

Updated Process for Initially Assessing the Potential for Petroleum Vapor Intrusion

Implementation Memorandum No. 14

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To: Interested Persons

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Attachments: A – Petroleum Vapor Intrusion Decision-Making Flowchart
B – Recommended vertical separation distances between contamination and building basement, floor, foundation, or crawlspace surface

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Purpose and Applicability

This implementation memo provides guidance on how to initially assess whether vapor intrusion (VI) is a potential concern at sites with petroleum contamination. The term “initially” is used throughout this memo and refers to the portion of the VI assessment process for determining if mitigation or some other interim action is necessary based on existing conditions. This will generally occur at the time a remedial investigation is being conducted to define the nature and extent of contamination at the site. When the memo indicates that “the initial assessment process is complete,” this means that the existing situation does not pose a current vapor intrusion threat.

This memo supplements Chapter 2, “Preliminary VI Assessments,” in Washington Department of Ecology’s (Ecology’s) 2009 draft [Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action](#) (Ecology 2009).

If the initial assessment indicates existing conditions may pose a potential for petroleum vapor intrusion, then a Tier I and (if necessary) Tier II assessment should be completed. See Chapter 3, “VI Assessment during the Remedial Investigation (Tiers I and II)” in Ecology’s 2009 draft guidance.

This memo does not discuss how to establish final site cleanup levels that are protective of the VI pathway for current site conditions, nor does it provide details on how to address the MTCA requirement that the selected cleanup action be protective of potential future site and resource uses. However, it should be kept in mind that if the approved cleanup action results in contamination remaining on the site for a prolonged period, further vapor assessment or potential restrictions on building use, modifications or new construction may be necessary. Ecology intends to provide additional direction on how to address these issues as part of comprehensive revisions to the 2009 draft vapor intrusion guidance. Until then, see Chapter 6, “VI Considerations for Site Cleanup,” in the 2009 draft guidance for information on these topics.

Background

In October 2009, Ecology issued a draft vapor intrusion guidance document for public review. Work began to address the public’s comments and Ecology established an external workgroup to obtain feedback and direction while the final guidance was being developed. An initial meeting with the workgroup in May 2010 generated good discussions about the guidance’s content and level of detail. For several reasons, however, further work was suspended shortly after that meeting and the 2009 draft guidance has been used since.

The primary document used to develop the 2009 guidance was the Environmental Protection Agency’s (EPA’s) 2002 [*Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*](#) (USEPA 2002). Ecology used many other draft and final guidance documents to supplement the EPA reference.

Over the last 15 months, three major vapor intrusion guidance documents have been finalized:

1. In October 2014, ITRC finalized a detailed document titled [*Petroleum Vapor Intrusion: Fundamentals of Screening, Investigation, and Management*](#) (ITRC 2014).
2. In June 2015, EPA issued two major VI guidance documents:
 - a. The comprehensive technical guide applicable to any VI situation: [*Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air*](#) (USEPA 2015)
 - b. [*Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*](#) (USEPA June 2015).

Now that the EPA documents have been finalized, Ecology believes this is an opportune time to update and finalize the 2009 draft guidance. However, given the number of changes that have occurred in assessing the vapor intrusion pathway since the 2009 draft guidance was issued, it will likely be a lengthy process to update it.

This implementation memo is the first of several documents that will address issues related to the vapor intrusion pathway until the 2009 guidance is revised. This memo primarily applies to releases of petroleum-containing fuels from underground storage tanks. This memo can also be used for the initial screening of other fuel releases of similar magnitude (e.g. small spills), as well as for releases from home heating oil tanks. When working with large releases such as those from bulk tank farms, this memo should only be used in concurrence with the Ecology cleanup project manager.

General Discussion

EPA's and ITRC's petroleum VI documents rely on information contained in EPA's [Evaluation of Empirical Data to Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds](#) (USEPA 2013b). The document summarizes data from a large number of petroleum-contaminated sites.

Given the scrutiny these data have received, Ecology believes that using the vertical separation distances empirically derived from this information is a reasonable approach for initially assessing the petroleum VI pathway at many fuel-release sites, provided the criteria set out later in this memo are met.

Ecology has reviewed both of the EPA and ITRC petroleum VI documents. While both documents are technically sound, this memo relies primarily on EPA's guidance for initially assessing and screening sites. If a site cannot be screened out using the EPA distance-based criteria, then further investigation work should be done using the applicable portions of Ecology's Tier I and Tier II assessment process discussed in the 2009 draft guidance.

MTCA Rule Requirements Regarding Vapor Intrusion

There are provisions in the Model Toxics Control Act ([MTCA](#)) that apply to evaluating the VI pathway for potential impacts from petroleum (Ecology 2013). Specifically, four provisions contain requirements related to soil vapors:

- [WAC 173-340-740\(3\)\(b\)\(iii\)\(C\)](#)
- [WAC 173-340-740\(3\)\(c\)\(iv\)](#)
- [WAC 173-340-745\(5\)\(b\)\(iii\)\(C\)](#)
- [WAC 173-340-745\(5\)\(c\)\(iv\)](#)

In general, the vapor pathway must be evaluated for sites with petroleum contamination when soil concentrations are significantly higher than a concentration derived for the protection of

groundwater. However, the phrase “significantly higher” is not defined in either rule or guidance.

MTCA also specifies that for sites with diesel contamination, the vapor pathway must be evaluated when total petroleum hydrocarbons (TPH) concentrations in soil are greater than 10,000 mg/kg. This concentration-based criteria was developed in the late 1990’s as part of the 2001 MTCA rule revisions.

Since that time, additional research has been completed, in particular by the [Hawai’i Department of Health](#) (HDOH 2012) that indicates that a number of petroleum products, including diesel, have a significant amount of aliphatic compounds in the mixture. This is important because aliphatic constituents have much higher Henry’s Law constants than either the aromatics or specific petroleum compounds such as BTEXN, and therefore may present a VI risk at concentrations lower than the 10,000 mg/kg level found in MTCA.

EPA’s guidance uses a diesel TPH screening value of 250 mg/kg or greater as an indication that a) light non-aqueous phase liquid (LNAPL) is present, and b) additional vertical separation is necessary between the contamination and any overlying structures. Both EPA and the Hawai’i Department of Health recommend fully characterizing the fractions of TPH present to accurately assess the potential for vapor intrusion. Given recent research and the guidance developed by EPA, it may be appropriate to assess the vapor intrusion pathway even if the soil TPH concentrations for diesel-range organics are below 10,000 mg/kg.

Modified Approach for Assessing the Vapor Intrusion Pathway for Sites with Petroleum Contamination

This section provides guidance on how to integrate EPA’s 2015 petroleum VI guidance with Ecology’s 2009 draft guidance. Each step is discussed below and summarized in the flowchart (Attachment A).

Ecology’s 2009 draft vapor intrusion guidance discusses assessment recommendations for both “recalcitrant” volatile organic compounds (VOC’s) and volatile petroleum hydrocarbons. The document acknowledges that many petroleum compounds are amenable to aerobic biodegradation in the vapor phase. However, since the 2009 guidance was developed, much more has been learned about the degree to which biodegradation will limit the potential for significant indoor vapor impacts when sufficient oxygen is present in the subsurface.

Based on this new information, the recommendations in the 2009 draft guidance concerning the use of groundwater and deep soil gas screening levels will often be overly-conservative when the VOC’s of interest are those associated with the types of fuel releases described in EPA’s 2015 document [Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites](#). For that reason, Ecology recommends the following steps to initially assess the potential for petroleum vapor intrusion.

Note: This process assumes that sufficient site characterization work has been performed to allow each specific step to be completed.

STEP 1: Confirm the release.

When a release of petroleum is suspected, the first step is to confirm that a release has occurred. In some cases this will consist of soil and groundwater sampling to determine potential impacts to the environment, but in others it may be a qualitative assessment. A good discussion of options for completing this evaluation is found in Chapter 3 of Ecology's [Guidance for Remediation of Petroleum Contaminated Sites](#) (Ecology 2011).

STEP 2: Determine if an immediate action is necessary.

While most sites do not pose safety concerns or acute exposure threats from vapor intrusion, there are several scenarios identified in the 2009 draft VI guidance where this could be the case. The 2009 guidance was not developed to respond to these relatively rare situations, and this implementation memo assumes that an immediate action is either not necessary or that the immediate action has already been completed.

STEP 3: Characterize the site and develop a conceptual site model (CSM).

Conduct a site characterization and prepare a conceptual site model. If the initial site investigation is too limited to prepare an adequate CSM, gather additional information and revise the CSM accordingly. For more information, see Chapter 3 of EPA's technical guide [Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites](#) (USEPA 2015, June).

STEP 4: Evaluate whether there are any contaminants besides petroleum.

If any volatile contaminants other than those typically found in petroleum fuel products are discovered, the site is not eligible to use this implementation memo for assessing the VI pathway. With the exception of polychlorinated biphenyls (PCB's) and Halogenated VOC's, the compounds in MTCA Table 830-1 are considered to be those "typically found in petroleum."

□ **STEP 5: Determine if there are precluding factors.**

“Precluding factors” are site conditions “that may justify a greater separation distance” during the vapor screening process (see EPA’s [Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites](#) (USEPA 2015, June) and [Evaluation of Empirical Data to Support Soil Vapor Intrusion Screening Criteria for Petroleum Hydrocarbon Compounds](#) (USEPA 2013b). Use the site characterization information and the conceptual site model to determine if there are any such factors, including:

- Changing site conditions such as an expanding plume or planned development above/adjacent to the contamination;
- Preferential pathways such as utility corridors or highly permeable soil zones;
- Extremely low soil moisture content¹;
- Limited oxygen in the soil due to the presence of: relatively impermeable ground cover surrounding the building of interest, large structures, or methanogenesis (due to the release of higher ethanol blends of gasoline or the presence of very high organic material in the soil);
- The presence of lead scavengers such as 1,2-dibromoethane (also known as ethylene dibromide or EDB) or 1,2-dichloroethane (also known as ethylene dichloride or EDC) in the released fuel;
- The presence of other additives in the released fuel that may aerobically biodegrade more slowly than benzene; and
- Subsurface petroleum VOC contamination in direct contact with the building’s foundation.

If precluding factors are present, the appropriateness of using the screening criteria in Steps 6 and 7 below must be evaluated. This may require additional site characterization. If it appears that one or more precluding factors could undermine the conservativeness of the distance-based screening criteria, then Steps 6 and 7 would not be appropriate for assessing the VI pathway. Instead, the Tier I or Tier II process in the 2009 draft guidance should be used to continue the assessment.

¹ EPA’s guidance defines this as less than 2 percent soil moisture. This should only be a potential issue at some locations in Eastern Washington.

STEP 6: Determine if buildings are within the lateral inclusion zone.

The lateral inclusion zone is defined as the area surrounding a contaminant source through which vapor phase contamination might travel and intrude into buildings. Determining the lateral distance within which buildings or other structures might be threatened by petroleum vapors is a site-specific decision. EPA's petroleum VI guidance indicates that "though in theory the length of the lateral separation may be on the same scale as the vertical separation distance, a greater lateral distance is generally warranted in the down gradient direction because the lateral boundaries of a migrating plume are more difficult to accurately delineate, as they are not stationary."

EPA has a technical paper that can be used to calculate a lateral inclusion zone: [*An Approach for Developing Site-Specific Lateral and Vertical Inclusion Zones within which Structures Should be Evaluated for Petroleum Vapor Intrusion due to Releases of Motor Fuel from Underground Storage Tanks*](#) (USEPA 2013b). The paper provides an approach for calculating a lateral inclusion zone using the separation distances between clean monitoring points. ITRC's 2014 petroleum VI guidance, as well as numerous state agencies' vapor intrusion guidance documents, rely on a 30-foot horizontal separation distance from the edge of the contamination to provide an adequate separation distance.

For the purposes of this implementation memo:

- If the degree and extent of contamination is well-defined and the dissolved phase plume is stable or receding, then a horizontal separation distance of 30 feet would generally be appropriate for establishing a lateral inclusion zone.
- If limited site characterization information is available, then the EPA technical paper referenced above should be used to develop the lateral inclusion zone.

If no existing buildings are in the lateral inclusion zone, then the initial VI assessment process is complete.

STEP 7: Evaluate the vertical screening distances for buildings in the lateral inclusion zone.

Use the site characterization data and guidance contained in Chapter 5 of EPA's [*Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites*](#) (EPA June 2015) to determine the appropriate vertical separation distances. Table 3 (p. 52) of EPA's guidance contains the recommended vertical separation distances and is included with this memo as Attachment B. If the vertical separation distance criteria are met, based on the measured soil and groundwater concentrations for benzene and TPH, then the initial VI assessment process is complete.

STEP 8: Approach to use if the vertical screening distance criteria are not met.

If the site cannot be screened out because the vertical separation distance criteria from the lowest point of the building to the highest point of measured contamination is not met, the next step is to utilize the Tier I or Tier II assessment approach described in Chapter 3 of Ecology's 2009 draft vapor intrusion guidance (Ecology 2009). Once the Tier I or Tier II process is initiated to evaluate the potential for vapor intrusion, this implementation memo is no longer applicable.

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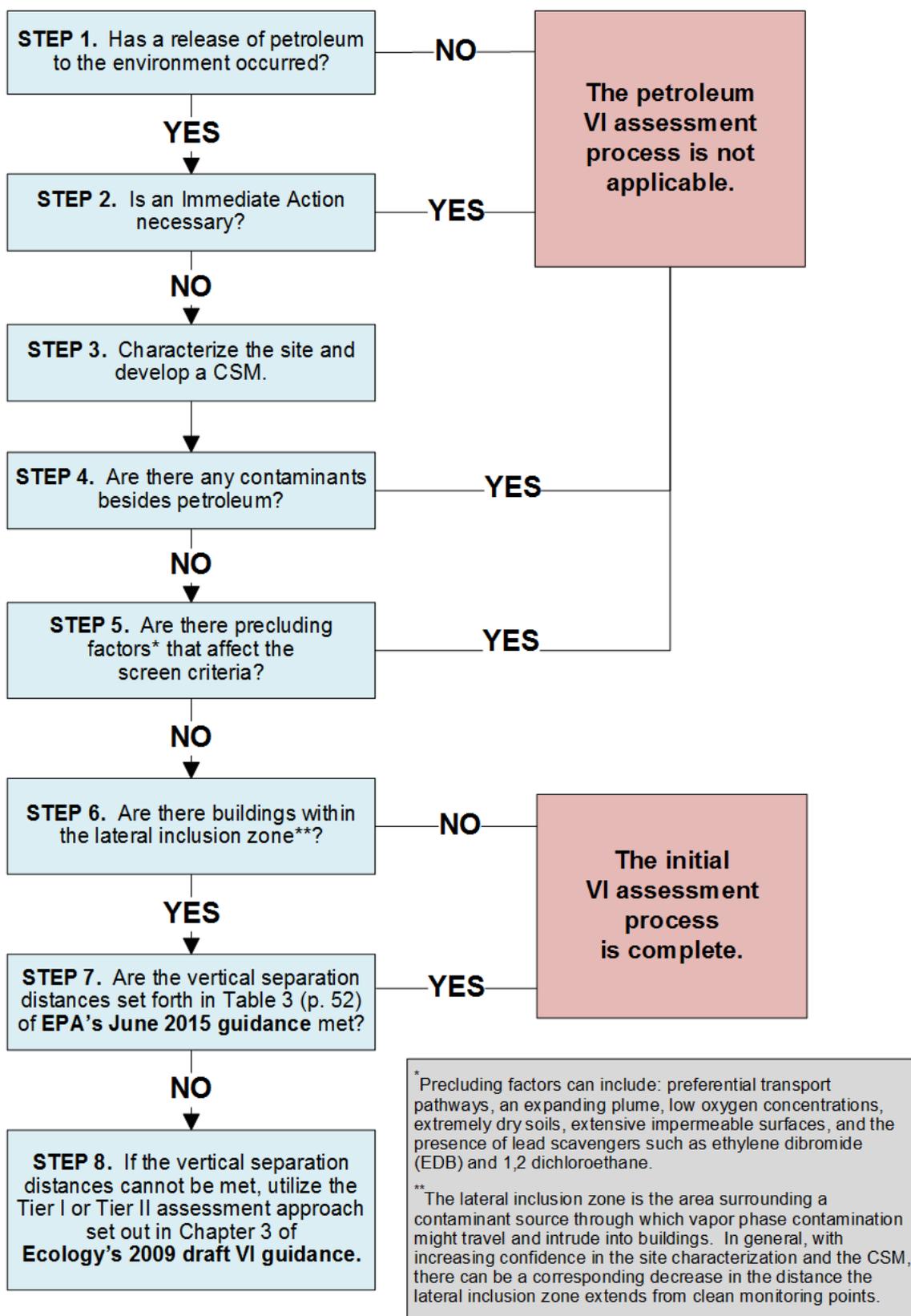
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Attachment A

Petroleum Vapor Intrusion Decision-Making Flowchart

Attachment A: Petroleum Vapor Intrusion Decision-Making Flowchart



Attachment B

Recommended Vertical Separation Distances between Contamination and Building Basement Floor, Foundation, or Crawlspace Surface

Source: [Technical Guide for Addressing Petroleum Vapor Intrusion
at Leaking Underground Storage Tank Sites](#)

(USEPA 2015, June)

Attachment B: Recommended vertical separation distances between contamination and building basement floor, foundation, or crawlspace surface.

Media	Benzene	TPH	Vertical Separation Distance (feet)*
Soil (mg/Kg)	≤10	≤ 100 (unweathered gasoline), or ≤ 250 (weathered gasoline, diesel)	6
	>10 (LNAPL)	> 100 (unweathered gasoline) >250 (weathered gasoline, diesel)	15
Groundwater (mg/L)	≤5 [5,000 µg/l]	≤30 [30,000 µg/l]	6
	>5 (LNAPL) [5,000 µg/l]	>30 (LNAPL) [30,000 µg/l]	15

The thresholds for LNAPL indicated in this table are indirect evidence of the presence of LNAPL. These thresholds may vary depending on site-specific conditions (e.g., soil type, LNAPL source). The value of 5 mg/L benzene is from EPA (2013a, p.31). A study by Peargin and Kolhatkar (2011) suggests that a dissolved source with benzene greater than 1 mg/L may behave like a LNAPL source in terms of vapor-generating capability. Decision-makers may have different experiences with LNAPL indicators and may use them as appropriate. For more information, see Section 6 (p.57) and Figure 7 in particular.

Bulk soil samples should be analyzed for Total Petroleum Hydrocarbon (TPH) and BTEX (plus any other potential contaminants). The objective of measuring TPH is to quantify the total vapor phase concentration of PHCs. TPH may be analyzed by methods appropriate for the type of fuel released. These methods may be designated as TPH-gasoline (or sometimes gasoline range organics or GRO), TPH-diesel (or sometimes diesel range organics or DRO). Method TO-15 (see <http://www.epa.gov/ttn/amtic/files/ambient/airtox/to-15r.pdf>) by itself only measures a small fraction of PHCs that may be present in the vapor-phase. TO-15 analyses require a correction factor to estimate bulk TPH. An extended TO-15 analysis can provide such an estimate. For more information on TPH in vapor intrusion studies, see Brewer et al. (2013).

*The vertical separation distance represents the thickness of clean, biologically active soil between the source of PHC vapors (LNAPL, residual LNAPL, or dissolved PHCs) and the lowest (deepest) point of a receptor (building basement floor, foundation, or crawlspace surface).

Source: [Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites](#) (USEPA 2015, June)