
INDOOR AIR PROGRAM AND DATA EVALUATION

Marilyn S. Hajicek, P.G.

Colorado Department of Labor and Employment
Division of Oil and Public Safety

OPS Vapor Intrusion Program

- Regulations effective 2/1/99
- Regulations and Guidance available at:
<http://oil.cdle.state.co.us>

Overview

- Discussion of current program
- Rationale for development of database
- Key elements of the database
- Findings to-date
- Future data evaluation and collection

Initial Screening Criteria

- RBSLs in groundwater to protect indoor air exposure pathway.
 - Benzene – 0.015 mg/L
 - Toluene – 6.9 mg/L
 - Ethylbenzene – 18 mg/L
 - Xylenes – 14 mg/L
- RBSLs apply to structures within the influence of contamination (exceptions: businesses that dispense petroleum products).

Immediate Indoor Air Sampling

- In some situations, indoor air samples are collected immediately.
 - Presence of free product in close proximity to the structure.
 - Presence of petroleum odors inside the structure.
 - Complaints of possible exposure effects from building occupants.

Indoor Air BTEX Thresholds

Benzene	0.23 $\mu\text{g}/\text{m}^3$ (10^{-6} carcinogenic risk)
Toluene	120 $\mu\text{g}/\text{m}^3$ (Hazard Index = 1)
Ethylbenzene	300 $\mu\text{g}/\text{m}^3$ (HI= 1)
Xylenes	210 $\mu\text{g}/\text{m}^3$ (HI= 1)

Secondary Screening Criteria

Soil vapor concentrations that exceed the RBSL for the soil vapor to indoor air exposure pathway

$$\text{Benzene} = 2,700 \mu\text{g}/\text{m}^3$$

Advantages of Soil Vapor Sampling

- Can be used to screen both soil to indoor air and groundwater to indoor pathways.
- Does not have the background issue that indoor air sampling poses.
- Does not unduly alarm potential receptors.
- Soil vapor concentrations represent average conditions over larger areas (than a point soil sample).
- Sub-slab soil vapor samples are potentially useful but may be difficult to obtain.

Attenuation Factor

Johnson & Ettinger model used to calculate attenuation factor.

$$AF = \frac{RBSL_{indoor\ air}}{RBSL_{soil\ vapor}}$$

Sample Collection Locations and Depths

- Locations for permanent soil vapor wells
 - At source of contamination
 - Between source of contamination and structure
- Depths of well screens
 - At source of contamination
 - At depth of foundation
 - Additional samples based on heterogeneity

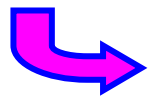
Site Specific Screening Criteria

Examples of parameters that can be changed:

- Distance between foundation and soil vapor source
- Total soil porosity unsaturated zone
- Air and water content of unsaturated zone
- Total building area
- Intrinsic permeability of soil adjacent to foundation

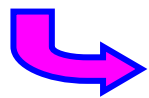
Soil Sampling Results

- Soil vapor concentrations $>$ RBSL near structure at the depth of foundation



collect indoor air samples

- Soil vapor concentrations $>$ RBSL at source and/or at depth of contamination near structure, but $<$ RBSL at depth of foundation near structure



continue monitoring

Background Issues

- Screen for potential sources in building
- Sample indoor air in other structures of similar use and construction in vicinity, outside of the influence of contamination
- Collect outdoor air samples concurrently

Indoor Air Sampling

Collected from:

- Occupied living areas
- Basement, if applicable

Indoor Air Mitigation

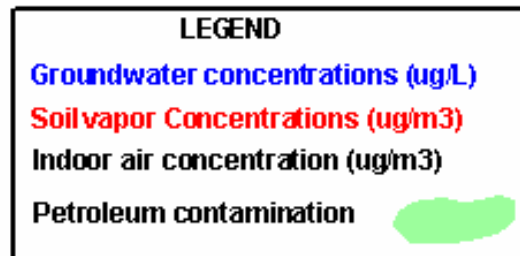
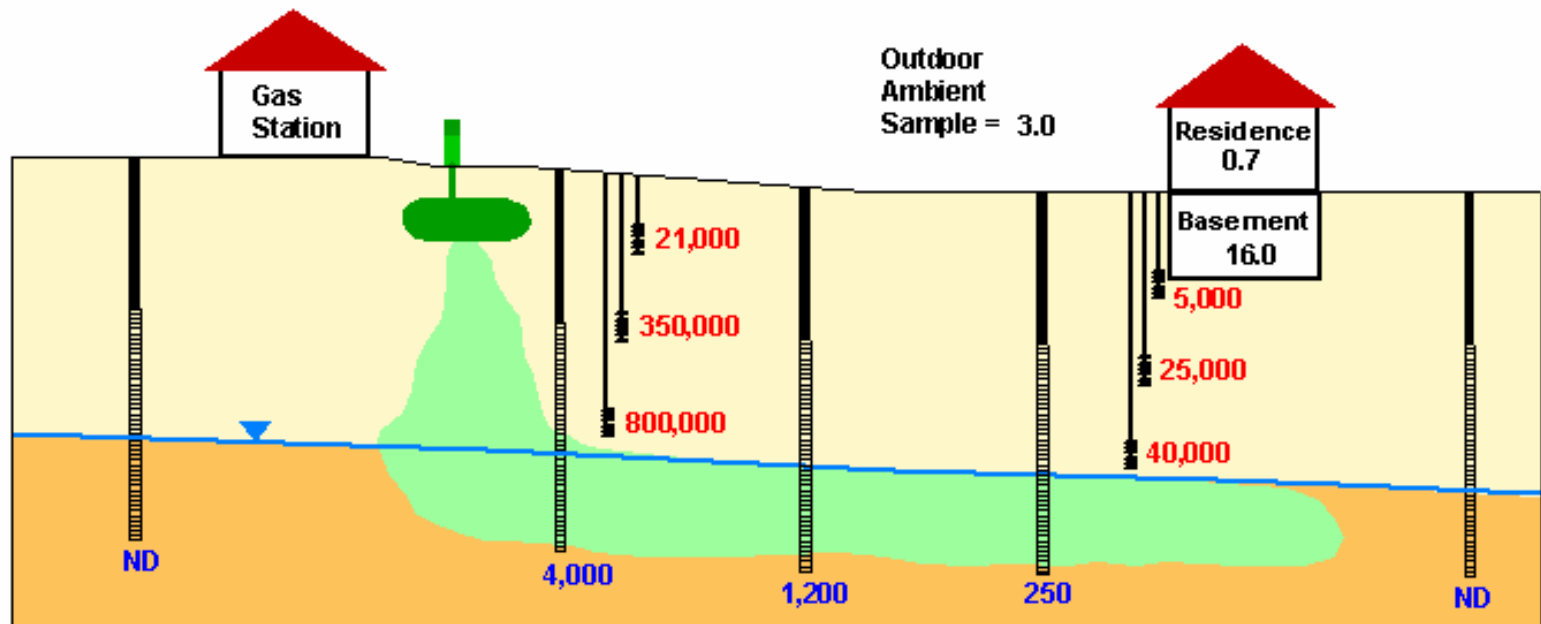
Immediate mitigation activities are implemented at sites where indoor air samples exceed the site-specific threshold (and are not eliminated through the background screening process).

Post-Assessment Monitoring

Regular monitoring of indoor air and soil vapor will continue:

- At any site where indoor air concentrations do not exceed the indoor air threshold, but soil vapor samples exceed RBSLs or SSTLs, or
- At any site where indoor air samples exceed the indoor air threshold, and mitigation has been implemented.

Typical Program Scenario



Database Evaluation Goals

- Identify if there are trends based on site conditions (soil types, depth to groundwater, source concentrations, etc.)
- Compare results with current process to identify if additional screening criteria is appropriate
- Determine additional data collection needs
- Determine whether vadose biodegradation can be characterized using site information in the database

Media Concentration Samples

Type of Sample	Number of Sites
Soil vapor	109
Groundwater	109
Soil	103
Indoor air	22
Crawl space	2
Sub-slab	1

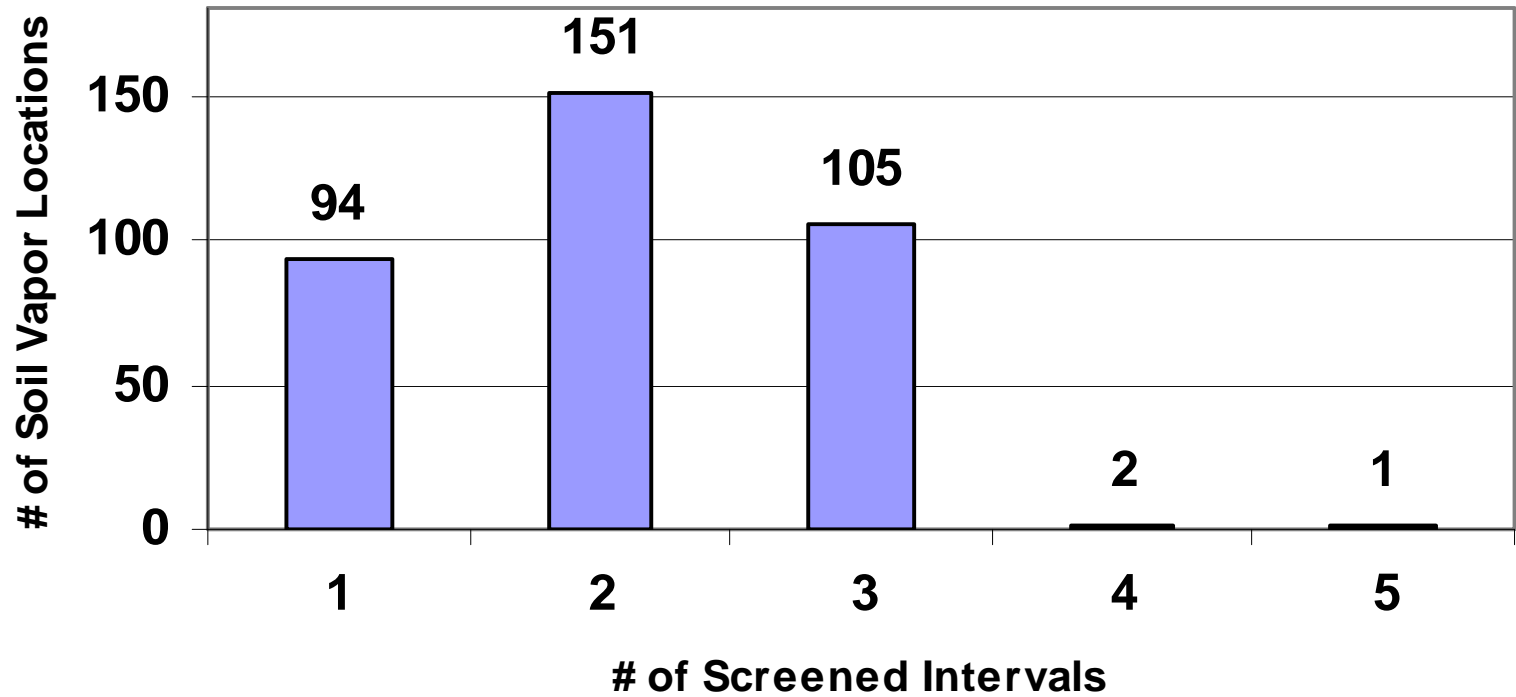
Physical Parameters Measured

Type of Data Collected	Sites (Total = 109)
CO ₂	31
O ₂	32
USCS Soil Type	109
Depth to water	109
FOC	14
Porosity	14
Moisture content	17

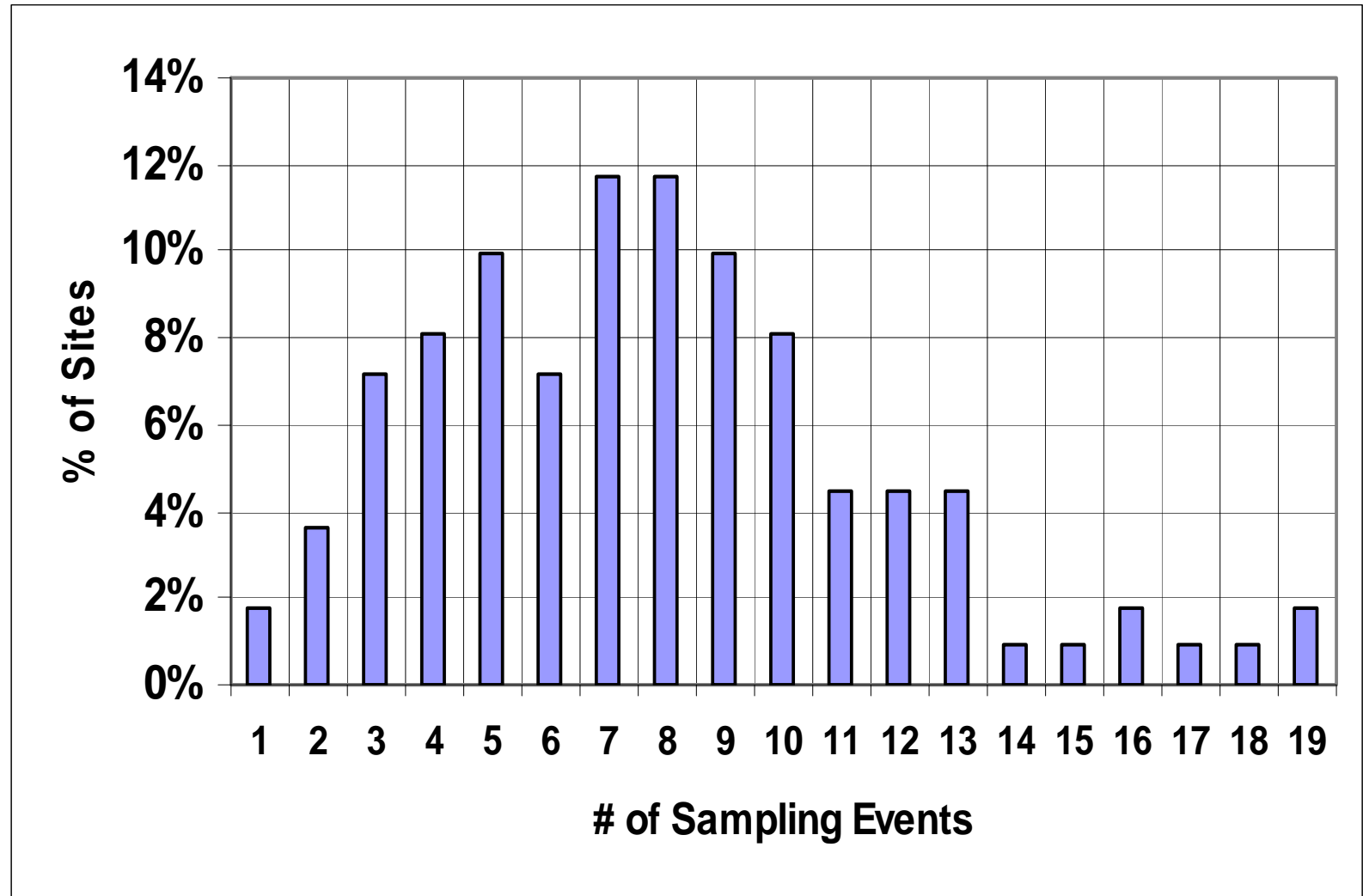
Summary of Soil Vapor Data

Total number of sites	109
Number of soil vapor wells	353
Number of sampling events at each site	Range 1 to 19 Average 7
Total number of samples collected	4025

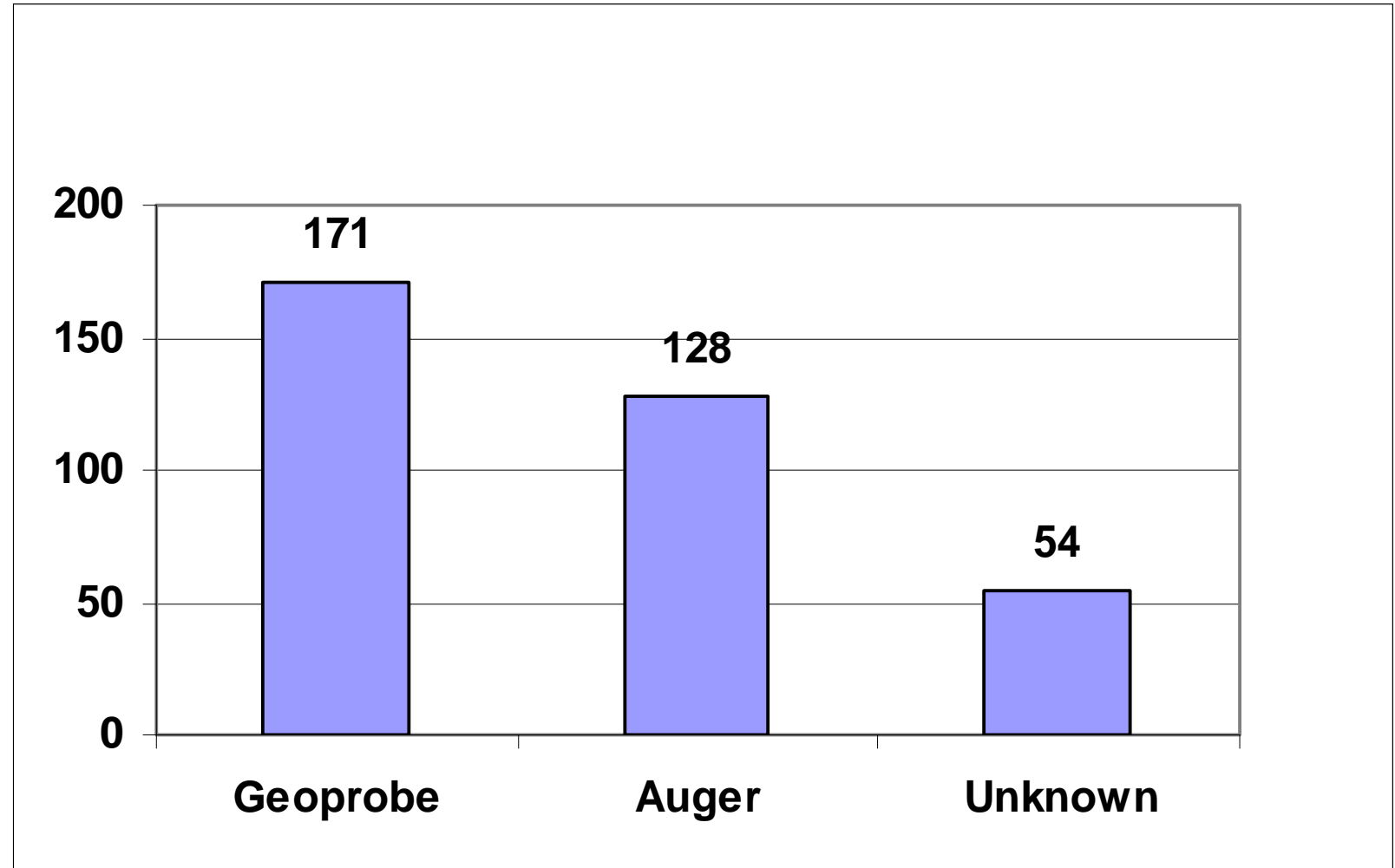
Distribution of Soil Vapor Well Screens



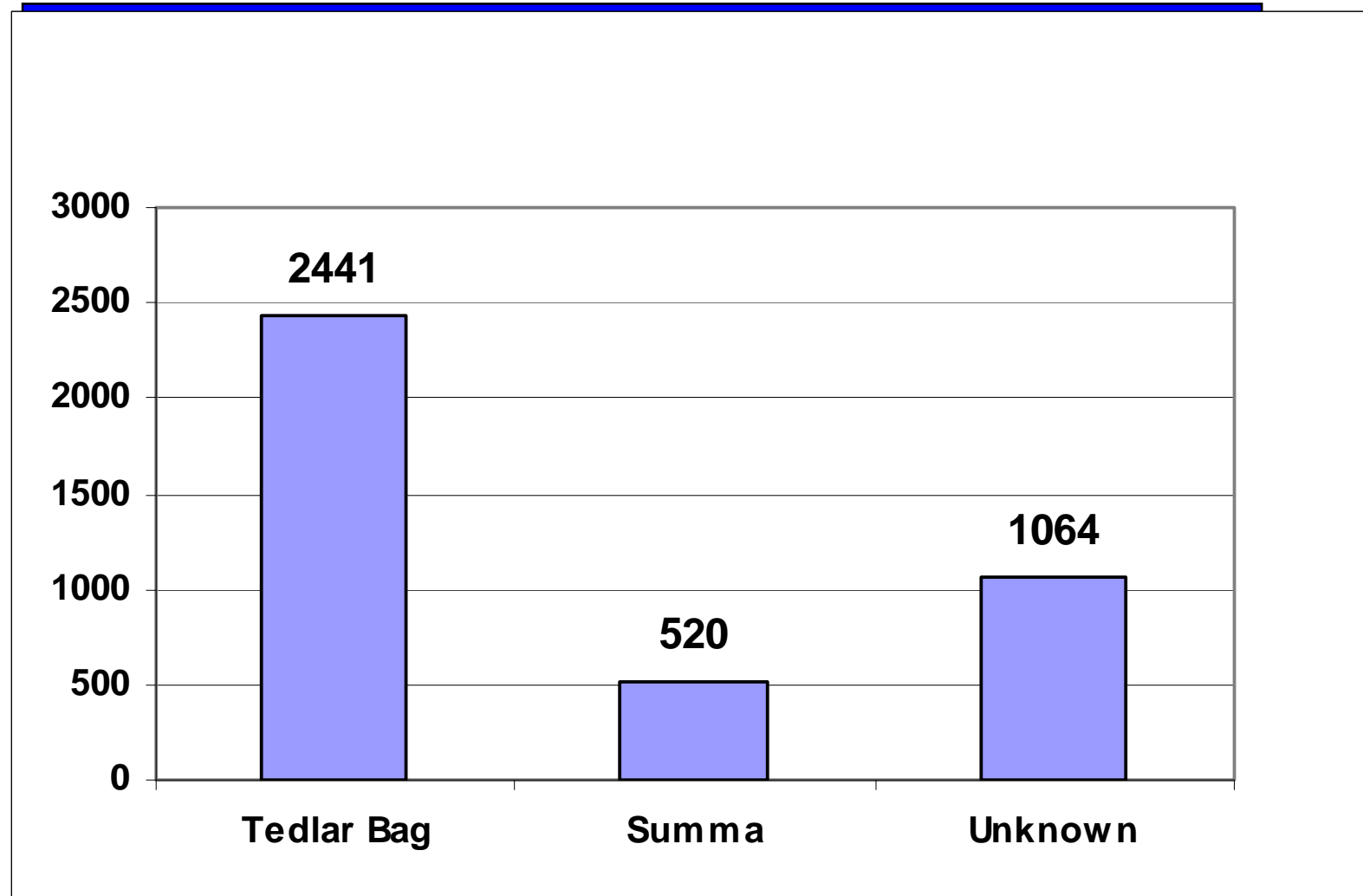
Soil Vapor Sampling Events at Sites



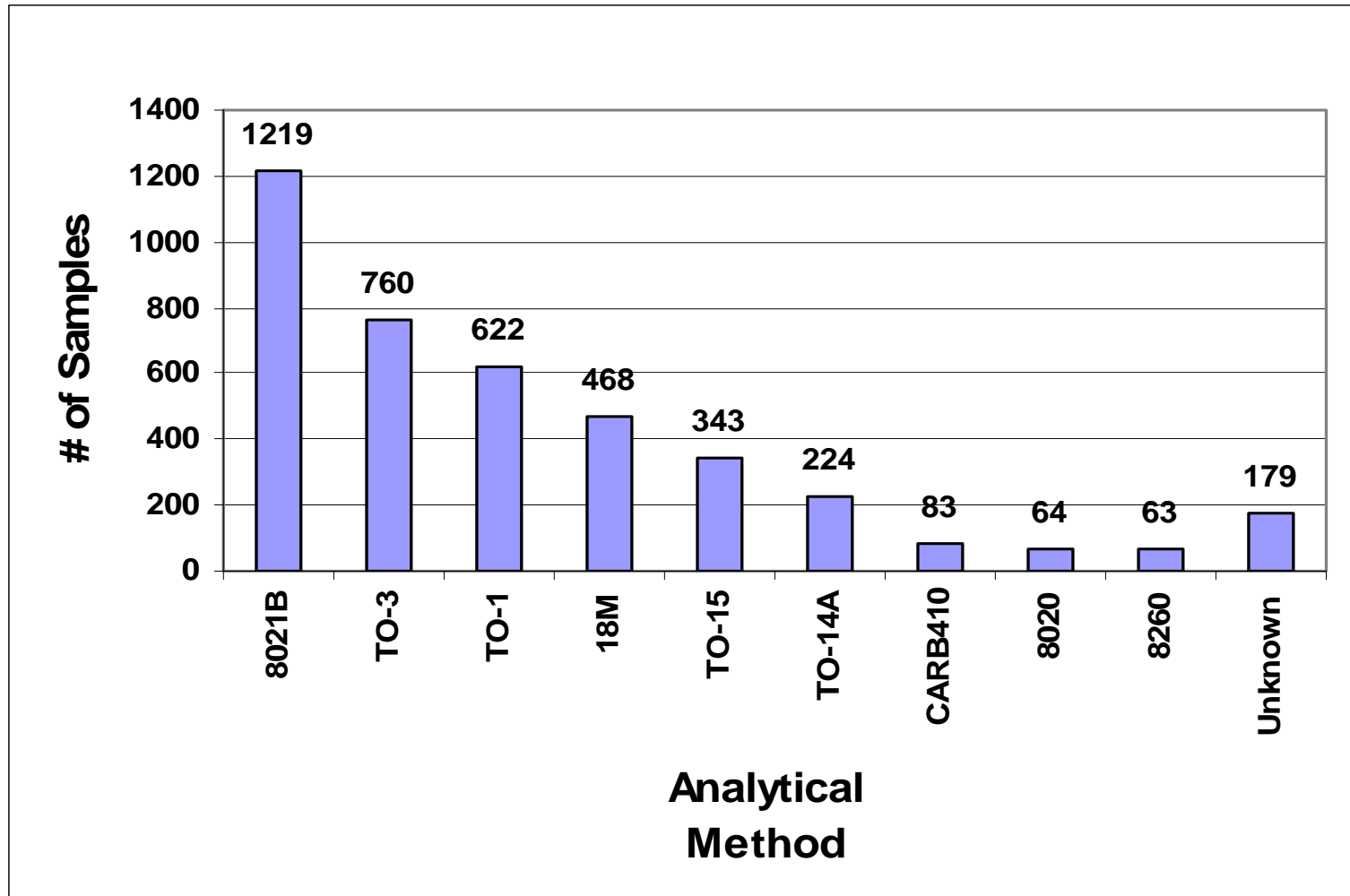
Vapor Well Construction Methods



Soil Vapor Sample Collection Methods



Soil Vapor Analytical Methods

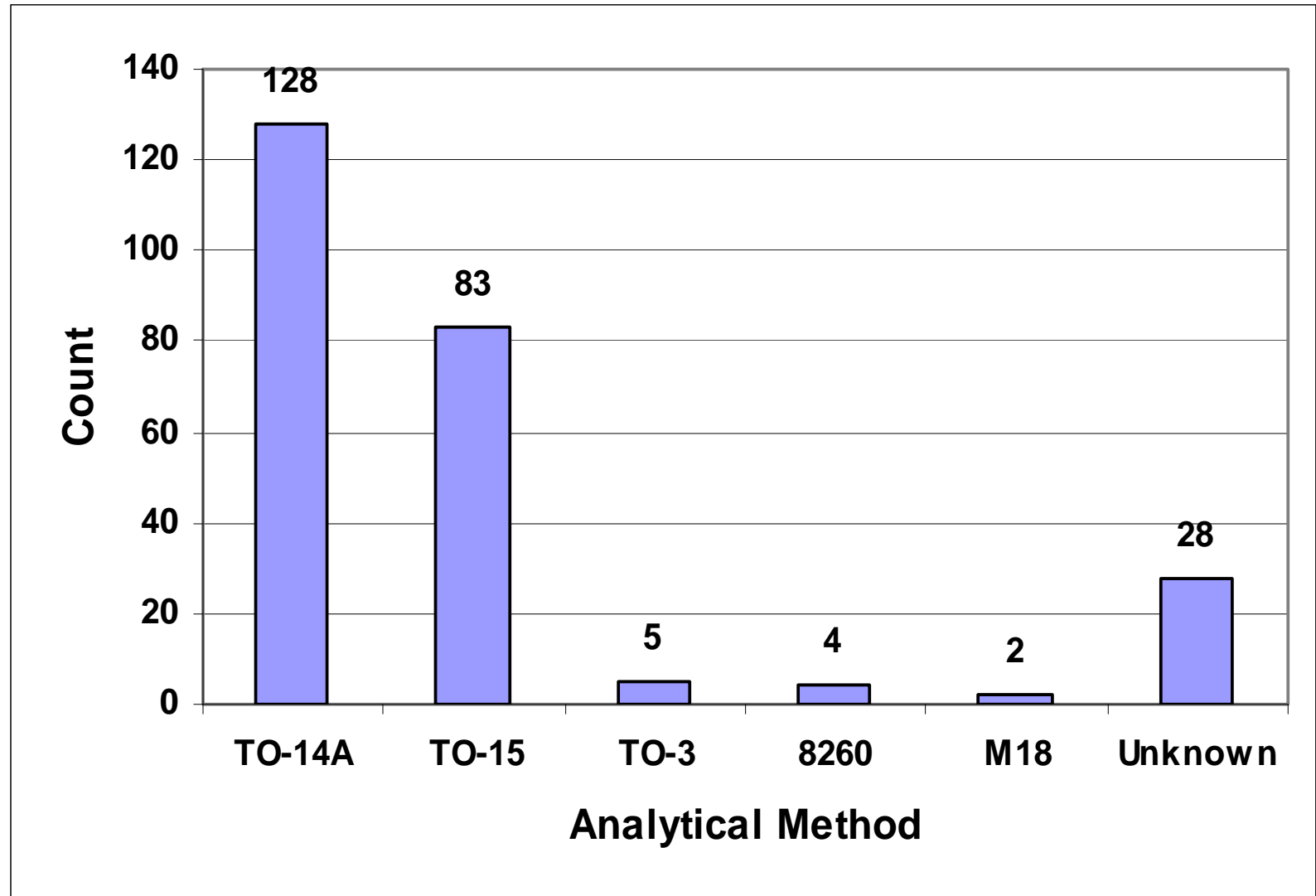


Air Samples

Air Sample Location	Number of Sites
Indoor air (main level)	22
Basement	11
Outdoor air (ambient air)	21

Indoor Air Collection Methods	Number of Samples
24-hr Summa	92
8-hr Summa	28
Summa (unknown duration)	7
Unknown method	123

Indoor Air Analytical Methods



Current Activities

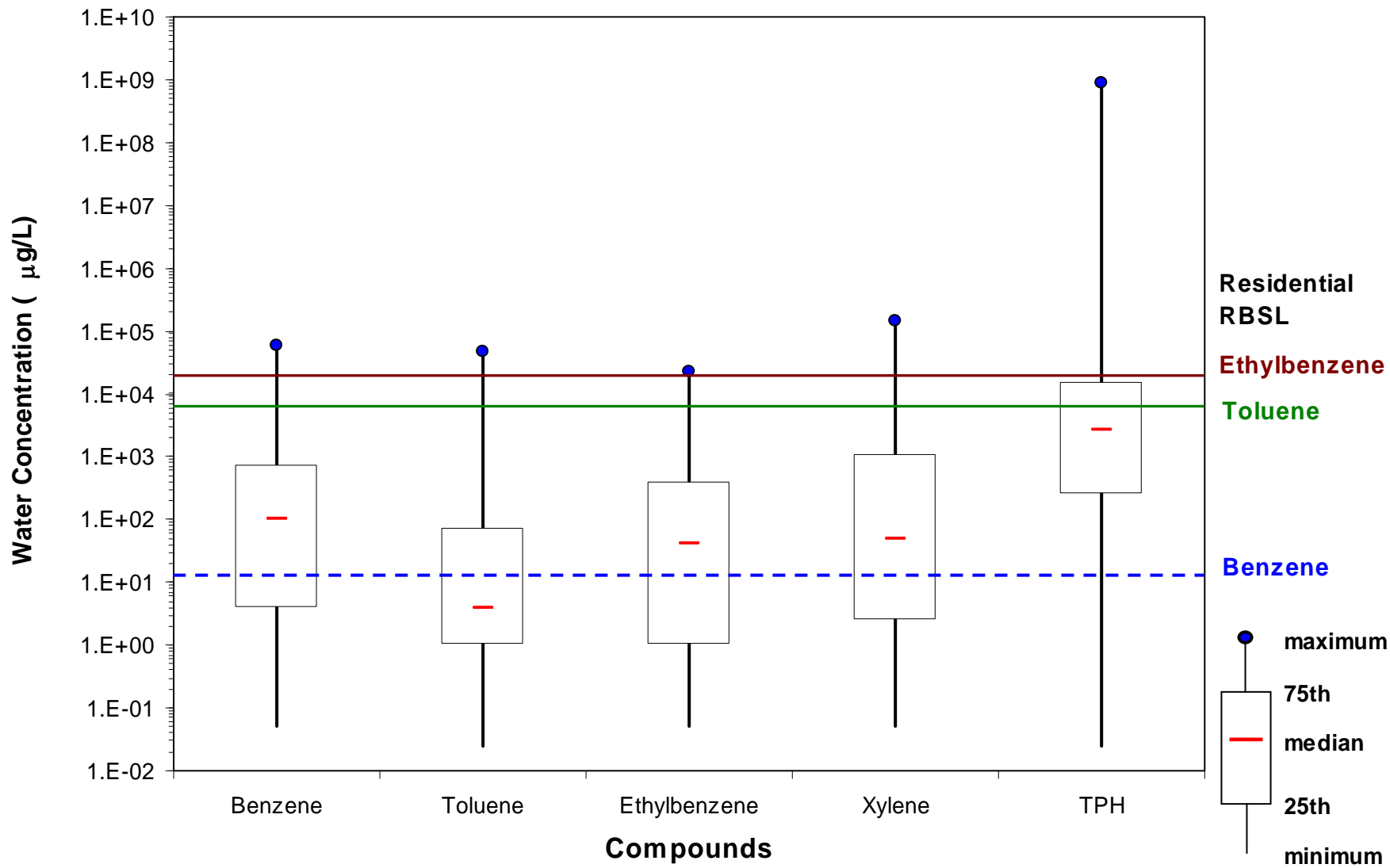
- Develop a Microsoft Access database of OPS sites that have soil vapor data
- Review and summarize information in the database
- Perform QA/QC evaluation of the data

Data Evaluation

- Evaluate BTEX concentrations in soil vapor, groundwater, indoor air and outdoor air for all sites
 - Compare to RBSLs and background values
- Examined sites with indoor air and soil vapor data (22 sites)

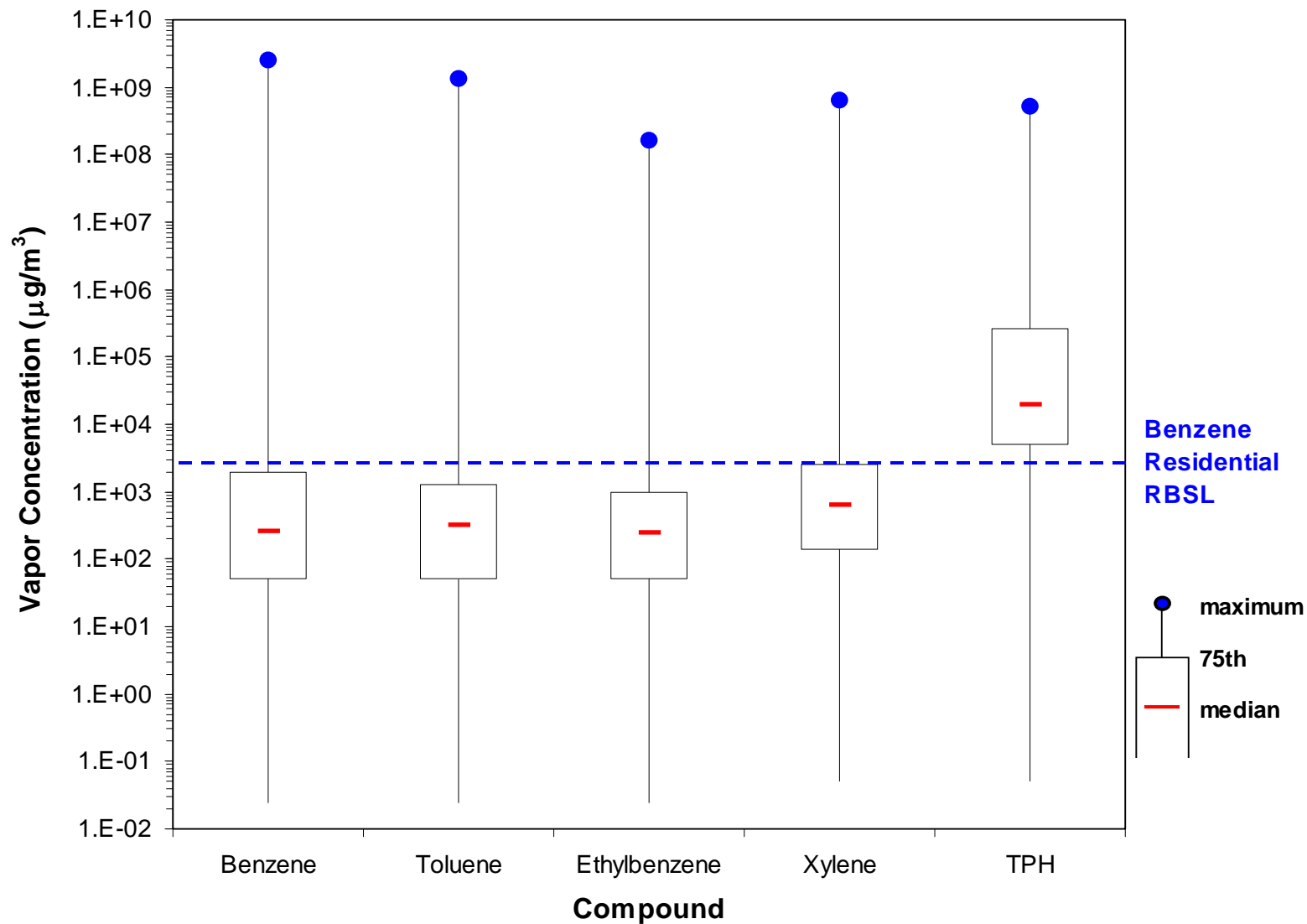
BTEX in Groundwater by Site

109 Sites

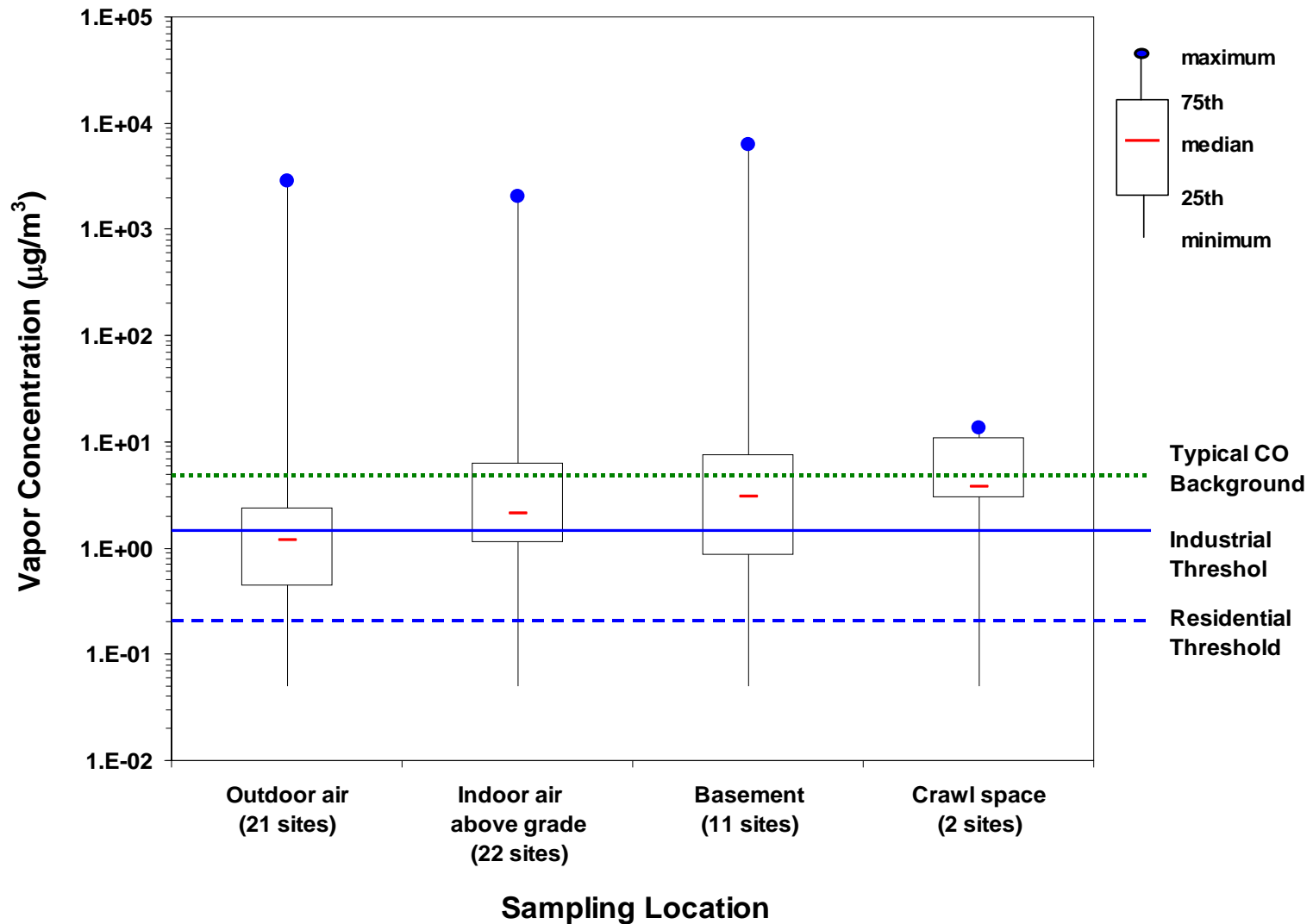


BTEX in Soil Vapor by Site

109 Sites

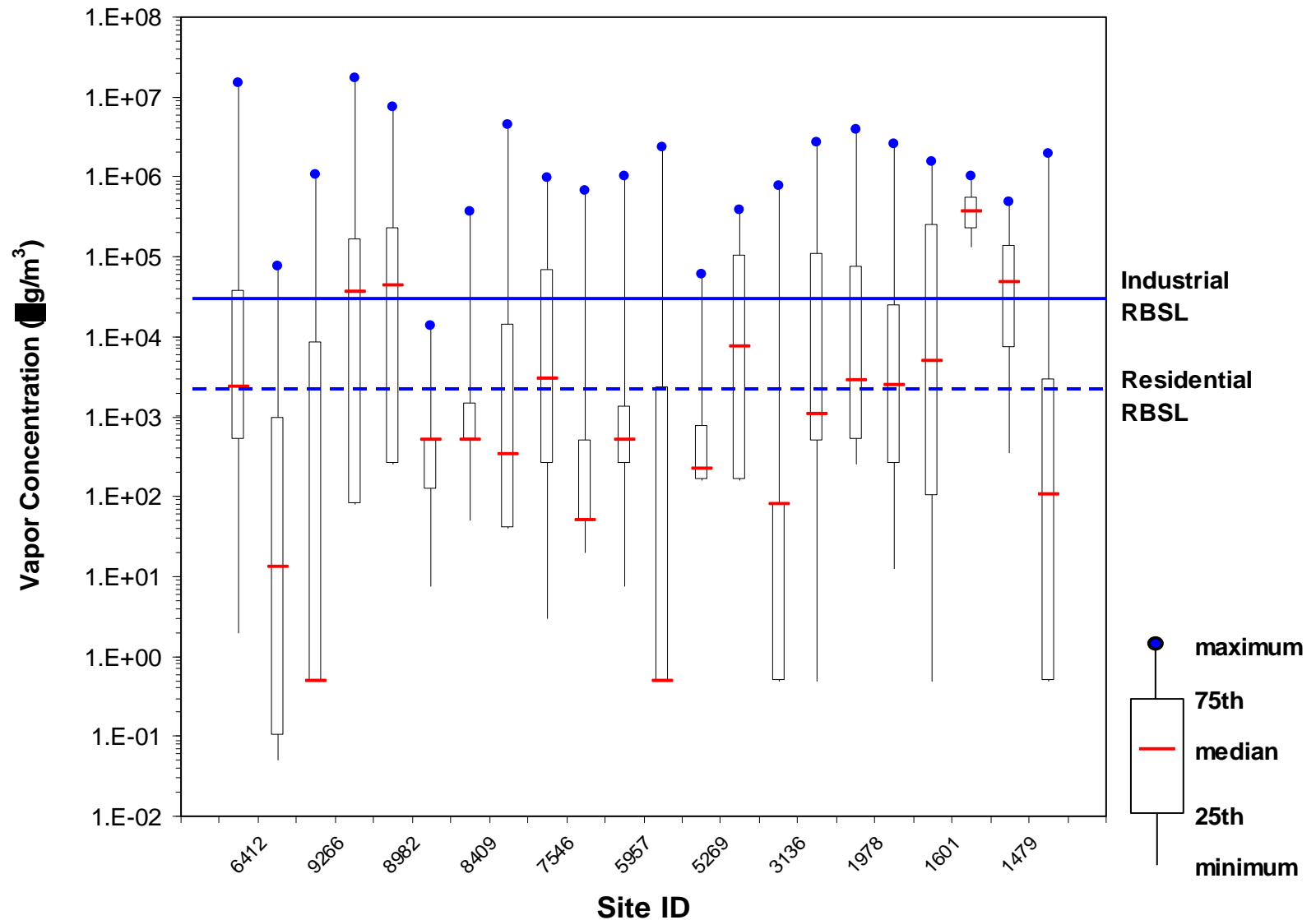


Benzene Concentrations in Air

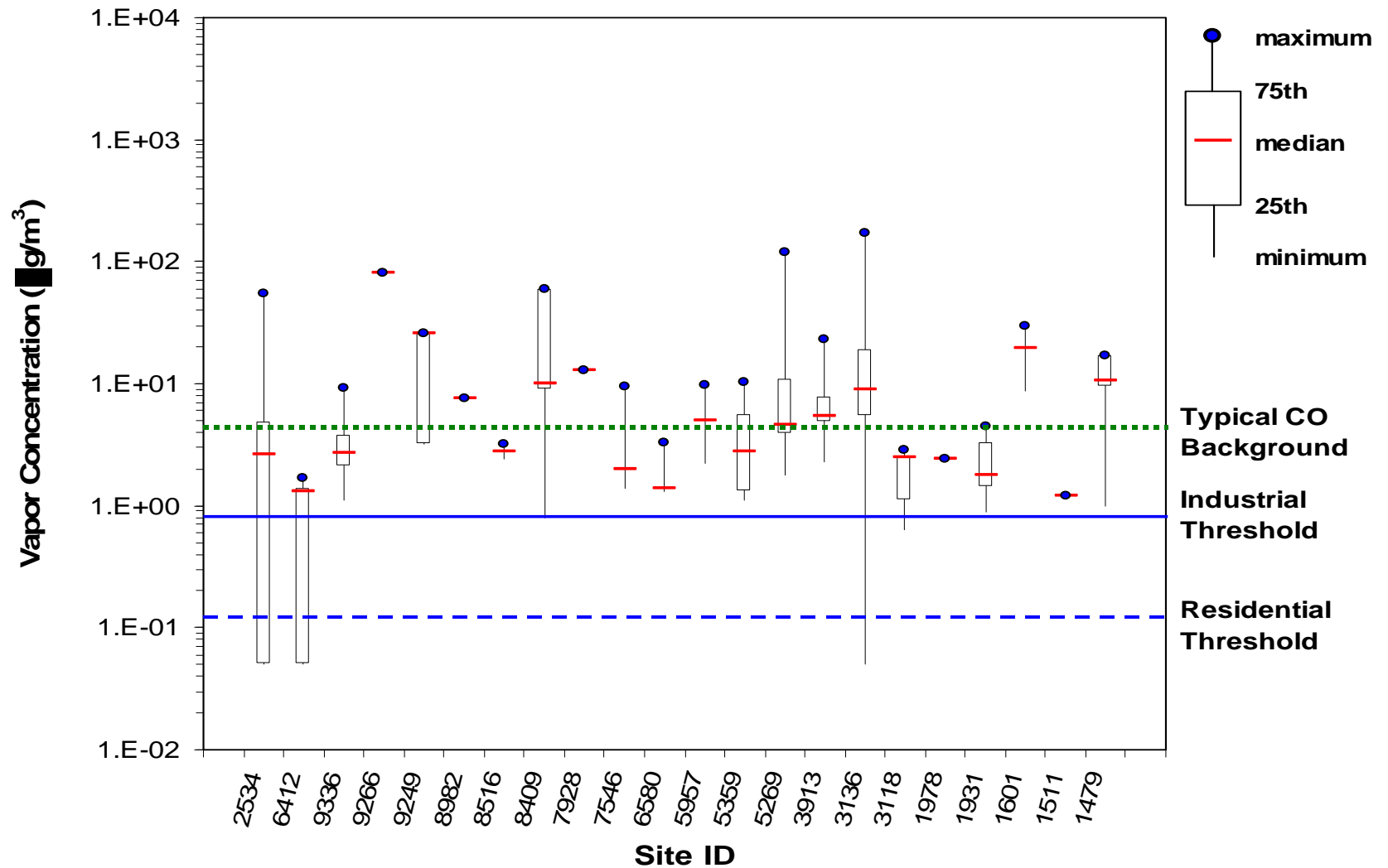


Benzene in Soil Vapor

(from the 22 sites that had indoor air samples)



Benzene in Indoor Air (22 Sites)



Data Evaluation Conclusions

- Benzene is primary chemical of concern
- Benzene concentration in groundwater exceeds RBSL at **more than** 50% of the sample locations
- Benzene concentration in soil vapor exceeds RBSL at **less than** 25% of sample locations
- Benzene concentration in outdoor and indoor air exceeds threshold value at **more than** 75% of sites
- Benzene concentration in outdoor and indoor air exceeds typical background values at **less than** 50% of sites

Data Evaluation Conclusions

- Estimation of empirical attenuation factors difficult due to:
 - Variability in soil vapor and indoor air data
 - Indoor air concentrations at/near background levels
- Additional evaluation and population of database warranted

Continuing Work

- Continue to QA/QC the data
- Provide an interim guidance document to contractors regarding requirements and methodology (currently developed and in draft form)
- Collect additional site data to enhance the study
- Identify if there are trends based on site conditions (soil types, depth to groundwater, source concentrations, etc.)
- Compare results with current process to identify if additional screening criteria is appropriate
- Determine whether vadose biodegradation can be characterized using site information in the database

Guidance to Contractors

Interim vapor intrusion guidance

- Program requirements
- Soil vapor and sub-slab sample point construction
- Soil vapor and indoor air sampling methodology
- Laboratory analyses
- Indoor air screening checklist
- Vapor intrusion mitigation

Enhance Existing Data

- Toluene, ethylbenzene, xylenes, MTBE, and total volatile hydrocarbon analyses
- Measure radon at vapor intrusion sites
- Additional information regarding lithologic profile
- Measurement of O₂ and CO₂
- Sub-slab sampling
- Measure pressure gradients