RISK BULLETIN

Vapor Intrusion – An Emerging Environmental Liability

From companies that use volatile organic compounds (VOCs) in their processes to firms that develop land, environmental impacts to soil and groundwater may exist from previous and current operations. Federal environmental regulatory programs (e.g. RCRA and CERCLA), Brownfields programs, and voluntary cleanup programs impose various requirements for investigating and remediating environmental impacts.

An emerging route of VOC exposure is the air pathway which can result in vapor migration from the environment into buildings. Historically, building air quality exposures were focused on industrial hygiene and personnel exposures to compounds used in the workplace. More recently, the focus has shifted to contaminants found in commercial and habitational buildings that have resulted in poor indoor air quality (IAQ). These areas of concern have been further expanded as a result of external environmental exposures that can impact IAQ, namely vapor intrusion (VI).

Awareness of VI as an environmental exposure is increasing. However, previous human health based risk assessments have not always evaluated this pathway. Some closed sites may be subject to regulatory reopeners requiring additional risk assessment and site investigation if land use or contamination exposure levels change. This has the potential to result in additional investigation and legal defense costs for site owners along with property damage and bodily injury claims. Inadequate evaluation of this pathway also presents additional professional and pollution liability for environmental contractors and consultants.

WHAT IS VAPOR INTRUSION?

There are several definitions of vapor intrusion available:

- **US Environmental Protection Agency (USEPA):** The entry of a specific type of contaminant, volatile organic compounds (VOCs), to indoor air from underlying soil and groundwater.
- **Interstate Technology and Regulatory Council (ITRC):** Migration of volatile chemicals from the subsurface into overlying buildings. Volatile chemicals may include VOCs, select semi VOCs (SVOCs), and some inorganic analytes, such as mercury and hydrogen sulfide. Methane should be considered where appropriate.
- **ASTM International (ASTM):** The migration of a contaminant of concern (COC) vapor from a subsurface soil or a groundwater source into the indoor air environment of an existing or planned structure.

While the three definitions vary, a common element in each definition is the exposure pathway of vapors entering a building. ITRC and ASTM acknowledge that there are exposures to compounds other than VOCs.

WHY THE CONCERN?

Vapor intrusion can create bodily injury, property damage, remedial expense, and possibly toxic tort claims against a previous or existing property owner or developer. Exposure to vapors in ambient air is not as critical as in confined space such as a house, basement, or office building. Therefore, sites with existing structures or undergoing redevelopment, construction activities, and other land use changes that will result in permanent structures have the potential to result in increased VI liability. Environmental consultants and contractors also may be subject to increased pollution and professional liability for services provided at these sites.

The inhalation pathway was a missing link in site assessments when the RCRA Subtitle C, Corrective Action Program and the CERCLA (Superfund) Hazard Ranking System were originally established. In the 1980s, radon exposures helped raise awareness of indoor air quality issues and external factors. VI then appeared in July 1989 Superfund assessment requirements and then in pathway evaluations beginning in 1992.

The focus on VI increased with the ASTM Risk Based Corrective Action standard in 1995. Next, USEPA issued draft vapor intrusion guidance in 2002, which remains a good overview document on the issue. USEPA proposed various revisions to this document in 2005. As of June 2008, the draft document is still the primary guidance provided by USEPA. (This draft superseded the 2001 RCRA draft Corrective Action guidance document.

More recently, the ITRC issued a guidance document in 2007 to address the VI issue. This document is a widely referenced and accepted document. Finally, ASTM issued guidance in March 2008 on assessment and sampling considerations, which were based heavily on the ITRC and USEPA guidance documents.

Although there has been an increasing awareness, there remains a lack of cohesive regulatory oversight on this topic. As a result, states have proposed and adopted different VI guidance, assessment, and remedial requirements.

VI EXPOSURE AWARENESS

Historically, the VI pathway was considered an insignificant exposure route. One of the sites that helped create a wider regulatory and public awareness of the VI issue was the Redfield Site in Denver, CO. Contamination assessment activities at the site between 1997 and 1999 eventually included indoor air quality sampling that reveled impacts from a solvent groundwater contamination plume. Previous risk assessments and VI modeling had not accurately predicted this exposure. Since this time, VI has received increasing attention from many stakeholders.

Increased VI exposure awareness may lead to regulatory agency reopeners and pollution liability claims at remediated sites with VOC contamination. There appear to be two drivers for re-evaluating an impacted site: 1) commonly used models for VI pathways were found to be inadequate for predicting IAQ (e.g. Redfield site); and 2) reevaluation certain VOC toxicities and lowering of exposure threshold standards is resulting in more scrutiny at previously closed sites.

One of the sites that helped create a wider regulatory and public awareness of the VI issue was the Redfield Site in Denver, CO.

Pathway evaluation is complex since many variables can affect migration into a building. Thus, additional sampling, modeling and risk assessment work has been required at an increasing number of sites to further evaluate the VI pathway. VOC toxicity is impacted by the dose and duration of exposure, which are often dependent on the pathway. Consider for example that given the same concentration of benzene in air and water that exposure via an inhalation pathway is much more toxic than exposure via a drinking water (ingestion) pathway. This increased dosage and toxicity makes VI a concern that should be addressed.

Today, VI assessment should be considered at all sites with VOC contamination. An important question to ask in assessing VI exposures – is the pathway from soil vapor to inhalation complete? If not, then an exposure cannot occur. For the VI pathway to be complete, all of these factors must be present:

- Source of toxic chemicals;
- Release mechanism (volatilization);
- Migration to the receptor (diffusion and advection)
- Receptors (i.e., humans);
- Contact with the receptor

WHEN CAN VI BE AN ISSUE?

VI may be an issue if various compounds are located at any given site in soil or groundwater: VOCs, some SVOCs, and mercury. Drycleaners are common sources of VOCs at commercial properties and vapor degreasers are a common source of VOCs at industrial properties.

Key Questions

- Are VOCs or other COC sources present in soil/groundwater?
- Has the VI pathway been considered and/or assessed?
- What is the risk due to soil vapor concentrations below or adjacent to the building?
- Are indoor concentrations protective of the receptor?
- What are the soil/groundwater concentrations that will be protective of the indoor receptor?

HOW TO INVESTIGATE?

It is important to evaluate vapor movement and transport mechanisms (such as advection and molecular diffusion) in soil that could allow migration through basement foundations and building floors. The following sections briefly present some variabilities that should be considered when designing or reviewing soil vapor investigations.

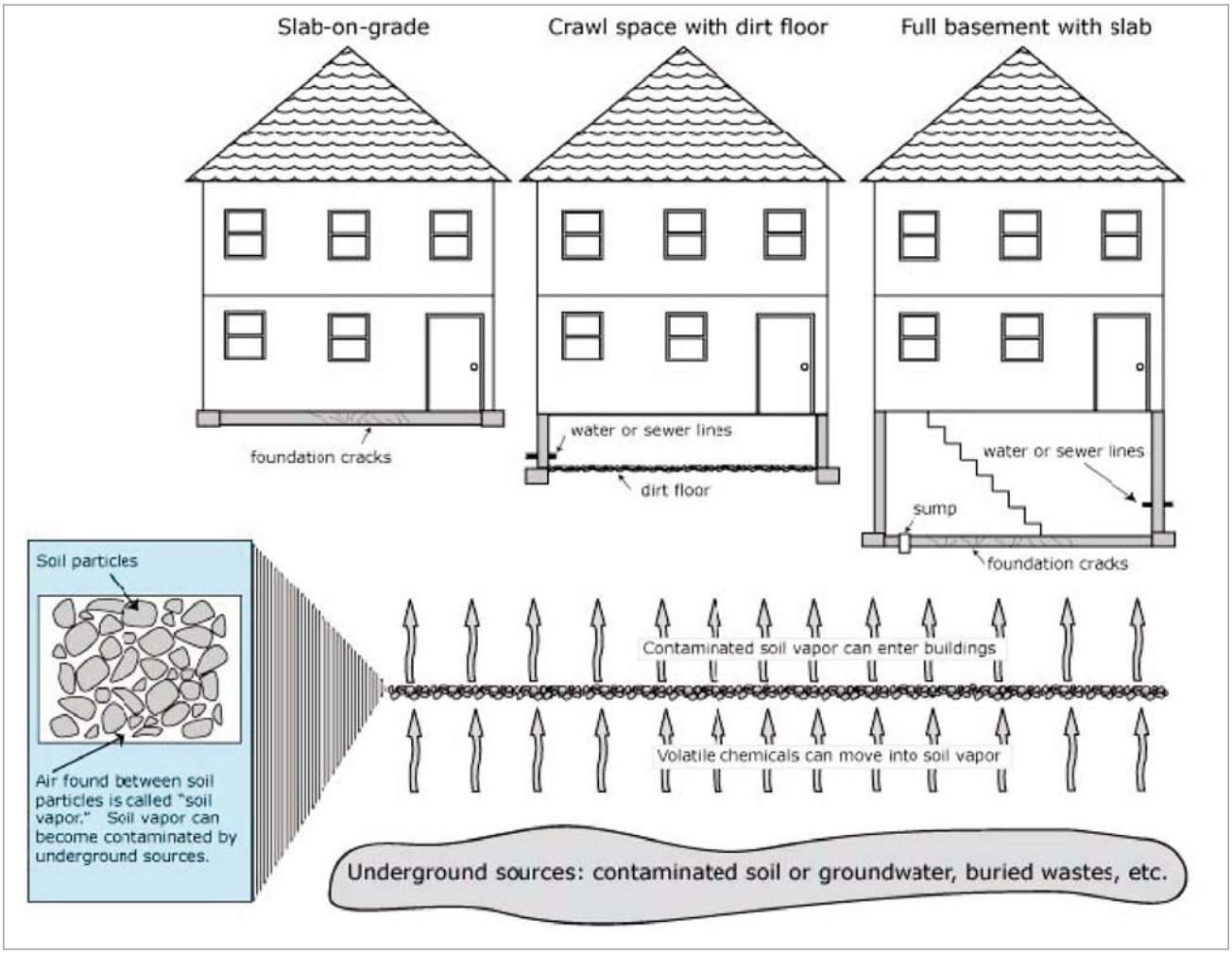
Sampling

- An investigation/field program should be conceptualized prior to collecting and analyzing soil gas samples.
- Various sampling techniques and collection canisters are available. Ensure that appropriate techniques and sample containers are used.
- Sampling should be performed outside of the structure rather than inside to prevent false positives.
- Measuring indoor concentrations should be a last resort as indoor vapor concentrations are affected by other products and VOCs present in the building.

Vapor Movement

Evaluate movement in soils and mechanisms to allow vapor migration through basement/building floors. Some complicating vapor transport mechanisms to be aware of when designing a sampling program should include:

- **Stack effects.** Buildings have unique air flows and characteristics due to the existing heating ventilation and air conditioning systems (HVAC). VI into a building may be subject to vapors being drawn into a building from the existing air exchange system (i.e. negative pressure). This may create a stack or chimney effect that pulls vapors into a building and may increase indoor air VOC concentrations.
- **Seasonal variability.** The time of year can affect vapor readings. For example, Spring can have frequent precipitation events which saturate the soil. The saturated soil absorbs the vapors and may result in a false negative. A sampling event at that time could indicate lower or no soil vapors. The same investigation during summer could detect higher soil vapors illustrating the true concentration. Also, during winter, vapors may preferentially migrate to warmer indoor spaces and create a seasonal stack effect.
- **Vertical and Horizontal variability.** Soil vapors can have horizontal and vertical variability. Investigations should collect vapor samples at



Generalized Diagram of Soil Vapor Intrusion

more than one depth to avoid incorrect data and false conclusions. Similarly, a vapor plume can have a horizontal variability starting at its source and extending outward. Sub-slab sampling, building footprint/perimeter, and other site locations should be considered when developing sampling plans. With a combined vertical and horizontal sampling program, one can obtain a better profile of the extent of vapor contamination.

Models

Vapor concentration models are reportedly the simplest of the fate and transport models commonly used in risk assessment procedures. They are used to justify and link risk based corrective action levels to appropriate indoor air quality levels. They may also be used to propose mitigation measures for exposure concentrations that exceed regulatory action levels. However, modeling results should be approached with caution as they can be controversial based on their assumptions. As such, models should be developed, used, and interpreted by experienced professionals.

Once data are generated, they should be compared to the appropriate regulatory action level(s). With the variety of action thresholds from state to state, it is important to determine what action levels apply to any given situation. Next, one can evaluate what pathway migration and exposure factors might be considered to reduce and/or justify an appropriate risk based corrective action level. Finally, the goal is to use an action level that matches conditions that could exist at any time at the subject site.

Radon has been used as an exposure indicator and may be a useful tool in evaluating if a pathway is complete. As noted earlier, various regulatory standards exist and these may not always consider exposure routes that can be mitigated. Radon assessment models, exposure routes, and mitigation measures have been used to propose greatly reduced VI exposure threshold numbers. If vapor concentrations are identified above regulatory standards, some consultants have scrutinized the pathway of exposure to identify mitigating factors. This approach may be used to justify proposals to regulators for increases in exposure source concentrations based on limitations present in the exposure pathway.

Data Needs Summary

The following topics should be evaluated and considered when assessing VI pathways and exposure potential:

- Chemical sources and location;
- Environmental media characteristics between groundwater, soil and building foundation;
- Building foundation characteristics;
- Building characteristics (including HVAC systems);
- Receptor activities; and
- How sampling results will be used.

EXISTING GUIDANCE AND STANDARDS

The person reviewing the data generated from the field investigation should consider the property's end use (industrial vs. commercial vs. residential). Depending on that end use, different VI standards may apply to the site. Most regulatory standards appear to be very conservative in providing action levels.

Regulators use different methods and levels for assessing exposures, so it is important to know what regulators are asking for and what data you have available before proposing a cleanup standard for agency evaluation.

The ASTM VI standard (E2600-08) provides guidance on sampling schemes and other considerations. This supplements the aforementioned ITRC and USEPA guidance documents, which are widely recognized and cited. ASTM emphasizes the importance of training on implementing the ASTM standard for consultants and other users.

MITIGATION AND REMEDIATION SYSTEMS

Once VI is confirmed to be a problem, vapor mitigation and remediation systems can be considered. Some approaches to mitigation can include:

- **Building pressurization.** Creating a positive pressure in the building (or sub-slab) to prevent vapors from entering the building.
- **Vapor barriers.** Using membranes that block vapors and allow the contamination to flow preferentially away from indoor air space.
- **Passive ventilation systems.** Using differences in air pressure created by the wind to exhaust vapors out into the atmosphere.
- **Active ventilation systems.**Using fans and other mechanical systems to create pressure differences and ventilation that exhaust vapors into the atmosphere.
- **Soil-Vapor Extraction (SVE) remediation systems.** Using in-ground vacuum systems and air treatment to address the source of the contamination and decrease concentrations over time.

SUMMARY

Some key points to remember for this emerging exposure pathway:

- Vapor intrusion is a real exposure. It can be a liability for building owners, redevelopers, contractors, and environmental professionals.
- Regulators are evaluating exposures on new and sometimes closed sites. The VI pathway may need to be considered during future property transactions if it was not adequately evaluated in the past.

– It is important to properly evaluate vapor exposures and use accepted protocols. Otherwise, false positives or false negatives may be generated in sampling results and additional risk assessment may be necessary.

– ASTM, USEPA, and ITRC provide guidance on how to investigate the VI pathway, but refer to individual State standards and methodologies.

REFERENCES

OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), USEPA 11/02, EPA530-D-02-004 www.epa.gov/epawaste/hazard/correctiveaction/eis/vapor.htm

RCRA Draft Supplemental Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway (Vapor Intrusion Guidance), USEPA, 12/01.

Vapor Intrusion Trends Regulatory and Liability Assessment, Trihydro Corp., 11/05.

Redfield Site Update ON Testing And Indoor Air Ventilation For 1,1-Dichloroethene (1,1-DCE), Brown Retail, 3/06.

Redfield Site Environmental Fact Sheet, Brown Retail, 9/06.

Evaluation of Indoor Inhalation Pathway, ASTM Seminar, Presented by RAM Group, 8/29/06.

Technical and Regulatory Guidance Vapor Intrusion Pathway: A Practical Guide, ITRC, 1/07. www.itrcweb.org/Documents/VI-1.pdf

Time Efficient and Cost Effective Vapor intrusion Assessment; A Case History, H&P Mobile Geochemistry, 11/07.

Standard Practice For Assessment of Vapor Intrusion Into Structures On Property Involved In Real Estate Transactions E2600-08, ASTM, 3/08.

Sustainable Property Transactions: New Trends, New Deals, & Redevelopments, & Vapor Intrusion Session In-Focus, RTM Communications, Inc. Conference April 2–4, 2008.

Vapor intrusion: The Latest information For Attorneys and Environmental Managers; Geosyntec, 4/17/08.

New ASTM Standard For Assessment Of Vapors Intrusion: More Harm Than Good?, BNA Environmental Reporter, V. 39, No. 21, 5/23/08.

Direct Push Sampling - USEPA New England Regional Laboratory www.epa.gov/NE/lab/investigations/directpush.html

RRD Operational Memorandum No. 4, Attachment 4 Soil Gas and Indoor Air, Michigan Department of Environmental Quality, Remediation and Redevelopment Division, 6/08.

XL INSURANCE

505 Eagleview Boulevard
Suite 100
PO Box 636
Exton, PA 19341-0636
Phone: +1 800-327-1414
www.xlinsurance.com/environmental

8273_10/2008