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ASTSWMO
Petroleum Vapor Intrusion
Status Report

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Prepared by the LUST Task Force of the ASTSWMO Tanks Subcommittee

Introduction

This Status Report was developed for State and Territorial regulators who oversee the investigation and cleanup of petroleum products that have leaked from underground storage tanks. Specifically, the Status Report summarizes background information on petroleum vapor intrusion (PVI), identifies problems and needs, and describes possible solutions and a future course of action.

Background

In 2002, the EPA released the *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance)* (EPA 2002). The guidance stated that it was not recommended for use at Subtitle I UST sites because of certain conservative assumptions designed to address chlorinated solvents that may not be appropriate at a majority of petroleum release sites (LUST Sites). In addition, the guidance stated that the EPA was forming an EPA/State work group to study petroleum vapor intrusion. The primary purpose of the work group was to determine how to incorporate bioattenuation into petroleum vapor intrusion evaluations to address documented biodegradation of petroleum compounds in the subsurface environment.

In 2003, USEPA OUST formed the USEPA/State Petroleum Vapor Intrusion Work Group. The work group consisted of 45 EPA and State regulatory agency personnel. From 2003–2005, the work group had over 20 conference calls and created a repository of documents on petroleum vapor intrusion, including the bioattenuation of petroleum vapors in the subsurface.

In 2007, the ITRC published a technical and regulatory guidance document titled: "Vapor Intrusion Pathway: A Practical Guide (ITRC 2007). The guide stated that many hydrocarbons (notably petroleum-based hydrocarbons) are readily degraded to carbon dioxide (CO_2) in the presence of oxygen (O_2) by ubiquitous soil microbes. Oxygen is supplied from the atmosphere by vapor diffusion and barometric pumping and as a dissolved solute in infiltrating rainwater. Aerobic degradation is a rapid process and frequently occurs in a relatively thin (a few feet thick) zone where the concentrations of O_2 and hydrocarbons are most ideal for microbial processes. The bioattenuation of hydrocarbons can potentially reduce soil gas concentrations and vapor

intrusion by several orders of magnitude. However, the guide did not present a method to quantify the effects of bioattenuation on petroleum vapor intrusion.

In 2008, the ASTSWMO Information Exchange sent out a request to several states for information on vapor intrusion. 28 state regulatory agencies responded to the survey. A copy of the responses is available from Julius Shapiro (ASTSWMO).

In early 2009, the ASTSWMO LUST Task Force requested assistance from USEPA OUST to prepare a national guidance document on petroleum vapor intrusion for state and federal regulators similar to the OUST Monitored Natural Attenuation (MNA) Guidance prepared in the 1990s.. The purpose of the guidance document would be to provide a rational and practical framework for states to evaluate petroleum vapor intrusion while ensuring that financial resources used to address petroleum vapor intrusion are used effectively and public health is protected.

In response to this request the USEPA OUST reactivated it's efforts by organizing a new Petroleum Vapor Intrusion Workgroup. The first meeting of the workgroup was conducted on September 11, 2009 in Arlington, Virginia and included representatives from ASTSWMO, EPA ORD, API, state regulatory agencies, private consultants, and major oil companies. The goal of this effort is to have an EPA OUST approved petroleum vapor intrusion guidance document for the states to use at LUST sites by the end of 2010.

What Do Regulators Need To Better Evaluate the Petroleum Vapor Intrusion Pathway?

1. ***A better understanding of petroleum vapor biodegradation in vadose zone soils.***

   A database of actual measurements of petroleum compounds in soil gas and groundwater has been compiled and analyzed by Robin Davis (Utah Department of Environmental Quality). Ms. Davis concluded in an article published in LUSTLine #61 (May 2009): "If five feet of clean soil consistently overlie dissolved sources where benzene is less than or equal to 1,000 µg/L and TPH is less than or equal to 10,000 µg/L (in groundwater), a vapor-intrusion investigation is not necessary." (Davis 2009).

   Ms. Davis' article documents, with data, that clean soil with sufficient oxygen is an excellent medium for biodegrading slowly diffusing petroleum vapors.

   Another recent article (Sanders and Hers, 2006) documented apparent biodegradation of benzene vapors under residential homes at a large petroleum release site in New Jersey.

   If scientific consensus can be reached that petroleum vapors are readily biodegraded in clean and well-oxygenated vadose zone soils, then a biodegradation factor could be suggested for inclusion into vapor intrusion models to back-calculate screening levels in groundwater and soil gas.

2. ***Incorporation of biodegradation into vapor intrusion models for calculating screening levels in groundwater and soil gas.***

Dr. George DeVaull (Shell Global Solutions, Westhollow Technology Center, U.S.) has developed a model that incorporates biodegradation of petroleum vapors in the vadose zone (DeVaull 2007). The API has contracted with GSI to develop a user-friendly version of Dr. DeVaull's model called "BioVapor."

At the EPA OUST Petroleum Vapor Intrusion meeting on September 11, 2009, Dr. Jim Weaver (EPA ORD) volunteered to evaluate the BioVapor Model. If Dr. Weaver concludes that the BioVapor Model is sound, the model should be validated using input parameters and real soil gas data from Ms. Davis' database.

The model can then be used to back-calculate screening levels in groundwater. If contamination in groundwater underlying a building is greater than the back-calculated screening levels, then a vapor intrusion assessment should be conducted. A vapor intrusion assessment includes collection of representative sub-slab or subsurface soil gas samples, or in the case of high water table conditions, indoor air samples.

It is recognized that there is uncertainty in modeling complex subsurface processes, therefore, the use of models should not be used in situations where sensitive receptors or public health are likely to be adversely impacted if the modeling is incorrect. It is incumbent upon State Regulators to use professional judgment in allowing the use of models on a site-specific basis. State Regulators must ensure that model input parameters are realistic and conservative. They must run the model themselves to verify that it has been run correctly. Finally (and most importantly), modeling should not be performed under certain circumstances. For example, if free product is present below an occupied building and the vadose zone soils are highly permeable, sub-slab soil gas and/or indoor air samples should be collected instead of modeling.

3. ***A consistent approach to vapor intrusion investigation that includes procedures for properly collecting sub-slab and subsurface soil gas samples. A compilation of information presented in the following, and other documents, is needed.***

Sub-slab soil gas sampling is described in a 2006 EPA ORD publication titled: "Assessment of Vapor Intrusion in Homes Near the Raymark Superfund Site Using Basement and Sub-Slab Air Samples" (DiGiulio 2006).

Subsurface soil gas sampling is described in a 2007 EPA ORD publication titled: "Development of Active Soil Gas Sampling Method" (Schumacher 2007).

Currently, the ASTM is working on a standard that describes active soil gas sampling techniques that are directly applicable to vapor intrusion evaluations (Everett 2009).

4. ***A realistic slab attenuation factor.***

In 2002, the EPA OSWER recommended the use of a 0.1 slab attenuation factor (EPA 2002).

In 2004/2005, the California EPA/DTSC recommended the use of a 0.01 slab attenuation factor (CalEPA 2004/2005).

In 2007, the ITRC stated that attenuation factors for sub-slab soil gas are typically based on empirical data and generally range from 0.01–0.1 for residential buildings (ITRC 2007).

In 2008, a paper was published in Environmental Science & Technology titled: "Oxygen Transport From the Atmosphere to Soil Gas Beneath a Slab-on-Grade Foundation Overlying Petroleum-Impacted Soil." (Lundegard 2008). The paper describes a field experiment conducted on a residential house which indicates that atmospheric oxygen was rapidly replenished in the sub-slab soils facilitating aerobic biodegradation of methane emanating from petroleum contaminated soils located about 5 feet below the bottom of the house. Note that the bottom of the house slab and the petroleum contaminated soil was separated by 5 feet of clean fill soil (see conclusions from Ms. Davis' database analysis in No. 1 above).

The Oregon DEQ (Oregon DEQ 2009) has evaluated the EPA's database and have recommended the use of a 0.005 slab attenuation factor for residential buildings and 0.001 for commercial buildings.)

In order to estimate the contaminant concentrations in indoor air from sub-slab soil gas samples, a slab attenuation factor must be applied. If sub-slab soil gas concentrations multiplied by a slab attenuation factor exceed a risk-based air concentration (for example, 0.3 µg/m3 benzene in a residential exposure scenario and 0.5 µg/m3 benzene in a commercial exposure scenario), then indoor air samples should be collected.

5. ***Background concentrations of petroleum compounds.***

Low concentrations of some petroleum compounds, including benzene, can be present in indoor and outdoor ambient air. Indoor sources of petroleum compounds in indoor air should be evaluated.

According to the EPA's Draft "Vapor Intrusion Database: Preliminary Evaluation of Attenuation Factors" (EPA 2008), background residential indoor air concentrations of benzene measured in North American residences can range from 1.5–16 µg/m3.

6. ***Vapor intrusion mitigation methods and verification procedures.***

If it is determined that vapor intrusion into indoor air from subsurface contamination is occurring, vapor mitigation measures should be taken. Indoor air sampling should be performed to ensure that the vapor mitigation measures are effective.

The EPA has published a comprehensive document on indoor air vapor intrusion mitigation (EPA 2008a).

Future Course of Action

Continue with conference calls and meetings of the EPA OUST/State Petroleum Vapor Intrusion Work Group with the goal of publishing an EPA OUST/State Petroleum Vapor Intrusion Guidance Document for LUST sites by the end of 2010. The final guidance document should include proposed and accepted ranges of attenuation factors; the application and use of models, including acceptable ranges and applications; mitigation approaches and verification methods; sampling procedures and methodology; as well as the use of bioattenuation factors in assessing vapor intrusion conditions.

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