in the sampling enclosure, identify how the helium is leaving the enclosure and return to Step 6 and seal the enclosure as appropriate.

Figure 12

Figure 13

18. Disconnect or remove the sampling lines from the sampling enclosure leaving the flow regulator assembly and the lines connecting it into the sampling point in place (Figure 12).

19. Open the valve on sampling line.

20. Immediately connect the flow regulator assembly to the Bottle-Vac® using the quick connect adaptor and record the start time and vacuum gauge reading (Figure 13). The vacuum gauge should register about -28 millimeters mercury when it is first attached.

21. Check every two minutes and record the time at which the vacuum gauge reaches 0 pounds per square inch.

22. Calculate and confirm that the sampling rate is less than 200 ml/min. Record the flow regulator number on the sampling form and note any sampling discrepancies in the field notes and sampling form.

23. Disconnect the quick connect adaptor from the Bottle-Vac® and place paraffin on the top of the Entech Micro-QT® Valve.

24. Confirm the container has the proper label with the sample identification information.

25. Remove the flow regulator from the tubing and record the regulator number on the sampling form.

26. Complete the air volatiles request form. Be sure to circle Bottle-Vac® in the upper right.

27. Return everything including the Bottle-Vac®, adaptor, vacuum gauge, flow regulator assembly, and notes on equipment issues to the MDEQ Laboratory for analysis, cleaning, and calibration.

3.0 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES AND FIELD RECORDS

The Quality Assurance/Quality Control (QA/QC) procedures are an integral part of any sampling activities. The most important QA/QC procedures in collecting soil gas sampling are ensuring that the samples are representative of the subsurface conditions. For soil gas sampling, that means the QA/QC program identify procedures that verify that the sample is properly collected. Recording the pressure reading throughout the process is a critical component. Unlike soil or groundwater sampling, most of the containers and sampling devices utilized for sampling are verified clean. Upon request, the laboratory can provide laboratory batch cleaning results.

Trip blanks are typically not collected due to the sampling process and sampling devices that prevent the intrusion (or introduction) of air or other media into the sampling device. In addition, the failure of one flow regulator sampling assembly on a specific Bottle-Vac® does not provide an indication that any of the other sampling assemblies or Bottle-Vacs® have failed. Sampling blanks for soil gas sampling equipment including tubing and fittings may be collected if the source of the material is unknown or suspected to be contaminated.

Duplicate samples including blind duplicates are recommended to be collected to verify laboratory procedures and should include the collection of at least one field duplicate per sampling event or one per 20 samples, whichever is greater. When collecting duplicate samples in the field, it is imperative that the duplicate samples are collected simultaneous to collection of the primary sample using a sampling tee and at a combined sample rate to not exceed 200 ml/min from each point. Laboratory duplicate samples can also be collected from the same sampling Bottle-Vac® if the duplicate is not required to be a blind sample.

3.1 Soil Gas Sampling Record

The following information should be recorded in a field notebook or on sampling forms similar to those shown in Attachment 1 to document the procedures utilized at a specific site to collect soil gas data. In general, the fields should include the following information:

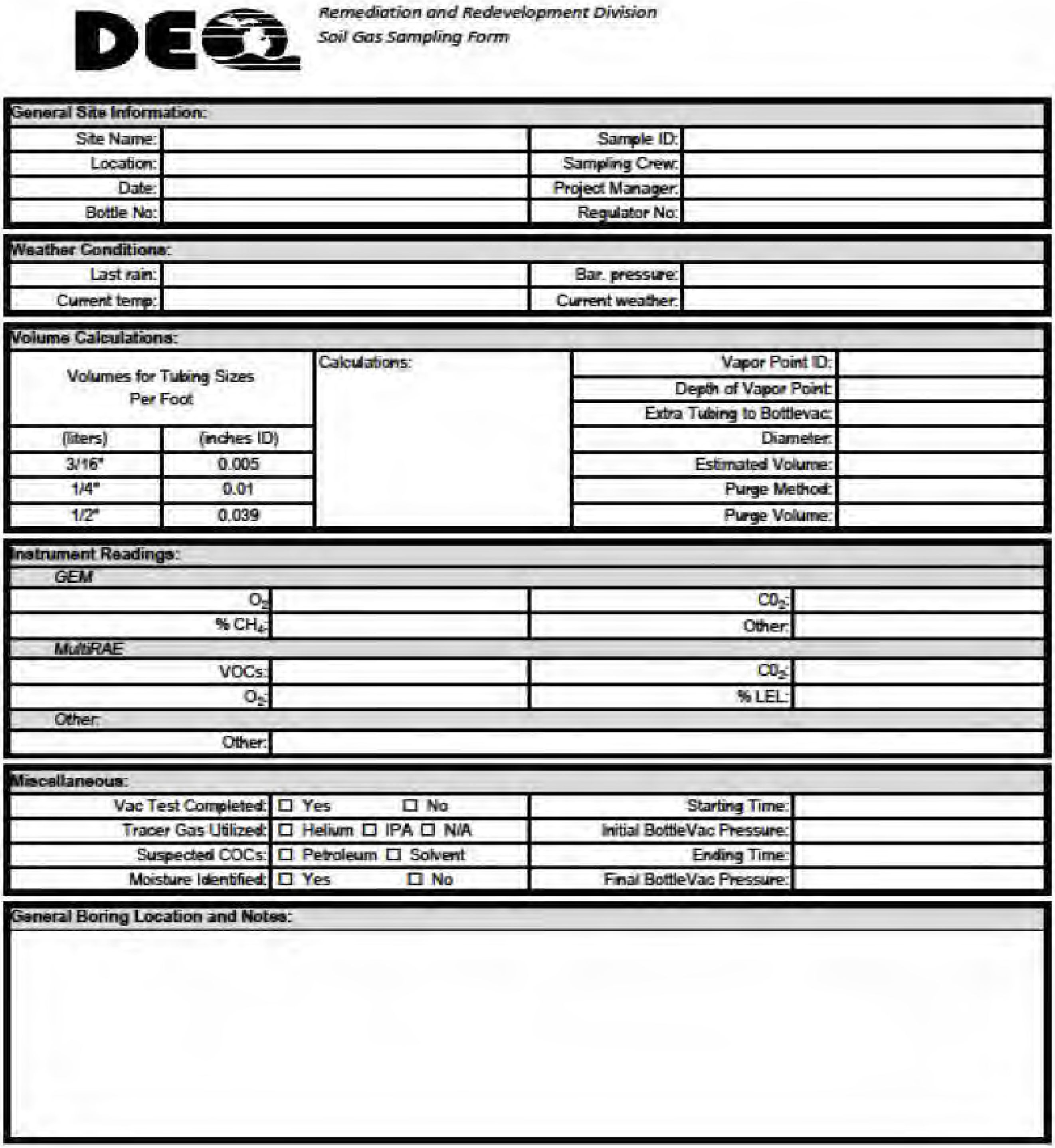
1. Sample identification information including the locations and depths at which the samples were collected, sample identifiers, date, and time
2. Identify the field personnel involved in the sample collection
3. Weather conditions (e.g., temperature, wind speed, barometric pressure, precipitation, etc.)
4. Sampling methods, devices, and equipment used
5. Purge volumes prior to sample collection. Relate the purge volumes to the volume of the sampling equipment, including the tubing connecting the sampling interval to the surface.
6. Volume of soil gas extracted (i.e., volume of each sample)
7. Vacuum of canisters before and after samples collected
8. Tracer gas utilized and whether it is a liquid or a solid
9. Field screening of any tracer gas

4.0 REFERENCES

Benton, Diane and Shafer, Nathan. 2007. Evaluating Leaks in a Soil Gas Sample Train, Paper #45 Extended Abstract, Air Toxics, Ltd.

United States Environmental Protection Agency. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15 Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, United States Environmental Protection Agency. Document No. EPA/625/R-96/010b.

Attachment 1



Remediation and Redevelopment Division
Soil Gas Sampling Form

General Site Information:

Site Name:		Sample ID:	
Location:		Sampling Crew:	
Date:		Project Manager:	
Bottle No:		Regulator No:	

Weather Conditions:

Last rain:		Bar. pressure:	
Current temp:		Current weather:	

Volume Calculations:

Volumes for Tubing Sizes Per Foot		Calculations:	Vapor Point ID:	
			Depth of Vapor Point:	
			Extra Tubing to Bottlevac:	
(liters)	(inches ID)		Diameter:	
3/16"	0.005		Estimated Volume:	
1/4"	0.01		Purge Method:	
1/2"	0.039		Purge Volume:	

Instrument Readings:

GEM			
O_2:		CO_2:	
% CH_4:		Other:	
MultiRAE			
VOCs:		CO_2:	
O_2:		% LEL:	
Other:			
Other:			

Miscellaneous:

Vac Test Completed:	☐ Yes ☐ No	Starting Time:	
Tracer Gas Utilized:	☐ Helium ☐ IPA ☐ N/A	Initial BottleVac Pressure:	
Suspected COCs:	☐ Petroleum ☐ Solvent	Ending Time:	
Moisture Identified:	☐ Yes ☐ No	Final BottleVac Pressure:	

General Boring Location and Notes:

Remediation and Redevelopment Division

Standard Operating Procedure

INDOOR AIR SAMPLING
VIA
USEPA METHOD TO-15

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

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PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

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1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for the collection of an indoor air sample and the analysis of volatile organic compounds (VOCs) by the United States Environmental Protection Agency Method TO-15 (TO-15) (USEPA, 1999). Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

The objective of this SOP is to describe the equipment and techniques utilized for the collection of time-integrated air samples in a Summa canister, with the ultimate goal of ensuring that similar methods and protocols are used when collecting such samples for analysis of VOCs to evaluate vapor intrusion. This is a SOP (i.e., typically applicable) which may need to be varied or changed dependent on site conditions, equipment limitations, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented.

This SOP does not cover, nor is it intended to provide, a justification or rationale for when this sampling is conducted. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work.

The TO-15 Method in this procedure has been established for the use of a Summa canister equipped with a regulator that will collect an indoor air sample continually over a 24-hour period. If a shorter time frame is necessary to evaluate nonresidential conditions, the following procedures will need to be modified accordingly. Laboratory detection limits must be compared from each method to the acceptable indoor air concentrations (AIAC) to assure that the detection limits will be equal to or less than the corresponding generic AIACs.

2.0 PRE-SAMPLING INSPECTION

An adequate background review must be conducted before sampling to obtain information on each structure from which a sample is collected. The background review should include a visual survey of each structure to ascertain the basement, crawl space, or slab-on-grade building configuration; determine if sumps, wells, or cisterns are associated with each structure; evaluate the condition of the floors and walls; and describe the heating and ventilation system within each structure. These features may act as conduits that will facilitate the migration of VOC vapors from the subsurface. An attached garage, basement, or workshop may store products that can contribute to indoor air impacts.

Interviews should be conducted with the owner/occupant of the building(s) to assess the use of potential contaminants, frequency of use, storage, as well as methods of handling and disposal. This information is vital to adequately evaluate activities that may influence the air sampling results and includes, but is not limited to: the length of occupant residency; ages of adults and children living in the structure; if occupants smoke and how often; and any hobbies using paints, solvents, and/or other potential contaminants.

A pre-sampling inspection must be performed prior to each sampling event to identify conditions that may affect or interfere with the proposed testing. The inspection should evaluate the type of structure, floor layout, physical conditions, and airflow of the building(s) being studied. The inspection information should be identified on a form similar to those included in Attachment 1. In addition, potential sources of chemicals of concern should be evaluated within the building by conducting a product inventory. The primary objective of the product inventory is to identify potential air sampling interference by characterizing the occurrence and use of chemicals and products throughout the building, keeping in mind the goal of the investigation and site-specific contaminants of concern (COCs). For example, it is not necessary to provide detailed information for each individual container of like items. However, it is necessary to indicate that "20 bottles of perfume" or "12 cans of latex paint" were present with containers in good condition. This information is used to help formulate the indoor environment profile.

Each room on the floor of the building being tested and on lower floors, if possible, should be inspected and an inventory provided. This is important because even products stored in another area of a building can affect the air of the room being tested. For example, when testing for a petroleum spill, all indoor sources of petroleum hydrocarbons should be scrutinized. These can include household and commercial products containing VOCs, petroleum products including fuel from gasoline-operated equipment, unvented space heaters and heating oil tanks, storage and/or recent use of petroleum-based finishes and paints, or products containing petroleum distillates. This information should be detailed in the survey forms in Attachment 1.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., photoionization detectors (PIDs) for VOCs, Jerome Mercury Vapor Analyzer for mercury) should be used to help evaluate potential sources. This includes taking readings near products stored or used in the building. Products in buildings should be inventoried **every time** air is tested to provide an accurate assessment of the potential contribution of volatile chemicals. If available, chemical ingredients of interest should be recorded for each product. If the ingredients are not listed on the label, record the product's exact full name, and the manufacturer's name, address, and phone number, if available. In some cases, Material Safety Data Sheets may be useful for identifying confounding sources.

3.0 PREPARATION OF BUILDING

Potential interference from products or activities releasing volatile chemicals may need to be controlled. Removing the source from the indoor environment prior to testing is the most effective means of reducing the interference. Ensuring that containers are tightly sealed may be acceptable. When testing for VOCs, containers should be tested with a field instrument to assess whether VOCs are leaking. The investigator should consider the possibility that chemicals may adsorb onto porous materials and may take time to dissipate. The goal of the testing is to evaluate the impact from products used or stored in the building (e.g., pesticide misapplications, school renovation projects). Depending on the field instrumentation utilized, small sources that may potentially impact indoor air may not be detected.

Once interfering conditions are corrected (if applicable), ventilation may be needed prior to testing to eliminate residual contamination in the indoor air. If ventilation is appropriate, it should be completed 24 hours or more prior to the scheduled sampling time. Where applicable, ventilation can be accomplished by operating the building's heating, ventilation, or air conditioning (HVAC) system to maximize outside air intake. Opening windows and doors and operating exhaust fans may also help or may be needed if the building has no HVAC system.

Air samples are sometimes designed to represent a typical exposure in a mechanically ventilated building, and the operation of the HVAC systems during sampling should be noted (see HVAC section on the attached indoor air quality questionnaire). In general, the building's HVAC system should be operating under normal conditions. Unnecessary building ventilation should be avoided within the 24 hours prior to and during testing. During colder months, heating systems should be operating under normal occupied conditions (i.e., 65° to 75°Fahrenheit) for at least 24 hours prior to and during the scheduled sampling time.

Depending on the goal of the indoor air sampling, some situations may warrant deviation from the above protocol regarding building ventilation. In such instances, building conditions and sampling efforts should be understood and noted within the framework and scope of the investigation.

FOR 24 HOURS PRIOR TO SAMPLING, ALL REASONABLE MEASURES SHOULD BE TAKEN TO AVOID:

- Smoking in the house
- Painting
- Using wood stoves, fireplaces, or other auxiliary heating equipment (e.g., kerosene heaters)
- Operating or storing automobiles in an attached garage
- Allowing containers of gasoline or oil to remain within the house, except for fuel oil tanks
- Cleaning, waxing, or polishing furniture or floors with petroleum- or oil-based products
- Using air fresheners or odor eliminators
- Engaging in any hobbies that use materials containing VOCs
- Using cosmetics, including hairspray, nail polish, nail polish removers, perfume/cologne, etc.
- Applying pesticides

4.0 COLLECTION OF SAMPLES

Air samples should be collected from an adequate number of locations to assess potential exposures to occupants. In private residences, air samples may be collected from each floor including: the basement, first floor living space, and from outdoors. The rate and number of sampling locations should be established by evaluating the building construction as well as the location of the sources. In general the number of samples should be collected at a rate of one indoor air sample per 1,000 sq ft of open space; however, the number of samples could be adjusted based on the following:

- A smaller number of samples may be appropriate for larger open spaces
- Samples need not be collected from the entire structure and should only be based on the location of the source of vapors
- Sampling locations should reflect where the inhabitants spend their time indoors and be centrally located to be representative of as large an area as possible, so living rooms or family rooms are often the sampling locations of choice
- Avoid locations where dilution air enters the building (e.g., near outside doorways) or where indoor emission sources may be nearby (e.g., utility rooms connecting the house to the garage)

Sampling devices should not be placed near doors, windows, stairways, or air supplies. In settings with diurnal occupancy patterns, such as schools and office buildings, samples should be collected during normally occupied periods to be representative of typical exposure. However, in special circumstances it may be necessary to collect air samples at other times in order to minimize disruptions to normal building activities. Sample collection intakes should be located to approximate the breathing zone for building occupants (i.e., three feet above the floor level where occupants are normally seated or sleep). To ensure that an air sample is representative of the conditions being tested and to avoid undue influence from sampling personnel, personnel should avoid lingering in the immediate area of the sampling device while samples are being collected. If the goal of the sampling is to represent average concentrations over longer time periods, then longer duration sampling periods may be appropriate. The sampling team members should avoid actions (e.g., fueling vehicles, using permanent marking pens) that can cause sample interference in the field.

4.1 Sample Analysis

Indoor air samples must be collected and analyzed in accordance with this SOP. In determining laboratory detection limits, the samples must be compared from each method to the AIACs to assure that the detection limits will be equal to or less than the corresponding generic AIACs.

Indoor air sampling to evaluate potential impacts from chemical contaminant sources (i.e., old spills, soil vapor, groundwater) should generally include the full list of compounds identified in Appendix C of the Remediation Division Guidance Document. The "Target Compounds List" identified in Appendix C includes a smaller subset of compounds than the entire list of compounds capable of being identified. Each analysis must also include the reporting of the top five Tentatively Identified Compounds greater than five parts per billion by volume that are not attributed to column breakdown, as compared to response of the nearest internal standard, when using the full-scan mode of the mass spectrometer. The laboratory will also report within the narrative if a hump is seen within the chromatogram such as is typical for gasoline, fuel oil, mineral spirits, etc.

4.2 Sampling Equipment

Time-integrated indoor air samples will be collected in specially prepared six liter (L) Summa canisters. Airflow into the canister is regulated by a sampling valve or a pneumatic flow controller attached to an in-line particulate filter. The sampling valve is typically used for short duration grab samples; however, the valve can be set for longer duration sampling. Flow controllers are precalibrated to regulate flow for sample collection times of 8 hours, 12 hours, or 24 hours.

Canisters will be cleaned and certified by the laboratory as per the USEPA TO-15 Method guidelines. During the planning stage for the sampling event, the laboratory will need information on the contaminants of interest, the analytical method, and reporting limits required for the project so that appropriately cleaned canisters can be selected. Also, the sampling team should consider requesting extra canisters and flow controllers from the laboratory due to the potential for equipment failure.

A vacuum gauge is utilized to measure and record the initial canister vacuum. A post-sampling vacuum reading is also taken to ensure that a sufficient sample has been collected and that some residual vacuum remains in the canister. The initial canister vacuum should be at least -26 inches of mercury (Hg). If the initial vacuum is less than -26 inches Hg (i.e., between 0 inches Hg and -25 inches Hg), the canister should be rejected and returned to the laboratory.

Stainless steel, Teflon, or nylon tubing can be attached to the in-line filter to obtain samples from the breathing zone or a remote location. The inlet manifold is placed in the breathing zone at approximately three to six feet above grade.

4.3 Quality Assurance/Quality Control

Extreme care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Appropriate quality assurance/quality control measures must be followed for sample collection and laboratory analysis. Items that should be addressed in sampling protocols include sampling techniques, certified-clean sampling apparatus, appropriate sample holding times, temperatures, and pressures. In addition, laboratory procedures must be followed including: field documentation (sample collection information and locations), Chain-of-Custody, field blanks, field sample duplicates and laboratory duplicates, as appropriate.

4.4 Sampling Information

Detailed information must be gathered at the time of sampling to document conditions prior to and during sampling to aid in the interpretation of the test results. The information should be recorded on the building inventory form along with the date and the investigator's initials. Floor plan sketches must be drawn for each floor and should include the floor layout with sample locations; chemical storage areas; garages; doorways; stairways; location of basement sumps; HVAC systems, including air supplies and returns; compass orientation (north); and any other pertinent information. In addition, observations such as odors, PID readings, and airflow patterns should be recorded on the building inventory form. Smoke tubes or other devices are helpful and should be used to confirm pressure relationships and airflow patterns, especially between floor levels and between suspected contaminant sources and other areas. Photos should be collected of each sampling container deployed within the structure.

Outdoor plot sketches must include the building site, area streets, outdoor sample location, the location of potential interference (e.g., gas stations, factories, lawn mowers), wind direction, and compass orientation (north arrow identified).

4.5 Sample Hold Time

The hold time is very compound-specific. For example, compounds such as chloroform, benzene, and vinyl chloride are typically stable in a canister for at least 30 days. The USEPA TO-15 Method states, "Fortunately, under conditions of normal usage for sampling ambient air, most VOCs may be recovered from canisters near their original concentrations for after storage times of up to thirty days." However, some VOCs degrade quickly and demonstrate low recovery even after seven days (Hayes, 2007).

5.0 SAMPLING PROCEDURES

5.1 Associated Hardware

5.1.1 Valve

A 1/4 inch stainless steel bellows valve (manufactured by Swagelok or Parker Instruments) should be mounted at the top of the canister. The valve allows vacuum to be maintained in the canister prior to sampling and seals off the canister once the sample has been collected. No more than a half-turn by hand is required to open the valve. Do not over tighten the valve after sampling or it may become damaged. A damaged valve can leak, possibly compromising the sample. Some canisters have a metal cage near the top to protect the valve (Hayes, 2007).

5.1.2 Brass Cap

Each canister comes with a brass cap (i.e., Swagelok 1/4 inch plug) secured to the inlet of the valve assembly. The cap serves two purposes: first, it ensures that there is no loss of vacuum due to a leaky valve or a valve that is accidentally opened during handling; second, it prevents dust and other particulate matter from fouling the valve. The cap is removed prior to sampling and replaced following sample collection (Hayes, 2007).

5.1.3 Particulate Filter

Particulate filters may be used when sampling with a canister. A separate filter (Figure 1) should be used for each sample collection to prevent any cross-contamination (Hayes, 2007).

Figure 1. Provided by Hayes, 2007

5.1.4 Fittings

Standard hardware fittings are 1/4 inch Swagelok; a 9/16 inch wrench is used to assemble the hardware. Compression fittings should be used for all connections; never use tube-in-tube connections. It is critical to avoid leaks in the sampling train. Leaks of ambient air through fittings between pieces of the sampling train (e.g., tubing to particulate filter) will dilute the sample and cause the canister to fill at a faster rate than desired (Hayes, 2007).

5.1.5 Vacuum Gauge

A vacuum gauge (Figure 2) is used to measure the initial vacuum of the canister before sampling and the final vacuum upon completion. A gauge can also be used to monitor the fill rate of the canister; however, most gauges should be considered as only a rough estimate of the pressure and should only be used to obtain a relative measure of “change” (Hayes, 2007).

Figure 2. Provided by Hayes, 2007

5.1.6 Flow Controllers

An air sample collected over time is referred to as an integrated sample and can provide information on compound concentrations in air averaged or composited over time. Illustrated here are some of the most common hardware configurations used to take an integrated sample. Flow controllers are devices that regulate the flow of air during sampling into an evacuated canister, (also known as flow restrictors). These devices enable a sampler to achieve a desired flow rate and, thus, a sampling interval. The flow controller (Figure 3) should allow the sample to be collected equally over a set period of time (Hayes, 2007).

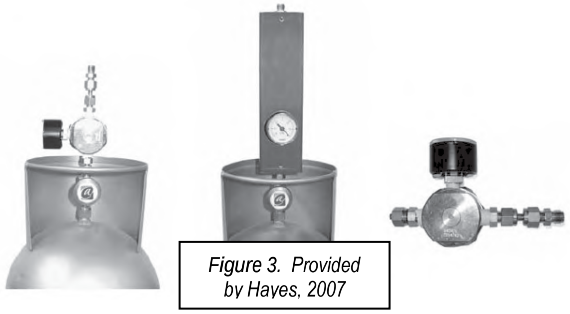


Figure 3. Provided by Hayes, 2007

5.2 Final Canister Vacuum and Flow Controller Performance

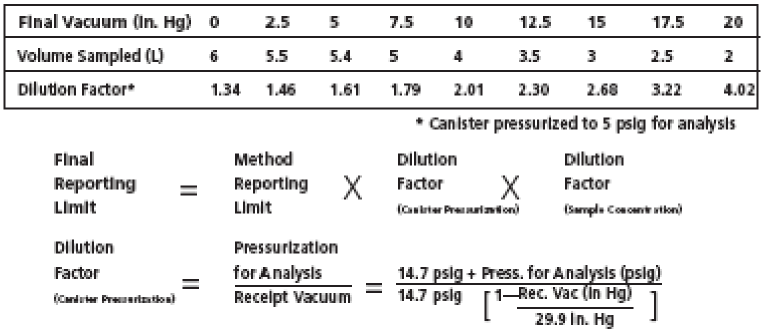
The final vacuum of a 6 L canister should be between five and ten inches Hg. As long as the differential pressure is greater than four inches Hg ambient pressure, the flow through the device will remain approximately constant as the canister fills. If there is insufficient differential pressure, the flow through the controller will decrease as the canister pressure approaches ambient. Because of the normal fluctuations in the flow rate (due to changes in ambient temperature, pressure, and diaphragm instabilities) during sampling, the final vacuum will range between two and ten inches Hg.

General considerations of the final canister vacuum include:

- If the residual canister vacuum is greater than five inches Hg (i.e., more vacuum), and less than 5 L of sample was collected in a 6 L canister. When the canister is pressurized to five pounds per square inch prior to analysis, sample dilution will be greater than normal. This will result in elevated reporting limits.
- If the residual canister vacuum is less than five inches Hg (i.e., less vacuum), the initial flow rate was high or there was a leak in the connection. Once the vacuum decreases below five inches Hg, the flow rate begins to drop significantly. This scenario indicates that the sample is skewed in favor of the first portion of the sampling interval.
- If the final vacuum is near ambient (i.e., less than one inch Hg), there is inadequate differential pressure to drive the flow controller. The sampler cannot be certain the desired sampling interval was achieved before the canister arrived at ambient conditions. Although the actual sampling interval is uncertain, the canister still contains a sample from the site.

Table 5.1 identifies the relationship between the final canister vacuum and the dilution factor, which may affect the ability of the sample to reach the required detection limits (Hayes, 2007).

Table 5.1: Relationship between Final Canister Vacuum, Volume Sampled, and Dilution Factor of a 6 L Canister



Final Vacuum (In. Hg)	0	2.5	5	7.5	10	12.5	15	17.5	20
Volume Sampled (L)	6	5.5	5.4	5	4	3.5	3	2.5	2
Dilution Factor*	1.34	1.46	1.61	1.79	2.01	2.30	2.68	3.22	4.02

* Canister pressurized to 5 psig for analysis

$$\text{Final Reporting Limit} = \text{Method Reporting Limit} \times \underset{\text{(Canister Pressurization)}}{\text{Dilution Factor}} \times \underset{\text{(Sample Concentration)}}{\text{Dilution Factor}}$$

$$\underset{\text{(Canister Pressurization)}}{\text{Dilution Factor}} = \frac{\text{Pressurization for Analysis}}{\text{Receipt Vacuum}} = \frac{14.7\text{ psig} + \text{Press. for Analysis (psig)}}{14.7\text{ psig}\left[1 - \frac{\text{Rec. Vac (in Hg)}}{29.9\text{ in. Hg}}\right]}$$

(Provided by Hayes, 2007)

5.3 Considerations for Sampling with Canisters

Avoid Leaks in the Sampling Train: A leak in any connection will mean that some air will be pulled in through the leak and not through the flow controller. A final pressure reading near ambient is one indication that there may have been a leak.

Verify Initial Vacuum of Canister: See Section 4.2 for detailed instructions on verifying initial canister vacuum.

Monitor Integrated Sampling Progress: It is a good idea to monitor the progress of the sampling during the sampling interval. The volume of air sampled is a linear function of the canister vacuum. For example, halfway (four hours) into an eight-hour sampling interval, the canister should be half filled (2.5 L), and the gauge should read approximately 17 inches Hg. More vacuum than 17 inches Hg indicates that the canister is filling too slowly; less than 17 inches Hg and the canister is filling too quickly. If the canister is filling too quickly because of a leak or incorrect flow controller setting, corrective action can be taken. Ensuring all connections are tight may eliminate a leak. It is possible to take an intermittent sample.

Avoid Contamination: Flow controllers should be cleaned between uses. This is done by returning them to the laboratory.

Caution Against Sampling in Extreme Temperatures: There can be some flow rate drift if the temperature of the controllers is allowed to vary significantly.

5.4 Step-by-Step Procedures for Integrated Sampling

These procedures are for a typical air sampling application and must be documented; actual field conditions and procedures may vary.

Before Arriving at the Field

1. Verify contents of the shipped package (e.g., Chain of Custody, canister, particulate filter, and flow controller)
2. Verify the gauge is working properly
3. Verify the initial vacuum of the canister

It is important to check the vacuum of the canister prior to use. The initial vacuum of the canister should be greater than -26 inches Hg. If the canister vacuum is less than -26 inches Hg, do not use it.

Vacuum Verification

The procedure to verify the initial vacuum of a canister is simple but unforgiving:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove the brass cap
3. Attach gauge
4. Attach brass cap to side of gauge tee fitting, if one is not already there, to ensure a closed train
5. Open and close valve quickly (a few seconds)
6. Read vacuum on the gauge
7. Record gauge reading on “Initial Vacuum” column of Chain of Custody

8. Verify the canister valve is closed and remove gauge
9. Replace the brass cap

Sample Collection

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove brass cap from canister
3. Attach flow controller to canister
4. Place the brass cap at the end of the flow controller creating an airtight train, and quickly open and close the canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady.
5. Once the sample train is airtight, remove the brass cap from the flow controller and open the canister valve, one-half turn.
6. Monitor integrated sampling progress periodically
7. Verify and record final vacuum of canister (simply read built-in gauge)
8. Close valve by hand tightening knob clockwise
9. Replace brass cap
10. Fill out canister sample tag (make sure the sample identification (ID) and date of collection recorded on the sample tag matches what is recorded on the COC exactly).
11. Return canisters in boxes provided
12. Return sample media in packaging provided
13. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
14. Place Chain of Custody in box and retain copy
15. Tape box shut and affix custody seal at each opening (if applicable)
16. Ship accordingly to meet method holding times

The final vacuum of a 6 L canister should be between five and ten inches Hg and the final vacuum should be noted on the Chain of Custody. This will enable the laboratory to compare the final vacuum with the receipt vacuum (i.e., the vacuum measured upon arrival at the laboratory).

Important Information for Canister Sampling

- *Do not* use a canister to collect explosive substances, radiological or biological agents, corrosives, extremely toxic substances, or other hazardous materials. Please check applicable regulations and guidance for shipping limitations.
- *Always* use a filter when sampling.
- *Never* allow liquids (including water) or corrosive vapors to enter canister.
- *Do not* attach labels to the surface of the canister or write on the canister.
- *Do not* over-tighten the valve and remember to replace the brass cap.

6.0

REFERENCES

Hayes, H. 2007. Canister and Bag Sampling Guide. *Air Toxics Ltd. Publication, Revision 5,* March 2007, http://www.airtoxics.com/literature/AirToxicsLtdSamplingGuide.pdf.

United States Environmental Protection Agency. 1999. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Second Edition. Compendium Method TO-15 Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS). Center for Environmental Research Information, Office of Research and Development, United States Environmental Protection Agency. Document No. EPA/625/R-96/010b.

ATTACHMENT 1

INDOOR AIR SAMPLING EVENT INSTRUCTIONS

and

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM

Instructions for Occupants

INDOOR AIR SAMPLING EVENTS

____will be collecting one or more indoor air samples from your building in the near future. In order to collect an indoor air sample in your structure that is both representative of indoor conditions and avoids the common sources of background air contamination associated with household activities and consumer products, your assistance is requested.

Please follow the instructions below starting at least 48 hours prior to and during the indoor air sampling event:

- Operate your furnace and whole house air conditioner as appropriate for the current weather conditions.
- Do not use wood stoves, fireplaces, or auxiliary heating equipment.
- Avoid using window air conditioners, fans, or vents.
- Do not smoke in the building.
- Do not use air fresheners or odor eliminators.
- Do not use paints or varnishes (up to a week in advance, if possible).
- Do not use cleaning products (e.g., bathroom cleaners, furniture polish, appliance cleaners, all-purpose cleaners, floor cleaners).
- Do not use cosmetics, including hair spray, nail polish remover, perfume, etc.
- Avoid bringing freshly dry-cleaned clothes into the building.
- Do not partake in hobbies indoors that use solvents.
- Do not apply pesticides.
- Do not store containers of gasoline, oil, or petroleum based or other solvents within the building or attached garages (except for fuel oil tanks).
- Do not operate or store automobiles in an attached garage.
- Do not operate gasoline powered equipment within the building, attached garage, or around the immediate perimeter of the building.

You will be asked a series of questions about the structure, consumer products you store in your building, and household activities typically occurring in the building. These questions are designed to help us differentiate chemical vapors from your household products from those related to subsurface contamination. Additionally, the analyte list may include only a select few target analytes and not a "wide variety of chemicals." Various compounds found in common household products (such as paint, new carpeting, nail polish remover), might be found in your sample results.

Your cooperation is greatly appreciated. If you have any questions about these instructions, please feel free to contact: ____

____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM

Date: ________________ Survey Performed by: ____

1. OCCUPANT:

Rent: _____ Own: _____

Resident Name: ____

Address: ____

Telephone: Home: ______________________ Work: ________________________

How long have you lived at this location? _________________________

List current occupants/occupation below (attach additional pages if necessary):

Age (If under 18)	Sex (M/F)	Occupation

2. OWNER OR LANDLORD: (If same as occupant, check here ___ and go to Item No. 3).

Last Name: ______________________________ First Name: _____________________

Address: ____

City and State: ____

County: __________________________________

Home Phone: ___________________________ Office Phone: ________________________

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

3. SENSITIVE POPULATION:

Daycare/Nursing Home/Hospital/School/Other (specify): ________________________

4. BUILDING CHARACTERISTICS:

Residential/Multi-family Residential/Office/Strip Mall/Commercial/Industrial/School

Describe Building: ___________________________________ Year Constructed: ______

Number of floors at or above grade: ______

Number of floors below grade: _______ (full basement/crawl space/slab on grade)

Depth of structure below grade: _______ ft.   Basement size: ________ ft^2

If the property is residential, what type? (Circle all appropriate responses.)

Ranch
Split Level
Mobile Home
Modular
2-Family
Colonial
Duplex
Log Home
3-Family
Cape Cod
Apartment House
Other: _________________________________
Raised Ranch
Contemporary
Townhouses/Condos

If multiple units, how many? ________

If the property is commercial:

Business type(s) ____

Does it include residences (i.e., multi-use)? Yes   No   If yes, how many? _____

5. OCCUPANCY:

Is basement/lowest level occupied? (Circle one)

Full-time   Occasionally   Seldom   Almost Never

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Level **General Use**
(e.g., family room, bedroom, laundry, workshop, storage)

Basement ____

1st Floor ____

2nd Floor ____

3rd Floor ____

4th Floor ____

(Use additional page(s) as necessary)

6. CONSTRUCTION CHARACTERISTICS: (Circle all that apply.)

a. Above Grade Construction: (Describe type: wood frame, concrete, stone, brick).

____

b. Basement Type: Full Crawlspace Slab Other: __________

c. Basement Floor: Concrete Dirt Stone Other: __________

d. Finished Basement Floor: Uncovered Covered

If covered, what with? ____

e. Foundation Walls: Poured Block Stone Other: __________

f. Foundation Walls: Unsealed Sealed Sealed with: ______________

g. The Basement is: Wet Damp Dry

h. The Basement is: Finished Unfinished Partially Finished

i. Sump Present (Y / N) If yes, how many? __________________

Where Discharged? ______________________________

Water in Sump? Yes No Not Applicable

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Identify all potential soil vapor entry points and estimated size (e.g., cracks, utility parts, drains).

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Yes No

Type of ground cover outside of building: Grass Concrete Asphalt Other ________

Is an existing subsurface depressurization (radon) system in place? Yes No

If yes, is it active, or passive?

Is a sub-slab vapor/moisture barrier in place? Yes No

Type of barrier: ____

7. HEATING, VENTING, and AIR CONDITIONING

Type of heating system(s) used in this building: (Circle all that apply: Note the primary).

Hot Air Circulation
Space Heaters
Electric Baseboard
Heat Pump
Steam Radiation
Wood Stove
Hot Water Baseboard
Radiant Floor
Outdoor Wood Boiler
Other: ____________________________________

The primary type of fuel used is:

Natural Gas
Electric
Wood
Fuel Oil
Propane
Coal
Kerosene
Solar

Domestic hot water tank fueled by: ____________________________________

Location of Boiler/Furnace: Basement Outdoors Main Floor Other ______________

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Air Conditioning: Central Air Window Units Open Windows None

Are air distribution ducts present? Yes No

Is there a whole house fan? Yes No

Describe the air intake system (outside air supply, cold air return, ductwork, etc.) and its condition where visible. Indicate the locations on the floor plan diagram.

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

a) Is there an attached garage? Yes No

If yes, does it have a separate heating unit? Yes No

b) Are any petroleum-powered machines or vehicles stored in an attached garage (e.g., lawn mower, ATV, car) Yes No

c) Has the building ever had a fire? Yes No

d) Is there a fuel burning or unvented gas space heater? Yes No

e) Is there a workshop or hobby/craft area? Yes No

If yes, where and what type? ________________________________

f) Is there smoking in the building? Yes No

If yes, how frequently? ________________________________

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

g) Have cleaning products been used recently? Yes No

If yes, when and what type? ______________________________

h) Have cosmetic products been used recently? Yes No

If yes, when and what type? ______________________________

i) Has there been painting or staining in the last six months? Yes No

If yes, when and where? ______________________________

j) Is there new carpet, drapes, or other textiles? Yes No

If yes, when and where? ______________________________

k) Have air fresheners been used recently? Yes No

If yes, when and what type? ______________________________

l) Is there a kitchen exhaust fan? Yes No

If yes, where is it vented? ______________________________

m) Is there a clothes dryer? Yes No

If yes, is it vented outside? Yes No

n) Has there been a pesticide application? Yes No

If yes, when and what type? ______________________________

____

o) Are there odors in the building? Yes No

If yes, please describe: ______________________________

____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

p) Do any of the building occupants use solvents at work (e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetology)?

Yes No

If yes, what types of solvents are used?____

____

If yes, are their clothes washed at work? Yes No

q) Do any of the building occupants regularly use or work at a dry-cleaning service? (Circle appropriate response.)

No Unknown

Yes, use dry-cleaning regularly (weekly)

Yes, use dry-cleaning infrequently (monthly or less)

Yes, work at a dry-cleaning service

r) Is there a radon mitigation system for the building/structure? Yes No

If yes, what is date of installation? __________________ Active Passive

s) Additional mitigation system information (fan size, location, operating status, liner installed, etc.):

____

____

____

____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

9. SAMPLE COLLECTION

This is to be completed by the sample collection team. On a separate sheet(s), provide a sketch of the building (including each floor as applicable), all (nonremovable) potential indoor sources found in the building (including attached garages), the location of the source (floor and room), and each sample location (see below). Any ventilation implemented after removal of potential sources shall be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Photographs should be taken at each sample location, and of any nonremovable source, to supplement the documentation recorded below. The photographs must be of good quality and any labels must be legible.

Location	Sample ID	Sample Container Size	Sample Duration	Flow Rate Verification (Y / N)	Comments

Sampling Information:

Sample Technician: ______________________________ Telephone No.:________________

Analytical Method: TO-15 / TO-17 / Other: ____

Laboratory: ____

INDOOR AIR BUILDING SURVEY AND SAMPLING FORM (continued)

Were "Instructions for Occupants" followed? Yes No

If not, describe modifications:

____

____

____

____

Was field screening performed? Yes No

If yes, describe Make and Model of field instrument used:

____

Meteorological Conditions

Was there significant precipitation within 12 hours prior to (or during) the sampling event? Yes No

Describe the general weather conditions:

____

____

____

____

General Observations:

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process:

____

____

____

____

BUILDING: ________________________

FLOOR: __________________________

ATTACH ADDITIONAL DETAIL AS NECESSARY

Remediation and Redevelopment Division

Standard Operating Procedure

DYNAMIC FLUX CHAMBER METHOD FOR MONITORING SOIL SURFACE EMISSION RATES

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: __________ Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

Written by: **Matthew Williams, Vapor Intrusion Specialist**
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Remediation and Redevelopment Division
Michigan Department of Environmental Quality

The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. Differences may exist between the procedures referenced in this SOP and what is appropriate under site-specific conditions. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

1.0 INTRODUCTION

This SOP outlines the MDEQ's method and considerations for Dynamic Flux Chamber sampling and is based on the methodology outlined by Radian, 1986, with consideration of issues identified by Eklund, 1992 and Hartman, 2003. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Volatile organic compounds (VOCs) in contaminated soil have the potential to migrate into ambient or indoor air where they may be inhaled by people or animals. The rate at which a vapor-phase chemical crosses the soil-air interface is called the contaminant "flux" rate, which is measured as mass per unit area per unit time (e.g., micrograms of contaminant per square meter of soil surface per minute). Contaminant flux rates can be estimated based on general assumptions about chemical characteristics, partitioning, soil conditions, diffusion rates, and attenuation, among other things (Radian, 1986). However, flux estimates based on mathematical models may not be sufficiently accurate for assessing risks in some circumstances. In such cases, the isolation flux chamber method can be used to directly measure the contaminant's concentration at the soil-air interface as well as the rate at which the compound moves from soil to air.

The isolation flux chamber approach uses an enclosure device, referred to as a flux chamber, to sample gaseous emissions from a defined surface area. The chambers may be used with a flow of sweep gas through the chamber (a "dynamic" test) or without a flow of sweep gas (a "static" test). With the dynamic-chamber method, a clean, dry sweep gas (e.g., high-purity "zero" air) is introduced to the chamber at a fixed, controlled rate (e.g., 0.005 cubic meters per minute (m^3/min)) that is selected based on site conditions. The volumetric flow rate of sweep air through the chamber is recorded, and the concentrations of the VOCs of interest are measured at the exit port of the chamber (Eklund, 1992). As the flux chamber isolates the soil surface from external site conditions, the potential impacts of many meteorological conditions that may be highly variable throughout the day are minimized.

The emission rate of each contaminant can be calculated as:

$$\mathbf{EF_1 = C_1 * Q / A} \qquad \mathbf{(1)}$$

where:

EF$_1$ = emission rate of contaminant 1 (micrograms per square meter per minute (ug/m^2–min))
C$_1$ = measured concentration of contaminant 1 (units must be micrograms per cubic meter (ug/m$^{3]}$))
Q = sweep airflow rate (m^3/min)
A = surface area (m^2) enclosed by flux chamber

In this method, all parameters in Equation 1 are measured directly through the collection of air samples exiting the chamber. The use of this equation assumes that: (1) the chamber is operating under steady state (i.e., the rate of air flow through the chamber is constant and not a function of time); (2) contaminant flux is uniform over the entire covered surface and relatively constant during the sampling interval of ($t_2 - t_1$); (3) the incoming air stream and the emissions from the soil are well mixed inside the chamber; and (4) the diffusive process is dominant and the advective mass flow from the soil is negligible (Gao et al., 1997).

2.0 GENERAL CONSIDERATIONS FOR FLUX CHAMBER SAMPLING

As with any environmental sampling effort, the overall goal of flux chamber sampling is to obtain representative samples. Care should be taken to avoid cross-contamination or other poor field practices that could bias the analytical data either high or low. Each sampling event must be guided by a sampling and analytical plan prepared in advance and all field conditions and methodology must be documented. The sampling and analytical plan must contain a discussion of the following:

- **Equipment –** The typical flux chamber is a hemispherical "bowl" or cylinder fitted with a number of small-diameter ports for controlling the flow of gas into and out of the chamber and for measuring the temperature, pressure, or other conditions inside the chamber. See Figure 1. Flux chambers should be constructed from stainless steel or polycarbonate; flexible plastic materials are unacceptable. Various sample trains can be attached to an outlet port to collect samples for analysis in the field or at a fixed laboratory. See Section 3.0 for more information on the construction of a flux chamber.

Figure 1 *Flux chamber before deployment.*

- **Sealing the Chamber** – When measuring the flux from the soil surface, the edge of the chamber should be pushed approximately two centimeters (cm) into the soil to minimize the entry of ambient air around the edge of the chamber. In compacted soil or similar locations where a reasonably tight seal may be difficult to achieve in this way, hydrated bentonite should be placed around the edge of the chamber to improve the seal and prevent leakage.
- **Background Concentrations –** To the extent practicable, avoid collecting samples near potential sources of VOCs in ambient air that could enter the flux chamber and affect the results (e.g., motor vehicle exhaust, gasoline and other fuels, aerosol sprays, marking pens, adhesive tape, insect repellent, sunscreen, etc.). Note the presence of such factors in the field documentation.
- **Time of Deployment –** It is necessary to make a series of flux measurements in several locations to assess the spatial variability in emissions for a given source. It is also important that repeated measurements at a given location are performed to assess the temporal variability (Eklund, 1992). The collection of this data allows an estimation of an emission rate with a known confidence limit.
- **Sweep Air –** The sweep air carrier gas should be dry, organic-free air, equal to or better than commercial ultrahigh-purity grade (less than 0.01 parts per million by volume total hydrocarbons).

- **Sweep Airflow Rate –** This is perhaps the single most important operating factor. The sweep airflow rate can be varied to achieve the desired analytical sensitivity. The slower the flow rate, the lower the detection limits, but the longer it will take to reach steady-state concentrations within the chamber. However, the sweep airflow rate must be high enough to ensure that good mixing occurs within the chamber and to create sufficient turbulence to disrupt any laminar film boundary that may form above the soil surface. The sweep air flow should be set based on the results of previous testing; however, it is generally recommended that the sweep airflow rate be established based on a ratio of 25 liters of air per minute per square meter ($L/min/m^2$) of exposed surface area (St. Croix Sensory, Inc., 2010). The sweep gas must be allowed to exit at the same rate at which it is added to prevent a buildup of pressure or the formation of a vacuum inside the chamber, which would alter the flux rate and bias the data.
- **Chamber Purging –** The residence time (T) is defined as the chamber volume divided by the sweep air flow rate. It typically takes three to four residence times before steady-state concentrations are reached inside the chamber and sampling can be initiated. For example, a 0.030 m^3 chamber with a sweep air flow rate of 0.005 m^3/min has a residence time of six minutes, which means that sample collection can be started 24 minutes after the chamber is placed on the surface.
- **Sampling Time –** The minimum sampling time necessary is that time required to approach a steady-state concentration within the flux chamber (at least three to four residence times). The maximum acceptable sampling time will depend on the nature of the emission source and the objectives of the monitoring program. In general, whenever possible the sampling duration for soil should be held to 30 to 60 minutes.
- **Sampling Rate –** The sampling rate (i.e., the rate at which the gas sample is withdrawn from the discharge line) should be less than the flow rate of sweep gas. Otherwise, the outside air would be drawn into the chamber to dilute the sampling gas, which may result in inaccuracy of calculated emissions. Therefore, the sampling rate must be equal to or less than 0.75 times the flow rate of sweep gas.
- **Environmental Conditions –** Emission rates from soil immediately after a significant rainfall event typically will be lower than from drier soils, as a greater portion of the soil pore space is blocked by water. It is not acceptable for flux chamber sampling to occur for several days after a minor rain event and for up to seven days after 0.3 inches of rain or more has fallen (Radian, 1986). Barometric pressure has also been documented to have an effect on emission rate - higher emission rates are found during periods of lower atmospheric pressure. An effort should be made to avoid flux chamber sampling during periods of unusually high or low barometric pressure. Historical barometric pressure measurements should be reviewed to establish a normal range for the area and weather forecasts should be consulted during the project planning stage.
- **Chamber Pressure and Temperature –** The pressure and temperature inside the flux chamber should be kept as close to ambient conditions as possible. The temperature inside and outside of the flux chamber must be recorded several times during the sampling event and each time a sample is drawn from the chamber.
- **Analytical Techniques –** Assessing VOC emissions from soil using flux chambers is done by the USEPA TO-15 Method (USEPA, 1999) via Summa canister or Bottle-Vac®. This method provides the typical reporting limit of 0.1 to 0.001 micrograms per liter.
- **Sample Collection Intervals –** In addition to the initial (t_0) sample, at least three flux chamber samples should be collected at the same grid coordinates throughout the day to evaluate the daily variation of flux. If a 95 percent upper confidence limit is to be used in future calculations for determining an emission rate, then an appropriate number of samples (e.g., a minimum of nine samples) must be collected from each location.

FLUX CHAMBER CONSTRUCTION AND DESIGN

Flux chamber data can be significantly affected by chamber design and the rules-of-thumb applicable to one design may or may not be applicable to an alternate design (Eklund, 1992). As a result, widely different design and operating practices can produce significantly different results.

This section is included as a general guide to the construction of flux chambers, additional information can be found in Eklund, 1992. Important design factors include chamber size, volume, geometry, construction materials, length of sampling lines, line construction, and air delivery system, some of which are described further below.

Figure 2 represents a generic construction diagram and its supporting equipment as depicted by Radian, 1986.

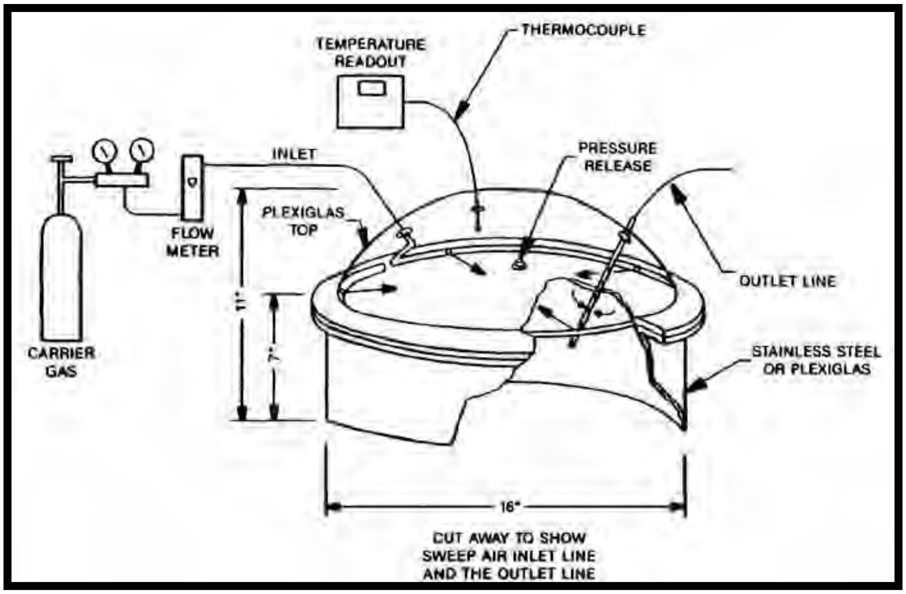


Figure 2 *Flux chamber construction diagram*

3.1. Chamber Size and Volume

In general, flux chamber sampling results are not heavily dependent on the chamber size and volume. The chamber size used is a trade-off among several considerations. The surface area enclosed should be as large as is feasible so that the observed emission flux is not unduly biased by relatively small areas of unrepresentative emissions, the areas perturbed by the chamber edge or seal are a small percentage of the total sampling area, and the wall effects are minimal (Eklund, 1992).

A smaller chamber volume may be advantageous since it minimizes the amount of sweep air used per measurement, is lightweight and easier to transport, and is simpler to fabricate. The volume should be large enough, however, that the volume of gas withdrawn for analysis is a small fraction of the volume in the flux chamber (i.e., the collection of samples from the discharge line does not significantly perturb the chamber atmosphere or pressure). As a general rule of thumb, flux chambers should not be smaller than 0.0074 m^3.

3.2 Materials of Construction

Typically, the flux chamber is constructed with a cylindrical skirt of stainless steel that has the necessary rigidity to be pushed into the soil with a dome made of polycarbonate, acrylic, or stainless steel. Suggested materials are nylon, Teflon®, polyethylene, copper, glass, or stainless steel. The sampling lines used for gas sample collections are typically Teflon® with stainless steel fittings. Based on this construction (and assuming the chamber is cleaned between sampling events), the carry-over of the VOCs from the chamber has never proven to be a problem under field conditions. In addition, sorption of the VOCs has typically not been found to be a problem, although adsorption onto long Teflon® lines (e.g., greater than three meters) is a potential concern, as is adsorption of polar VOCs such as methanol and acetone onto chamber surfaces (Eklund, 1992).

3.3 Air Delivery System

The introduction of sweep air into the flux chamber is perhaps the most important design factor. The air delivery system consists of a cylinder of compressed air fitted with a pressure regulator, small-diameter tubing, a flow meter, and small-diameter tubing inside the chamber to encourage mixing and minimize “short circuiting” between the inlet and outlet ports. Based on a typical sweep airflow rate of 0.005 m^3/min, a standard 149 $foot^3$ tank of gas should be sufficient for one flux chamber over two days of non-continuous sampling.

The USEPA’s approach to the air delivery system (shown on Figure 2) is to place 0.6-cm diameter tubing around the inside of the chamber near the intersection of the cylinder and the dome. The line must contain at least four perforations spaced uniformly around the base of the entire chamber that are parallel to the soil surface to eliminate components of airflow perpendicular to the soil surface (either downward or upward) (Gao et al., 1997).

4.0 SAMPLING METHODOLOGY

4.1 Office Preparation

Prior to departure for the field site, the following supplies should be assembled:

- Log book
- Appropriate field forms such as Soil Surface Flux Log Sheets (Attachment A) and Chain of Custody forms
- Flux chambers
- Sample containers with pressure regulators
- Cylinder of compressed zero-air or nitrogen
- Flow meters
- Ground probe or rod (minimum of three feet in length)
- Clean tubing and fittings
- Ground tarp or plastic
- Weather station for measuring ambient temperature, barometric pressure, and relative humidity
- Temperature probes
- Handheld VOC detector
- Laptop computer with charged internal battery and a sufficient number of charged external batteries to last over the sampling period

In addition, it is important to confirm that the volume of the flux chamber is several times greater than the volume of the container (e.g., Summa canister or "Bottle-Vac®") used to collect the sample. Flux chamber volumes of ten liters or greater are typical. Flux chambers must be cleaned using Alconox (or equivalent) and/or heated and then wrapped in aluminum foil for transport.

4.2 Field Procedures

1. Sample locations must be cleared of all vegetation, gravel, or manmade surfaces (concrete, asphalt) to a depth where the upper soil horizon is visible. Where pavement or asphalt must be cut to access the soil surface, the hole will be sized to allow at least 6 to 12 inches of open area around the chamber. Locations where soil pores are likely to be plugged (e.g., by standing water or extreme compaction) will be recorded in the field notes and avoided.
2. At each location identified in the sampling plan, a probe will be pushed into the ground to a depth of at least two feet to check for the presence of buried foundations or pavement that could limit vapor migration and emissions.
3. Unwrap and inspect the flux chamber. Any residue should be removed using high pressure steam, then rinsed, and dried before use. Wipe the flux chamber clean using a clean cloth.
4. Position the flux chamber on the substrate at the sample location. The rim of the flux chamber should be worked into the surface a minimum of one inch to minimize ambient air intrusion. If a seal between the soil and the chamber cannot be established, hydrated bentonite should be placed around the edge of the chamber.
5. Attach all sampling lines and meters to the flux chamber (and to the sample canister) using a clean, 1/8 or 1/4 inch Teflon® or stainless steel tubing with Swagelok® (or equivalent) valve fittings.
6. Prepare all necessary equipment and supplies. Sample containers, equipment, and supplies should not be placed directly on the ground, on top of waste containers (e.g., drums), or on other potentially contaminated surfaces. Disposable tarps or construction plastic can be spread on the ground downwind from the chamber to provide a clean surface for temporary placement of the sampling equipment.
7. Seal all probes and access points, and/or close off all tubing so that the flux chamber is isolated from the ambient air, with the exception of the exhaust/sampling port, which should remain open. Note that care should be taken to avoid a positive pressure from developing within the chamber.
8. Connect the flux chamber to the sweep air through the inlet port.
9. Record the air temperature inside the flux chamber, the air temperature outside the flux chamber, and the barometric pressure.
10. Open the chamber inlet valve and begin airflow into the chamber at a predetermined rate.
11. For each chamber volume (residence time) record the flow rate, internal temperature, and reading collected with the handheld VOC detector.
12. Monitor emissions and note when steady-state concentrations are reached (approximately 3 to 5 residence times).
13. Record the air temperature inside the flux chamber, the air temperature outside the flux chamber, and the barometric pressure and begin sample collection.

4.3 Sample Collection

1. At the designated sampling time, attach the sampling device to the tubing connected to the exhaust/sampling port.
2. Record the starting canister vacuum and air temperature inside and outside of the flux chamber. The initial pressure of the canister should be between -30 and -27 inches of mercury. However, the canister will be considered acceptable (useable) if the pressure reading is between -30 and -24 inches of mercury.

3. Enter the sample number on the field sample data logging form as provided in Figure 3.
4. Record the start time on the data sheet and open canister inlet valve slowly (in some cases, the canister will begin filling at a predetermined rate as soon as it is connected to the flux chamber). The canister grab samples typically will be collected over a 1 to 3 minute period. A slight hissing sound can be heard during sampling by placing an ear against the canister. Sample containers will remain connected to the flux chamber until the pressure gauge reads zero.
5. After the sample container is filled, close the canister inlet valve and disconnect the sample line from the canister. Some quick-connect fittings will close automatically when they are disconnected from the flux chamber.
6. Record the final pressure reading shown on the gauge attached to the canister (it should be zero). Enter this information along with the stop time on the field sample record and on the sample Chain of Custody form.
7. Enter the sample number, the serial number of the sampling device (canister or sorbent cartridge), and other requisite information on the Chain of Custody form. Label the sampling device with the sample number, date, and time.
8. Ensure that all canister valves are tight and stem nuts are sealed with Swagelok® (or equivalent) plugs before transporting sample containers to the laboratory.

4.4 Quality Assurance/Quality Control Samples

4.4.1 Equipment Blanks

One equipment blank is taken at the beginning of the day and at the conclusion of sampling for each flux chamber. This is done by placing the flux chamber on a contaminant-free stainless steel surface and sealing it around the edge with bentonite or a product like plumber's putty that is determined to be free of potential VOCs. After the chamber is affixed to the stainless steel surface, the chamber is purged with zero-air or nitrogen and a blank sample is collected.

4.4.2 Co-located Samples

Co-located samples should be collected at the frequency indicated by the sampling plan, which for Summa canisters, is typically ten percent.

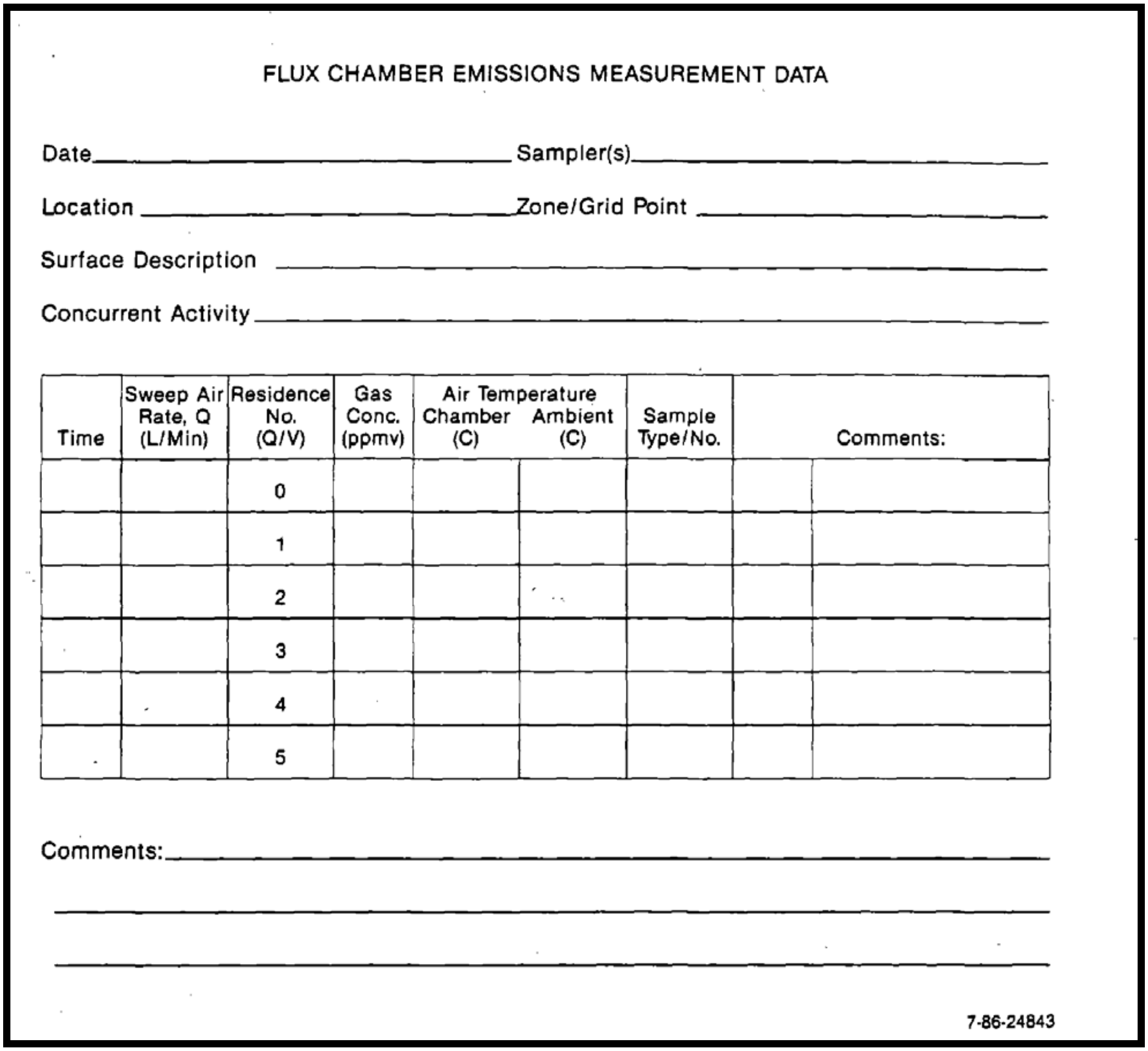
5.0 FORMS

Sample possession during all testing efforts must be traceable from the time of collection until the results are verified and reported. Sample custody procedures provide a mechanism for documentation of all information related to sample collection and handling to achieve this objective.

5.1 Documentation Procedures

5.1.1 Field Records

In addition to the Field Sample Data Logging Form shown in Figure 3, all field personnel will be required to keep accurate written records of their daily activities in a bound log book. All entries will be legible, written in waterproof ink, and contain accurate and inclusive documentation of an individual's field activities, including field data and observations, any problems encountered, and actions taken to solve the problem. The type of data recorded in the field log book includes field measurements, ambient conditions, and any other information pertinent to the sample collection. Entry errors or changes will be crossed out with a single line, dated, and initialed by the person making the correction. Entries made by individuals other than the person to whom the log book was assigned will be dated and signed by the individual making the entry.



FLUX CHAMBER EMISSIONS MEASUREMENT DATA

Date____________________ Sampler(s)____________________

Location ____________________ Zone/Grid Point ____________________

Surface Description ____

Concurrent Activity ____

Time	Sweep Air Rate, Q (L/Min)	Residence No. (Q/V)	Gas Conc. (ppmv)	Air Temperature		Sample Type/No.	Comments:	
				Chamber (C)	Ambient (C)			
		0						
		1						
		2						
		3						
		4						
		5						

Comments:____

____

____

7-86-24843

Figure 3. Field Sample Data Logging Form

5.1.2 Sample Labels

Each sample will receive a sample label that identifies the sample by a unique sample identification number. These labels are affixed to the sample container prior to the sample collection.

5.1.3 Sample Log Book

A sample master log will be maintained for all samples collected. Each sample will be assigned a unique identification number, a full description of the sample, its origin, and disposition will be included in the log entry.

5.1.4 Chain of Custody Procedures

Team members collecting the samples are responsible for the care and custody of the samples until they are transferred or dispatched to the appropriate laboratory. When transferring samples, the individuals relinquishing and receiving the samples will sign, date, and note the time on the record.

This record documents sample possession from the time of collection to the time the sample is dropped off at the laboratory. When the samples are received by the laboratory, the sample control officer will verify the Chain of Custody form against the samples received. If any discrepancies are observed, they will be recorded on the Chain of Custody Form and the project manager will be notified.

5.2 Shipment

All sample shipments will be accompanied by the Chain of Custody form, which identifies the contents of each crate. The person relinquishing the samples to the laboratory will request the signature of a laboratory representative to acknowledge receipt of the samples. Sample collection and shipment will be coordinated to ensure that the receiving laboratory has staff available to process the samples according to the method specifications.

All shipping containers will be secured for safe transportation to the laboratory. The method of shipment, courier name(s), and other pertinent information is entered in the "Remarks" section when the samples are to be shipped (i.e., FedEx, Express Mail, etc.) instead of hand delivered.

5.2.1 Sample Handling Procedures

The objective of the sample handling procedures is to ensure that samples arrive at the laboratory intact, at the proper temperature, and free of external contamination. Sample packaging requirements for hazardous materials requiring interstate transport are defined in Title 40 of the Code of Federal Regulations (CFR), Chapter 1, Part 171. These requirements outline in detail the proper classification and transportation procedures for hazardous materials that will be used in the transporting of samples.

5.2.2 Sample Preservation

Sample preservation, storage requirements, and holding time limitations are specified in the standard analytical methods. In general, soil gas samples should be placed in a container without ice and stored at room temperature in an area away from direct sunlight.

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Remediation and Redevelopment Division

Standard Operating Procedure

VAPOR POINT NAMING CONVENTION

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
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The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

The MDEQ is not responsible for the misuse or misinterpretation of the information presented herein. Please note that because the SOP was written for the MDEQ staff, it may contain references to specific equipment for field investigations that the MDEQ currently uses. Such references do not represent endorsements of particular vendors.

1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for the naming convention for the sampling points that are installed as a vapor intrusion investigation. The naming convention is utilized to provide vital information for future sampling as most vapor points are not constructed in a manner to confirm the depth of installation. In all instances, the ultimate procedures employed must be documented. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

This SOP does not cover, nor is it intended to provide, a justification or rationale for when this sampling is conducted. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work.

2.0 NAMING CONVENTION

A vapor point must be named using a minimal of three unique number/letter designations to provide clarification and vital information for field sampling and inspection personal. Each boring has a unique number regardless of the horizontal distance between sampling points. Multiple points installed within the same boring will carry an identical numerical identification (see C below). Each of the designations are detailed below.

Format:

A	B	C	D

A (optional) – Two digit number representing the year the vapor point was installed may be utilized.
B – The code VP must be utilized to represent that the point is installed as a vapor point.
C – The sequential number of the point that has been installed. No numbers must be skipped or repeated even if a point is intended to replace a point that had been previously installed in the same area.
D – Depth of the installed sampling point. Sub-slab or foundation samples may be designated with the optional use of an SS.

Please Note: Items B, C, and D must be included in the name of each vapor point.

Examples of naming designations:

(1) 11VP7SS
Description: Vapor Point installed in 2011, the 7th Vapor Point installed in the series, and the point is installed within one foot of the floor

(2) VP2 -16
Description: Vapor Point installed as the 2nd in the series, installed 16 feet below the ground surface

(3) 09VP11-10
Description: Vapor Point installed in 2009, the 11th in the series, installed 10 feet below the ground surface

Remediation and Redevelopment Division

Standard Operating Procedure

INSTALLATION OF A VAPOR PIN™ TO SUPPORT VAPOR INTRUSION INVESTIGATIONS

Original Date of Issuance: April 30, 2012

Revision #: 1 **Revision Date: February 1, 2013**

Approved by: Robert Wagner Date: 2/6/13

Robert Wagner, Chief
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

Written by: **Matthew Williams, Vapor Intrusion Specialist**
Superfund Section
Remediation and Redevelopment Division
Michigan Department of Environmental Quality

The information contained in this Standard Operating Procedure (SOP) is explanatory and provides direction to staff and guidance to the regulated community, but does not have the force and effect of law and is not legally binding on the public or the regulated community. The information contained in this SOP is drawn from existing manuals, various reference documents, and a broad range of colleagues with considerable practical experience and diverse educational backgrounds. This SOP outlines generic procedures for installing a soil gas probe, vapor monitoring point, or sub-slab vapor implant. Site conditions, contaminants, and geology may require modifications of this procedure.

PLEASE NOTE:

This SOP was developed based on a compilation of available information, knowledge, field experience, and general industry practices to provide guidance to the Michigan Department of Environmental Quality (MDEQ) staff and their contractors conducting investigations and remedial activities at sites with known or potential vapor intrusion issues. The SOP was created to promote a consistent, informed, and practical approach for the MDEQ staff to follow that achieves the performance standards required by Part 201, Environmental Remediation, and Part 213, Leaking Underground Storage Tanks, of the NREPA. The methods outlined in this document will produce reliable data that can support the various decisions required throughout the environmental process.

This SOP is available as a technical reference that may be informative when conducting work at sites where vapor intrusion issues are of concern and may be used as a reference for those conducting vapor intrusion evaluations under Part 201 or Part 213. This SOP is not intended to prohibit those conducting evaluations from using means other than those specified herein to measure soil gas concentrations; however, departures from this guidance will often need to include information for a more detailed review.

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Installation of a Vapor Pin™

1.0 SCOPE AND APPLICATION

This SOP describes the MDEQ's procedure for installing a sub-slab soil gas probe/vapor monitoring point using a Vapor Pin™. Please note that this procedure is written for use by MDEQ staff and their contractors. Its use is optional for all others.

Sub-slab soil gas samples are vapor samples collected within two feet of the floor of the lowest point of the structure and must be referenced as sub-slab soil gas samples. Though these samples may provide beneficial information to support various lines of evidence, the effects due to barometric pressure, temperature, and the potential breakthrough of ambient air from the surface have the potential to cause these samples to be less reliable than soil gas samples collected at greater depths.

This SOP does not cover, nor is it intended to provide, a justification or rationale for where a sampling point is installed. It is assumed by using this SOP that site conditions have been fully evaluated and that the sampling location and depth meet the objectives outlined in the work plan or scope of work. For example, considerations must be given to the types of chemicals of concern, lithology encountered, surrounding buildings and underground structures, and the depth of the vapor source.

2.0 SAMPLING POINT INSTALLATION

2.1 Boring Advancement

Borings should be through the use of a rotary hammer drill. The specific drill utilized must be capable of utilizing the drill and coring bits identified by the SOP (see below) as well as sufficient size to penetrate the expected thickness of the concrete present.

2.2 Soil Gas Well Materials (General List of Materials)

This SOP utilizes products available from Cox-Colvin & Associates, Inc. The materials list is given below:

Equipment needed for installation	**Equipment needed for abandonment:**
• Vapor Pin™ • Silicone sleeve • Hammer drill • 5/8 inch diameter hammer bit (Hilti™ TEYX 5/8" x 22" #00206514 or equivalent) • 1½ inch diameter hammer bit (Hilti™ TEYX 1½" x 23" #00293032 or equivalent) for flush mount applications • 3/4 inch diameter bottle brush • Wet/dry vacuum with HEPA filter (optional) • Vapor Pin™ installation/extraction tool • Dead blow hammer • Vapor Pin™ flush mount cover, as necessary • Vapor Pin™ protective cap	• Vapor Pin™ installation/extraction tool • Dead blow hammer • Volatile organic compound-free hole patching material (hydraulic cement) and putty knife or trowel

2.3 Flush mount Vapor Pin™ Installation Protocol

Figure 1. Hammer Drill

1. Prior to drilling holes in a foundation or slab, contact local utility companies to identify and mark utilities coming into the building from the outside (e.g., gas, water, sewer, refrigerant, and electrical lines). Consult with a local electrician and plumber to identify the location of utilities inside the building.

2. Prior to fabrication of the sub-slab vapor probes, use the rotary drill and the **1-1/2 inch diameter drill bit** to create an outer hole that partially penetrates the slab and is at least 1-3/4 inches in depth (Figure 1). This outer hole will allow the protective cap to be flush with the concrete surface.

3. Brush the hole with a bottle brush and use a small portable vacuum cleaner to remove cuttings from the outer hole.

Figure 2. Inner & Outer Holes

4. Use the rotary hammer drill and the **5/8 inch drill bit** to create a smaller diameter “inner” hole through the remainder of the slab and at least 6 inches into the underlying soil to form a void. Figure 2 illustrates the appearance of the “inner” and “outer” holes. Drilling into the sub-slab material will create an open cavity which will prevent obstruction of probes during sampling by small pieces of gravel.

5. Brush the hole with a bottle brush and use a small portable vacuum cleaner to remove cuttings from the hole. Cuttings should be removed prior to advancing completely through the cement as much as possible. Once through the slab, care should be taken to minimize the amount of vacuum applied beneath the slab.

Figure 3. Vapor Pin™ assembly with silicone sleeve over the barbed end

6. Determine the thickness of the slab and record the measurement.

7. Assemble the Vapor Pin™ assembly (Figure 3) by threading the Vapor Pin™ into the extraction/installation tool and placing the silicone sleeve over the barbed end.

Figure 4. Place Vapor Pin™ in hole.

Figure 5. Tap Vapor Pin™ into place.

8. Place the lower end of the Vapor Pin™ assembly into the drilled hole (Figure 4).

9. Place the small hole located in the handle of the extraction/installation tool over the Vapor Pin™ to protect the barb fitting and cap, and tap the Vapor Pin™ into place using a dead blow hammer (Figure 5). Make sure the extraction/ installation tool is aligned parallel to the Vapor Pin™ to avoid damaging the barb fitting.

10. Unscrew the threaded coupling from the installation/extraction handle and use the hole in the end of the tool to assist with the installation. During installation, the silicone sleeve will form a slight bulge between the slab and the Vapor Pin™ shoulder. Installed Vapor Pin™ is shown in Figure 6.

11. Place the protective cap on the Vapor Pin™ (Figure 7).

12. Cover the Vapor Pin™ with a flush mount cover (Figure 8).

Figure 6. Installed Vapor Pin™.

Figure 7. Place Protective Cap.

Figure 8. Flush mount cover.

2.4 Temporary Vapor Pin™ Installation Protocol

Follow the protocol outlined in Section 2.3 Flush mount Vapor Pin™, above with the exception of Steps 2 and 3. These steps are omitted as it is not necessary to drill an outer hole for a temporary installation. An example of a temporary installation is shown in Figure 9.

Figure 9. Temporary Vapor Pin™ Installation.

2.5 Abandonment

All vapor monitoring wells, including those used for soil gas monitoring, must be abandoned upon completion of site activities.

Vapor wells constructed in the manner identified by this SOP may be abandoned by removing any tubing and all surface protective covers. The boring annulus can then be backfilled with uncontaminated native material or grout and returned as close as possible to the original site conditions. The Vapor Pin™ is designed to be used repeatedly; however, replacement parts and supplies will be required periodically. If the tubing cannot be removed, the tubing should be cemented in place. All surface protective covers must be removed and returned to as close as possible to the original site conditions.

Extraction procedure:

1. Remove the protective cap and thread the installation/ extraction tool onto the barrel of the Vapor Pin™ (Figure 10). Continue turning the tool to assist in extraction, then pull the Vapor Pin™ from the hole.

2. Fill the void with hydraulic cement and smooth with the trowel or putty knife.

3. Prior to reuse, remove the silicone sleeve and discard.

4. Decontaminate the Vapor Pin™ in a hot water and Alconox® wash, then heat in an oven to a temperature of 130^{o} Celsius.

Figure 10. Removing the Vapor Pin™

3.0 SOIL BORING LOGS AND VAPOR COMPLETION DIAGRAM

Boring logs and diagrams may be completed utilizing a variety of programs. The following information must be included for every sub-slab vapor point installed:

- Project information
- Boring location
- Date installed
- Total depth
- Thickness of concrete
- Project personnel including drilling contractor, driller, and geologist
- Boring diameter
- Soil description (if identified)
- Field screening performed
- A diagram representing installed sampling point that includes:
  - Surface completion
  - Seal used
  - Probe and screen construction materials and specifications
  - Depth of all installed materials including screen, bottom of screen, sand pack, and tubing

4.0 REFERENCES

Though not specifically referenced, the SOP is based upon the SOP by Cox-Colvin & Associates, Inc. with some modifications.

Appendix G – Laboratory Quality Assurance and Quality Control for Vapor Intrusion Data

Each laboratory analyzing samples by Method TO-15 shall follow the method as defined by the United States Environmental Protection Agency in the EPA/625/R-96/010b dated January 1999 or subsequent updates or revisions. Additional details and/or modifications are included in the following:

- **Section A – Method TO-15 Standard**
- **Section B – Method TO-15 Modified for Bottle-Vac® Air Samplers by Entech Instruments, Inc.**

Special thanks for assistance:
Fibertec Environmental Services

Section A – Method TO-15 Standard

1. The laboratory shall supply the following data with each report:
    a. All results from analysis of the method blank should be less than the reporting limits. If concentrations are reported above the reporting limits, the laboratory will document this occurrence within the narrative and flag any concentration reported above the reporting limit for this compound up to ten times the level measured in the blank. The area responses for the internal standards (ISs) must be within ± 40 percent of the area response of the ISs of the mean area response of the most recent calibration. The response time (RT) for each IS must be within ± 0.33 minutes between the blank and the most recent calibration. Method blanks shall be run every 20 environmental samples or once per day, whichever is more frequent.
    b. Laboratory Control Sample (LCS): The laboratory will report the percent of recoveries from all analytes spiked into the LCS. One LCS will be run within each 24-hour period of Method TO-15 samples analyzed.
    c. The narrative of the laboratory report will define if the initial calibration curve, continuing calibration check sample (when appropriate), and internal quality assurance (such as ISs, blanks, etc.), and the receipt of the samples met the method requirements for each report.
    d. The chromatogram for each analysis will be available electronically and the data will have at least 50 percent of the compounds identified in Appendix E clearly identified.
    e. The laboratory shall report the results using the field sample identification (ID) and the associated laboratory sample number.
    f. The laboratory shall report all compounds in units of micrograms per cubic meters (µg/m^3) at the standard ambient temperature and pressure (SATP) of 25^{o}C and 760mm Hg.
    g. The laboratory report must contain the following information: Cover sheet with signature of a laboratory supervisor or designee, a narrative discussing the sample results and any irregularities that were found during the analysis, Chain of Custody and sample condition upon receipt forms, tables containing the volatile organic compounds (VOCs), the chemical abstract service (CAS) number of each reported compound, measured concentration in µg/m^3, reporting limit, date of analysis, labeled sample chromatograms, method blank data for the batch, assigned regulator, flow rate, and a summary of applicable quality control.

2. The laboratory is required to maintain the data for a minimum of five years with the ability to reconstruct the data either via a computer or paper.

3. Laboratories must verify their reporting limits by running a standard at the reporting limit once every month. The recovery of the reporting limit shall be ± 40 percent of the true value or limit of quantification (LOQ) as defined by the National Environmental Laboratory Accreditation Conference (NELAC).

4. Laboratories shall verify their calibration curve a minimum of every 24 hours. The 24-hour clock will begin at the injection of a standard for tuning the instrument, (bromofluorobenzene [BFB] is the suggested tune check standard). The calibration verification standard must be at the midpoint (or lower) of the calibration curve. The standard must meet Method TO-15 or laboratory generated limits for the compounds of interest/target compounds (as identified on the Chain of Custody), not a set of continuing calibration check compounds. If no direction is given to the laboratory for check compounds, then the laboratory Standard Operating Procedures (SOPs) shall be followed.

5. Laboratories should run ten percent laboratory duplicates. Duplicate samples should have less than or equal to 25 percent relative percent difference or corrective action should be initiated.

6. The Michigan Department of Environmental Quality (MDEQ) accepts a holding time of 30 days for the Method TO-15 analysis.

7. Reporting Limits: The MDEQ expects that for the following compounds: benzene, toluene, the xylenes, ethylbenzene, the trimethylbenzenes, trichloroethene, and vinyl chloride will have reporting limits between 0.2-0.4 parts per billion per volume (ppbv) (reported as µg/m^3). The other compounds in Appendix C should have reporting limits between 0.5-1.0 ppbv (reported as µg/m^3). The MDEQ does recognize that some compounds will have issues with chromatography or interferences that will prevent the expected reporting limits

from being met. Laboratories should clearly document these cases within their SOPs and on reports as necessary.

8. Canisters: The laboratory providing Summa canisters shall verify each batch of 20 canisters by analyzing one container after cleaning. The canister chosen for post-cleaning analysis shall be the canister with the highest recorded VOC concentration from prior analyses. The container shall be verified by charging the canister with clean zero-air or nitrogen, analyzing the container by Method TO-15, and verifying no compounds are found above the required reporting limits. Additionally, the supplier of Summa canisters is expected to verify the operability of the canisters. The Method TO-15 SOP (or equivalent) should describe the preventative maintenance performed on the canisters. One hundred percent certified canisters may be required in certain situations.

9. Flow Restrictor/Regulator: Each canister assigned to a site must also have a dedicated regulator assigned that has a flow rate established and clearly referenced. Each regulator should be assigned a unique designation for tracking and cleaning purposes. The laboratory is required to verify the flow rate of each regulator at a minimum of every three months and should be used as part of the assembly identified in the batch cleaning process identified above. The dedicated flow regulator must be calibrated to a flow rate that is identified and reported in the laboratory report discussed in item 1.g. above.

10. Whenever a high concentration sample is analyzed (sample with concentrations outside the calibration curves), a zero canister analysis should be performed to check for carry-over. If carry-over is detected, lab should take corrective action to resolve.

11. Tentatively Identified Compounds: Each Method TO-15 analysis is to include the reporting of the top five tentatively identified compounds greater than five ppbv that are not attributed to column breakdown, as compared to response of the nearest IS, when using full scan mode of the mass spectrometer. The laboratory will also report within the narrative if a hump is seen within the chromatogram such as is typical for gasoline, fuel oil, mineral spirits, etc. The laboratory is not required to quantify this as part of the analysis, although this may be requested of the laboratory at a later date for an additional cost.

12. Method Detection Limit (MDL) studies must be performed at least annually. The MDLs should be ≤ RL for all target analytes. The LOQs may be adequate if done in compliance with NELAC requirements.

13. Field samples can be analyzed after successfully meeting all criteria established for instrument performance checks, calibrations, and blanks. All target analyte peaks should be within the initial calibration range. The RT for each IS must be within ± 0.33 minutes of the IS in the most recent calibration. The area response for the ISs must be within ± 50 percent of the area response of the ISs of the mean area response of the most recent initial calibration.

14. Daily check standard must be analyzed every 24 hours. This standard is at the midpoint of the calibration curve (ten ppbv suggested). The %D must be within ± 30 percent for each target analyte. Control charts should be maintained for the %D values.

15. Internal Standard: A suggested IS mixture of bromochloromethane, chlorobenzene-d5, and 1,4-difluorobenzene will be added to each sample as standard. The resulting concentrations are at ten ppbv (suggested).

Section B – Method TO-15 Modified for Bottle-Vac® Air Samplers by Entech Instruments, Inc.

1. The laboratory shall supply the following data with each report:
    a. All results from analysis of the method blank should be less than the reporting limits. If concentrations are reported above the reporting limits, the laboratory will document this occurrence within the narrative and flag any concentration reported above the reporting limit for this compound up to ten times the level measured in the blank. The area responses for the ISs must be within ± 40 percent of the area response of the ISs of the mean area response of the most recent calibration. The RT for each IS must be within ± 0.33 minutes between the blank and the most recent calibration. Method blanks shall be run every 20 environmental samples or once per day, whichever is more frequent.
    b. Laboratory Control Sample: The laboratory will report the percent of recoveries from all analytes spiked into the LCS. One LCS will be run within each 24-hour period of Method TO-15 samples analyzed.
    c. The narrative of the laboratory report will define if the initial calibration curve, continuing calibration check sample (when appropriate), and internal quality assurance (such as ISs, blanks, etc.), and the receipt of the samples met the method requirements for each report.
    d. The chromatogram for each analysis will be available electronically and the data will have at least 50 percent of the compounds identified in Appendix E clearly identified.
    e. The laboratory shall report the results using the field sample ID and the associated laboratory sample number.
    f. The laboratory shall report all compounds in units of $\mu g/m^3$ at the SATP of 25^oC and 760mm Hg.
    g. The laboratory report must contain the following information: Cover sheet with signature of a laboratory supervisor or designee, a narrative discussing the sample results and any irregularities that were found during the analysis, Chain of Custody and sample condition upon receipt forms, tables containing the volatile organic compounds (VOCs), the chemical abstract service (CAS) number of each reported compound, measured concentration in $\mu g/m^3$, reporting limit, date of analysis, labeled sample chromatograms, method blank data for the batch, assigned regulator, flow rate, and a summary of applicable quality control.

2. The laboratory is required to maintain the data for a minimum of five years with the ability to reconstruct the data either via a computer or paper.

3. Laboratories must verify their reporting limits by running a standard at the reporting limit once every month. The recovery of the reporting limit shall be ± 40 percent of the true value or LOQ as defined by the NELAC.

4. Laboratories shall verify their calibration curve a minimum of every 24 hours. The 24-hour clock will begin at the injection of a standard for tuning the instrument, (BFB is the suggested tune check standard). The calibration verification standard must be at the midpoint (or lower) of the calibration curve. The standard must meet Method TO-15 or laboratory generated limits for the compounds of interest/target compounds (as identified on the Chain of Custody), not a set of continuing calibration check compounds. If no direction is given to the laboratory for check compounds, then the laboratory SOP shall be followed.

5. Laboratories should run ten percent laboratory duplicates. Duplicate samples should have less than or equal to 25 percent relative percent difference or corrective action should be initiated.

6. The MDEQ accepts a holding time of 30 days for the Method TO-15 analysis.

7. Reporting Limits: The MDEQ expects that for the following compounds: benzene, toluene, the xylenes, ethylbenzene, the trimethylbenzenes, trichloroethene, and vinyl chloride will have reporting limits between 0.2-0.4 ppbv (reported as $\mu g/m^3$). The other compounds in Appendix C should have reporting limits between 0.5-1.0 ppbv (reported as $\mu g/m^3$). The MDEQ does recognize that some compounds will have issues with chromatography or interferences that will prevent the expected reporting limits from being met. Laboratories should clearly document these cases within their SOPs and on reports as necessary.

8. Bottle-Vac® Air Sampler: The laboratory providing the Bottle-Vac® shall supply a pre-cleaned or new one-liter amber bottle for each sampling event. Each batch of bottles utilized shall be verified for by analyzing one container for every 20 bottles utilized. The container shall be verified by charging the Bottle-Vac® with clean zero-air or nitrogen, through a Entech Micro-QT™ Valve and a dedicated regulator; and then analyzing the container by Method TO-15 and verifying no compounds are found above the reporting limits required by the MDEQ. Additionally, the supplier of Bottle-Vac® is expected to verify the operability of the Entech Micro-QT™ Valves and any other flow restrictors provided.
9. Flow Restrictor/Regulator: Each Bottle-Vac® assigned to a site must also have a dedicated regulator assigned that has a flow rate established and clearly referenced. Each regulator should be assigned a unique designation for tracking and cleaning purposes. The laboratory is required to verify the flow rate of each regulator at a minimum of every three months and should be used as part of the assembly identified in the batch cleaning process identified above. The dedicated flow regulator must be calibrated to a flow rate that is identified and reported in the laboratory report discussed in item 1.g. above
10. Whenever a high concentration sample is analyzed (sample with concentrations outside the calibration curves), a zero canister analysis should be performed to check for carryover. If carry-over is detected, during the verification with clean zero-air, the bottles must be replaced and each Entech Micro-QT™ Valve and a dedicated regulator must be re-cleaned prior to retesting the batch in accordance with item 8 above.
11. Tentatively Identified Compounds: The MDEQ requires each Method TO-15 analysis to include the reporting of the top five tentatively identified compounds greater than five ppbv that are not attributed to column breakdown, as compared to the response of the nearest IS, when using full scan mode of the mass spectrometer. The laboratory will also report within the narrative if a hump is seen within the chromatogram such as is typical for gasoline, fuel oil, mineral spirits, etc. The laboratory is not required to quantify this as part of the analysis, although this may be requested of the laboratory at a later date for an additional cost.
12. MDL studies must be performed at least annually. The MDLs should be ≤ RL for all target analytes. The LOQs may be adequate if done in compliance with NELAC requirements.
13. Field samples can be analyzed after successfully meeting all criteria established for instrument performance checks, calibrations, and blanks. All target analyte peaks should be within the initial calibration range. The RT for each IS must be within ± 0.33 minutes of the IS in the most recent calibration. The area response for the ISs must be within ± 50 percent of the area response of the ISs of the mean area response of the most recent initial calibration.
14. Daily check standard must be analyzed every 24 hours. This standard is at the midpoint of the calibration curve (ten ppbv suggested). The %D must be within ± 30 percent for each target analyte. Control charts should be maintained for the %D values.
15. Internal Standard: A suggested IS mixture of bromochloromethane, chlorobenzene-d5, and 1,4-difluorobenzene will be added to each sample as standard. The resulting concentrations are at ten ppbv (suggested).

APPENDIX H

Model for a Declaration of a Restrictive Covenant

8/8/2011

DECLARATION OF RESTRICTIVE COVENANT

This document provides instruction for the model Declaration of Restrictive Covenant to be used to place land use or resource use restrictions pursuant to Section 20114c(3) of Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), MCL 324.20101 *et seq.*

Pursuant to Section 20114c(5) of Part 201, a copy of the recorded Declaration of Restrictive Covenant shall be provided to the Michigan Department of Environmental Quality within 30 days after recording with the appropriate Register of Deeds. The recording requirements for instruments filed with Michigan County Register of Deeds offices are contained in Section 1 of the Recording Requirements Act, 1937 PA 103, as amended (Act 103), MCL 565.201 et seq.

The lettered instructions below explain what information should be inserted into the corresponding blanks identified by letter in the Declaration of Restrictive Covenant Model. Drafting notes, examples, and insertion directions appear as ***bold italicized print***.

A. DEQ Reference No: RC-RD-201-[*year*]-[*number*]. ***This Reference Number ensures the protectiveness, enforcement, and tracking of land use and resource use restrictions. All Restrictive Covenants must have a Reference Number assigned and prominently displayed on the first page of the document. The DEQ Reference Number will be assigned by DEQ Remediation and Redevelopment Division staff. The DEQ Reference Number can be obtained by contacting the Remediation and Redevelopment Division at deq-rrd@michigan.gov or by calling 517-373-4805.***

B. ***Enter the name of the county where the Property is located.***

C. ***Enter the address location of the Property including city or township and county.***

D. ***Select one of the following options as appropriate:***

OPTION 1: If the DEQ reviewed and approved a Response Activity Plan to address the environmental contamination at the Property, insert the following paragraph:

Response activities **[*insert as appropriate: are being <u>OR</u>* were]** implemented to address environmental contamination at the Property pursuant to Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), MCL 324.20101 *et seq.* The response activities that **[*insert as appropriate: are being <u>OR</u>* were]** implemented to address environmental contamination are fully described in the Response Activity Plan titled **[*insert the title of plan*]** dated **[*Insert date*]**, and prepared by **[*insert the name of the entity that prepared the plan*]**. The Michigan Department of Environmental Quality (DEQ) approved the Response Activity Plan on **[*insert the date the DEQ approved the***

***plan*]**, pursuant to Part 201 of the NREPA.

OPTION 2: If the DEQ did not review and approve a Response Activity Plan to address the environmental contamination at the Property, insert the following paragraph:

Response activities **[*insert as appropriate:* are *being* *OR* were]** implemented to address environmental contamination at the Property pursuant to Part 201, Environmental Remediation, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), MCL 324.20101 *et seq.* The adequacy of the response activities implemented at the Property has not been subject to a facility-specific review by the Michigan Department of Environmental Quality (DEQ) nor has the DEQ determined that the response activities comply with Part 201 of the NREPA.

E. ***Insert as appropriate:***

- Residential cleanup criteria under Section 20120a(1)(a)
- Nonresidential cleanup criteria under Section 20120a(1)(b)
- Site-specific cleanup criteria under Sections 20120a(2) and 20120b

F. ***Insert the following sentence if there is a long-term physical component of the response activity (e.g., exposure barrier, permanent marker, or monitoring wells):*** and 3) to prevent damage or disturbance of any element of the response activity constructed on the Property.

If there is no long-term physical component of the response activity, remove the semi-colon and end the sentence.

G. **Select one of the following options as appropriate:**

OPTION 1: If the entire Property will be subject to all of the land or resource use restrictions provided in the restrictive covenant, insert the following:

Exhibit 2 provides a survey of the Property that is subject to the land use or resource use restrictions specified herein.

OPTION 2: If not all of the Property is to be subject to all of the land or resource use restrictions provided in the restrictive covenant, insert the following:

The “Survey of Property and Limits of Land or Resource Use Restrictions,” attached as Exhibit 2, provides a survey of the Property that depicts the area or areas subject to restriction and contains legal descriptions that distinguish those portions of the Property that are subject to land use or resource use restrictions specified in this Restrictive Covenant.

H. ***Insert a paragraph similar to the following that briefly describes the nature of the hazardous substances, the affected media, and how the response activities implemented, including the land or resource use restrictions, will be effective to address risks for all relevant pathways that require restrictions.***

***Example*: Hazardous substances including lead, trichloroethylene (TCE), cyanide**

and phenols have been released and/or disposed of on the Property. Prior to the recording of this Restrictive Covenant, response activities have been undertaken to remove or treat in-place some of the hazardous substances. Lead and TCE remain present at levels that require controls to prevent unacceptable exposures. An exposure barrier, consisting of six (6) inches of clean soil and vegetation, has been placed, as described below, to prevent direct contact with the lead impacted soils. A vapor barrier has been placed under Building B (identified in Exhibit 2) to prevent migration of TCE into the building at levels that would result in unacceptable exposures through inhalation.

I. ***If the Restrictive Covenant is being recorded in association with response activities that do not address all areas of the Property that contain hazardous substances, insert the following paragraph and attach an exhibit which provides a survey and legal description of the areas of the Property or general description of the specific media (i.e., groundwater, soils, etc.) that are not being addressed pursuant to the response activities*****:**

Areas of the Property described in Exhibit **[*insert appropriate Exhibit #*]** have not been addressed through the response activities undertaken at the Property and may contain hazardous substances in excess of the concentrations developed as the unrestricted residential criteria under Section 20120a(1)(a) or (17) of the NREPA.

J. ***Enter the name of the owner of the property or the name of the person proposing to file the Restrictive Covenant.***

K. ***Insert as appropriate:***

- as the Owner of the Property
- with the express written permission of the Owner of the Property

L. ***Select one of the following options as appropriate to describe the restrictions on land use necessary to comply with the appropriate cleanup criteria:***

OPTION 1: If the property is subject to land use restrictions required to satisfy the nonresidential cleanup criteria, insert the following paragraph below:

a. <u>Prohibited Land Uses</u>: The Owner shall prohibit all uses of **[insert as appropriate: *the Property <u>OR</u> portions of the Property as described in Exhibit 2*]** that are not compatible with or are inconsistent with the assumptions and basis for the nonresidential cleanup criteria established pursuant to Section 20120a(1)(b) of the NREPA. Uses that are compatible with nonresidential cleanup criteria are generally described in Exhibit 3 (Allowable Uses). **[*If the local zoning ordinance allows for residential uses within the Property's current zoning, insert the following*: The following uses allowed under the [*insert name of local zoning authority and zoning code designation*] zoning code designation are prohibited: [*list prohibited uses.*]]** Cleanup criteria for land-use based response activities are located in the Government Documents Section of the State of Michigan Library.

OPTION 2: If the property is subject to land use restrictions required to satisfy site-specific cleanup criteria, insert the following paragraph below:

a. <u>Prohibited Land Uses</u>: The Owner shall prohibit all uses of **[insert as appropriate:**

***the Property OR portions of the Property as described in Exhibit 2*]** that are not compatible with or are inconsistent with the assumptions and basis for the site-specific cleanup criteria developed for the Property pursuant to Section 20120a(2) and 20120b of the NREPA. Uses that are compatible with the site-specific criteria developed for the Property are generally described in Exhibit 3 (Allowable Uses).

OPTION 3: If the property does not require any restrictions on land use because hazardous substances left in place would allow for a limited or restricted residential cleanup with the appropriate resource use restrictions, there is no need to insert any restriction language under "Prohibited Land Uses." Therefore this paragraph should be excluded from the restrictive covenant and the remainder of the paragraphs should be renumbered accordingly.

M. Insert as appropriate:

- on the Property
- within the portions of the Property designated in Exhibit 2 as **[*insert designation*]**.

N. Enter additional paragraphs, as appropriate, to describe the prohibited activities necessary to reliably restrict exposure to hazardous substances located on the Property or within the portions of the Property designated in Exhibit 2.

Example exposure restriction for use of groundwater:
The construction and use of wells or other devices on the Property to extract groundwater for consumption, irrigation, or any other purpose, except as provided below:

(a) Wells and other devices constructed as part of a response activity for the purpose of evaluating groundwater quality or to remediate subsurface contamination associated with a release of hazardous substances into the environment are permitted provided the construction of the wells or devices complies with all applicable local, state, and federal laws and regulations and does not cause or result in a new release, exacerbation of existing contamination, or any other violation of local, state, or federal laws or regulations.

(b) Short-term dewatering for construction purposes is permitted provided the dewatering, including management and disposal of the groundwater, is conducted in accordance with all applicable local, state, and federal laws and regulations and does not cause or result in a new release, exacerbation of existing contamination, or any other violation of local, state, and federal environmental laws and regulations.

Example direct contact exposure barrier restriction:
The [*insert thickness and material of barrier*] that has a base elevation of [*insert reproducible benchmark*] at the locations shown in Exhibit 2 serves to prevent exposures to contaminated soils at the Property. Any excavation or other intrusive activity that could affect the integrity of the [*insert material of barrier*] is prohibited, except during short-term construction or repair projects or for purposes of further treating or remediating the subject contamination. Any excavation or other intrusive activity, including removing, altering, or disturbing the [*insert material of barrier*], that could affect the integrity of the barrier, must be

replaced with a cover that provides at least an equivalent degree of protection as the original barrier within 14 days of completion of the work. Repair and/or replacement of the barrier must be completed unless additional sampling is conducted that demonstrates that a barrier in the area is no longer necessary in accordance with the applicable provisions and requirements of Part 201 of the NREPA.

Example vapor intrusion exposure restriction (no buildings):
The construction of new structures, unless such construction incorporates engineering controls designed to eliminate the potential for subsurface vapor phase hazardous substances to migrate into the new structure at concentrations greater than applicable criteria; or, unless prior to construction of any structure, an evaluation of the potential for any hazardous substances to volatilize into indoor air assures the protection of persons who may be present in the buildings and is in compliance with Section 20107a of the NREPA.

O. Enter additional paragraphs, as appropriate, to describe the prohibited activities necessary to maintain the effectiveness and integrity of the response activity implemented at the Property.

Example infiltration barrier restriction:
The [*insert thickness and material of barrier*] that has a base elevation of [*insert reproducible benchmark*] at the locations shown in Exhibit 2 serves to prevent infiltration of water through contaminated soil at the Property. Any excavation or other intrusive activity that could affect the integrity of the [*insert material of barrier*] is prohibited, except during short-term construction or repair projects or for purposes of further treating or remediating the subject contamination. Any excavation or other intrusive activity, including removing, altering, or disturbing the [*insert material of barrier*], that could affect the integrity of the barrier, must include the use of engineering controls to prevent the infiltration of water into the contaminated soil underlying the barrier until the barrier is repaired or replaced. The barrier must be repaired or replaced with a cover that provides at least an equivalent degree of protection as the original barrier within 14 days of completion of the work. Repair and/or replacement of the barrier must be completed unless additional sampling is conducted which demonstrates that a barrier in the area is no longer necessary in accordance with the applicable provisions and requirements of Part 201 of the NREPA.

Example monitoring well disturbance restriction:
Any activity that would interfere with the function of or obstruct access to any monitoring wells and devices located on the Property. This includes, but is not limited to, removing, destroying, or altering any well or device in any way that renders it inoperable or incapable of functioning as intended.

Example treatment system restriction:
Any activity that could affect the integrity, effectiveness, and operation of the groundwater interception trench and treatment system depicted in Exhibit 2.

Example containment and treatment system restriction:

Any excavation or other intrusive activity that could affect the integrity, effectiveness, and operation of the slurry wall and Light Non-Aqueous Phase Liquid (LNAPL) collection system as designated in Exhibit 2, and any activities that would interfere with access to the slurry wall and LNAPL collection system.

P. **Insert as appropriate:**

- on the Property
- within the portions of the Property designated in Exhibit 2 as **[*insert designation*]**.

Q. ***Insert the following paragraph if permanent markers are required; if not, renumber the paragraphs as appropriate:***

Permanent Markers. The Owner shall not remove, cover, obscure, or otherwise alter or interfere with the permanent markers placed at the locations noted in Exhibit 2. The Owner shall keep vegetation and other materials clear of the permanent markers to assure that the markers are readily visible.

R. ***Enter the name of the owner of the entity responsible for assuring compliance with the Restrictive Covenant.***

S. ***Insert the following if portions of the property subject to land use or resource use restrictions overlap and affect any easement holders' property interests*:**

- and all other holders of a legal interest whose interest is materially affected by this Restrictive Covenant as documented and attached hereto as Exhibit **[*insert number of the exhibit that contains the Consent of Easement Holder documentation*].**

T. ***Enter the name of the person proposing to file the Restrictive Covenant.***

U. ***Insert the day of the month.***

V. ***Insert the month and year.***

W. **Insert Notary Public information as:**
Name of state
County

X. **Insert the appropriate form of acknowledgement from the following:**

OPTION 1*:** ***For an individual:
The foregoing instrument was acknowledged before me this **[*date*]** by **[name of individual]**.

OPTION 2*:** ***For a corporation:
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of officer or agent, title of officer or agent*]** of **[*name of corporation*]**, a **[*state or place of incorporation*]**, on behalf of the corporation.

OPTION 3*:** ***For a partnership:

The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of partnership or agent*]**, partner **[*or agent*]** on behalf of **[*name of partnership*]**, a partnership.

<u>OPTION 4</u>: For an individual acting as principal by an attorney in fact (power of attorney):
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of attorney in fact*]** as attorney in fact on behalf of **[*name of principal*]**.

Y. **Print, Type, or Stamp name of Notary Public.**

Z. **Insert name of the person who prepared the restrictive covenant.**

AA. **Insert the address of the person who prepared the restrictive covenant.**

CONSENT OF OWNER ATTACHMENT:

This form is only necessary if the current property owner and the person signing the restrictive covenant are <u>not</u> the same person. This document provides the express written permission of the current property owner for recording.

A. **Enter the name of the current property owner.**

B. **Insert the year and number of the DEQ assigned reference number.**

C. **Enter the name of the person recording the restrictive covenant.**

D. **Enter the name of the county where the property is located.**

E. **Insert Notary Public information as:**
Name of state
County

F. **Insert the appropriate form of acknowledgement from the following:**

<u>OPTION 1</u>: For an individual:
The foregoing instrument was acknowledged before me this **[*date*]** by **[name of individual]**.

<u>OPTION 2</u>: For a corporation:
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of officer or agent, title of officer or agent*]** of **[*name of corporation*]**, a **[*state or place of incorporation corporation*]**, on behalf of the corporation.

<u>OPTION 3</u>: For a partnership:
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of partnership or agent*]**, partner **[*or agent*]** on behalf of **[*name of partnership*]**, a partnership.

<u>OPTION 4</u>: For an individual acting as principal by an attorney in fact (power of attorney):

The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of attorney in fact*]** as attorney in fact on behalf of **[*name of principal*]**.

G. Print, Type, or Stamp name of Notary Public.

EXHIBIT 1 LEGAL DESCRIPTION OF PROPERTY:

This exhibit must provide the legal description of the property, including parcel identification number(s) of the property.

EXHIBIT 2 SURVEY OF PROPERTY *OR* SURVEY OF THE PROPERTY AND LIMITS OF LAND AND RESOURCE USE RESTRICTIONS.

This exhibit must be titled as appropriate for the restricted area. All surveys must be conducted by a licensed surveyor; identify, clearly delineate, and graphically depict the spatial extent of all restricted areas in relation to the Property boundaries and the key features of the response activities, including permanent markers if required; and provide a legal description of the restricted areas of the Property if not all areas of the Property are subject to the same restrictions.

EXHIBIT 3 DESCRIPTION OF ALLOWABLE USES

This exhibit is only necessary when the property is restricted to nonresidential or site-specific land uses. It must be consistent with the zoning of the property and with the generic exposure assumptions used to develop the cleanup criteria established pursuant to Section 20120a(1)(b) of the NREPA or the alternative exposure assumptions used to develop site-specific criteria pursuant to Section 20120a(2) and 20120b of the NREPA.

OPTION 1: Insert the following if the property is restricted to the nonresidential land use category:

Nonresidential Land Use: This land use is characterized by any use which is not residential in nature and is primarily characterized by industrial and commercial uses. Industrial uses typically involve manufacturing operations engaged in processing and manufacturing of materials or products. Other examples of industrial uses are utility companies, industrial research and development, and petroleum bulk storage. Commercial uses include any business or income-producing use such as commercial warehouses, lumber yards, retail gas stations, auto dealerships and service stations, as well as office buildings, banks, and medical/dental offices (not including hospitals). Commercial uses also include retail businesses whose principal activity is the sale of food or merchandise within an enclosed building and personal service establishments which perform services indoors such as health clubs, barber/beauty salons, photographic studios, etc.

Any residential use is specifically prohibited from the non-residential land use category. This would include the primary use of the property for human habitation and includes structures such as single family dwellings, multiple family structures, mobile homes, condominiums, and apartment buildings. Residential use is also characterized by any use which is intended to house, educate, or provide care for children, the elderly, the infirm, or other sensitive populations, and therefore could include day care centers, educational facilities, hospitals, elder care facilities, and nursing homes. The use of any accessory building or portion of an existing building as a dwelling unit permitted for a proprietor or storekeeper and their families, located in the same building as their place of occupation, or for a watchman or caretaker is also prohibited. Any authority that allows for residential use of the Property as a legal non-conforming is also restricted per the prohibitions contained in this restrictive covenant.

OPTION 2: ***If the property is restricted to the site-specific land use category, insert a paragraph that describes those uses that are consistent with assumptions used to develop site-specific criteria pursuant to Section 20120a(2) and 20120b of the NREPA as approved by the DEQ.***

EXHBIT 4 CONSENT OF EASEMENT HOLDERS

This Exhibit is only necessary if easement holders on the property have their rights materially impacted by the restrictions set forth in the Restrictive Covenant. This document provides the express written permission of the easement holder to record the restrictive covenant and have their property rights subject to and subordinate to the terms of the restrictive covenant. Insert additional pages if multiple easement holders exist for the Property.

A. ***Insert name of the easement holder.***

B. ***Insert Notary Public information as:***
Name of state
County

C. **Insert the appropriate form of acknowledgement from the following:**

***OPTION 1**: For an individual:*
The foregoing instrument was acknowledged before me this **[*date*]** by **[name of individual]**.

***OPTION 2**: For a corporation:*
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of officer or agent, title of officer or agent*]** of **[*name of corporation*]**, a **[*state or place of incorporation*]**, on behalf of the corporation.

***OPTION 3**: For a partnership:*
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of partnership or agent*]**, partner **[*or agent*]** on behalf of **[*name of partnership*]**, a partnership.

***OPTION 4**: For an individual acting as principal by an attorney in fact (power of attorney):*
The foregoing instrument was acknowledged before me this **[*date*]** by **[*name of attorney in fact*]** as attorney in fact on behalf of **[*name of principal*]**.

D. **Print, Type, or Stamp name of Notary Public.**

EXHIBIT [ ] AREAS OF THE PROPERTY NOT ADDRESSSED BY THE RESPONSE ACTIVITIES

This Exhibit is to be used when certain areas of the Property will not be addressed by the response activities implemented at the Property. The survey must be conducted by a licensed surveyor. The survey shall include the legal descriptions of those areas on the Property that are not addressed by the response activities and clearly delineate and graphically depict those areas in relation to the Property boundaries.

-- END OF INSTRUCTIONS --

Michigan Department of Environmental Quality
Remediation and Redevelopment Division

Restrictive_Covenant.doc
8/1/2011

THE ATTACHED MODEL DOCUMENT ENTITLED:

DECLARATION OF RESTRICTIVE COVENANT

IS A DRAFT DOCUMENT WHICH IS SUBJECT TO REVISION. IT IS PROVIDED TO THE PUBLIC AS PRELIMINARY GUIDANCE AS TO THE CONTENT, FORMAT, AND TERMS OF THIS COVENANT. IT IS NOT INTENDED, NOR CAN IT BE RELIED UPON, TO CREATE ANY SUBSTANTIVE OR PROCEDURAL RIGHTS BY ANY OTHER PARTY.

PLEASE CONTACT THE COMPLIANCE AND ENFORCEMENT SECTION, REMEDIATION AND REDEVELOPMENT DIVISION, MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY, AT 517-373-7818 TO RECEIVE THE MOST RECENT DRAFT OF THIS DOCUMENT.

> **NOTE**: There are recording requirements for instruments filed with Michigan county register of deeds offices contained in Section 1 of the Recording Requirements Act, 1937 PA 103, as amended (Act 103), MCL 565.201, link to Act 103.

DECLARATION OF RESTRICTIVE COVENANT

DEQ Reference No: RC-RD-201-____**(A)**____

This Declaration of Restrictive Covenant ("Restrictive Covenant") has been recorded with the ____**(B)**____ County Register of Deeds for the purpose of protecting public health, safety, and welfare, and the environment by prohibiting or restricting activities that could result in unacceptable exposure to environmental contamination present at the property located at ____**(C)**____ and legally described in Exhibit 1 attached hereto ("Property").

____**(D)**____

The Property described contains hazardous substances in excess of the concentrations developed as the unrestricted residential criteria under Section 20120a(1)(a) or (17) of the NREPA. The DEQ recommends that prospective purchasers or users of the Property undertake appropriate due diligence prior to acquiring or using this Property, and undertake appropriate actions to comply with the requirements of Section 20107a of the NREPA.

The response activities required the recording of this Restrictive Covenant with the ____**(B)**____ County Register of Deeds to: 1) restrict unacceptable exposures to hazardous substances located on the Property; 2) assure that the use of Property is consistent with the exposure assumptions used to develop the ____**(E)**____ of the NREPA and the exposure control measures relied upon at the Property; ____**(F)**____.

The restrictions contained in this Restrictive Covenant are based upon information available at the time the response activities were implemented. Failure of the response activities to achieve and maintain the criteria, exposure controls, and any requirements specified by the response activities; future changes in the environmental condition of the Property or changes in the ____**(E)**____ of the NREPA; the discovery of environmental conditions at the Property that were not accounted for during implementation of the response activities; or use of the Property in a manner inconsistent with the restrictions described herein, may result in this Restrictive Covenant not being protective of public health, safety, and welfare, and the environment.

____**(G)**____

Definitions

For the purposes of this Restrictive Covenant, the following definitions shall apply:

"DEQ" means the Michigan Department of Environmental Quality, its successor entities, and those persons or entities acting on its behalf.

"Owner" means at any given time the then current title holder of the Property or any portion thereof.

All other terms used in this document which are defined in Part 3, Definitions, of the NREPA; Part 201 of the NREPA; or the Part 201 Administrative Rules, 2002 Michigan Register; Effective December 21, 2002, shall have the same meaning in this document as in Parts 3 and 201 of the NREPA and the Part 201 Administrative Rules, as of the date of filing of this Restrictive Covenant.

Summary of Response Activities

____(H)____

____(I)_____

NOW THEREFORE,

1. Declaration of Land Use or Resource Use Restrictions

____(J)____, **____(K)_____**, hereby declares and covenants that the Property shall be subject to the following restrictions and conditions:

a. **____(L)____**

b. Prohibited Activities to Eliminate Unacceptable Exposure to Hazardous Substances. The Owner shall prohibit activities **____(M)____** that may result in exposures to hazardous substances at the Property. These prohibited activities include:

____(N)____

c. Prohibited Activities to Ensure the Effectiveness and Integrity of the Response Activity. The Owner shall prohibit activities on the Property that may interfere with any element of the response activities, including the performance of operation and maintenance activities, monitoring, or other measures necessary to ensure the effectiveness and integrity of the response activities implemented at the Property. These prohibited activities include:

____(O)____

d**.** Contaminated Soil Management. The Owner shall manage all soils, media and/or debris located **____(P)____** in accordance with the applicable requirements of Section 20120c of the NREPA; Part 111, Hazardous Waste Management, of the NREPA; Subtitle C of the Resource Conservation and Recovery Act, 42 U.S.C. Section 6901 *et seq.*; the administrative rules promulgated thereunder; and all other relevant state and federal laws.

2. **____(Q)____**

3. Access. The Owner grants to the DEQ and its designated representatives the right to enter the Property at reasonable times for the purpose of determining and monitoring compliance with the response activities, including the right to take samples, inspect the operation of the response activities and inspect any records relating thereto, and to perform any actions necessary to maintain compliance with Part 201.

4. Conveyance of Property Interest. The Owner shall provide notice to the DEQ of the Owner's intent to transfer any interest in the Property at least fourteen (14) business days prior to consummating the conveyance. A conveyance of title, easement, or other interest in the Property shall not be consummated by the Owner without adequate and complete provision for compliance with the applicable provisions of Section 20116 of the NREPA. The notice required to be made to the DEQ under this Paragraph shall be made to: Chief, Remediation and Redevelopment Division, Michigan DEQ, P.O. Box 30426, Lansing, Michigan 48909-7926; and shall include a statement that the notice is being made pursuant to the requirements of this Restrictive Covenant, DEQ Reference Number RC-RD-201-____**(A)**____. A copy of this Restrictive Covenant shall be provided to all future owners, heirs, successors, lessees, easement holders, assigns, and transferees by the person transferring the interest.

5. Term of Restrictive Covenant. This Restrictive Covenant shall run with the Property and shall be binding on the Owner; future owners; and their successors and assigns, lessees, easement holders, and any authorized agents, employees, or persons acting under their direction and control. This Restrictive Covenant shall continue in effect until the DEQ or its successor determines that hazardous substances no longer present an unacceptable risk to the public health, safety, or welfare, or the environment. This Restrictive Covenant may only be modified or rescinded with the written approval of the DEQ.

6. Enforcement of Restrictive Covenant. The State of Michigan, through the DEQ, and ____**(R)**____ may individually enforce the restrictions set forth in this Restrictive Covenant by legal action in a court of competent jurisdiction.

7. Severability. If any provision of this Restrictive Covenant is held to be invalid by any court of competent jurisdiction, the invalidity of such provision shall not affect the validity of any other provisions hereof, and all such other provisions shall continue unimpaired and in full force and effect.

8. Authority to Execute Restrictive Covenant. The undersigned person executing this Restrictive Covenant is the Owner, or has the express written permission of the Owner ____**(S)**____, and represents and certifies that he or she is duly authorized and has been empowered to execute and deliver this Restrictive Covenant

IN WITNESS WHEREOF, **____(T)____** has caused this Restrictive Covenant, RC-RD-201-**____(A)____**, to be executed on this **____(U)____** day of **____(V)____**.

____(T)____

By: ______________________________
Signature

Name: ___________________________
Print or Type Name

Its: ______________________________
Title

STATE OF **____(W)____**
COUNTY OF **____(W)____**

____(X)____

____
Notary Public Signature

____(Y)____
Notary Public, State of ____________________
County of _______________________________
My Commission Expires: __________________
Acting in the County of ___________________

Prepared by and when recorded return to:

____(Z)____
____(AA)____

CONSENT OF OWNER

I, ____**(A)**____, the current and legal Owner of the Property, do hereby consent to the recording of this Restrictive Covenant, RC-RD-201-____**(B)**____, and authorize ____**(C)**____ to file the Restrictive Covenant with the ____**(D)**____ County Register of Deeds for recording.

____**(A)**____

By: ______________________________
Signature

Name: ___________________________
Print or Type Name

Its: ______________________________
Title

STATE OF ____**(E)**____
COUNTY OF ____**(E)**____

____**(F)**____

____
Notary Public Signature

____**(G)**____
Notary Public, State of ___________________
County of ______________________________
My Commission Expires: _________________
Acting in the County of ___________________

EXHIBIT 1

LEGAL DECRIPTION OF PROPERTY

EXHIBIT 2

SURVEY OF THE PROPERTY

OR

SURVEY OF THE PROPERTY AND LIMITS OF LAND OR RESOURCE USE RESTRICTIONS

EXHIBIT 3

DESCRIPTION OF ALLOWABLE USES

EXHIBIT 4

CONSENT OF EASEMENT HOLDERS

As evidenced below by my signature, I agree and consent to the recording of the land use and resource use restrictions specified in this Restrictive Covenant and hereby agree that my property interest shall be subject to, and subordinate to, the terms of the Restrictive Covenant.

____(A)____

By: ______________________________
Signature

Name: ___________________________
Print or Type Name

Its: ______________________________
Title

STATE OF **____(B)____**
COUNTY OF **____(B)____**

____(C)____

____
Notary Public Signature

____(D)____
Notary Public, State of ___________________
County of _____________________________
My Commission Expires: _________________
Acting in the County of ___________________

EXHIBIT [ ]

AREAS OF THE PROPERTY NOT ADDRESSED BY THE RESPONSE ACTIVITIES

Appendix I – Table of Contents

APPENDIX I.1 – Rule 290 of the Michigan Air Pollution Control Rules
APPENDIX I.2 – Rule 290 Permit to Install Exemption: Sources with Limited Emissions Record

APPENDIX I.1

Rule 290 of the Michigan Air Pollution Control Rules

Rule 290 of the Michigan Air Pollution Control Rules is provided as an exert below:

R 336.1290 Permit to install exemptions; emission units with limited emissions.

Rule 290. The requirement of R 336.1201(1) to obtain a permit to install does not apply to any of the emission units listed in (a) if the conditions listed in (b), (c), and (d) are met. Notwithstanding the definition in R 336.1121(a), for the purpose of this rule, uncontrolled emissions are the emissions from an emission unit based on actual operation, not taking into account any emission control equipment. Controlled emissions are the emissions from an emission unit based on actual operation, taking into account the control equipment.

(a) An emission unit which meets any of the following criteria:

(i) Any emission unit that emits only noncarcinogenic volatile organic compounds or noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, if the uncontrolled or controlled emissions of air contaminants are not more than 1,000 or 500 pounds per month, respectively.

(ii) Any emission unit that the total uncontrolled or controlled emissions of air contaminants are not more than 1,000 or 500 pounds per month, respectively, and all of the following criteria are met:

(A) For noncarcinogenic air contaminants, excluding noncarcinogenic volatile organic compounds and noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, with initial threshold screening levels greater than or equal to 2.0 micrograms per cubic meter, the uncontrolled or controlled emissions shall not exceed 1,000 or 500 pounds per month, respectively.

(B) For noncarcinogenic air contaminants, excluding noncarcinogenic volatile organic compounds and noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, with initial threshold screening levels greater than or equal to 0.04 micrograms per cubic meter and less than 2.0 micrograms per cubic meter, the uncontrolled or controlled emissions shall not exceed 20 or 10 pounds per month, respectively.

(C) For carcinogenic air contaminants with initial risk screening levels greater than or equal to 0.04 micrograms per cubic meter, the uncontrolled or controlled emissions shall not exceed 20 or 10 pounds per month, respectively.

(D) The emission unit shall not emit any air contaminants, excluding noncarcinogenic volatile organic compounds and noncarcinogenic materials which are listed in R 336.1122(f) as not contributing appreciably to the formation of ozone, with an initial threshold screening level or initial risk screening level less than 0.04 micrograms per cubic meter.

(iii) Any emission unit that emits only noncarcinogenic particulate air contaminants and other air contaminants that are exempted under paragraphs (i) or (ii) of this subdivision if all of the following provisions are met:

(A) The particulate emissions are controlled by an appropriately designed and operated fabric filter collector or an equivalent control system which is designed to control particulate matter to a concentration of less than or equal to 0.01 pounds of *R 336.1290 2-83 As Amended 6/20/2008* particulate per 1,000 pounds of exhaust gases and which do not have an exhaust gas flow rate more than 30,000 actual cubic feet per minute.

(B) The visible emissions from the emission unit are not more than 5% opacity in accordance with the methods contained in R 336.1303.

(C) The initial threshold screening level for each particulate air contaminant, excluding nuisance particulate, is more than 2.0 micrograms per cubic meter.

(b) A description of the emission unit is maintained throughout the life of the unit.

(c) Records of material use and calculations identifying the quality, nature, and quantity of the air contaminant emissions are maintained in sufficient detail to demonstrate that the emissions meet the emission limits outlined in this rule.

(d) The records are maintained on file for the most recent 2-year period and are made available to the air quality division upon request.

APPENDIX I.2

Rule 290 Permit to Install Exemption: Sources with Limited Emissions Record

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY, ENVIRONMENTAL SCIENCE AND SERVICES DIVISION

RULE 290 PERMIT TO INSTALL EXEMPTION: SOURCES WITH LIMITED EMISSIONS RECORD

This record is provided as a courtesy for businesses by the Michigan Department of Environmental Quality (MDEQ), Environmental Science and Services Division, Clean Air Assistance Program, and is not required to be returned or submitted to the MDEQ.

Applicable Rule: Rule 290 of the Michigan Air Pollution Control Rules

NOTE:

- Rule 290 of the Michigan Air Pollution Control Rules exempts an emission unit with limited emissions from having to apply for Permit to Install. Rule 201 requires sources to obtain a Permit to Install prior to the installation, construction, reconstruction, relocation, or modification of an emission unit. Sources using this exemption must not meet any of the criteria in Rule 278 and must be able to demonstrate compliance with the various emission limits contained in Rule 290.

- Utilization of this form is not the sole method of demonstrating compliance with the requirements of Rule 290, unless required by a permit such as a Renewable Operating Permit (ROP). For example, an alternative method of demonstrating compliance could be determining the emissions of air contaminants from a single unit of production and recording the number of production units generated per month.

- ROP subject sources – This document must be used to track emissions unless an alternate format has been approved by the District Supervisor or alternate format is cited in the ROP.

- An emission unit that emits an air contaminant, excluding noncarcinogenic Volatile Organic Compounds (VOCs) and noncarcinogenic, non-ozone forming materials listed in Rule 122(f), which has an Initial Threshold Screening Level (ITSL) or Initial Risk Screening Level (IRSL) less than 0.04 micrograms per cubic meter (ug/m3) cannot use Rule 290.

- For all emission units exempt pursuant to Rule 290 that emit particulate emissions which have an ITSL equal to or less than 2.0 ug/m3 and greater than or equal 0.04 ug/m3, the particulate emissions must be included in Section 2.

- For all emission units exempt pursuant to Rule 290 that emit particulate emissions which have an IRSL equal to or greater than 0.04 ug/m3, the particulate emissions must be included in Section 3.

- Perchloroethylene is the only non-ozone forming material listed in Rule 122(f) that is a carcinogen. Two of the stabilizers in Rule 122(f) Table 11, tertiary butyl alcohol and 1,2-butylene oxide, are carcinogenic and are ozone forming materials.

- If an emission unit is equipped with a control device (i.e., equipment that captures and/or destroys air contaminants) and the control device is not vital to production of the normal product of the process or to its normal operation, then there are two options of recording emissions in Sections 2, 3, and 4:
    1. record all uncontrolled emissions of air contaminants (i.e., all air contaminants entering the control device); or
    2. record all controlled emissions of air contaminants (all air contaminants leaving the control device).

  Whatever option is chosen, make sure that option is used consistently throughout Sections 2, 3, 4, and 5.

- If the emission unit is not equipped with a control device or the control device is vital to production of the normal product of the process or to its normal operation, then the quantity of each emission of air contaminant identified in Sections 2, 3, 4, and 5 should be recorded as uncontrolled emissions.

- Monthly emission records are required to be maintained on file for the most recent two-year period and made available to the MDEQ, Air Quality Division upon request. (ROP subject sources must keep records for the most recent five year period.)

Please print or type all information.

1. COMPLETE FOR EACH EMISSION UNIT USING THE EXEMPTION IN RULE 290.

SOURCE NAME:

MONTH/YEAR:

DESCRIPTION OF EMISSION UNIT (including control devices):

2. RECORD EMISSIONS OF NONCARCINOGENIC AIR CONTAMINANTS (EXCLUDING NONCARCINOGENIC VOCS AND NONCARCINOGENIC, NON-OZONE FORMING MATERIALS LISTED IN RULE 122(f)) (see Appendix A)

ITSL ≥ 2.0 ug/m3

(The emissions of noncarcinogenic particulate air contaminants with an ITSL > 2.0 ug/m3 do not have to be recorded in this table as long as the emission unit is in compliance with the requirements in Section 6.)

CAS #	**Chemical Name**	**Uncontrolled Emissions (lbs/month)**	**Controlled Emissions (lbs/month)**
Monthly Total		①	②

2.0 ug/m3 > ITSL ≥ 0.04 ug/m3

CAS #	**Chemical Name**	**Uncontrolled Emissions (lbs/month)**	**Controlled Emissions (lbs/month)**
Monthly Total		③	④

Compliance Criteria:

- The total in Box ① must be ≤ 1,000 pounds or the total in Box ② must be ≤ 500 pounds. If the total in Box ① or in Box ② is greater than the respective emission limitations, contact your local district office.
- The total in Box ③ must be ≤ 20 pounds or the total in Box ④ must be ≤ 10 pounds. If the total in Box ③ or in Box ④ is greater than the respective emission limitations, contact your local district office.

3. RECORD EMISSIONS OF CARCINOGENIC AIR CONTAMINANTS

IRSL ≥ 0.04 ug/m3

(The emissions of carcinogenic particulate air contaminants with an IRSL ≥ 0.04 ug/m3 must be recorded in this table even though it is also exempt under Section 6.)

CAS #	Chemical Name	Uncontrolled Emissions (lbs/month)	Controlled Emissions (lbs/month)
Monthly Total		⑤	⑥

Compliance Criteria:

- The total in Box ⑤ must be ≤ 20 pounds or the total in Box ⑥ must be ≤ 10 pounds. If the total in Box ⑤ or in Box ⑥ is greater than the respective emission limitations, contact your local district office.

4. RECORD EMISSIONS OF ALL NONCARCINOGENIC VOCS AND NONCARCINOGENIC, NON-OZONE FORMING MATERIALS LISTED IN RULE 122(f) (see Appendix A)

CAS #	Chemical Name	Uncontrolled Emissions (lbs/month)	Controlled Emissions (lbs/month)
Monthly Total		⑦	⑧

Compliance Criteria:

- The total in Box ⑦ must be ≤ 1,000 pounds or the total in Box ⑧ must be ≤ 500 pounds. If the total in Box ⑦ or in Box ⑧ is greater than the respective emission limitations, contact your local district office.

5. RECORD TOTAL MONTHLY EMISSIONS

	lbs/month
Total uncontrolled emissions (Box ① + Box ③ + Box ⑤ + Box ⑦)	
Total controlled emissions (Box ② + Box ④ + Box ⑥ + Box ⑧)	

Compliance Criteria:

- The total uncontrolled emissions (Box ① + Box ③ + Box ⑤ + Box ⑦) must be ≤ 1,000 pounds. If the total uncontrolled emissions are greater than 1,000 pounds, contact your local district office; or
- The total controlled emissions (Box ② + Box ④ + Box ⑥ + Box ⑧) must be ≤ 500 pounds. If the total controlled emissions are greater than 500 pounds, contact your local district office.

6. NONCARCINOGENIC PARTICULATE AIR CONTAMINANTS

The emission unit may emit noncarcinogenic particulate air contaminants provided that the emission unit is in compliance with the following:

Y N

☐ ☐ Are the particulate emissions controlled by an appropriately designed and operated fabric filter collector or an equivalent control system which is designed to control particulate matter to a concentration of less than or equal to 0.01 pounds of particulate per 1,000 pounds of exhaust gases and which do not have an exhaust gas flow rate of more than 30,000 actual cubic feet per minute?

☐ ☐ Are the visible emissions from the emission unit not more than 5% opacity in accordance with the methods contained in Rule 303?

☐ ☐ Is the Initial Threshold Screening Level (ITSL) for each particulate air contaminant, excluding nuisance particulate > 2.0 ug/m3?

Notes:

- Quantities of particulates being emitted from an emission unit complying with the requirements in this Section should not be included in Section 2.
- Quantities of noncarcinogenic particulates with an ITSL ≤ 2.0 ug/m3 and ≥ 0.04 ug/m3 must be included in Section 2.
- Quantities of carcinogenic particulates ≥ 0.04 ug/m3 must be included in Section 3.

Compliance Criteria:

- If any of the preceding questions concerning noncarcinogenic particulate air contaminants are answered “No”, contact your local district office.

7. OTHER REQUIREMENTS

- Attach emission calculations to demonstrate compliance with the emission limits identified in Sections 2, 3, 4, and 5.
- Keep this record on file for a minimum of 2 years, if not required for a longer period from other requirements, i.e. ROP.

APPENDIX A

R 336.1122 Definitions; V.

Rule 122. As used in these rules:

(f) "**Volatile organic compound**" means any compound of carbon or mixture of compounds of carbon that participates in photochemical reactions, excluding the following materials, all of which have been determined by the United States environmental protection agency to have negligible photochemical reactivity:

(i) Carbon monoxide.

(ii) Carbon dioxide.

(iii) Carbonic acid.

(iv) Metallic carbides or carbonates.

(v) Boron carbide.

(vi) Silicon carbide.

(vii) Ammonium carbonate.

(viii) Ammonium bicarbonate.

(ix) Methane.

(x) Ethane.

(xi) The methyl chloroform portion of commercial grades of methyl chloroform, if all of the following provisions are complied with:

(A) The commercial grade of methyl chloroform is used only in a surface coating or coating line that is subject to the requirements of part 6 or 7 of these rules.
(B) The commercial grade of methyl chloroform contains no stabilizers other than those listed in table 11.
(C) Compliance with the applicable limits specified in part 6 or 7 of these rules is otherwise not technically or economically reasonable.
(D) All measures to reduce the levels of all organic solvents, including the commercial grade of methyl chloroform, from the surface coating or coating line to the lowest reasonable level will be implemented.
(E) The emissions of the commercial grade of methyl chloroform do not result in a maximum ambient air concentration exceeding any of the allowable ambient air concentrations listed in table 11.
(F) The use of the commercial grade of methyl chloroform is specifically identified and allowed by a permit to install, permit to operate, or order of the department.
(G) Table 11 reads as follows:

TABLE 11

Commercial grade of methyl chloroform --
allowable ambient air concentrations

Compound	ppm[1]	Time[2]
Methyl chloroform	3.5	1 hour
Tertiary butyl alcohol[3]	1.0	1 hour
Secondary butyl alcohol[3]	1.0	1 hour
Methylal[3]	10.0	1 hour
1,2-butylene oxide[3]	0.028 and 0.00041	1 hour annual

---

1. Parts per million, by volume
2. Averaging time period
3. This compound is a stabilizer

(xii) The methyl chloroform portion of commercial grades of methyl chloroform that contain any other stabilizer not listed in table 11 of this rule, if all of the following provisions are complied with:

(A) The commercial grade of methyl chloroform is used only in a surface coating or coating line that is subject to the requirements of part 6 or 7 of these rules.
(B) Compliance with the applicable limits specified in part 6 or 7 of these rules is otherwise not technically or economically reasonable.
(C) All measures to reduce the levels of all organic solvents, including the commercial grade of methyl chloroform, from the surface coating or coating line to the lowest reasonable level will be implemented.
(D) The emissions of any compound in the commercial grade of methyl chloroform that is listed in table 11 of this rule do not result in a maximum ambient air concentration exceeding any of the allowable ambient air concentrations listed in table 11.
(E) The emission of all compounds in the commercial grade of methyl chloroform that are not listed in table 11 is demonstrated to comply with R 336.1901.
(F) The use of the commercial grade of methyl chloroform is specifically identified and allowed by a permit to install, permit to operate, or order of the department.

(xiii) Acetone.

(xiv) Cyclic, branched, or linear completely methylated siloxanes.

(xv) Parachlorobenzotrifluoride.

(xvi) Perchloroethylene.

(xvii) Trichlorofluoromethane (CFC-11).

(xviii) Dichlorodifluoromethane (CFC-12).

(xix) 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113).

(xx) 1,2-dichloro 1,1,2,2-tetrafluoroethane (CFC-114).

(xxi) Chloropentafluoroethane (CFC-115).

(xxii) 1,1-dichloro 1-fluoroethane (HCFC-141b).

(xxiii) 1,chloro 1,1-difluoroethane (HCFC-142b).

(xxiv) Chlorodifluoromethane (HCFC-22).

(xxv) 1,1,1-trifluoro 2,2-dichloroethane (HCFC-123).

(xxvi) 2-chloro-1,1,1,2-tetrafluoroethane (HCFC-124).

(xxvii) Trifluoromethane (HFC-23).

(xxviii) Pentafluoroethane (HFC-125).

(xxix) 1,1,2,2-tetrafluoroethane (HFC-134).

(xxx) 1,1,1,2-tetrafluoroethane (HFC-134a).

(xxxi) 1,1,1-trifluoroethane (HFC-143a).

(xxxii) 1,1-difluoroethane (HFC-152a).

(xxxiii) 3,3-dichloro-1, 1,1,2,2-pentafluoropropane (HCFC-225ca).

(xxxiv) 1,3-dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb).

(xxxv) 1,1,1,2,3,4,4,5,5,5-decafluoropentane (HFC 43-10mee).

(xxxvi) Difluoromethane (HFC-32).

(xxxvii) Ethyl fluoride (HFC-161).

(xxxviii) 1,1,1,3,3,3-hexafluoropropane (HFC-236fa).

(xxxix) 1,1,2,2,3-pentafluoropropane (HFC-245ca).

(xl) 1,1,2,3,3- pentafluoropropane (HFC-245ea).

(xli) 1,1,1,2,3- pentafluoropropane (HFC-245eb).

(xlii) 1,1,1,3,3- pentafluoropropane (HFC-245fa).

(xliii) 1,1,1,2,3,3-hexafluoropropane (HFC-236ea).

(xliv) 1,1,1,3,3-pentafluorobutane (HFC365mfc).

(xlv) Chlorofluoromethane (HCFC-31).

(xlvi) 1,2-dichloro-1,1,2-trifluoroethane (HCFC-123a).

(xlvii) 1-chlor-1-fluoroethane (HCFC-151a).

(xlviii) 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane.

(xlix) 2-(difluoromethoxymethyl)-1,1,1,2,3,3,3-heptafluoropropane.

(l) 1-ethoxy-1,1,2,2,3,3,4,4,4-nonafluorobutane.

(li) 2-(ethoxydifluoromethyl)-1,1,1,2,3,3,3-heptafluoropropane.

(lii) Methyl acetate.

(liii) Perfluorocarbon compounds that fall into the following classes:

(A) Cyclic, branched, or linear, completely fluorinated alkanes.
(B) Cyclic, branched, or linear, completely fluorinated ethers with no unsaturations.
(C) Cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations.
(D) Sulfur-containing perfluorocarbons with no unsaturations and with sulfur bonds only to carbon and fluorine.

(liv) Methylene chloride.

The methods described in R 336.2004 and R 336.2040 shall be used for measuring volatile organic compounds for purposes of determining compliance with emission limits. Where such a method also measures compounds with negligible photochemical reactivity, these negligibly-photochemical reactive compounds may be excluded as volatile organic compounds if the amount of such compounds is accurately quantified and such exclusion is approved by the department.

History: 1979 ACS 1, Eff. Jan. 19, 1980; 1985 MR 2, Eff. Feb. 22, 1985; 1988 MR 5, Eff. May 20, 1988; 1989 MR 4, Eff. Apr. 19, 1989; 1993 MR 4, Eff. Apr. 28, 1993; 1997 MR 5, Eff. June 15, 1997; 2000 MR 18, Eff. November 30, 2000; 2003 MR 5, Eff. March 13, 2003.