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Risk Assessment, Risk Management, and Risk Communication at Vapor Intrusion Sites

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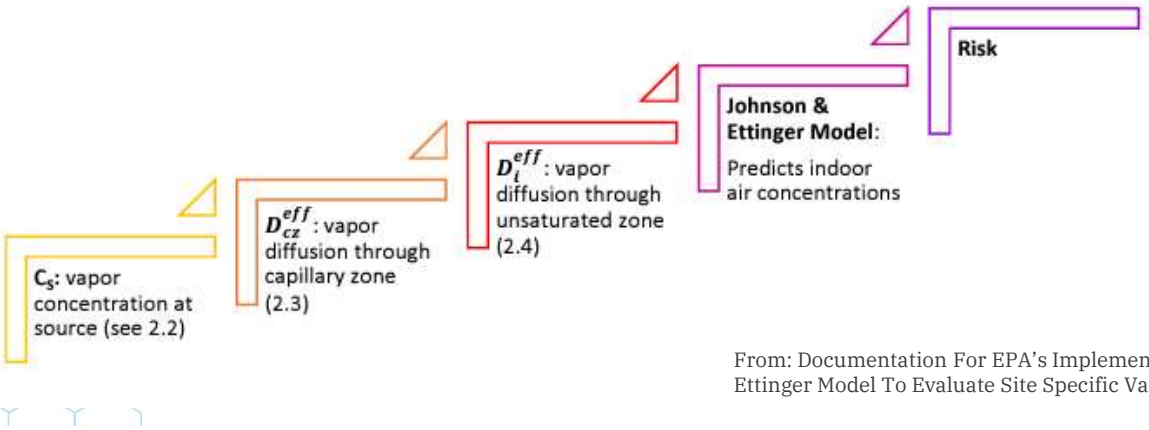
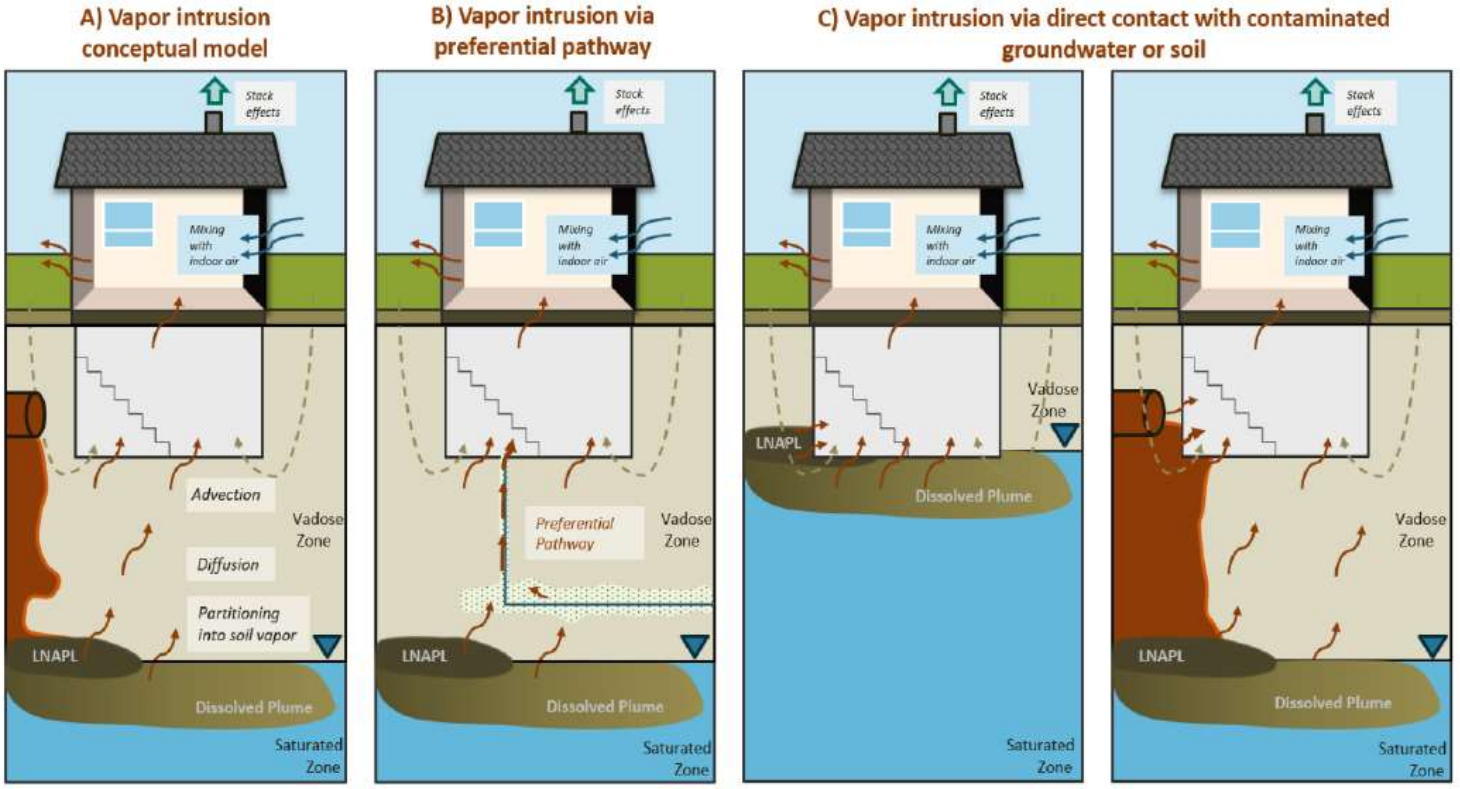
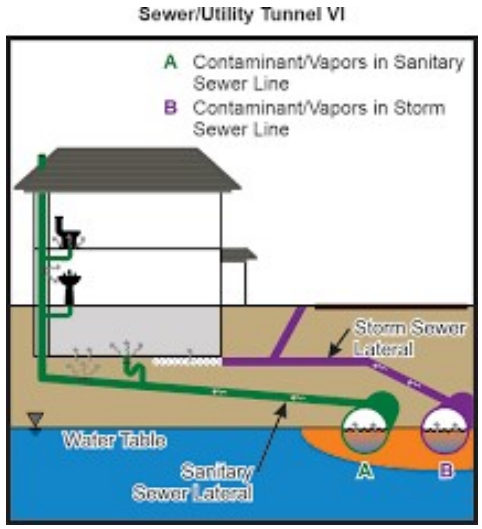
Vapor Intrusion Risks: Key Issues and Trends

- Volatile organic chemicals (VOCs) in subsurface migrate up through soil into buildings, causing an unacceptable chemical exposure for occupants
- Not all vapor intrusion (VI) sites are the same in terms of physical attributes, exposure scenarios, and receptors
- Standard modeling questioned and shift to indoor air data focus for decision-making (where you can)
- Consideration of both current and potential future exposure scenarios



From: Documentation For EPA's Implementation Of The Johnson And Ettinger Model To Evaluate Site Specific Vapor Intrusion Into Buildings (2017)





Examples of conceptual site models with complete VI pathways.

From: ODEQ Draft Guidance for Assessing and Remediating Vapor Intrusion into Buildings - Updated March 2024

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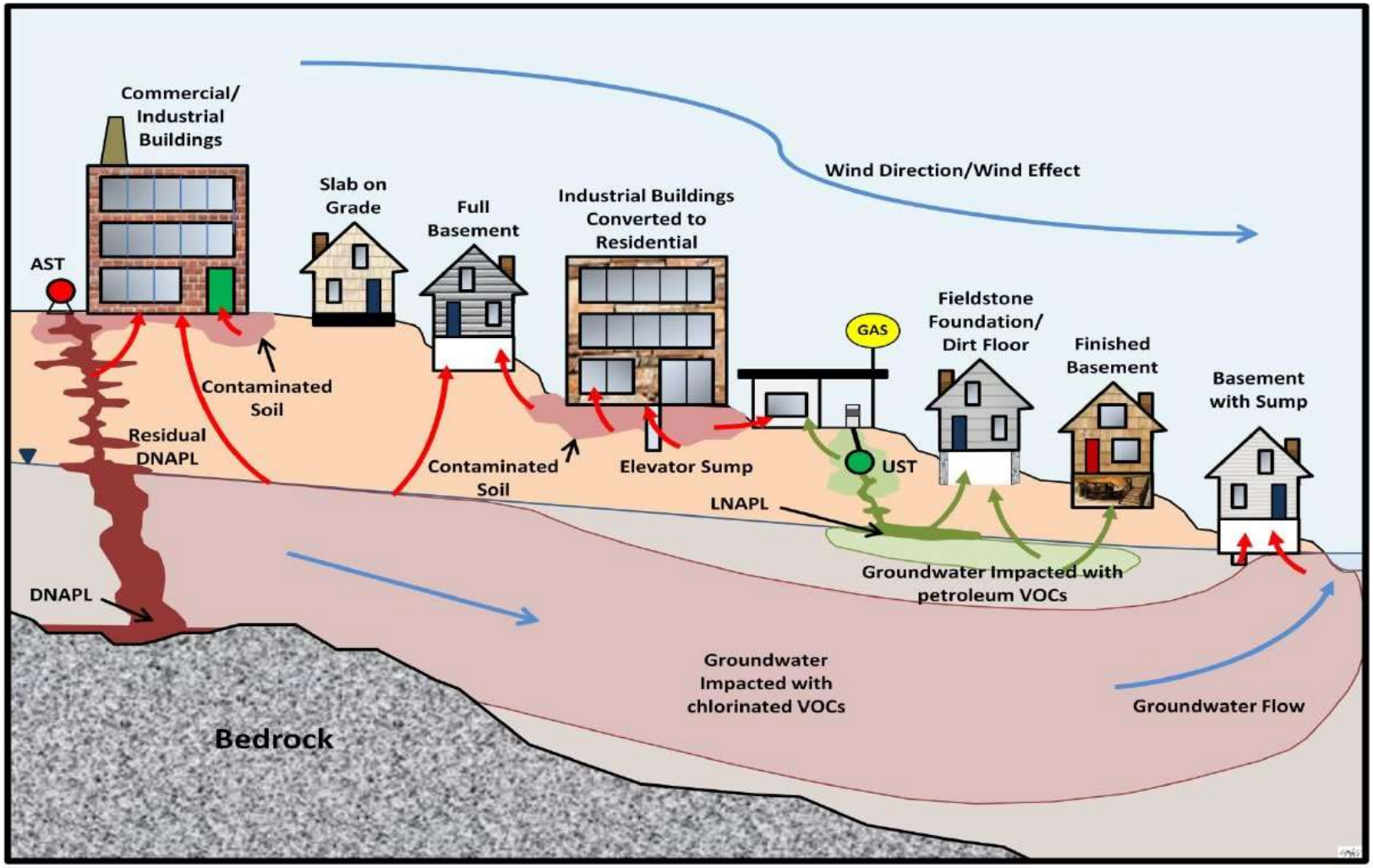

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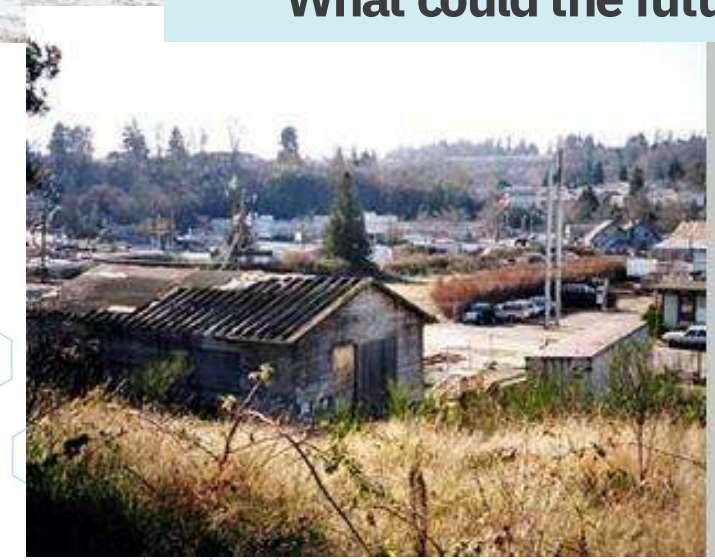
What could the future hold for VI?



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Key Regulatory Guidance

- **USEPA:** 2015 Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air
- **ITRC** (new guidance in development): 2007 Vapor Intrusion Pathway: A Practical Guide (VI-1)
- **Washington:** 2022 Guidance for Evaluating Vapor Intrusion in Washington State
- **Oregon:** 2024 Draft Guidance for Assessing and Remediating Vapor Intrusion into Buildings
- **California:** 2023 Supplemental Guidance: Screening and Evaluating Vapor Intrusion

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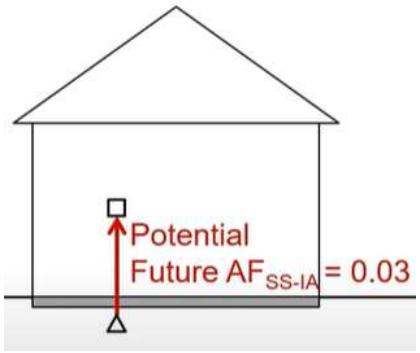
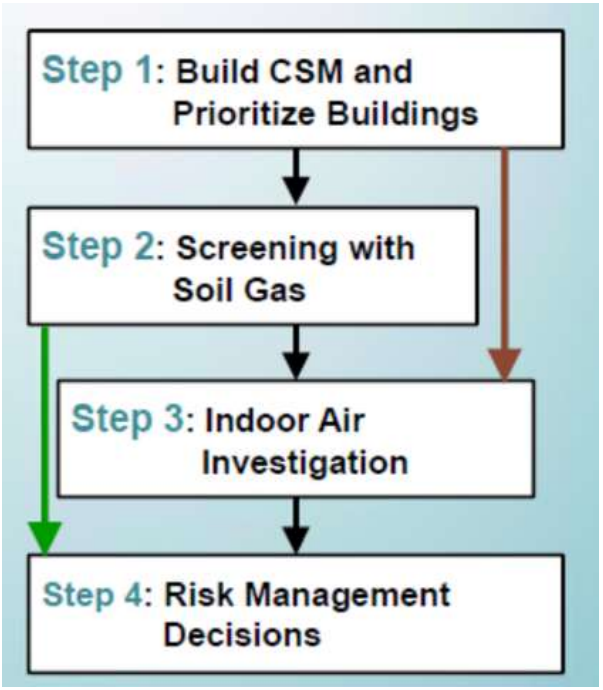
Direction for Risk Evaluations

- Eliminating use of models (e.g., Johnson & Ettinger) and screening levels for soil and groundwater
- Requiring collection of indoor air data
- Use of conservative default attenuation factors
- Start with assumption of unrestricted use (i.e., residential)
- Current and future





Consider future changes that could increase VI:

- **Changes to HVAC operation**
- **Remodeling**
- **New cracks or damage**

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Attenuation Factors

Medium	California	Oregon	Washington
Crawl space gas	1	1	NA
Subslab soil gas	0.03	0.03	0.03
Soil gas	0.03	0.03	0.03
Groundwater (generic)	0.001		0.001
Groundwater (fines)	0.0005		0.001

$$RBC_{air} = RBC_{media} * AF$$

Paired subslab and indoor air samples
can be used to calculate a building's current attenuation factor (AF).

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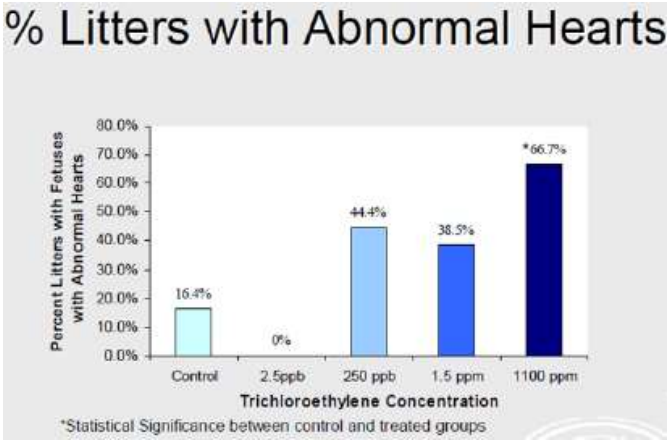
When is an Immediate Action Needed?

› TCE Action Levels

EPA Region 9 Interim TCE Indoor Air Response Action Levels - Residential and Commercial TCE Inhalation Exposure from Vapor Intrusion		
Exposure Scenario	***Accelerated Response Action Level*** *(HQ=1)*	***Urgent Response Action Level*** *(HQ=3)*[4]
Residential *	2 µg/m^3	6 µg/m^3
Commercial/Industrial ** (8-hour workday)	8 µg/m^3	24 µg/m^3
Commercial/Industrial ** (10-hour workday)	7 µg/m^3	21 µg/m^3



From: Symposium on New Scientific Research Related to the Health Effects of Trichloroethylene, Washington, DC, February 26–27, 2004. (http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=75934)

California's Proposition 65 law requires businesses to notify persons before exposing them to chemicals identified as carcinogens or reproductive toxins.

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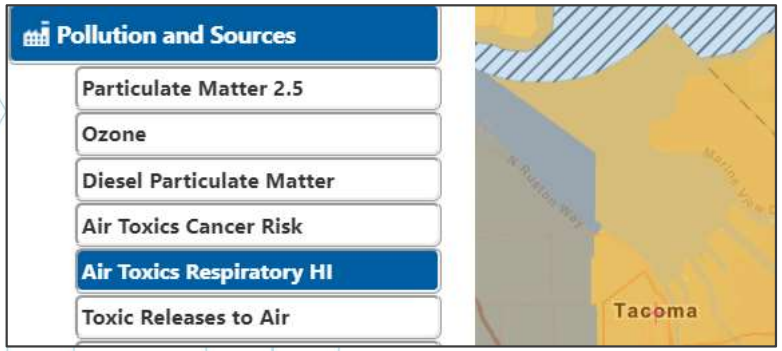
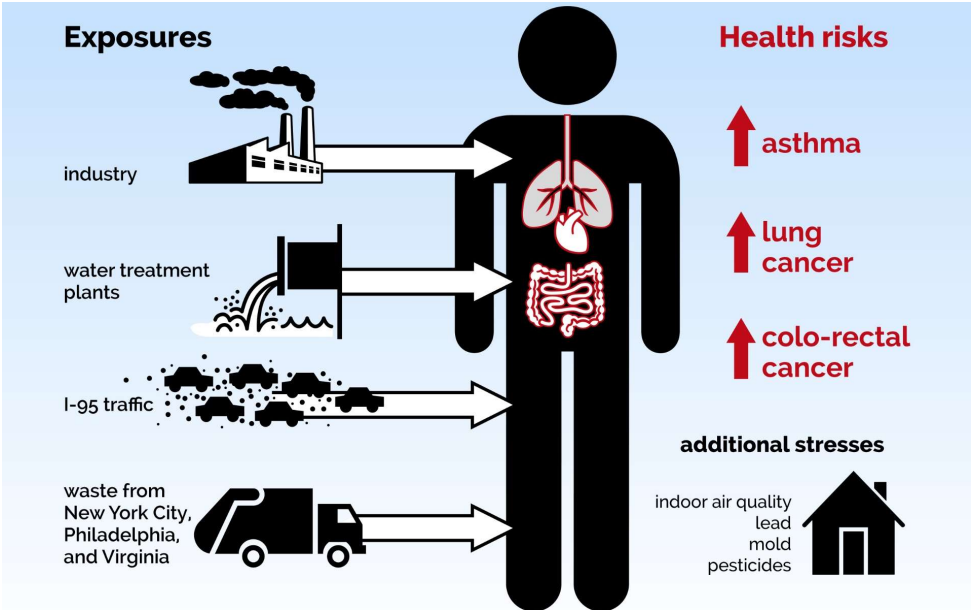
Other Circumstances

- Sensitive uses
  - School, day care, hospital, senior facility
- Trench workers
- Communities with high pollution burden





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What is the Bottom Line?

More Sampling

Mitigation/Cleanup

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What Risk Management Actions Can Be Taken Short Term?

- Increase pressurization/ventilation

- Seal potential conduits

- Carbon filtration, air purifiers

- Decrease exposure time

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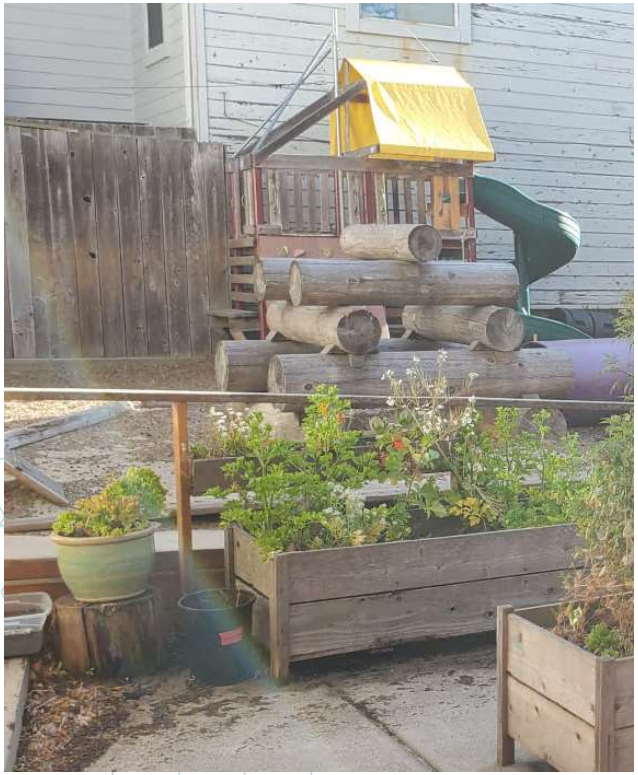
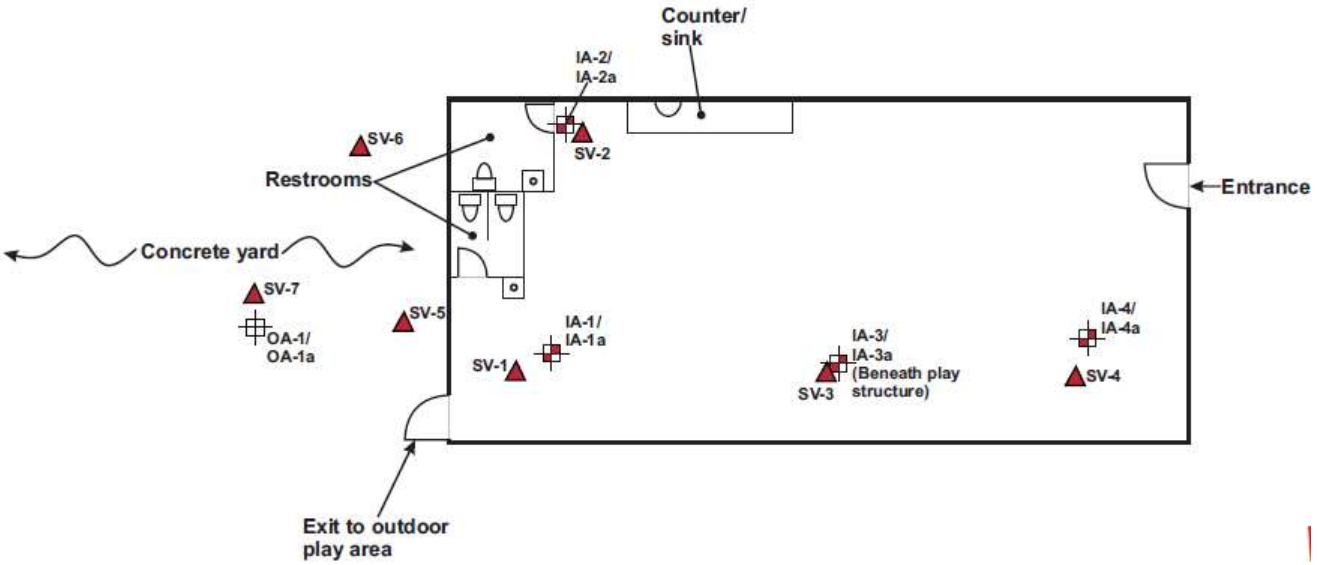
Other Considerations

- Risk management plan
- Land use covenants
- Inspections

Case Studies

San Francisco: Preschool Setting





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Soil Vapor

Sample ID	Date	PCE	TCE
SV-1	8/26/2018	180,000	<790
SV-1a	5/12/2020	180,000	460
SV-1ar	5/12/2020	190,000	480
SV-2	8/26/2018	9,200	51
SV-2a	5/12/2020	5,200	30
SV-3	8/26/2018	63,000	280
SV-3a	5/12/2020	45,000	220
SV-4	8/26/2018	23,000	68
SV-4a	5/12/2020	11,000	43
SV-7	8/26/2018	62,000	500
SV-9	5/12/2020	220	<6.4
SV-10	5/12/2020	41	<12
SV-11	5/11/2020	<8.4	<6.6
SV-13	5/11/2020	<7.9	<6.3
SV-14	5/11/2020	21	<6.6
Tier 1 Residential Soil Vapor ESL [1]		15	16

Indoor Air

(All Results in µg/m^3)

Sample Location	Sample ID	Date	PCE
Bldg 1	IA-1	8/18/2018	0.69
	IA-1a	9/9/2018	0.30
	IA-1b	5/18/2020	15
	IA-1b DUP	5/18/2020	15
	IA-1c	6/17/2020	0.651
	IA-2	8/18/2018	0.63
	IA-2a	9/9/2018	0.30
	IA-2b	5/18/2020	14
	IA-2c	6/17/2020	0.434
	IA-3	8/18/2018	0.68
	IA-3a	9/9/2018	0.34
	IA-3b	5/18/2020	15
	IA-3c	6/17/2020	0.590
	IA-4	8/18/2018	0.63
	IA-4a	9/9/2018	0.28
	IA-4b	5/18/2020	15
	IA-4c	6/17/2020	0.624
	OA-1	8/18/2018	<0.22
	OA-1a	9/9/2018	<0.23
	OA-1b	5/18/2020	<0.22
	OA-1c	6/17/2020	0.495
Bldg 2	IA-5	5/18/2020	1.9
	IA-6	5/18/2020	1.9
Bldg 3	IA-1	5/18/2020	<0.22

Indoor Air Screening Levels for PCE

Default = 0.46 ug/m^3
Site-specific = 2 µg/m^3

May 2020 sampling event – ventilation supply and exhaust fans had been inadvertently shut off

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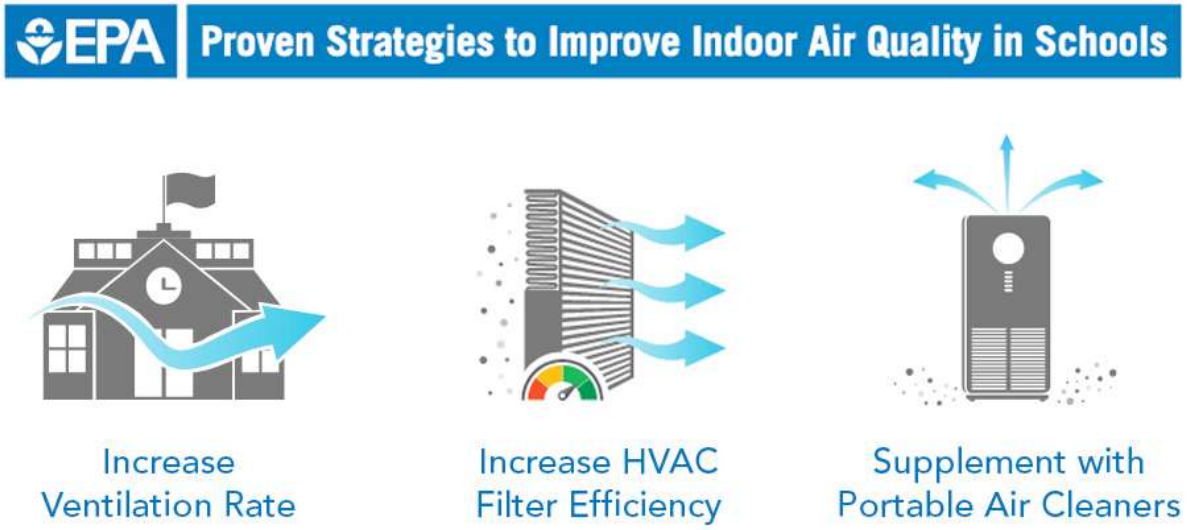
Mitigation and Risk Communication

- Site-specific risk
- Letters and fact sheets
- Workshop/meeting
- Follow up sampling quarterly
- Long-term mitigation strategy
- Detailed risk assessment



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Seattle Area: Characterization and Engineering Controls

- Site: Former Dry Cleaners (1992–2007)
- Planned for site redevelopment as a restaurant
- PCE, TCE, 1,1-DCE, cis/trans-1,2-DCE
- Media: subslab soil and soil vapor
- Site selected subslab depressurization system (SSDS) and natural attenuation under Model Toxics Control Act in 2017
- SSDS shut off in 2019

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Seattle Area: Risk Management

- Recording of the Environmental Covenant in 2022 and subsequent No Further Actions letter from Ecology
- Annual visual inspections
- Risk management plan
  - Pipe trenching protocols
  - Soil management plan

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Risk Assessment and Communication: After School Program Screening Values for Site-Specific Scenario (PCE)

Higher Indoor Air Protective Exposure Level

Lower exposure duration, frequency, intensity

Increased exposure duration, frequency, and intensity

Lower Indoor Air Protective Exposure Level

Example for Child Exposure

Hours per day	Days per year	Years	Protective Level (ug/m³)
3.5	115	6	42
5	180	13	8.6

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Risk Communication: Safe Exposure Levels

Sampling Dates	Indoor Air Concentration (ug/m^3)	Safe Exposure Level for Child (ug/m^3)	Is there a Risk?
6/28–7/9/2021	4.5	8.6	NO
7/21–7/22/2021	2.0	8.6	NO
8/24–8/25/2021	1.6	8.6	NO

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Sunmary

- Both current and future risks need to be considered when developing a mitigation and remedial strategy
- Site-specific conditions and exposure should be considered
- The need for short-term mitigation and risk communication should be part of the site strategy
- Consider all the changes that could occur over time to a property and its buildings and put safeguards in place

Extra slides

Oregon Vapor Intrusion Guidance: Risk Assessment

- Department of Environmental Quality (DEQ) preference for risk evaluations = collect indoor air data to compare to RSCs
  - Develop conceptual site model and multiple lines of evidence evaluation
  - Consider hot spots
- Risk-Based Concentrations (RBC)
  - Chronic air RBCs reflect default resident and worker regional screening levels (RSLs)
  - Chronic soil vapor and groundwater RBCs generally equivalent to EPA Vapor Intrusion Screening Levels
    - Modification to groundwater RBCs to account for Oregon specific average groundwater temperature (default 25°C vs. 12.5°C) – less conservative
    - DEQ attenuation factors (AFs) equivalent to EPA defaults
    - Site-specific AFs can be calculated using paired subsurface and indoor air data
  - Acute RBCs available for short-term exposures based on Cleaner Air Oregon program

Oregon Vapor Intrusion Guidance: Risk Assessment

- Interpretation of results
  - Compare data to RBCs per specific scenario
  - Exceedance of RBCs “does not automatically demonstrate unacceptable risk”
    - Spatial distribution and temporal variability of VOC concentrations
    - Meteorological conditions
    - Tracer gases
    - Background contributions
    - Building pressure cycling tests
    - HVAC/ventilation

Washington Vapor Intrusion Guidance: Risk Assessment

- Preliminary Assessment (PA) -> Tier 1 -> Tier 2
  - PA determines chemicals of sufficient volatility and toxicity near current or future buildings
  - Tier 1: evaluation outside the building
    - Consider preferential pathways
    - Compare soil gas and/or groundwater data to Cleanup Levels and Risk Calculation (CLARC) screening levels (use EPA default AFs)
    - Determine cumulative risk for multiple VOCs
  - Tier 2: evaluations inside the building
    - PA evaluations can skip to Tier 2 in select scenarios
    - Evaluate indoor air concentrations against CLARC screening levels (use EPA default AFs)
    - Can develop risk-based indoor air levels for commercial buildings outside defaults
    - Determine cumulative risk for multiple VOCs

Washington Vapor Intrusion Guidance: Risk Assessment

- Interpretation of results
  - Consideration if VI is causing acceptable or unacceptable risks based on preponderance of data
    - Multiple types of data (ambient air, indoor air, subslab samples)
    - Multiple lines of evidence (meteorological conditions, building specific information, tracer measurements, etc.)

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Washington State

Table 1. Vapor intrusion indoor air cleanup and action levels for TCE

Level of Concern	Concentration ($\mu g/m^3$)	Risk Basis
TCE Indoor Air Cleanup Levels Chronic (mean long-term air concentration for RME receptor)*		
Method B (unrestricted land use)	**0.37**	Cancer risk 1E-6
	0.91	Hazard quotient 1
Method C (industrial land use)	**6.3**	Cancer risk 1E-5
	2.0	Hazard quotient 1
TCE Indoor Air Action Levels Short-term (maximum 3-week mean concentration for women of childbearing age)		
Unrestricted (residential) land use	**2.0**	Noncarcinogenic effect based on 24 hours/day, 7 days/week
Workplace scenario (commercial or industrial)	**7.5**	Noncarcinogenic effect based on 45-hour work week

* These values are available in CLARC (Ecology 2018a).

Table 2. Vapor intrusion subsurface screening levels for short-term exposures to TCE

Short-term TCE Subsurface Screening Levels	Concentration	Basis
groundwater (in µg/l)		
residential short-term VI Screening Level for groundwater	**8**	• TCE as a non-carcinogen • receptor of concern: women of childbearing age • residential indoor scenarios
non-residential short-term VI Screening Level for groundwater	**31**	• TCE as a non-carcinogen • receptor of concern: women of childbearing age • commercial/industrial workplace scenarios
soil gas (in µg/m³)		
residential short-term VI Screening Level for sub-slab soil gas	**67**	• TCE as a non-carcinogen • receptor of concern: women of childbearing age • residential indoor scenarios
non-residential short-term VI Screening Level for sub-slab soil gas	**250**	• TCE as a non-carcinogen • receptor of concern: women of childbearing age • commercial/industrial workplace scenarios

WDOE 2019: Vapor Intrusion (VI) Investigations and Short-term Trichloroethene (TCE) Toxicity, Implementation Memorandum No. 22

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