Risk navigator

CalEPA DTSC Work Group – vapor intrusion

Supplemental guidance: screening and evaluating vapor intrusion (VI)

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Environmental

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At least thirty seven (37) out of fifty (50) states provide some guidance and/or supplemental guidance documents regarding the evaluation of vapor intrusion (VI)/vapor migration into buildings. In the state of California in 2020, under the guidance of CalEPA, a supplemental guidance document was prepared to augment and assist with the screening and evaluating of vapor intrusion (VI) in California.

The California Environmental Protection Agency (CalEPA) Department of Toxic Substances Control (DTSC), the San Francisco Bay Regional Water Quality Control Board (SF Bay Regional Water Board), and California Water Resources Control Board as a work group under the guidance of CalEPA released: "Supplemental Guidance: Screening and Evaluating Vapor Intrusion, Draft for Public Comment, February 2020" in 2020. The complete public draft can be viewed at (https://dtsc.ca.gov/wp-content/uploads/sites/31/2020/02/Public-Draft-Supplemental-VI-Guidance_2020-02-14.pdf).

The CalEPA Work Group developed the subject supplemental guidance to promote additional state-wide standard practice and consistency for screening buildings for vapor intrusion (VI) and to establish appropriate sampling to protect building occupants from vapors off-gassing from contaminated sources. The work group, consisting of members from the agencies previously listed, worked under the guidance of the CalEPA to prepare the subject supplemental document as a **supplement to existing information**, and not as a standalone document. The urgency to protect building occupants from the short-term exposure effects of trichloroethylene (TCE), even at relatively low concentrations, was part of the impetus that led to the formation of the CalEPA Work Group.

The California supplemental guidance addresses assessment of VI risk from vapor forming chemicals (VFCs) **but does not constitute complete guidance for the overall evaluation and management of VI.** Practitioners and jurisdictions in California are cautioned to use the supplemental guidance **in conjunction with** existing California guidance (DTSC Vapor Intrusion Guidance [2011a], the DTSC Vapor Intrusion Mitigation Advisory [2011b], and the SF Bay Regional Water Board Interim Framework [2014]). Where there is conflict with the above-mentioned guidance documents, the supplemental guidance is recommended. Additionally, it should be noted that USEPA continues to use the framework set forth in its 2015 "Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air" (USEPA, 2015a) at any site subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) where vapor intrusion may be of potential concern. (CalEPA DTSC Work Group, 2020)

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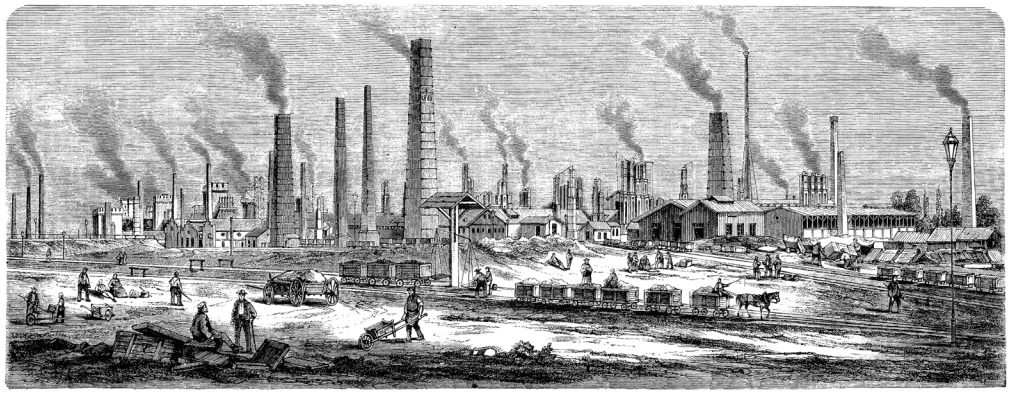
Scope

The recommendations in the California Supplemental Guidance are focused on the protection of current occupants of buildings from potential exposure to VFCs that can contaminate indoor air through the VI pathway. The same logic and approach can be extended to the evaluation and management of future VI risk for sites with existing buildings or open lots planned for redevelopment.

Vapor intrusion (VI) background

According to the United States Environmental Protection Agency (US EPA), vapor intrusion (VI), or vapor encroachment, occurs when there is a migration of vapor-forming chemicals from the subsurface into an overlying structure. Though not new, current interest in vapor risk was first spotlighted in the 1980s with concerns over naturally-occurring radon intrusion and cancer. Currently, the interest in risk for vapor intrusion also now extends to anthropogenic chemicals (those caused or produced by humans) (e.g. chlorinated solvents and petroleum hydrocarbons, synthetic organic materials and heavy metals.) Anthropogenic pollution is not new either—humans have contributed to the environmental burden since they learned to control fire and smelt metals. However, the nature and distribution of contaminants in the environment has changed in recent history as new compounds have been created.

Most early anthropogenic pollution was relatively localized although early metal smelting, even 2,000 years ago, resulted in hemispheric-scale pollution (Hong et al. 1996). The industrial revolution concentrated people in cities and resulted in increased pollution of the air, as a result of the burning of fossil fuels, and pollution of rivers, with organic pollutants in the form of sewage, including tanning chemicals, etc. which in turn caused disease and illness in humans and killed fish and other wildlife in the rivers (Halliday 1999; Davis et al. 2002).



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Vapor intrusion (VI) or vapor encroachment is an important consideration particularly in assessing the risk that indoor air is contaminated at existing buildings or when assessing if VI could pose a threat when a new construction project is undertaken. (See RSS Technical Guide, entitled, "Vapor Intrusion" for further details.

Subsequent to radon awareness by the general public, there was an increasing awareness that anthropogenic chemicals principally petroleum hydrocarbons and chlorinated solvents in soil, groundwater, and sewers and drain lines could also pose threats to indoor air quality via the vapor intrusion pathway. Society particularly in developed countries became sensitized to the fact that vapor-forming chemicals were a problem. This awareness included exposures to:

- Volatile organic compounds (VOCs), such as trichloroethylene and benzene
- Select semi-volatile organic compounds, such as naphthalene
- Elemental mercury
- Some polychlorinated biphenyls and pesticides, insecticides, and rodenticides

Just to name a few, and, that in extreme cases, the vapors could accumulate in dwellings or occupied buildings to levels that could pose:

- Near-term safety hazards (e.g., explosion)
- Or, acute health effects

In buildings with lower concentrations of vapor-forming chemicals arising from VI, the main concern is whether the chemicals may pose an unacceptable risk of health effects (usually cancer) due to long-term (i.e., chronic) exposure to these lower levels.

Vapor intrusion (vi) migration pathway

A key to the California Work Group supplemental guidance document is migration pathway. The migration pathway into a building is typically through cracks, holes, or utility conduits in a foundation. A concentration of vapor-forming chemicals within a building can cause an acute health effect or safety hazard (explosion) or a potential chronic risk (low concentrations over a longer period of time), which can cause human health risks such as cancer over time.

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The California Environmental Protection Agency Work Group: Screening and evaluating vapor intrusion risk management decision framework for vapor intrusion matrix

To assist with risk management evaluations and decisions, the CalEPA Work Group incorporated the following decision matrix framework for vapor intrusion into their guideline. However, it should be considered that the EPA Office of Solid Waste and Emergency Response (OSWER) Publication 9200.2-154, 2015/2015a further delineates risk management principals and guidelines.

Risk Management Decision Framework for Vapor Intrusion

Current VI Risk and Hazard Estimate primarily using indoor air data	**Future VI Risk and Hazard** Estimate primarily using subslab / soil gas data	**Risk Management Decision**	**Potential Response Actions**
Risk < $1x10^{-6}$ and HI < 1	Risk < $1x10^{-6}$ and HI < 1	Low Priority	• None
Risk from $1x10^{-6}$ to $1x10^{-4}$ and HI ≤ 1	Risk from $1x10^{-6}$ to $1x10^{-4}$ and HI ≤ 1	Determine Appropriate Action	• None • Institutional Controls • Additional Investigation/Sampling • Monitoring • Refine Risk Assessment • Mitigation • Remediation
Risk > $1x10^{-4}$ or HI > 1	Risk > $1x10^{-4}$ or HI > 1	Response Action Needed	• Mitigation • Remediation

(CalEPA DTSC Work Group, 2020)

Federally, according to the EPA, a complete vapor intrusion pathway indicates that there is an opportunity for human exposure, which warrants further analysis to determine whether there is a basis for undertaking a response action(s). Depending upon building- and site-specific circumstances, concentrations of chemical vapors indoors arising from a complete vapor intrusion pathway may threaten the health of building occupants (e.g., residents, workers, etc.), which may warrant a response action(s). On the other hand, if one (or more) of the five specific pathway conditions is currently absent and is reasonably expected to be absent in the future (e.g., vapor migration is significantly and persistently impeded by natural geologic, hydrologic, or biochemical (e.g., biodegradation) processes and conditions), the vapor intrusion pathway is referred to as "incomplete."

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In such a case, EPA recommends that any determination that the vapor intrusion pathway is incomplete be supported by site-specific evidence to demonstrate that the nature and extent of vapor-forming chemical contamination in the subsurface has been well characterized (Section 6.3.1, (OSWER Publication 9200.2-154, 2015/2015a)) and the types of vapor sources and the conditions of the vadose zone (a/k/a unsaturated zone) and surrounding infrastructure do not present opportunities for unattenuated or enhanced transport of vapors (Sections 5.4 and 6.5.2, (OSWER Publication 9200.2-154, 2015/2015a)) toward and into any building (see Section 7.3 for further discussion). When the vapor intrusion pathway is determined to be incomplete, then vapor intrusion mitigation is not generally warranted. (OSWER Publication 9200.2-154, 2015/2015a)

OSWER Publication 9200.2-154, 20152015a

In June 2015, the US EPA provided OSWER Publication 9200.2-154, "OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air." a technical guide meant to be utilized when assessing and mitigating the VI pathway from subsurface vapor sources to indoor air. The June 2015 technical guidance provided steps for evaluating if the human exposure pathway for vapor intrusion is complete. And, among other sections and topics included the following:

- Definition of vapor intrusion (VI)
- Conceptual model of vapor intrusion
- Considerations for nonresidential buildings
- Preliminary analysis of vapor intrusion
- Detailed investigation of vapor intrusion
- Building mitigation and subsurface remediation
- Vapor intrusion mitigation quick guide for existing buildings

The OSWER Technical Guide has become a cornerstone document as regards VI. (OSWER Publication 9200.2-154, 2015/2015a). However, vapor migration in the subsurface, through building foundations, and within buildings is complex and influenced by many natural and human-caused factors.

OSWER and CalEPA Work Group

To assist with vapor migration/vapor intrusion (VI) complexities and to provide some update to principals and industry currently acceptable measures the CalEPA Work Group provided the supplemental guidance document of 2020 to provide a consistent and proactive approach to evaluate buildings that may be at risk from VI and to provide a framework to decide when such risk should be managed. The supplemental guidance document of 2020 also incorporates and updates information from recent technical and regulatory publications that have highlighted the variable nature of vapor behavior and lessons learned in the assessment of VI. (CalEPA DTSC Work Group, 2020)

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This supplemental guidance also provides information and recommendations on the following topics:

- Using United States Environmental Protection Agency (USEPA) 2015 attenuation factors
- Establishing a four-step evaluation process to assess VI
- Considering sewers as a potential VI migration route and pathway of exposure
- Building a California-specific VI database

Vapor intrusion attenuation factors

This supplemental guidance recommends the use of USEPA empirically-derived attenuation factors (AFs) (USEPA, 2015a) for the screening of sites in California. These AFs are protective of public health under most building occupancy scenarios and should be used for the initial screening of sites. Site-specific AFs derived from mathematical models, such as the Johnson and Ettinger model, are not recommended for the initial screening of occupied buildings.

Transport of vapor contamination through sewers

Sampling sewer air may be an important line of evidence (LOE) in diagnosing the source of VFCs in indoor air. Recent scientific literature highlights the importance of sewer lines as a potential preferential pathway for vapor migration. Vapors may enter sewer pipes that intersect contaminated soil or groundwater that may be off-gassing chemicals into the vapor phase. Once inside the sewer pipe, VFCs can be transported beneath or directly into buildings. Soil gas and groundwater sampling alone may not adequately evaluate the potential risk posed by VFCs in sewers. Where VFCs are likely to have impacted sewer air, and the conduit(s) connects to or has the potential to release vapors below a specific building, then an indoor air investigation for that building should proceed.

Four-step process for VI assessments

The California supplemental guidance outlines and describes a four-step process to determine whether buildings located near known or suspected subsurface vapor forming chemicals (VFCs) contamination are potentially affected by VI that may pose a health risk to occupants. Background sources of VFCs include consumer products, chemical usage, building materials, or outdoor (ambient) air (USEPA, 2011). The four-step process is summarized below:

- Prioritize buildings in proximity to source contamination for a VI assessment
- Collect exterior soil gas samples to determine if buildings have potential for VI
- Collect indoor air, sub slab soil gas, and outdoor air samples if buildings have potential VI risks
- Evaluate the need to manage current and future VI risk based on both indoor air concentrations and soil gas concentrations

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California VI database

To better understand how human-caused and natural factors influence VI, data will be compiled into a statewide VI database. To facilitate constructing the database, the State Water Board has added capabilities to the GeoTracker statewide data management system to accept building-specific data and differentiate types of vapor samples. Once GeoTracker has sufficient statewide data, the CalEPA Work Group will evaluate the VI database to determine if California-specific AFs are justified. (CalEPA DTSC Work Group, 2020)

Risk management issues to consider

- At least thirty-seven (37) out of fifty (50) states also have some guidance documents regarding the evaluation of vapor intrusion into buildings.
- There are some differences in the definitions of vapor intrusion; some are broader and some are narrower. The most struct should always be utilized.
- According to CalEPA, vapor intrusion (VI) is the migration of chemical vapors from the subsurface into buildings and is a frequent problem at contaminated sites.
- According to USEPA, vapor intrusion is the general term given to migration of hazardous vapors from any subsurface contaminant source, such as contaminated soil or groundwater or contaminated conduit(s), into an overlying building or unoccupied structure via any opening or conduit.
- The new California supplemental guidance document of 2020 was created and meant to serve as a supplement to existing information, and not as a standalone document.
- It is important to note that the CalEPA Work Group document is a **draft supplemental guidance document** and addresses assessment of vapor intrusion (VI) risk from vapor forming chemicals (VFCs); but, **does not** constitute complete guidance for the overall evaluation and management of VI.
- California environmental practitioners and jurisdictions should use the supplemental guidance document in conjunction with existing California guidance (DTSC Vapor Intrusion Guidance [2011a], the DTSC Vapor Intrusion Mitigation Advisory [2011b], and the SF Bay Regional Water Board Interim Framework [2014]). Where there is conflict with the above-mentioned guidance documents, the 2020 supplemental guidance is recommended.
- Initially, this supplemental guidance recommends the use of the USEPA empirically-derived AFs (USEPA, 2015a) for the screening of buildings. Data collected during site investigations and reported to GeoTracker will be compiled in a California database to support development of California-specific AFs that may be incorporated into a future version of the California supplemental guidance document.

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- A vapor forming chemical (VFC) is a volatile chemical that USEPA recommends be routinely evaluated during a site-specific VI assessment when it is present as a subsurface contaminant (USEPA, 2015a). A volatile chemical is defined as a chemical with a vapor pressure greater than 1 milliliter of mercury, or Henry's law constant greater than 10–5 atmosphere-meter cubed per mole.

VFC site-specific identification steps

- Identifying a potential vapor intrusion site at the subject property or in the vicinity.
- Conducting sub-slab and soil vapor sampling. These results can then be used to calculate the cancer risk and non-cancer hazard quotient for the sub-slab or soil vapor.
- Should detections be found, an indoor and outdoor air sampling event can be conducted. These results can also be used to calculate the cancer risk and non-cancer hazard quotient for the indoor air.
- Two season sampling events are recommended.
- The results are compared to the risk management decision framework for vapor intrusion.
- Potential response actions are provided based on the level of the risk and hazard values.
- Costs to be considered for construction projects that may include a potential vapor intrusion issue could include additional investigation/sampling, continued monitoring and based on new results a new assessment, mitigation, or remediation.

Once it is established that a vapor intrusion pathway is complete, then a vapor assessment can be conducted, which may include both or either of the following:

- A preliminary analysis based on the review of available and readily ascertainable information regarding known/reported releases that have impacted the subsurface with vapor-forming chemicals; and/or
- A detailed investigation which consists of collecting samples for laboratory analysis from the sub-slab soil vapor, soil gas, indoor air, and/or outdoor air.

Should the results of a detailed investigation indicate that vapor-forming chemicals are migrating into a building, response actions can be taken to reduce or mitigate the migration of these chemicals into the building to reduce human exposure. Based on the results of the detail investigation, human health risk assessments can also be conducted to determine if the concentrations detected have the potential to impact human health and/or cause cancer over short and long periods of exposure.

Examples of mitigation include passive (no fan) and active (fan) sub-slab depressurization systems (SSDS) or placement of a vapor barrier prior to the construction of a future building. Examples of remediation systems include soil vapor extraction (SVE) systems to treat contaminated soil and soil vapor, air sparge (AS) systems, or pump and treat systems to treat contaminated groundwater.

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A state EPA example: California vs. New York

It should be remembered that many states have differing rules as regards VI. As an example, the guidance for evaluating soil vapor intrusion in the state of New York, provided by the New York State Department of Health (NYSDOH), October 2006, has its similarities and differences when compared to the California soil vapor intrusion guidance documents.

In some respects, the initial evaluation for the potential for soil vapor intrusion into the building is similar between New York and California. However, when conducting the detailed investigation, concurrent samples are collected from the sub-slab, indoor air, and outdoor air for New York while California breaks the sampling events into a two-step process (sub-slab during one sampling event followed by indoor air if deemed necessary). For California, the sub-slab soil vapor results and/or the indoor air results are compared to the risk management decision framework, which provides risk and hazard estimates for current and future use, risk management decision levels (low, determine appropriate action, or response action needed), and potential response actions (none, use restrictions, monitoring, mitigation, or remediation). For New York, the sub-slab soil vapor and indoor air results for specific solvent-based chemicals are plugged into one of three decision matrices (A, B, C). The results will fall into a range of concentrations which are associated with specific potential response actions (no further action, monitor, or mitigate).

For risk management purposes, the following questions should be asked:

- Is the current use or previous/historical use of the site high risk in regards to the use, storage, or disposal of vapor-forming chemicals (dry cleaners, petroleum retail station, industrial manufacturing, major oil storage facility, chemical bulk storage facility, etc.)?
- Are there high-risk use properties in proximity to the site (dry cleaners, petroleum retail station, industrial manufacturing, major oil storage facility, chemical bulk storage facility, etc.)?
- Are there reported/known vapor-forming chemical release sites or groundwater plumes in proximity to the site?
- Is the vapor intrusion pathway complete for the building at the site?
- Has a Phase I Environmental Site Assessment (ESA) been performed?
- Has the Phase I ESA been conducted to the latest standard, which currently is the American Society for Testing and Materials (ASTM) Standard Practice E 1527-13 and the Environmental Protection Agency Standards and Practices for All Appropriate Inquiries (AAI) (40 CFR Part 312)?
- Does the Phase I ESA provide a section regarding a Tier 1 Vapor Encroachment Screening (VES), as outlined in ASTM E-2600-15, to determine if a potential vapor encroachment condition (VEC) exists at the subject property?

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- If so, does the VES include a review of the reasonably ascertainable information for the subject property and nearby properties contained in the database report as well as professional judgment?
- Based on the results of the Tier 1 VES screening, was a decision made as to whether or not a VEC is evident at the subject property?

Partial references include:

Supplemental Guidance: Screening and Evaluating Vapor Intrusion, Draft for Public Comment, California Department of Toxic Substances Control, California Water Resources Control Boards, February 2020

OSWER Technical Guide For Assessing and Mitigating the Vapor Intrusion Pathway From Subsurface Vapor Sources to Indoor Air, US Environmental Protection Agency, Office of Solid Waste and Emergency Response, June 2015

ASTM E2600 - 15 Standard Guide for Vapor Encroachment Screening on Property Involved in Real Estate Transactions, 2015

Final Guidance For Evaluating Soil Vapor Intrusion in the State of New York, New York State Department of Health, Center For Environmental Health, Bureau of Environmental Exposure and Investigation, October 2006

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