

Best management practices for vapor investigation and building mitigation decisions

Purpose

This best management practices (BMPs) document describes the processes used to conduct vapor investigations and provides a mitigation decision framework for determining when building mitigation is necessary.

This document is applicable to the Minnesota Pollution Control Agency (MPCA) Resource Conservation and Recovery Act (RCRA) program and the following programs under the Minnesota Environmental Response and Liability Act (MERLA):

- Superfund
- Site Assessment
- Voluntary Investigation and Cleanup (VIC)

When is vapor investigation necessary?

Vapor investigation is necessary whenever there is a known or potential release of vapor forming chemicals. Vapor forming chemicals are defined in the June 2015, United States Environmental Protection Agency (EPA) “Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Source to Indoor Air” (2015 EPA Technical Guide). If a vapor forming chemical is identified as part of a release or potential release and the chemical is not on the TO15 Minnesota soil gas list (Appendix A) and/or an intrusion screening value (ISV) has not been derived, contact the MPCA project team for assistance.

Some examples of potential sources of vapor forming chemicals include:

- Known and suspected releases
- Shallow groundwater contamination
- The presence of Non-Aqueous Phase Liquids (NAPL)

What are the main goals of vapor investigation?

The main goals of vapor investigation are:

- Determine the extent and magnitude of soil gas impacts
- Evaluate vapor intrusion (VI) risk to building receptors
- Mitigate VI risk to building receptors

What are the vapor investigation steps?

There are five general vapor investigation steps summarized below. Not all of the steps may be applicable for all sites. MPCA has also developed five geographic information systems (GIS) VI map templates corresponding to each step to document the results of the work performed and to provide an effective way to readily communicate the information collected. These templates should be used to create site-specific maps and be included in the vapor investigation results submitted to MPCA. An introduction to the VI map templates can be found on the MPCA website at: <https://www.pca.state.mn.us/sites/default/files/c-s4-10.pdf>.

A zip folder containing the map templates and associated GIS files can be found at:
https://www.pca.state.mn.us/sites/default/files/Vapor_Intrusion_Map_Templates.zip.

Step 1 – GIS Template 1 – Evaluate known and potential vapor release sources, and identify buildings and their use (i.e. residential, industrial, commercial)

Step 2 – GIS Template 2 – Conduct soil gas and/or sub-slab investigation within the immediate vicinity of known and potential VI release sources

Step 3 – GIS Template 3 – Determine VI area of concern (AOC) based on the soil gas and/or sub-slab sample results

Step 4 – GIS Template 4 – Make vapor mitigation decisions for buildings based on building specific investigation results and building conditions

Step 5 – GIS Template 5 – Establish vapor mitigation area based on the defined extent and magnitude of vapor impacts and building mitigation status

The following sections provide additional details on each of the VI investigation steps.

Step 1 – Evaluate vapor sources and identify nearby buildings and their use

First, review available site information to determine if there is a known and/or potential release source of vapor forming chemicals. When there is a known and/or a potential source of a vapor forming chemical(s) and a building receptor, there is potential for VI risk that must be investigated.

Next, identify building receptors and building use (residential, commercial, industrial, etc.) within 100 feet of known and/or potential release sources of vapor forming chemicals. Building receptors can include both existing habitable structures and proposed new buildings that are designed for human occupancy.

Illustrate known and/or potential release sources of vapor forming chemicals and building receptors (include usage, i.e. residential or commercial/industrial) on GIS Template 1.

Step 2 – Conduct soil gas and/or sub-slab investigation

Soil gas and/or sub-slab samples should be collected within 100 ft. of known or suspected vapor sources to define extent and magnitude of soil gas impacts and develop a VI AOC. Use GIS Template 2 to assist in developing the proposed VI investigation sampling locations and illustrate the proposed sample locations.

Collect soil gas and/or sub-slab samples within a 100 ft. buffer of known or suspected vapor sources [i.e. groundwater plumes, known volatile organic compounds (VOC) release sources]. If soil gas and/or sub-slab concentrations are detected above 33 times an intrusion screening value (33X ISV) a vapor source with potential VI risk is present.

Multiple sampling events are necessary due to the temporal and seasonal variability that can be observed in soil gas and sub-slab sampling to conclude there is not a potential VI risk. EPA's 2015 Technical Guide states, "Seasonally variable conditions (e.g., soil moisture levels, depth to groundwater) can lead to seasonally variable concentrations and distributions of vapors in the vadose zone. An individual sample (or single round of sampling) would be insufficient to characterize seasonal variability, or variability at any other time scale."

The minimum sampling necessary to address seasonal temporal sampling for vapor investigation includes collecting samples at least 30 days apart and under differing seasonal conditions as follows:

- One sampling event in the heating season, which MPCA defines as November 1 thru March 31
- One sampling event in the non-heating season, which MPCA defines as April 1 thru October 31

Collect soil gas and sub-slab samples in accordance with the sampling methodologies included as Appendix B. Appendix C consists of a table with a recommended number of sub-slab samples to collect based on building size.

If the first round of samples collected indicate that a vapor screening level (i.e. 33X ISV) is exceeded, the next phase of investigation (or mitigation for sub-slab samples) can commence without collecting a second seasonal sample. If both seasonal soil gas-sampling events within 100 feet of a building are less than 33X ISVs, a building specific investigation (sub-slab sampling and VI building survey) will typically not be necessary. However, if site contaminant conditions are not stable (i.e. migrating soil gas or groundwater plumes), ongoing sentinel soil gas monitoring may be required. If soil gas concentrations within 100 feet of a building receptor are greater than ISVs, and there is reason to believe that use of the 33X ISV screening level is not valid based on building conditions, a VI building survey (Appendix D) should be conducted to determine if a building specific vapor assessment is necessary.

Historic VOC analytical data for a soil gas or sub-slab sample is generally acceptable if the sample was collected within the previous two years. However, if there is a recent known or suspected release after the historic analytical data was collected, and/or evidence of groundwater or soil gas migration, two current rounds of seasonal soil gas or sub-slab sampling are necessary.

Step 3 – Determine VI Area of Concern

The VI AOC defines the area where building specific investigation (VI building survey and sub-slab sampling) is necessary. However, building specific investigation can commence before, and/or concurrent with, defining the VI AOC. The VI AOC can be delineated through:

- Soil gas sampling
- Sub-slab sampling
- A combination of soil gas and sub-slab sampling concurrently

The VI AOC is defined by the area where sub-slab and/or soil gas concentrations are detected above the applicable vapor screening level (33X ISVs). If the VI AOC extent is not defined (e.g. perimeter soil-gas concentrations > 33X ISV) in all directions, continue collecting soil gas and/or sub-slab samples outward in all undefined directions until the vapor impacts are defined. For non-responsible parties conducting VI investigation on their property, the VI AOC should be defined to the property boundaries and all buildings on the property within the VI AOC should be evaluated for potential vapor intrusion risk.

Two sub-slab or soil gas-sampling events are the minimum requirement to document that there is not a VI AOC. This consists of two seasonal (described in Step 2 above) soil gas or sub-slab sampling events within 100 feet of known or potential vapor sources.

Document the VI AOC on GIS Template 3. The original VI AOC will likely be updated and revised as the vapor investigation progresses and additional sampling data is obtained.

Step 4 – Make vapor mitigation decisions

The following sections provide guidance on making mitigation decisions. There are two mitigation decision frameworks based on the type of building use. The two building use categories are:

1. Residential
2. Commercial and/or industrial

The residential building use category includes the following; single family homes, multi-family housing (apartments, townhomes, condominiums, etc.), long-term care facilities, correctional housing, hospitals, childcare centers, churches and schools. Buildings in the residential building use category should be evaluated using the residential framework.

Residential building mitigation decision framework

The decision to mitigate residential buildings is based on **potential VI risk to the building**. Potential VI risk is determined by collecting sub-slab samples from beneath the building and evaluating building conditions to determine if it is valid to use the 33X ISV screening level to evaluate the sub-slab sampling results. All references to ISVs in this section correspond to the **residential ISVs**.

Steps for evaluating potential VI risk to a residential building and determining if building mitigation is necessary are provided below. Mitigation decisions based on sub-slab sampling results and building conditions are also summarized in Table 1 below.

1. Conduct 2 sub-slab sampling events (one sampling event in heating season and one in non-heating season) to evaluate soil gas concentrations beneath the floor slab. Sub-slab samples should be collected in accordance with the sub-slab sampling methodology found in Appendix B.
2. The number of sub-slab samples to be collected from a building is dependent upon the size (area) of the building foundation and the building construction. Appendix C includes a summary table with a recommended number of sub-slab samples to be collected based on building size.
3. Measure and record pressure differential readings between the indoor building air and the air beneath the building at each sub-slab sampling point with a micro-manometer during each sampling event.
4. Complete a VI building survey (Appendix D) to determine if building conditions warrant the use of 33X ISV when evaluating sub-slab sample results. Per the 2015 EPA Technical Guide, specific building factors that may result in 33X ISV not being valid for a specific building and make the building more susceptible to soil gas entry include:
 - *Significant openings to the subsurface that facilitate soil gas entry into the building (e.g., sumps, unlined crawl spaces, earthen floors) other than typical utility penetrations.*
 - *buildings with deteriorating basements or dirt floors, which generally provide poor barriers to vapor (soil gas) entry*
5. For buildings where use of the 33X ISV screening level is valid based on building conditions, compare sub-slab soil gas concentrations to 33X ISVs. If sub-slab concentrations for either sampling event (heating season or non-heating season) exceed 33X ISVs, building mitigation is necessary.
6. For buildings where the use of the 33X ISV screening level is not valid based on building conditions, collect soil gas samples from a depth of 3 feet below the building floor level in accordance with the recommended number of samples per building foundation area in Appendix C. If collection of soil gas samples from a depth of 3 feet is not feasible due to shallow groundwater or bedrock, collect paired 24-hour indoor air and outdoor air samples to evaluate VI risk to the building. Compare the soil gas or indoor air samples concentrations directly to the appropriate ISVs to determine the need for mitigation. **Building mitigation is necessary** if any soil gas or indoor air sample concentrations for either seasonal sampling event exceed the ISVs, and the presence and concentration of the COC cannot be attributed to an indoor or outdoor ambient source.
7. When vapor mitigation is necessary for a residential building, an active sub-slab depressurization (SSD) system should be installed and verified. Additional details regarding SSD system installation and verification testing can be found in the MPCA's diagnostic testing, installation and confirmation sampling for active vapor mitigation systems in single-family residential buildings (MPCA Form c-rem3-06 dated March 2015).
8. Section 6.3.3 of the 2015 EPA Technical Guidance also recommends that appropriate lines of evidence be evaluated to assess building susceptibility to soil gas entry (e.g. concurrently monitoring indoor air samples for presence of radon and finding radon in indoor air at levels greater than in ambient air). In addition to the sampling, investigation and building specific assessment in this BMP, appropriate lines of evidence may also be evaluated on a site-specific basis to assist in determining a building's susceptibility to vapor intrusion. Contact the MPCA Project Team to discuss site-specific appropriate lines of evidence.

9. An additional important part of the mitigation decision process is determining if expedited actions are needed to protect human health. Expedited action decisions are discussed below after Table 2 under the section titled “**When should expedited action be evaluated?**”
10. Illustrate the vapor mitigation decision for each building on GIS Template 4.

Table 1 – Residential mitigation decision – based on sub-slab sampling

Sub-slab Concentrations	Mitigation decision	
	33X ISV is valid ¹	33X ISV is NOT valid ¹
SS ² < ISV	Active mitigation is not necessary. Additional sampling not required unless Site or building conditions change ³	Active mitigation is not necessary. Additional sampling not required unless Site or building conditions change ³
SS ² > ISV and < 33X ISV	Active mitigation is not necessary. Additional sampling not necessary unless Site or building conditions change ³	Active mitigation is necessary ⁴ OR Sample paired sub-slab (or soil-gas below building), indoor and outdoor air and report results to MPCA immediately to determine mitigation action ⁴ OR Address building conditions so 33X ISV screening level is valid, then repeat seasonal sub-slab sampling to determine mitigation ⁴
SS ² > 33X ISV and <33X EISV	Active mitigation is necessary ⁴	Active mitigation is necessary - Contact MPCA to determine the need for expedited ⁵ action
SS ² > 33X EISV	Active mitigation is necessary - Contact MPCA to determine the need for expedited ⁵ action	Active mitigation is necessary - Contact MPCA to determine the need for expedited ⁵ action

Notes:

SS = Sub-slab
 ISV = Intrusion screening value
 EISV = Expedited intrusion screening value

Active Mitigation Necessary	Expedited Action Evaluation
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1. The validity of using 33X ISV for attenuation of sub-slab vapors is based on the building conditions, which are evaluated as part of the VI building survey.
2. Requires two seasonal samples to make determination that mitigation is not necessary. If initial sample concentrations exceed 33X ISV, the decision to progress to mitigation of the building can be made with one sample
3. Examples of changed site conditions can include but are not limited to; migration of a soil gas and/or groundwater plume, changed building conditions (i.e. cracks in floor, building additions, HVAC changes)
4. If Trichloroethylene (TCE) is present in the sub-slab or soil gas below the building above the ISV, and the attenuation factor is **not** valid and a woman who is pregnant or may become pregnant is present, expedited action is necessary. If the TCE sub-slab is >33X ISV, and the attenuation factor is valid and a woman who is pregnant or may become pregnant is present, contact MPCA to determine if expedited action is necessary.
5. Expedited action = paired sub-slab, indoor air and outdoor air sampling or system installation work shall begin as soon as possible and no longer than 30 days after receiving laboratory analytical results.

Commercial and industrial building mitigation decision framework

The decision to mitigate commercial and industrial buildings is also based on **potential VI risk to the building**. However, **completed pathway evaluation for VI** may also be used for determining the need to mitigate when sub-slab concentrations are below the 33X EISVs (expedited intrusion screening value). All references to ISVs in this section correspond to the **industrial ISVs**.

Steps for evaluating VI risk to a commercial and/or industrial building and determining if building mitigation is necessary are provided below. Mitigation decisions based on sampling results are also summarized on Table 2.

1. Conduct 2 sub-slab sampling events (one sampling event in heating season and one in non-heating season) to evaluate soil gas concentrations beneath the floor slab. Sub-slab samples should be collected in accordance with the sub-slab sampling methodology found in Appendix B.
2. The number of sub-slab samples to be collected from a building is dependent upon the size (area) of the building foundation, the building construction and areas of known or suspected contamination. Appendix C includes a summary table with a recommended number of sub-slab samples to be collected based on building size. Additional samples may be necessary to define vapor impacts beneath a building within known or suspected contamination.
3. Measure and record pressure differential readings between the indoor building air and the air beneath the building at each sub-slab sampling point with a micro-manometer during each sampling event.
4. Complete a VI building survey (Appendix D) to document building conditions to determine if conditions warrant the use of 33X ISV when evaluating sub-slab sample results. Per the 2015 EPA Technical Guide, specific building factors that may result in 33X ISV not being valid for a specific building and make the building more susceptible to soil gas entry include:
 - a. *Significant openings to the subsurface that facilitate soil gas entry into the building (e.g., sumps, unlined crawl spaces, earthen floors) other than typical utility penetrations.*
 - b. *Buildings with deteriorating basements or dirt floors, which generally provide poor barriers to vapor (soil gas) entry*
5. For buildings where the use of the 33X ISV screening level is valid (based on building conditions), compare the sub-slab soil gas concentrations to 33X ISVs and 33X EISVs.
 - a. If sub-slab concentrations for any sampling event exceed 33X ISVs, **building mitigation or completed pathway evaluation** is necessary.
 - b. If sub-slab concentrations exceed 33X EISVs, **building mitigation is necessary** and conducting a **completed pathway evaluation** “in lieu of” mitigation is not an option.
6. For buildings where the use of the 33X ISV screening level is not valid based on building conditions, collect soil gas samples from a depth of 3 feet below the building floor level in accordance with the recommended number of samples per building foundation area in Appendix C. If collection of soil gas samples from a depth of 3 feet is not feasible due to shallow groundwater or bedrock, collect paired 24-hour indoor air and outdoor air samples to evaluate VI risk to the building. Compare the soil gas or indoor air samples concentrations directly to the appropriate ISVs to determine the need for mitigation. **Building mitigation is necessary** if any soil gas or indoor air sample concentrations for either seasonal sampling event exceed the ISVs, and the presence and concentration of the COC cannot be attributed to an indoor or outdoor ambient source.
7. Installation of an SSD system is also an acceptable mitigation approach for commercial or industrial buildings. However, additional mitigation approaches (i.e. building pressurization, HVAC controls) may also be effective, where applicable. Forthcoming updates to the MPCA Residential Mitigation BMP (March 2015) will include additional mitigation options for commercial and industrial buildings. Contact the MPCA project team if proposing a mitigation option other than SSD system for a commercial or industrial building.
8. An additional important part of the mitigation decision process is determining if expedited actions are needed to protect human health. Expedited action decisions are discussed below after Table 2 under the section titled “**When should expedited action be evaluated?**”
9. Illustrate vapor mitigation decisions for buildings on GIS Template 4.

Completed pathway evaluation

1. Completed pathway evaluation for a commercial and/or industrial building where sub-slab concentrations are below 33X ISVs consists of the following:
 - a. Conduct a VI building survey (Appendix D) to assess building susceptibility to VI and identify potential VI entry points including:
 - Floor slab conditions (thickness, excessive cracking and/or deterioration)
 - Crawl spaces with earthen floors
 - Unsealed groundwater sumps
 - Floor drains open to the subsurface
 - Utility penetrations with significant openings to the sub-surface
 - b. Document the operating characteristics of the HVAC system for the building on the VI building survey (Appendix D).
 - c. Identify and evaluate potential vapor contributions from indoor and ambient background sources (i.e. chemical storage inventory, known use of chlorinated VOCs within the building)
 - d. Conduct a **minimum** of two semi-annual seasonal sampling events (two heating season and two non-heating season) that includes concurrent paired sampling of; sub-slab, indoor air and outdoor ambient air.
 - e. Evaluate whether VI is occurring by comparing indoor air concentrations to:
 - Industrial ISVs
 - Sub-slab concentrations
 - Outdoor air concentrations
 - f. In addition to the above analytical sampling, for each seasonal sampling event monitor the pressure differential between the indoor building air and the air beneath the building at each sub-slab sampling location under various occupancy conditions to determine if a pressure differential exists that would cause movement of vapors from the subsurface into the building.
 - g. Submit the completed pathway evaluation results to MPCA for review and determination of a completed pathway. MPCA will evaluate the following general criteria for determining whether the VI pathway is complete or likely to be complete:
 - Are there Indoor air concentrations above ISVs in any of the indoor air samples that are not attributable to an indoor or outdoor source?
 - Are there building conditions that indicate the 33X ISV screening level is not valid and the building is susceptible to VI?
 - Do the differential pressure measurements indicate positive pressure between the building indoor air and the sub-surface?
 - What are the source and sub-surface concentrations and stability of soil gas and groundwater plumes?
 - h. If evidence of a confirmed completed pathway including vapor concentrations exceeding ISVs is observed, the MPCA should be notified immediately and building mitigation is necessary.
 - i. Additional investigation, completed pathway evaluation or building mitigation is necessary if the completed pathway evaluation is inconclusive that:
 - VI is not occurring
 - There is no VI risk to the building
2. An additional important part of the mitigation decision process is determining if expedited actions are needed to protect human health. Expedited action decisions are discussed below after Table 2 under the section titled **“When should expedited action be evaluated?”**
3. Illustrate vapor mitigation decisions for buildings on GIS Template 4.

Table 2 – Commercial/Industrial mitigation decision – Based on sub-slab sampling

Sub-slab concentrations	Mitigation decision	
	33X ISV is valid ¹	33X ISV is NOT valid ¹
SS ² < ISV	Active mitigation not necessary Indoor air sampling not necessary Additional sampling not necessary unless Site conditions change ³	
SS ² > ISV and < 33X ISV	No further investigation or mitigation is necessary unless site conditions change ³	Active mitigation is necessary ⁴ OR Sample paired sub-slab (or soil-gas below building), indoor and outdoor air and report results to MPCA immediately to determine mitigation ⁴ OR Address building conditions so 33X ISV screening level is valid, then repeat seasonal sub-slab sampling to determine mitigation ⁴
SS ² > 33X ISV and <33X EISV	Active mitigation is necessary ⁴ OR Conduct completed pathway ⁵ investigation	Active mitigation is necessary ⁴ OR Conduct completed pathway ⁵ investigation - Contact MPCA to determine the need for expedited ⁶ action
SS ² > 33X EISV	Active mitigation is necessary ⁴ Contact MPCA to determine the need for expedited ⁶ action	Active mitigation is necessary ⁴ Contact MPCA to determine the need for expedited ⁶ action

Notes:

EISV – Expedited ISV
ISV – Intrusion screening value
SS – sub-slab

Active Mitigation or Completed Pathway

Expedited Action Evaluation

1. The validity of using 33X ISV for attenuation of sub-slab vapors is based on the building conditions, which are evaluated as part of the VI building survey.
2. Requires two seasonal sub-slab sample events to make determination not to mitigate. If the initial sub-slab sample concentration exceeds 33X ISV, mitigation or indoor air sampling can commence
3. Examples of changed site conditions can include but are not limited to; migration of an unstable soil gas and/or groundwater plume, changed building conditions (i.e. cracks in floor, building additions, HVAC changes)
4. If Trichloroethylene (TCE) is present in the sub-slab or soil gas below the building above the ISV, and the attenuation factor is **not** valid and a woman who is pregnant or may become pregnant is present, expedited action is necessary. If the TCE sub-slab is >33X ISV, and the attenuation factor is valid and a woman who is pregnant or may become pregnant is present, contact MPCA to determine if expedited action is necessary.
5. Requires a minimum of two semi-annual seasonal sampling events (two heating season and two non-heating season)
6. Expedited action = paired sub-slab, indoor air and outdoor air sampling or system installation work shall begin as soon as possible and no longer than 30 days after receiving laboratory analytical results.

When should expedited action be evaluated?

The following expedited action evaluation discussion applies to residential, commercial and industrial buildings.

Expedited action is **necessary** for both of the following scenarios when TCE is present

- Indoor air TCE > ISV, and a woman who is pregnant or may become pregnant is present
- Sub-slab or soil-gas from beneath the building TCE > ISV, and a woman who is pregnant or may become pregnant is present and the 33X attenuation factor is not valid

Expedited action **may be necessary** for any of the following scenarios when TCE is present. For these situations, contact the MPCA Project Team.

- Sub-slab TCE > 33X ISV, and a woman who is pregnant or may become pregnant is present and 33X attenuation factor is valid
- Indoor air TCE > ISV, and a *sensitive individual* (described below) is present with *greater potential for exposure* (described below)

Expedited action may be necessary for any of the following scenarios when contaminants other than TCE are present. For these situations, contact the MPCA Project Team.

- Indoor air > ISV, and a sensitive individual is present with greater potential for exposure
- Indoor air > EISV
- Sub-slab > 33X EISV

Expedited action options include:

- Expedited mitigation – mitigation system installation work shall begin as soon as possible and no longer than 30 days from receipt of laboratory analytical data (standard mitigation installation timeframe is generally 60 to 90 days)
- Expedited paired sub-slab, indoor air and outdoor air sampling and pressure differential measurements at the sub-slab sampling points to determine if vapor intrusion is occurring or likely to occur (expedited sampling timeframe is sample as soon as possible, rush (three-day turn around) laboratory analysis and report results to MPCA immediately upon receipt)

When expedited action may be necessary, collect the following information and provide it to the MPCA project team to assist in determining the need for expedited action:

- Sub-slab sampling results compared to 33X ISVs and 33X EISVs
- Completed Building Survey Form (Appendix D) with building conditions and building use information
- Provide *sensitive individual* information for the building to Minnesota Department of Health (MDH) per the *Your Health and Vapor Intrusion* fact sheet discussed below (<http://www.health.state.mn.us/divs/eh/hazardous/topics/vapintrusensid.pdf>)

Scenarios where there is a “*greater potential for exposure*” may include:

- Individuals sleeping in the lowest level of a building
- Individuals spending a significant amount of time in the lowest level of a building
- Individuals that rarely leave the building

Sensitive individuals may include:

- Women who are pregnant or may become pregnant
- Infants and young children
- Elderly persons
- Immunocompromised individuals
- Individuals with chronic disease

The Minnesota Department of Health (MDH) fact sheet titled *Your Health and Vapor Intrusion* (<http://www.health.state.mn.us/divs/eh/hazardous/topics/vapintrusensid.pdf>) provides information about the

potential risks to sensitive individuals from vapor intrusion. This fact sheet gives MDH contact information and describes a process for sensitive individuals to notify MDH. Provide the MDH fact sheet to the property owner, and all tenants and building occupants when property access is requested at the start of a vapor investigation and again when reporting results indicate that mitigation is necessary.

Partial Building Investigation

All buildings within the VI AOC need sub-slab sampling as part of a building specific investigation. The best practice is to investigate the entire building footprint, collecting the density of samples as summarized in Appendix C. However, for larger buildings on the outer boundary of a VI AOC, or larger buildings with a vapor source and/or a recognized environmental condition (REC) in an isolated portion of the building, a partial building investigation (PBI) may be considered to determine the presence and/or extent of the VI AOC beneath the building.

Conditions when PBI is appropriate:

- Building footprint is larger than 30,000 square feet. If the building footprint is less than 30,000 square feet, conduct the building VI investigation in accordance with the appropriate (residential or commercial/industrial) building mitigation decision framework listed above
- All known vapor sources and RECs within the building footprint must be investigated for VI
 - Example 1 - If a shallow VOC groundwater plume is present beneath the entire building, VI evaluation for the entire building is necessary
 - Example 2 - If there are other vapor sources and/or RECs in areas of the building that are not within the proposed PBI area, these vapor sources and RECs will also need to be evaluated regardless of where they are located relative to any proposed PBI areas within the building
- There are no preferential vapor migration pathways beneath the building beyond the partial building investigation area (see preferential vapor migration pathways description/examples below)

Preferential Vapor Migration Pathways

Preferential vapor migration pathways are sub-surface conditions that allow for significant lateral transport of vapors beneath a building. For vapor migration to occur via a preferential pathway, subsurface conditions must allow vapors to reach the preferential pathway – either by direct contact with a vapor source (e.g. vapor plume, contaminated soil/groundwater) or by vapor migration to/along the pathway.

Examples of preferential vapor migration pathways beneath a building include:

- Utility corridors (sanitary sewer, drain tile, HVAC ducts)
- Tunnels
- Permeable fill zones (i.e. utility backfill)
- Soil voids beneath the floor slab
- Geologic features (bedrock fractures, karst terrain, joints, bedding planes, buried streambeds)

Steps for Partial Building Investigation

- Collect sub-slab samples in alternating seasons (heating & non-heating) within a minimum of 30,000 square feet of the building that is within, or closest to, the VI AOC and/or at vapor sources and RECs at the sample density provided in Appendix C
- Compare the sub-slab sampling results to the appropriate 33X ISV based on building occupancy (residential or commercial/industrial) to determine the boundaries of the VI AOC beneath the building, or confirm the absence of a VI AOC beneath the building.
- If there are any vapor sources or RECs within or beneath the building, these areas need to be fully investigated (including sub-slab sampling) regardless of location and proximity to a VI AOC or other areas of PBI within the building
- Any areas that are preferential vapor migration pathways which lead from the PBI area to other areas of the building that are not being investigated will also require investigation (including sub-slab sampling)

- If the results of the PBI indicate that the VI AOC extends beyond the initial 30,000 square foot PBI area, additional investigation (sub-slab sampling) will be necessary to further define the VI AOC and determine the building mitigation extents

Partial Building Mitigation

Building mitigation is necessary for all areas of the building where sub-slab concentrations exceed 33X ISVs (VI AOC). Partial building mitigation (PBM) may be appropriate for larger buildings (footprint larger than 30,000 square feet) where the VI AOC is defined beneath the building and does not encompass the entire building footprint.

Conditions when PBM is appropriate:

- Building footprint is larger than 30,000 square feet. The area needing mitigation (VI AOC) may end up being smaller than 30,000 square feet ; however, the initial PBI must start with a minimum of 30,000 square feet
- There are no preferential vapor migration pathways beneath the building beyond the PBM area
- The VI AOC (concentrations greater than 33X ISV) beneath the building has been adequately defined with two sub-slab sampling events conducted in opposite seasons (one heating season and one non-heating season)
 - Installation of an SSD system can commence based on the first round of sub-slab sampling out to the VI AOC boundary. However, the second seasonal sub-slab sampling event is still necessary to confirm that the VI AOC boundary is defined. If the second seasonal sub-slab sampling event indicates the VI AOC needs to be expanded, the mitigation area will need to be expanded as well.

Steps for Partial Building Mitigation

1. Determine the area(s) of the building that need(s) mitigation (VI AOC beneath building) based on the sub-slab sampling data collected for the PBI
2. All areas beneath the building with sub-slab concentrations exceeding 33X ISVs require mitigation. Note: completed pathway evaluation may also be an option for commercial/industrial buildings with sub-slab concentrations >33X ISVs and <33X EISVs
3. Install building mitigation to cover the entire VI AOC(s) beneath the building
4. Collect post mitigation analytical samples and diagnostic testing to verify effectiveness of the mitigation system within the VI AOC
5. Conduct any follow-up seasonal sub-slab sampling to confirm the VI AOC boundaries, if necessary

Step 5 – Establish vapor mitigation area

The vapor mitigation area defines the area where active mitigation is required for building receptors. At this stage of the investigation the extent and magnitude of vapor impacts should be mostly defined and building receptors should be evaluated and mitigated (if required).

- If the extent and magnitude of soil gas impacts are defined and soil gas and groundwater plumes are demonstrably stable: prepare a Mitigation Area Map using GIS Template 5
- If the extent and magnitude of soil gas impacts are not defined, and/or all sources and potential sources have not been evaluated, conduct additional investigation to evaluate soil, groundwater, and soil-vapor. Repeat vapor investigation steps as necessary to identify additional properties that need building specific investigation. Continue vapor investigation until extent of soil gas and groundwater impacts are defined and stable and building receptors are evaluated and mitigated.
- If the soil gas plume and/or groundwater plumes are not stable, install and sample sentinel groundwater and soil gas monitoring points quarterly to monitor plume stability and evaluate the potential VI risk to buildings outside the vapor mitigation area. The sentinel network sampling frequency should be reviewed annually and may be reduced depending on site conditions.

Brownfield redevelopment

What if my need is only to demonstrate an identified release (IR) for vapor for a brownfield assurance letter?

An IR can be demonstrated with one sampling event. However, to make risk based decisions regarding VI, additional sampling events may be necessary. In addition to soil gas and/or sub-slab sampling, soil and groundwater investigation are necessary to evaluate an IR. Soil gas only investigations are not acceptable to demonstrate an IR and receive assurance letters from the MPCA Brownfields program.

If I am a non-responsible party doing a Brownfield redevelopment project, do I have to conduct vapor investigation work beyond the property boundary?

No; however, the non-responsible party will need to define the VI AOC on their property and conduct building specific investigations and mitigation as necessary, for all habitable structures and proposed buildings within the AOC on the property. It is not necessary for a non-responsible party to investigate the VI AOC beyond the property boundary. If the VI AOC extends beyond the property boundaries, the IR may be referred to the MPCA Site Assessment program for further investigation. Non-responsible parties are responsible for assuring and documenting that VI does not pose a risk to proposed and existing buildings that are part of the redevelopment.

How can I resolve the VI pathway for proposed building receptors?

Collect soil gas samples at any known or suspected release areas and collect a sufficient number of soil gas samples to define the vapor AOC on the property including within the proposed building footprint (see Appendix C for appropriate sampling depths based on construction and sampling frequency).

If soil gas concentrations within the proposed building footprint exceed 33X ISVs, there are two options:

1. Pre-emptively mitigate the building and conduct post-construction, post-mitigation sub-slab sampling prior to occupation in accordance with the MPCA Mitigation BMP (March 2015)
2. After the building is constructed, conduct two seasonal sub-slab sampling events to make a mitigation decision. The first sub-slab sampling event should be conducted prior to occupation. If the initial sub-slab sampling event indicates mitigation is necessary, mitigation should be conducted prior to occupation of the building or for commercial/industrial buildings; completed pathway evaluation can be conducted. If the initial completed pathway evaluation does not indicate the presence of indoor air concentrations above ISVs, the building can be occupied. If subsequent completed pathway evaluations indicate the presence of indoor air concentrations above ISVs and attributable to VI, building mitigation is required.

References

- EPA, 2015, OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air, EPA Office of Solid Waste and Emergency Response, 267 pp.
- MPCA, 2015, Diagnostic Testing, Installation and Confirmation Sampling for Active Vapor Mitigation Systems in Single-Family Residential Buildings, MPCA document c-rem3-06, 7 pp.
- MPCA, Introduction to Vapor Intrusion Map Templates, MPCA Document c-s4-10, 8 pp.