Final at Last: Notes on EPA's Vapor Intrusion Technical Guide

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On June 11, 2015, the U.S. Environmental Protection Agency finally released its *Vapor Intrusion Technical Guide,* known officially as the *OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air.* The 3.2 MB PDF document is available on line from U.S. EPA, along with the simultaneously released 3.0 MB PDF *Technical Guide for Addressing Petroleum Vapor Intrusion At Leaking Underground Storage Tank Sites* and several related technical documents and tools, at http://www.epa.gov/oswer/vaporintrusion/guidance.html#EO12866OSWERVI.

EPA had originally published its *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soil* in 2002, but the George W. Bush Administration dropped the project in 2003. When Mathy Stanislaus, President Obama's appointee as EPA Assistant Administrator in the Office of Solid Waste and Emergency Response, took office in 2013, he made completion of the document a priority.

It took six years, the release of technical papers and tools, informal and formal public comments, and running the gauntlet of other federal agencies at the White House Office of Management and Budget. Meanwhile, ongoing research and field practice continued to yield new science, new equipment, and new procedures for vapor intrusion response—that is, the investigation and mitigation of the movement of toxic volatile substances from the soil and/or groundwater into overlying buildings. Most significantly, multi-year continuous measurements at fully instrumented, unoccupied residences in Indiana and Utah demonstrated conclusively that the indoor air concentrations of intruding vapors varied significantly over time—daily, seasonally, and by the weather.

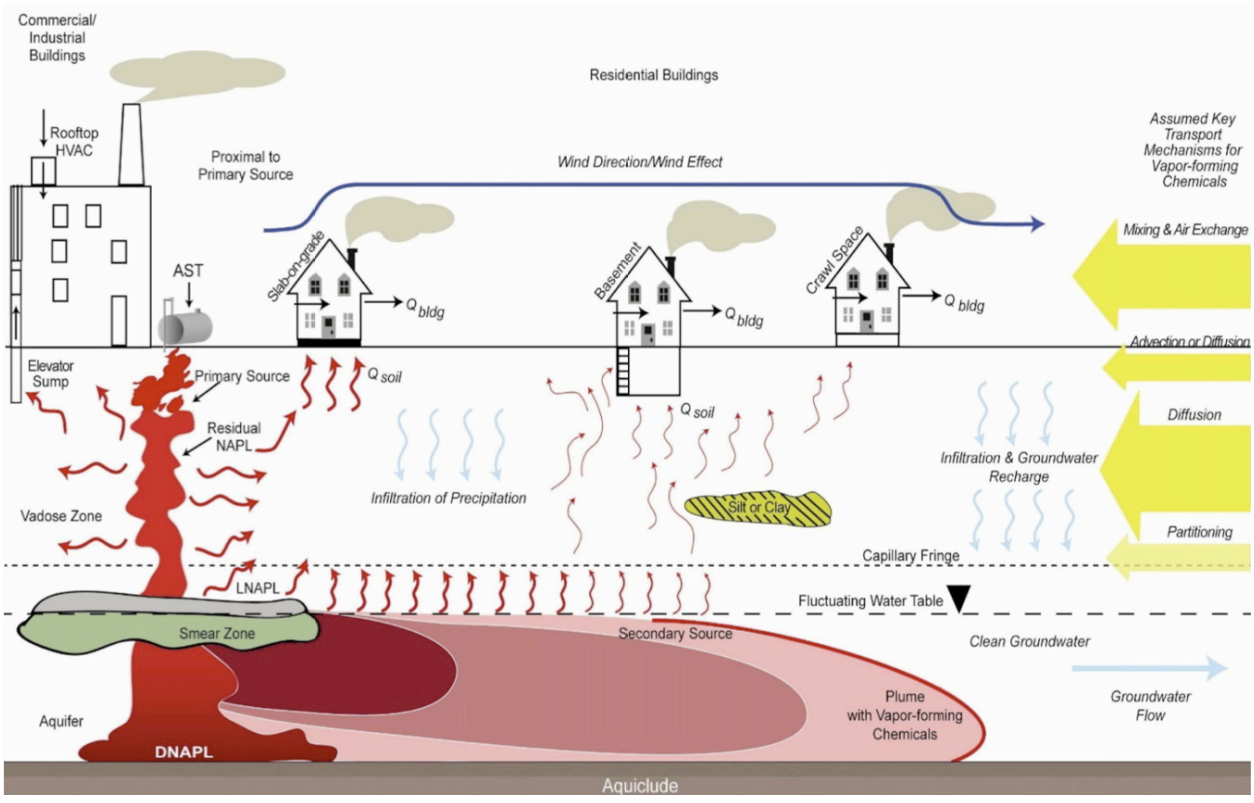
The *Technical Guide* reinforces best practices at EPA and other vapor intrusion projects, and it is expected to influence responses led by EPA and state regulators and well as private parties, such as developers conducting independent responses. It is not a statute or regulation. That is, it does not impose any new requirements. Rather, it explains **how** to protect building occupants from potential vapor intrusion at sites being addressed under Superfund (CERCLA, the Comprehensive Environmental Response, Compensation, and Liability Act), RCRA (Resource Conservation and Recovery Act) Corrective Action, and their state counterparts. I expect states with their own guidance documents to incorporate EPA's *Guide* by reference.

The *Guide* is thorough, comprehensible, and flexible. At 267 pages, it is not a quick read. But I suggest that all vapor intrusion stakeholders peruse the document, learning enough about it to use it as a reference throughout any vapor intrusion response project. The following notes are not comprehensive. Instead I have tried to highlight significant recommendations, as well as pointing out surprises and other sections that answer long-asked questions. I annotate this document with page-number references, using the PDF page numbers (instead of the page numbers from the printed version) for ease of search. This document is not a complete review of the *Technical Guide.* **People who want the whole picture should read the whole document.**

The most significant differences from the 2002 draft, supported by years of field experience, are that EPA no longer prefers that soil gas samples be evaluated before deciding whether to sample indoors, and that it believes that sometimes it is suitable to install mitigation systems as a preventive measure, rather than continue sampling in buildings where there is uncertainty over the level of vapor intrusion.

In addition, EPA recognizes that evaluating vapor intrusion at small petroleum hydrocarbon release sites, such as gasoline stations, is a special case. Primarily because petroleum compounds tend to break down as they approach the surface, the conditions associated with vapor intrusion are much narrower. Though much of the *Technical Guide* applies to petroleum sites, at the same time EPA issued the *Guide* it also released a separate *Technical Guide for Addressing Petroleum Vapor Intrusion at Leaking Underground Storage Tank Sites* to describe the different treatment that is appropriate at certain petroleum sites. For more information on that guide, see my summary at http://www.cpeo.org/pubs/PVISummary.pdf or go to EPA's Petroleum Vapor Intrusion web site at http://www.epa.gov/oust/cat/pvi/ .

Conceptual Site Model (CSM)



Each investigation begins with the development of a **conceptual site model**. In simplest terms, this is a site-specific description or diagram that defines the likely sources of contamination, the receptors (building occupants), the pathways through which contamination may enter the building, and the forces that bring the toxic substances into the building. That conceptual site model helps define **data quality objectives**, "the type, quantity, and quality of data need to reach defensible decisions or make credible estimates." Thus, from the start vapor

intrusion investigations (and later mitigation activities) depend upon site-specific judgments. There is no one-size-fits-all proper response. While this makes it hard for people from impacted communities to predict exactly how responses will be conducted, it gives stakeholders who take the time to learn the science and the process the opportunity to shape the decisions that will determine the safety of their families, property, workplaces, and schools.

The illustration above, Figure 2-1 *(page 42 of the PDF)* from the *Guide*, is designed to show the key elements of a conceptual site model, for four types of buildings.

Spatial Variability

Recent findings on both temporal (over time) and spatial variability show up throughout the *Guide*. (See for example Section 2.6 on page *56 of the PDF*.) The document distinguishes among the airspaces in typical buildings:

> Therefore, buildings subject to vapor intrusion may exhibit differences in concentration of vapor-forming chemicals among building areas (e.g., rooms) as a result of the differential proximity to openings for soil gas entry (see Section 2.3) and openings for air leakage and ventilation and the magnitude and balance of inter-zonal airflows. For example, rooms with perforations through the foundation (e.g., bathrooms or utility rooms) may have greater concentrations of vapor-forming chemicals in air compared to rooms that do not. Generally, basements can reasonably be expected to exhibit greater concentrations of vapor-forming chemicals than upper occupied levels. *(53 of PDF)*

Later in the document it recommends:

> For commercial and industrial buildings, each distinct zone of influence may warrant sampling, when indoor air testing is selected as part of a site-specific investigation plan for vapor intrusion assessment. *(119)*

Exterior Soil Gas

The *Guide* warns against excessive reliance on shallow exterior soil gas measurements. This is a problem I've noticed at some non-EPA sites. EPA concludes:

> Therefore, soil gas concentrations at exterior locations (i.e., outside a building's footprint) may be substantially different from the concentration underneath the building (e.g., the sub-slab concentration), depending on site-specific conditions and the location and depth of the exterior soil gas sample. *(55)*

Exposure Controls vs. Remediation

The *Guide* reminds one that even successful engineered exposure controls are no substitute for remediating the subsurface source:

> Even when operated for prolonged periods, engineered exposure controls are considered 'interim' remedies for purposes of this Technical Guide, because their implementation does not substitute for remediation of the subsurface source(s) of vapor-forming chemicals. Engineered exposure controls may, nevertheless, become part of a final cleanup plan. *(64)*

Non-Residential Buildings

Chapter 4 of the *Guide* is devoted to Non-Residential Buildings, which include factories, offices, warehouses, stores, schools, libraries, hospitals, gyms, hotels, etc. A later section (7.4.3) discusses Occupational Exposure Limits. In one of the few weak spots in the *Guide*, EPA does not require notification of building occupants of the vapor intrusion potential. Instead, it leaves it to the discretion of building owners:

> EPA recommends that information be provided to building owners concerning the potential for vapor intrusion so that this information can be communicated to building employees, tenants, and other occupants. Building occupants include, but are not limited to, facility employees, visitors, customers, suppliers, and building maintenance personnel. *(68)*

Single Mobilization

EPA recognizes that investigations may disrupt the activities of building occupants, so it recommends that investigators consolidate their activities:

> EPA recommends that the scope of investigations within buildings and on individual properties be contemplated, planned, and implemented with the goal of limiting, to the extent practical, return visits, which can cause disruption and inconvenience for building occupants and owners. For example, it may be preferable to collect a comprehensive set of data (e.g., indoor air, sub-slab soil gas, and ambient air samples; pressure readings; see Section 6.4) and confirm information about building occupancy, building usage, heating, cooling, and ventilation (see Section 6.4.1) in a single mobilization, rather than over separate visits, when the investigation objectives include indoor air sampling (see Section 6.3.4) or evaluating contributions of 'background' sources on levels of vapor-forming chemicals in indoor air (see Section 6.3.5). *(89)*

Buffer Zone

EPA notes that it is standard practice to investigate buildings within 100 feet of known plume boundaries, but it suggest that the distance be adjusted based upon site-specific factors.

> EPA recommends investigating soil vapor migration distance on a site-specific basis. That is, larger or smaller distances may need to be considered when developing objectives for detailed vapor intrusion investigations and interpreting the resulting data. *(91)*

Worst First

Section 6.2.2 (starting page *91 of the PDF*) suggests a priority-setting approach where numerous buildings are involved. It recommends the standard practice of starting with those structures at greatest risk of vapor intrusion.

Susceptibility

Section 6.3.3 (starting *100)* discusses factors that may make certain buildings susceptible to soil gas entry, as well as lines of evidence for checking those structures.

Radon

EPA discusses how radon sampling may be used to investigate chemical vapor intrusion:

> Because vapor intrusion and radon intrusion entail similar mechanisms for subsurface vapor migration and gas entry into buildings and structures (Section 2.3), naturally occurring radon may serve as a tracer to help identify those buildings that are more susceptible to soil gas entry than others. Buildings with radon concentrations greater than levels in ambient air are likely susceptible to soil gas intrusion and would likely be susceptible to intrusion of any chemical vapors in the subsurface. On the other hand, the radon concentration in a building is not generally expected to be a good quantitative indicator of indoor air exposure concentrations of vapor-forming chemicals arising from sub-surface contamination. Hence, radon measurement is not generally recommended as a proxy for directly measuring vapor-forming chemicals in indoor air. Among other factors, the distribution of radon-emanating rock and soil and the spatial and temporal variability of their source strength are generally expected to be very different (e.g., tending to be broader and more uniform) than the distribution and source strength variability for subsurface sources of chemical vapors. *(Footnote 124, page 101)*

It also suggests *(102)* that radon mitigation systems (already operating within buildings of concern) be turned off when sampling for chemical vapor intrusion.

Indoor Sampling with HVAC Off

The *Guide* also recommends the increasingly common practice of sampling non-residential buildings when the heating, ventilation, and air-conditioning (HVAC) systems are not operating

> Reasonably expected future risks posed by subsurface contamination warrant consideration, in addition to risks posed under current conditions, "in order to demonstrate that a site does not present an unacceptable risk to human health and the environment" (EPA 1991a). For example, current building use and HVAC systems might not be sustained perpetually. Therefore, when the subsurface vapor source(s) underneath or near a building with an over-pressurizing HVAC system has (have) significant potential to pose a vapor intrusion threat, it may be useful to assess susceptibility to soil gas entry and diagnose vapor intrusion (also see Sections 6.3.4 and 6.4.1) in such buildings under conditions when the HVAC system is not operating. (In addition, indoor air testing could be conducted during periods when the HVAC system operates with diminished flows, such as weekends or evenings.) *(102)*

On the other hand, the *Guide* states, "single-family detached homes can generally be presumed susceptible to soil gas entry when heating or cooling systems are operating." *(142)*

Multiple Indoor Samples

The likelihood of temporal variability in indoor air concentrations emanating from the subsurface suggests the need to collect multiple samples over time. EPA highlights this more than once:

> A goal of collecting multiple samples is to observe and characterize a reasonable maximum vapor intrusion condition for the respective building. Because weather conditions and building operations can lead to time-variable contributions from vapor intrusion (e.g., driving forces for vapor intrusion; see Section 2.3) and ambient air infiltration (see Sections 2.4), indoor air concentrations of vapor-forming chemicals can be expected to vary over time. An individual sample, collected at a randomly chosen time, may under-estimate or over-estimate average and reasonable maximum exposure conditions (see Section 6.4.1) to different degrees, depending upon the season of sample collection and other factors. *(Footnote 138, page 106)*.

Generic Background

For too long, some investigators have used generic values for outdoor and indoor air contamination to rule out vapor intrusion. EPA rejects that approach:

> [C]urrent levels of vapor-forming chemicals in ambient air and in indoor air due to indoor and ambient air sources are likely to be lower than those observed historically, due to regulations and business practices fostering less use of toxic chemicals in consumer products and industrial processes and reduced emissions from mobile and stationary sources. As a result of this expectation, EPA does not recommend the use of generic values of historical background concentrations, even those cited in peer-reviewed publications or available from databases maintained by regulatory agencies, to characterize current levels in any building, for purposes of supporting conclusions that indoor air concentrations are due to 'background' sources. *(107)*

Overpressurization

Tom McHugh of GSI Environmental and the Air Force team at Hill Air Force Base (UT), among others, have shown how building pressurization can be used to distinguish vapor intrusion from indoor sources, thus making indoor air sampling (as opposed to soil gas sampling) a strong line of evidence. EPA recognizes this but still considers it a novel approach suitable in special situations. This may be simply because the approach is new and still not widely used.

> McHugh et al. (2012) have demonstrated the principle that building over-pressurization can be employed temporarily to minimize vapor intrusion and facilitate measuring indoor air concentrations under conditions where only indoor sources may be contributing. At this time, however, there are no standard practices for using over-pressurization to assess 'background' contributions, which is a research and development need. *(107)*

Sorbent Samplers

EPA devotes a subsection *(113 ff)* to the use of passive sorbent samplers. EPA Region 9 has pioneered their widespread use in homes in my community (Mountain View, CA), and its research comparing passive samplers to the more conventional Summa® Canisters is cited.

Real-Time Sampling

The *Guide* mentions in three places the use of near-real-time and real-time instrumentation to measure contaminant concentrations in air. The focus is on locating indoor sources. In fact, these devices can also be used to determine pathways, and as less expensive, smaller instruments become available they should be available for routine use in continuous, remote monitoring. EPA could have emphasized the value of such instrumentation to help encourage their move from the laboratory to the field.

> Vapor-detecting field instruments and in-field gas chromatographs can be used to locate indoor sources of vapors. For example, Gorder and Dettenmaier (2011) reported on the use of a field-portable gas chromatograph and mass spectrometer to identify specific sources of vapor-forming chemicals. EPA's Environmental Response Team has employed the Trace Atmospheric Gas Analyzer (TAGA) mobile laboratory for similar purposes. *(Footnote 156 on page 116)*

Measuring Pressure Differences

EPA's recommendation that investigators measure pressure differentials, whenever either indoor air or sub-slab soil gas are sampled, strikes me as a practice that is not yet standard, but it clearly adds value:

> EPA recommends that the pressure difference between the indoors and the subsurface be measured whenever **indoor air** samples are collected. Ideally, differential pressure data would be collected continuously starting several days before sampling and throughout the sample collection period. *(118)*

> EPA recommends that the pressure difference between the indoors and the subsurface be measured whenever **sub-slab soil gas** samples are collected. Ideally, differential pressure data would be collected continuously starting several days before sampling and throughout the sample collection period. *(124) (Emphasis Added)*

Basement Walls

Most of what is written about vapor intrusion focuses on slab-on-grade construction, but EPA notes that basements sometimes require additional sampling:

> Consider whether to augment sub-slab samples with samples through the basement walls, as the primary entry points for vapors in basements might be through the sidewalls rather than from below the floor slab. *(123)*

Attenuation Factors

In Table 6-1 *(132)* the *Guide* presents generic, or default attenuation factors for five media, and the preceding text explains how those factors were derivcd. (More detail is found in Appendix A, beginning *page 237*.) The vapor intrusion attenuation factor "is defined as the ratio of the indoor air concentration arising from vapor intrusion to the soil gas concentration at the source or a depth of interest in the vapor migration route." These factors, which are used to

predict indoor air concentrations from soil gas, crawlspace air, and groundwater, are deliberately conservative. That is, most of the time indoor air concentrations turn out to be below the predicted levels, but those predictions are useful to ensure that exceedances of health-based levels are not missed. Here are the generic attenuation factors for the three most commonly measured media. Some state guidances use much lower factors—that is, they predict much lower concentrations of intruding contaminants. The factor of 1.0 for crawl space air says that contaminants in a crawl space may be found in the overlying room at the same concentration.

Sub-slab soil gas, generic value	0.03
"Near-source" exterior soil gas, generic value except for sources in the vadose zone (less than five feet below foundation) or presence of routes for preferential vapor migration in vadose zone soils	0.03
Crawl space air, generic value	1.0

Ruling Out

One of my greatest concerns, in the more than a dozen years I have been following vapor intrusion responses in my own community and across the country, has been the tendency to rule out vapor intrusion risks based upon insufficient investigation. This statement, from the *Guide*, is therefore re-assuring:

> Owing to the temporal variability in building-specific data and the potential temporal and spatial variability in soil gas vapor concentrations, EPA generally recommends multiple samples be collected (see Section 6.4) and compared to the respective medium-specific screening level. In addition, the results of risk-based screening are generally most useful when they can be evaluated for indoor air and subsurface vapor sources concurrently and in the context of the CSM. EPA, therefore, generally recommends that multiple lines of evidence be developed and their results weighed together when evaluating and making risk-informed decisions pertaining to vapor intrusion. *EPA generally recommends that concordance among the multiple lines of evidence be obtained, particularly when considering a determination that the vapor intrusion pathway is incomplete or does not pose an unacceptable human health risk. (Emphasis added. 134)*

Mathematical Modeling

The *Guide* devotes more than three pages (beginning *135*) to the appropriate use of mathematical modeling as a line of evidence in vapor intrusion investigations, typically to predict indoor air concentrations. Models should be explicit and justified. Modeling may be suitable when calibrated to measured vapor concentrations, run through uncertainty analysis, or subject to bounding-case analysis. In addition, "Mathematical modeling of vapor intrusion is … not generally recommended for sites and buildings where unattenuated or enhanced transport of vapors toward and into a building is reasonably expected." *(138)*

Non-Concordance

When it is difficult to draw conclusions from available evidence, EPA suggest re-considering the Conceptual Site Model:

> In general, when lines of evidence are not concordant and the weight of evidence does not support a confident decision, EPA recommends re-evaluating the CSM, which may warrant adjusting the CSM to better represent the weight of the available evidence. *(142)*

"Potentially Complete"

The *Guide* recognizes that there are situations in which the vapor intrusion pathway is not currently complete, but may be completed in the future:

> As noted previously (e.g., Section 3.2), EPA recommends that risk management decisions also consider whether the vapor intrusion pathway is 'potentially complete' under reasonably expected future conditions. The vapor intrusion pathway is referred to as 'potentially complete' for a building when:
> • a subsurface source of vapor-forming chemicals is present underneath or near an existing building or a building that is reasonably expected to be constructed in the future;
> • vapors can form from this source(s) and have a route along which to migrate (be transported) toward the building; and i.e.,
> • three additional conditions are reasonably expected to all be met in the future, which may not all be met currently;
> * the building is susceptible to soil gas entry, which means openings exist for the vapors to enter the building and driving forces exist to draw the vapors from the subsurface through the openings into the building;
> * one or more vapor-forming chemicals comprising the subsurface vapor source(s) is (or will be) present in the indoor environment (see Sections 6.3.4 and 6.4.1); and
> * the building is or will be occupied by one or more individuals when the vapor-forming chemical(s) is (or are) present indoors. *(144)*

Short-Term Exposure

One of industry's sharpest criticisms of EPA's approach to vapor intrusion is the agency's recognition of the short-term non-cancer risk of trichloroethylene (TCE) exposure to the fetuses of women in their first trimester of pregnancy, based on EPA's September 2011 IRIS (Integrated Risk Information System) Toxicity Assessment. The *Guide* does not address the toxicity of specific chemicals. Instead, it makes a general statement about short-term exposure:

> EPA recommends the noncancer assessment consider the potential for adverse health effects from short-duration inhalation exposures (i.e., acute, short-term, or subchronic exposure durations), as well as longer term inhalation exposure (i.e., chronic exposure) conditions. *(147)*

Where short-term exposure thresholds are exceeded, EPA recommends prompt action, as well as longer term mitigation:

> When indoor air concentrations in an occupied space exceed health-protective concentration levels for short-term or acute inhalation exposures arising from a complete vapor intrusion pathway, ventilation, indoor air treatment, temporary relocation, and other response actions may be implemented to reduce or avoid these threats promptly (see Section 8.2.1). Construction and operation of engineered systems that can reduce or eliminate vapor intrusion into existing buildings (see Section 8.2) may also warrant consideration after urgent threats to human health have been addressed. *(152-153)*

Risk Range

Much to the pleasure of industry, and to my consternation, EPA's April 2013 External Review Draft of the *Guide* left out key language expressing its preference for more protective criteria for the cleanup of cancer-causing substances. That language *is* included in the final *Guide*. I emphasize it below with italics:

> EPA generally uses a cancer risk range of 10^{-6} to 10^{-4} as a "target range" within which to manage human health risk as part of site cleanup. For judging whether indoor air exposures may pose acceptable health risk based upon potential non-cancer effects, EPA generally recommends that the target HQ [Hazard Quotient] or HI [Hazard Index] not exceed 1.
>
> Once a decision has been made to undertake a response action, *EPA has expressed a preference for cleanups that are at the more protective end of the cancer risk range.* Thus, EPA recommends using an individual lifetime cancer risk of 10^{-6} as a point of departure for establishing cleanup levels based upon potential cancer effects (see Section 7.6). *(Emphasis added. 149)*

The *Guide* continues later:

> Calculating candidate cleanup levels based upon potential cancer effects entails selecting a target cancer risk. As noted above (Section 7.4.1), once a decision has been made to undertake a response action, EPA has expressed a preference for cleanups achieving the lower end of the cancer risk range (i.e., 10^{-6}) (EPA 1991a). Response actions achieving reductions in human health risk anywhere within the cancer risk range may be deemed acceptable by the EPA risk manager, however. *(153)*

OSHA

Industry and federal polluting agencies asked the EPA to defer to oversight by the Occupational Safety and Health Administration for certain workplace exposures to vapors migrating from the subsurface, but EPA concluded otherwise, with agreement from OSHA, and noted:

> PELs [Permissible Exposure Limits] (and TLVs [Threshold Limit Values]), however, are not intended to protect sensitive workers, may not incorporate the most recent toxicological data, and may differ from EPA derivations of toxicity values with respect to weight-of-evidence considerations and use of uncertainty factors. For these and other reasons, EPA does not recommend using OSHA's PELs (or TLVs) for purposes of assessing human health risk posed to workers (EPA 1991c, Appendix C) by the vapor intrusion pathway or supporting final "no-further-action" determinations for vapor intrusion arising in nonresidential buildings. *(150-151)*

In a footnote *(204, page 151),* EPA adds, "OSHA's website (May 2015) currently states: 'OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health.'"

Preemptive Mitigation

One of the biggest steps forward in the new *Guide* is the option of Preemptive Mitigation (PEM) or Early Action. Instead of continuing sampling for multiple rounds, decision-makers may elect to install mitigation systems. This can be quicker, more protective, and even less expensive than the sampling option, but the site team has a great deal of discretion in considering it. At redevelopment sites, such as brownfields, early action may help accelerate construction while providing developers with the certainty they need about the environmental aspects of their projects.

An entire section (7.8) is devoted to determining the suitability of Early Action. Earlier in the *Guide*, EPA explains:

> There may be situations where a party may wish to implement mitigation or control measures for vapor intrusion, even though only limited lines of evidence or measurements may be available to characterize the overall vapor intrusion pathway. For example, a party may be aware that vapor intrusion has been documented at neighboring structures, where measures are being implemented to mitigate the vapor intrusion pathway. A party may conclude there is a reasonable basis to take action, but each building presents a fact-specific situation that calls for its own individual judgment. Likewise, it may be appropriate and cost-effective to design, install, operate, and monitor engineered exposure controls for individual buildings to mitigate vapor intrusion in newly constructed buildings, or in buildings to be constructed in the future, that are located in areas of vapor-forming subsurface contamination, rather than potentially allow vapor intrusion to occur later and assess vapor intrusion after the fact. The term "preemptive mitigation/early action" is used in this Technical Guide to describe these situations. *(65)*

This applies to new construction as well as existing buildings:

> It may be appropriate to implement mitigation of the vapor intrusion pathway as an early action, even though all pertinent lines of evidence have not yet been completely developed to characterize the vapor intrusion pathway for the subject building(s)… *(156)*
>
> [I]t may be appropriate and cost-effective to design, install, operate, and monitor mitigation systems (including passive barrier systems) in newly constructed buildings (or buildings planned for future construction) that are located in areas of vapor-forming subsurface contamination, rather than allow vapor intrusion (if any) to occur and address vapor intrusion after the fact. *(157)*

Furthermore, "EPA generally recommends that decision-making about PEM include a consideration of the O&M [Operation and Maintenance] and monitoring obligations." *(157)*

Other Approaches for New Construction

While the installation and operation of active or passive depressurization systems is often the most suitable approach when building and potential or confirmed vapor intrusion sites, EPA points out that new construction opens up opportunities for other approaches:

> • At some sites, contaminated areas most likely to produce unacceptable vapor intrusion exposures can be avoided and designated for another purpose, such as recreational space or undeveloped landscape.
>
> • Mitigation needs can also be considered in the selection of heating and cooling systems, which are normally selected based only on economics, aesthetics, preference, and custom. A system design that avoids creating under-pressurization inside the structure and maintains over-pressurization inside the structure may be effective in mitigating vapor intrusion.
>
> • Passive barriers, such as a low-permeability membrane, can be more readily installed between the soil and the building during new building construction. Passive barriers are intended to reduce vapor intrusion by limiting openings for soil gas entry. However, passive barriers as stand-alone technologies may not adequately reduce vapor intrusion owing to difficulties in their installation and the potential for perforations of the barrier during or after installation. They are commonly combined with ADT systems or with sub-membrane ventilation systems to help improve their efficiency.
>
> • Venting layers can be more readily installed between the soil and the building during new building construction.
>
> • New buildings may be designed to include a highly ventilated, low-occupancy area at ground level, such as an open parking garage. *(172)*

Community Preferences on Preemptive Mitigation

The *Guide* offers numerous reasons for selecting preemptive mitigation, but it cautions that it is not always appropriate. Communities that want preemptive mitigation should note EPA's observation, "EPA's experience with residential communities suggests that many affected residents seek and prefer that mitigation systems be installed when vapor intrusion is suspected." *(158)*

But EPA also realizes that not all communities are alike

> Some owners and occupants may view PEM as a precautionary measure and be willing to have mitigation systems installed; some may even request them before characterization is completed. On the other hand, some home owners may not agree to have a mitigation system installed unless the pathway is demonstrated to be complete.
>
> Others may be reluctant to install mitigation systems because of the operation costs or the inconvenience associated with the installation and subsequent monitoring. Although some owners may view mitigation systems as an advantage when they sell a property, others may be concerned with the possible negative effect on property values. *(164)*

Passive Barriers

EPA, like many states, considers passive vapor barriers useful but non necessarily sufficient to prevent vapor intrusion:

> Passive barriers are intended to reduce vapor intrusion by limiting openings for soil gas entry. However, passive barriers as stand-alone technologies may not adequately reduce vapor intrusion owing to difficulties in their installation and the potential for perforations of the barrier during or after installation. They are commonly combined with ADT systems or with sub-membrane ventilation systems to help improve their efficiency. *(172)*

Venting Layers

The *Guide* acknowledges the value of venting layers for the successful operation of active depressurization systems, noting that is easier to install porous media during new construction. EPA appears to also endorse the use of constructed voids such as the Cupolex® system:

> Constructed sub-slab ventilation systems typically consist of: a venting layer (e.g., filled with porous media such as sand or pea gravel; or suitably fabricated with continuous voids) below a floor slab to allow soil gas to move laterally to a collection piping system for discharge to the atmosphere; and a sub-slab liner that is installed on top of the venting layer to reduce entry points for vapor intrusion. These and other sub-slab ventilation systems function by drawing outside air into and through the sub-slab area, which dilutes and reduces concentrations of vapor-forming chemicals, and provides a route for soil gas to vent to the atmosphere or migrate outside the building footprint, rather than into a building. *(Footnote 224, page 172).*

Change of Owner/Occupant

In the Section, "Operation and Maintenance of Vapor Intrusion Mitigation Systems," the *Guide* recommends that the site team track changes in ownership or occupancy. While this seems like a no-brainer, in my experience this is done infrequently.

> EPA also recommends that the site team determine if there has been any change in ownership/occupant. If such a change has occurred, EPA recommends the site manager work with the new owner/occupant to ensure continued integrity and operation of the vapor intrusion mitigation system. *(174)*

Monitoring Passive Systems

The *Guide* notes situations in which the more intensive monitoring of mitigation systems may be necessary, including: "Passive systems are generally less predictable and less efficient at preventing vapor intrusion than active systems and, therefore, typically warrant more intensive monitoring, all else being equal."*(175)*

Long-Term Air Sampling

While the *Guide* describes various forms of mitigation system monitoring, it recognizes that indoor air sampling provides the most direct measure of exposure levels:

> Once an adequate demonstration of vapor intrusion mitigation system effectiveness has been made, indoor air quality generally will be acceptable as long as an adequate pressure difference is maintained throughout the footprint of the building. Periodic or intermittent sampling of indoor air, nevertheless, warrants consideration, since indoor air data can provide direct confirmation that the system is reducing exposure levels of vapor-forming chemicals and because depressurization technologies can be expected to alter the distribution of vapors in the vadose zone and available for soil gas entry, if any. *(176)*

Communications

The *Guide* recognizes that building occupants play a key role in ensuring the proper operation of their mitigation systems. It suggests that each affected property owner and occupant be given a User's Guide that includes an explanation of why the mitigation was installed and how it works. *(179)* It also states.

> Communication with building owners and occupants about vapor intrusion and the O&M of a vapor intrusion mitigation system is critically important. For example, building owners may be concerned about some aspect of system operation and decide to turn it off. It is important to communicate that turning off the system may result in harmful indoor air concentrations inside the building. *(178)*

Using placards to inform them also seems to be a no-brainer, but I doubt that the practice is currently widespread:

> EPA also recommends that permanent placards be placed on the system to describe the system's purpose and operational requirements (e.g., power source) and instructions on what to do if the system does not operate as designed (for example, a phone number to call for corrective action). EPA recommends the placard provide information about how to read and interpret the monitoring instruments or warning devices provided. EPA also recommends that these placards be placed as close to the monitoring/alarm part of the system as possible, as well as close to the fan or other active parts of the system. *(177)*

Furthermore, the *Guide* stops short of recommending entryway placards designed to warn non-residential building visitors and occupants—such as students or employees—that the structures are being investigated or mitigated for vapor intrusion.

Contingency Planning

I've read management plans for vapor intrusion response where the Contingency Plan consists entirely of emergency contact information. The *Guide* makes it clear that more is necessary:

> Some site remedial systems may also warrant the use of a regulatory agency-approved contingency plan or similar corrective response document approved by the regulatory agency to identify conditions that may trigger the need for additional maintenance, collection of additional data, modifications of monitoring frequency, or other responses to ensure the remedy remains effective. *(178)*

Working with Cities

Cities can also play a key role, particularly in ensuring that new construction is properly designed to protect against vapor intrusion. The *Guide* devotes a page to a case study describing how my community (Mountain View, California) works with EPA:

> In 2009, EPA published the Proposed Plan for the MEW Study Area that identified EPA's preferred alternatives for the vapor intrusion remedy. The Proposed Plan identified the adoption of a municipal ordinance as EPA's preferred IC, but the City of Mountain View and concerned property owners raised concerns that this was not necessary. Instead, EPA worked with the City of Mountain View, California, to have the City formalize its permitting procedures that apply to future construction. These permitting procedures oblige those proposing new building construction within the MEW Study Area to obtain EPA approval of construction plans to ensure that, where necessary, the appropriate vapor intrusion control system is integrated into building construction. *(186)*

Community Involvement

The *Guide* places a strong emphasis on Community Engagement and Risk Communications, devoting an entire chapter to it as well as including recommendations throughout the document. It explains, "Because of the potentially intrusive nature of assessment and mitigation for vapor intrusion, stakeholder involvement is important throughout the process." *(197)* It "recommends that community outreach activities be initiated as soon as possible after determining that vapor intrusion may exist at a particular site." *(201)*. Those who are unfamiliar with best practices for community involvement should read the entire chapter, but I will highlight some key or new points.

In-person Visits

EPA recognizes the importance of one-on-one communications with people whose homes may be affected by underlying volatile contamination. The *Guide* urges, "Try to schedule in-person visits with individual property owners and renters. These visits also may include owners and renters of properties located outside the planned investigation area." *(203)*

Access to Rental Properties

Conducting investigations within buildings, as well as installing mitigation systems, requires formal permission from property owners. For residential rental properties, gaining access can be complicated. While the *Guide* explains, "EPA generally prefers to obtain access through consent and cooperation." *(26),* it later goes into more detail:

> Site planning teams often deal with both owners and renters when there is a need to sample on, in, or under a rental property. There are different legal and communication issues for owners and renters. For example, the owner is responsible for granting access for sampling and for installation of mitigation measures, if they are necessary; however, if the owner grants access, logistics normally are arranged with the renter. EPA recommends apprising both the owner and the renter of human health risk that may be posed by vapor intrusion, which includes providing building-specific sampling results to both parties when available. If the owner of a rental property refuses access, EPA may, nevertheless, pursue access, in the interest of protecting the occupants, for determining the need for response, choosing a response action, taking a response action, or otherwise enforcing CERCLA or RCRA. Notifying the owner of a rental property of this statutory authority may help to avoid the need for legal action. *(205)*

Property Ownership Changes

Just as the *Guide* recommends tracking ownership change for buildings with mitigation (see above), it also suggests tracking changes of ownership for buildings where access was not initially authorized:

> For owners of homes or buildings who did not provide access for assessment sampling or installation of a mitigation system, EPA recommends that the site planning team make reasonable attempts to track ownership changes, although the appropriate state, tribal, or local agency or PRP may be in a better position to track this information. *(205)*

Communicating Results

EPA not only recognizes that people want to learn sampling results as soon as possible, but that they wish to make personal risk management decisions based upon those results:

> Prompt communication of sampling results to building or home owners is important as some people may choose to make precautionary decisions prior to regulatory decisions on remediation or mitigation measures. *(205)*

Confidentiality

Historically EPA project teams have been careful to keep property-specific data confidential for residential units they have sampled. That is, they provide each resident data on his/her home, but the public only sees results without addresses. The *Guide* seems to recognize that sometimes residents or other building occupants want to share test results:

> EPA recommends the site planning team inquire about stakeholder preferences for confidentiality with regards to property-specific data. It may be appropriate to segregate data for private residential properties versus community properties (e.g., schools, daycare centers, commercial buildings) or provide different types of property identifiers for these respective building types in reports and maps and tables displayed at public meetings or otherwise made available to the community. *(205-6)*

Background Sources

I have seen environmental regulators respond to evidence of background (indoor or outdoor) sources of volatile contaminants by saying, in essence, "That's not my problem." Indeed, managing background sources is beyond the scope of cleanup teams. The *Guide*, at least, provides a path forward:

> With such information, EPA can help advise citizens about the environmental and public health threats they face that are within their control (e.g., from indoor sources). In cases where 'background' contamination may pose a human health risk, but its remediation is beyond the authority of the applicable statute, risk communication to the public may be most effective when coordinated with public health agencies (EPA 2002e). The public may also be advised about the scope and limits of EPA's statutory authorities. *(Footnote 253. Page 206)*

Property Values

While EPA is willing to at least discuss background sources, it remains unwilling to directly assist property owners in determining the real or suspected impact of vapor intrusion responses on property values. I believe that a proper vapor intrusion response restores property values that have fallen because of contamination or even the perception of contamination. In fact, the *Guide* states, "In some instances, mitigation systems and other clean-up measures may help to restore property values." It is my hope that EPA will conduct or sponsor the research necessary to demonstrate that outcome. For now, the *Guide* merely states:

> [P]roperty value issues are outside the scope of Agency authority. In general, if asked, EPA recommends that regional staff suggest that prospective buyers and sellers contact real estate professionals and lenders from the local area with questions about property values. *(209)*

In Summary

EPA's release of the *Technical Guide* is a giant step forward in the effort to protect the public from vapor intrusion. In particular, it should help fill knowledge gaps in states that do not have their own comprehensive vapor intrusion guidance documents. Even in states with strong programs it should help bring practices up to date.

It behooves the people whose homes, schools, businesses, and communities are threatened with vapor intrusion to read the full *Guide*, because it may be up to them to ensure that regulators, developers, and responsible parties do the right thing.