Developing a Quantitative Decision Framework for Residential Vapor Intrusion Evaluations

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CH2M is now Jacobs

Agenda

- Introduction
- Overview of Industrial QDF
- Development of Residential QDF
- Summary
- Q&A

QDF = Quantitative Decision Framework

Introduction

- Multiple lines of evidence (MLE) typically considered
    - Analytical and non-analytical

- EPA default attenuation factors (AFs) based on residences
    - VI not observed at industrial buildings using EPA default AFs

- Navy created VI database and quantitative decision framework (QDF) for industrial buildings
    - Defend moving off residential defaults
    - Used to systematically evaluate MLE

- DoD EDQW developing VI UFP-QAPP template
    - Utilizing industrial VI database and QDF
    - Developing/utilizing residential QDF
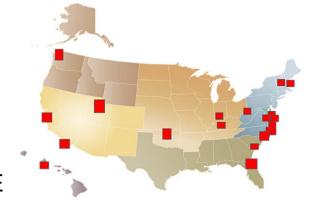   - Intergovernmental Data Quality Task Force (IDQTF)

> **Objective: Describe Residential QDF**

DoD = Department of Defense   EDQW = Environmental Data Quality Workgroup
UFP-QAPP = Uniform Federal Policy – Quality Assurance Project Plan

Overview of Navy Industrial VI Database & QDF

- Objectives
  - Create DoD-specific VI database for industrial buildings
  - Better understand attenuation and key factors influencing VI potential in industrial buildings
  - Create framework to assist RPMs in evaluating MLE
- 22 installations, 27 sites, and 79 buildings
  - Majority of sites have depth to water <15 ft
  - Large (50%), medium (35%), and small (15%) buildings
- Statistical analysis of database to guide:
  - Building prioritization (planning)
  - Likelihood of VI occurrence (investigation)
  - Planning for long-term stewardship

Refer to NESDI Project #476: Quantitative Decision Framework for Assessing Navy Vapor Intrusion Sites
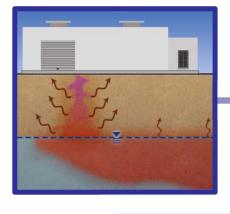**www.nesdi.navy.mil/Files/FinalReports/FR_476.pdf**

NESDI = Navy Environmental Sustainability Development to Integration

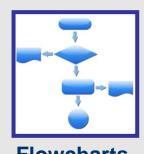# Overview of Industrial VI Database and QDF (cont'd)

Navy Industrial
VI Database

Data Analysis →

Key Influencing Factors/Empirical Relationships

Data Interpretation →

Flowcharts

Scorecard

Decision Matrix

- Considers multiple factors
- Decision science to weight importance of key factors
- Facilitates systematically evaluating MLE
- Undergoing peer-review and validation

Development of Residential VI QDF

- Additional analysis of EPA 2012 residential database

- Review of residential research (e.g., ASU & Indy)

- Literature review of VI residential studies

  – Re-analyses of EPA database by universities

  – 3-dimensional modeling studies (e.g., Brown Univ.)

- Compared findings for >30 factors from >25 studies

  – Example factors – VOC source strength, distance, depth, meteorology, building characteristics, etc.

- Identified most significant influencing factors based on:

  – Consistency in studies and results of additional analysis

- Key influencing factors used to develop residential QDF

USER'S QUICK START GUIDE

Residential Quantitative Decision Framework

Prepared for
Naval Facilities Engineering Command

March 2018

Residential VI QDF

- Subslab (SS) and indoor air (IA) concentrations are correlated
  - Non-linear relationship

- SS predicts ~40-percent of measured IA… but consider MLE

Subslab source strength weighted using non-linear scale

PCE in Subslab Soil Gas, Residential Only, 50x Screen

Log of PCE in Indoor Air [ug/m3] vs Log of PCE in Subslab Soil Gas[ug/m3]

Data from EPA (2012)

Weighting of Subslab Source Strength

Factor	Subslab Concentration	Weight
Average Subslab Soil Gas (SSSG) Concentration	**SSSG** < [33 x Indoor Air (IA) VISL]	0
	[33 x IA VISL] < **SSSG** <[130 x IA VISL]	0.5
	[130 x IA VISL] < **SSSG** < [530 x IA VISL]	1
	[530 x IA VISL] < **SSSG** < [2,100 x IA VISL] (or no information available)	2
	[2,100x VISL] < **SSSG** < 8,400 x VISL]	4
	[8,400 X VISL] < **SSSG** < 34,000 x VISL]	8
	SSSG > [34,000x IA VISL]	16

SSSG = Subslab Soil Gas   VISL = Vapor Intrusion Screening Level
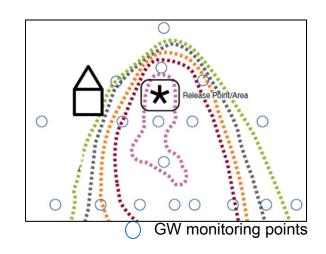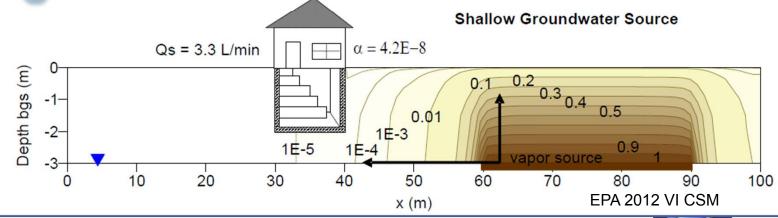
- Vapors decrease exponentially with lateral distance
  - Yao et al. (2013)
  - EPA 2012 VI CSM guidance
  - DoD 2015 industrial VI database
- Measured from point of release

Distance from high VOC source weighted using non-linear scale

Release Point/Area

○ GW monitoring points

Shallow Groundwater Source

$Q_s = 3.3$ L/min $\alpha = 4.2E{-8}$

Depth bgs (m)

0.1   0.2   0.3   0.4   0.5   0.9   1

0.01   1E-3   1E-4   1E-5

vapor source

x (m)

EPA 2012 VI CSM

Weighting of Distance to High Source
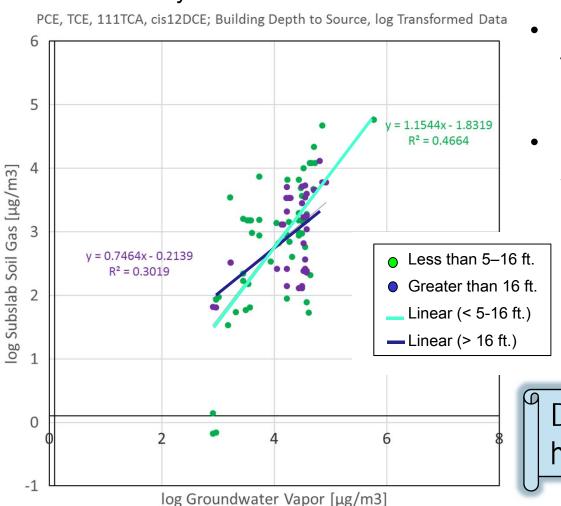
Factor	Distance	Weight
Distance to primary release point or high concentration mass storage area	**Distance** < 10 ft	8
	10 ft < **Distance** < 30 ft	6
	30 ft < **Distance** < 100 ft [or no information available]	4
	100 ft < **Distance** < 200 ft	2
	Distance >200 ft	0

Findings of Literature Review: Depth to Groundwater

Analysis of EPA 2012 Data

PCE, TCE, 111TCA, cis12DCE; Building Depth to Source, log Transformed Data

y = 1.1544x - 1.8319
R² = 0.4664

y = 0.7464x - 0.2139
R² = 0.3019

Legend:
- ● Less than 5–16 ft.
- ● Greater than 16 ft.
- — Linear (< 5-16 ft.)
- — Linear (> 16 ft.)

x-axis: log Groundwater Vapor [μg/m3]
y-axis: log Subslab Soil Gas [μg/m3]

- Several studies suggest slight-to-moderate relationship with GW depth and subslab

- Relationship is stronger at shallow GW depths (e.g., 5 ft. below foundation)

Depth to groundwater weighted highest for very shallow depths

Weighting for Depth-to-Groundwater
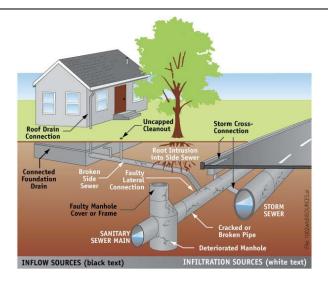
Factor	Depth to Groundwater	Weight
Depth to impacted groundwater	<5 feet (1.5 meters)	4
	5 to 10 feet (1.5 to 3 meters) [or no information available on depth to groundwater]	1
	10 to 16 feet (3.0 to 5.0 meters)	0.5
	>16 feet (5 meters)	0
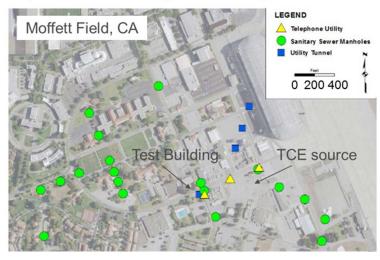
Findings of Literature Review: Preferential Pathways

A feature that intercepts a VOC source, is connected to bldg., and that has little resistance to vapor flow

Adapted from McHugh & Beckley, AEHS 2017

Moffett Field, CA

LEGEND
- ▲ Telephone Utility
- ● Sanitary Sewer Manholes
- ■ Utility Tunnel

Feet
0 200 400

Test Building   TCE source

- TCE vapors detected in manhole (●)
  - Background contribution unclear
- Manhole-to-IA attenuation using tracers ≥1,300x

- Site VOCs observed in utilities intercepting source area
  - Vapors migrate/attenuate into bldgs.
- Potential for preferential vapor transport should be considered

Weighting for Potential Preferential Pathways

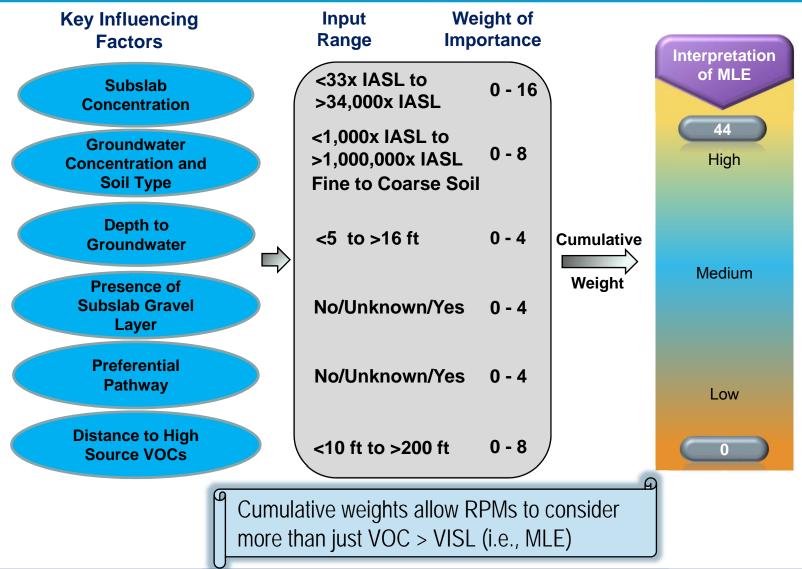| Factor	Subslab Concentration	Weight
Presence of atypical preferential pathway connecting building to strong source of contamination?	yes	4
	insufficient information	2
	known to be absent	0

Residential QDF Weighting of MLE

Key Influencing Factors	Input Range	Weight of Importance
Subslab Concentration	<33x IASL to >34,000x IASL	0 - 16
Groundwater Concentration and Soil Type	<1,000x IASL to >1,000,000x IASL Fine to Coarse Soil	0 - 8
Depth to Groundwater	<5 to >16 ft	0 - 4
Presence of Subslab Gravel Layer	No/Unknown/Yes	0 - 4
Preferential Pathway	No/Unknown/Yes	0 - 4
Distance to High Source VOCs	<10 ft to >200 ft	0 - 8

Cumulative Weight

Interpretation of MLE

44

High

Medium

Low

0

Cumulative weights allow RPMs to consider more than just VOC > VISL (i.e., MLE)
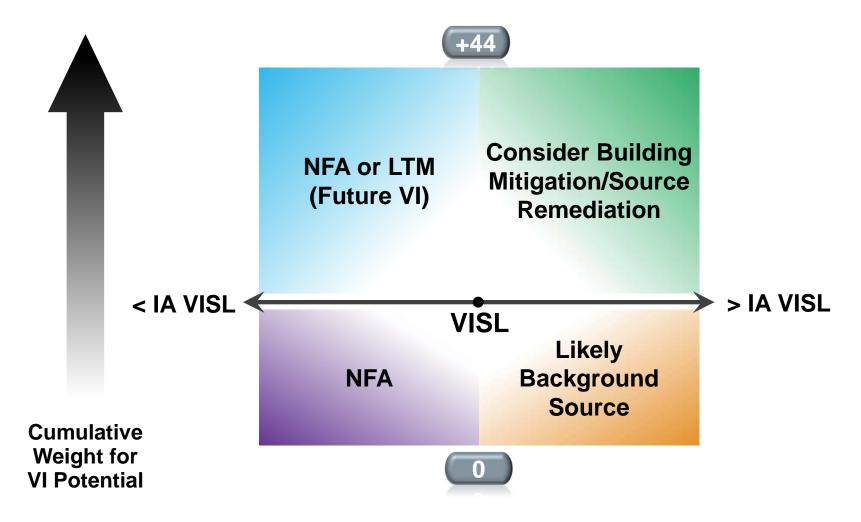
Residential QDF Decision Matrix with Indoor Air Data

IA = Indoor Air   NFA = No Further Action   VISL = Vapor Intrusion Screening Level

Summary

- Developed QDF so RPMs have a procedure to evaluate MLE (not just VOC > VISL)

- Residential QDF based on review of VI literature and reanalysis of EPA residential database

- Identified key VI influencing factors

- Applied decision science to weight the importance of MLE

- Cumulative weights allow RPMs to:

  - Consider more than just VOC > VISL and

  - Plan, implement, and interpret VI investigations

- VI UFP-QAPP template (in progress) incorporates the QDF, with plans to engage IDQTF

IDQTF = Intergovernmental Data Quality Task Force

Contacts and Questions

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Questions?