CalEPA California Environmental Protection Agency

Department of Toxic Substances Control

California Water Boards
State Water Resources Control Board
Regional Water Quality Control Boards

Supplemental Guidance:

Screening and Evaluating Vapor Intrusion

Draft for Public Comments

California Department of Toxic Substances Control

California Water Resources Control Boards

February 2020

PUBLIC DRAFT
Supplemental Guidance:
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Disclaimer: This document is guidance and is not intended as regulation or water quality control plan or policy. This Supplemental Guidance describes a consistent approach recommended for evaluating vapor intrusion in California. This Supplemental Guidance is not binding on California Environmental Protection Agencies or staff, or on members of the public. This Supplemental Guidance is not intended to exclude alternative methodologies nor is it intended to provide prescriptive or inflexible requirements. This Supplemental Guidance does not supersede or implement laws or regulations and does not have the force or effect of law.

Petroleum releases from underground storage tanks (USTs) must be evaluated for vapor intrusion using the State Water Resources Control Board's Resolution 2012-0062, Low-Threat Underground Storage Tank (UST) Case Closure Policy (LTCP) adopted November 6, 2012 (State Water Board, 2012b).

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Executive Summary

Introduction

The Department of Toxic Substances Control (DTSC), the San Francisco Bay Regional Water Quality Control Board (SF Bay Regional Water Board), and the State Water Resources Control Board (State Water Board) developed this Supplemental Guidance to promote state-wide standard practice and consistency for screening buildings for vapor intrusion and to establish appropriate sampling to protect building occupants from vapors off-gassing from contaminated sources. Addressing vapor intrusion is critical to protect people from exposures that may pose a risk of adverse health effects. A workgroup, consisting of members from the agencies listed above under the guidance of California Environmental Protection Agency (CalEPA), prepared this document as a supplement to existing information, not a standalone document. The urgency to protect building occupants from the short-term exposure effects of trichloroethylene (TCE) at relatively low concentrations was part of the impetus that led to the formation of the CalEPA Workgroup. The Supplemental Guidance recommends a consistent approach to be used by practitioners and regulators when screening buildings for subsurface vapor risk to building occupants. It does not provide guidance on the sampling required for all media (soil, vapor, and groundwater) to determine the nature and extent of contamination in development of a conceptual site model. This Supplemental Guidance describes a framework for deciding when cleanup and/or mitigation is needed.

This Supplemental Guidance is published as a draft document available for public comment. The CalEPA workgroup will review and consider the public comments for incorporation into a future, finalized version of this Supplemental Guidance. Additionally, the CalEPA workgroup will evaluate the vapor and building data submitted through the State Water Board's GeoTracker Electronic Submittal of Information (ESI) process and other available data to assess and develop California-specific vapor intrusion evaluation criteria. At the completion of the analysis, the California-specific information will be shared with the public.

The following websites provide general information on vapor intrusion and how to provide comments on this Draft Supplemental Guidance:

> State Water Board:
> https://www.waterboards.ca.gov/water_issues/programs/scp/vapor_intrusion/
>
> DTSC: https://www.dtsc.ca.gov/vapor-intrusion/

Background

Vapor intrusion (VI) is the migration of chemical vapors from the subsurface into buildings and is a frequent problem at contaminated sites. If uncontrolled, chemical vapors can migrate into buildings and pose a risk to human health. Vapor migration in the subsurface, through building foundations, and within buildings is complex and influenced by many natural and human-caused factors. These factors include climate (e.g., temperature, pressure, precipitation), building conditions (e.g., foundation type and status, age, size), and heating, ventilation, and air conditioning (HVAC) operation. The combination of these factors can result in significant spatial and temporal variability in subsurface and indoor air vapor concentrations. With the potential for such high variability, the probability of false negatives increases – a concern that potential risks associated with VI into indoor air will be underestimated. To address this, the Supplemental Guidance provides a consistent and proactive approach to evaluate buildings that may be at risk from VI and a framework to decide when such risk should be managed. This Supplemental Guidance incorporates information from recent technical and regulatory publications that have highlighted the variable nature of vapor behavior and lessons learned in the assessment of VI.

This Supplemental Guidance 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

Scope, Applicability, and Relation to Existing Guidance and Policy

This Supplemental Guidance addresses assessment of VI risk from vapor forming chemicals (VFCs)[1] but does not constitute complete guidance for the overall evaluation and management of VI. Practitioners should use this 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, this Supplemental Guidance is recommended.

Additionally, 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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) where vapor intrusion may be of potential concern.

[1] Vapor forming chemical (VFC) – 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. Common VFCs include volatile organic compounds and mercury.

Petroleum releases from underground storage tanks (USTs) must be evaluated for vapor intrusion using the State Water Board's Resolution 2012-0062, Low-Threat Underground Storage Tank (UST) Case Closure Policy (LTCP) adopted November 6, 2012 (State Water Board, 2012b). Attachment 1 (Petroleum-Specific Considerations) describes petroleum-specific issues that should be considered when using this Supplemental Guidance for other petroleum release sites.

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. The following table shows the recommended AFs for screening buildings during a VI assessment.

Table: Medium-Specific Attenuation Factors for VI to Indoor Air

Medium	Attenuation Factor
Crawl Space Gas	1
Subslab Soil Gas	0.03
Soil Gas	0.03
Groundwater	0.001

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

This Supplemental Guidance outlines and describes a four-step process (shown in the following flow chart) to determine whether buildings located near known or suspected subsurface VFC contamination are potentially affected by VI that may pose a health risk to occupants. The four-step process is summarized below:

- Prioritizing buildings in proximity to source contamination for a VI assessment
- Collecting exterior soil gas samples to determine if buildings have potential for VI
- Collecting indoor air, subslab soil gas, and outdoor air samples if buildings have potential VI risks
- Evaluating the need to manage current and future VI risk based on both indoor air concentrations and soil gas concentrations

California VI Database

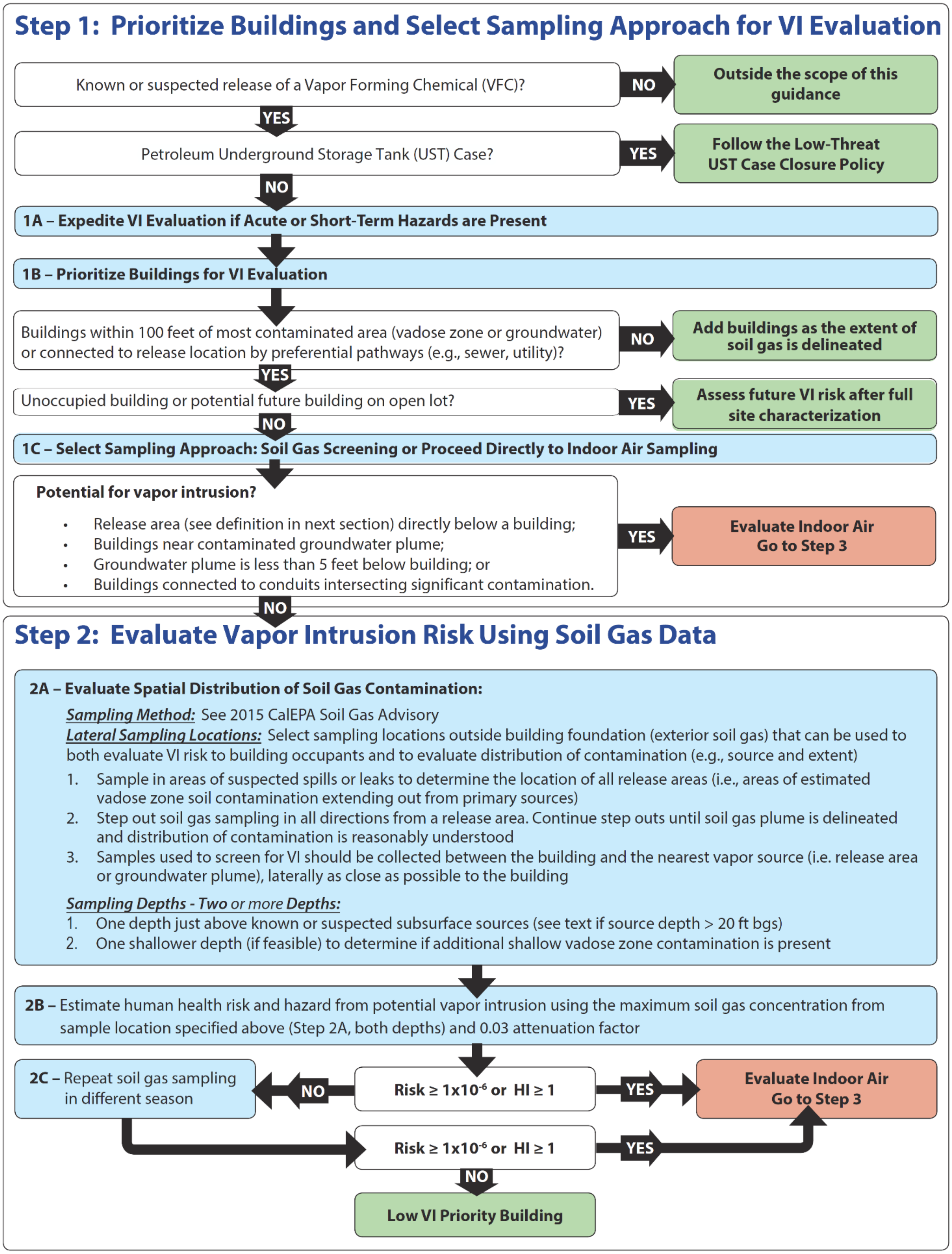
To better understand how human-caused and natural factors influence VI, data will be compiled into a statewide VI database. To facilitate constructing the database, the State Water Board has added capabilities to the GeoTracker statewide data management system to accept building-specific data and differentiate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

Conclusion

Evaluating the potential risk associated with exposure to VFCs migrating from contaminated soil and groundwater into occupied buildings is a key element to ensure adequate protection of human health. Assessing the potential risk to occupant health, screening the vulnerability of individual buildings to VI, and identifying nature of contaminant/vapor mobility over time poses many challenges to regulators, practitioners, and public. Through a four-step process outlined in this Supplemental Guidance, regulators and practitioners can evaluate whether occupants of buildings located near known or suspected subsurface VFC sources are at potential health risk from VI. Moreover, this Supplemental Guidance provides a reasonable framework to decide when the potential VI risk should be managed.

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 this Supplemental Guidance.

Flowchart



Step 1: Prioritize Buildings and Select Sampling Approach for VI Evaluation
Known or suspected release of a Vapor Forming Chemical (VFC)?
NO
Outside the scope of this guidance
YES
Petroleum Underground Storage Tank (UST) Case?
YES
Follow the Low-Threat UST Case Closure Policy
NO
1A – Expedite VI Evaluation if Acute or Short-Term Hazards are Present
1B – Prioritize Buildings for VI Evaluation
Buildings within 100 feet of most contaminated area (vadose zone or groundwater) or connected to release location by preferential pathways (e.g., sewer, utility)?
NO
Add buildings as the extent of soil gas is delineated
YES
Unoccupied building or potential future building on open lot?
YES
Assess future VI risk after full site characterization
NO
1C – Select Sampling Approach: Soil Gas Screening or Proceed Directly to Indoor Air Sampling
Potential for vapor intrusion?
• Release area (see definition in next section) directly below a building;
• Buildings near contaminated groundwater plume;
• Groundwater plume is less than 5 feet below building; or
• Buildings connected to conduits intersecting significant contamination.
YES
Evaluate Indoor Air Go to Step 3
NO
Step 2: Evaluate Vapor Intrusion Risk Using Soil Gas Data
2A – Evaluate Spatial Distribution of Soil Gas Contamination:
Sampling Method: See 2015 CalEPA Soil Gas Advisory
Lateral Sampling Locations: Select sampling locations outside building foundation (exterior soil gas) that can be used to both evaluate VI risk to building occupants and to evaluate distribution of contamination (e.g., source and extent)
1. Sample in areas of suspected spills or leaks to determine the location of all release areas (i.e., areas of estimated vadose zone soil contamination extending out from primary sources)
2. Step out soil gas sampling in all directions from a release area. Continue step outs until soil gas plume is delineated and distribution of contamination is reasonably understood
3. Samples used to screen for VI should be collected between the building and the nearest vapor source (i.e. release area or groundwater plume), laterally as close as possible to the building
Sampling Depths - Two or more Depths:
1. One depth just above known or suspected subsurface sources (see text if source depth > 20 ft bgs)
2. One shallower depth (if feasible) to determine if additional shallow vadose zone contamination is present
2B – Estimate human health risk and hazard from potential vapor intrusion using the maximum soil gas concentration from sample location specified above (Step 2A, both depths) and 0.03 attenuation factor
2C – Repeat soil gas sampling in different season
NO
Risk ≥ 1x10⁻⁶ or HI ≥ 1
YES
Evaluate Indoor Air Go to Step 3
Risk ≥ 1x10⁻⁶ or HI ≥ 1
YES
NO
Low VI Priority Building

Step 3: Evaluate VI Using Concurrent Indoor Air, Subslab, and Outdoor Air Data

3A – Conduct In-Depth Evaluation of Building:

- Complete building survey form
- Locate and remove potential indoor air sources of VFCs
- Screen for indoor sources and vapor entry points
- Observe surrounding area for potential outdoor sources

3B - Evaluate Spatial Distribution of Contamination using Concurrent Sampling:

These sampling recommendations are for small, single story, slab-on-grade foundation buildings. Modify the number of samples for large buildings and modify subslab samples for building with other foundation types (see text section "Application to Other Building Types").

Indoor Air Samples

Select 3 locations considering:

- Primary living/work areas
- Near slab/floor penetrations
- Near suspected maximum sub-surface contamination

Sampling Method: See 2011 DTSC VIG

Subslab Samples

3 locations co-located with the indoor air samples

(alternatively, exterior soil gas can be considered; see text)

Sampling Method:

See 2015 CalEPA Soil Gas Advisory

Outdoor Air Samples

Select 3+ locations:

- Not influenced by site contamination (e.g., upwind and away from release area)

Sampling Method:

See 2011 DTSC VIG

Complementary Sampling Lines of Evidence - Consider concurrent measurement/sampling of:

- Cross-slab pressure differential
- Vapor entry points
- Exterior soil gas
- Radon or tracer gases
- Vapor conduit air
- Mass flux/mass discharge for VI

3C - Assess Risk using the Maximum Indoor Air and Subslab Soil Gas Concentrations:

- Identify and address any confounding factors (e.g. indoor/outdoor sources, preferential pathways)
- Estimate current VI risk and hazard using maximum measured indoor air concentrations
- Estimate future VI risk and hazard using potential future indoor air concentrations predicted from maximum subslab soil gas concentration and an attenuation factor of 0.03

Current VI:
Risk ≥ $1x10^{-6}$ or HI ≥ 1

NO → **3D – Evaluate Temporal Variability (Repeat Step 3B):**

- One to two more sampling events (two to three events total)
- At least one sampling event in a different season
- One event should include both HVAC-Off and HVAC-On sampling

YES → Step 4

Step 4: Decide if Risk Management is Needed to Address Current and Future VI Risk

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

Introduction

Vapor intrusion (VI) is the migration of chemical vapors from the subsurface into buildings and is a frequent problem at contaminated sites. If uncontrolled, chemical vapors can migrate into buildings and pose a risk to human health. Vapor migration in the subsurface, through building foundations, and within buildings is complex and influenced by many natural and human-caused factors. Recent technical and regulatory publications have highlighted challenges and lessons learned concerning the assessment of VI. Historically, practitioners and state regulators have used various methods to assess vapor migration and predict if subsurface concentrations pose a risk to building occupants, thus resulting in variable VI assessment from site to site.

Technical and regulatory publications have recently highlighted additional challenges and advances concerning the assessment of VI (McHugh et al., 2007; Eklund et al., 2008; Folkes et al., 2009; Luo et al., 2009; Holton et al., 2013; Pennell et al., 2013; USEPA, 2015a). The intent of this document is to provide guidance on these recent advances in VI, thus providing a framework for updating VI guidance in California to promote statewide consistency. This Supplemental Guidance provides information and recommendations on the following topics:

- Using United States Environmental Protection Agency (USEPA) 2015 attenuation factors
- Establishing a four-step evaluation process:
    - Prioritizing buildings near contamination for VI evaluation
    - Screening buildings by sampling exterior soil gas
    - Evaluating buildings by sampling indoor air, subslab soil gas (subslab), and outdoor air
    - Managing current and future VI risk
- Considering sewers as a potential VI migration route and pathway of exposure
- Building a California-specific VI database

This Supplemental Guidance should be used within the context of investigation of known or suspected releases of vapor forming chemicals (VFCs). The approach in this Supplemental Guidance should be used in conjunction with full site characterization and the development of a conceptual site model (CSM). This document provides a reasonable framework for evaluating VI with a high level of confidence and promoting consistency at State-lead sites in California. The preceding flow chart illustrates the steps in a VI investigation.

A – Scope and Applicability

The recommendations in this 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 at residential or commercial buildings located near known or suspected subsurface contamination by VFCs can be evaluated through the four-step process described below. Step 1 describes how to prioritize buildings and decide whether to screen buildings based on soil gas (Step 2) or proceed directly to an indoor air evaluation (Step 3). Step 4 provides a framework for making risk management decisions.

This Supplemental Guidance describes procedures for evaluating VI at cleanup sites and cases with releases of VFCs, but does not constitute complete guidance for the overall subsurface investigation and evaluation and management of VI. This Supplemental Guidance does not provide details on how to conduct a full site characterization of all media or how to collect vapor samples. Cleanup goals, remedial strategies, and closure criteria should be established on a site-specific basis, which is outside the scope of this document. Investigation of sites without known or suspected chemical releases, as a precautionary measure (e.g., due diligence investigations), is outside the scope of this document.

Due to the complexity of VI, many professional disciplines may be needed to evaluate and mitigate exposure. Accordingly, a multidisciplinary project team should be gathered to provide sound, scientific judgment when evaluating VI issues and to make decisions concerning potential human exposure. To comply with the Geologist and Geophysicist Act, codified in Section 7835 of the California Business and Professions Code, and the Professional Engineers Act, codified in Sections 6700-6799 of the California Business and Professions Code, any report submitted that contains geologic or engineering conclusions, recommendations, or technical interpretations must be signed and stamped by an appropriately licensed professional who takes responsibility for the report’s technical content. Use of this Supplemental Guidance does not take the place of professional judgment.

Professional judgment should be used as appropriate during any VI investigation and explained in VI investigation reports. This document does not eliminate the need for work plans or sampling and analysis plans.

This Supplemental Guidance is not intended to exclude alternative approaches for evaluating exposure, nor is it intended to provide prescriptive or inflexible requirements. However, alternative approaches and technologies should be supported by adequate technical documentation.

B – Relation to Existing Guidance or Policy

This Supplemental Guidance is meant to supplement, and be used in conjunction with, existing California VI guidance documents. Where existing California guidance conflicts with this Supplemental Guidance, this guidance should be followed until the pre-existing

California guidance is revised.[2] It is important to review the Vapor Intrusion Public Participation Advisory (DTSC, 2012) or consult with the State Water Board Office of Public Participation regarding the public outreach process.

Additionally, 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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) where vapor intrusion may be of potential concern.

Petroleum releases from underground storage tanks (USTs) must be evaluated for VI using the State Water Board's Low-Threat Underground Storage Tank (UST) Case Closure Policy (LTCP) (State Water Board, 2012b). Attachment 1 (Petroleum-Specific Considerations) describes petroleum-specific issues that should be considered when using this Supplemental Guidance for other petroleum release sites.

C – Conceptual Model for Vapor Intrusion

The conceptual model for VI includes transport of VFCs from the subsurface source[3] toward the building, vapor entry into the building, and contaminant mixing with indoor air. Overall, vapor transport in the subsurface is controlled by contaminant partitioning, diffusion (transport from high to low concentration), and advection (transport from high to low pressure) (USEPA, 2012a). Diffusion typically dominates the transport of vapor phase contaminants from the subsurface source toward a building or ground surface. Vapors near the building can be transported by both diffusion and advection into indoor air via cracks or other openings. Advection resulting from negative indoor air pressure relative to the subsurface immediately adjacent to the building (i.e., the building's envelope) typically dominates transport of vapors into indoor air (Johnson, 2005; Yao et al., 2013; USEPA, 2015a). Building heating, ventilation, and air conditioning (HVAC) operations (e.g., stack effects from heating/air conditioning) and weather conditions (e.g., barometric pressure, wind, and temperature) can affect the pressurization of a building.

In this Supplemental Guidance, the terms "vapor entry point," "preferential pathway," and "vapor conduit" are assigned specific meanings:

- "**Vapor entry point**" is used to describe any penetration in the building foundation (or subsurface walls) such as cracks, expansion joints, utility conduits,

[2] This guidance document will provide a framework for the revision of DTSC's Vapor Intrusion Guidance and Vapor Intrusion Mitigation Advisory, and the SF Bay Regional Water Board's Environmental Screening Levels and Vapor Intrusion Framework.

[3] "Sources" are release points of contamination, such as tanks, waste ponds, sumps, drains, pipelines, clarifiers, and landfills. "Subsurface sources" are the associated contaminated soil or groundwater, sometimes referred to as secondary sources.

sumps, and elevator shafts, through which subsurface vapors can be transported into the building.

- "**Preferential pathway**" is a general term used to define all high-capacity transport pathways for vapors from the subsurface source to the building foundation or into the building (USEPA, 2015a; McHugh et al., 2017b). Examples of preferential pathways are bedrock fractures, sand lenses, dry wells, rodent tunnels, vapor pathways inside conduits (e.g., sewers, storm drains, utilities, fiber optic cable housing), and engineered backfill material along conduits.
- **"Vapor conduit**" is a subset of preferential pathways that provide little to no resistance to vapor flow. For example, vapors can flow through the pipes of the sanitary sewer, utility conduits, or other drains or conduits. When a vapor conduit penetrates the building foundation, the preferential pathway can also serve as a potential vapor entry point.

A growing body of evidence is highlighting the importance of sewer lines as potentially significant preferential pathways for VI (Pennell et al., 2013; Guo et al., 2015; Jacobs et al., 2015 and 2016; Kastanek et al., 2016; McHugh et al., 2017a and 2017b; McHugh and Beckley, 2018; and Wallace et al., 2017). VFCs may enter sewer pipes that intersect contaminated soil or groundwater. Once inside the sewer pipe, VFCs can be transported beneath or directly into the building. While sewer plumbing systems inside buildings are designed to prevent sewer gases from entering the building, many components of sewer systems leak or become compromised. Compromised features can include cracked or punctured pipes, loose fittings, degraded toilet gaskets (e.g., wax rings), and dry plumbing traps (e.g., p-traps) (Pennell et al., 2013). Both the sewer pipe itself and backfill material can be preferential pathways. Due to greater void space in the pipe, vapor transport can be greater than the backfill (porous media). Testing at two research houses indicated the sewer acted as a preferential pathway for transport of VFC-contaminated air through the pipes into indoor air (Guo et al., 2015; McHugh et al., 2017a). Overall, this evidence shows that conventional methods used to assess VI (i.e., groundwater and soil gas sampling outside the building) may not adequately represent the potential risk posed by VFCs.

This Supplemental Guidance describes when the sewer pathway should be integrated into a VI evaluation. Attachment 2 (Sewers and Other Vapor Conduits as Preferential Pathways for Vapor Intrusion) provides more information on sewers, findings of select sewer VI studies, and methods for sampling sewer air.

D – Vapor Attenuation Factors

Vapor attenuation refers to the reduction in VFC concentrations that occurs during vapor migration in the subsurface, coupled with the dilution that can occur when the vapors enter a building and mix with indoor air (Johnson and Ettinger, 1991). The attenuation factor (AF) is a unitless number defined as the ratio between the indoor air concentration (C_{IA}) for a given VFC and its subsurface concentration as follows, using soil gas concentrations (C_{SG}) as an example:

$$AF = \frac{C_{IA}}{C_{SG}}$$

The AF is an inverse measure of the overall decrease in concentration due to attenuation mechanisms that occur as vapors migrate from the subsurface into a building. That is, the greater the attenuation, the smaller the value of AF (USEPA, 2012b; USEPA, 2015a). Concentrations of VFCs in soil gas (subslab soil gas, exterior soil gas, or deeper soil gas) or groundwater can be used to estimate indoor air concentrations.

The indoor air concentration of a VFC can be estimated from a subsurface concentration and the AF by rearranging the equation above:

$$C_{IA} = C_{SG} \times AF$$

Indoor air concentrations and potential risk estimated from groundwater VFC concentrations can be used as a supporting line of evidence, but should rarely be a primary line of evidence for VI decision-making. See Attachment 3 (Groundwater as a Line of Evidence to Evaluate VI Risk) for more information on using groundwater data to evaluate VI risk.

D1 – Recommended Attenuation Factors for Screening

USEPA empirically-derived AFs as shown in Table 1 (USEPA, 2015a) should be used for the screening of sites in California. These conservative AFs are protective of public health under most building occupancy scenarios and should be used for the initial screening of sites. Site-specific AFs based on mathematical models, such as the Johnson and Ettinger model, are not recommended for the screening described in this Supplemental Guidance for the following reasons:

Table 1: Medium-Specific Attenuation Factors

Medium	Attenuation Factor
Crawl Space Gas	1
Subslab Soil Gas	0.03
Soil Gas	0.03
Groundwater	0.001

- Current VI models with scientifically defensible input parameters cannot predict the range of results observed in empirical VI studies (Derycke, et al., 2018; USEPA, 2012b);
- Current VI models do not address how buildings change over time as they are modified, damaged, age, or as ventilation and/or HVAC operation change; and

- An increasing number of studies are showing that preferential pathways can contribute to VI (Pennell et al., 2013; Guo et al., 2015; Jacobs et al., 2015 and 2016; Kastanek et al., 2016; McHugh et al., 2017a and 2017b; McHugh and Beckley, 2018; and Wallace et al., 2017), but current VI models do not consider this pathway.

D2 – Alternatives for Screening

Although this guidance supports the use of USEPA's AFs (USEPA, 2015a) for initial screening of buildings, alternative approaches may be used if supported by adequate technical and site information. Alternative approaches should evaluate the spatial and temporal variability of VFC concentrations in various media; be based on multiple lines of evidence; account for on-site and off-site building types, and current and future site and building conditions. Alternative approaches may need more sampling than proposed in this guidance to confirm the alternative satisfies the data quality objectives for the investigation.

E – Evaluation of Lines of Evidence

Multiple lines of evidence (LOEs) should be used at VI sites to reduce the considerable uncertainty associated with individual LOEs due to the spatial and temporal variability of VFCs in groundwater, soil gas, and indoor air (Holton et al., 2013; Winkler et al., 2001). Multiple lines of evidence are used to provide a more comprehensive understanding of VI and to increase confidence in making site management decisions regarding VI. Lines of Evidence may be weighted differently for each site and building, depending on their characteristics and quality. Some LOEs may conflict, and this should be anticipated in the project planning process. Professional judgment should be used to evaluate all LOEs throughout the process.

In addition to VFC concentration data, LOEs also include an understanding of site history, contaminant sources, release mechanisms, contaminant migration, location of possible preferential pathways, location of nearby receptors, and information about the construction of potentially impacted buildings.

The following considerations are intended to supplement existing California VI guidance and provide the basic principles for evaluating LOEs:

- **Developing and Maintaining the CSM** – All LOEs should be used to develop the CSM, and the CSM should be revised as LOEs are added or conflicting LOEs are resolved.
- **Weighting Based on Proximity of Sampled Medium to the Receptor** – Typically, the closer the sampled medium is to the receptor, the greater those concentration data are weighted. For example, indoor air concentration data generally are the preferred LOE for current risk because the VFCs and concentrations in the actual breathing zone are measured. However, the concentration data may also be weighted on sample quality and

representativeness (e.g., influences from other VFCs sources like consumer products and outdoor air).

- **LOEs for Evaluating Future Risk** – Subsurface concentration data are the preferred LOE to evaluate long-term future VI risk to building occupants of existing and potential future buildings. Current indoor air concentration data will not necessarily predict long term indoor air quality as a building changes over time. In addition, indoor air data are not available for potential future buildings.
- **Limitations of LOEs** – Each LOE should be weighted based on an understanding of its limitations. For instance, soil gas concentrations may show considerable spatial and temporal variability. Therefore, reliance on a few soil gas samples from a single sampling event would pose significant uncertainty in a risk management decision.
- **Special Considerations** – Factors that should be routinely evaluated include proximity to the subsurface source, the mass of VFCs remaining in the subsurface, potential preferential pathways, and building susceptibility to VI.

F – California Vapor Intrusion Database

The State Water Board has updated the GeoTracker[4] database to accurately report vapor data in Electronic Data Format (EDF) and building-specific information as Electronic Submittals of Information (ESI). Attachment 4 (Guidance on Uploading Vapor Intrusion Information Into GeoTracker) provides direction on the new functionality of creating onsite and offsite building information and linking field points to appropriate buildings.

Once sufficient data has been compiled, the data will be evaluated to determine if there is sufficient justification to support California-specific AFs.

Data gathered under this Supplemental Guidance will improve our understanding of VI in these ways:

- **Building-Type-Specific AFs** – Compiled data will be evaluated to assess whether building-type attenuation factors can be derived. Few buildings designed for commercial or industrial use are included in the USEPA VI Database.
- **Climate-Related VI Variability** – California data can be used to identify how AFs vary by climate throughout the state. Very few California data are included in the USEPA VI Database.
- **Distinguishing between Site-Related and Non-Site-Related Sources of VFCs** – The recommended indoor air investigation approach includes updated building screening techniques along with concurrent sampling of indoor air, subslab soil gas, and outdoor air. This prospective approach will improve upon the USEPA VI Database, which included data where site-specific outdoor air data were rarely

[4] http://geotracker.waterboards.ca.gov/

collected and at a time when building screening techniques and tools were less well-developed.

- **Spatial and Temporal Variability of Contamination** – Data from multiple sampling locations at a given building and from multiple rounds of sampling will help quantify the spatial and temporal variability, so that VI can be more effectively understood. For most buildings in the USEPA VI Database only one indoor air sample and one subsurface sample were collected per building.

The sampling recommendations in this Supplemental Guidance are needed to evaluate VI risk for building occupants. Adding building information and linking field points in GeoTracker is expected to require minimal extra effort. The database is intended to maximize the benefit of data collected in the course of routine site investigations and provide the basis for developing California-specific attenuation factors.

Step 1: Prioritize Buildings and Select Sampling Approach for VI Evaluation

Site background information should be collected, and the type, quality, and quantity of data that are needed and the intended use of the data should be identified through the data quality objective (DQO) process (CalEPA, 2015; DTSC, 2015; USEPA, 2015a). Known or suspected subsurface sources of VFCs contamination should be investigated starting with Step 1A, below.

Consistent with established practice, planning for public outreach should begin as soon as VFCs are suspected in the subsurface at locations near or adjacent to existing buildings. The DTSC Vapor Intrusion Public Participation Advisory (DTSC, 2012) provides guidance on public outreach.

Step 1A – Expedite VI Evaluations: Acute and Short-Term Hazard

When acute or short-term exposures may result in adverse health effects, promptly evaluate the need for immediate action and expedited turnaround times for laboratory analyses. Threats can also include fire and explosion hazards as well as acute toxicity (see DTSC, 2011a and USEPA, 2015a). For information about short-term response actions for trichloroethene (TCE), see USEPA (USEPA, 2014a), DTSC's "Human Health Risk Assessment [HHRA] Note Number 5" (DTSC, 2014) or the SF Bay Regional Water Board's "Vapor Intrusion Framework" (SF Bay Regional Water Board, 2014).

Step 1B – Prioritize Buildings for VI Evaluation

For situations where multiple buildings require investigation, a "worst first" approach should be employed for VI evaluations. When prioritizing which buildings should be evaluated first to address potential VI concerns, factors to be considered include proximity to contamination, vapor conduits, and building occupancy.

1B.1 – Proximity to Contamination

Buildings closest to the greatest subsurface contaminant concentrations should be prioritized for VI evaluations. The closer a building is to subsurface contamination, the greater the potential for VI. Both the lateral and vertical distance of a building from soil and groundwater contamination should be considered.

- **Proximity to Source and Release Areas**[5]
  Buildings within 100 feet of the *area of estimated vadose zone soil contamination extending from a source* (release area) should be prioritized for VI evaluation.

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[5] The release area is the area of estimated vadose zone soil contamination extending from a source. Soil gas samples can be useful for locating soil contamination and contaminant release points.

- **Proximity to Groundwater Plumes**
  Available groundwater information can be used to prioritize buildings for VI screening. Buildings overlying contaminated groundwater with high VFCs concentrations are more likely to pose a VI risk. Shallow groundwater plumes are more likely to contribute to VI than deeper groundwater plumes. The presence of clean groundwater overlying a VFC plume can significantly reduce the potential for VI.

1B.2 – Contaminated Vapor Conduits

Buildings potentially connected to VFC vapor sources through vapor conduits should be prioritized. Vapor conduits may include the sanitary sewer, drains, electrical pipes, or other large pipes. It is important to evaluate vapor conduits because conventional methods (i.e., soil gas and groundwater sampling) may not detect the migration of VFCs through this transport mechanism. Situations where conduit air is likely to be impacted by site contamination include:

- Known discharge directly into a sewer or drain;
- Conduits intersecting soil contamination within a VFC release area;
- Conduits intersecting groundwater contamination; or
- Conduits located directly above contaminated groundwater.

If it is determined that conduit air is likely to be impacted and the conduit(s) is connected to a building or has the potential to release vapors below a building, proceeding to an indoor air investigation (Step 3) is recommended for that building. If indoor air results indicate the presence of VFCs, but these VFCs do not appear to be migrating through subsurface soil, then sampling the air inside the vapor conduit should be considered. See Attachment 2 (Sewers and Other Vapor Conduits as Preferential Pathways for VI) for information on sewers as a potential VI pathway and the current understanding of sewer air sample collection methods.

1B.3 – Occupancy and Receptors

Currently-occupied buildings should be given priority for VI evaluation. Residences and buildings with sensitive receptors, such as schools and day-care centers, should be high priority. Vapor intrusion evaluations should not be postponed unless it is confirmed that a building is unoccupied. Unoccupied buildings near subsurface contamination should be evaluated for potential VI prior to occupancy.

Step 1C – Select Sampling Approach: Soil Gas Screening or Indoor Air

Some sites may be at the beginning of the investigation process; others may be much further along but in need of a VI risk re-evaluation due to new information. In some situations, pre-existing information and sampling data can be used to determine if soil gas sampling will be useful for screening or if it is more appropriate to go directly to indoor air sampling (Step 3). Examples of such situations that may warrant proceeding to indoor air sampling (Step 3) include, but are not limited to:

- Known or suspected release area directly below a building – External soil gas concentrations are likely lower than the concentration directly below the building at the same depth;
- Buildings near a significantly contaminated groundwater plume – Collecting soil gas concentration data before sampling indoor air (Step 3) would unduly delay direct evaluation of risk to occupants;
- Groundwater shallower than five feet beneath a building – Collecting soil gas samples may not be possible, soil gas samples may be impacted by the capillary fringe, or soil gas samples can be biased low from breakthrough of ambient air; or
- Buildings connected to vapor conduits that intersect significant levels of contamination.

Step 2: Evaluate Vapor Intrusion Risk Using Soil Gas Data

Over the course of a site investigation, defining the nature and extent of contamination in all media is an iterative process that may take months or years. Screening buildings for VI risk should be integrated early into the investigation to protect human health. As in many other areas of site investigation, sampling for the full characterization of the nature and extent of the contamination may be more extensive than what is needed for screening risk assessment purposes. In this document, the focus is on the collection of information to assess potential threats to human health and not, for example, to develop the design of a remedy.

Step 2 describes a general strategy to integrate VI screening into overall soil gas plume investigations. This section first provides recommendations for sample location and depth for the overall soil gas plume investigation. Next, this section describes how to optimize the sampling plan for VI screening of both current buildings and potential future buildings on open lots.

Collecting and analyzing soil gas concentration data is an appropriate early screening step to evaluate the potential for VI. Soil gas concentration data is generally preferred as a LOE for assessing VI risk as opposed to groundwater or soil matrix concentration data (USEPA, 2014b) for several reasons:

- Uncertainty in predicting contaminant partitioning from groundwater or soil moisture to soil gas (uncertainty in organic content in soil, moisture content, and Henry's law constants)
- Uncertainty in predicting transport through the capillary fringe
- Soil matrices typically are heterogeneous
- Soil matrix sampling is subject to loss of volatiles

- The standard reporting limits for VFCs in soil (5 µg/kg) are typically greater than estimated levels of concern for some VFCs.

While soil gas concentration data are typically the preferred LOE for assessing VI risk, soil matrix and groundwater concentration data are needed to identify release areas, provide full characterization, and assess risk through other exposure pathways. These are also supporting LOEs for evaluating the VI risk and help determine soil gas sampling locations.

Step 2A – Evaluate Spatial Distribution of Soil Gas Contamination

Soil gas sampling to screen individual buildings for VI should be integrated into the overall site characterization strategy. The objectives are to (1) evaluate the distribution and extent of contamination; and (2) evaluate VI risk to building occupants. Sample locations and depths should be designed to address both objectives, with the priority on assessing risk.

2A.1 – Soil Gas: Sampling Method

Use the sampling methods described in the Active Soil Gas Investigations Advisory (CalEPA, 2015).

2A.2 – Sampling to Characterize the Overall Soil Gas Plume

- Evaluate the Lateral Distribution of Soil Gas Contamination

  Select soil gas sample locations to help identify release areas and the distribution of contamination. In this Supplemental Guidance, the term **"release area"** is assigned a specific meaning: *the area of estimated vadose zone soil contamination extending out from a source*. Soil gas sampling locations should initially be based on the location of known or suspected release(s), site operations, history of chemical use, topography, and complexity of the geology; and start with a grid or radial sampling pattern. The spacing of samples should be designed to provide a good understanding of the location of all release areas and a conceptual understanding of how soil gas contamination can be transported from those areas.

  Sampling will most likely be an iterative process starting at the suspected points of release within a site and stepping out until the soil gas plume is delineated. If soil gas concentrations are elevated in unexpected directions, consider the presence of additional sources and preferential pathways and adjust the sampling plan as appropriate. For vapor conduits acting as preferential pathways, see Attachment 2 (Sewers and Other Vapor Conduits as Preferential Pathways for VI) for more information.

- Evaluate the Vertical Distribution of Soil Gas Contamination

  Soil gas samples from multiple depths should be collected to delineate the contamination vertically to verify that the subsurface source of the VFC vapors is accurately reflected in the CSM. The number of depths should be based on site-specific conditions (e.g., soil type, stratigraphy). The sample depths generally should be no shallower than five feet below ground surface (bgs) to reduce the likelihood of ambient air breakthrough (CalEPA, 2015). Shallow groundwater can limit the ability to collect soil gas samples.

2A.3 – Sampling to Evaluate Risk to Building Occupants

- Sample Locations for Evaluating Risk

  Current Buildings: Soil gas data used for VI screening evaluations should be collected as close as possible to the building on the side(s) of the building where concentrations are expected to be highest. Site-specific conditions such as utilities and access may limit options for sample placement.

  Samples should be located as follows:

  a) Buildings Potentially Impacted by Release Area Contamination
  Soil gas samples should be collected between the building and the release area(s) as close to the building as possible, preferably within 10 lateral feet of the building. Alternatively, if access is limited or not granted, soil gas sampling in the nearest right-of-way should be considered.

  b) Buildings Potentially Impacted by Groundwater Plumes
  Soil gas samples should be collected between the building and the location of the maximum concentrations of VFCs in groundwater near the building, preferably within 10 lateral feet of the building.

  Future Buildings: While vacant lots or unoccupied buildings are a lower priority for screening than occupied buildings, they should be investigated for potential future VI risk. Every potential future building or ground floor unit should have at least one soil gas sample location. For open lots without a specific development plan, use a recommended initial lateral spacing of 100 feet which assumes that diffusion is the primary mechanism of vapor migration in the absence of preferential pathways (USEPA, 2015a). Adjustment of the lateral spacing should be based on site-specific conditions and the CSM.

- Soil Gas Sample Depths for Evaluating Risk to Current and Future Building Occupants

  Soil gas data used for VI screening evaluations should come from sample depths immediately above the known or suspected highest concentrations of subsurface contamination (e.g., vadose zone soil or groundwater) in the vicinity of the building, except for deep subsurface contamination as described below. The goal is to locate the soil gas concentrations outside the building footprint that best represent conditions immediately below the building. Less attenuation is expected beneath buildings with a slab (e.g., slab-on-grade or basement) due to the slab capping effect, which is a result of a concrete slab acting as a barrier or cap limiting the downward flow of ambient air and the upward venting of contaminated soil gas (Figure 1a) (Schumacher et al. 2010; Shen et al. 2014). Therefore, concentrations collected from samples just above the source of contamination ("near-source soil gas") better correlate with the subslab soil gas concentrations (Figure 1b; DTSC, 2011a; USEPA, 2012a and 2015a).

As indicated in the Step 2 introduction, soil gas samples are recommended as the primary line of evidence for evaluating VI risk when groundwater is contaminated. Attachment 3 describes the use of groundwater data as a line of evidence for evaluating VI when soil gas data have not yet been collected.

Soil gas samples should be located just above the capillary fringe, if possible. However, if soil or groundwater contamination are greater than 20 feet bgs, samples can be approximately 15 feet below a building's foundation and still be representative of concentrations immediately below the building as illustrated in Figure 1b (USEPA, 2012a). Therefore, the deepest soil gas samples for assessing risk should be approximately 15 feet below the foundation, assuming no preferential pathways or other deeper geotechnical anomalies. If there are preferential pathways deeper than 15 feet below the foundation, consider sampling below these pathways. If there is no building present, deeper soil gas samples may best represent anticipated conditions immediately below a future building, and are typically more appropriate for risk assessment than shallow samples.

The deepest sample should be placed at the estimated depth with the most contaminated soil gas, typically near soil contamination or just above the capillary fringe. To verify that this is the depth with the most contaminated soil gas, soil gas samples should be collected from at least two depths.

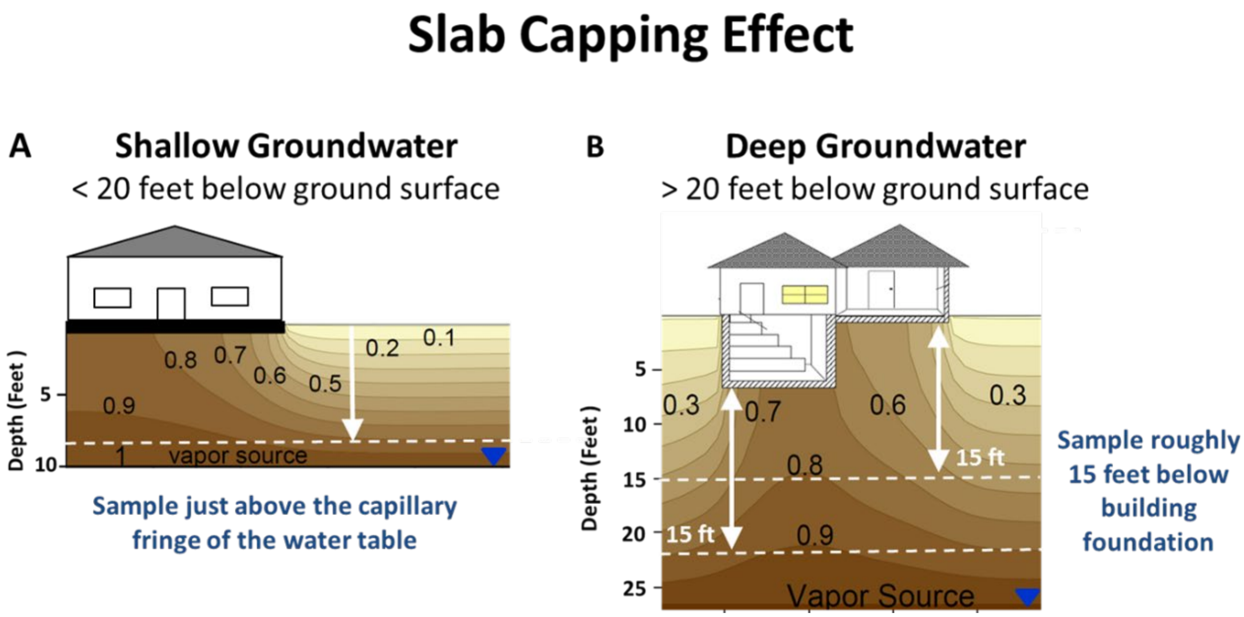

Figure 1. Diagram showing the slab capping effect for shallow or deep groundwater contamination scenarios in order to determine the appropriate soil gas sampling depths. The concrete slab acts as a barrier or cap that limits the downward flow of ambient air and the upward venting of contaminated soil gas. The distribution of soil gas contamination is shown for homogeneous sand. The soil gas concentration contour lines are normalized by the subsurface source vapor concentration. Diagrams taken from *Conceptual Model Scenarios for the Vapor Intrusion Pathway* (USEPA 2012a) and based on three-dimensional (3-D) mathematical model simulations (Abreu, 2005; Abreu and Johnson, 2005; 2006).

Step 2B – Estimate Human Health Risk from Vapor Intrusion

The incremental cancer risk and noncancer hazard associated with indoor air exposure to chemicals of potential concern through the VI pathway should be estimated from soil gas concentration data. Risk should be evaluated as follows:

2B.1 – Estimate Potential Indoor Air Concentration

Estimate the potential indoor air concentration (C_{IA} in micrograms per cubic meter (µg/m^3)) using the maximum soil gas concentration (C_{SG} in µg/m^3) detected in samples located close to the building (or in areas where there is a potential for future buildings), using Equation 1. The default AF of 0.03 should be used to screen all buildings (see section D1).

$$C_{IA} = C_{SG} \times AF$$

(Equation 1)

2B.2 – Estimate Cancer Risk and Noncancer Hazard Quotient

Calculate the cancer risk and noncancer hazard quotient using the estimated C_{IA} from Equation 1. Select either the standard (Equations 2 and 3) or the simplified equations (Equations 4 and 5) as follows:

- **Standard Equations** – Input the most current chemical-specific toxicity criteria consistent with the regulation "Toxicity Criteria for Human Health Risk Assessment" (California Code of Regulations, Title 22, Division 4.5, sections 68400.5, 69020-69022) and default receptor-specific exposure factors (DTSC Human Health Risk Assessment (HHRA) Note 1, 2019 or current SF Bay Regional Water Board's ESLs). For a listing of both required and recommended toxicity criteria see the most current DTSC HHRA Note 10-.

$$\text{Cancer Risk} = \frac{C_{IA} \text{ x IUR x ET x EF x ED}}{AT_c \text{ x 365 days/year x 24 hrs/day}}$$

(Equation 2)

Equation 2 should be modified when appropriate to take into account increased sensitivity during childhood (USEPA, 2018; OEHHA, 2009).

$$\text{Hazard Quotient} = \frac{C_{IA} \text{ x ET x EF x ED}}{\text{RfC x } AT_{nc} \text{ x 365 days/year x 24 hrs/day}}$$

(Equation 3)

IUR = Inhalation Unit Risk (cubic meter per microgram ($m^3/\mu g$))
RfC = Reference Concentration ($\mu g/m^3$)
ET = Exposure Time (hours per day)
EF = Exposure Frequency (days per year)
ED = Exposure Duration (years)
AT_c = Averaging Time for Carcinogens (years)
AT_{nc} = Averaging Time for Noncancer Toxic Effects (years), equal to ED

- **Simplified Equations** – Use indoor air (IA) screening levels (SLs) that are consistent with the site's conceptual site model and exposure scenario. The appropriate cancer and noncancer IA SLs recommended by the oversight agency should be used (DTSC HHRA Notes 3 through 5: 2018, 2016, 2014 or updates and the current SF Bay Regional Water Board ESLs). The CIA and IA SL inputs should have the same units (e.g., $\mu g/m^3$).

$$\text{Cancer Risk} = \frac{C_{IA} \text{ x } (1\text{x}10^{-6})}{\text{(IA Cancer SL)}}$$

(Equation 4)

$$\text{Hazard Quotient} = \frac{C_{IA} \times 1}{(\text{IA Noncancer SL})}$$

(Equation 5)

2B.3 – Estimate Cumulative Risk and Hazard

When more than one VFC is present, the cumulative cancer risk from all carcinogenic VFCs is calculated by summing the chemical-specific risks. The hazard index (HI) is calculated by summing the respective chemical-specific hazard quotients. The hazard quotients for noncarcinogenic toxicity posed by carcinogenic contaminants must be included.

2B.4 – Evaluate Risk

If the cumulative risks based on soil gas concentration data are below the points of departure (1×10^{-6} for cancer risk and 1 for HI), then proceed to Step 2C. **For any exceedance of the points of departure for risk or hazard based on soil gas data, proceed to Step 3 for an indoor air investigation at current buildings, or if there is no building proceed to Step 4 for risk management decisions**.

Step 2C – Evaluate Temporal Variability

When risk calculated from a single sampling event is below the points of departure, at least one additional sampling event is recommended before concluding that subsurface contamination is unlikely to pose a health risk. Contaminant plume migration and seasonal factors, including but not limited to, weather conditions, groundwater levels, soil temperature, and soil moisture, can cause significant temporal variability in soil gas concentration.

2C.1 – Sampling Frequency

Soil gas probes should be sampled at least twice, in different seasons (e.g., as determined by average seasonal temperatures, precipitation [levels of rain/snow fall], or depth to groundwater).

2C.2 – Re-Evaluate Risk

The results of the second sampling event should be evaluated for potential cancer risk and hazard as described in Step 2B.

Step 2D – Decide on Next Step

For any exceedance of the points of departure for risk or hazard based on soil gas data, proceed to Step 3 for an indoor air investigation at current buildings or if there is no building proceed to Step 4 for risk management decisions. If, after the second sampling event, the levels are confirmed to be below the points of departure, the building is considered low priority for further VI evaluation.

Step 3: Indoor Air Investigation – Identify Buildings Where Vapor Intrusion is Occurring Using Concurrent Indoor Air, Subslab Soil Gas, Soil Gas, and Outdoor Air Sampling Data

Step 3 focuses on indoor air sampling to determine if VI is occurring and to assess potential human health risks posed by VFCs migrating into indoor air. When sampling indoor air, concurrent sampling of other media in a *multiple lines of evidence* approach decreases uncertainty and minimizes the challenges posed by the potential presence of VFCs in indoor air from non-subsurface sources. Background sources of VFCs include consumer products, chemical usage, building materials, or outdoor (ambient)[6] air (USEPA, 2011).

Plan, schedule, and conduct in-person visits with individual property owners and building occupants according to the site-specific Public Participation Plan developed for the site (DTSC, 2012; USEPA, 2015a). The activities associated with indoor air investigations can be disruptive to occupants. Developing a cooperative working relationship with owners and occupants for risk communication and sampling is critical. To minimize disruptions, work with occupants, be flexible, and prioritize the need for data when looking for indoor sources of VFCs (e.g., inspecting cabinet contents), placing sampling equipment, or drilling through floors to install subslab vapor probes. The results of indoor air investigations should be communicated promptly to owners and occupants.

Step 3A – Conduct In-Depth Building Survey

The in-depth building survey should be used to support the: (a) development of a conceptual understanding of how VI may be occurring at the building; (b) design sample locations for Step 3B; (c) identify and resolve background sources; and (d) interpret sampling results. Building survey activities include visually observing the building (interior and exterior) and surrounding area, reviewing building layout and drawings, interviewing occupants, and conducting real-time vapor screening.

3A.1 – Identify Building Type, Characteristics, and Condition

Information needed includes building design, use, age, size, dimensions, number and types of rooms, building foundation/slab condition, and occupancy. Understanding how

[6] USEPA defines ambient air as the outdoor air surrounding a building or site (USEPA, 2015a). Outdoor air and ambient air are used interchangeably in this Supplemental Guidance.

a building's heating, ventilation, and air conditioning (HVAC)[7] system operation is critical for the appropriate placement of samples and for interpreting the results of the indoor air investigation. Understanding how occupants use windows and doors to ventilate the building is also important. See the Attachment 5 (Building Survey Forms) for a complete list. In addition, consider consulting the building engineer or other person with knowledge of the building's HVAC system. See the VIG (DTSC, 2011a) for more information on conducting a building survey.

3A.2 – Locate and Remove Potential Indoor Sources of VFCs

As part of the building survey, identify and remove potential indoor sources (e.g., cleaners, glues, fingernail polish remover, aerosol sprays, paint, and dry-cleaned clothes). USEPA recommends removal 24 to 72 hours before a sampling event (USEPA, 2015a). Not all sources may be identifiable or removable. For example, VFCs adsorbed to carpets or other fabrics may continue to off-gas into indoor air and may be detected in indoor air samples.

3A.3 – Conduct Field Screening for VFCs Using a Sufficiently Sensitive Field Instrument

The purpose of the field screening is to identify indoor sources and vapor entry points. Screening commonly includes use of field instruments but may alternatively consist of collecting grab samples for laboratory analysis. Such grab samples might include, but are not limited to, samples collected near suspected vapor entry points to assess whether VFCs are entering the building at that location or breathing zone samples. Field instruments that can detect low levels (e.g., parts per billion by volume) and speciate compounds are recommended over instruments that are less sensitive (e.g., parts per million by volume detection limits) or that only measure the total concentration of detectable VFCs. Other considerations in selecting instruments include reliability, calibration requirements, sensitivity to moisture, cost, and personnel training and experience for proper use.

3A.4 – Observe Surrounding Area for Potential Outdoor Sources

During the field screening, observe nearby businesses or other operations that may emit VFCs to outdoor air. Sources can also include groundwater extraction systems, mitigation systems, or other remediation activities.

Field screening information collected from in-depth building survey activities should be evaluated and used in designing the building-specific sampling plan in Step 3B. The information should be documented on the Building Survey Form (Attachment 5) and reported.

Step 3B – Evaluate Spatial Distribution

[7] HVAC as used in this document refers to all types of heating, cooling, or ventilation systems in both residential and commercial buildings.

The distribution of VFCs inside and beneath a building should be investigated by collecting indoor air and subslab samples at multiple locations throughout the building. Outdoor air samples should be collected to evaluate the potential influence of ambient air on indoor air quality. Step 3B describes a generic sampling design and recommended numbers and locations of indoor air, subslab, and outdoor air samples along with recommended complementary LOEs. The building-specific sampling plan should be based on findings from the building survey. The sampling plan should include contingencies for response actions that may be warranted to protect occupants. The VIG (DTSC, 2011a) summarizes the additional information to be included in a building-specific sampling plan.

The following description for the indoor air sampling program is for a slab-on-grade building. Buildings with crawl spaces or other construction types are discussed in the Application for Other Building Types section.

3B.1 – Indoor Air: Sampling Method

Indoor air samples should be collected in accordance with the VIG (DTSC, 2011a), except where this Supplemental Guidance supersedes (e.g., locations and numbers of samples and sampling events). If the subsurface contamination is well characterized, consider limiting the analyte list to the known subsurface VFCs.

Time-integrated, rather than "grab" sampling methods are preferred for sampling indoor air to better characterize the average daily inhalation exposure for building occupants. Expedited turnaround times for laboratory analyses may be appropriate given the priority (Step 1) and subsurface threat level (Step 2 or existing information). Typical sampling methods include:

- Conventional sampling methods (e.g., canisters) have sampling durations of 24 hours for residential exposure and eight hours for workplace exposure.
- Passive air sampling technology has advanced and should be considered for quantitative, time-integrated indoor air sampling over longer periods.[8] Appropriate use of passive samplers requires knowledge of the target chemicals, sorbent capabilities, and required detection limits. Passive samplers may not be suitable for all situations or chemicals (e.g., high moisture or poor chemical sorption). The analytical laboratory should be consulted when developing the sampling plan to ensure appropriate samplers are selected to meet data quality objectives. More information on passive samplers is presented in USEPA guidance (USEPA, 2015a).
- Real-time monitoring (e.g., a portable Gas Chromatography-Electron Capture Detector (GC/ECD) or Gas Chromatography-Mass Spectrometry (GC/MS) with a datalogger) can provide immediate results and information on potential

[8] At this time, quantitative passive sampling for soil gas is undergoing research and not recommended as a sole line of evidence for soil gas screening evaluations.

fluctuations in concentration over shorter time intervals (see Temporal Variability), and allows calculation of time-integrated average concentrations (Beckley et al., 2014, Hosangadi et al., 2017). In addition, such data can be used to identify patterns and help distinguish between VFC sources and to diagnose VI.

3B.2 – Subslab Soil Gas: Sampling Method

Subslab soil gas samples should be collected in accordance with the Active Soil Gas Investigations Advisory (CalEPA, 2015). Subslab samples typically are grab samples and ideally should be collected within 48 hours of indoor air sampling (USEPA 2012b). To avoid potential cross-contamination of indoor air samples from VFCs released during subslab purging and sampling, subslab samples should be collected after indoor air samples. Alternatively, if subslab samples must be collected before indoor air sampling, allow sufficient time for subsurface VFCs released into indoor air during subslab sampling to dissipate. Exterior soil gas sampling may be used in place of subslab sampling on a site-specific basis (e.g., permission to drill through floors is declined). Subslab sampling is recommended when there is a known or suspected release within or just below the building footprint and exterior soil gas concentration data may not be representative.

3B.3 – Outdoor Air: Sampling Method

Outdoor air samples should be collected in accordance with the VIG (DTSC, 2011a) using the same method as indoor air sampling. USEPA generally recommends beginning ambient air sampling at least one hour before indoor air monitoring begins, but preferably two hours, and continuing to sample until at least 30 minutes before indoor monitoring is complete (USEPA, 2015a). This practice is recommended because most residential buildings have an hourly air exchange rate in the range of 0.25 to 1.0. Recommended lag times may need to be adjusted for nonresidential buildings with different air exchange rates (e.g., lag times may be shorter if the expected indoor air exchange rate is higher for a nonresidential building). If the subsurface contamination is well characterized, consider limiting the analyte list to the known subsurface VFCs.

3B.4 – Indoor Air and Subslab Soil Gas: Location and Number of Samples

Collect a sufficient number of co-located indoor air (from the breathing zone)[9] and subslab sample pairs per building to provide coverage over the building footprint, targeting these locations:

1) Primary living/work areas (e.g., bedroom, living room, or office)
2) Near slab/floor penetrations (e.g., bathroom, kitchen, or laundry room)

[9] All indoor air sampling locations should have sampling devices placed in the breathing zone, approximately three to five feet off the ground for adults and at lower sampling heights if the receptors of concern are children as in a day-care center or school.

3) Near suspected maximum subsurface contamination (e.g., near the center of the building, or known subsurface source).

For situations where the targeted locations are clustered in one area of a building due to the layout, additional locations should be sampled as needed for spatial coverage. The recommended number of sample pairs to provide adequate spatial coverage is three for a small building (≤1,500 ft^2) that is assumed to have a single HVAC zone. For larger buildings, see the section Application to Other Building Types.

Paired indoor air and subslab samples are recommended to provide information about the source(s) of indoor air contamination by comparing detected VFCs and concentrations in the subslab to concentrations in indoor air. Sampling subslab soil gas is recommended as an LOE used to: (a) understand the extent and magnitude of VFC contamination beneath the building; (b) assess potential current and future VI risk; and (c) distinguish indoor air VFCs originating from the subsurface contamination versus those originating from indoor sources. These samples should be collected concurrently, which means that they should be collected as close together in time as possible while minimizing the potential for release of VFCs into indoor air during the subslab sampling process (see subslab sampling method paragraph above). Sampling concurrently, rather than in separate events, minimizes disturbance to building occupants.

3B.5 – Outdoor Air: Location and Number of Samples

Outdoor air sampling should be conducted in conjunction with indoor air sampling to provide information regarding ambient air influences on indoor air quality. Typical sources of VFCs in outdoor air include, but are not limited to, vehicle exhaust, industrial emissions, and dry cleaners. Ambient air data available through the local air district or California Air Resources Board can be helpful for planning purposes and as a line of evidence for interpreting sampling results (e.g., identifying VFCs commonly detected in the vicinity). Concurrent with indoor air samples, outdoor air samples should be collected to characterize conditions in the vicinity of the subject building and away from the influence (vertically and laterally) of subsurface VFC vapor contamination, chemical storage areas, and remediation systems. At least three sample locations are recommended to provide spatial coverage around the building and address changes in wind direction. Samples should be collected approximately six feet above the ground surface.

3B.6 – Complementary Lines of Evidence

Additional LOE should be considered to complement the indoor air sampling program. Evaluating LOE is discussed in the Introduction. Complementary LOEs can include, but are not limited to, the following:

- Cross-Slab Pressure Differential Measurements – Measuring the pressure difference between the subsurface and indoor air can indicate whether subsurface VFCs are potentially migrating into the building (i.e., depressurized building interior) or not (i.e., pressurized building interior) (USEPA, 2015a).

Sampling indoor air when the building is positively pressurized and there is no driving force for VI indicates the concentration data are not likely to characterize exposure due to VI. USEPA recommends continuous pressure monitoring, starting days in advance of sampling and continuing through the sampling process. Pressure differentials typically are measured using micromanometers with pressure transducers and dataloggers installed at subslab probes. USEPA recommends measuring pressure differential at different probes than those used for subslab sampling.

- Exterior Soil Gas Sampling – If a soil gas probe was installed near the building in Step 2, collecting soil gas samples concurrently with indoor air sampling is recommended during at least one event. This correlated data provides information about the vapor transport through the subsurface and into the building.
- Vapor Conduit Air Sampling – Sampling inside sewers and other vapor conduits concurrently with indoor air and subslab sampling is recommended to determine if such preferential pathways are enhancing VI (see Step 1B.2 Contaminated Vapor Conduits section). Attachment 2 (Sewers and Other Vapor Conduits as Preferential Pathways for VI) discusses sewer and other vapor conduit sampling methods.
- Vapor Entry Point Sampling – Indoor air samples can be collected as described in Step 3A.3 (qualitative) or 3B.4 (quantitative) to assess whether VFCs are entering through particular features (e.g., cracks, openings to the subsurface, etc.). Vapor entry point samples typically are collected close to the feature rather than at breathing height.
- Radon and Other Tracer Data – Measuring naturally-occurring radon or injecting tracers into the subsurface and detecting the radon or tracer in indoor air are qualitative LOEs that may be used for evaluating subsurface VI (McHugh et al., 2008; USEPA, 2015a, 2015c; McHugh et al., 2017c).
- Mass Flux/Mass Discharge for VI – Mass flux/mass discharge for VI is a methodology to estimate the rate of VFC mass moving into and out of a building (Holton et al., 2015; McHugh et al. 2017b; Dawson et al., 2018). Mechanical ventilation (e.g., blower door fans) can be used to manipulate indoor pressure conditions relative to outdoor pressure and induce or suppress VI (McHugh et al., 2012). Measuring building pressure differentials, building ventilation rates, and indoor VFC concentrations while depressurizing a building can be used to induce a scenario with greater potential for VI, thereby decreasing the likelihood of underestimating risk.

Step 3C – Assess Risk from Contaminated Indoor Air and Subslab Soil Gas

3C.1 – Identify and Address Confounding Factors

Indoor air, outdoor air, and subslab (or soil gas) data from the same sampling event should be used to assess the presence of confounding factors. Confounding factors can include:

- Outdoor sources of VFCs
- Indoor sources of VFCs
- Subsurface VFCs transported through vapor conduits

See the VIG (Step 10 - DTSC, 2011a) for more information about how to interpret indoor air data when confounding factors are present.

3C.2 – Estimate Risk from Indoor Air Data

The results of the first indoor air sampling event (Step 3B) should be used to assess potential human health risks posed by subsurface VI. The maximum measured indoor air concentration should be input into either the Standard Equations (Equations 3 & 4) or the Simplified SL Equations (Equations 5 & 6) in Step 2B. The appropriate receptor exposure parameters and the corresponding inhalation toxicity criteria are entered into the Standard Equations (see 2B.2); conservative default exposure parameter values should be used for screening. Alternatively, when the CSM and the exposure scenario are consistent with those used to develop risk-based indoor air screening levels (DTSC, 2014, 2017, and 2016; SF Bay Regional Water Board, 2016) the Simplified SL Equations can be used.

3C.3 – Estimate Potential Future Risk from Subsurface Data

Even when indoor air concentrations are low, potential risk associated with the subsurface VFC concentrations should also be estimated. The risk and hazard under possible future conditions are estimated by:

1. Predicting potential future indoor air (IA) concentrations using the maximum soil gas (SG) or subslab (SS) concentrations and generic, conservative AFs in Equation 1 of Step 2B; and

2. Calculating the potential future indoor air risk and hazard, inputting the predicted future indoor air concentration into either the Standard Equations (Equations 3 & 4) or the Simplified SL Equations (Equations 5 & 6) as described in Step 2B.

3C.4 – Assess Cumulative Risk

The cumulative incremental cancer risk from carcinogenic VFCs should be calculated by summing all of the chemical-specific cancer risks for the VI pathway. The hazard index for the VI pathway should be calculated by summing the chemical-specific hazard quotients, including the hazard quotients for noncarcinogenic effects posed by carcinogenic contaminants. If multiple chemicals are present and the hazard index exceeds one (1) but hazard quotients for individual chemicals are each less than (1), a toxicological evaluation to segregate chemicals by target organ(s) and/or mechanisms of action may be conducted to further evaluate hazard (DTSC, 2011a; DTSC, 2016). Risk from all potentially complete exposure pathways should be considered as part of the sitewide evaluation and is outside the scope of this document.

3C.5 – Characterize Risk

Cumulative risks and hazard indices (HI) estimated from both indoor air data and from subsurface data should be used in the determination of appropriate mitigation and remediation response actions (see Step 4). The points of departure for risk management decisions are 1 x 10^{-6} cancer risk and a noncancer HI of 1. If any calculation of risk exceeds the point of departure, proceed to Step 4. If all calculations of risk, based on both indoor air and subsurface data, do not exceed the point of departure, proceed to Step 3D to assess temporal variability.

Risk characterization integrates quantitative and qualitative information from the VI risk assessment and identifies the important strengths and uncertainties for each component of the assessment as part of the discussion of the confidence in the risk assessment (USEPA, 1989 and 1995). Risk characterization is not considered complete unless the numerical expressions of risk are accompanied by explanatory text interpreting and qualifying the results (USEPA, 1989). In addition to exposure estimates and uncertainties, the chemical-specific toxicity and uncertainties must be considered when evaluating potential risks. For example, excessive hazard from acute or relatively short-term exposures, such as the developmental effects of TCE, may warrant more immediate and/or additional actions than in cases when the concern is linked to the effects resulting only from long-term exposure.

Step 3D – Evaluate Temporal Variability

The goal of Step 3D is to understand the variability of indoor air contamination over time to ensure that risks are not underestimated.

The current understanding of VI is that heating of buildings during cold weather typically induces greater depressurization of the building relative to the subsurface, resulting in increased VI and higher indoor air concentrations of VFCs. However, other conditions may also increase VI, such as mechanical ventilation (e.g., exhaust fans), strong directional winds, and increased temperature of the roof and highest enclosed space on sunny days. Indoor air concentrations can also increase when the indoor air exchange rate is decreased. This situation may occur even on temperate days when building occupants close windows and doors to avoid poor ambient air quality or allergens, or for security purposes, thereby decreasing natural ventilation and indoor air exchange with outdoor air. Cross-slab pressure differential measurements can be taken to understand when a building is pressured or depressurized, and thereby provide an important line of evidence when interpreting indoor air data. This is analogous to using the flow direction and gradient when interpreting groundwater data.

The wide ranges in California geography, local climates, and building construction and conditions require consideration of many additional factors when planning site and building-specific sampling. For example, in some regions, use of the heating system may occur at a time of year other than winter, and indoor air sampling should be conducted during this time.

3D.1 – Sampling Frequency

The sampling described in Step 3B should be repeated for one or two additional events, for a total of at least two events, before a building is considered low priority for VI.[10] The second sampling event should be conducted in a different season (e.g., as determined by average seasonal temperatures). If needed as described below, an additional sampling event should be conducted at least one to two months after the second event.

One of the sampling events described above should include both HVAC-On and HVAC-Off scenarios to determine the effects of the HVAC operation on VI. This means two periods of sampling as part of that event: one period with the HVAC on and one period with the HVAC off. Consider conducting this evaluation when operation of the HVAC system is likely to have the greatest influence on VI based on the findings of the building survey. For the HVAC-Off scenario, the sampling duration should begin at least 36 hours following shutdown of the HVAC (no outdoor air intakes into the building) and continue while HVAC systems remain off (USEPA, 2013b). Conversely, the HVAC should be run for 36 hours using typical heating and cooling settings prior to sampling with HVAC on (HVAC system cycling on and off normally).

If multiple LOEs are consistent with a robust CSM, two sampling events may be sufficient to evaluate temporal variability. To make this decision, the following conditions should be met:

- The events are conducted in different seasons.
- At least one of the indoor air sampling events should be conducted when conditions are expected to favor VI, as verified by cross-slab pressure differential readings, during sampling.
- Subsurface VFCs are either not detected in indoor air samples or the cumulative risk and hazard associated with detected concentrations are consistently below threshold values.
- The indoor air VFC concentrations of the two sampling events are similar.
- All subsurface data demonstrate that contaminant concentrations are stable or decreasing across multiple sampling events.

If these conditions are not met, a third sampling event should be conducted to evaluate temporal variability at least one to two months after the second sampling event.

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[10] The recommendation for three samples assumes 24-hour Summa canisters are used. If passive samplers are deployed for two-week periods, a total of two events can be considered adequate. Similarly, high frequency, real-time sampling may be used as an alternate approach to address the goal of evaluating short-term temporal variability.

3D.2 – Re-Evaluate Risk

After each sampling event, risk and hazards should be assessed in accordance with Step 3C. Risk characterization should also describe spatial and temporal variability in indoor air concentrations of VFCs migrating from the subsurface.

Step 3E – Decide on Next Step

If any indoor air results attributable to VI indicate a cumulative cancer risk or HI exceeding the points of departure, then proceed to Step 4. If the data indicate wide fluctuations in concentration(s) (i.e., more than an order of magnitude) or an increasing trend in indoor air or subsurface concentrations, additional sampling should be considered. If, after the conclusion of all sampling events, the levels are consistently below the points of departure, the building would be considered low priority for VI. The building should be reassessed if conditions change (e.g., nearby soil gas or groundwater concentrations increase).

Step 4: Current and Future Risk Evaluation and Management Decisions

Step 4 describes the process of using the characterization of health risks and all LOEs, both qualitative and quantitative, to determine the appropriate response action(s). Remediation and mitigation decisions should be made in consideration of the site as a whole. Selection of specific response action(s) and timing should be made on a site-specific basis, considering all media, all LOEs, and input from stakeholders.

Step 4A – Need for Risk Management

The following table, adapted from the Vapor Intrusion Mitigation Advisory (VIMA, DTSC 2011b), illustrates the potential decisions and actions for addressing both current and potential future VI risk. A building may be considered low priority for VI if the cumulative risk and hazard are consistently below threshold values (green). If the risks estimated from Step 3 exceed the points of departure (yellow), then the appropriate action(s) should be determined. When the risk exceeds the risk management range, then mitigation and/or remediation is warranted (red).

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

The DTSC VIG (DTSC, 2011a) and VIMA (DTSC, 2011b) present more information regarding risk management decisions. DTSC provides information related to several specific remediation technologies in Proven Technologies and Remedies Guidance (DTSC, 2010).

Step 4B – Manage Current Vapor Intrusion Risk

As previously discussed, if the risk or hazard estimated from indoor air data attributable to VI exceeds the point of departure, there is concern for potential current risk to receptors. The appropriate response action(s) and time frame for their implementation should be commensurate with the nature and magnitude of the potential human health risk (e.g., urgent or accelerated response actions for TCE short-term inhalation hazard; USEPA, 2014a; DTSC, 2014; SF Bay Regional Water Board, 2014).

Remediation should be the preferred response action to reduce VI risk by permanent reduction of contaminants. Mitigation is considered an interim response action until VFCs in soil, soil gas, or groundwater are confirmed to be at acceptable levels (DTSC, 2011b). For sites where site-specific conditions prevent remediation, mitigation may be necessary as a long-term measure. Mitigation is a complementary approach to remediation. However, mitigation or temporary relocation may be the most appropriate initial response action for reducing receptor exposure and risk in a timely fashion.

Mitigation approaches and technologies include short-term and long-term measures:

- Short term: Increasing building pressurization, increasing air exchange rates, sealing conduits, and treating indoor air with portable purification systems are short-term mitigation options (USEPA, 2015, 2017a; DTSC, 2011b). Short-term mitigation options for the sewer pathway include adding water to dry p-traps and replacing damaged toilet gaskets (Jacobs et al., 2015). Temporary relocation of building occupants may be warranted for acute or short-term hazards (e.g., TCE above short-term action levels in indoor air), if other controls are not immediately available or effective (USEPA, 2014a; DTSC, 2011a, 2011b, and 2014). Implementation of some of these options may not be feasible for the long term, and additional controls may be necessary.
- Long term: Subslab venting systems and depressurization systems are common long-term mitigation technologies. Such systems may be required where remediation to reduce contaminant concentrations to acceptable levels might take years or is not technically feasible. Vapor barriers such as subslab liners can be used in conjunction with these systems but are not, by themselves, an acceptable VI mitigation system (DTSC 2011b). Long-term options for mitigating sewer VI can include sewer venting, installing check valves, lining the sewer pipe, or rerouting the sewer pipeline (Wallace et al., 2017).

As established practice, monitoring is necessary to demonstrate the initial and continued effectiveness of mitigation. For further information on VI mitigation, see the DTSC VIMA (DTSC, 2011b), the SF Bay Regional Water Board VI Framework (SF Bay Regional Water Board, 2014), and USEPA (USEPA, 2015a).

All VI remediation and mitigation systems should be designed, built, installed, operated, and maintained in conformance with standard geologic, engineering, and construction principles and practices using appropriately licensed professionals.

Step 4C – Manage Future Vapor Intrusion Risk

It is important to recognize that, while the indoor air data for an existing building may indicate no current significant VI potential, subsurface contamination can remain a potential VI concern. Changes to existing buildings may result in increased VI susceptibility. In addition, new buildings constructed over former open space can significantly reduce natural venting of VFCs from soil and cause a redistribution of subsurface VFCs as a result of the slab capping effect (Schumacher et al., 2010; Shen et al., 2014; and USEPA, 2012a). Therefore, collecting near-source soil gas samples (as described in Section 2A.3) is recommended to evaluate VI risks for future buildings (open lots). Factors that may influence future VI include:

Land/Subsurface Conditions

- Site or subsurface conditions
  - Water table fluctuations
  - Surface grading, removal, or import of soil

    - Trenching and utility installation
    - Pavement or landscaping
- Subsurface contaminant migration or redistribution

Building Conditions

- Site redevelopment (e.g., new construction)
- Building structure (e.g., settling, modifications, damage)
- Land or building use (e.g., commercial to residential, increased density)
- Building operation (e.g., new HVAC system, changed HVAC operation, alternate business hours)

Based on risk and hazard estimated from subsurface data and considering all LOEs, select an appropriate response action(s) to manage risk to occupants of existing and future buildings (see table above).

Application to Other Building Types

The concepts used for assessing spatial distribution and temporal variability of contamination can be applied in general terms to larger buildings, building with crawl space construction, and occupied spaces over above- or below-ground parking structures. Sampling recommendations in Steps 2 and 3 were developed for a small, slab-on-grade building with only one HVAC zone; however, these recommendations can also be used for other building types.

For more complex buildings, understanding a building's HVAC system and the air flow through the building is critical to designing an indoor air investigation and interpreting the results. Also, these types of structures are more likely to have unusual features (e.g., utility tunnels) that can act as vapor conduits, and efforts should be made to understand building characteristics. Sampling considerations and recommendations for three common building types, labelled as Building I, II, III, are described below.

BUILDING I – Large Buildings and Multistory Buildings

For large or multistory buildings, the process and risk evaluation for Step 2 should be followed, but there are some changes for Step 3. In addition, for a mixed-use building, the risk evaluation should consider the most sensitive receptor. A combination of sampling approaches might be warranted depending on site-specific conditions.

I.A – Sample Locations in Step 3

The evaluation of large buildings warrants more sampling than described in Step 3B. The exact number and spacing of the samples should be determined based on the CSM, building characteristics, and DQOs. Sample locations should be selected consistent with the criteria in Step 3B and should consider these additional sample locations:

- For large multiunit structures, such as apartment buildings or strip malls, consider collecting at least one sample per ground floor unit.
- For buildings with foundations that segment the subsurface (e.g., grade beams), at least one sample should be collected in each separate area.
- For buildings with multiple HVAC zones, it may be appropriate to collect samples in each HVAC zone.
- For multistory buildings, sampling in occupied spaces on upper floors may be warranted in addition to sampling on the ground floor. Samples should be collected near conduits, such as utilities, stairwells, or elevator shafts, that may provide a vapor pathway to the upper floors.
- If results of initial sampling show concentrations vary by over an order of magnitude within a building; consider adding additional sample locations to evaluate the spatial distribution of VFCs.
- For large multiunit buildings with a release area under a small section of the building (e.g., strip mall dry cleaners), consider a phased approach starting at the release area and working outward. For example, initially sample indoor air only at the units directly above the suspected release area and sample subslab soil gas below all units. Conduct further investigation based on the initial results.

I.B – Calculate VI Risk Using Indoor Air in Step 3

Risk calculations described in Step 3C should be used for large or multistory buildings.

I.C – Sample Frequency in Step 3

Sampling frequencies discussed in Step 3D should also be used for large or multistory buildings.

BUILDING II – Crawl Space Buildings

Buildings with crawl spaces are common in California. Sampling of crawl spaces provides an additional line of evidence regarding VI. In this Supplemental Guidance, all buildings with space below the floor level should be treated similarly, including crawl spaces, unfinished basements, mobile homes, and portable buildings. The characteristics of these spaces can vary widely. Crawl spaces may be open or may be almost entirely enclosed and may have dirt or concrete floors. Well-ventilated crawl spaces may limit the ability for vapors to collect and migrate to indoor air but should not be assumed to completely prevent VI. Furthermore, if VI is occurring through the sewer or other vapor conduits, crawl space air samples may underestimate indoor air concentrations of VFCs.

Crawl space air samples can be collected as part of Step 2 or Step 3. If the crawl space is easily accessible from outside the building, consider sampling crawl space air concurrently with soil gas in Step 2; this may reduce inconvenience to building occupants. If crawl space air sampling is conducted in Step 3, the sampling should be concurrent with indoor air, soil gas, and outdoor air to characterize the vapor migration pathway(s).

A crawl space to indoor air AF of 1 should be used when calculating risk. USEPA found little vapor attenuation between crawl space air and indoor air. USEPA concluded either little attenuation occurs between the crawl space and indoor air space or that air exchange between the two spaces leads to approximate equilibration in the concentrations (USEPA, 2012b).

Indoor air concentrations remain the preferred LOE for evaluating the current risk to building occupants. While crawl space air data are a LOE for assessing current risk, the data should not be used for assessing future risk due to the dynamic nature of air in the crawl space. Subsurface data concentrations are the preferred LOE for evaluating future risk.

II.1 – Crawl Space Air: Sampling Methods

Crawl space air samples should be collected using the same methods recommended for indoor air sampling in the VIG (DTSC, 2011a).

II.2 – Crawl Space Air: Sample Locations in Step 2 and Step 3

The overall number and location of crawl space air samples should provide adequate building coverage, with a minimum of two samples (see section above for large buildings). The following sampling locations should be considered in the design of any crawl space air sampling plan:

- Near the center of the structure (away from vents to outside air);
- Near known or suspected subsurface VFC release areas; and
- Near emergent subsurface utilities.

II.3 – Step 2 Specific Criteria for Crawl Space Air Sampling

Crawl space air samples are recommended in addition to soil gas samples as part of Step 2, depending on site-specific conditions. Outdoor air samples should be concurrently collected with crawl space air samples to allow for the identification of outdoor sources of VFCs potentially entering crawl space air.

- Exterior Crawl Space Access – Where access is readily available *from outside the building*, crawl space air samples may be collected in conjunction with Step 2.
- Estimate VI Risk using Crawl Space Air – A crawl space to indoor air AF of 1 should be used when calculating risk, as described in Step 2B (crawl space air concentrations replace soil gas concentrations in Step 2B).
- Sample Frequency in Step 2C – Crawl space air should be sampled at least twice concurrently with soil gas, at times representative of two different seasons.

II.4 – Step 3 Specific Criteria for Crawl Space Air Sampling

Crawl space air samples should be collected concurrently with indoor air, soil gas, and outdoor air samples.

- Evaluate the Source of VFCs in Indoor Air – Crawl space air data are used in Step 3 along with other LOEs to evaluate the migration pathway and other potential sources of VFCs in indoor air (i.e., outdoor and/or indoor sources).
- Estimate VI Risk using Crawl Space Air (Step 3C) – A crawl space to indoor air AF of 1 should be used when calculating risk, as described in Step 2B (crawl space air concentrations replace soil gas concentrations in Step 2B).
- Sample Frequency in Step 3D – Crawl space air sampling should be repeated during each indoor air sampling event to characterize temporal variability.

BUILDING III – Building with Above-Grade or Below-Grade Parking Structures

Ground floor parking garages (podium parking) and below-grade parking garages tend to minimize the potential for VI due to passive or active ventilation but should not be assumed to completely prevent the migration of subsurface VFCs to upper floors (USEPA, 2015a).

The sampling approach for buildings with occupied space above parking garages is similar to the approach for buildings with crawl spaces. Sampling of parking garage air is recommended in Step 2 to provide additional information about VI while minimizing inconvenience to building occupants. Parking garage air samples are intended to determine if VI is occurring and are not representative of indoor air in the occupied upper floors due to the high ventilation rate typical in parking garages. Sampling should focus on potential vapor conduits from the subsurface. In Step 2, soil gas samples should be collected in addition to samples from vapor conduits, provided access is allowed. In Step 3, concurrent sampling of indoor air in routinely occupied spaces, subslab (or soil gas), and outdoor air is recommended. At least one outside air sample should be collected from a location near the HVAC intake(s) for the parking garage.

The building survey for parking garages should identify the following:

- Vapor conduits, such as elevator shafts, stairwells, and utilities can allow migration of subsurface VFCs upward into the occupied floors.
- Sumps with Contaminated Groundwater – If the parking garage floor extends to or below the water table and contaminated groundwater infiltrates into the parking area, VFCs may volatilize directly from contaminated groundwater into the garage air.
- Occupied Spaces – Most parking garages are not regularly occupied, but some have parking attendants or utility rooms that may be occupied on a routine basis and should be considered for sampling.

- Other Sources of VFCs – Vehicle exhaust, laundry rooms (e.g., hotels), and chemical storage areas are common sources of chemicals in these spaces.

The results of the building survey should be used to develop the building-specific sampling plan.

III.1 – Parking Garage Air: Sampling Methods

Parking garage air samples should be collected using the same methods recommended for indoor air sampling in the VIG (DTSC, 2011a).

III.2 – Parking Garage Sample Locations in Step 2 and Step 3

The overall number and location of parking garage air samples should provide adequate building coverage. Samples should generally be collected from the lowest level of the garage. The following sampling locations should be considered in the design of any parking garage air sampling plan:

- In or near potential conduits including elevators, stairwells, and utilities;
- In occupied spaces (e.g., toll booths and attendant offices);
- For large parking areas, near the center of the structure on the lowest floor (away from vents); and
- Near known or suspected subsurface VFC release areas.

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References include those in the main text and attachments. The most current version will supersede any older version of all California guidance documents referenced in this section.

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Glossary of Acronyms & Abbreviations

Abbreviation	Meaning
3-D	Three-dimensional
AF	Attenuation Factor
AT_c	Averaging Time for Carcinogens (years)
AT_{nc}	Averaging Time for Noncancer Toxic Effects (years)
BGS	Below Ground Surface
CalEPA	California Environmental Protection Agency
CDPH	California Department of Public Health
C_{IA}	Indoor Air Concentration
CIPP	Cure-In-Place-Piping
C_{SG}	Soil Gas Concentrations
CSM	Conceptual Site Model
DQO	Data quality objective
DTSC	Department of Toxic Substances Control
ED	Exposure Duration (years)
EDF	Electronic Data Format
EPA	Environmental Protection Agency
ESI	Electronic Submittal of Information
ESLs	Environmental Screening Levels
EF	Exposure Frequency (days per year)
GC/ECD	Gas Chromatography-Electron Capture Detector
GC/MS	Gas Chromatography-Mass Spectrometry
HHRA	Human Health Risk Assessment
HI	Hazard Index
HVAC	Heating, Ventilation, and Air Conditioning
IA	Indoor Air
IUR	Inhalation Unit Risk ($m^3/\mu g$)
LOEs	Lines of Evidence
LTCP	State Water Board's Low-Threat Underground Storage Tank Case Closure Policy
µg/L	Micrograms Per Liter
$m^3/\mu g$	Cubic Meter Per Micrograms
PCE	Tetrachloroethylene; tetrachloroethene
PEEK	Polyetheretherketone
PHCs	Petroleum Hydrocarbons
PVI	Petroleum Vapor Intrusion
RfC	Reference Concentration ($\mu g/m^3$)

Abbreviation	Meaning
SF Bay Regional Water Board	San Francisco Bay Regional Water Quality Control Board
SG	Soil Gas
SL	Screening Level
SS	Subslab
State Water Board	State Water Resources Control Board
TCE	Trichloroethylene; Trichloroethene
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tank
VFCs	Vapor Forming Chemicals
VI	Vapor Intrusion
VIG	Vapor Intrusion Guidance
VIMA	Vapor Intrusion Mitigation Advisory
VISL	Vapor Intrusion Screening Level
$\mu g/m^3$	Micrograms Per Cubic Meter

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Attachment 1

Petroleum Specific Considerations

Attachment 1 – Petroleum-Specific Considerations

Petroleum releases from underground storage tanks (USTs) must be evaluated for vapor intrusion using the State Water Board's Low-Threat Underground Storage Tank (UST) Case Closure Policy (LTCP) (State Water Board, 2012b).

BACKGROUND

Most petroleum hydrocarbons can biodegrade under aerobic (oxygenated) environmental conditions that are found at many sites (USEPA, 2012c). The VI threat related to petroleum hydrocarbon contamination in the subsurface is frequently reduced by fairly common conditions supporting biodegradation, combined with plentiful naturally-occurring microbes that are able to biodegrade petroleum hydrocarbons. Aerobic biodegradation limits the concentration of petroleum vapors in vadose zone soils where there is sufficient oxygen and clean soil between the petroleum contamination and building foundation. This phenomenon has been demonstrated with empirical data (Davis, 2009; Lahvis et al. 2013; USEPA, 2013a). Petroleum vapor intrusion (PVI) most often occurs where petroleum-impacted soil or groundwater is located near a building foundation and there is insufficient bioattenuation.

USEPA along with many state and other agencies have developed PVI guidance or policies considering the likelihood for biodegradation. Typically, PVI guidance documents or policies employ separation distances as part of screening. The use of separation distances requires a well-developed conceptual site model from soil, groundwater, and soil gas samples to determine if there is adequate bioattenuation. USEPA (2015b) specifically states "Until it is clear that human health and the environment are adequately protected from adverse impacts caused by the release, appropriate site characterization, risk assessment, and corrective action activities should continue." Recommended PVI guidance and policies include USEPA (2015b), ITRC (2014), and State Water Board's Low-Threat UST Case Closure Policy (State Water Board, 2012b).

USING THE SUPPLEMENTAL GUIDANCE IN CONJUCTION WITH PVI GUIDANCE FOR PETROLEUM RELEASE SITES

In general, the Supplemental Guidance can be followed for large, complex petroleum release sites (e.g. bulk terminal, refinery, or manufactured gas plant). For these limited number of large, complex petroleum sites where the data indicate insufficient bioattenuation and/or separation distance between the contamination and the building foundation, a site-specific biodegradation assessment can be performed as part of Step 2 as follows:

> **Site-Specific Biodegradation Assessment** – Multiple lines of evidence are collected at the same time as soil gas contaminant concentration data as part of

Step 2 of this Supplemental Guidance. The additional lines of evidence to evaluate whether there is sufficient bioattenuation of vapors due to biodegradation include:

- Soil Gas Data – Samples from multi-depth soil vapor probes should be analyzed for petroleum, oxygen, carbon dioxide, and methane. The presence of sufficient concentrations of oxygen indicates the potential for biodegradation. The carbon dioxide profile should be the opposite of the oxygen profile and serves as a confirming line of evidence. Elevated methane concentrations indicate anaerobic conditions. The methane concentration profile typically follows the same trend as the hydrocarbon concentration profile. For further information see Figure 1-1 below and USEPA (2012c).
- Soil Data – Soil samples should be collected for petroleum analysis between the ground surface and the known or suspected petroleum contamination to confirm the thickness of clean soil available for bioattenuation. Residual, less volatile hydrocarbons may be present in the soil that would provide competing oxygen demand, limiting bioattenuation of petroleum vapors.

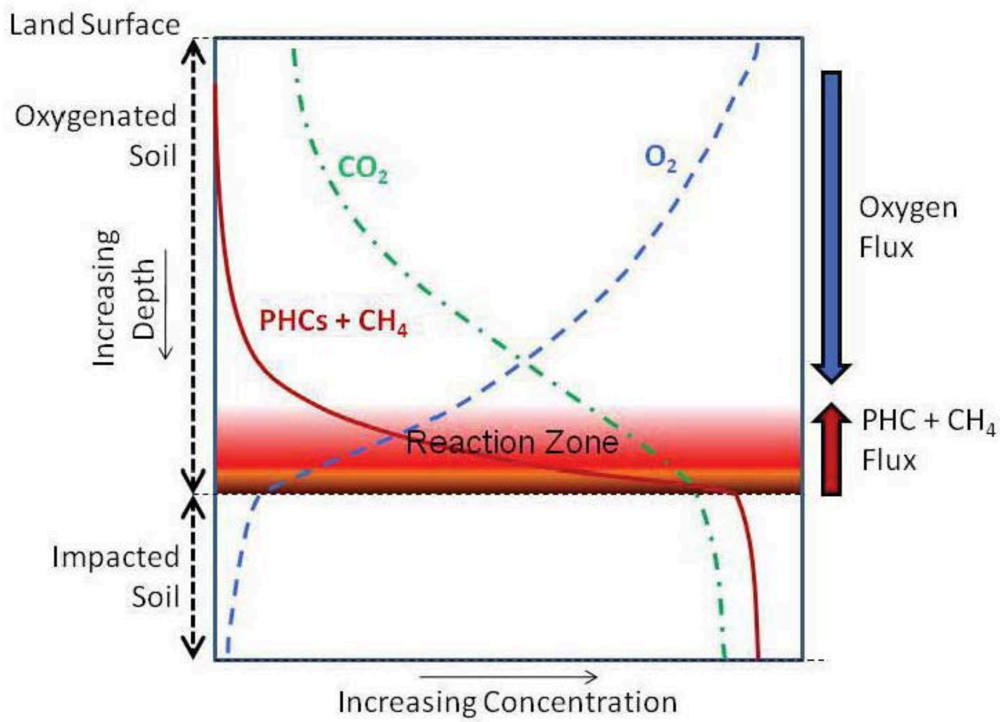

Figure 1-1. Diagram showing the typical vertical concentration profile in the unsaturated zone for petroleum hydrocarbons (PHCs) plus methane, carbon dioxide, and oxygen. With aerobic biodegradation in unsaturated soils, PHCs plus methane (red) degrade, carbon dioxide (green) is produced, and oxygen (blue) is consumed. The aerobic biodegradation zone extends over the area of active biodegradation. The source zone,

which is anaerobic, is characterized by the maximum vapor forming chemical concentrations and little biodegradation. Source: USEPA 2012c.

For situations where indoor air sampling (Step 3) is necessary, practitioners should be aware that petroleum chemicals can be detected in indoor and outdoor air samples from sources other than the suspected subsurface source(s), including ambient air impacted by vehicular emissions, consumer products, materials used for repairs and remodeling, and vehicle and fuel storage in attached garages (USEPA, 2011; ITRC, 2014; and McDonald et al., 2018). Building surveys, including chemical use inventories, and outdoor air petroleum concentrations are critical data that should be reviewed in conjunction with indoor air data when evaluating PVI.

Attachment 2

Sewers and Other Vapor Conduits as Preferential Pathways for Vapor Intrusion

Attachment 2 – Sewers and Other Vapor Conduits as Preferential Pathways for Vapor Intrusion

INTRODUCTION

Subsurface vapors can be drawn into indoor air through two routes. Vapor can migrate through the soil and enter buildings through openings in the foundation. Alternatively, vapors can migrate through subsurface pipe networks (e.g., sewers, drains, etc.) and enter buildings. These pipe networks can contain VFCs from waste discharge into the pipe network or through infiltration of groundwater or soil vapors from contaminated areas. Underground piping can distribute contamination beyond delineated groundwater and vapor plumes. Vapor transport through pipe networks has been demonstrated with direct release to indoor air through dry plumbing traps (e.g., p-traps), loose pipe fittings, and cracked pipes. In addition, cracked pipes or loose fittings can occur below the building with discharge of the vapors to the sub-foundation region and subsequent migration to indoor air through openings in the foundation. The presence of preferential pathways and their significance are not easily discerned by simple observation, review of building drawings, or traditional site characterization methods.

OVERVIEW OF SEWERS

Sewers are a network of pipes designed to convey sewage from buildings to sewage treatment plants. Sewers are filled with odorous and potentially toxic gases that must be prevented from entering buildings. Plumbing-traps prevent the escape of these gases from the sewer. Traps are kept continuously filled with water to create a barrier to vapor flow. Plumbing traps are typically U-shaped pipes located under sinks, toilets, and drains. Sewers are typically vented to roofs to equalize pressure in the system and keep water in the traps and vent gases away from building occupants. Sewer laterals connect buildings to municipal sewer mains. These typically gravity-drain to municipal sewage treatment facilities. Sewer mains are designed to allow water to flow downhill but are neither water- nor gastight. Cracks may develop as the system ages or as the system is penetrated by roots. Sewer mains have maintenance holes located throughout the system, and buildings typically are required to have a sewer access port, or “cleanout” for maintenance purposes.

Historically, sewers were used for the disposal of industrial waste (Vroblesky et al., 2011; Central Valley Regional Water Board, 1992). Today, municipal sewage or permitted discharges may contain VFCs which are released directly into sewers.

SUMMARY OF TECHNICAL STUDIES

Numerous recent studies illustrate the potential for sewers to impact indoor air quality. These are a few of the key studies in chronological order:

1. Riis et al. (2010) measured indoor air quality at 32 houses near or overlying subsurface contamination at a site in Denmark and found three houses with significant VI problems. Due to the lack of clear correlation between subsurface contamination and indoor air concentrations, the sewer lines were tested and found to contain chlorinated solvents. Tracer gases were injected into the sewer and showed that sewer air was transported into the houses through joints, pipe penetrations and floor drains.
2. Pennell et al. (2013) studied a residential neighborhood in the Boston, Massachusetts, area adjacent to a chemical facility. Seventy properties were evaluated for VI. Elevated concentrations of PCE were detected in indoor air on the first floor of a residence, but lower concentrations were observed in the basement. During the follow-up sampling event, similar results for PCE resulted but sewer odors were also observed. Sampling of the sewer detected PCE, and the elevated concentrations of PCE in the bathroom were attributed to a deteriorated seal on the toilet.
3. As indicated by Sivret et al. (2014), odorous compounds in sewers exhibit significant temporal variability. Their results indicate that strong diurnal variation occurs, with the highest concentrations observed near midnight. Additionally, sampling at successive 10-minute intervals showed concentration changes of 50 to 100 percent, demonstrating the dynamic nature of sewer gas. The authors also noticed reduced concentrations of odorous compounds during rainfall events.
4. Guo et al. (2015) determined that a land drain system acted as a vapor conduit for TCE migration into a home near Hill Air Force Base, Utah. At this residence, a lateral pipe, open at one end, terminated within the subfoundation gravel layer, and the other end of the lateral pipe connected to the neighborhood land drain system. The neighborhood land drain system contacted contaminated groundwater, providing a source for TCE inside the land drain system. Using a combination of controlled pressure testing, soil gas profiles, and mass flux estimates, the influence of the land drain system on indoor air was confirmed. TCE-containing vapor was directly transported through the land drain pipe to the subfoundation gravel layer and then into the building via cracks and other openings due to advection when the building was underpressurized.
5. McHugh et al. (2017c) conducted tracer, sewer vapor, soil gas, and indoor air testing at the USEPA research residential duplex in Indiana. The field investigation confirmed that the sewer line served as a local preferential pathway for the migration of vapors from the sewer into the duplex. Vapors were detected at multiple locations within the sewer, and tracers released into the sewer upstream and downstream were detected in the duplex. Furthermore, the mitigation system reduced indoor radon concentrations; however, a similar reduction in PCE was not observed, suggesting that most of the PCE did not originate from the vadose zone. The

migration pathway appears to be complex, with the tracer data suggesting there is leakage from the sewer lateral beneath the building rather than directly to indoor air.

6. Nielsen and Hvidberg (2017) state that sewer systems are a major intrusion pathway in more than 20 percent of the contaminated dry cleaner sites in central Denmark.
7. The California Department of Public Health (CDPH) issued a Safety Alert in 2017 concerning Cure-In-Place Pipe (CIPP). CIPP is one of several trenchless rehabilitation methods to repair existing sewers. CIPP is a jointless pipe-in-pipe tube inserted into existing damaged pipe. Hot water, UV light, or steam is used to cure the material to form a tight-fitting replacement pipe. CDPH issued the Safety Alert due to styrene vapors from the CIPP curing process entering nearby buildings.

COLLECTION OF SAMPLES

These papers provide information on potential sampling approaches. Necessary permits or access agreements should be obtained prior to sampling. Other sampling techniques may be considered as appropriate.

Street Sampling

For street sewers, vapor samples can be collected at sewer maintenance hole covers. Air samples should be collected either through the existing vent holes or by removing the cover enough to allow passage of a sampling tube. Vapor samples should be collected approximately one foot above the surface of the liquid (liquid level) in the sewer. If needed, the liquid level should be determined with a water level meter. The sampling tubing should be weighted prior to introduction into the sewer and composed of either high-density polyethylene, Teflon, or polyetheretherketone (PEEK). Three volumes of air in the sample tubing should be purged prior to sampling. Air samples should be collected in either polymer gas sampling bags or passivated stainless steel canisters. The holding time for polymer bags is six hours, but steel canisters can be held 30 days prior to analysis.

Cleanout Sampling

Buildings are required to have a sewer access port or, “cleanout,” for maintenance purposes. Cleanouts provide access to the building’s sewer system and are usually composed of a simple screw-on cap connected to a y-fitting. Buildings may have more than one cleanout. Typically, cleanouts are located inside the building near the water heater, mounted in an exterior wall near the kitchen, or at grade along the building’s perimeter. The section of pipe used to access the sewer system is hereby referred to as “cleanout pipe”. For sampling, the cleanout cap should be removed, and the sampling tubing should be inserted as far as possible without contacting sewage. To place the sampling tubing into the center of the cleanout pipe, a collar should be installed at the end of the tubing to suspend the tubing off the cleanout pipe wall. A temporary cover should be placed on the cleanout opening to minimize the introduction of ambient air into the sewer. After the temporary cover is installed, the sewer should be allowed to equilibrate for about an hour before sample collection. At least three volumes of air should be purged from the tubing prior to sample collection.

Passive Sampling

To provide an estimate of the average concentration over time, both street sewers and building cleanouts can be evaluated with passive air sampling devices. As discussed in Step 3B of this Supplemental Guidance, an appropriate evaluation of passive sampler efficacy should be performed before implementing a sampling program. The devices should be deployed in the middle of the maintenance hole or cleanout pipe, not contacting the maintenance hole or cleanout pipe walls, and maintenance holes and cleanouts should be covered with their lids to alleviate ambient air influences.

REFERENCES – included in main text

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Attachment 3

Groundwater as Line of Evidence to Evaluate VI Risk

Attachment 3 – Groundwater as Line of Evidence to Evaluate VI Risk

INTRODUCTION

Groundwater data are routinely collected during site cleanup activities to characterize the distribution of groundwater contamination, to evaluate if plumes are migrating, and to verify the effectiveness of remediation. Groundwater data can be used as a supporting line of evidence (LOE) to evaluate vapor intrusion (VI) potential when soil gas data have not yet been collected, but there are limitations associated with using groundwater data that should be taken into consideration (see the Step 2 introduction). This attachment describes the prediction of indoor air concentrations using groundwater data, calculation of cancer risk and noncancer hazard quotient, and considerations when using groundwater data to predict indoor air concentrations.

PREDICTION OF INDOOR AIR CONCENTRATIONS USING GROUNDWATER DATA

The concentration of a vapor forming chemical (VFC) migrating into indoor air through VI can be predicted from the groundwater concentration using two steps:

1. The VFC concentration in groundwater is used in the partitioning equation below to predict the equilibrium vapor concentration.

$$C_{Vapor-GW} = C_{GW}\ x\ H'\ x\ \left(\frac{1{,}000L}{m^3}\right)$$

where:

$C_{Vapor-GW}$	Vapor concentration in equilibrium with groundwater in µg/m³
C_{GW}	Groundwater concentration in micrograms per liter (µg/L)
H’	Chemical-specific Henry’s Law constant (unitless) at the specified groundwater temperature.[11]

2. The equilibrium vapor concentration is multiplied by the USEPA groundwater-to-indoor air attenuation factor (0.001) to predict the indoor air concentration after vapors have migrated through the capillary fringe and vadose zone into a building, as shown below.

[11] The USEPA Regional Screening Levels supporting table “Chemical-Specific Parameters” is a source for these values at 25 °C. The Vapor Intrusion Screening Level (VISL) Calculator User’s Guide (USEPA, 2014) describes how to adjust H’ for different temperatures.

$$C_{IA} = C_{Vapor-GW} \; x \; AF_{GW}$$

where:

C_{IA}	Indoor air concentration in μg/m^3
$C_{Vapor-GW}$	Vapor concentration in equilibrium with water in μg/m^3
AF_{GW}	Generic groundwater to indoor air attenuation factor of 0.001 (USEPA, 2015a)

CALCULATION OF CANCER RISK AND NONCANCER HAZARD QUOTIENT

Use the standard equations in Section 2B.2 to estimate cancer risk and the noncancer hazard quotient using the predicted indoor air concentration.

CONSIDERATIONS WHEN USING GROUNDWATER DATA TO PREDICT INDOOR AIR CONCENTRATIONS

Groundwater data are not the preferred LOE for evaluating VI because of the uncertainties associated with the partitioning equations and uncertainty about transport through the capillary fringe. Additionally, groundwater concentrations may not reflect vadose zone contamination. The direct measurement of soil gas concentrations bypasses these uncertainties, which is why soil gas is recommended as a preferred line of evidence in Step 2. In general, groundwater data should not be used as the sole LOE to support a decision not to sample soil gas. However, groundwater data from the first water-bearing zone can be used as a supporting LOE to make inferences about potential VI. Groundwater data may be useful when soil gas and indoor air cannot be sampled (e.g., an open lot with shallow groundwater) or for determining where to place soil gas samples for characterization of VI potential in the portion of the groundwater plume distal from the release area.

When groundwater data are used as a LOE for evaluating VI, the proximity of the groundwater data to the building under evaluation should be considered. While groundwater samples from directly beneath a building likely would be most representative of the potential VI threat, it may not be possible to collect such samples. In this case, collecting samples close to the building, potentially on the upgradient side, may be best for estimating groundwater concentrations directly beneath the building. In addition, groundwater samples collected near the top of the first water-bearing zone better represent the potential VI risk than samples collected at deeper depths.

REFERENCES – included in main text

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Attachment 4

Guidance on Uploading Vapor Intrusion Information into GeoTracker

Website Link:
https://www.waterboards.ca.gov/ust/electronic_submittal/docs/viesi_guide_v1.pdf

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Guidance on Uploading Vapor Intrusion Information into GeoTracker

Electronic Submittal of Information Format

GeoTracker

California State Water Resources Control Board

Version 1

August 2019

Web site: http://geotracker.waterboards.ca.gov/esi

TABLE OF CONTENTS

I. INTRODUCTION

The State Water Resources Control Board (State Water Board) added capabilities to the GeoTracker database including building-specific information for a cleanup case and the ability to differentiate Field Points for collecting samples.

This document provides instruction on how to create relevant vapor intrusion (VI) information to be used in a VI assessment including a building profile and how to assign vapor data related to a specific building. This capability is performed through the VI Building Tool in the electronic submittal of information (ESI) portal of GeoTracker. This document assumes the reader is aware of the GeoTracker ESI process. If unfamiliar with the GeoTracker ESI process, the reader should familiarize themselves with the "Electronic Submittal of Information (ESI) Beginner's Guide"[1] (ESI Beginner's Guide). ESI users should use the tool to track VI assessments for their Site/Facility, as well as, list VI building profiles in the study area with an associated Site/Facility.

The VI Buildings Tool contains the ESI user's Site/Facility, which has associated VI data. The VI building tool should be used for all the ESI user's Site/Facility with a VI assessment. Through the VI building tool, VI data are uploaded, assigned the appropriate Field Point Class, and then associated with its respective building within the Site/Facility. VI building data attributes include both building attributes (e.g., design, occupants, foundation type) and sample attributes (e.g., location, media, concentration).

Note: The Site/Facility used in this document is not an actual case and created only for demonstration purposes.

II. FIELD POINT AND SAMPLING SETUP

The "ESI Beginners Guide" provides information for ESI accounts, how to claim a Site/Facility, add Field Points to a site, and/or upload (submit) ESI data files.

A summary of the procedures for logging into an ESI account and adding/uploading ESI features is presented below.

Log into GeoTracker ESI: https://geotracker.waterboards.ca.gov/esi/

Once ESI users have access and have followed the steps outlined in the "ESI Beginner's Guide" to claim their Site/Facility, they may begin to assign Field Points, upload VI data, and create VI building profiles.

[1] ESI Beginner's Guide: https://www.waterboards.ca.gov/ust/electronic_submittal/docs/beginnerguide2.pdf

A. SETTING UP FIELD POINTS FOR VAPOR INTRUSION ASSESSMENT

When using the new VI features of GeoTracker (explained in subsequent sections), it is necessary that existing and new Field Points used for collection of vapor samples be assigned appropriate names and the appropriate "Field Point Class." For example, a soil gas sample location (Field Point) can be collected from a temporary grab sample, soil gas probe, or a monitoring gas well. Thus, the soil gas Field Point should be assigned a Field Point Class of Soil Gas (SG), Monitoring Gas Well (MGW), or a Transient Subsurface Sampling Point (TRS), respectively.

Note: The Field Point is the type of the sample point and a Field Point Class defines the sample media.

The table below shows the available Field Points, appropriate naming convention, available Field Point Class and description of each of vapor type sample available for the GeoTracker VI functionality.

Field Point	Appropriate Field Point Name	Available Field Point Class and (Valid Value)	Description
Indoor Air	IA – 1a, IA1, IA – Bath B1, IA – 1	1. Indoor Air (IA)	Air sample collected from within building.
Subslab	SSV– 1a, SSV1, SS – Bath B1, SS – 1	1. Subslab Soil Vapor (SSV)	Soil vapor sample collected beneath building foundation footprint.
Crawl space	CSA – 1, CSA – 1a	1. Crawl Space Air (CSA)	Air sample collected in the crawl space area of the building.
Soil Gas	SG – 1, SG – 1a, SG – 1b, SG1, GRB – 1a	1. Soil Gas (SG) 2. Monitoring Gas Well (MGW) 3. Transient Subsurface Sampling Point (TRS)	Soil vapor sample collected outside of the building foundation footprint. For non-permanent sample locations, use transient subsurface sampling point.
Ambient Air/ Outdoor	AAS – 1, AAS – 1a, OA – 1, OA – 1a	1. Ambient Air Sample (AAS)	Air sample collected outside of the building.
Sewer Air	SWAG – 1, SWAG – 1a	1. Sewer Air Gas (SWAG)	Air/vapor sample collected within a sewer line.
Groundwater	MW – 1, GB – 1a	1. Remediation/Groundwater Monitoring Well (MW) 2. Transient Subsurface Sampling Point (TRS)	Groundwater sample collected associated with Site/Facility. For nonpermanent sample locations, use transient subsurface sampling point.

Note: Many existing vapor sample Field Points with a Field Point Class identified as "vapor" should be changed for existing Field Points that are to be used in a vapor intrusion assessment. To re-assign a Field Point to the appropriate Field Point class use the edit Field Point functionality in the ESI portal (refer to Section II.D).

B. SAMPLE ID NOMENCLATURE

The SAMPID (Sample ID) field in the GeoTracker Electronic Deliverable Format (EDF) (EDFSAMP, EDFTEST, and EDFFLAT files)[2] is the unique identifier assigned to a field sample as it appears on the Chain-of-Custody. The Sample ID normally is the same as the Field Point Name, although for certain scenarios the Sample ID will be different to indicate heating, ventilation, and air conditioning (HVAC) conditions or subsurface depth. The Sample ID field entry can be up to 25 characters long.

Heating, Ventilation, and Air Conditioning Settings

As part of VI investigations, some information about HVAC settings should be contained within the Sample ID. As such, a Sample ID for an indoor air or subslab sample should indicate if heating or air conditioning is on or off. It is highly recommended that the nomenclature presented in the table below for Sample ID be used when submitting this sample event scenario to standardize vapor entry and to help identify HVAC conditions during sample collection in the database.

SAMPID	Field Point Name	Field Point Class	Description
IA – 1 – HEAT ON	IA – 1	Indoor Air	Air sample collected from within a building with the heating system on.
IA – 1 – COOL ON	IA – 1	Indoor Air	Air sample collected from within a building with the cooling system on.
IA – 1 – HVAC OFF	IA – 1	Indoor Air	Air sample collected from within a building with the HVAC system off.
SSV – 1 – HEAT ON	SSV – 1	Subslab	Subslab sample collected from within a building with the heating system on.
SSV – 1 – COOL ON	SSV – 1	Subslab	Subslab sample collected from within a building with the air conditioning system on.
SS – 1 – HVAC OFF	SSV – 1	Subslab	Subslab sample collected from within a building with the HVAC system off.

Soil Gas Depths for a Single Sampling Point

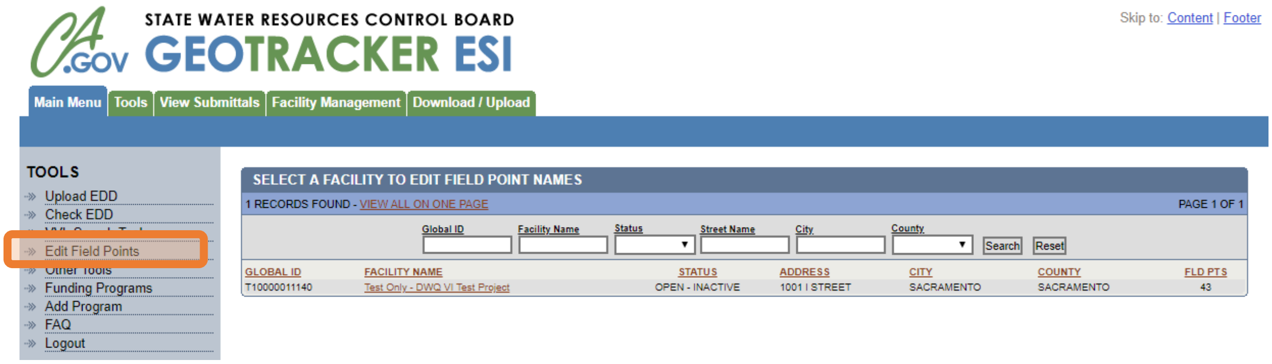
As part of VI investigations, information about depth-discrete sampling performed within a single sampling point should be contained within the Sample ID. As such, a Sample ID for this type of soil gas sample should indicate at what depth in feet the sample was collected. It is highly recommended that the nomenclature presented in the table below for Sample ID be used when submitting this sample event scenario to standardize vapor entry in the database.

SAMPID	Field Point Name	Field Point Class	Description
SG – 1a7.5 SG – 1b15.0	SG – 1	Soil Gas	Soil gas samples collected from a single sampling point at 7.5 feet and 15.0 feet.

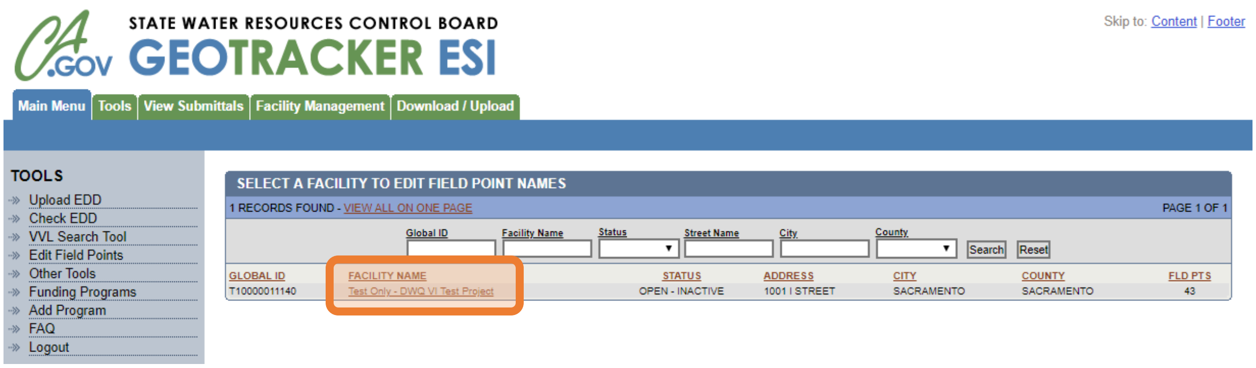
[2] https://www.waterboards.ca.gov/ust/electronic_submittal/docs/faq.pdf

C. CREATING FIELD POINT

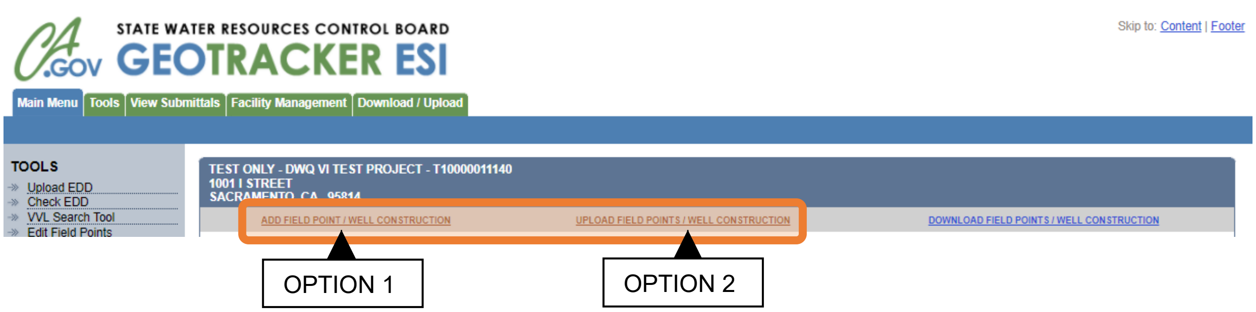
Under Tools on the left-hand side, select “Edit Field Points”; the user’s claimed sites will be displayed.



Select the “Site/Facility” for adding/uploading Field Points.



The Site/Facility page has two options for creating a Field Point and assigning a Field Point Class for every sample location at the study area for the purposes of assessing VI. Described below is how ESI users can either add individual Field Points manually (Option 1) or use an upload feature to add more than one Field Point at a time (Option 2).

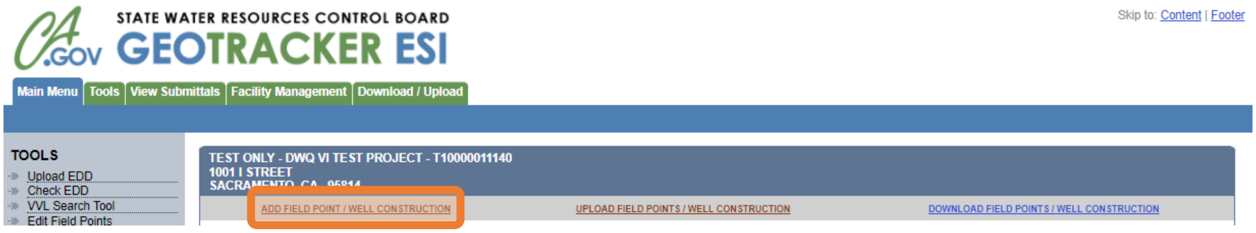


It is critical to have a consistent Field Point naming system and assign the appropriate Field Point Class. This will be important when assigning a Field Point to a VI building profile.

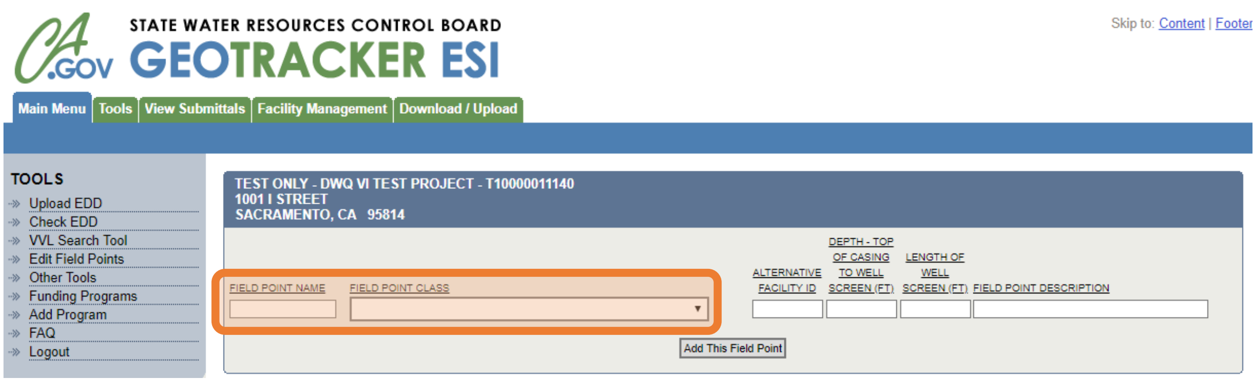
OPTION 1 – MANUALLY ADDING A FIELD POINT

The ESI user will manually enter the Field Point Name and select the Field Point Class. When appropriate the depth (top of casing to well screen), length of well screen, and Field Point description should be included (see below).

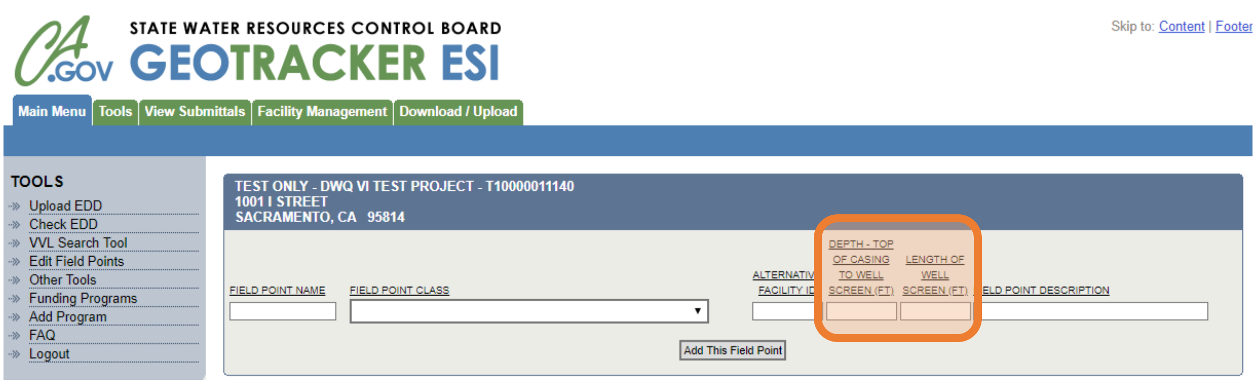
Select "Add Field Point/Well Construction."



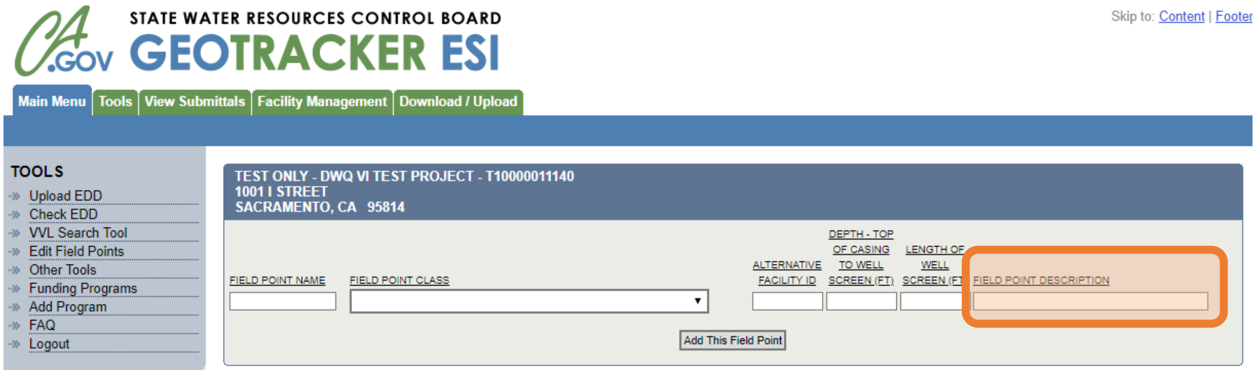
Input the assigned Field Point name and select the appropriate Field Point Class from the drop-down menu (described in Section II.A).



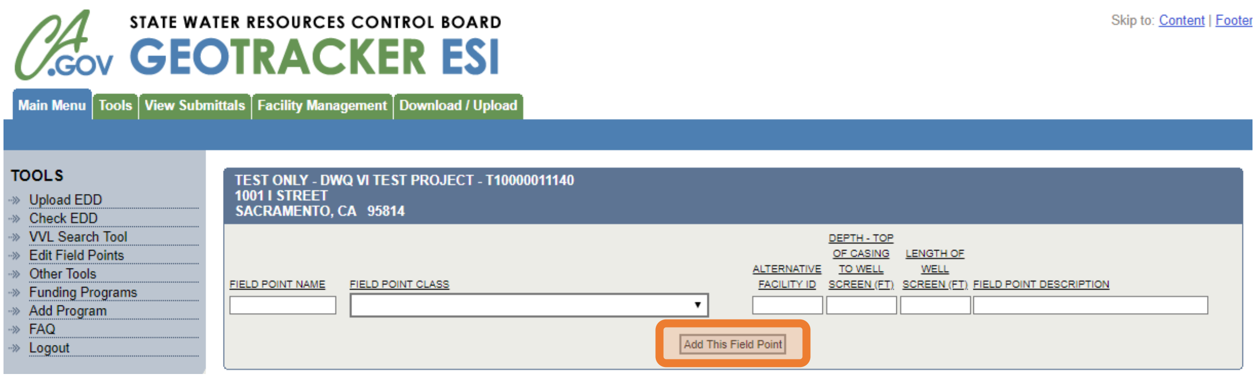
For Soil Gas and Groundwater Field Points, include the depth from the top of the casing to the well screen and the length of well screen.



For Field Point Description include the buildings name associated with the Field Point.



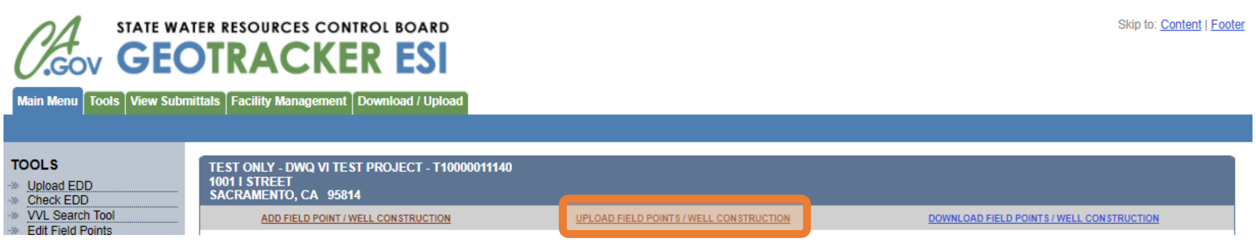
Select “Add This Field Point” to store the Field Point in the database.



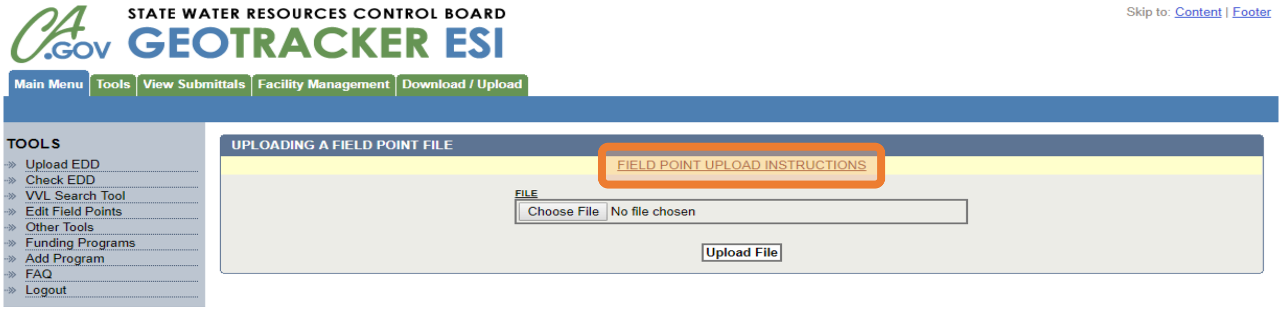
OPTION 2 – UPLOADING MANY FIELD POINTS

The ESI user will use an upload feature to add more than one Field Point at a time by using a text editor to create the upload file (see below).

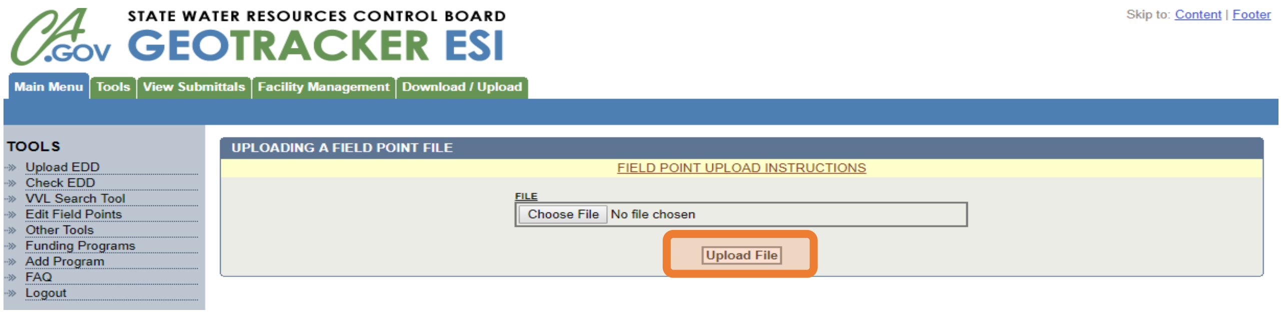
Select “Upload Field Points/Well Construction.”



Refer to “Field Point Upload Instructions” (shown below) for the type of files and format required for using this option.

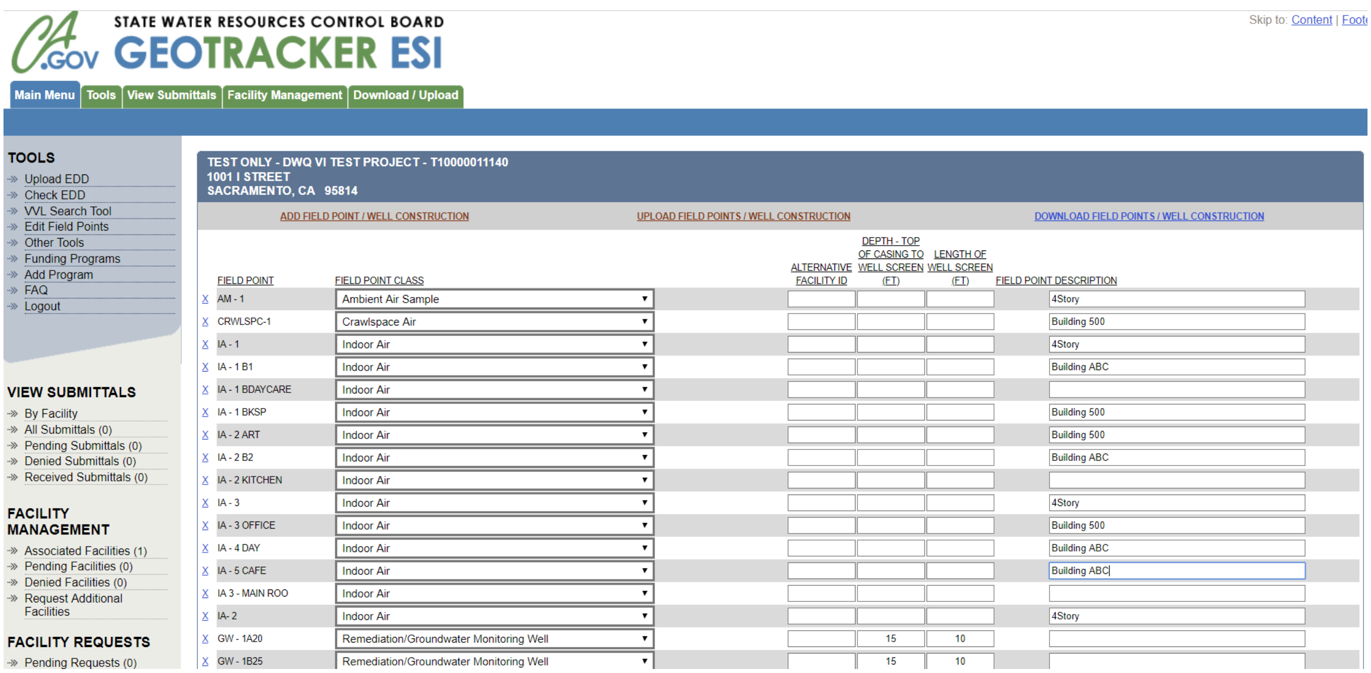


Choose the appropriate file and then select “Upload file” to store Field Points in the database.



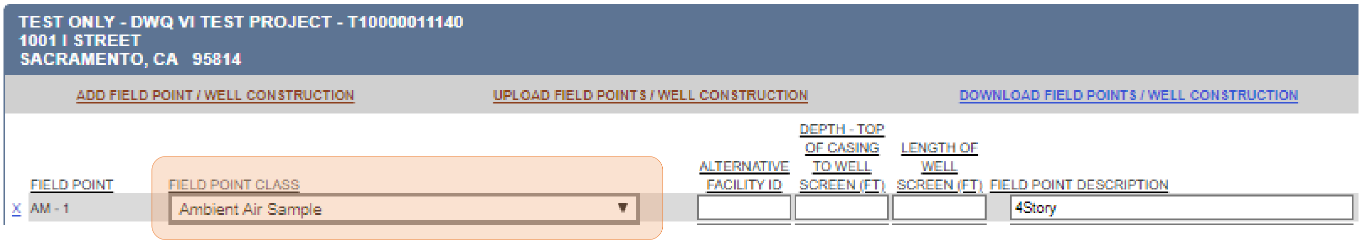
D. EDIT FIELD POINT

Once Field Points are added/uploaded to a Site/Facility, the list of Field Points for the VI study area will be stored in one location within the database shown below. This page also has the functionality to edit or delete Field Point information. Normally, the Alternative Facility ID is left blank.

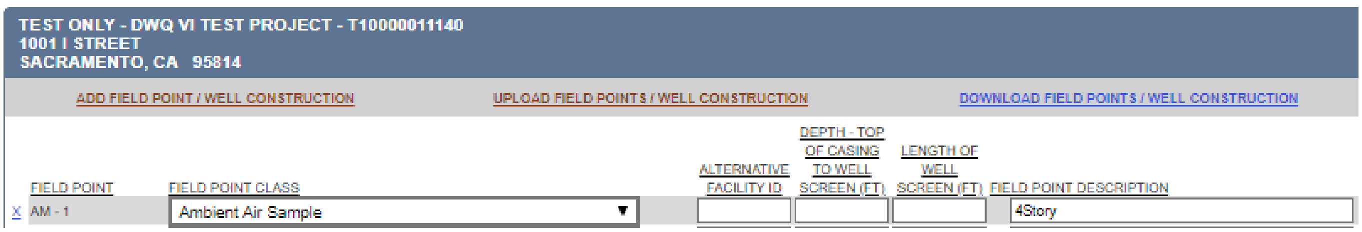


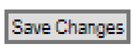
Note: The Field Point name can only be edited by deleting the Field Point and recreating the Field Point.

To edit Field Point Class, use the drop-down menu (refer to Section II.A).

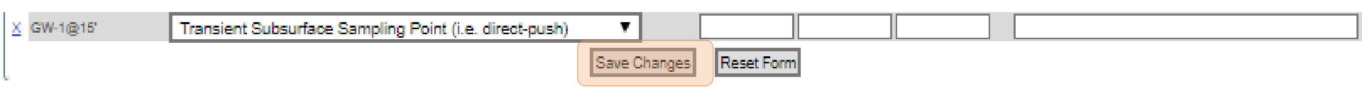


To edit depth (top of casing to well screen), length of well screen, or Field Point description, manually enter changes.

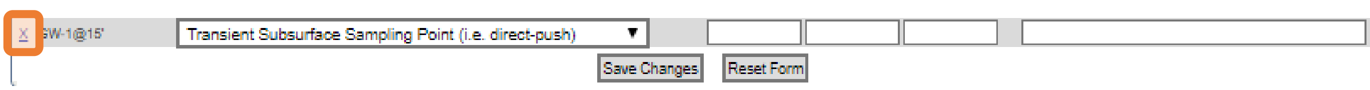


To save edits, select 

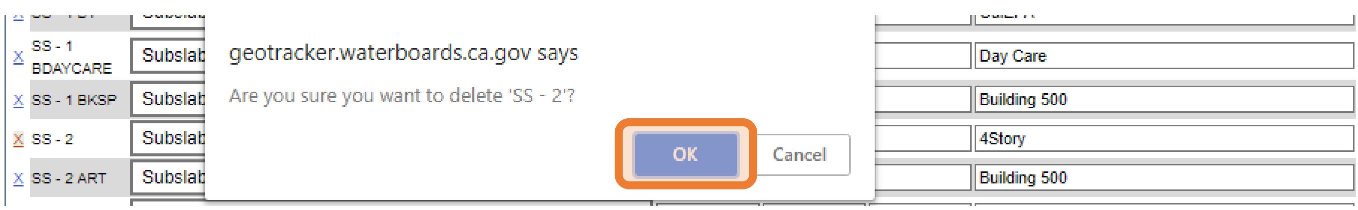
located at the bottom of the page.



To delete a Field Point, select X on the left-hand side of the list.



The system will ask the user to confirm deletion of the entry; select “OK” to delete Field Point from database.



Note: Once laboratory analytical data is uploaded to a Field Point, the Field Point is no longer available to be deleted.

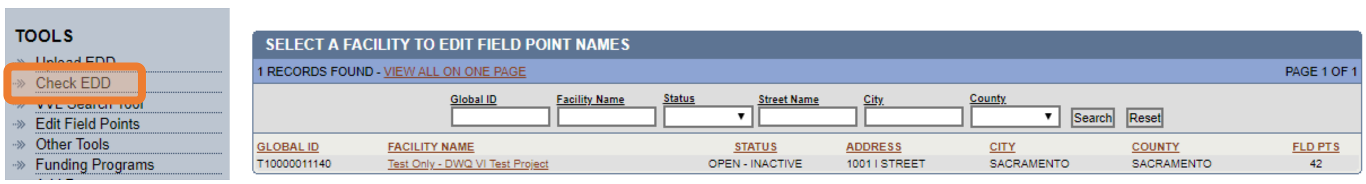
E. UPLOADING LABORATORY ANALYTICAL DATA TO FIELD POINTS FOR VAPOR INTRUSION ASSESSMENT

Once Field Points are created in the database for a Site/Facility, the user will need to upload laboratory analytical data (EDF) and the associated GEO_Report (written report) for a VI assessment. EDF files are normally created by the laboratory, not by the Responsible Party (RP) or consultant, but are normally uploaded by the RP or consultant, not by the laboratory (for information about the formatting and structure of EDF files, refer to "Technical Information on Uploading data").[3] The following sections outline how to check the data format, upload analytical data, and upload the associated report.

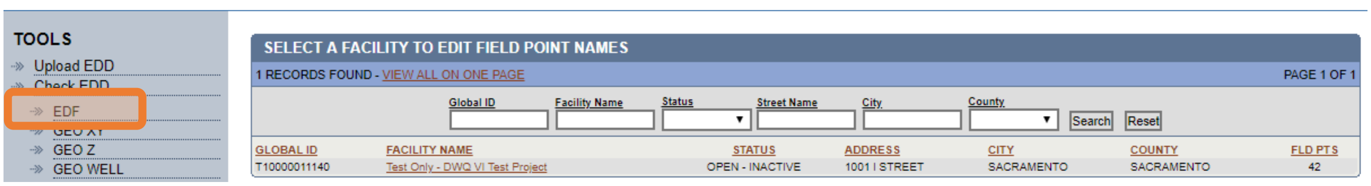
Check Laboratory Analytical Data

Before the laboratory analytical data for a VI assessment is uploaded to the database, verify that the EDF is valid to prevent errors in the upload format.

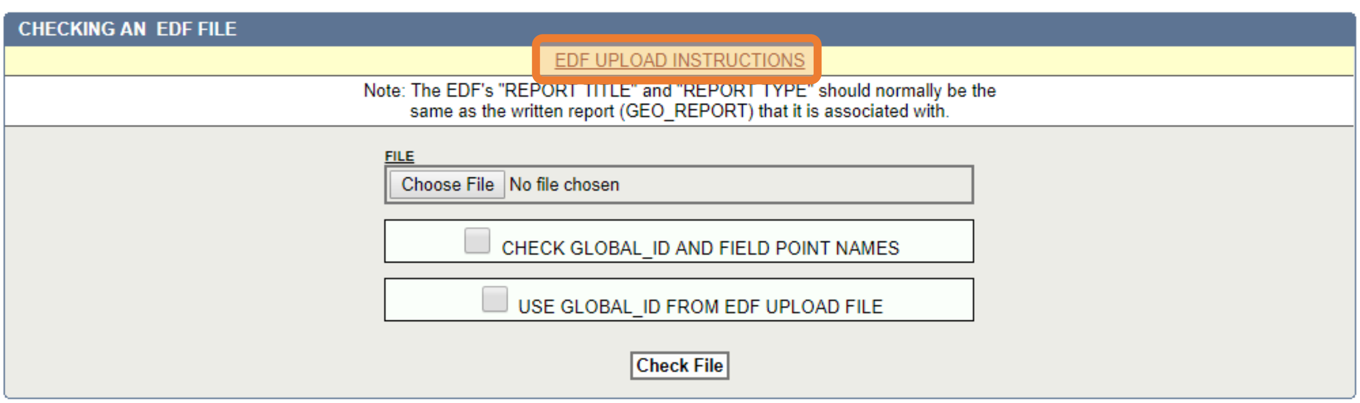
Under tools on the left-hand side, select "Check EDD."



Under check EDD, select "EDF."



Follow "EDF Upload Instructions" to error-check the lab analytical data file.



Upload Laboratory Analytical Data

Once the laboratory analytical data is verified, the EDF is ready to be uploaded to Field Points in the database.

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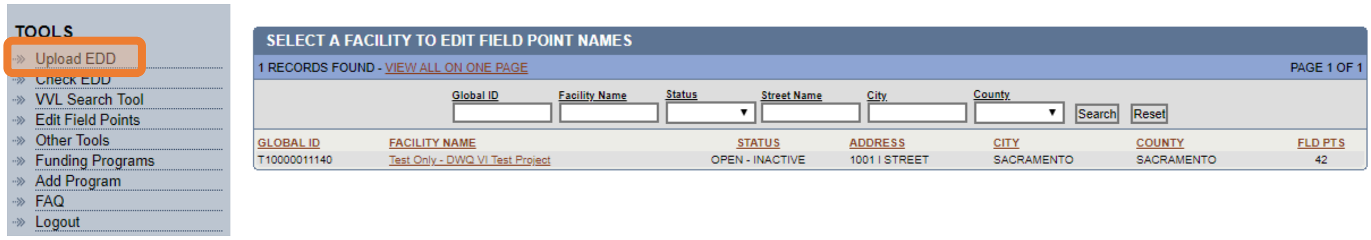
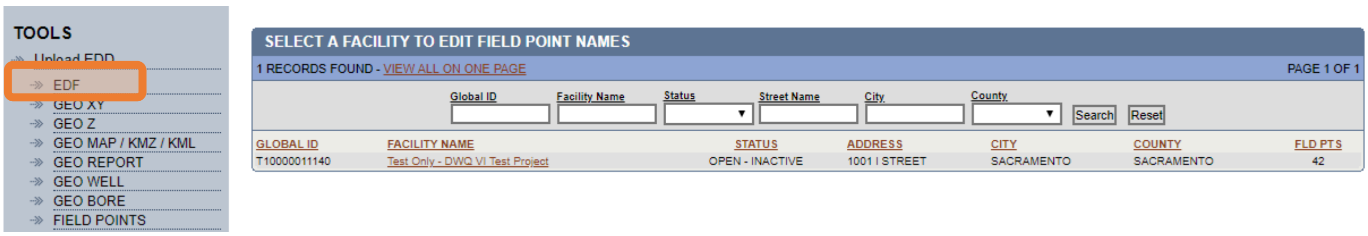
[3] https://www.waterboards.ca.gov/ust/electronic_submittal/index.shtml

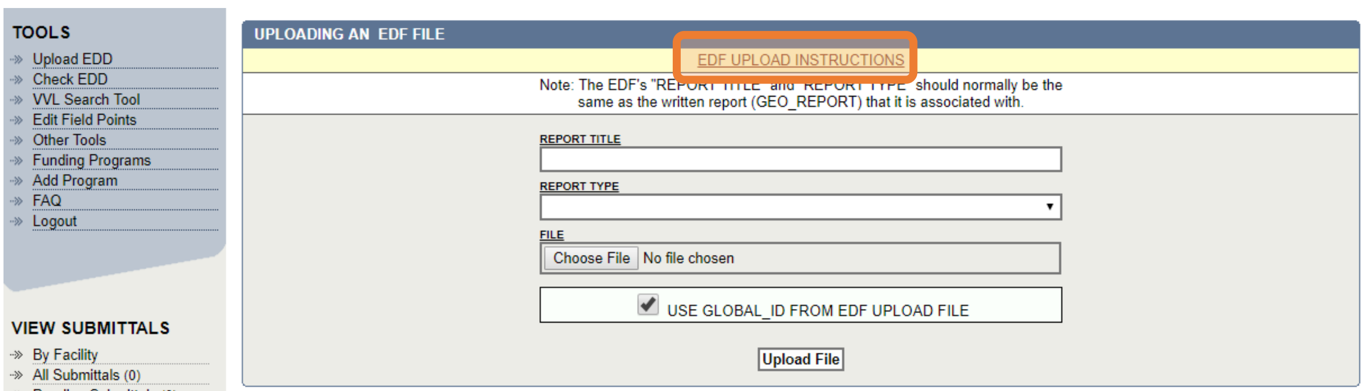
Under tools on the left-hand side, select “Upload EDD.”



Under Upload EDD, select “EDF.”



Follow “EDF Upload Instructions” to upload lab analytical data file.

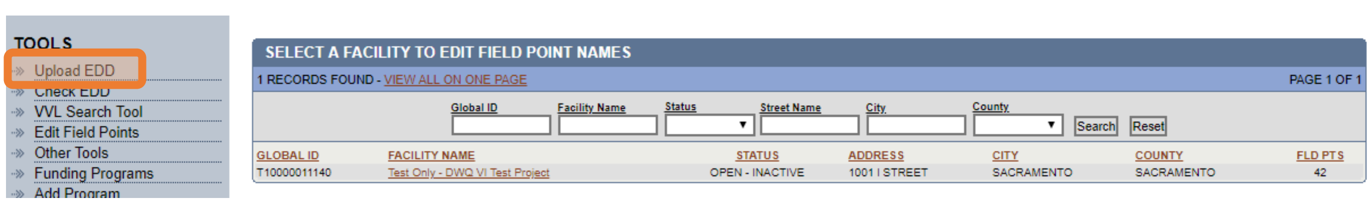


Note: The UPLOAD TITLE and REPORT TYPE for laboratory analytical data should match the UPLOAD TITLE and REPORT TYPE of its associated GEO_REPORT (the written report).

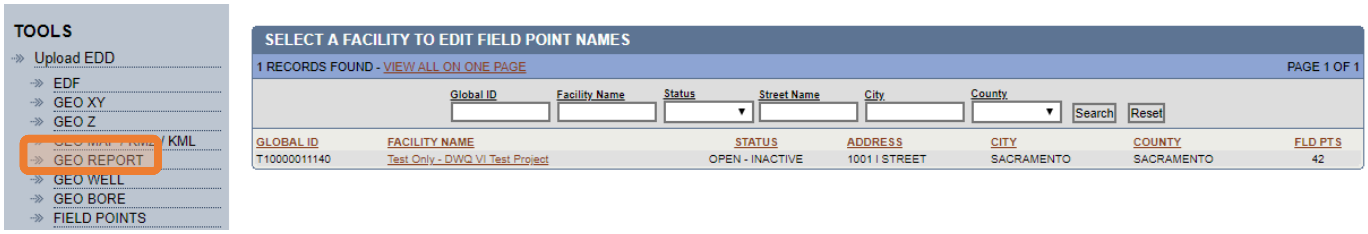
Upload GEO_Report Associated With Laboratory Analytical Data

The GEO_Report is an electronic version (PDF file format) of the complete written report. Upload the GEO_Report with the associated laboratory analytical data.

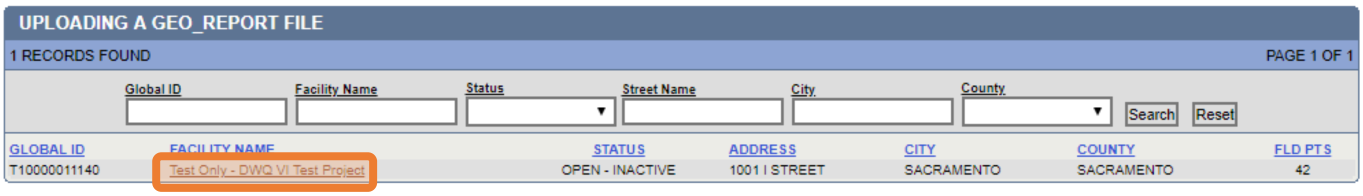
Under Tools on the left-hand side, select “Upload EDD.”



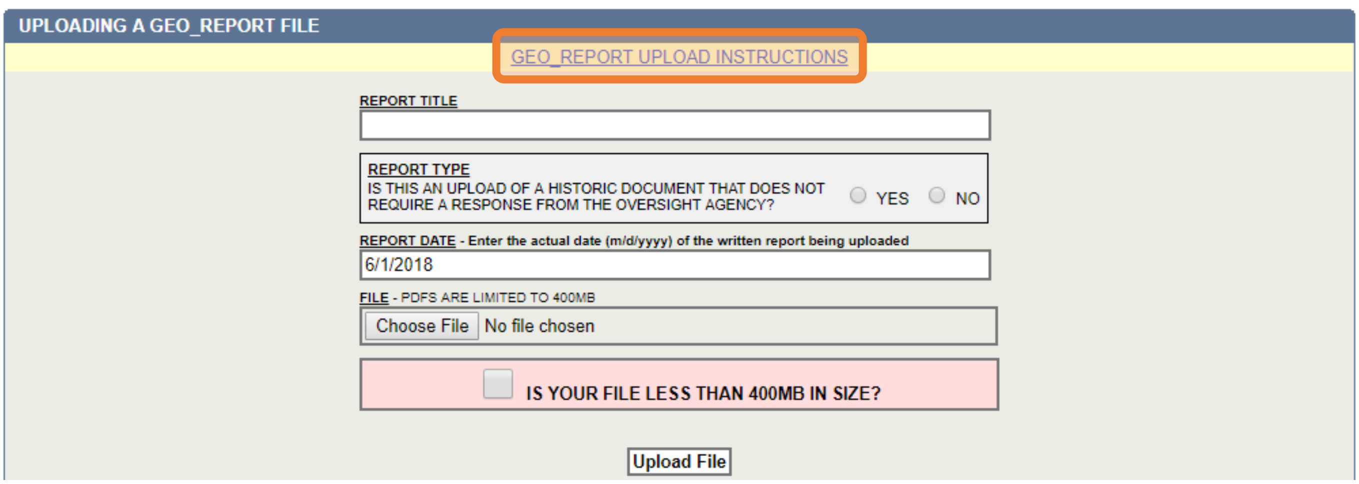
Under Upload EDD, select "GEO_Report."



Select the facility for uploading.



Follow the "GEO_Report Upload Instructions" to upload the report associated with the laboratory analytical data.



F. GEOTRACKER ESI INFORMATION & CONTACTS

For additional information, refer to GeoTracker's ESI informational page: https://www.waterboards.ca.gov/ust/electronic_submittal/index.shtml or contact the GeoTracker Help Desk: geotracker@waterboards.ca.gov.

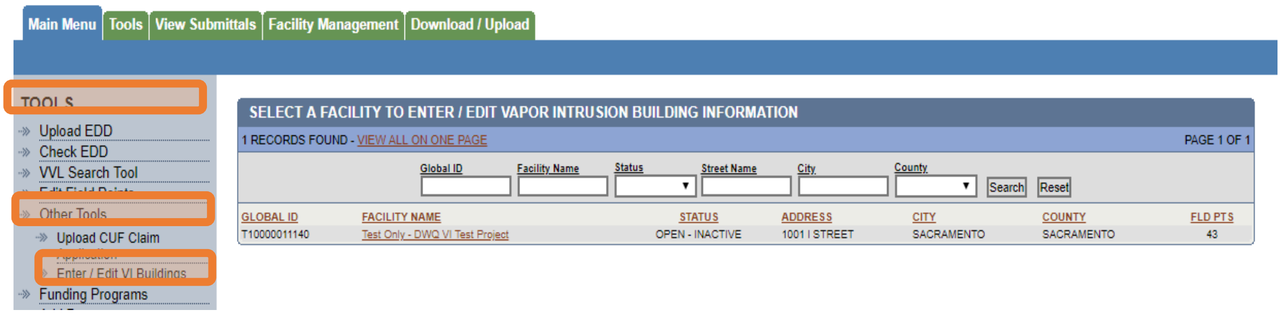
III. GEOTRACKER VAPOR INTRUSION ESI FUNCTIONALITY

The process for adding VI building profiles to a Site/Facility that will be used in a vapor intrusion assessment is outlined below. This process uses GeoTracker's ESI functionality for RPs and assigned contractors to enter the information.

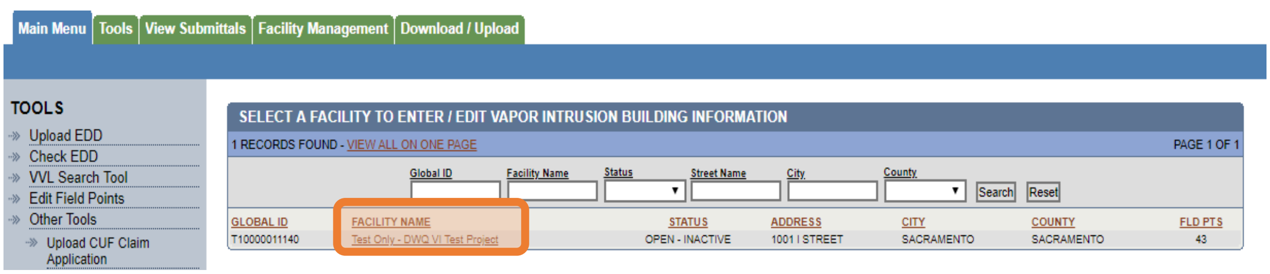
A. CREATING VAPOR INTRUSION BUILDING PROFILE

After adding Field Points and assigning the appropriate Field Point Class (refer to Section II.C), the next step is to create a building's VI building profile in the database. The VI building profile will also assist the user in co-locating Field Points within and in proximity to the building. It is important to co-locate indoor air and subslab samples when possible. VI building profiles are part of the conceptual site model for a Site/Facility and inputting each building's information into the database stores all available vapor data for a study area in one location.

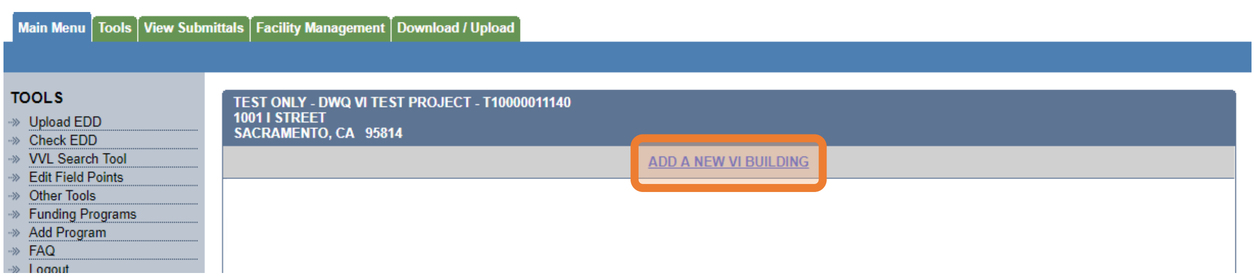
To add a VI building profile to a Site/Facility, under Tools on the left-hand side, select "Other Tools" and then select "Enter/Edit VI Buildings." This will display the available Site/Facilities the user has claimed.



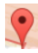
Select the Site/Facility to begin the process of adding VI building profiles for onsite and off-site buildings within the VI study area.



Select "Add a New VI Building" to create a VI building profile.

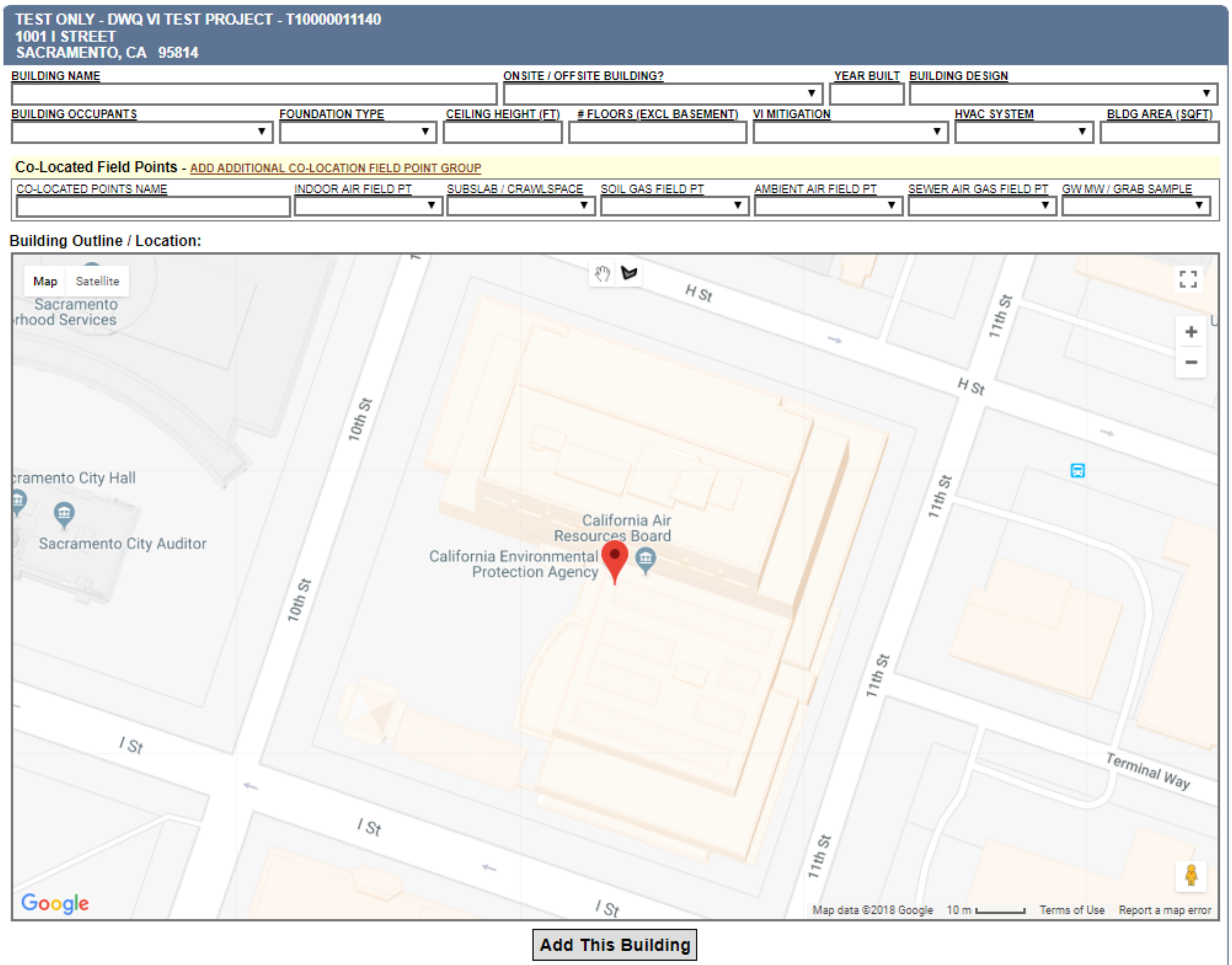


Shown below is the VI building profile page.

The locator pin  indicates the Site/Facility GeoTracker location.

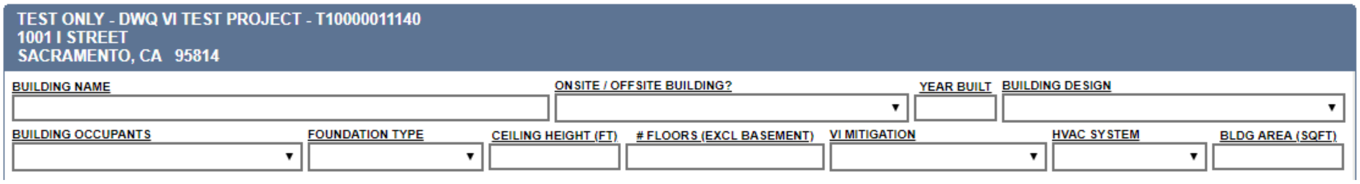
The Site/Facility's name, global ID, and address are displayed on the top menu and will be the same for all buildings in the study area for the purposes of assessing VI.

Note: There are three sections (building-specific information, co-located Field Points, and building outline/location) to complete in the VI building profile (outlined below).



B. BUILDING-SPECIFIC INFORMATION

The first section of the VI building profile is the building-specific information. This includes the Building Name, Onsite/Offsite Building, Year Built, Building Design, Building Occupants, Foundation Type, Ceiling Height (feet), Number of Floors, VI Mitigation, HVAC System, and Building Area.



Boxes that are blank indicate fields that will need to be entered manually.

Boxes with a triangle in the right corner indicate a drop-down menu. The options are defined in Table 1 below for each field.

Table 1: BUILDING SPECIFIC INFORMATION

Field	Drop-Down Option	Description
Building Name	- -	User-defined name for a site building.
Onsite/Offsite Building	Offsite – building is outside of facility/site footprint	Building is outside of site/facility property boundary.
	Onsite – building is within facility/site footprint	Building is within site/facility property boundary.
Year Built	- -	The year the building was built.
Building Design	Single Unit Residential	A single unit building designed for residential use (e.g., single-family home).
	Multi-Unit Residential	Multiple unit building designed for residential use (e.g., duplex, apartments).
	Single Unit Commercial	A single unit building designed for commercial use of one business.
	Multi-Unit Commercial	A building with multiple separate units designed for commercial use (e.g., strip mall).
	Multi-Unit Mixed Use	A multiple unit building with a combination of units either designed for commercial or residential use.
	Auditorium	A large building or hall with an open space designed for gatherings (e.g., church, theater).
	School	A large building designed with multiple rooms to facilitate educational activities.

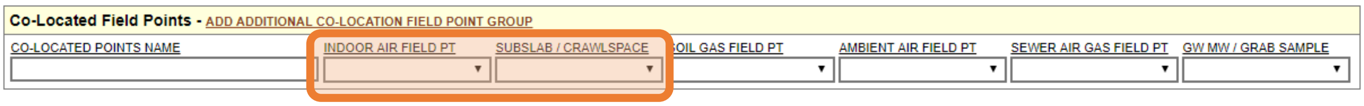
Field	Drop-Down Option	Description
	Industrial	A large building designed for the systematic processing of goods or products (e.g., packaging plant).
	Manufacturing Facility	A building designed for the manufacturing of goods from raw materials (e.g., chemical plants, research and development facilities).
	Warehouse	A large building designed to store raw materials or manufactured goods.
	Other	A building with a design type not listed.
Building Occupants	Residential	Occupants could be inside building for up to 24 hours a day.
	Commercial	Occupants could be inside building for up to 8 hours a day (typical work day).
	Residential Unit Over Commercial Unit	Residential use is prohibited only on the first floor for the occupied space.
	Sensitive Use	Building occupants that may have significantly increased sensitivity or exposure to contaminants by virtue of their age (e.g., school, child care, retirement community) or heath condition (e.g., medical facility).
	Other	Building occupants not listed.
Foundation Type	Slab-on-Grade	There is no space between the ground and the foundation system (bedding gravel and slab).
	Crawl Space	An area of limited height between the ground surface and the ground floor of a building, giving access to wiring and plumbing.
	Partial Crawl Space	Foundation is partially a crawl space and partially slab-on-grade.
	Basement	One or more floors of a building that are either completely or partially below the ground surface. Basement foundation is assumed slab-on-grade.
	Partial Basement	Foundation is partially a basement and partially slab-on-grade.
	Podium	The lowest floor of the building is constructed with more than 5 feet above the ground surface and not regularly occupied (e.g., car port beneath a building).
	Earthen	Made of compressed earth with no covering.
	Secondary Slab Pour	Modifications have been made to the original slab-on-grade foundation (e.g., remodels, garage addition, porch addition).
	Other	Foundation type is not listed.

Field	Drop-Down Option	Description
Ceiling Height (ft)	- -	The distance from the averaged floor height to the averaged ceiling height of the lowest floor, measured in feet.
# Floors (excluding Basement)	- -	Total number of floors within the building excluding the basement (i.e., 3 story building = 3).
VI Mitigation	Vapor Intrusion Barrier Only	A subslab liner (passive membrane or vapor barrier) is a material or structure installed below a building to limit the upward flow of vapors.
	Passive Vented System	A system designed to function by venting soil gas (or crawl space air) to the exterior of the building. Passive venting relies on natural thermal and wind effects to withdraw vapors from below the building.
	Active Vented System	A venting system equipped with a fan-powered vent that actively draws soil gas (or crawl space air) from beneath the building to the exterior of the building.
	Subslab Depressurization	A system designed to continuously create lower pressure directly underneath a building floor relative to the pressure within the building.
	Other	A vapor intrusion mitigation system not listed above.
	None	No vapor intrusion mitigation system in place.
HVAC System	Cooling Only	The building contains a system whose purpose is to provide cooling or significant ventilation within the building (e.g., air conditioner, whole house fans).
	Heating Only	The building contains a system whose purpose is to generate heat within the building (e.g., furnaces, fireplaces, baseboard heaters, radiators, or other regularly used system).
	Heating & Cooling	The building contains both a cooling system and a heating system.
	None	No heating or cooling systems are installed in the building.
Building Area (ft^2)	- -	The building's foundation footprint in square feet (e.g., 1,200 ft^2).

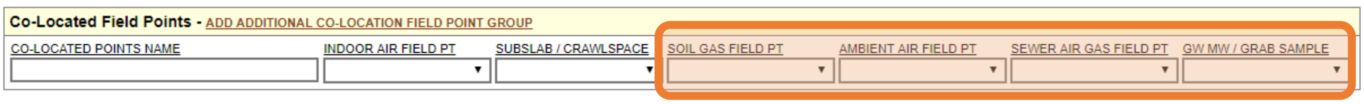
C. CO-LOCATED FIELD POINTS

The second section of the VI building profile allows the user to link each Field Point with a building for a VI assessment with the following Field Point Class types: indoor air, subslab, crawl space, soil gas, ambient (outdoor) air, sewer gas air, and groundwater. Within a building the user should co-locate the indoor air Field Points with the associated subslab (or crawl space) Field Points that are collected within the same area of the building (e.g., bathroom, kitchen, office, etc.). The co-located indoor air and subslab Field Points are the primary data pairs for a building. All applicable soil gas, ambient air, sewer air gas, and groundwater Field Points should be linked to the building as secondary data Field Points, and if appropriate linked to the primary data pair.

Primary Data Pair – Indoor Air and Subslab (or Crawlspace) Field Points



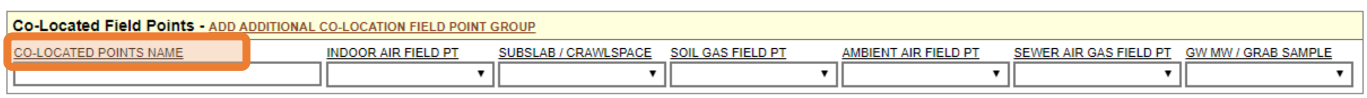
Secondary Data – Soil Gas, Ambient Air, Sewer Air Gas, and Groundwater Sample Field Points



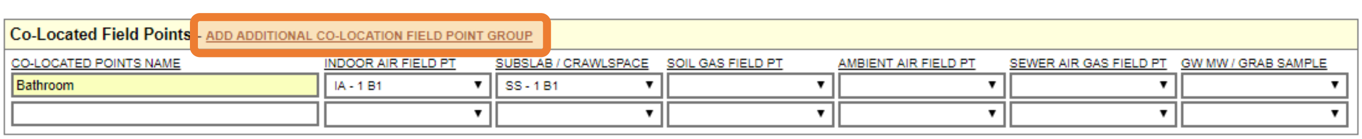
Adding a Co-Located Field Point Group

The database has the capability for the user to set up multiple Field Point Groups for a building. All co-located and linked Field Points for a building should be listed in this section of the VI building profile tool.

The "Co-Located Points Name" refers to either the specific area within the building (e.g., bathroom, kitchen) where the primary data pairs were collected or to the building name linked to the secondary data Field Points.



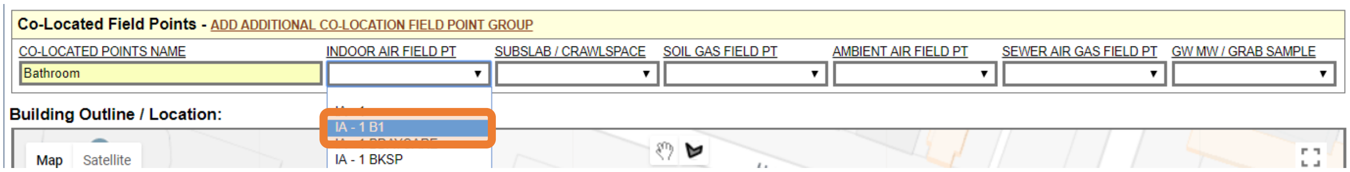
To set up multiple Field Point Groups, select "Add Additional Co-Location Field Point Group" for as many co-located or linked Field Points as needed.



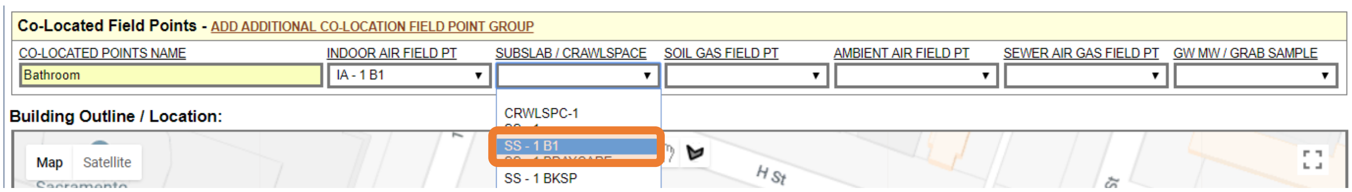
Once a co-located area has an assigned Co-Located Points Name (e.g., bathroom, building name), the associated primary data pair and secondary data Field Points should be populated by using the drop-down menu.

Co-Locating Field Point Process – Primary Data Pair

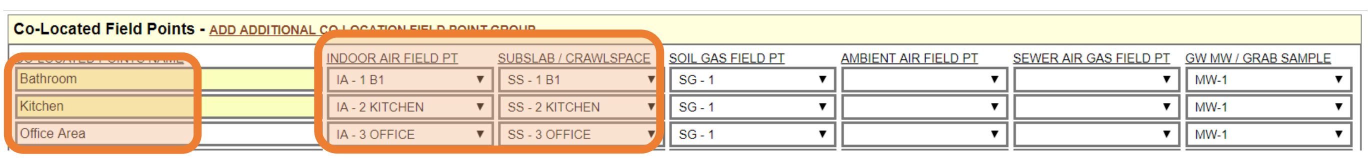
First, populate the primary data pair by clicking in the Indoor Air Field Point box; then select from the drop-down menu, and select the correct Field Point that is associated with that specific area.



Next, complete the primary data pair by clicking in the Subslab/Crawlspace Field Point box and selecting from the drop-down menu the correct Field Point that is paired with the Indoor Air Field Point and the specific area.



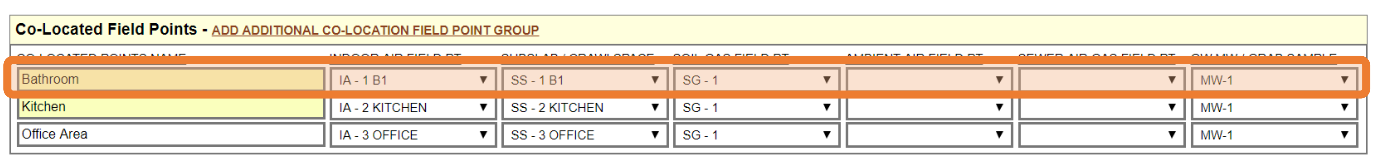
Continue to add the primary data pairs and co-locate to the specific areas within the building.



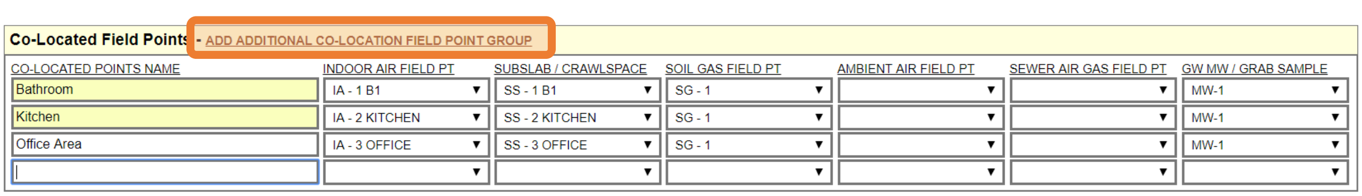
Co-Locating Field Point Process – Secondary Data

Next, populate the secondary data Field Points by clicking in the Soil Gas Field Point box, Ambient Air Field Point box, Sewer Air Gas Field Point box, or Groundwater Sample Field Point box, and select from the drop-down menu the correct Field Point that is linked to the building.

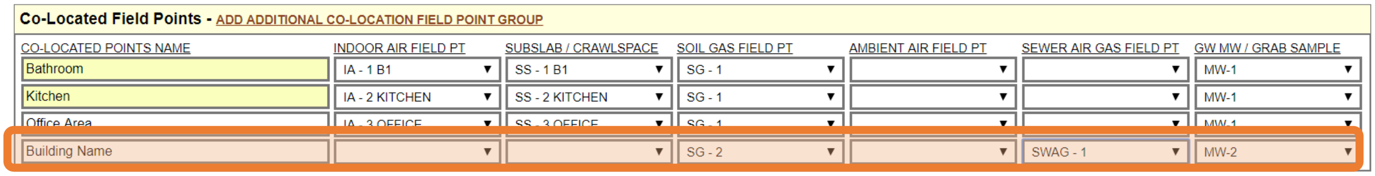
To link a secondary data Field Point to a primary data pair, select a secondary data Field Point from the drop-down box menu on that row.



To link a secondary data Field Point to the building, select “Add Additional Co-Location Field Point Group” to add a blank Co-Located Points Name.



Enter the appropriate building name, then select the secondary data Field Points from the drop-down box menu on that row.



Check to make sure the appropriate Field Point is assigned to the correct Co-Located Points Name.

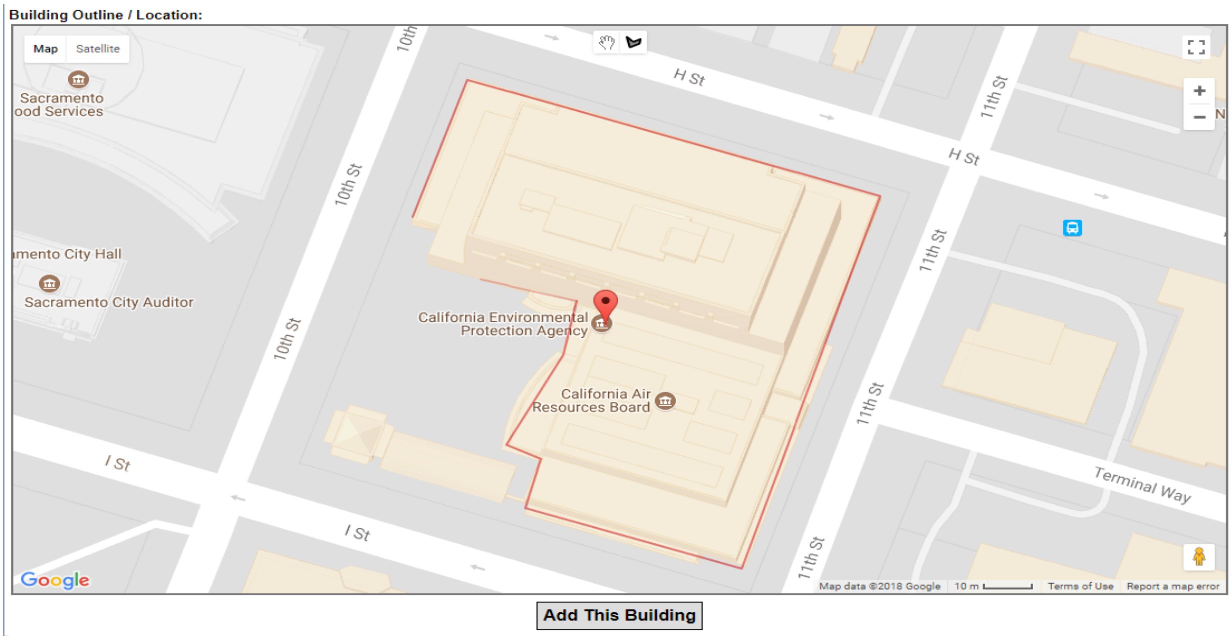
> ***Note: The drop-down boxes will only populate with the available Field Point that was assigned to a Field Point Class (refer to Section II.C). It is critical to check the Field Point to ensure it has the appropriate "Field Point Class," otherwise it will not populate as an option in the drop-down menu.***

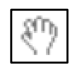
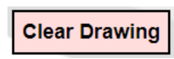
D. BUILDING OUTLINE/LOCATION

The third section of the building profile defines the spatial attributes of a building and Field Points associated with them. Certain Field Points do not have geospatial data collected and cannot be placed on a map, therefore drawing the building on the map is representative of those sample locations.

Select  the drawing tool at the top of the map to start drawing the building outline.

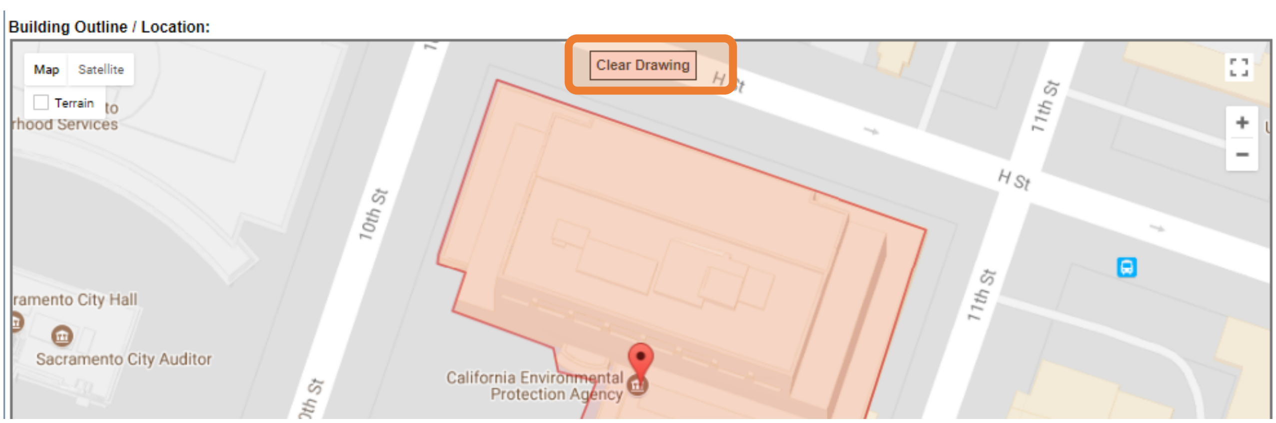
Each click on the map will place a point; use as many points necessary to outline the building shape.



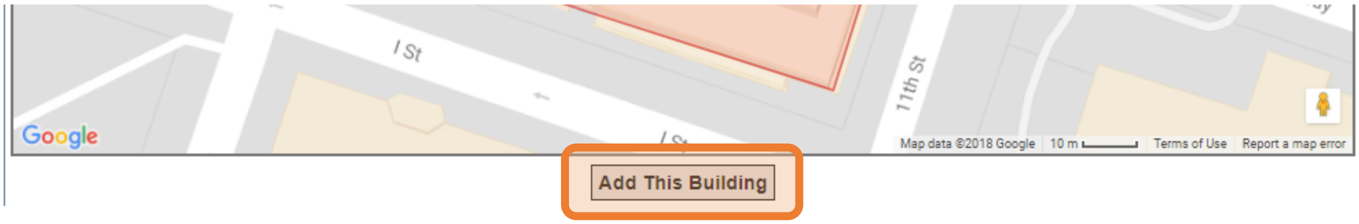
To complete the shape, double-click with mouse or select the hand at the top of the map  and the shape will connect itself and fill in with a shaded red color. Once the shape is connected, 

will appear in place of .

Select "Clear Drawing" if a mistake was made while drawing and the building outline/location will be cleared.



To complete the VI building profile, select “Add This Building” located at the bottom of the page.



The VI building profile is now stored in the database.

E. SITE/FACILITY BUILDING LIST

Once a VI building profile is stored within the Site/Facility database, the list of onsite and offsite buildings and their locations will be displayed on the Site/Facility page shown below. This page also has the functionality to edit or delete a building (described in the following section).

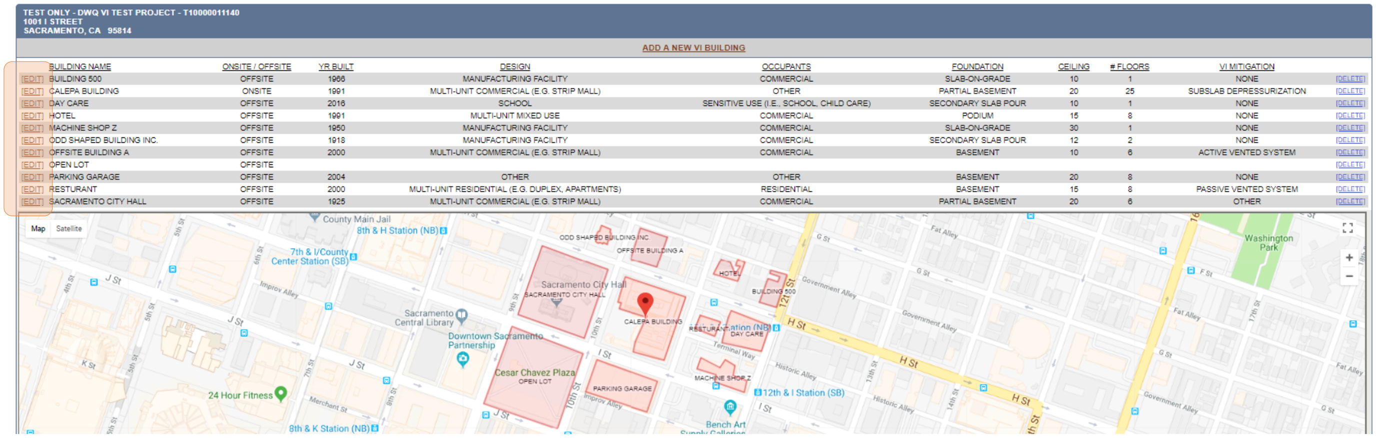

TEST ONLY - DWQ VI TEST PROJECT - T10000011140
1001 I STREET
SACRAMENTO, CA 95814

ADD A NEW VI BUILDING

	BUILDING NAME	ONSITE / OFFSITE	YR BUILT	DESIGN	OCCUPANTS	FOUNDATION	CEILING	# FLOORS	VI MITIGATION	
[EDIT]	BUILDING 500	OFFSITE	1966	MANUFACTURING FACILITY	COMMERCIAL	SLAB-ON-GRADE	10	1	NONE	[DELETE]
[EDIT]	CALEPA BUILDING	ONSITE	1991	MULTI-UNIT COMMERCIAL (E.G. STRIP MALL)	OTHER	PARTIAL BASEMENT	20	25	SUBSLAB DEPRESSURIZATION	[DELETE]
[EDIT]	DAY CARE	OFFSITE	2016	SCHOOL	SENSITIVE USE (I.E., SCHOOL, CHILD CARE)	SECONDARY SLAB POUR	10	1	NONE	[DELETE]
[EDIT]	HOTEL	OFFSITE	1991	MULTI-UNIT MIXED USE	COMMERCIAL	PODIUM	15	8	NONE	[DELETE]
[EDIT]	MACHINE SHOP Z	OFFSITE	1950	MANUFACTURING FACILITY	COMMERCIAL	SLAB-ON-GRADE	30	1	NONE	[DELETE]
[EDIT]	ODD SHAPED BUILDING INC.	OFFSITE	1918	MANUFACTURING FACILITY	COMMERCIAL	SECONDARY SLAB POUR	12	2	NONE	[DELETE]
[EDIT]	OFFSITE BUILDING A	OFFSITE	2000	MULTI-UNIT COMMERCIAL (E.G. STRIP MALL)	COMMERCIAL	BASEMENT	10	6	ACTIVE VENTED SYSTEM	[DELETE]
[EDIT]	OPEN LOT	OFFSITE								[DELETE]
[EDIT]	PARKING GARAGE	OFFSITE	2004	OTHER	OTHER	BASEMENT	20	8	NONE	[DELETE]
[EDIT]	RESTURANT	OFFSITE	2000	MULTI-UNIT RESIDENTIAL (E.G. DUPLEX, APARTMENTS)	RESIDENTIAL	BASEMENT	15	8	PASSIVE VENTED SYSTEM	[DELETE]
[EDIT]	SACRAMENTO CITY HALL	OFFSITE	1925	MULTI-UNIT COMMERCIAL (E.G. STRIP MALL)	COMMERCIAL	PARTIAL BASEMENT	20	6	OTHER	[DELETE]

F. EDIT/DELETE VAPOR INTRUSION BUILDING PROFILE

To edit or input additional building-specific information to a VI building profile, select [EDIT] located to the left of “Building Name”; this returns the user back to the VI building profile page.



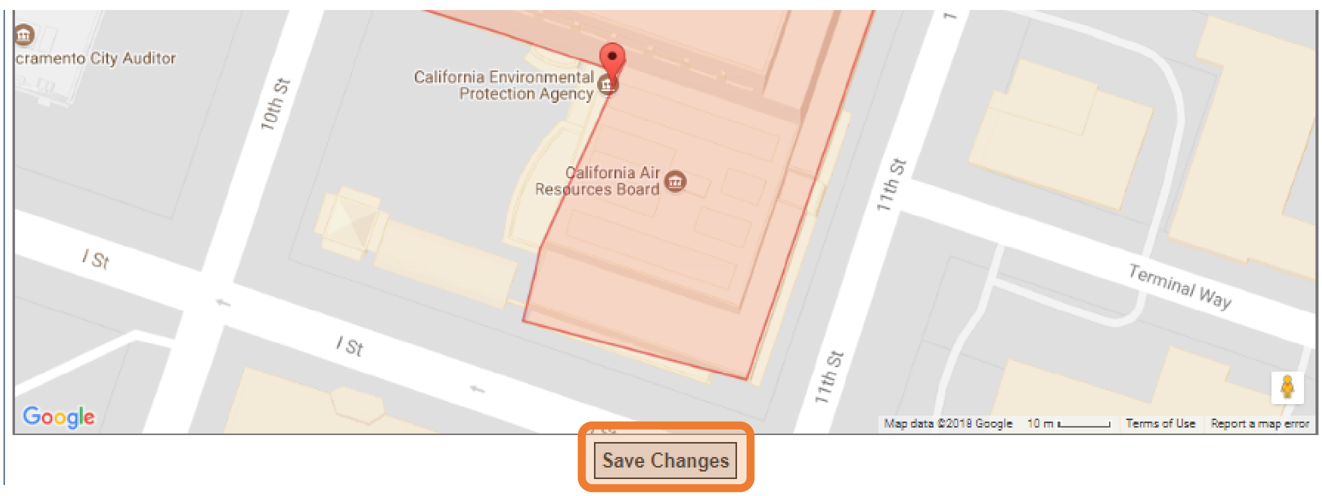
TEST ONLY - DWQ VI TEST PROJECT - T10000011140
1001 I STREET
SACRAMENTO, CA 95814

ADD A NEW VI BUILDING

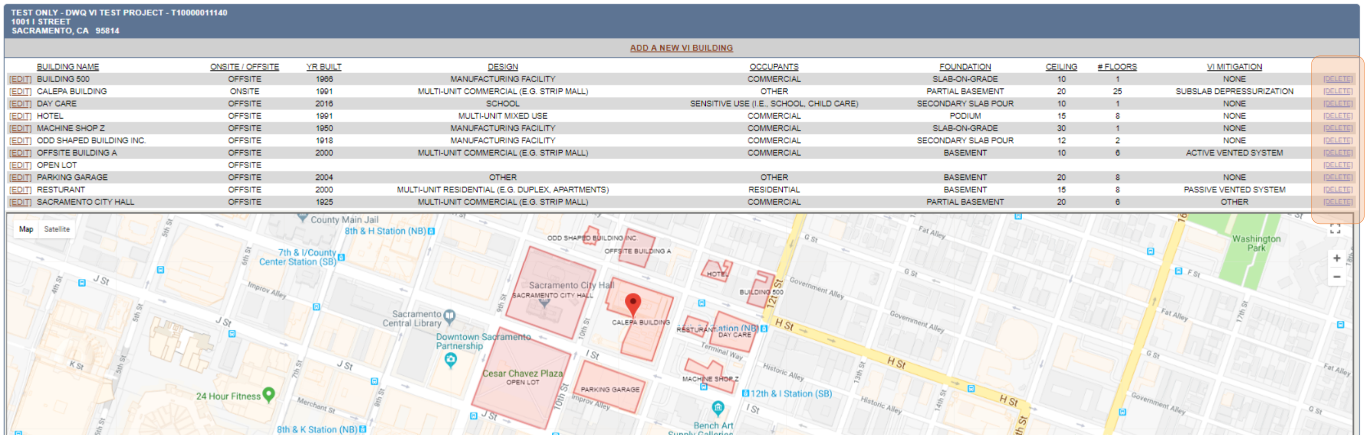
	BUILDING NAME	ONSITE / OFFSITE	YR BUILT	DESIGN	OCCUPANTS	FOUNDATION	CEILING	# FLOORS	VI MITIGATION	
[EDIT]	BUILDING 500	OFFSITE	1966	MANUFACTURING FACILITY	COMMERCIAL	SLAB-ON-GRADE	10	1	NONE	[DELETE]
[EDIT]	CALEPA BUILDING	ONSITE	1991	MULTI-UNIT COMMERCIAL (E.G. STRIP MALL)	OTHER	PARTIAL BASEMENT	20	25	SUBSLAB DEPRESSURIZATION	[DELETE]
[EDIT]	DAY CARE	OFFSITE	2016	SCHOOL	SENSITIVE USE (I.E., SCHOOL, CHILD CARE)	SECONDARY SLAB POUR	10	1	NONE	[DELETE]
[EDIT]	HOTEL	OFFSITE	1991	MULTI-UNIT MIXED USE	COMMERCIAL	PODIUM	15	8	NONE	[DELETE]
[EDIT]	MACHINE SHOP Z	OFFSITE	1950	MANUFACTURING FACILITY	COMMERCIAL	SLAB-ON-GRADE	30	1	NONE	[DELETE]
[EDIT]	ODD SHAPED BUILDING INC.	OFFSITE	1918	MANUFACTURING FACILITY	COMMERCIAL	SECONDARY SLAB POUR	12	2	NONE	[DELETE]
[EDIT]	OFFSITE BUILDING A	OFFSITE	2000	MULTI-UNIT COMMERCIAL (E.G. STRIP MALL)	COMMERCIAL	BASEMENT	10	6	ACTIVE VENTED SYSTEM	[DELETE]
[EDIT]	OPEN LOT	OFFSITE								[DELETE]
[EDIT]	PARKING GARAGE	OFFSITE	2004	OTHER	OTHER	BASEMENT	20	8	NONE	[DELETE]
[EDIT]	RESTURANT	OFFSITE	2000	MULTI-UNIT RESIDENTIAL (E.G. DUPLEX, APARTMENTS)	RESIDENTIAL	BASEMENT	15	8	PASSIVE VENTED SYSTEM	[DELETE]
[EDIT]	SACRAMENTO CITY HALL	OFFSITE	1925	MULTI-UNIT COMMERCIAL (E.G. STRIP MALL)	COMMERCIAL	PARTIAL BASEMENT	20	6	OTHER	[DELETE]

Note: Since the VI building profile has already been stored in the database, Save Changes **_will now be at the bottom of the VI building profile page._**

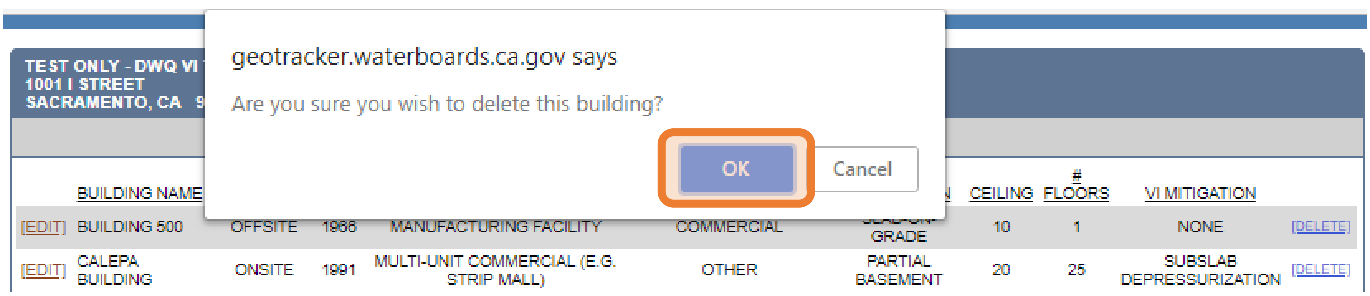
Select “Save Changes” to save modifications to the VI building profile.



To delete a VI building profile, select [DELETE] located to the right of VI Mitigation.



The system will ask the user to confirm deletion of the building, select “OK” to delete the building from the database.



Deleting a building from the database will not delete Field Points from the database.

IV. GEOTRACKER VAPOR INTRUSION DATABASE

One component of the State Water Board data management system (GeoTracker) is the VI database, which has the capability to easily accept electronic data to populate vapor concentration information for a Site/Facility and differentiate vapor concentration by the sample media. The VI database will also include building-specific information. Housing all this information in one database is a tool that helps RPs, contractors, and regulators evaluate sites for risk. The vapor concentration information is available through the public and secure portals.

The State Water Board will be assessing future modifications to the VI database to help with VI investigations.

APPENDIX A: GLOSSARY OF TERMS

EDD (Electronic Data Deliverable) – Information stored in a defined format, accessible via a computer (e.g., stored on diskette, internal hard drive, CD-ROM, magnetic tape, etc.).

EDF (Electronic Data Deliverable Format) – A comprehensive data standard designed to facilitate the transfer of electronic data files between data producers and data users. The GeoTracker EDF is specific to analytical laboratory data.

ESI (Electronic Submittal of Information) – Data submitted electronically.

Field Point – The name of a sample location (e.g., IA-1, SG-1, SSV-1, etc.).

Field Point Class – Defines the sample location's medium (e.g., indoor air sample, soil gas sample, subslab sample, etc.).

Study Area – The area that encompasses any building undergoing a vapor intrusion assessment for a particular Site/Facility.

Valid Value – Specially assigned, standardized coded value designating an approved (i.e., "valid") value for entry into a field in the database.

Vapor Intrusion Building Profile – Information collected on an individual building; the "profile" stores building-specific information, co-located Field Points, and building outline/location in one location in the GeoTracker database.

FREQUENTLY ASKED QUESTIONS

1. Why doesn't my Field Point show up as part of the co-located Field Point drop-down option?

Check that the Field Point has the appropriate Field Point Class. Field Points will only populate in the associated Field Point class as a drop-down option.

2. What do I do with previously uploaded vapor concentration data?

Previously uploaded vapor concentration data will still be in the database and will not change. It will be useful to update the Field Point Class for the vapor (Field Point) to represent the sample medium. Prior to the added capabilities of the database, Field Point Class options were limited to vapor or air.

3. Why am I getting a Global ID or Field Point Name error while checking an EDF file?

The user uploading does not have access to the specific site (labs typically do not have access); leave both checkboxes ("Check Global_ID and Field Point Names" and "Use Global_ID from EDF upload file") unchecked, and the user will be able to verify if the lab analytical data has errors.

4. What if I am the lab trying to upload EDF to a Site/Facility and the Site/Facility is not listed?

A lab will not be able to upload EDF to a Site/Facility without the Responsible Party (RP) claiming a site first. Contact the RP to gain access.

5. How do I delete a Field Point after uploading an EDF file?

Contact the GeoTracker Help Desk for assistance in deleting a Field Point.

6. How do I make corrections, additions, or delete an EDF submittal?

If your submittal has not been "Received" yet, you can delete it and then resubmit a corrected version. "Pending" submittals uploaded by you will have a "Delete Submittal" option. If your submittal has already been "Received," you'll need to contact your Lead Agency Regulator, who can retroactively "Deny" a previously "Received" submittal.

7. Where do I get help for troubleshooting?

Contact the GeoTracker Help Desk: geotracker@waterboards.ca.gov.

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Attachment 5

Building Survey and Indoor Air Source Screen Forms

Forms found at:
https://www.waterboards.ca.gov/water_issues/programs/scp/vapor_intrusion/

Attachment 5 – Building Survey and Indoor Air Source Screen Forms

Complete the Building Survey Form and Indoor Air Source Screen Form for each building where indoor air sampling is needed to assess vapor intrusion risk. Printable versions of the Forms are included in this appendix; however, users should download and complete the forms electronically in Microsoft Excel™ format found on the State Water Board's Vapor Intrusion website: https://www.waterboards.ca.gov/water_issues/programs/scp/vapor_intrusion/.

Gather information to enter into the forms during Step 3A of the indoor air investigation process described in this document. As appropriate, entries should either be typed in or selected from drop-down lists (green and yellow boxes). See Table 1 of Attachment 4 (Guidance on Uploading Vapor Intrusion Information into GeoTracker) for the building field descriptions.

Building Survey Form

Type in or select answers from drop-down lists in the righthand column.
Upload answers to GeoTracker database for criteria marked with an asterisks (*).
See Table 1 in the *Guidance on Uploading Vapor Intrusion Information into GeoTracker* (Attachment 4 of Supplemental Vapor Intrusion Guidance) for a description of Building Design Type input choices.

Person Conducting Survey	Input
Name:	
Company:	
Phone Number:	
Email:	

Building Contact Information	Input
Name:	
Contact Title:	-
Phone Number:	
Email:	
Building Occupant Interviewed?	-

Building Information	Input
Date of Building Survey (dd/mm/yy):	
*Building Name:	
*Building Address (Street, City):	
Coordinates for Center of Building (Latitude, Longitude; decimal degrees to 0.00000):	
*Building Location Onsite/Offsite with respect to Site/Facility:	-
*Year Built (yyyy; approximate if unsure):	
*Building Occupants:	-

Building Survey Form

Building Dimensions	Input
*Building Footprint Area (within enclosed space; square feet [Ft2]):	
Building Dimensions (at grade; feet by feet):	
*Ceiling Height of Ground Floor (Feet):	
*Number of Floors (excluding the basement):	

Building Design	Input
*Building Design Type:	-
Has the design been modified?	-
*Foundation Type:	-
*Building Vapor Intrusion Mitigation System:	-
*Heating, Ventilation, & Air Conditioning (HVAC) System:	-
Type of Energy Used in Building?	-
Energy Primarily Used For?	-
Number of Units for Multi-Unit Buildings:	
Number of Rooms (average per unit for multi-unit buildings):	
Number of Exterior Doors:	
Number of Elevators:	
Number of Active Exhaust Fans (e.g., kitchen/bathroom):	
Chimney or Other Vertical Draft Source?	-

Building Slab	Input
Slab Thickness (inches; approximate if unsure):	
Large Slab Penetrations (> 1 Foot Diameter):	-
Soil Type 0 to 3 Feet Below Building:	-
Evidence of moisture intrusion from Below Slab?	-

Building Survey Form

Building Windows	Input
Number of Windows:	
Weather Sealed Windows and Exterior Doors?	-
Average Area of Window Open to Outside Air (Feet2):	
Ventilation During Sampling:	-

Building Crawl Space	Input
Crawl Space Height (Feet):	
Number Crawl Space Vents:	
Average Area per Crawl Space Vent (Feet2):	
Evidence of moisture intrusion into Crawl Space from Soil?	-

Building Basement	Input
Basement Height (Feet):	
Basement Footprint Area (Feet2):	
Basement Wall Area Below Ground Surface (Feet2):	
Exposed Basement above grade?	-
Vents or Windows above-grade in exposed basement?	-
Unfinished Basement?	-
Evidence of moisture intrusion into Basement from Soil?	-

Building Survey Form

Factors Potentially Influencing Indoor Air Quality	Input
Is there an attached garage?	-
Is there smoking in the building?	-
Is there new carpet or furniture?	-
Have clothes or drapes been recently dry cleaned?	-
Has painting or staining been done within the last six months?	-
Has the building been recently remodeled?	-
Has the building ever had a fire?	-
Is there a hobby or craft area in the building?	-
Are cleaning solvents stored in the building (e.g., spot cleaner, gun cleaner?	-
Is there a fuel oil tank on the property?	-
Is there a septic tank on the property?	-
Has the building been fumigated or sprayed for pests recently?	-
Historically the building was primarily used for?	-
Do current building occupants use solvents at another location (e.g., work, hobby)?	-

Meteorological Conditions	Input
Weather:	
Outdoor Temperature - High (°F):	
Outdoor Temperature - Low (°F):	
Indoor Temperature (°F):	
Barometric Pressure Reading (mmHg):	
Wind Direction:	-
Average Wind Speed (mph):	
HVAC Setting for Current Season:	-

(End of Form)

Building Survey Form Drop Down Lists

Building Contact Information

Contact Title:
Owner
Manager
Occupant
Other

Building Occupant Interviewed?
Yes
No

Building Information

***Building Location Onsite/Offsite/Offsite with respect to Site/Facility**
Onsite
Offsite

***Building Occupants:**
Residential
Commercial
Residential Unit over Commercial Unit
Sensitive Use (e.g. Child Care or Medical Facility)

Building Design

***Building Design Type:**
Single Unit Residential
Multi-Unit Residential (e.g. duplex, apartments)
Single Unit Commercial
Multi-Unit Commercial (e.g. strip mall)
Multi-Unit Mixed Use
Auditorium (e.g. church, theater)
School
Industrial
Manufacturing Facility
Warehouse
Other

Has the design been modified?
Yes
No
Unknown

***Foundation Type:**
Slab-on-Grade
Crawl Space
Partial Crawl Space
Basement
Partial Basement
Podium
Earthen
Secondary Slab Pour
Other

***Building Vapor Intrusion Mitigation System:**
Vapor Intrusion Barrier Only
Passive Vented System
Active Vented System
Subslab Depressurization System
Other
None

***Heating Ventilation, & Air Conditioning (HVAC) System:**
Heating Only
Cooling Only
Heating & Cooling
None

Type of Energy Used in Building?
Natural Gas
Fuel Oil
Propane
Electricity
Wood
Kerosene
More Than One Type
Other
None
Unknown

Energy Primarily Used For?
Space Heating
Water Heating
Cooking
Drying Laundry (Interior)
Commercial/Industrial Processes
Other
Unknown

Chimney or Other Vertical Draft Source?
Yes
No

Building Slab

Large Slab Penetrations (> 1 Foot Diameter):
Sump
Elevator Shaft
Floor Drain
Other
None

Soil Type 0 to 3 Feet Below Building:
Fine
Coarse
Fine and Coarse
Unknown

Evidence of moisture intrusion from Below Slab?
Yes
No
N/A

Building Windows

Weather Sealed Windows and Exterior Doors?
All Sealed
Some Sealed
None Sealed
Unknown

Ventilation During Sampling:
Open Windows
Closed Windows
Some Windows Open

Building Crawl Space

Evidence of moisture intrusion into Crawl Space from Soil?
Yes
No
N/A

Building Basement

Exposed Basement above grade?
Yes

No
N/A

Vents or Windows above-grade in exposed basement?
Yes
No
N/A

Unfinished Basement?
Yes
No
N/A

Evidence of moisture intrusion into Basement from Soil?
Yes
No
N/A

Factors Potentially Influencing Indoor Air Quality

Is there an attached garage?
Yes
No
N/A

Is there smoking in the building?
Yes
No

Is there new carpet or furniture?
Yes
No
N/A

Have clothes or drapes been recently dry cleaned?
Yes
No
N/A

Has painting or staining been done within the last six months?
Yes
No
N/A

Has the building been recently remodeled?
Yes
No
N/A

Has the building ever had a fire?
Yes
No
N/A

Is there a hobby or craft area in the building?
Yes
No
N/A

Are cleaning solvents stored in the building (e.g., spot cleaner, gun cleaner?)
Yes
No
N/A

Is there a fuel oil tank on the property?
Yes
No
N/A

Is there a septic tank on the property?
Yes
No
N/A

Has the building been fumigated or sprayed for pests recently?
Yes
No
N/A

Historically the building was primarily used for?
Dy Cleaner
Industrial Degreasing/Cleaning
Laboratory
Manufacturing
Painting/Finishing
Other
None

Do current building occupants use solvents at another location (e.g., work, hobby)?
Dy Cleaner
Industrial Degreasing/Cleaning
Laboratory
Manufacturing

Painting/Finishing
Other
None

Meteorological Conditions

Wind Direction:
N
NW
NE
W
S
SW
SE
E

HVAC Setting for Current Season?
Heating
Cooling
Off

Indoor Air Source Screen Form

This form should be used while conducting field screening (Step 3A.3, Supplemental Vapor Intrusion Guidance). An Indoor Air Source Screen Survey of indoor air will help identify potential sources of vapor forming chemicals (VFCs) and/or potential subsurface vapor entry points. Common screening tools, such as, Photoionization Detector (PID), Gas Chromatography-Photoionization Detector (GC-PID), Gas Chromatography-Mass Spectrometry (GC-MS), or Gas Chromatography-Electron Capture Detector (GC-ECD), should be used to detect the presence of VFCs in the air.

Use this form to document the room/area and location where the measurement was recorded during the Indoor Air Source Screen Survey, the field instrument type used, and the instrument reading and units. If a consumer product is identified and surrounding air tested, the location and the volatile ingredients of the product should be noted. (If the item(s) may be contributing VFCs to the indoor air, the items should be removed in advance of indoor air sampling.) This survey should be used to support the development of a conceptual understanding of how vapor intrusion may be occurring at the building and used in selecting sample locations for evaluating spatial distribution of VFCs in indoor air.

Site Information	Input
Building Address:	
Site/Facility Name:	
Screening Event Date:	
Screening Event Time:	
Event Weather Conditions:	
Name of Person(s) Conducting Sampling:	
Company Conducting Sampling:	
Field Instrument Type[1] (List All):	
Instrument Calibration Date:	

1 - Photoionization Detector (PID), Gas Chromatography-Photoionization Detector (GC-PID), Gas Chromatography-Mass Spectrometry (GC-MS), Gas Chromatography-Electron Capture Detector (GC-ECD), etc.

Indoor Air Source Screen Form

Sample Room/Area	Sample Location	Sample ID	Instrument Reading	Units	Volatile Ingredients in Consumer Products Identified Near Sample
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				
-	-				
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-	-				
-	-				

Comments:

Indoor Air Source Screen Form Drop Down Lists

Sample/Room Area

Bathroom
Kitchen
Bedroom
Living Room
Retail Area
Workshop
Garage
Office
Dining
Storage
Attic
Other

Sample Location

Breathing Zone (Indoor)
Ambient Air (Outdoor)
Foundation Opening
Consumer Product
Other

End of Document