



**U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE AND EMERGENCY RESPONSE**

REVIEW OF THE DRAFT 2002 SUBSURFACE VAPOR INTRUSION GUIDANCE

BACKGROUND

Vapor intrusion is a potential pathway for human exposure to subsurface contamination. Vapor intrusion occurs when volatile compounds migrate from contaminated groundwater or soil into the indoor air of an overlying or nearby building. Vapor intrusion can result in human exposure to vapor-forming chemicals, such as volatile organic compounds (VOCs) and some other organic and inorganic compounds, which may pose a potential health risk.

In November 2002, the U.S. Environmental Protection Agency (EPA) released the *Draft OSWER Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soil (Subsurface Vapor Intrusion Guidance)* (EPA 530-D-02-004; henceforth referred to as 2002 Draft Vapor Intrusion Guidance).¹ Since the November 2002 Draft Vapor Intrusion Guidance was released, EPA's knowledge and experience with vapor intrusion has increased considerably. In the past 8 years, federal and state cleanup agencies have been investigating contaminated sites across the country for possible exposure via the vapor intrusion pathway, and when warranted, have taken action to significantly reduce vapor intrusion exposure. These experiences have led to an improved understanding and approaches for assessing and managing vapor intrusion.

In 2009, EPA's Office of the Inspector General (OIG) released the evaluation report *Lack of Final Guidance on Vapor Intrusion Impedes Efforts to Address Indoor Air Risks* (Report No. 10-P-042; U.S. EPA, 2009a) and made a number of recommendations regarding vapor intrusion guidance efforts. Among other things, the OIG recommended that EPA identify and publicly report the portions of Office of Solid Waste and Emergency Response's (OSWER's) November

¹ The 2002 Draft Vapor Intrusion Guidance was designed for investigations of vapor intrusion conducted under authority of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA), and other relevant authorities and programs, such as Brownfields. However, it was not recommended for use at Subtitle I Underground Storage Tank sites. Available at: <http://www.epa.gov/epawaste/hazard/correctiveaction/eis/vapor/complete.pdf>.

2002 Draft Vapor Intrusion Guidance that remain valid and the portions that should be updated.² This document provides OSWER's commitment to carry out that recommendation.

The following review of the 2002 Draft Vapor Intrusion Guidance summarizes EPA's current understanding of the portions of the guidance that remain valid and those that may need to be updated. However, this review summary may not fully capture all possible areas that will be updated in the final version of the Vapor Intrusion Guidance, which EPA has committed to release by November 2012.

REVIEW OF THE 2002 DRAFT VI GUIDANCE

EPA has reviewed the 2002 Draft Vapor Intrusion Guidance and the public comments received on the guidance in detail. Most of the draft guidance remains consistent with the current state-of-the-science (i.e., remains valid) and is appropriate for its intended scope and purpose. However, there are areas of the 2002 Draft Vapor Intrusion Guidance, detailed below, that should and will be updated based on the Agency's current understanding of vapor intrusion. In particular, considerable information, primarily observational data sets has been generated since publication of the 2002 Draft Vapor Intrusion Guidance.³ These observations and experience with vapor intrusion investigations enabled the Agency to more fully appreciate the fact that the spatial and temporal distribution of VOC concentrations in the subsurface and in indoor air can be highly variable. Some of this variability can be attributed to vertical and horizontal differences in subsurface conditions, the differences in structural conditions (e.g., foundation cracks) and the air exchange rates from one building to another. Variation in weather conditions (e.g., rainfall, barometric pressure, wind) has also been observed to have a potentially significant impact on the distribution of VOCs in the environment near a building and the entry of VOCs into a building via the vapor intrusion pathway. In summary, EPA's observations and experiences have indicated that there is greater complexity in the processes and number of variables that affect the migration and distribution of VOCs, and consequently, the potential for vapor intrusion than was generally appreciated when EPA issued the 2002 Draft Vapor Intrusion Guidance.

TIER 1 – Primary Screening

Tier 1 of the 2002 Draft Vapor Intrusion Guidance identifies potential contaminants of concern and locations where there is potential for unacceptable vapor intrusion. In general, the approach described in this section remains largely consistent with the current state of the science (i.e., remains valid). However, based on new information, EPA plans to update some aspects of Tier 1, including a few chemical-specific physical characteristics used for identifying the vapor-forming chemicals of concern. In addition, since the 2002 Draft Vapor Intrusion Guidance was issued, EPA has updated the toxicity values for many of the chemicals found in Table 1.

² OIG's 2009 Report also contained a number of other recommendations, which are not discussed in this document. See <http://www.epa.gov/oig/reports/2010/20091214-10-P-0042.pdf> for a copy of OIG's report and a complete list of the recommendations.

³ It is important to note that the vast majority of the observational data sets are for the more common chlorinated solvents, and the generalized statements in this document may not pertain to the more readily degradable petroleum compounds. A separate component to the guidance is being developed that focuses on petroleum vapor intrusion.

Therefore, the toxicity-based concentration criteria in Table D-1 in the draft guidance will be updated accordingly.⁴ Finally, based on knowledge gained from vapor intrusion site evaluations since 2002 and based on public comments on the 2002 Draft Vapor Intrusion Guidance, this section's limited guidance for the documentation of the extent of subsurface contamination, including spatial and temporal variability, as well as the potential for future building construction in potentially impacted areas is being considered for updates.

TIER 2 – Secondary Screening

In Tier 2, contaminant concentrations for single environmental media (from samples collected external to a building of potential concern) are quantitatively compared to their appropriate (i.e., groundwater or soil gas) concentration screening values. These screening values were designed to be sufficiently protective such that the risk of vapor intrusion related exposure at sites where the concentrations are below the screening levels was not considered significant. Tier 2 uses two methods to estimate the reduction (attenuation) in vapor concentrations as vapor migrates between the locations of subsurface samples and indoor air:

1. The first part of the Tier 2 screening process uses conservative (health-protective) “generic” attenuation factors that are considered to reflect generally reasonable high-end conditions for a first-pass screening (e.g., 95th percentiles). This portion of the draft guidance allows the “screening out” of entire sites from further consideration for vapor intrusion by performing a basic ‘source-strength’ screen based on a single line of evidence (in this case, external samples of groundwater or soil-gas, or interior structure samples of sub-slab vapor, crawlspace, or indoor air), combined with observation-based conservative (health-protective) “generic” attenuation factors. These attenuation factors were developed from the limited databases of observed attenuation factors that existed in 2002. These factors are being updated with a larger database developed since 2002. Although the analysis is ongoing, the evidence collected to date appears to support the continued use of the 2002 observation-based generic attenuation factors for screening populations of samples from the groundwater media (i.e., for the groundwater media, this approach appears to remain valid), although as discussed below, the Agency believes that a multiple-lines of evidence approach would provide greater certainty in the decisions made.⁵ However, the evidence collected to date indicates that the 2002 generic attenuation factors (and/or the sampling methodologies) for external soil-gas needs to updated.
2. The second part of Tier 2 allows the use of EPA’s ‘semi-site-specific’ spreadsheet implementation of the Johnson and Ettinger (1991) model to modify the generic screening levels for groundwater and external soil-gas samples in situations where the model (with some site-specific inputs) estimates a greater reduction in vapor concentrations than the generic estimates. This portion of the draft guidance allows the screening out of entire sites from further consideration for vapor intrusion based on a single line of external evidence (in this case, externally collected groundwater or

⁴ One of the bases for some of the changes in toxicity values is that EPA is no longer routinely using inhalation toxicity values derived from route-to-route extrapolation (e.g., from oral-based studies; see EPA 2009).

⁵ Note that these screening values may not be appropriate for some individual site conditions with exceptional ‘precluding’ factors.

soil-gas samples), combined with a semi-site-specific, model-based estimated attenuation factor. Although the analysis of this screening process is ongoing, observational data collected since 2002 suggest that the EPA's 2002 approach (see Figure 3 of the 2002 Draft Vapor Intrusion Guidance) may be sufficiently protective for site screening based on groundwater data.⁶ However, experience gained since 2002 has indicated that assessments involving a multiple lines of evidence⁷ approach is generally better for understanding site conditions, and improving the level of confidence and reducing uncertainty when evaluating vapor intrusion at such sites. Furthermore, the observational data collected indicates the 2002 "single line of evidence" approach with site-estimated (Figure 3 of the Draft 2002 Guidance) attenuation factors is generally not appropriate for external soil-gas samples (collected using existing sampling methodologies) and needs to be updated. EPA is currently conducting further analyses and preparing documentation to support updates to this approach in the guidance.

Tier 2 is generally focused on existing buildings, and particularly, existing single-family residential buildings. EPA's experiences since 2002 have shown that other types of buildings, such as multi-family residential, non-residential and mixed-use buildings are a part of many vapor intrusion sites. For example, at some sites, retail stores, civic and municipal buildings, and apartments have represented more than one-third of the structures of concern for potential vapor intrusion exposures. Furthermore, many subsurface contaminant vapor source areas include large areas that are currently undeveloped, but have a potential for future buildings. Site experiences and research studies of both subsurface and building variables suggest that predictions of indoor air concentrations on yet-to-be-constructed (i.e., future) buildings can be even more challenging than for existing buildings. Thus, the portions of the 2002 Draft Vapor Intrusion Guidance with limited guidance for a number of building types, including non-residential and future-use buildings, are likely to be updated. Also, we would note that EPA issued a Brownfield Primer on Vapor Intrusion (U.S. EPA, 2007) that generally recommended the 'preemptive'⁸ installation of cost-effective passive vent piping beneath new buildings overlying subsurface vapors for a number of reasons, such as costs, time, and confidence in the results. The EPA Office of the Inspector General's evaluation report made a specific request for further guidance on "when or whether preemptive mitigation is appropriate" and the Brownfield's Primer provides a relevant basis for 'preemptively' addressing the potential impacts of vapor intrusion for future buildings.

Finally, it is notable here and in the next section that the sequence of screening in the 2002 Draft Vapor Intrusion Guidance was generally intended to begin with sampling near the

⁶ Note that these screening values may not be appropriate for some individual site conditions with exceptional 'precluding' factors.

⁷ When more than one independent line of evidence from, for example, multiple types samples of environmental media (e.g., groundwater, soil-gas, sub-slab vapor, crawlspace, and indoor air) and/or other measurements come together to provide mutually supporting evidence for a common understanding of the site conditions/scenarios and the potential for vapor intrusion, the confidence in the assessment is expected to be higher. Such techniques have been described as a multiple lines of evidence approach.

⁸ The term 'preemptive' has been used to describe the use of various types of controls that can prevent vapor intrusion from occurring prior to having fully demonstrated that unacceptable vapor intrusion currently exists in specific buildings being considered.

subsurface source (Tier 2), then progress closer to the overlying building, and ultimately, to include indoor air sampling (Tier 3) (i.e., an “indoor air last” approach). However, experiences since 2002 illustrate the value of collecting indoor air samples earlier in the investigations, including the more rapid and direct assessment of the quality of indoor air. Benefits can also include improved public relations and clearer communication of the results, both of which can improve the opportunities for meaningful public involvement. These observations suggest that while valid, the “indoor air last” approach of 2002 is being considered for updates that will allow more flexibility in the sequencing of subsurface and interior/indoor sample collection.

TIER 3 – Site-Specific Assessment

When environmental sample concentrations from a site exceed the Tier 2 screening values, Tier 3 recommends the collection of samples from within individual buildings (indoor air and/or sub-slab vapor or crawl space air). While these samples can be more useful for assessing the vapor intrusion pathway than samples collected further from the building/structure of interest, they should be evaluated in light of the possibility that ‘background’ sources of VOCs (e.g., consumer products and outdoor air) may impact indoor quality as much as or more so than vapor intrusion in some structures. The concern for background contamination in indoor air can be found throughout the 2002 draft. It was generally considered a disincentive to collecting indoor air data and one of the major considerations for using the “indoor air last” approach. While the issue of ‘background’ sources is still an issue to be considered, the portions of the 2002 Draft Vapor Intrusion Guidance addressing background contamination in indoor air are likely to be updated as new resources are now available. For example, EPA is preparing a compilation of literature background values specifically intended for use in vapor intrusion assessments, and these data support the conclusion that many of the chemicals present in the subsurface at vapor intrusion sites are not expected to be present at concentrations of concern in indoor or outdoor air. Additionally, while the 2002 Draft Vapor Intrusion Guidance recommended background contaminants in indoor air be carefully considered and accounted for, it only provided limited methodologies for doing so. EPA is considering the possibility of updates with more specific methodologies for evaluating and/or decision making and managing background contamination for those constituents that may be present at concentrations of concern in indoor or outdoor air during vapor intrusion site investigations.

Tier 3 is largely based on an expectation that a 24-hour duration indoor air sample, most commonly using canister methodologies (e.g., TO-15), will be used to sample indoor air. Vapor intrusion experiences since 2002, as well as decades of radon studies, have indicated that other approaches can also be used. For example, short duration (i.e., real-time) samples collected with EPA’s mobile Trace Atmospheric Gas Analyzer (TAGA), as well as field-portable gas chromatographs and/or mass spectrometers, have proven very useful for identifying background sources and confirming vapor intrusion in building openings to the subsurface (i.e., pathway samples). Also, longer-term duration samples (e.g., days or longer) have been shown to greatly reduce temporal variability in indoor air concentrations and improve risk estimates. In summary, the portion of the 2002 Draft Vapor Intrusion Guidance focusing primarily on 24-hour time-composite samples for testing indoor air, while still valid, is likely to be updated to allow more flexibility in the duration of sampling to take advantage of the benefits of other sampling durations and methods.

Finally, the 2002 Draft Vapor Intrusion Guidance allows a site-wide decision to be made based on the measurement, or estimation, of indoor air concentrations in a relatively few representative buildings. However, experiences since 2002 have indicated that vapor intrusion is much more building-specific than appreciated in 2002. For example, observations have shown that adjacent buildings overlying similar subsurface contaminant concentrations can have very different indoor air concentrations, based on various factors, due to vapor intrusion. While the approach described in the 2002 Draft Vapor Intrusion Guidance would generally remain appropriate and valid if the few sampled buildings were fully representative of all current and future buildings, this portion of the guidance will likely be updated to increase the confidence that the approach fully addresses building-by-building variability.

APPENDICES

The appendices to the 2002 Draft Vapor Intrusion Guidance include technical specifics related to implementing the guidance recommendations (e.g., sampling and analytical methods; indoor air background levels), as well as technical background for guidance components, such as the empirical data behind the generic attenuation factors and toxicity benchmarks for screening chemicals of potential concern for vapor intrusion. Given the previously mentioned advances in the science of vapor intrusion since 2002, updates will be made for most of the information contained in the appendices to the 2002 Draft Vapor Intrusion Guidance, and as discussed elsewhere in this document. For example, any changes in the chemical-specific physical characteristics, toxicity values, or methods required for Question 1 will require updates to information in Appendix D (Development of Tables 1, 2, and 3), as well as Table 1. Similarly, the updated vapor intrusion database and documentation and updated compilation of background indoor air concentrations will supersede the information currently in Appendix F (Empirical Attenuation Factors and Reliability Assessment) and it is anticipated that the Reliability Assessment analysis will also be updated using the newer available data.

EPA will also be updating and expanding Appendix H (*Community Involvement Guidance: Recommendation for What to Do If You Have a Neighborhood Needing Indoor Air Sampling Due to Subsurface Vapor Intrusion*) because the EPA views improving public outreach in neighborhoods surrounding vapor intrusion sites as a critical component of finalizing the Vapor Intrusion Guidance. Although the current Appendix H language remains valid, it is general, limited (e.g., is only focused on community involvement in the indoor air sampling phase), and not as specific to vapor intrusion sites as it could be. EPA is considering—and will be soliciting EPA regional, state, and public input on—how to restructure and expand the community involvement components of the 2002 Draft Vapor Intrusion Guidance to be more specific to community involvement at vapor intrusion sites, including vapor intrusion-specific guidelines for effective risk communication, and available resources, outreach products and tools for public outreach at vapor intrusion sites.

REFERENCES

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