Frequently Asked Questions (FAQs) Regarding Vapor Intrusion (VI) and Ecology's 2009 Draft VI Guidance

Implementation Memorandum No. 21

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To: Interested Persons

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Contact: Policy & Technical Support Unit, Headquarters

Attachments: A – Continuous TCE Sampling Results

B – Response to comments on the June 22, 2018, review draft of this memo

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Acronyms and Abbreviations

Acronym or Abbreviation	Description
ATSDR	Agency for Toxic Substances and Disease Registry (an agency of the United States Department of Health & Human Services)
BTEX	benzene, toluene, ethylbenzene, and xylenes
CLARC	Ecology's Cleanup Levels and Risk Calculation data tables
COPC	contaminant of potential concern
CUL	cleanup level
DTSC	California Department of Toxic Substances Control
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program (a United States Department of Defense's Environmental Research Program)
FAQ	frequently asked question
GW	groundwater
HI	non-carcinogenic Hazard Index
HQ	non-carcinogenic Hazard Quotient

Acronym or Abbreviation	Description
HVAC	heating, ventilation, and air conditioning
JEM	Johnson and Ettinger Model
m^3	cubic meter
µg/l	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
MTCA	Model Toxics Control Act
NAVFAC	Naval Facilities Engineering Command
O&MMI	operation and maintenance, monitoring, inspection
QA	quality assurance
QC	quality control
PID	photoionization detector
PLIA	Washington State's Pollution Liability Insurance Agency
PLP	potentially liable person under MTCA
ppbv	parts per billion by volume
PTAP	PLIA's Petroleum Technical Assistance Program
RCW	Revised Code of Washington
RI	Remedial Investigation
SAP	Sampling and Analysis Plan
SL	screening level
SERDP	Strategic Environmental Research and Development Program (a United States Department of Defense's Environmental Research Program)
TCE	trichloroethylene
TCP	Toxics Cleanup Program
TPH	total petroleum hydrocarbons
VI	vapor intrusion
VOCs	volatile organic compounds
WAC	Washington Administrative Code
WDOH	Washington State Department of Health

1.0 Purpose and Applicability

This implementation memo answers a number of questions on whether specific portions of Washington State Department of Ecology's (Ecology's) 2009 Draft Vapor Intrusion (VI) Guidance are still applicable. Most of these questions address technical or policy changes that have occurred since the draft guidance was issued.

Ecology has begun work to update the VI guidance, but since completing comprehensive revisions will be a lengthy process, this document will serve to provide interim recommendations and direction. It is Ecology's intent to incorporate the content of this FAQ implementation memo into the updated guidance. This memo applies to any cleanup site where VI is a potential concern.

Note: The answers to these frequently asked questions represent Ecology's advice based on the collective experience of those involved in preparing and reviewing this 2018 document. In some cases, we have included references to a particular guidance or technical paper as supporting justification. For several questions, it was not possible to address every scenario, so an attempt was made to provide advice that covers the most common circumstances. If the site in question has factors that don't fit standard scenarios, Ecology recommends discussing the proposed approach with the cleanup project manager (also called a site manager), or one of Ecology's regional VI contacts to ensure the strategy is an acceptable one.

2.0 Background

In October 2009, Ecology issued a draft VI guidance titled, *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action* (Publication No. 09-09-047), which is available at https://fortress.wa.gov/ecy/publications/SummaryPages/0909047.html. Since the 2009 publication date, the Environmental Protection Agency (EPA) and several states have issued new or revised VI guidance documents.

Detailed reports and technical papers have also been prepared on a number of VI-impacted sites across the country. This information has significantly improved the VI knowledge base and changed how the VI pathway is conceptualized and evaluated. On one hand, this information generally makes VI assessments more difficult at many sites that have recalcitrant VOCs.[1] On the other hand, assessments for petroleum releases can often use screening methodologies that will eliminate VI concerns for many existing buildings.

[1] Those vapor-phase volatile compounds, such as tetrachloroethylene or trichloroethylene, that are unlikely to significantly biodegrade in the vadose zone.

Of the EPA VI documents issued since 2009, at least five are key:

1. *EPA's Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings*, issued in 2012.

2. *Conceptual Model Scenarios for the Vapor Intrusion Pathway*, also issued in 2012.

3. *Vapor Intrusion Screening Level (VISL) Calculator User's Guide for Chemical Contaminants* and on-line calculating tool, made available in 2014.[2]

4. *Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*, issued in June 2015 to replace EPA's 2002 draft VI guidance.

5. *Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*, issued in June 2015.

Over the last four years, Ecology has taken several actions to supplement or supersede portions of the 2009 draft guidance. These changes include:

1. **Updated and revised VI screening levels.** The cleanup and screening levels in Appendix B of the 2009 guidance were outdated and were replaced by Ecology's Cleanup Levels and Risk Calculation (CLARC) VI data tables in 2015. The CLARC VI table values are based on toxicity data that were current as of April 2015. They also use attenuation factors for determining sub-slab soil gas and groundwater screening levels that are generally consistent with EPA's recommendations.

2. **New guidance related to petroleum VI (PVI) screening.** Implementation Memorandum No. 14 titled *Updated Process for Initially Assessing the Potential for Petroleum Vapor Intrusion* (Ecology 2016) incorporates a majority of EPA's recommendations for assessing sites where the only volatile subsurface contaminants of concern are petroleum hydrocarbons primarily associated with a fuel release.

3. **New guidance related to PVI evaluation.** Implementation Memorandum No. 18, *Petroleum Vapor Intrusion (PVI): Updated Screening Levels, Cleanup Levels and Assessing PVI Threats to Future Buildings* (Ecology 2018), provides a generic Method B TPH indoor air cleanup level to account for the additive effects of the compounds present in petroleum mixtures. The memo also provides recommendations for assessing the potential threat of petroleum VI on future buildings.

[2] The *VISL Calculator User's Guide for Chemical Contaminants* was updated in May 2018 and is available at https://www.epa.gov/vaporintrusion/visl-users-guide

3.0 General Questions Related to Vapor Intrusion

Question No. 1:

Is 100 feet still a good "rule of thumb" for whether a building is close enough to the contamination to be potentially impacted by vapor migration?

Answer:

In general, this rule of thumb remains a good screening distance for recalcitrant VOCs, provided all three of the following criteria are met:

1. Preferential flow paths, which have the capability of transporting contaminants to buildings located more than 100 feet away, are not present. This includes:

    - fractured bedrock,
    - utility trenches backfilled with highly permeable material, or
    - utility lines such as sewers that contain site-related VOCs.

    Note: See Question No. 4 for more discussion on how utility lines can potentially result in vapor intrusion issues.

2. A continuous barrier or cover does not exist between the contamination and the buildings in question; and

3. The plume is not expanding.[3]

Most petroleum-only sites should complete an initial VI assessment using the process found in Implementation Memo No. 14 (Ecology 2016).[4] The memo generally allows using a 30-foot horizontal separation distance from the edge of contamination. It also includes a list of site conditions that, if applicable, could result in a greater separation distance being necessary.

[3] While the 100-foot distance remains valid, an expanding plume means buildings that were initially too far away to be impacted could be at risk in the future.

[4] See Implementation Memorandum #14, *Updated Process for Initially Assessing the Potential for Petroleum Vapor Intrusion* (Ecology 2016): https://fortress.wa.gov/ecy/publications/SummaryPages/1609046.html

Question No. 2:

Should Table B-1 in the 2009 draft guidance still be used for determining indoor air cleanup levels and screening levels, as well as determining which substances could potentially pose a VI problem?

Answer:

No, Table B-1 is out of date. Refer instead to the CLARC VI data tables:

- https://fortress.wa.gov/ecy/clarc/FocusSheets/CLARC%20Vapor%20Intrusion%20Method%20B.pdf (Method B) and
- https://fortress.wa.gov/ecy/clarc/FocusSheets/CLARC%20Vapor%20Intrusion%20Method%20C.pdf (Method C)

The data tables are also available via TCP's Vapor Intrusion webpage at https://ecology.wa.gov/Regulations-Permits/Guidance-technical-assistance/Vapor-intrusion-overview/Vapor-intrusion-2015-changes-to-the-2009-toxicit

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Question No. 3:

What degree of attenuation was used for developing the soil gas and groundwater screening levels?

Answer:

The current soil gas and groundwater screening levels recommended by Ecology are listed in the table below.

Table 1: Current Ecology vapor intrusion attenuation factors

	Screening Level Attenuation Factor
Groundwater	0.001
Deep Soil Gas	0.01
Shallow Soil Gas/Sub-Slab	0.03

All but the deep soil gas attenuation factor are consistent with EPA's June 2015 guidance documents. Those documents recommend that the groundwater attenuation factor remain unchanged from 0.001, but EPA changed the suggested shallow/sub-slab soil gas attenuation factor from 0.1 to 0.03 and the deep ("near source") soil gas attenuation factor from 0.01 to 0.03.

These updated values were derived from measurements made during vapor intrusion case studies at sites with chlorinated solvent contamination, and therefore assumed little aerobic biodegradation within the vadose zone. As a result, the groundwater and deep soil gas screening levels for many petroleum constituents may be overly conservative. Ecology's 2009 draft guidance attempted to account for the aerobic biodegradation of certain petroleum compounds by allowing ten times more attenuation when deriving generic groundwater and deep soil gas screening levels, provided certain criteria were met. This portion of the 2009 draft guidance has been superseded with the screening levels and separation distances found in Implementation Memo No. 14.

Ecology intends to evaluate the appropriateness of the current deep soil gas attenuation factor during upcoming revisions to the 2009 draft VI guidance. Until then, Ecology recommends that only samples collected deeper than 15 feet below the base of the building foundation use an attenuation factor of 0.01.[5]

A related issue that will be evaluated as part of the VI guidance revisions is whether different generic attenuation factors are appropriate for: a) petroleum contaminants vs. recalcitrant compounds, and b) large commercial buildings with demonstrably greater outdoor/indoor air exchange rates and air volumes than residential structures. Until formal changes to the guidance are adopted, the attenuation factors listed in Table 1 above should typically be used.

Note: As part of a detailed VI evaluation, it may be possible to develop a building-specific attenuation factor in lieu of using the generic values listed above. This approach will typically require multiple lines of evidence including empirical data. For example, using concentration ratios for paired soil gas and indoor air data, or using tracer compounds such as radon, may provide some of the information necessary to help justify a building-specific attenuation factor.

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[5] The 2009 draft VI guidance currently specifies that only samples collected deeper than 15 feet below the ground surface should use the deep soil gas screening levels.

Question No. 4:

Has the generic VI "conceptual model" changed since Ecology's 2009 draft guidance was released?

Answer:

The major change since 2009 is that there have been multiple reports of subsurface piping acting as a conduit for VOC migration. As shown in Figure 1 below, most buildings are connected to a sewer main by one or more laterals. Some buildings will also have foundation, footing, or land drains that discharge to the storm or sanitary sewer. Sewer laterals can serve as a conduit to vapor migration if the sewer main contains site VOCs and if:

1. Contaminated sewer gas enters the building via poorly sealed indoor plumbing connections or through ineffective P-traps, or

2. There are cracks, breaks, or other openings in sewer laterals that allow the VOCs to leak out of the lateral, resulting in a potential VI source near the building, or

3. Foundation, footing, or land drains connect to a sewer main and vapor-phase VOCs discharge at the end of the piping system very near the building.

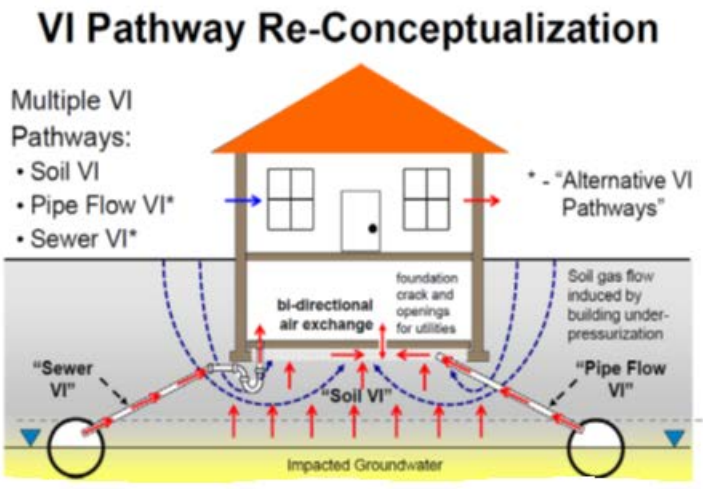

Figure 1: Vapor intrusion pathway re-conceptualization. Source: Folkes 2017

In the first scenario, the degree of VOC impacts will only be apparent if indoor air is sampled. For all three scenarios, the likelihood of VOC contamination toward the building will typically depend on the proximity of the sewer main relative to the soil and/or shallow groundwater contamination and the strength of those impacts.

Question No. 5:

Section 1.2 of the draft 2009 document indicates that the guidance does not apply to VI scenarios where workers in an industrial/manufacturing setting are routinely exposed to much higher concentrations of the same chemicals present in soil gas, when those exposures are directly regulated by OSHA. Does Section 1.2 continue to accurately describe when the guidance is not applicable to potential VI scenarios?

Answer:

While much of Section 1.2 remains valid, the following discussion provides additional clarification on when the VI guidance may apply:

- If the site investigation confirms that vapor intrusion is (or may be) impacting neighboring buildings or adjacent businesses, then the vapor pathway must be assessed.

- If the manufacturing process changes such that the chemicals of concern are no longer being used, it will be necessary to re-evaluate the pathway to ensure vapor intrusion is not causing an unacceptable exposure.

- If it is suspected that ambient air is causing exceedances of the applicable indoor air cleanup levels (e.g., a convenience store located in close proximity to fueling operations), it will generally be necessary to perform sampling to support this conclusion.

- If the VI pathway cannot be fully assessed due to concentrations in the indoor air from manufacturing operations or ambient sources that exceed the applicable indoor air cleanup levels, then an environmental covenant will be necessary to ensure a change in land use doesn't occur prior to completing additional vapor assessment work.

When the presence of non-target compounds in manufacturing facilities results in the reporting limits for some or all chemicals of concern to be above the specified cleanup levels, the following discussion provides additional direction on how to account for the particular situation.

- If the presence of non-target compounds does not result in all of the chemicals of concern having practical quantitation limits (PQLs) above the applicable indoor air cleanup levels, then those contaminants should still be evaluated for compliance, provided the compound is not being used in the manufacturing facility.

- If the presence of non-target compounds results in some or all contaminants of concern having PQLs above the applicable indoor air cleanup level and these compounds aren't being used in the manufacturing facility, the measured sub-slab soil gas levels along with other lines of evidence should be used to evaluate the potential for vapor intrusion.

- Regardless of whether the VI pathway can be fully evaluated, cleanup of the subsurface contamination must still be completed.

Note: The Toxics Cleanup Program's *Procedure 440A: Establishing Environmental Covenants under the Model Toxics Control Act* (Publication No. 15-09-054) is being updated to specifically include language that prohibits future land use changes for these types of situations without prior Ecology approval.

4.0 Questions Related to Sampling

Question No. 6:

Does Ecology have a preference for the units that should be used when submitting VI data (e.g. ppbv or µg/m^3)?

Answer:

All VI soil gas and air sampling results should be reported in micrograms per cubic meter (µg/m^3). Groundwater sampling results should be reported in micrograms per liter (µg/l).

Question No. 7:

The draft guidance indicates that, due to the possibility of diluting a soil gas sample with atmospheric air, samples should not be collected from depths shallower than 5 feet below ground surface (unless located sub-slab). Are there any exceptions to this provision?

Answer:

While this is generally a good guideline when performing soil gas sampling, there may be situations where collecting a shallower sample may be appropriate, for example, if the depth to groundwater was less than 5 feet and access to the building of concern couldn't be obtained. In these cases, the sampling protocol should include using a tracer (such as lab grade helium) to help ensure that the vacuum applied to collect the sample was not significant enough to draw in atmospheric air.

Appendix G of the ITRC guidance, *Petroleum Vapor Intrusion – Fundamentals of Screening, Investigation, and Management,* contains useful information when collecting shallow soil gas samples. The document is available at:
http://www.itrcweb.org/Guidance/ListDocuments?TopicID=28&SubTopicID=48

Note: In addition to situations where shallow soil gas probes are used, tracer testing should also be performed when sub-slab soil gas samples are being collected. In both situations, Ecology recommends that if the tracer is detected in the sample at greater than 5% of the concentration within the shroud, the result should be rejected.

Question No. 8:

Can passive indoor air samplers be used instead of evacuated canisters when conducting Tier II air sampling?

Answer:

While summa canisters or active sample collection on sorbent tubes are the most common approaches for collecting indoor air samples, Ecology acknowledges that the use of passive samplers may be appropriate in certain situations to help with decision making, especially when longer collection periods are necessary. The decision on which method to use should be based on site-specific circumstances such as the contaminants of concern, likely receptors, the necessary reporting limits, sampling locations, and other applicable factors. There is a significant amount of information in the literature about using passive samplers. The following references provide excellent discussions on applicability, and which factors to consider when evaluating whether passive sampling is appropriate:

NAVFAC. (2015). *Passive sampling for vapor intrusion assessment*. Technical Memorandum TM-NAVFAC EXWC-EV-1503 (July 2015). Naval Facilities Engineering Command, Engineering and Expeditionary Warfare Center. Prepared for NAVFAC EXWC by Dawson, H., McAlary, T., and Groenevelt, H., Geosyntec. Retrieved from: https://clu-in.org/download/issues/vi/VI-passive-sampling-EXWC-EV-1503.pdf

USEPA. (2014). *Passive samplers for investigations of air quality: Method description, implementation, and comparison to alternative sampling methods.* (EPA 600-R-14-434, July 2014). Washington, DC: United States Environmental Protection Service, Engineering Technical Support Center. Retrieved from: https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=308311&subject=Health%2520Research&showCriteria=0&searchAll=Environmental%2520Health&sortBy=revisionDate.

McAlary, T., Wang, X., Unger, A., Groenevelt, H., Gorecki, T. (2014). Quantitative passive soil vapor sampling for VOCs–part 1: Theory. *Environmental Science: Processes & Impacts, 16*:482–490. Retrieved from: http://dx.doi.org/10.1039/c3em00652b.

Question No. 9:

What conditions (e.g. temperature, barometric pressure, etc.) are most likely to result in the highest potential for vapor intrusion?

Answer:

In general, a greater degree of vapor intrusion occurs when the building's interior pressure is less than the subsurface pressure immediately below and adjacent to the building. These conditions are conducive to advective soil gas flow into the building. Building depressurization typically occurs when outdoor (ambient) temperatures are much lower than interior temperatures. All else being equal, the potential for vapor intrusion is likely to be greater during the winter season when outdoor temperatures are low and falling.

While building depressurization is conducive to higher vapor migration rates into the building, the effect on indoor air quality is also influenced by the VOC concentrations of the soil gas, where it enters, and how much dilution occurs from indoor air. Greater soil gas concentrations and reductions in the exchange rate with outdoor air may not always correlate with periods of colder temperatures.

Therefore, obtaining an accurate representation of vapor intrusion impacts on indoor air concentrations is a very difficult undertaking. There are numerous factors that can affect the ability of any single sampling event to provide accurate results. Nevertheless, it is recommended that when time-weighted sampling is performed (i.e. summa canisters, sorbent tubes, or passive diffusive samplers), at least one sampling event should be conducted when the indoor air pressure is less than sub-slab soil gas pressure, and the difference between the two would likely be at or near the anticipated maximum during the year. To ensure these conditions are present, Ecology recommends:

1. Scheduling sample collection during periods of cold ambient air temperatures. Use pressure transducers and data loggers to document pressure differentials throughout the event, or

2. Mechanically creating a negative pressure within the building to achieve a maximum pressure differential so conditions are conducive to vapor movement across the slab and into the building. The following references provide information on the process and merits of creating negative building pressure for evaluating the potential for vapor intrusion:

McHugh, T., Beckley, L., Bailey, D., Gorder, K., Dettenmaier, E., Rivera-Duarte, I., Brock, S., and McGregor, I. (2012). Evaluation of vapor intrusion using controlled building pressure. *Environmental Science & Technology*. *46*(9): 4792–4799. doi 10.1021/es204483g. Retrieved from: https://pubs.acs.org/doi/10.1021/es204483g

Holton, C., Guo, Y., Luo, H., Dahlen, P., Gorder, K., Dettenmaier, E., and Johnson, P.C. (2015). Long-term evaluation of the controlled pressure method for assessment of the vapor intrusion pathway. *Environmental Science & Technology*. *49* (4): 2091–2098. doi 10.1021/es5052342. Retrieved from: https://pubs.acs.org/doi/abs/10.1021/es5052342

Measuring differential pressure and pressure trends should be conducted in either case to help confirm that sampling is being conducted when the potential for vapor migration toward the building is most likely to occur.

Note: If available information suggests that vapor intrusion may be occurring, indoor air sampling with concurrent sub-slab (or crawlspace) and ambient air sampling should be conducted as soon as possible. The first sampling event shouldn't be delayed just to schedule it during more desirable meteorological conditions. Information such as temperature, barometric pressure trends and pressure differentials should be collected to help assess the sampling results. Perform additional sampling events if conditions were not ideal for evaluating vapor intrusion potential (e.g. indoor air pressures were greater than soil gas pressures), even if the measured indoor air concentrations were less than cleanup levels.

Question No. 10:

How many sampling events are necessary to make a decision regarding the presence or absence of a potential vapor risk?

Answer:

The following answer applies to situations where indoor air sampling has **not** been conducted. When indoor air has been sampled, see Question No. 11.

While one or two sampling rounds are often enough to determine if additional VI work is needed, it is much more difficult to generically recommend the minimum number of subsurface sampling rounds necessary to screen out the pathway. There are numerous factors that affect this decision, including the media to be sampled and the site-specific characteristics. The following is a general discussion about some of the most important concepts that should be considered when evaluating whether sufficient samples have been collected.

For many sites, several soil and groundwater sampling events are often completed before initiating a vapor intrusion assessment. For petroleum releases, the measured benzene and TPH concentrations in soil and groundwater should be used to initially assess the vapor intrusion pathway. If the applicable separation distances in Implementation Memo No. 14 are met and an adequate site characterization has been performed, then the initial VI assessment is complete.

When releases of non-petroleum VOCs have contaminated vadose zone soils, the next step is usually to collect soil gas samples directly above that contamination. This is necessary because Ecology does not have soil screening levels that can be used to evaluate the potential for indoor air impacts from these types of contaminants. If vadose zone soil data indicate the presence of a strong VI source, such as residual free product, in close proximity to occupied structures, these data alone would generally be sufficient to trigger indoor air sampling.

When shallow groundwater is contaminated but no impacted soil is present above the groundwater sample location, the measured VOC concentrations can be directly compared to Ecology's groundwater VI screening levels in CLARC.[6] Before screening out individual buildings or the entire site, a sufficient number of samples must be collected over time to ensure the measured groundwater concentrations accurately represent the contamination present.

Shallow and sub-slab soil gas levels will generally have more temporal variability than groundwater or deep soil gas concentrations. This is the primary reason Ecology recommends conducting at least one sub-slab/indoor air sampling event when the differential pressure across the building foundation is the highest. Sampling during this timeframe should help ensure the measured results represent the upper end of the temporal range.

Note: Multiple compounds (e.g. benzene, 1,2 dichloroethane, mercury, naphthalene, TCE, and xylenes) have groundwater VI screening levels less than the Method A groundwater cleanup levels. For these contaminants, it may not be possible to screen out the vapor pathway, even when the measured groundwater concentrations do not exceed the MTCA standards.

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[6] For petroleum releases, this comparison is only necessary when compounds other than benzene or TPH are the contaminants of concern.

Question No. 11:

How many indoor air sampling events are needed to "screen out" the VI pathway? Does it depend on *how* the air is sampled?

Answer:

Attachment A shows the results of continuous sampling of TCE at the Sun Devil Manor Study Site in Layton, Utah. The data show that the measured sample concentrations vary by more than two orders of magnitude over relatively short periods of time. Significant temporal variability has also been documented at other locations that used similar sampling techniques. Due to this variability and the difficulty in predicting when VI impacts are likely to be most severe, it is difficult to schedule enough 8- or 24-hour sampling events to capture the maximum influence of VI on indoor air quality, or even be representative of the long-term average.

While Ecology's guidance generally recommends collecting at least two separate rounds of samples before screening out the VI pathway, relying on a generic "minimum" number does not necessarily account for the many factors that can affect the representativeness of sampling results. Instead, using multiple lines of evidence provides the best mechanism for assessing whether the pathway is a potential concern. Applicable lines of evidence generally consist of sampling results from source areas and potentially affected media, site characterization data, and building-specific information. When a preponderance of the data support a conclusion that indoor air is not likely being impacted, fewer indoor air sampling events should be necessary to screen out the pathway.

The protocol used for indoor air sampling can certainly affect the number of necessary sampling events. Some methodologies, such as passive sampling, are chosen primarily because of their ability to measure VOC concentrations over prolonged periods, thereby reducing the number of individual sampling events that would otherwise be performed over those periods. Continuous sampling can capture the short-term variability, but unless it is utilized over extended periods, it is possible to miss long-term variability.

See the response to Question No. 9 for additional supporting information.

Question No. 12:

Do all samples need to be collected at the same time (e.g. groundwater, deep soil gas, shallow/sub-slab soil gas, indoor air, and ambient air)?

Answer:

It is not always necessary to collect all of the samples at the same time. For example, an initial investigation typically involves just soil and groundwater sampling. For sites with petroleum impacts, if the results exceed the applicable screening levels, the next step would typically be limited to just soil gas sampling, since aerobic biodegradation will often result in measured soil gas concentrations below the applicable screening levels.

However, for sites with impacts from other VOCs, indoor air sampling is likely warranted if any of the following situations exist beneath or in close proximity to an existing structure:

1. Measured soil concentrations exceed the Method A soil cleanup levels for unrestricted use by more than an order-of-magnitude;

2. Groundwater concentrations exceed the applicable screening levels for protection of indoor air quality; or

3. Soil gas sampling results exceed the applicable screening levels.

In situations where indoor air will be sampled, Ecology recommends also collecting sub-slab soil gas or crawl space air along with ambient air samples. To avoid the potential for cross-contamination, installation of the sub-slab probe(s) can be delayed until shortly after the indoor air samples are collected. It may also be possible to install the probes prior to indoor air sampling if enough time is allotted for the concentrations to return to pre-installation levels. Since numerous factors can affect indoor air results and since the results can change by several orders of magnitude over short periods of time, having results from these other locations can help limit the uncertainty.

Question No. 13:

Can indoor air samples be collected as the first line of evidence?

Answer:

Yes, and Ecology's 2009 draft VI guidance includes a number of scenarios where we recommend proceeding directly to indoor air sampling. This is especially important when high levels of the more toxic volatile contaminants are found in soil or groundwater near buildings with sensitive receptors such as schools or day care facilities. In these situations, indoor air sampling should usually be performed as soon as possible. If the likelihood is high that VI is impacting indoor air quality (especially for sensitive receptors), it may be advantageous to install a mitigation system at the same time the VI evaluation is conducted.

As discussed in the response to Question No. 12, whenever indoor air samples are collected, Ecology also recommends that ambient air and sub-slab soil gas or crawl space air samples are collected concurrently.

Question No. 14:

Are more samples needed in a building that has a large footprint?

Answer:

In general, yes: more sub-slab soil gas and indoor air samples are needed as the size of the building foundation increases. Determining the appropriate number is a site-specific determination and should be based on factors such as:

- The extent of the subsurface contamination
- Preferential pathways and likely points where vapors could enter the structure
- Building construction and configuration
- How the interior spaces and HVAC systems are configured
- Areas where indoor air screening levels are more likely to be exceeded
- Building occupants (e.g. residential use, workers, sensitive receptors, etc.) and where the occupants spend most of their indoor time.

EPA and several states have guidance that can help determine the appropriate locations and number of indoor air and sub-slab samples necessary. The New Jersey Department of Environmental Protection issued a 2018 VI guidance document, for example, that includes a

detailed discussion on this topic. It is available at:
http://www.nj.gov/dep/srp/guidance/vaporintrusion/vig_main.pdf?version_4

Question No. 15:

Sub-slab soil gas sampling data can have significant spatial variability across the building slab. How can a sampling protocol be established to account for this?

Answer:

This answer was developed assuming indoor air will be sampled at the same time sub-slab samples are collected and that other supporting data such as temperature and barometric pressure will also be gathered. Even with this additional data, it is often difficult to accurately determine where soil gas VOC concentrations are likely to be the highest, and as a result, the typical approach is to uniformly distribute the sampling locations across the slab. When a large building is being evaluated, it may be appropriate to focus the initial sampling effort on areas of known contamination.

Another option is to use "Large Volume Purge Sampling" with the goal of obtaining more representative data on the potential risks posed to the buildings being evaluated. This sampling option is discussed in more detail in Section 7.0 of the Hawaii Department of Health (HDOH) Soil Vapor and Indoor Air Sampling Guidance, which is available at http://www.hawaiidoh.org/tgm-pdfs/TGM.pdf.

Note: See Question No. 10 for a discussion on the temporal variability of sub-slab soil gas.

5.0 Questions Specific to Data Evaluation

Question No. 16:

If individual VOC measurements are less than their respective soil gas VI screening levels, can the VI pathway be "screened out?"

Answer:

In general, yes. However, there are some situations where additional work would be necessary. For example, Ecology's 2009 draft VI guidance includes several scenarios where actual VOC attenuation could be less than the assumed value. This generally occurs when preferential flow paths exist between the source of contamination and the building. In addition, the adequacy of soil gas screening levels for individual contaminants should be evaluated when multiple VOCs are present. Factors that should be considered include:

1. For carcinogenic VOCs, the individual Method B VI screening levels for soil gas in the CLARC tables are based on air cleanup levels set to an excess cancer risk of one in one million (1E-6). It may be necessary to adjust the individual levels downward a) if numerous compounds are present, and b) if the total excess cancer risk would exceed one in one hundred thousand (1E-5) without the adjustment.

2. CLARC's Method C carcinogenic VI screening levels for soil gas are based on air cleanup levels set to an excess cancer risk of one in one hundred thousand (1E-5). If multiple carcinogenic compounds are present in soil gas, the individual screening levels will need to be adjusted downward to ensure that the total excess cancer risk does not exceed 1E-5.

3. For non-carcinogenic compounds, the individual Method B and C non-carcinogenic VI screening levels for soil gas in CLARC are based on air cleanup levels set to a hazard quotient (HQ) of 1.0. If multiple non-carcinogenic compounds are present in soil gas, the individual VOC screening levels may need to be adjusted downward to ensure that the hazard index (HI) does not exceed 1.0.

Note: This scenario is most likely to occur with non-carcinogenic petroleum compounds. Ecology issued Implementation Memo No. 18 (January 2018), which includes several options to account for the cumulative effects of these compounds. Specifically, the memo provides TPH screening levels that account for the additive effects of the non-carcinogenic petroleum compounds present. A footnote will be added to CLARC indicating that the screening levels for non-carcinogenic compounds can only be used if that compound is the only contaminant present.

Question No. 17:

How should VI screening levels be calculated for commercial buildings when the indoor receptors of concern are workers?

Answer:

For commercial buildings that don't meet the definition of an industrial property, the Method B VI cleanup levels in CLARC will likely be overly conservative This is because some of the Method B indoor VI cleanup levels were determined by assuming that receptors are always present and include children. In these situations, Ecology would typically allow the default assumptions to be adjusted as follows:

1. For non-carcinogenic cleanup levels, the average body weight could be changed from 16 kg (representing a child) to 70 kg (representing an adult), and

2. The exposure frequency could be modified to better represent the amount of time workers are actually present (e.g. 50 hours/week x 50 weeks/year = 0.30 vs. a default of 1.0), and

3. For non-carcinogenic cleanup levels, the breathing rate should be increased from 10 m^3/day to 20 m^3/day.

Indoor air screening levels in a commercial building are intended to be protective of existing workers. Since these are not cleanup levels, additional remediation would be necessary to allow for residential use. If the applicable cleanup levels for unrestricted use cannot be met, an institutional control would be needed to ensure long-term protectiveness.

Note: While Ecology anticipates the standard work week will often be 50 hours, it may be possible to justify the use of a lower number on a case specific basis.

Question No. 18:

Does Ecology still recommend the 2009 VI guidance Appendix E's "decision matrix" tables as a guide during VI decision-making?

Answer:

The tables are outdated, overly simplistic, and should no longer be used. Ecology included the tables to encourage using multiple lines of evidence when determining next steps during a Tier II evaluation. However, these tables only rely on indoor air and sub-slab sampling results. While these two factors are critical, they often need to be evaluated with other information such as: 1) ambient air concentrations and other "background" sources of VOCs; 2) the potential cumulative effects of multiple compounds; 3) building and foundation features; 4) receptor type and behavior; 5) the potential for preferential vapor migration pathways; and 6) various sampling conditions such as ambient temperature, barometric pressure, the pressure differential between the building and the sub surface, building ventilation characteristics, etc.

Question No. 19:

Are groundwater data enough to initially screen out the vapor intrusion pathway?

Answer:

In general, Ecology recommends using multiple lines of evidence when evaluating the VI pathway. In source areas this usually means that at a minimum, soil and groundwater samples will be collected. However, in areas downgradient from where VOCs were released—where the only VOC source is contaminated groundwater—CLARC's groundwater VI screening levels can be used to screen-out particular buildings, as long as the caveats and limitations in the 2009 draft VI guidance are followed. Among these limitations are preferential VOC migration pathways, which could result in higher soil gas concentrations than would be anticipated based on the measured groundwater concentrations.

In addition, when petroleum constituents are the only contaminants of concern, there may be situations where groundwater data alone would be sufficient to screen-out the VI pathway prior to completing the cleanup.[7] This would require that:

[7] Once the cleanup has been completed, the VI pathway should be re-evaluated to ensure that plausible future uses of the property would not result in a potential vapor issue.

1. The source area (including all of the contaminated soil) has been removed,

2. Groundwater monitoring confirms relatively low levels of contamination, and

3. The separation distances specified in Implementation Memo No. 14 have been met.

Question No. 20:

How can indoor sources be accounted for during assessments?

Answer:

Once a determination is made that indoor air sampling is necessary, there are several approaches that can be used to identify potential sources of indoor air contamination.

1. The standard approach is to inventory all products or materials in the building that could potentially contribute the same chemicals to indoor air that are being assessed as part of the VI evaluation. The New York State Department of Health has a fact sheet identifying a number of household products that can potentially impact indoor air quality, and identifies the compounds those products can contain. The document can be found at https://www.health.ny.gov/publications/6513.pdf. While this is not an exhaustive list, it does provide a number of useful examples.

   Other sources of information include the National Institute of Health's Household Products database, which is available at: https://hpd.nlm.nih.gov/ and Appendix L of ITRC's Petroleum VI Guidance (October 2014), which is available at: http://www.itrcweb.org/Guidance/ListDocuments?TopicID=28&SubTopicID=48.

   VOC-emitting materials identified in this building "walk through" process should be removed from the building prior to sampling. It is generally recommended that several days to a week be provided to allow air quality in the building to stabilize, although more recent research by Holton, et al (2018) suggests this timeframe may not always be sufficient. Placing the identified products in an attached garage is not recommended, as a 2006 study by McCafferty found that higher levels of VOCs have been observed in homes with attached garages.

2. While the process described above is used most frequently, it may also be beneficial to use a portable field sampling device such as a "Frog," "Hapsite," ppbRAE photoionization detector (PID), or other similar instrument. They have the potential to

identify household or business items that may not be obvious VOC sources. They may also be able to identify preferential routes of soil gas entry into the building. These devices can either be used in conjunction with the building "walk through" or later after the potential contaminant sources have been removed.

Note: Field screening with PIDs or other portable instruments can help identify VOC-emitting sources so their contributions to the sampling results can be minimized. This is important because several contaminants (e.g. benzene, naphthalene, and trichloroethylene) have very low indoor air cleanup levels. If indoor air sources of these contaminants are not identified and addressed up front, it is not uncommon for the applicable indoor air cleanup levels to be exceeded. This situation could result in unnecessary mitigation.

Question No. 21:

Can the ventilation system for a parking structure below the occupied space of a building be used to address potential VI concerns? Is specialized sampling necessary to justify using a ventilation system to protect against VI?

Answer:

There are several types of parking garage designs. Some are mostly or completely above ground with direct connections to the ambient air. This connection makes it very unlikely for soil gas below or adjacent to the structure to affect indoor air within an overlying building.

Other parking structures are located mostly or completely below grade. In these situations, there are typically three options that are used to prevent vehicle exhaust from entering the overlying structure. The first approach is to design the HVAC system to maintain positive pressure in the building. The second is to have an air exchange unit that brings in ambient air and discharges air in the garage outside. Finally, many designs use a combination of both methods.

Air exchange systems can create a negative pressure in the parking structure, which can result in soil gas from adjacent or below the parking structure to the garage space through advection. In these situations it may be necessary to sample the exhaust air to ensure that the contaminants of concern are not present at levels that could cause exceedances of the indoor air cleanup levels.

These types of parking structures often have elevators, stairs, and utility penetrations that could provide a direct connection to the occupied portions of the building. Ventilation systems may not always be sufficient to address vapor mitigation through these pathways. In particular, elevators often have an underlying sump that can extend below the garage floor. Movement of

the elevator can create negative pressure that results in soil vapors being pulled upward and bypassing the air exchange system. In these situations, sampling may be necessary to document that operation of the building elevators are not providing a direct conduit for vapors to enter the occupied portions of the building. It's possible that this evaluation could be completed using a tracer test.

In summary, it's possible that the design features of a parking structure can provide the necessary controls to address the VI pathway. However, these can be complicated situations and often require a number of factors to be considered and in some cases evaluated empirically to confirm the pathway is protected.

6.0 Petroleum-Specific Questions

Question No. 22:

On pages 3-7 and 3-13, the 2009 VI guidance indicates that groundwater and deep soil gas VI screening levels for BTEX can be multiplied by 10. Given the development of more recent approaches for addressing potential petroleum VI impacts, does this provision still apply?

Answer:

No. This language was developed to account for the aerobic biodegradation of petroleum compounds in the vadose zone between the VI source and building of concern. Information compiled by EPA and others over recent years makes this provision obsolete. Instead, Implementation Memorandum No. 14 should be used at sites with petroleum releases, as long as the eligibility criteria are met.

Question No. 23:

Why do the 2009 draft VI Guidance and CLARC use the O & M isomers for xylene instead of total xylenes?

Answer:

It appears this approach was used because the Henry's Law constants are different for each isomer, which resulted in different groundwater VI screening levels. Implementation Memo No. 18 provides a total xylenes groundwater PVI screening level of 333 µg/l using a Henry's Law constant of 0.138. This value was calculated using the mean of the three individual isomers at 13^0 C. Ecology is planning to change the VI data tables in CLARC to provide a total xylenes value that is consistent with the soil and groundwater screening levels in MTCA.

7.0 Questions Specific to TCE

Question No. 24:

In 2012, EPA Region 10 issued a memo[8] indicating that short-term exposures to trichloroethylene (TCE) vapors could cause fetal cardiac malformations during a 21-day early gestation window. In 2014, EPA Region 9 issued a memo[9] that recommended action levels and response actions for various exposures to TCE from vapor intrusion. Does Ecology have specific guidance for addressing the potential effects caused by short-term exposures to TCE?

Answer:

Ecology is developing an Implementation Memo for evaluating and responding to situations where vapor intrusion from TCE may be occurring. We anticipate having a draft memo available for external review in late 2018. In the interim, the Region 10 and 9 memoranda can be used as guidance. The Ecology site manager or Regional VI expert may also be contacted for assistance in dealing with TCE.

[8] Region 10 memorandum (USEPA 2012) is available at: https://ecology.wa.gov/DOE/files/33/33a04283-94c4-402d-a6be-220f05f32f7a.pdf

[9] Region 9 memorandum (USEPA 2014) is available at: https://ecology.wa.gov/DOE/files/4f/4fb8c34a-f785-41f7-8dea-e2ee341a31a2.pdf

8.0 Questions on the Use of Models

Question No. 25:

The draft guidance allows models such as Johnson and Ettinger to be used to predict the indoor air concentration of contaminants during Tier I assessment, provided conservative assumptions are used. Does Ecology still support the use of models in this manner?

Answer:

No. Consistent with EPA's 2015 VI guidance documents and recent guidance from several other states, Ecology no longer recommends VI modeling as the sole method to support a "screen-out" decision. Since models tend to be an "order of magnitude" estimate, if they are used during a VI assessment, Ecology recommends a weight of evidence evaluation that includes assembling the modeling results, plus collecting site-specific data to assess the potential for impacts to indoor air.

When sampling results show exceedances of the groundwater VI screening levels (or soil VI screening levels for petroleum) and buildings are present within the applicable horizontal screening distances, in most cases the next step should be soil gas sampling. For petroleum contaminated sites, Implementation Memo No. 18 indicates that soil gas sampling, coupled with the use of a predictive model may be sufficient to show the mass of contamination remaining is not sufficient to present a VI concern.

For chlorinated compounds, paired indoor air and sub-slab soil gas data would typically be necessary to provide the supporting data to confirm the modeling results. Other available information such as the building configuration; soil conditions; type and location of utilities; and plume stability data should also be evaluated.

Question No. 26:

Should the Johnson and Ettinger Model still be used to "back-calculate" subsurface media cleanup levels that are protective of indoor air quality?

Answer:

No. Ecology strongly recommends using the soil gas and groundwater screening levels provided in the CLARC VI data tables for VI screening evaluations.

Question No. 27:

Can models that consider aerobic biodegradation, such as BioVapor or PVIScreen, be used when assessing the potential for petroleum VI?

Answer:

Yes, provided that modeling is not used as the sole line of evidence for concluding that a building is not impacted or threatened by vapor intrusion. As discussed in the answer to Question No. 25, Ecology recommends a weight of evidence evaluation that includes results of the modeling, plus site-specific data, to assess the potential for impacts to indoor air.

9.0 Questions on Public Involvement and Outreach

Question No. 28:

Under what circumstances should a building owner be notified of a potential VI risk and who has responsibility for making the notification?

Answer:

Ecology recommends notifying property/building owners as soon as possible after a determination is made that a VI evaluation will be undertaken. In addition to notifying property owners in close proximity to the area where the work will take place, it may also be appropriate to notify homeowner/neighborhood associations and/or community representatives. The responsibility for notifying affected parties of a potential VI risk rests with the potentially liable person (PLP). If the PLP is no longer available (e.g. bankruptcy) and the investigation is being carried out by someone else, that entity should take responsibility for the notifications.

If the site has an Ecology site manager, s/he should be notified as soon as possible after a decision is made to complete a VI evaluation. For sites that are being addressed through a voluntary cleanup action, it may be helpful to make Ecology aware of the situation because property owners or community representatives often seek input from agency representatives. As an added benefit, Ecology staff can provide assistance working with the public, and help explain the work that is being undertaken and the regulatory requirements that apply.

Note: If the site is being addressed through the Petroleum Technical Assistance Program (PTAP), then Washington state's Petroleum Liability Insurance Agency (PLIA) should be notified instead of Ecology, as PLIA oversees the PTAP program. For more information, visit PLIA's website at www.plia.wa.gov

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Question No. 29:

Under what circumstances should Ecology be notified of a potential VI risk and who has responsibility for making this notification?

Answer:

Ecology should be notified within 90 days if a hazardous substance has been released to the environment and may threaten human health or the environment. Specifically:

- WAC 173-340-300(2) states that when an owner or operator has information that a hazardous substance has been released to the environment and may be a threat to human health or the environment, it must be reported to Ecology within 90 days of discovery.

- WAC 173-340-300(2)(b)(iii) goes on to indicate that discovery of vapors in a building, utility vault, or other structure from nearby contaminated soil or groundwater is an example of when a release should be reported.

Given this background, Ecology should be notified any time indoor air measurements indicate the cleanup levels specified in CLARC have been exceeded and the source of these exceedances is contaminated soil or groundwater.

- The results of those measurements should be provided to the TCP site manager.

- If no site manager has been assigned, call Ecology's reception desk in the region where the site is located to learn where to submit the results to TCP.

- Find Ecology's regional contact information at https://ecology.wa.gov/About-us/Get-to-know-us/Contact-us/Regional-contacts, or call TCP's main reception in Lacey, Washington, at 360-407-7170.

Ecology will assess the information and decide what follow-up is necessary. This includes determining if assistance from other agencies will be necessary.

Note: As noted in the previous question, if the site is already in the PTAP program, then PLIA should be consulted regarding necessary follow-up actions.

Note: Recently, the Agency for Toxic Substances and Disease Registry (ATSDR) did not renew grant funding for the Washington State Department of Health (WDOH). This funding, among other things, covered VI-related consultations. Currently, WDOH is able to provide only minimal VI assistance at cleanup sites.

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Attachment A:

Continuous TCE Sampling Results

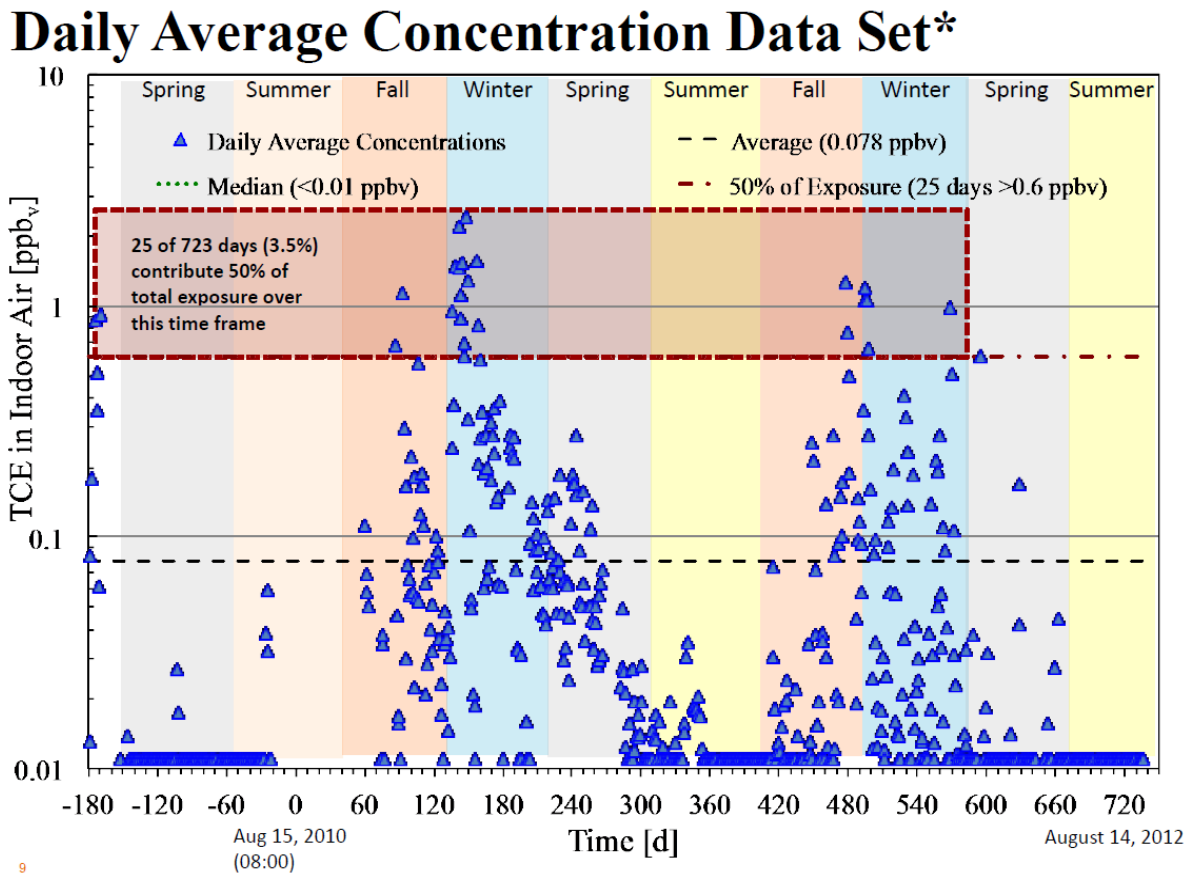

Figure 2: Continuous TCE sampling results from the Sun Devil Manor Study Site in Layton, Utah. (Holton, et al. 2013)

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Attachment B:

Response to comments on the June 22, 2018, review draft of this memo

Response to Comments: Frequently Asked Questions (FAQ's) Regarding Vapor Intrusion (VI) and Ecology's 2009 Draft VI Guidance

A public comment period was held from July 5 through August 10, 2018, for the review draft of this document dated June 22, 2018. The following comments were received during that period and helped inform updates to this final version dated November 2018.

Comment No. 1 – There are a number of areas in the FAQ where subjective terms like "high", "significant", "close", and others are used to describe the need for additional actions. We have attempted to point these out specifically below. Please consider removing this class of words from the document and replace with clearly defined objectives such as "within XX feet" or "XX times the CLARC screening level" to improve understandings between regulators and practitioners in terms of knowing when additional work may be necessary.

Response – The reason for using subjective terms was to provide flexibility for addressing case specific situations. Ecology has added some clarifying language or examples to try and better define the objectives of the referenced terms. However, in many cases there is not adequate technical information to support adding specific concentrations or distances to the memo.

Comment No. 2 – In the answer to FAQ No. 3, please include details in the upcoming VI guidance update on how site-specific attenuation factors should be calculated and used at sites in Washington.

Response – Ecology has expanded the discussion to identify the type of information that would typically be necessary when developing a building specific attenuation factor.

Comment No. 3 – Non-target compounds can increase laboratory reporting limits for chemicals of concern above applicable Ecology cleanup levels (CULs) in manufacturing facilities. In the response to FAQ No. 5, please provide recommendations for scenarios where indoor and outdoor air samples may not be technically feasible and how to address the VI pathway in those instances.

Define the term "significantly" when defining the vapor intrusion contributions to receptor risk.

Response – The following scenarios will be integrated into the response to FAQ No. 5:

- If the presence of non-target compounds does not result in all of the contaminants of concern having practical quantitation limits (PQL's) above the applicable indoor air cleanup levels, then those contaminants should still be evaluated for compliance provided the compound is not being used in the manufacturing facility.

- If the presence of non-target compounds results in some contaminants of concern having practical quantitation limits (PQL's) above the applicable indoor air cleanup level, but these contaminants of concern aren't being used in the manufacturing facility, the measured sub-slab soil gas levels should be used to evaluate the potential for vapor intrusion.

- If the VI pathway cannot be fully evaluated because the contaminants of concern are being used in the manufacturing facility, cleanup of the subsurface contamination must still be completed.

The language was also modified to better explain how to address situations where ambient air may be affecting potential receptors.

Comment No. 4 – In the response to FAQ No. 9, please include additional guidance in the regulatory update on building envelope pressure manipulation, both positive and negative induced differentials.

Please also include guidance on what periods should be targeted for cold weather sampling; perhaps November 15 to April 15, or similar. While we don't disagree that building pressure differential is very important, in many scenarios an investigator won't have the ability to monitor this over multiple months and will need to make a professional judgement on the worst-case sampling time period.

Please remove the additional note as there is not differentiation between action levels that trigger an immediate response and CULs based on chronic long-term exposure. Immediate action should be based on acute exposure thresholds only.

Response – Several references were added that discuss the issue of building envelope pressure manipulation in detail.

Ecology acknowledges that investigations can't always begin during cold weather months. Greater building depressurization, coupled with lower outdoor to indoor air exchange rates, are

more likely to occur during low temperatures, but significant building depressurization can also occur at other times such as during storm events where barometric pressures fall quickly and high winds occur. Regardless of the time of year, Ecology recommends collecting pressure data and trends along with other meteorological information to help analyze the results.

The intent of the note is not to create situations where immediate action is necessary but instead to indicate that when VI is anticipated, waiting extended periods for conditions that may be more favorable for VI to occur is not recommended.

Comment No. 5 – In the response to FAQ No. 10, rephrase first sentence in answer paragraph 2 – "...to determine *if* additional VI work is…"

Please provide lateral and vertical distances as well as concentrations within applicable media Ecology considers to be protective of potential VI risk. Terms such as "strong" and "close proximity" are not specific.

In our experience sub-slab soil vapor concentrations do not exhibit a large degree of temporal variability in commercial buildings as indicated in paragraph 6. Please clarify when sites can be screened out based on sub-slab soil vapor sample results. The phrase "at least one" indicates Ecology is expecting multiple rounds of samples from all sites although this is not expressly stated.

Response – The requested change to the first sentence of paragraph 2 was made.

As discussed in the response to FAQ No. 1, for non-petroleum contaminants buildings generally within 100 feet of the contamination should be assessed for VI potential. The FAQ also indicates the presence of preferential flow paths could result in buildings longer distances away also needing assessment. Unfortunately, there are no routinely accepted vertical screening distances for non-petroleum compounds and as a result, Ecology is reluctant to provide specific values.

The reference to temporal variability was intended to point out that in general the further the sample is from the vapor source the larger the potential for variations in the data. However, sub-slab soil gas concentrations may exhibit less temporal variability if the pressure gradient across the slab is relatively constant and/or if sub-slab VOC levels are not significantly higher than indoor levels. In any case, Ecology recommends conducting one coupled sample (sub-slab, indoor and ambient air) during building depressurization conditions. The minimum number of samples necessary to support a no further action determination will be a building specific decision.

Comment No. 6 – While the Sun Devil Manor data set is a good starting point, it is only data from a single residential building. Indoor air concentrations are not always variable, especially in commercial buildings where the HVAC system is tightly controlled. The use of multiple lines of evidence, including indoor air sampling, to build a conceptual site model is a sound approach to evaluating VI. In the response to FAQ No. 11, perhaps add a sentence here that says "at least two rounds of indoor air data" will be required to close a site.

Please clarify if the use of long term (i.e., 14 to 30-day) passive sampling methods for indoor air sampling would reduce the number of sampling events required to evaluate vapor intrusion related exposures.

Response – While in many cases multiple sampling rounds may be needed, Ecology is uncomfortable specifying that at least two rounds of indoor air data will be necessary to close a site as this could be viewed as using guidance to create rule language. It could also limit flexibility if the lines of evidence supported a conclusion that one sampling event was adequate.

In general, the longer sampling timeframes of passive samplers would be expected to provide a more reliable basis for determining long-term time weighted exposures. However, Ecology cannot definitively state this approach would always reduce the number of sampling events required.

Comment No. 7 – In the response to FAQ No. 12, please use threshold soil and groundwater concentrations that correspond with the terms "high" and "significantly". Also, please provide lateral or vertical distances that define "close proximity".

Response – The language has been modified to better clarify when certain types of samples are necessary.

Comment No. 8 – In the response to FAQ No. 13, please use threshold concentrations that correspond with the term "high level" or provide an action level that would indicate soil or groundwater concentrations with applicable lateral and vertical distances that could pose an immediate indoor air concern.

Response – Ecology currently provides horizontal screening distances for both petroleum and non-petroleum VOCs as well as vertical screening distances for petroleum contamination. Supporting technical information is not currently available to allow for establishing additional quantitative screening values.

Comment No. 9 – Please include the Table 3-2 from the referenced New Jersey Department of Environmental Protection VI Guidance document in the response to FAQ No. 14 or a similar version in the Ecology VI Guidance update.

Response – The primary reason Ecology did not include a copy of Table 3-2 is because if New Jersey DEP changes the recommended number of samples our guidance would no longer have up to date information. A similar problem occurred with the cleanup and screening levels in Appendix B in Ecology's 2009 draft VI guidance.

Comment No. 10 – In very large commercial/industrial buildings it can be difficult and cost prohibitive to uniformly distribute samples across the entire building footprint. In the response to FAQ No. 15 on spatial variability in large buildings, provide the option of using a phased sampling approach. In these scenarios the initial round of samples are biased towards the worst case areas including historical use areas, highest groundwater or soil areas, locations where sumps and drains are present, etc. Secondary sampling can then be used to refine the lateral extent of impacts, as needed.

Response – If indoor air will be sampled concurrently with sub-slab vapors and there is a high level of confidence with the location of the contamination, it may be appropriate to initially focus the sampling in the area(s) of known contamination for very large buildings. FAQ No. 15 was expanded to include a discussion on this scenario.

Comment No. 11 – The last paragraph of the response to FAQ No. 17 presumes that institutional controls will not be a sufficient risk mitigation tool and that cleanup actions will still be necessary if institutional controls are in place. Please rephrase this statement to include further guidance on how institutional controls can be used to mitigate potential vapor intrusion exposure in addition to the appropriate modifications based on associated receptor scenarios.

Response – The intent of the last paragraph was to indicate that if the contamination is not cleaned up to Method B levels then an institutional control would be necessary to ensure the building occupants are protected. The language was revised to better reflect this intent.

Comment No. 12 – In the response to FAQ No. 19, rephrase the first sentence in paragraph 2 to say – "…when petroleum *constituents* are the only…".

Response – The requested change to the first sentence of paragraph 2 was made.

Comment No. 13 – In the response to FAQ No. 12 regarding situations where indoor air will be sampled, Ecology recommends concurrent collection of sub-slab soil gas samples. Suggest clarifying that the act of penetrating the slab of a structure to install a soil gas sampling point, or opening an existing sub-slab soil gas sampling point, introduces the potential for interference with indoor air quality. Given the already acknowledged difficulties associated with indoor air sampling and interpretation of those results, it is not advisable to collect sub-slab soil gas and indoor air samples simultaneously. Indoor air sampling should precede sub-slab sampling to avoid the potential for cross-contamination.

Response – Ecology agrees that the potential exists for indoor air to be impacted from sub-slab soil gas during installation and/or sampling activities and so the discussion has been expanded to better clarify the term "concurrent". While installing the sub-slab probe(s) could be delayed until after the indoor air samples are collected, it may also be possible to install the probes prior to indoor air sampling provided enough time is allotted for the concentrations to return to pre-installation levels.

Comment No. 14 – In the response to FAQ No. 17 suggest clarifying:

1. The adjustments for average body weight and breathing rate are only applicable for the calculation of non-carcinogenic screening levels.

2. The exposure frequency adjustment. The conversion factor is calculated by dividing the commercial scenario (10 hours/day x 5 days/week) by the residential scenario (24 hours/day x 7 days/week). This actually yields a factor of 0.30 rounded to two significant digits.

3. If the example of 50 hours/week should be considered the default for commercial scenarios, or whether this is just an example. It has been our experience that 40 hours/week has been considered acceptable in the past. The conversion factor used can have a significant impact on the screening level for many chemicals of concern and whether the vapor pathway poses a risk.

Response – Answers No. 1 and 3 were modified to clarify that the changes only apply to non-carcinogenic cleanup levels.

The exposure frequency adjustment was changed from 0.29 to 0.30 as requested.

A note was added at the end of FAQ No. 17 to clarify that while Ecology anticipates the standard work week will often be 50 hours, it may be possible to justify the use of a lower number on a case specific basis.

Comment No. 15 – Ecology no longer recommends the use of predictive models such a JEM to be used as a sole method to "screen-out" the VI pathway. Please provide examples of the site-specific data that may be used in conjunction with a model to assess the potential for impacts to indoor air. For example, in situations where soil gas data exceeds MTCA screening levels for a VI assessment, models are routinely used to incorporated site-specific parameters such as building construction, size, soil type, ventilation rates, etc. to evaluate whether soil gas concentrations are likely to pose a risk to indoor air for that building. This is typically preferable in lieu of collecting indoor air samples which is problematic and inconclusive in many real-life scenarios. Does Ecology support the use of modeling in this manner? Otherwise what other lines of evidence would Ecology like to see evaluated to support this approach? Presumably soil and groundwater data have already lead to the collection of soil gas data and would not be helpful.

Response – Ecology's major concern with the use of predictive models is based on the information in the Table on page 3-5 of the 2009 guidance. This table provides 4 options for completing a Tier I assessment depending on the subsurface source of the contamination (shallow groundwater only, vadose zone soil only, shallow groundwater and vadose zone soil, and LNAPL on top of the water table). All of the options indicate a predictive model may be able to be used to determine whether indoor air concentrations will be below the established cleanup levels. In practice, our experience has been that numerous assumptions on the model input parameters needed to be made. Since other supporting data were rarely provided, concerns were raised about the accuracy of the model predictions.

When sampling results show exceedances of the groundwater VI screening levels (or soil VI screening levels for petroleum) and buildings are present within the applicable horizontal screening distances, in most cases the next step should be soil gas sampling. For petroleum contaminated sites, Implementation Memo No. 18 indicates that soil gas sampling, coupled with the use of a predictive model may be sufficient to show the mass of contamination remaining is not sufficient to present a VI concern.

For chlorinated compounds, paired indoor air and sub-slab soil gas data would typically be necessary to provide the supporting data to confirm the modeling results. Other available information such as: the building configuration, soil conditions, type and location of utilities and plume stability data should also be evaluated. FAQ No. 25 has been expanded to include this discussion on when modeling may be appropriate.

Comment No. 16 – Add an additional FAQ that addresses situations where contamination remains beneath a building that has a parking structure below the occupied space. In particular, could the vehicle exhaust system also be used as the mechanism to address any potential VI concerns?

Response – FAQ No. 21 was added to address situations where relying on the parking ventilation system may be appropriate for also addressing the VI pathway.

Comment No. 17 – This link provides information about the history and regulatory authority for exposure to hazardous substances in the workplace and is highly relevant: https://www.spencerfane.com/publication/epa-issues-final-vapor-intrusion-guidance-and-declares-epa-not-osha-in-charge-of-indoor-air-quality-at-the-workplace/. Seems that remains a topic of debate between EPA and OSHA. Ecology's legal footing for regulating workplace exposures by following EPA's approach in the 2015 EPA guidance doesn't seem very solid.

Response – Ecology's 2009 draft VI guidance (page 1-7) indicates that: "the guidance does not apply to potential VI scenarios where the receptors at risk are workers routinely exposed to higher concentrations of the same chemical(s) as part of an industrial/manufacturing process when these exposures are directly regulated by OSHA". While draft Implementation Memo No. 21 (FAQ No. 5) provides further explanation and discussion, it does not change how Ecology views OSHA's regulatory authority over chemicals used in the workplace.

OSHA does not regulate situations where indoor air constituents in the workplace are due to vapor intrusion. Conversely, MTCA contains numerous provisions that provide Ecology with the authority to ensure cleanup standards and cleanup actions are protective of human health and the environment, including indoor air quality.