

Vapor Intrusion Assessment and Mitigation: A Corporate Approach to Addressing the Legacy of Silicon Valley

California Industrial Hygiene Council,
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Michelle King, Ph.D.
President

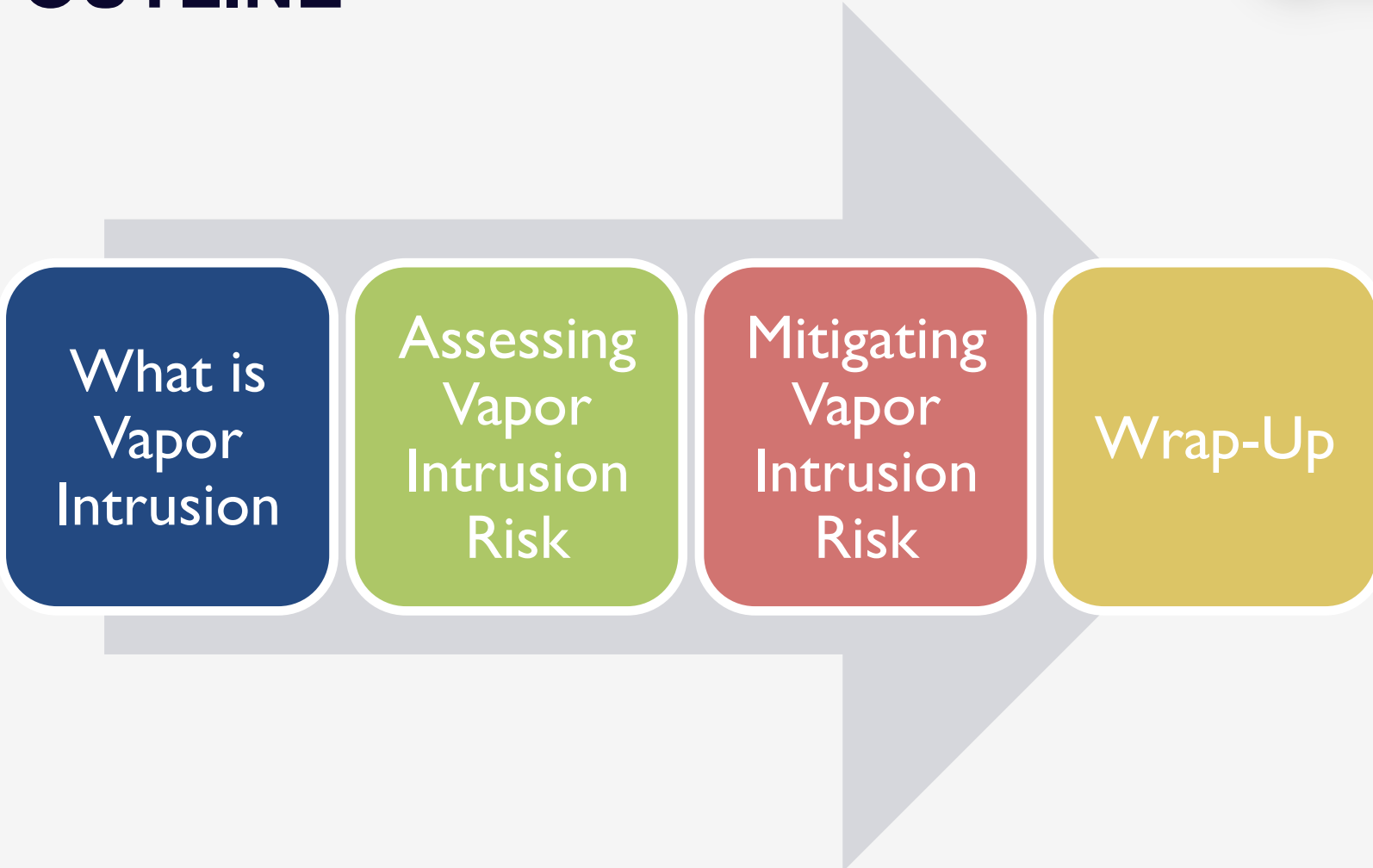
mkking@ekiconsult.com

Kat Wuelfing

kwuelfing@ekiconsult.com



OUTLINE

A large, light gray arrow pointing to the right, containing four colored boxes with white text. The boxes are: a dark blue box with 'What is Vapor Intrusion', a green box with 'Assessing Vapor Intrusion Risk', a red box with 'Mitigating Vapor Intrusion Risk', and a yellow box with 'Wrap-Up'.

What is
Vapor
Intrusion

Assessing
Vapor
Intrusion
Risk

Mitigating
Vapor
Intrusion
Risk

Wrap-Up

OUTLINE

What is
Vapor
Intrusion

Assessing
Vapor
Intrusion
Risk

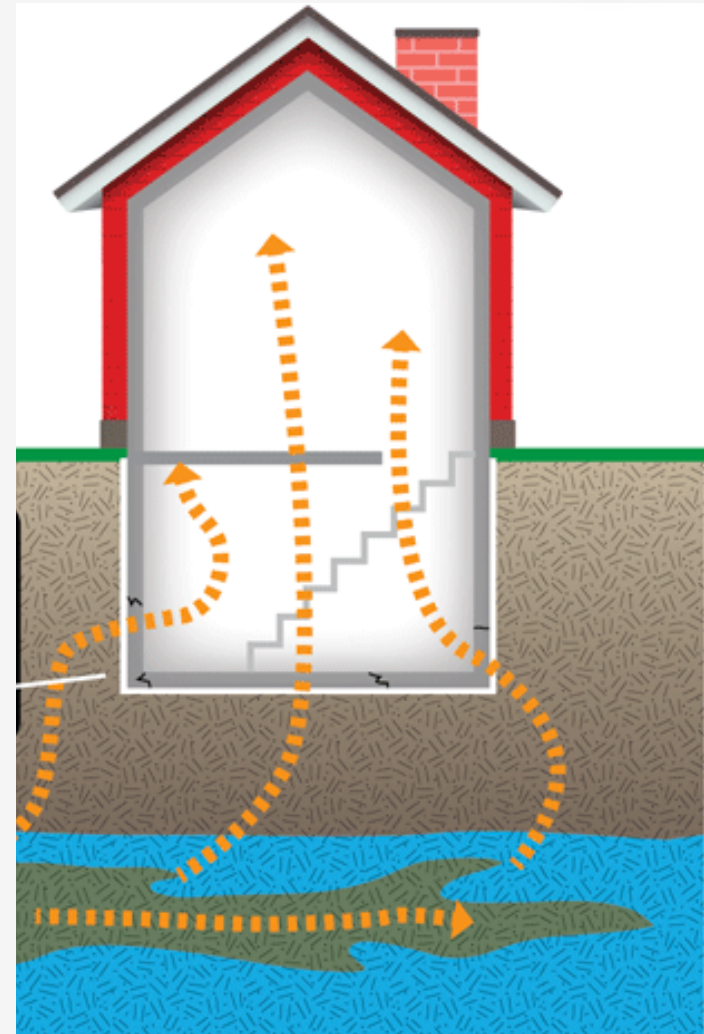
Mitigating
Vapor
Intrusion
Risk

Wrap-Up

WHAT IS VAPOR INTRUSION (VI)?



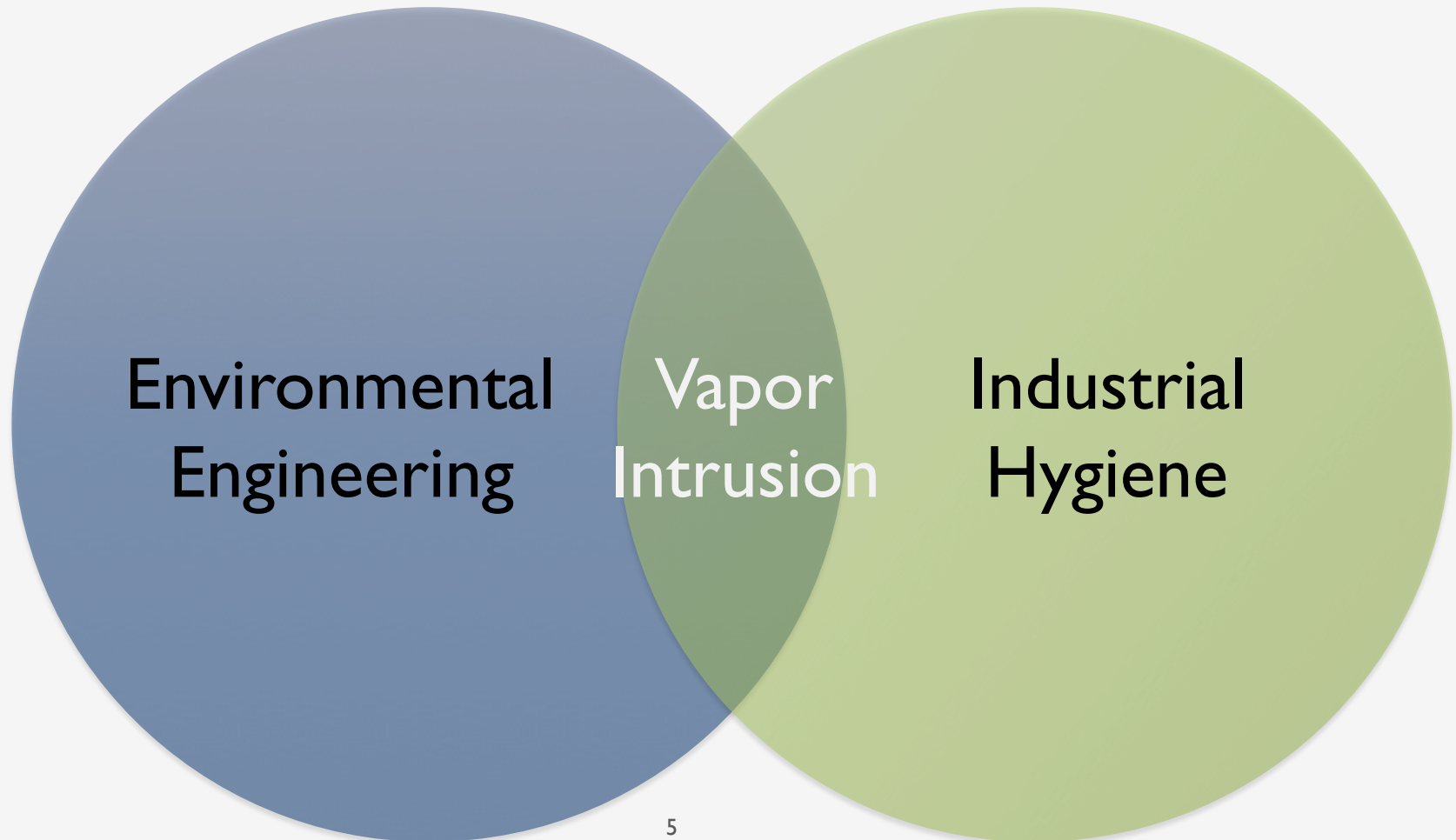
- Volatile organic chemicals (VOCs) in subsurface migrating upward through the soil into buildings, causing an unacceptable chemical exposure for building occupants
- Lower pressure inside a building is primary driving force for VI
- Early 2000's VI started to become a news item
- Standard modeling was questioned and focus began shifting to indoor air data
- SF Bay Area – TCE gets particular attention



VAPOR INTRUSION



Subsurface problem resulting in a health risk to building occupants



SIGNIFICANT FOCUS IN RECENT YEARS

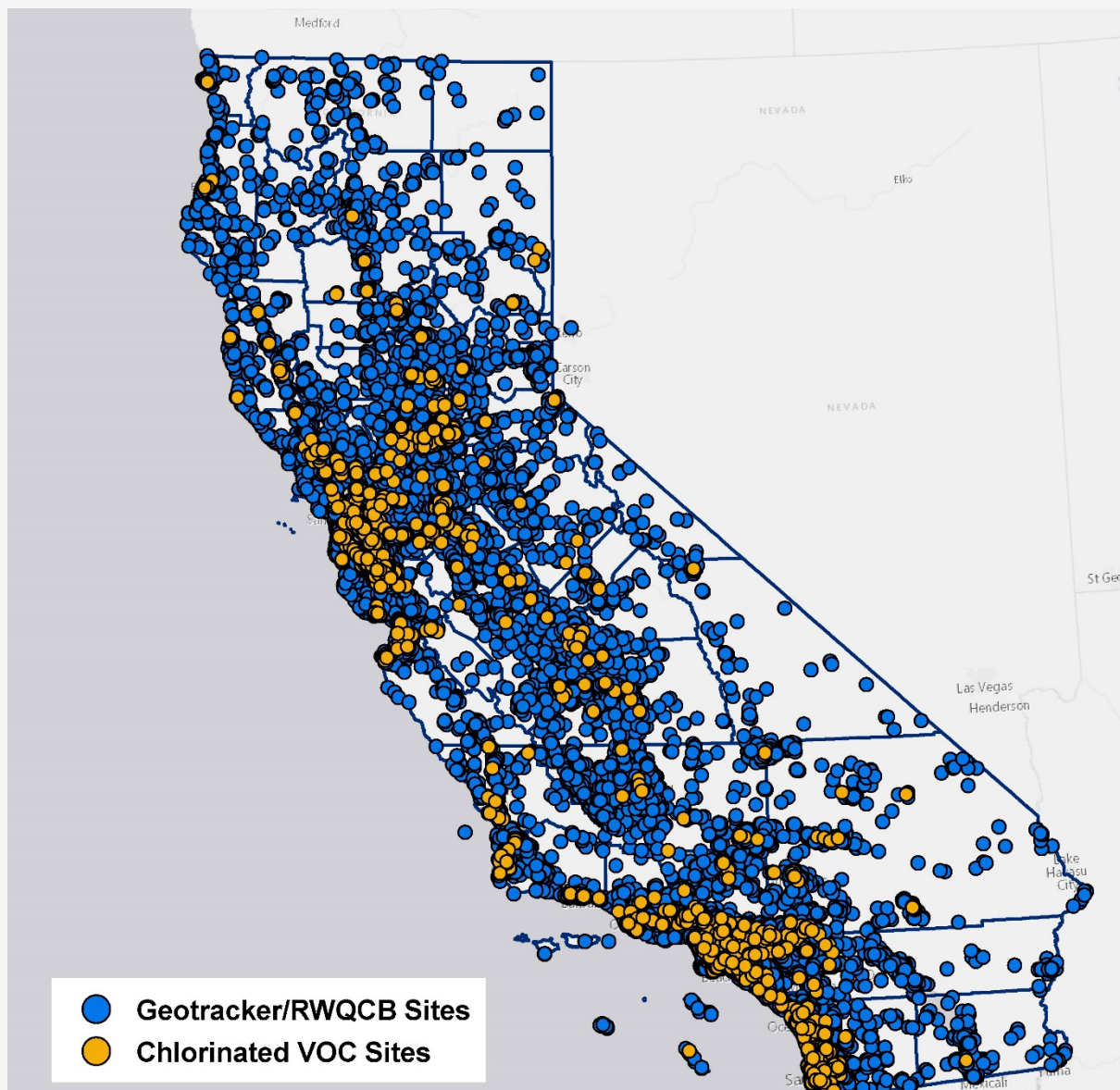
- New VI Information and research
- New TCE Information (EPA and RWQCB Guidance)
- Economic Recovery and Drive for Redevelopment
- Conversion of Industrial Properties to Residential & Mixed Use



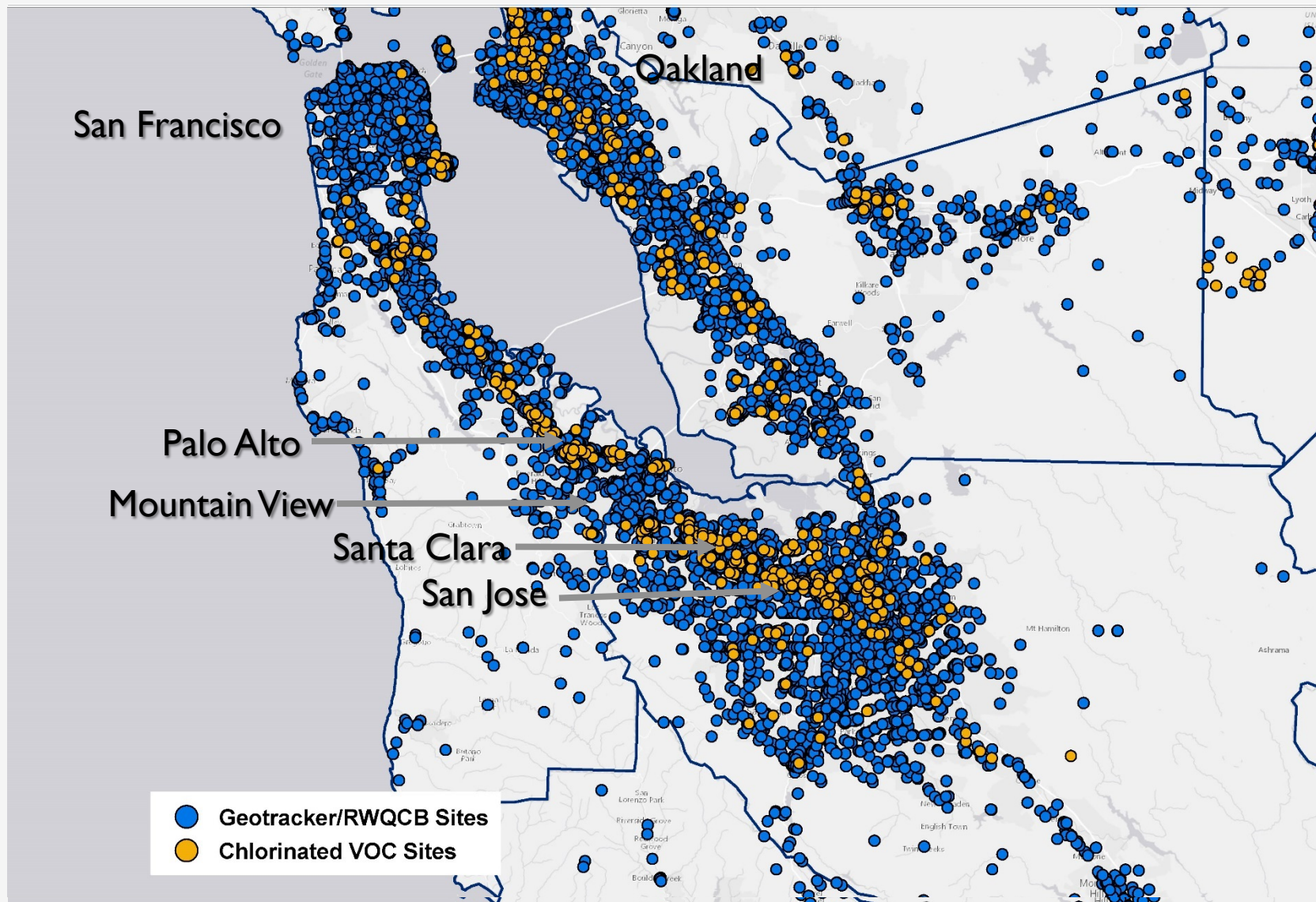
KEY REGULATORY GUIDANCE

- Vapor Intrusion Assessment Guidance (DTSC, 2011)
 - http://www.dtsc.ca.gov/AssessingRisk/upload/Final_VIG_Oct_2011.pdf
- Vapor Intrusion Mitigation Advisory (DTSC, 2011)
 - http://www.dtsc.ca.gov/SiteCleanup/upload/VIMA_Final_Oct_2011.pdf
- Advisory Active Soil Gas Investigations (Cal-EPA, 2015)
 - https://www.dtsc.ca.gov/SiteCleanup/upload/VI_ActiveSoilGasAdvisory_FINAL.pdf
- Final Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Sources to Indoor Air (U.S. EPA, 2015)
 - <https://www.epa.gov/sites/production/files/2015-09/documents/oswer-vapor-intrusion-technical-guide-final.pdf>
- Screening Criteria for Indoor Air
 - Environmental Screening Levels (ESLs) (SFRWQCB)
 - Regional Screening Levels (RSLs) (U.S. EPA)
 - HERO Note 3 (adaption of RSLs) (DTSC)

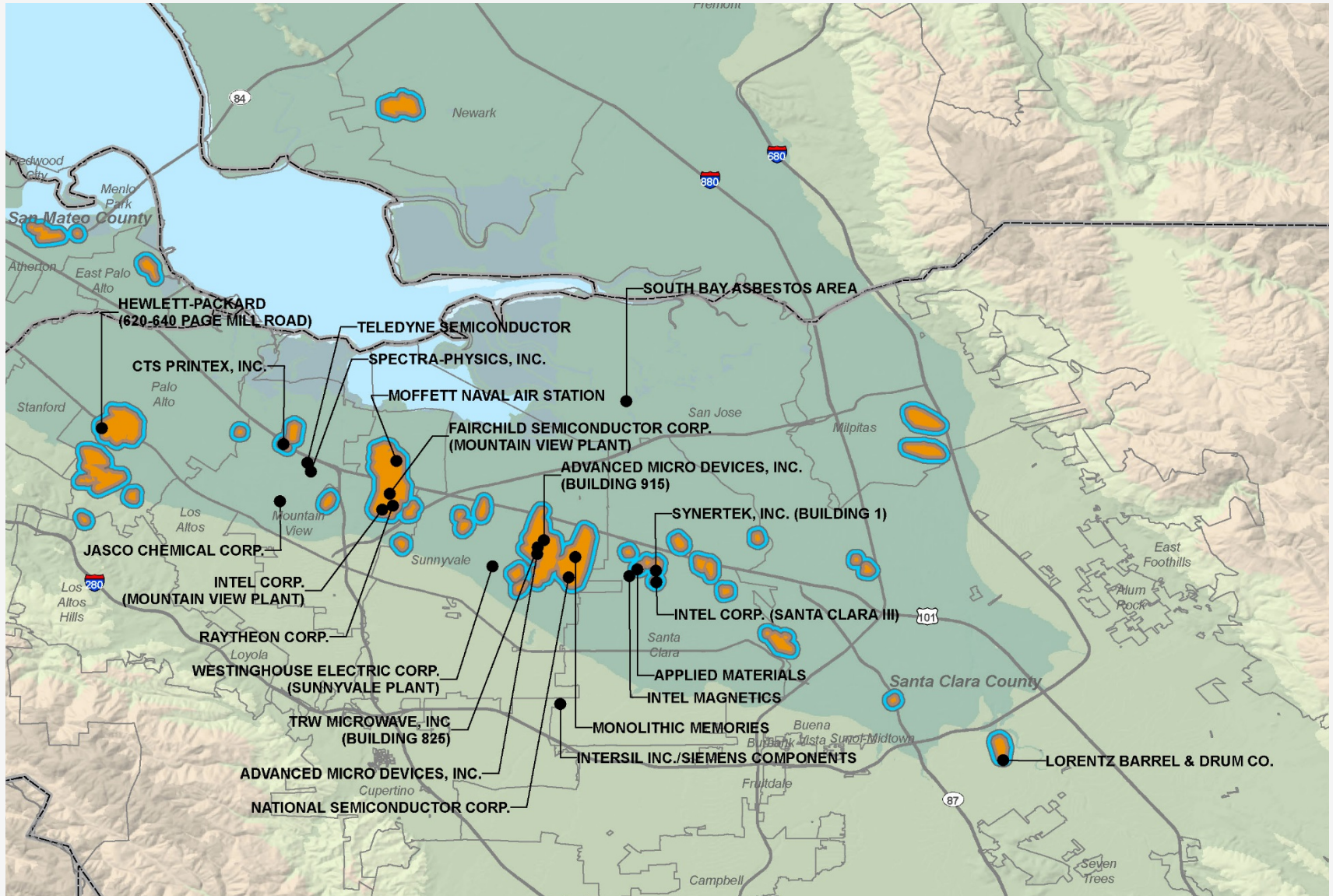
PREVALENCE OF CHLORINATED VOC SITES



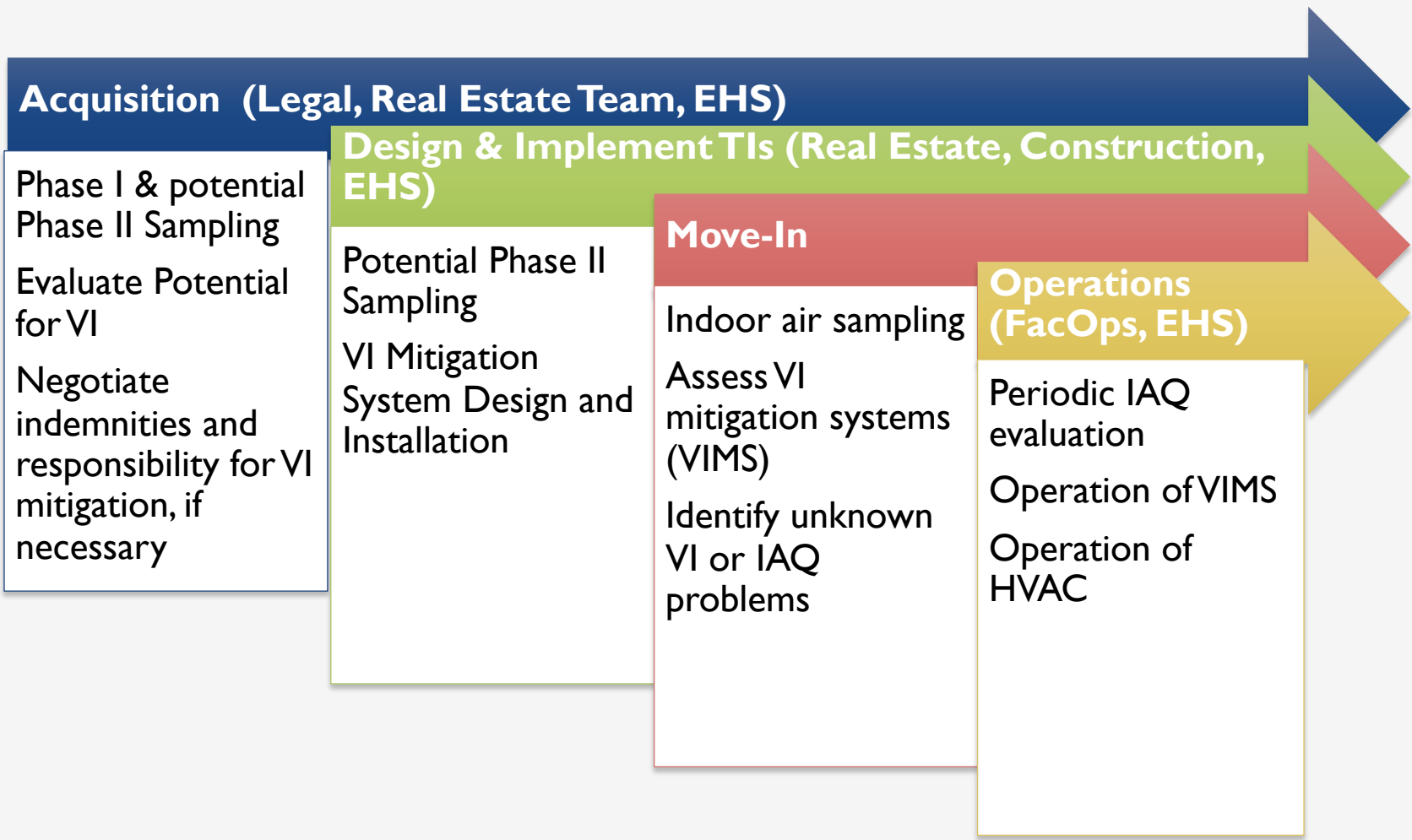
PREVALENCE OF CHLORINATED VOC SITES



PREVALENCE OF CHLORINATED VOC SITES



CORPORATE CONSIDERATIONS BY STAGE



EXAMPLE TECH COMPANY: “EX-TECH”

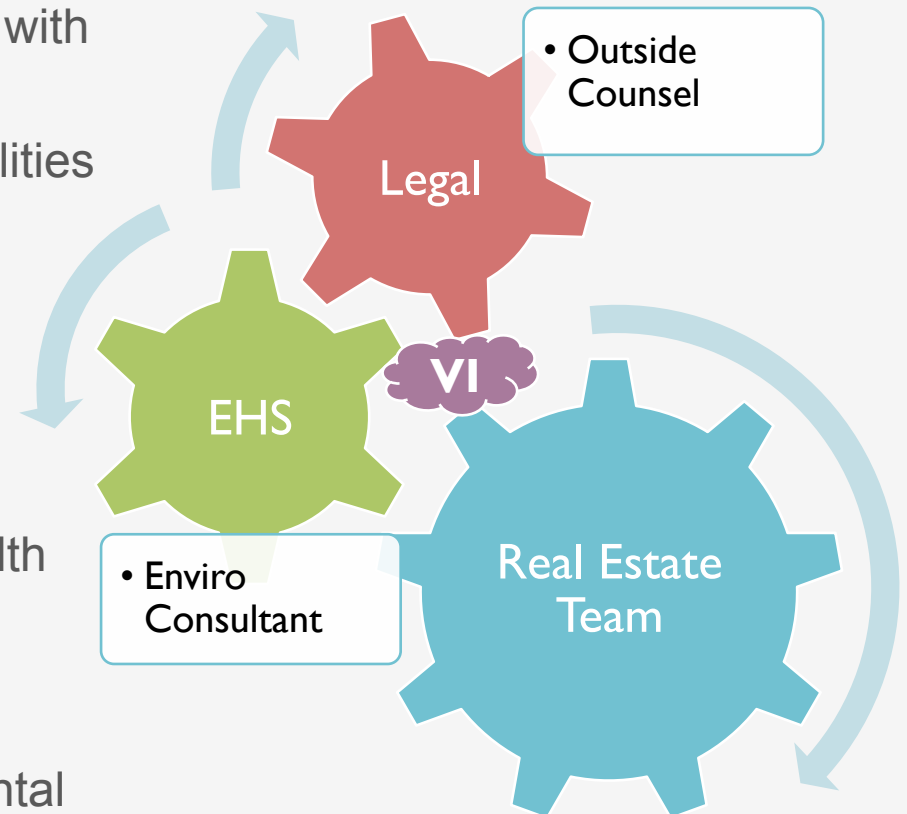


- Bay Area high-tech company
- Many buildings located in Silicon Valley
- Risk-averse approach to environmental issues and potential worker exposure
- Evaluates these issues during property acquisition or leasing
- Similar approach for leased and owned properties

DUE DILIGENCE TEAM DYNAMIC



- Real Estate Team
 - Driver to make deal happen with business needs at forefront
 - Less sensitive to enviro liabilities
- Legal
 - Driver to protect liability
 - Balance business needs
- EHS
 - Driver to protect human health
 - Balance business needs
- Environmental Consultant
 - Identify potential environmental concerns and liabilities
 - Identify options to inform decision making by team



OUTLINE

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Assessing
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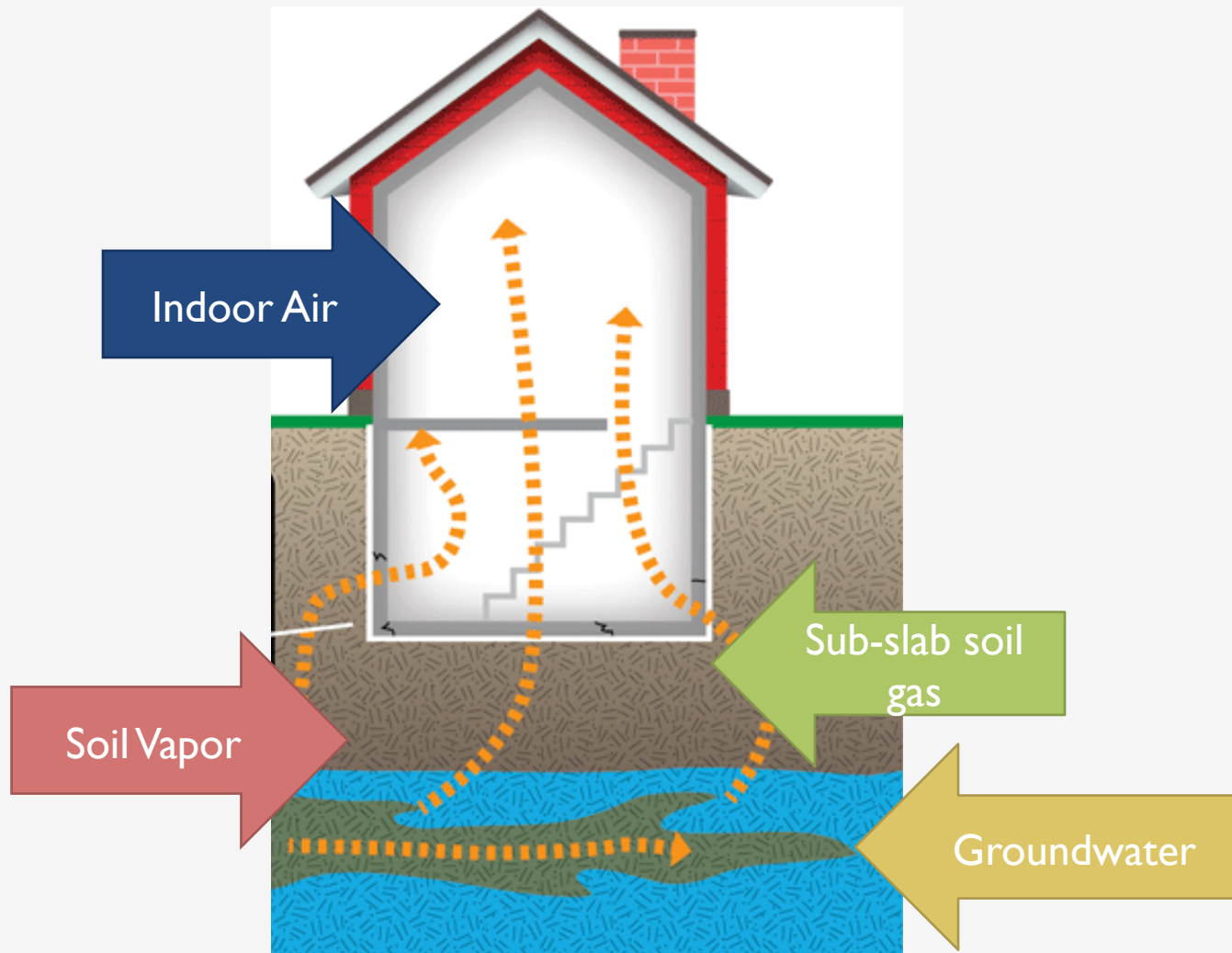
Mitigating
Vapor
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Risk

Wrap-Up

HOW DO YOU KNOW IF VAPOR INTRUSION IS A RISK?

- Evaluate site history
 - Past onsite VOC/solvent use
 - Offsite releases of VOCs
- Review or collect groundwater, soil gas, sub-slab soil gas, and/or indoor air data
 - Each data type has its own strengths/limitations
- Use multiple lines of evidence (if possible)

SAMPLING OPTIONS TO EVALUATE POTENTIAL VI RISK



SAMPLING OPTIONS: SUB-SLAB SOIL GAS AND INDOOR AIR

Implementation	Indoor Air Sampling	Sub-Slab Soil Gas Sampling
Invasive	No	Yes (minimally)
Preparation for Sampling	HVAC on vs. HVAC off	Utility clearance
Likelihood of Landlord Acceptance	Higher	Lower
Rounds of Sampling	At least 2 (seasonal)	1
Regulatory Trigger for Mitigation (in eyes of LL)	Yes	Maybe (VI potential)
Representative of Future VI Potential	Not necessarily	Yes, for existing building
Speed to mobilize	Fast	Fast
Relative cost	Minimal	Minimal

SAMPLING OPTIONS: SOIL GAS AND GROUNDWATER

Implementation	Soil Gas Sampling (Soil Vapor Probe)	Groundwater Sampling
Invasive	Yes	Yes
Preparation for Sampling	Utility clearance, drilling contractor scheduling, permit process*	Utility clearance, drilling contractor scheduling, permit process*
Likelihood of Landlord Acceptance	Low	Lowest
Rounds of Sampling	I	I
Regulatory Trigger for Mitigation (in eyes of LL)	Maybe (VI Potential)	Maybe (VI Potential)
Representative of Future VI Potential	Yes, current and future buildings	Yes, but only for VOCs in groundwater
Speed to mobilize	Slower	Slower
Relative cost	High	High or higher (depending on GW depth)

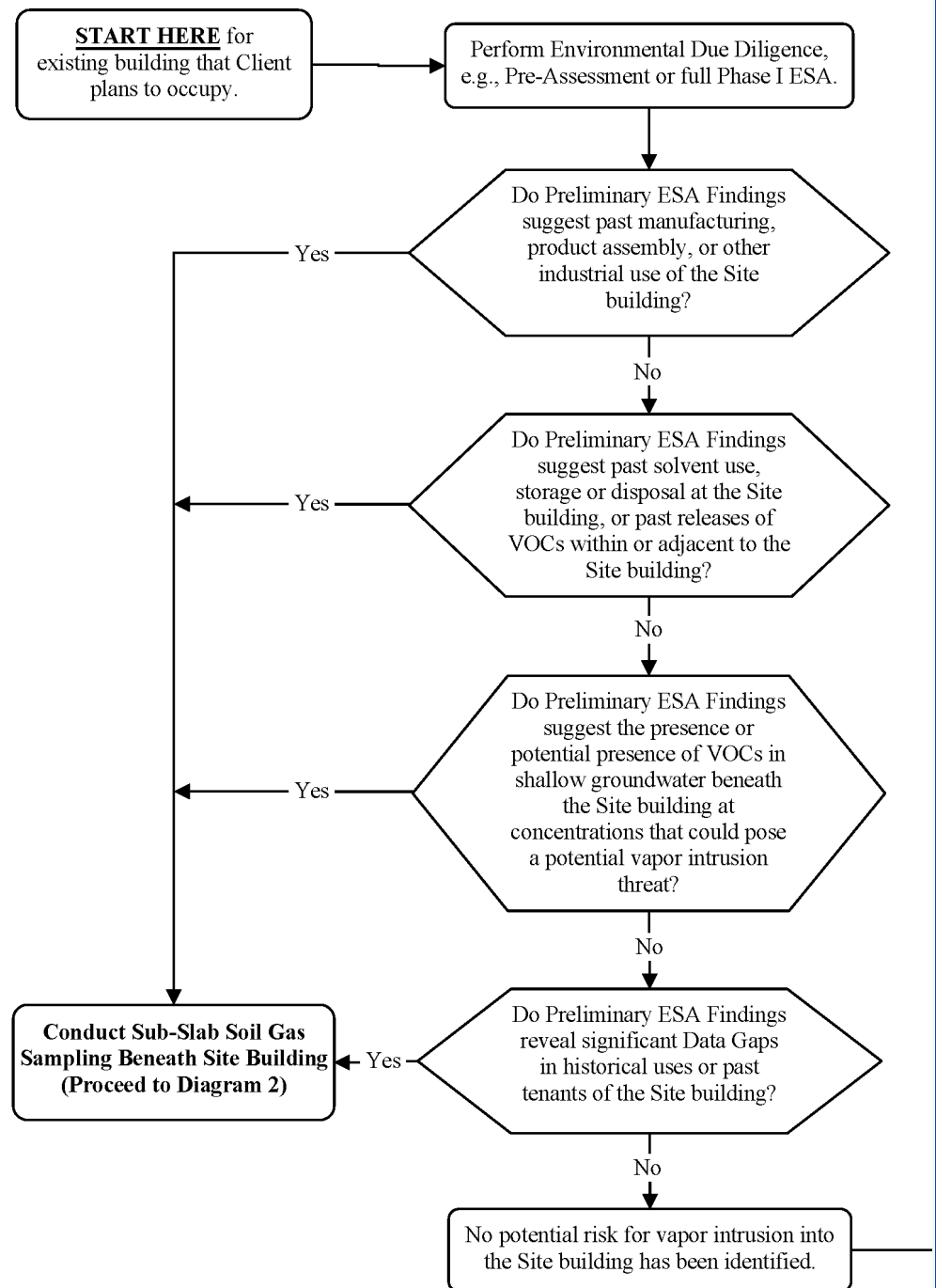
EX-TECH CORPORATE APPROACH FOR ACQUISITION



- Evaluate site history
- Review or collect groundwater, soil gas, **sub-slab soil gas**, and/or indoor air data
- Use multiple lines of evidence (if possible)
- **Assess building or deal constraints**
- Determine if mitigation needed

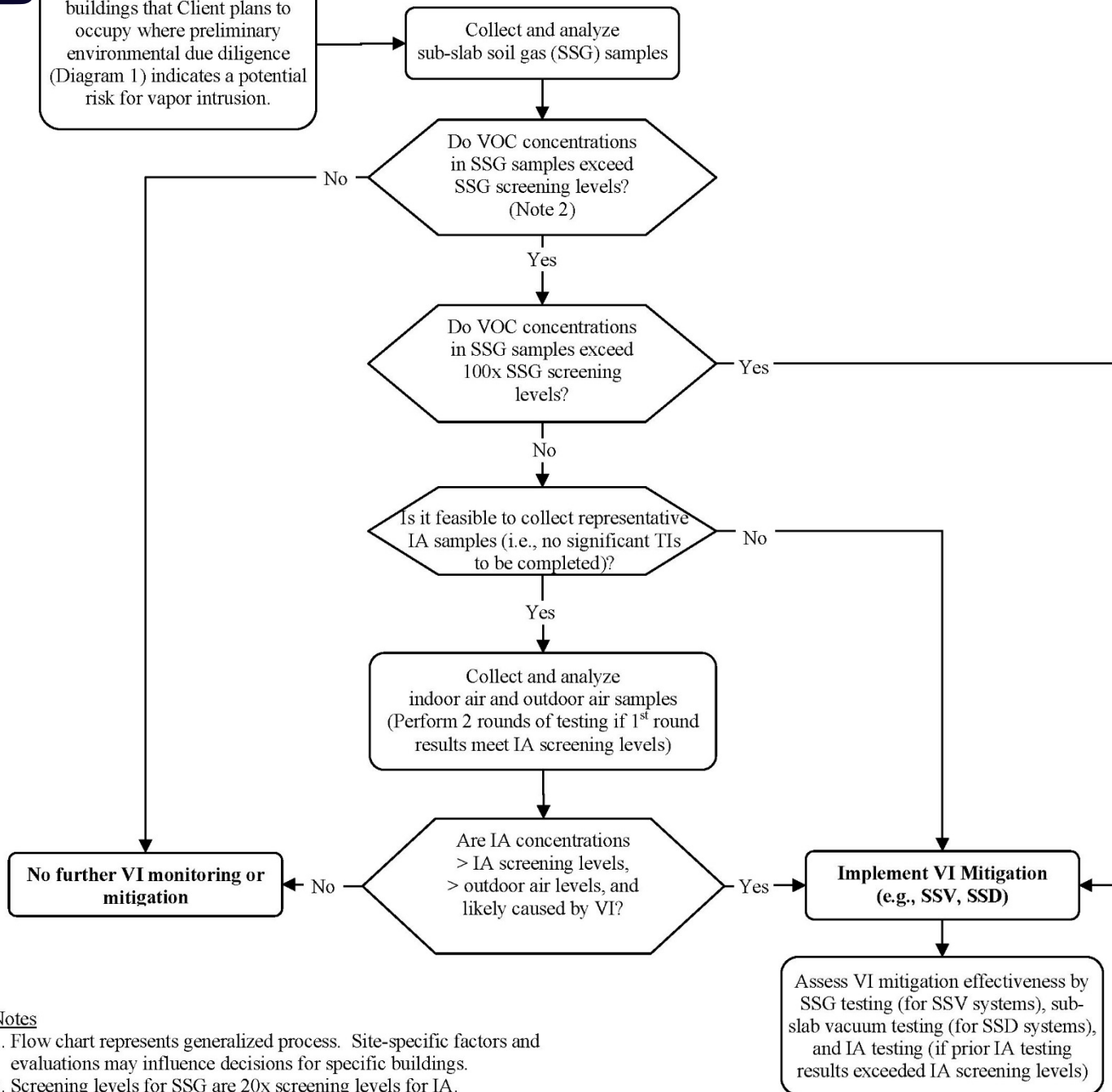
PRELIMINARY ASSESSMENT

- Evaluate whether VI is a possible concern based on historical information and available data



SUB-SLAB TESTING RESULTS

START HERE for existing buildings that Client plans to occupy where preliminary environmental due diligence (Diagram 1) indicates a potential risk for vapor intrusion.

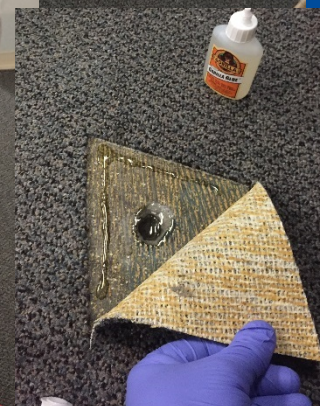
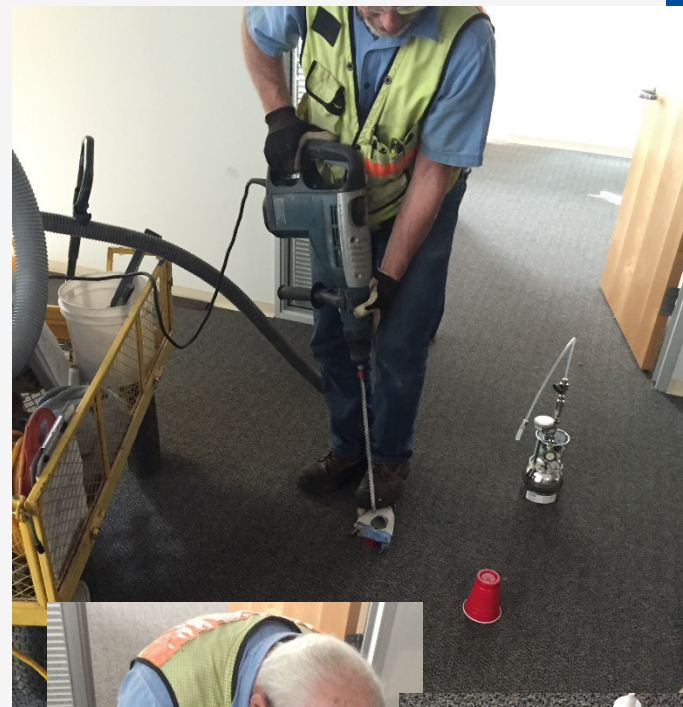


Notes

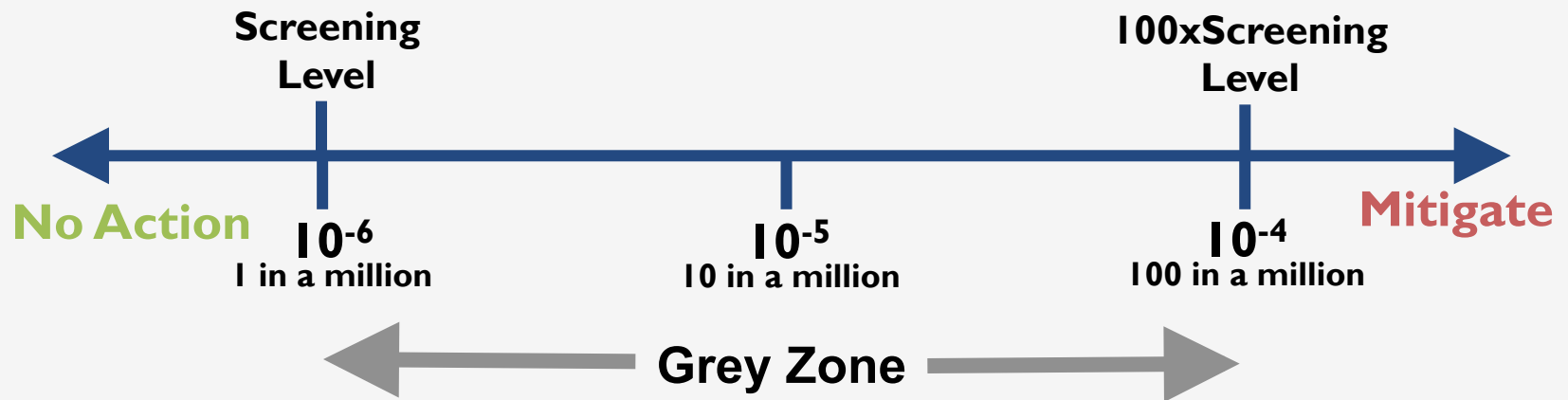
1. Flow chart represents generalized process. Site-specific factors and evaluations may influence decisions for specific buildings.
2. Screening levels for SSG are 20x screening levels for IA.

BENEFITS OF SUB-SLAB SOIL GAS (SSG) DATA

- SSG data indicate the long-term potential for VI
- If SSG data are modest (e.g., $<100\times$ SL)
 - VI is a low threat
 - IA testing can confirm whether VI is an issue
- If SSG data are higher ($>100\times$ SL)
 - VI is a longer term threat
 - Risky to assess with limited IA data
 - Mitigation is preferred risk management
- Indoor air (IA) test results can vary widely
 - Changes in building ventilation
 - Building modifications
 - Atmospheric conditions



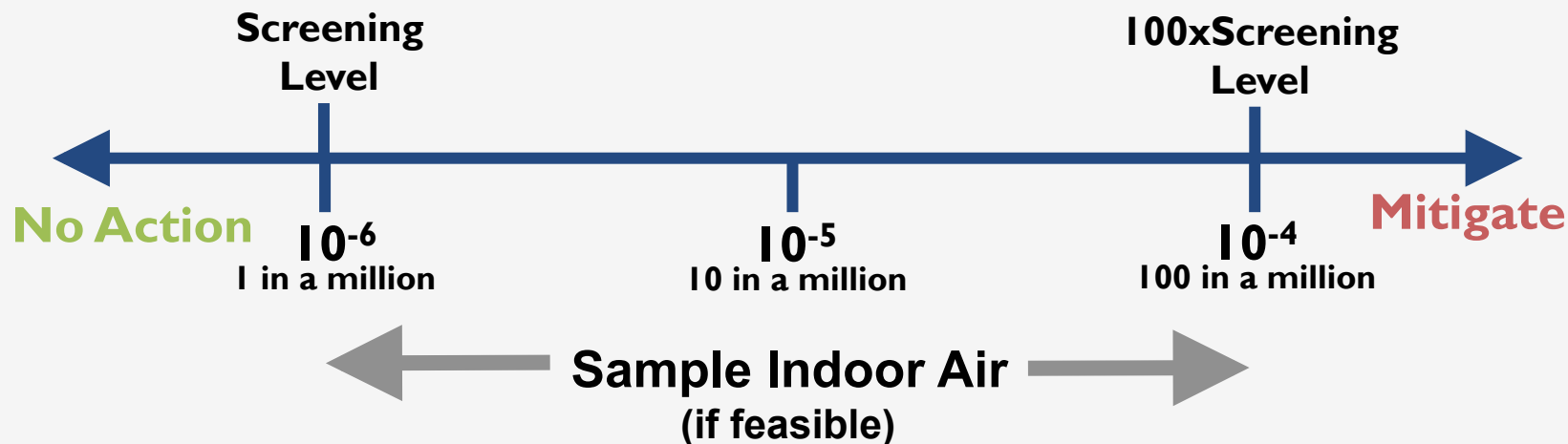
EXCEED SCREENING LEVELS— WHAT DOES IT MEAN?



Cal-EPA Regulatory Approach within Grey Zone

- Collect more data (for further VI evaluation)
- Indoor air testing
- On-going monitoring
- Remediation (remove source, if feasible)
- Mitigation (e.g., sub-slab depressurization, SSD)

EX-TECH APPROACH IF SUB-SLAB SCREENING LEVELS EXCEEDED



Practical limitations in Grey Zone

- If extensive remodel planned, IA testing may not be feasible or representative
- Consider proactive installation of mitigation piping

NEW TCE GUIDELINES



- EPA Region 9 Guidelines and Supplemental Information Needed for Vapor Intrusion Evaluations at South Bay NPL Sites (12/3/13)
 - [http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/b563f292da63ca2c88257c380075fab5/\\$FILE/68800995.pdf/EPA%20Region%209%20South%20Bay%20VI%20Letter%2012-3-13.pdf](http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/3dc283e6c5d6056f88257426007417a2/b563f292da63ca2c88257c380075fab5/$FILE/68800995.pdf/EPA%20Region%209%20South%20Bay%20VI%20Letter%2012-3-13.pdf)
- EPA Region 9 Response Action Levels and Recommendations to Address Near-Term Inhalation Exposures to TCE in Air from Subsurface Vapor Intrusion (7/9/14)
 - <http://www.epa.gov/region9/superfund/prg/files/r9-tce-interim-action-levels-response-recs-memo-2014.pdf>
- U.S. EPA, Compilation of Information Relating to Early/Interim Actions at Superfund Sites and the TCE IRIS Assessment (8/27/14)
 - http://www.epa.gov/superfund/sites/npl/TCE_compilation_final.pdf
- OEHHA, Memorandum to RWQCBs, U.S. EPA (Region 9) Recommendations for Addressing TCE Vapor Intrusion at Contaminated Sites (7/22/14)
- DTSC HERO, Note 5: Health-Based Indoor Air Screening Criteria for TCE (8/23/14)
 - http://www.dtsc.ca.gov/AssessingRisk/upload/HHRA_Note5-pdf-pdf.pdf
- Interim Framework for Assessment of Vapor Intrusion at TCE-Contaminated Sites in the San Francisco Bay Region (SFRWQCB, 16 October 2014)
 - http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/sitecleanup.shtml

TCE SCREENING LEVELS



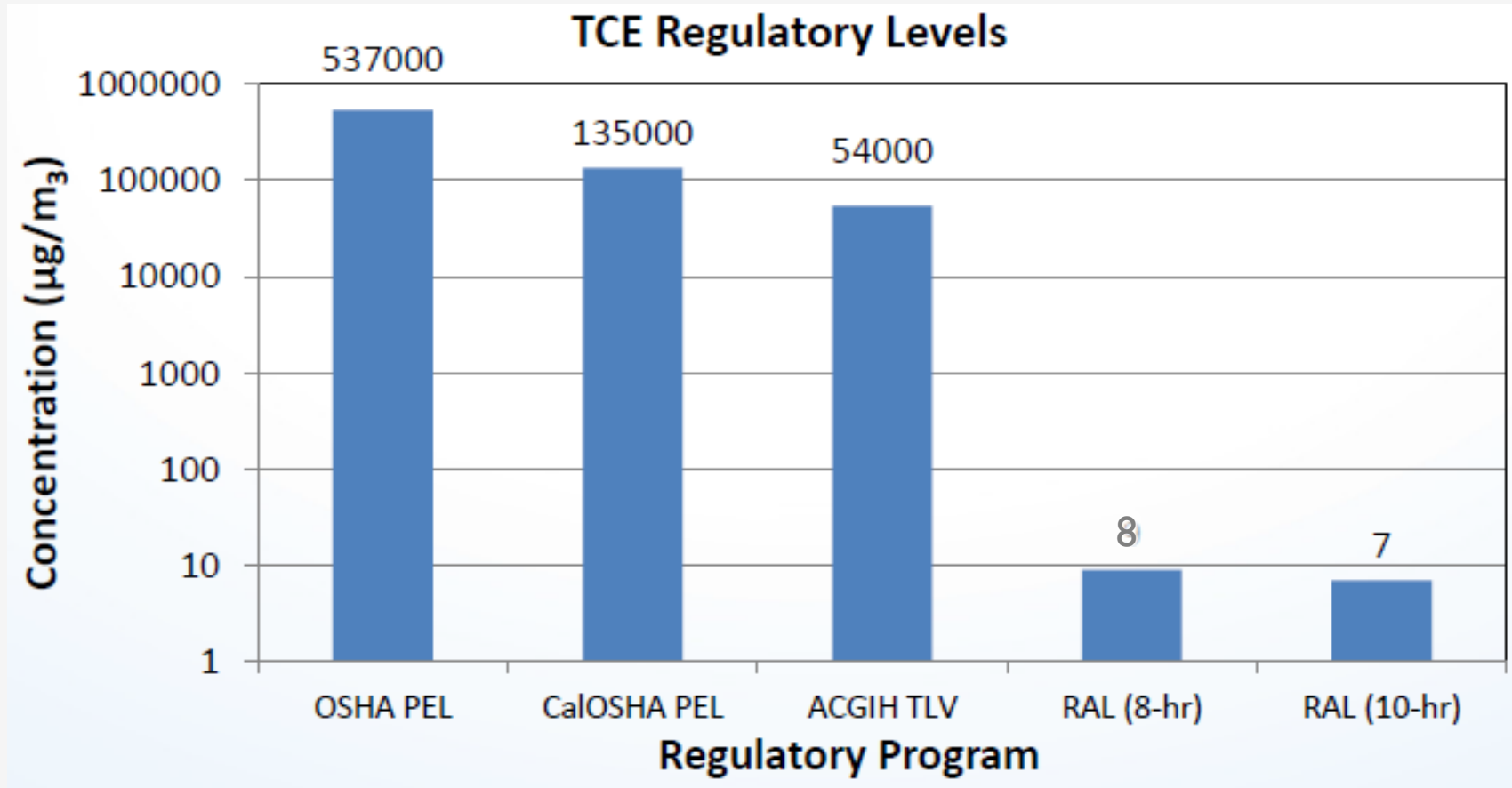
Media Sampled	Residential Screening Level (ug/m ³)	Commercial Screening Level (ug/m ³)
Indoor Air ¹	0.5 / 2	3 / 9
Indoor Air Accelerated Response Action Level ²	2	8 / 7
Indoor Air Urgent Response Action Level ²	6	24 / 21
Soil Gas (existing bldg) ³	250	3,000
Soil Gas (future bldg) ³	500	6,000

¹From ESLs and RSLs. Values based on one-in-a-million cancer risk endpoint and non-cancer endpoint, respectively.

²From EPA Region 9, July 2014 TCE Guidelines. Commercial based on 8-hr and 10-hr workday, respectively.

³Based on DTSC, 2011 attenuation factors.

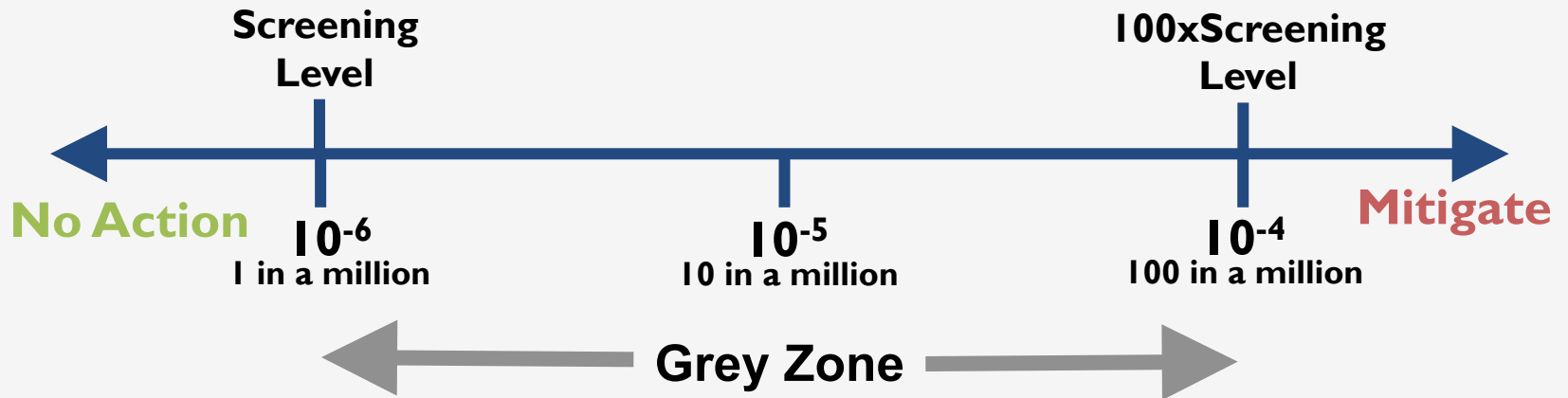
TCE OCCUPATIONAL EXPOSURE LIMITS VS U.S. EPA REGION 9



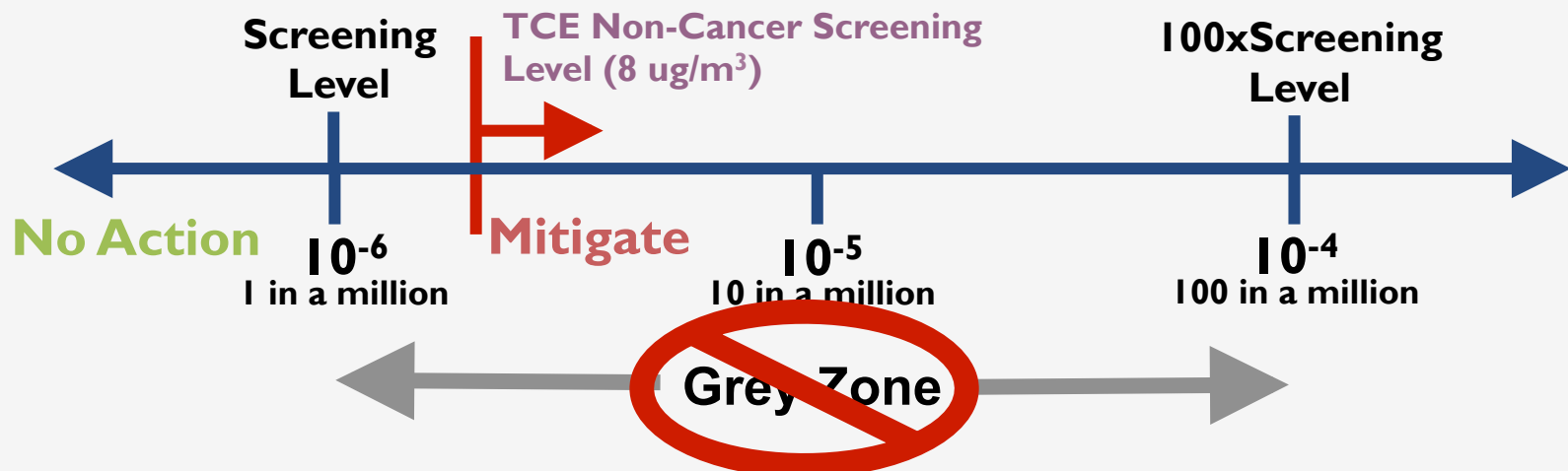
IMPACT OF NEW TCE POLICY (COMMERCIAL VALUES SHOWN)



Previous Regulatory Approach



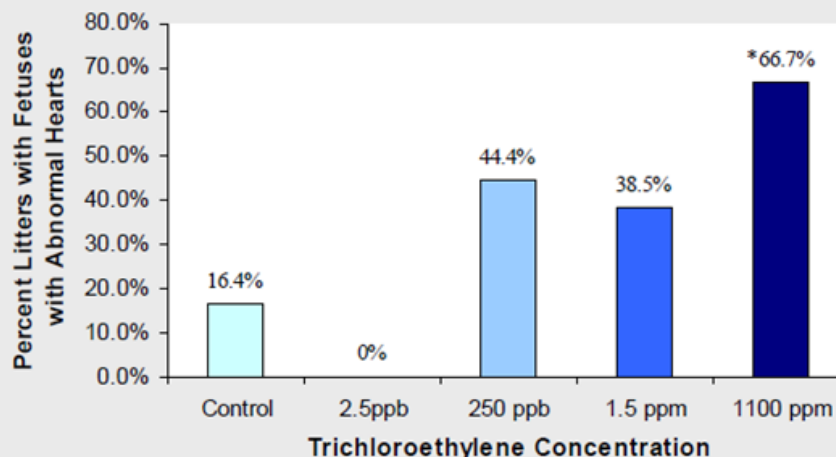
New Regulatory Approach for TCE



QUESTIONS RAISED: TCE AND FETAL HEART MALFORMATIONS

- Johnson Studies
 - Reproducibility
 - Laboratory procedures
 - Controls
- Endicott, NY
Epidemiological Study

% Litters with Abnormal Hearts



*Statistical Significance between control and treated groups

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>)

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VI MITIGATION APPROACHES

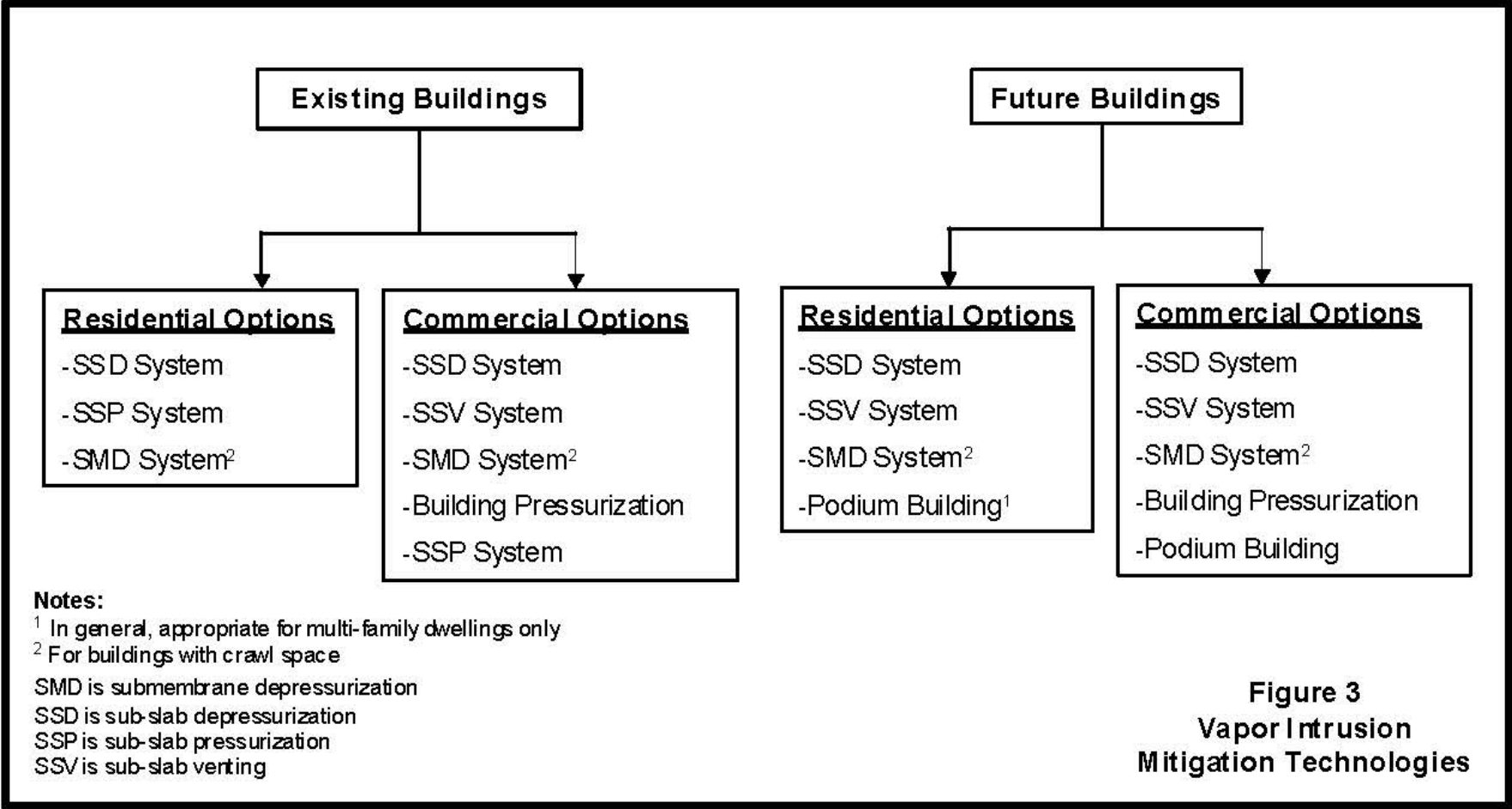
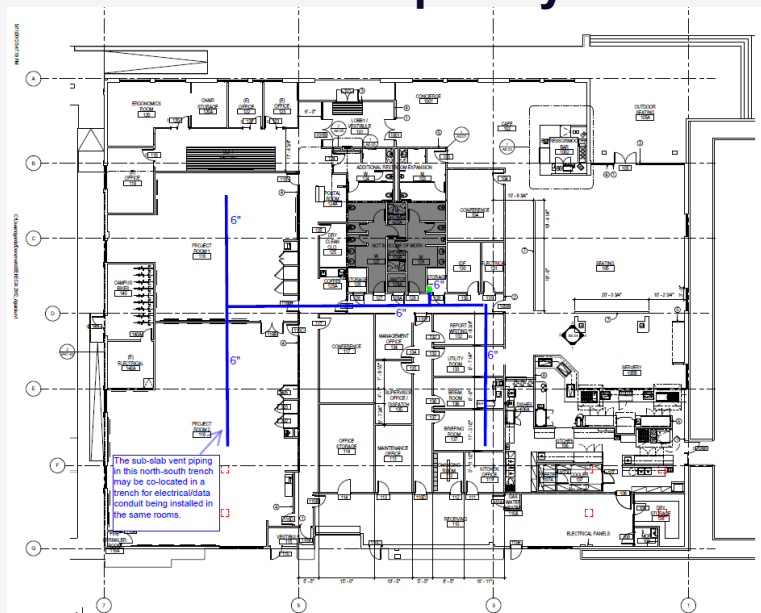


Figure 3
Vapor Intrusion
Mitigation Technologies

Source: DTSC, VIMA, 2011

VI MITIGATION: SUB-SLAB DEPRESSURIZATION (SSD)

Sub-Slab Vent Pipe Layout



Fan on rooftop

Sub-Slab Vent Pipe



Riser Pipe;
Vacuum Gauge

DECISION TO MITIGATE WITH ACTIVE SUB-SLAB DEPRESSURIZATION

Location	Sub-Slab Soil Gas > SLs?	Sub-Slab Soil Gas >100x SLs?	Pre-Mitigation Indoor Air > SLs?
Ex-Tech Bldg 1	Yes	No	Yes
Ex-Tech Bldg 2	Yes	No	Impractical to sample IA
Ex-Tech Bldg 3	Yes	Yes	--
Ex-Tech Bldg 4	Yes	Yes	--



Sub-slab trenching for vent pipe



Fan on rooftop

DECISION TO INSTALL CONTINGENT SYSTEM WITH PIPING AND DEFER DECISION TO ACTIVATE



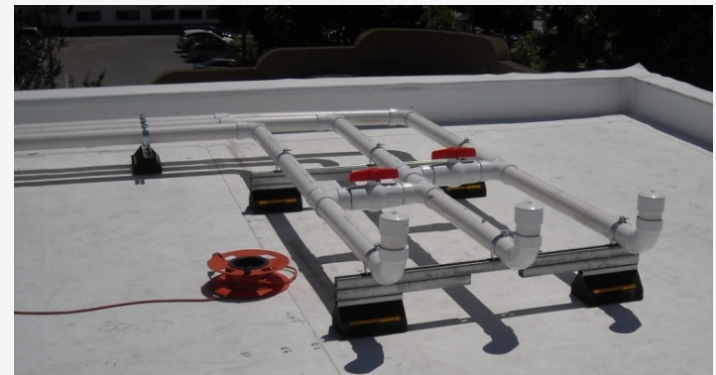
Location	Rationale	Post-Construction Indoor Air < SLs?
Ex-Tech Bldg 5	Remediated VOCs in soil, concern for residual	Yes
Ex-Tech Bldg 6	Remediated PCE in soil, concern for residual	Yes
Ex-Tech Bldg 7	Residual TCE in perched groundwater	NA
Ex-Tech Bldg 8	VOCs Sub-slab < 100x SLs VOCs Indoor > Bkgrd	Yes



Sub-slab vent piping

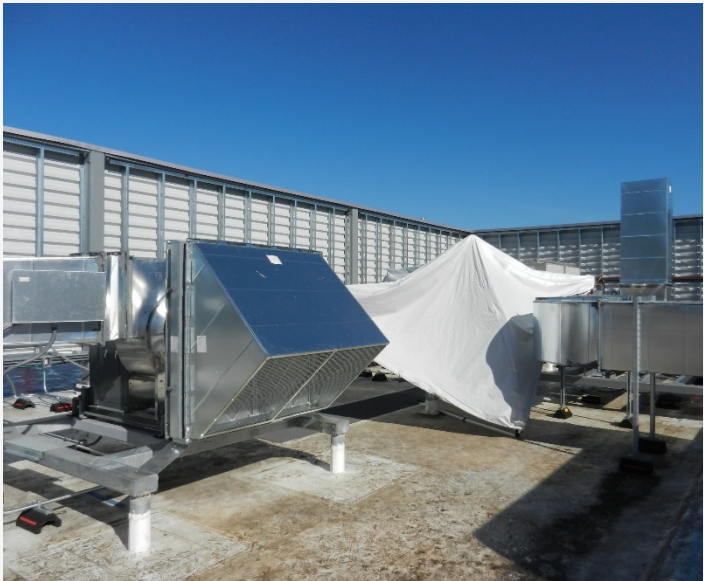


Riser pipes



Piping, but no fan on roof

SSD IN EXISTING BUILDINGS



Blower on rooftop



Residential Garage

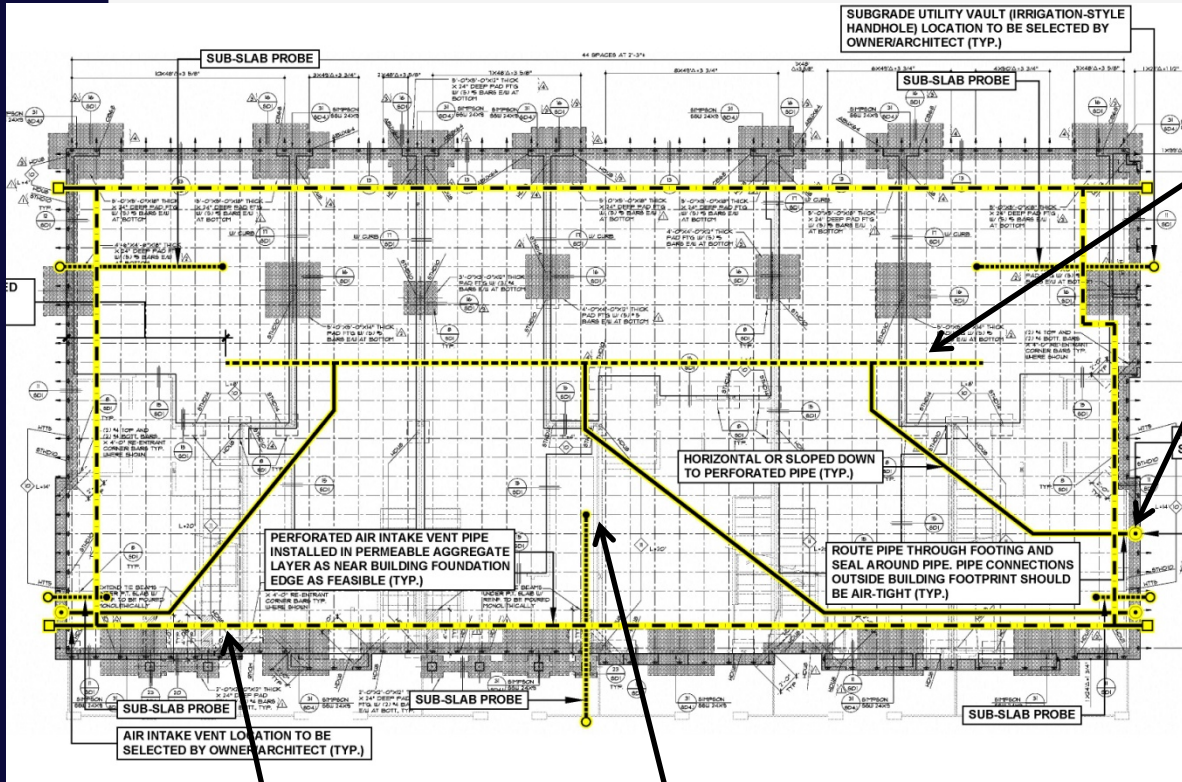


Sub-Slab Vent Pipe



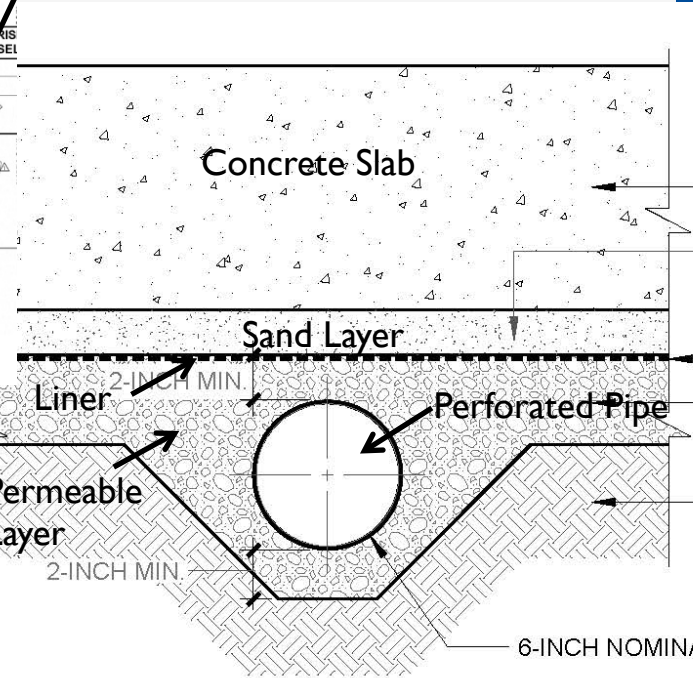
Suction Pit

VI MITIGATION: SUB-SLAB VENTILATION (SSV)



Perforated Vent Pipe

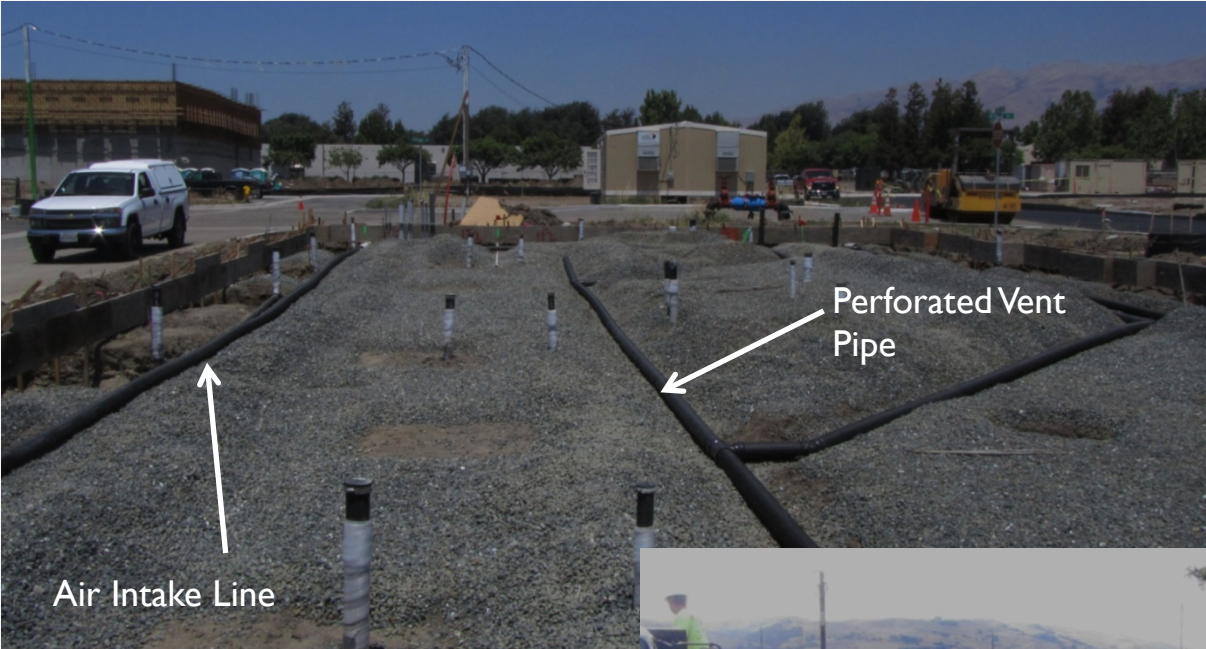
Riser Pipe to Roof (within Pipe Chase)



Air Intake Line

Sub-slab Monitoring Probe

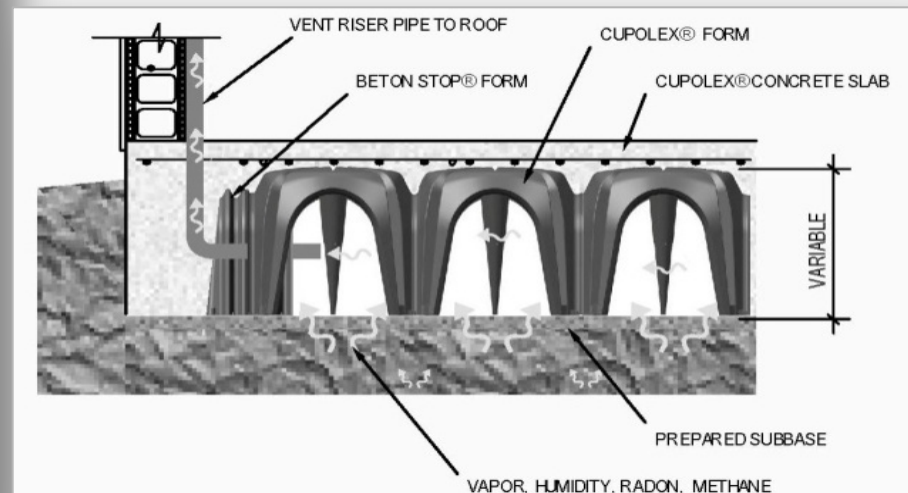
SSV AT NEW RESIDENTIAL COMPLEX



AERATED FLOOR (SSD OR SSV)



- Low resistance to air flow
- Easy to retrofit to active system
- No need to include liner
- More common for new buildings, but can be added on top of existing floor in some cases
- Structural engineer should evaluate suitability for a given building



Cupolex System

“JUST-IN-CASE IT’S NEEDED” SYSTEM

- Design system piping as if it is an active (or passive) system
- Install piping, sampling ports, and all elements of system except blower
- Perform post-construction monitoring (prior to occupancy and during occupancy)
- Upgrade to active system by adding roof-top blower (seal inlets if passive system)
- Building retrofit or new buildings



Sub-slab vent piping



Riser pipes



Piping, but no fan on roof

VI MITIGATION: SUB-SLAB PRESSURIZATION (SSP) REPAIR WITH BUILDING REMODEL



Liner Repair and
Testing

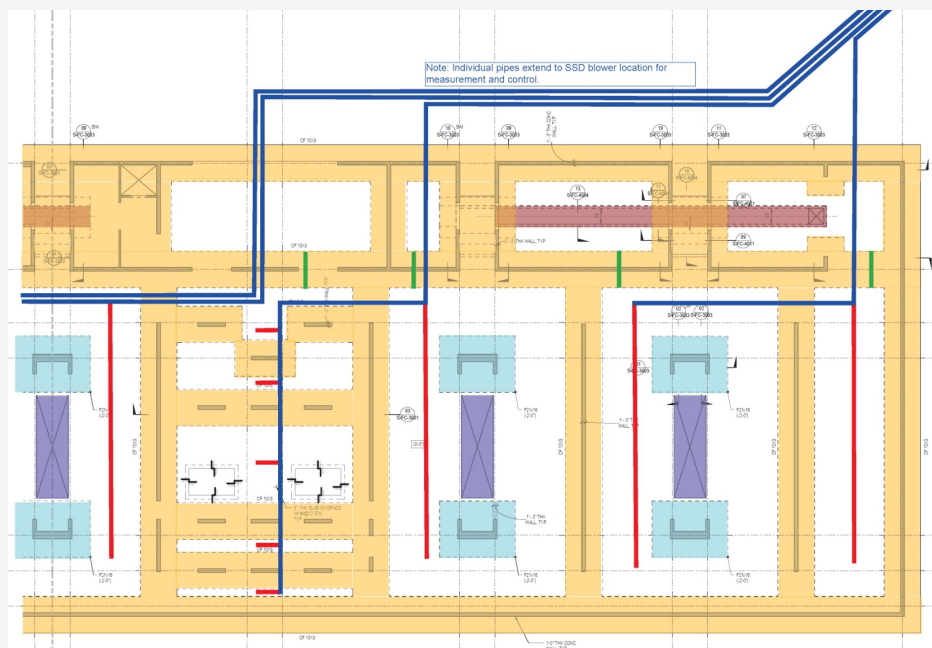
- Liners are needed with SSV, SSP, and Sub-membrane depressurization
- Repairs can be difficult and need to be leak tested

Before the
concrete pour



EX-TECH SSD SYSTEMS

- Installed to date (includes inside and outside the Bay Area):
 - 9 Active SSD systems
 - 6 “Just-in-case” systems in place
 - 1 system under construction



MITIGATION: CAUTIONARY TALES



- Assess and mitigate preferential pathways
- SSD systems can be ineffective if conduits are controlling VI
- Example preferential pathways
 - Elevator pits
 - Exterior utility vaults with conduit into utility or communications rooms
 - Floor drains, electrical lines, fire suppression risers, IT conduit
- Seal pathways to the extent feasible
- Ventilate vaults



OUTLINE



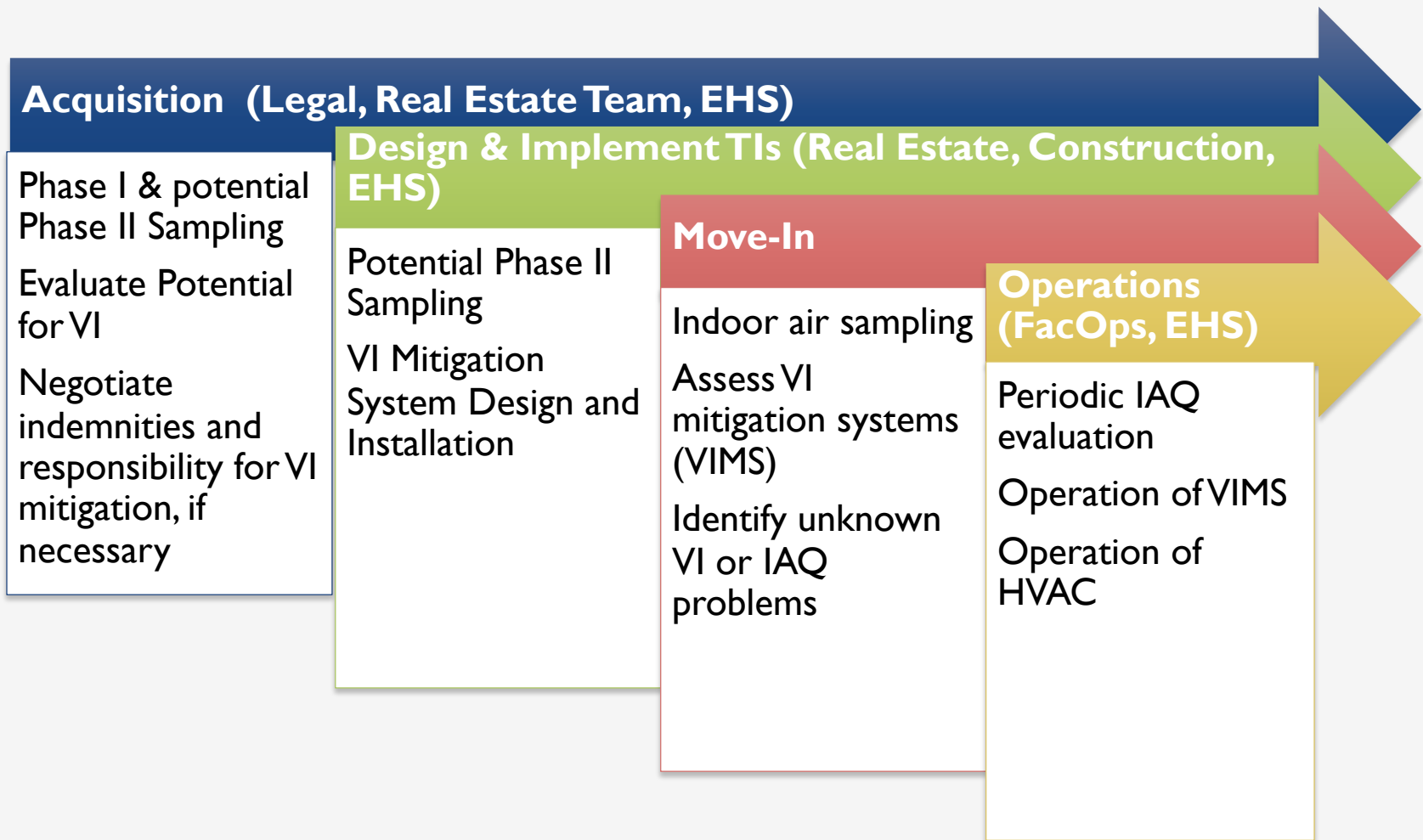
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Wrap-Up

VAPOR INTRUSION CONSIDERATIONS BY STAGE



A DEAL KILLER ?

- VI is rarely a deal killer
 - Most sites reviewed for Ex-Tech have not required mitigation
 - Mitigation is typically feasible when needed
- One site
 - Ex-Tech found VOCs in SSG well above screening levels
 - Indicated a significant VOC release and VI threat
 - Owner chose to proactively pursue cleanup making site use unavailable in the near term

EVALUATE EXISTING PROPERTY PORTFOLIO?

- Evaluate risk based on site history and offsite impacts
- Sample indoor air (2 seasons)
- Sub-slab sampling can help discern whether IA levels are from subsurface or business operations

TAKE-AWAYS

- Not all indoor air risks come from current operations
- The earlier VI potential can be evaluated, the better (i.e., before acquisition)
- TCE of particular regulatory concern
- VI is manageable with engineering controls



QUESTIONS?

Michelle King, Ph.D.
mkking@ekiconsult.com

Kat Wuelfing
kwuelfing@ekiconsult.com



www.ekiconsult.com