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# **INDOOR AIR PROGRAM AND DATA EVALUATION**

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# OPS Vapor Intrusion Program

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

# Overview

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- 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

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- 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

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- 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

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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

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

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

# Advantages of Soil Vapor Sampling

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- 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

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Johnson & Ettinger model used to calculate attenuation factor.

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

# Sample Collection Locations and Depths

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- 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

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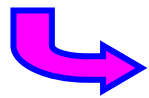
Examples of parameters that can be changed:

- 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

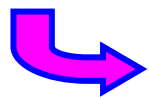
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- Soil vapor concentrations  $>$  RBSL near structure at the depth of foundation



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

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- 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

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Collected from:

- Occupied living areas
- Basement, if applicable

# Indoor Air Mitigation

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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

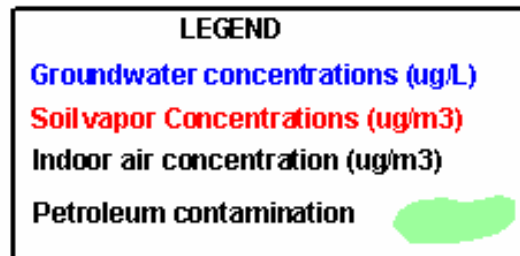
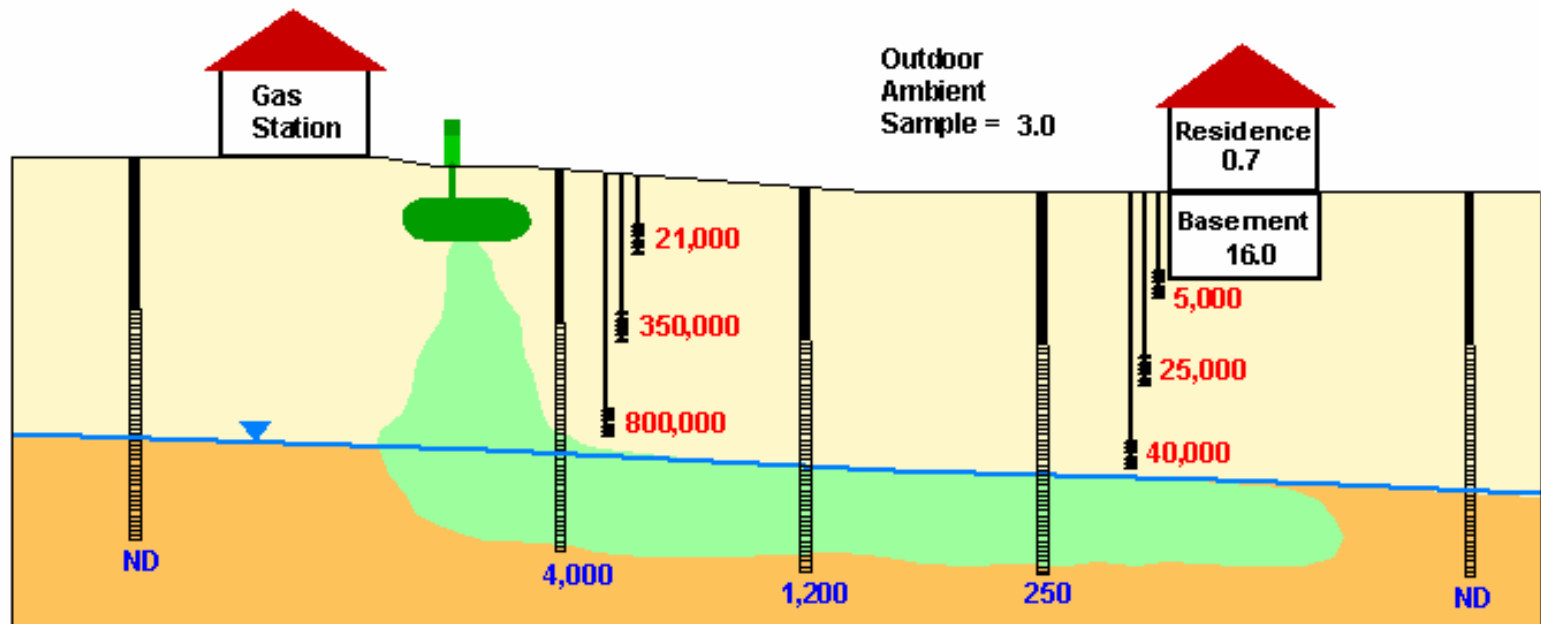
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Regular monitoring of indoor air and soil vapor will continue:

- 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

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- 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

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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

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

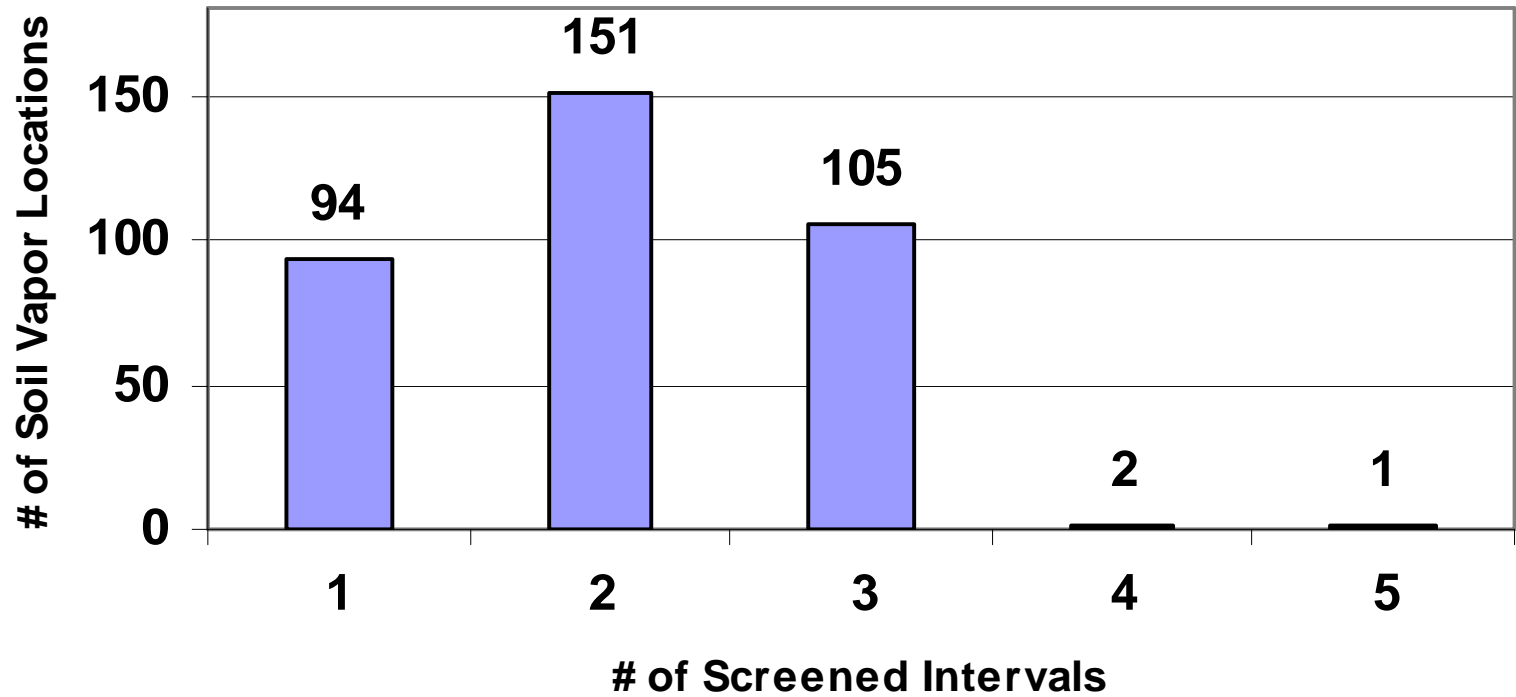
# Summary of Soil Vapor Data

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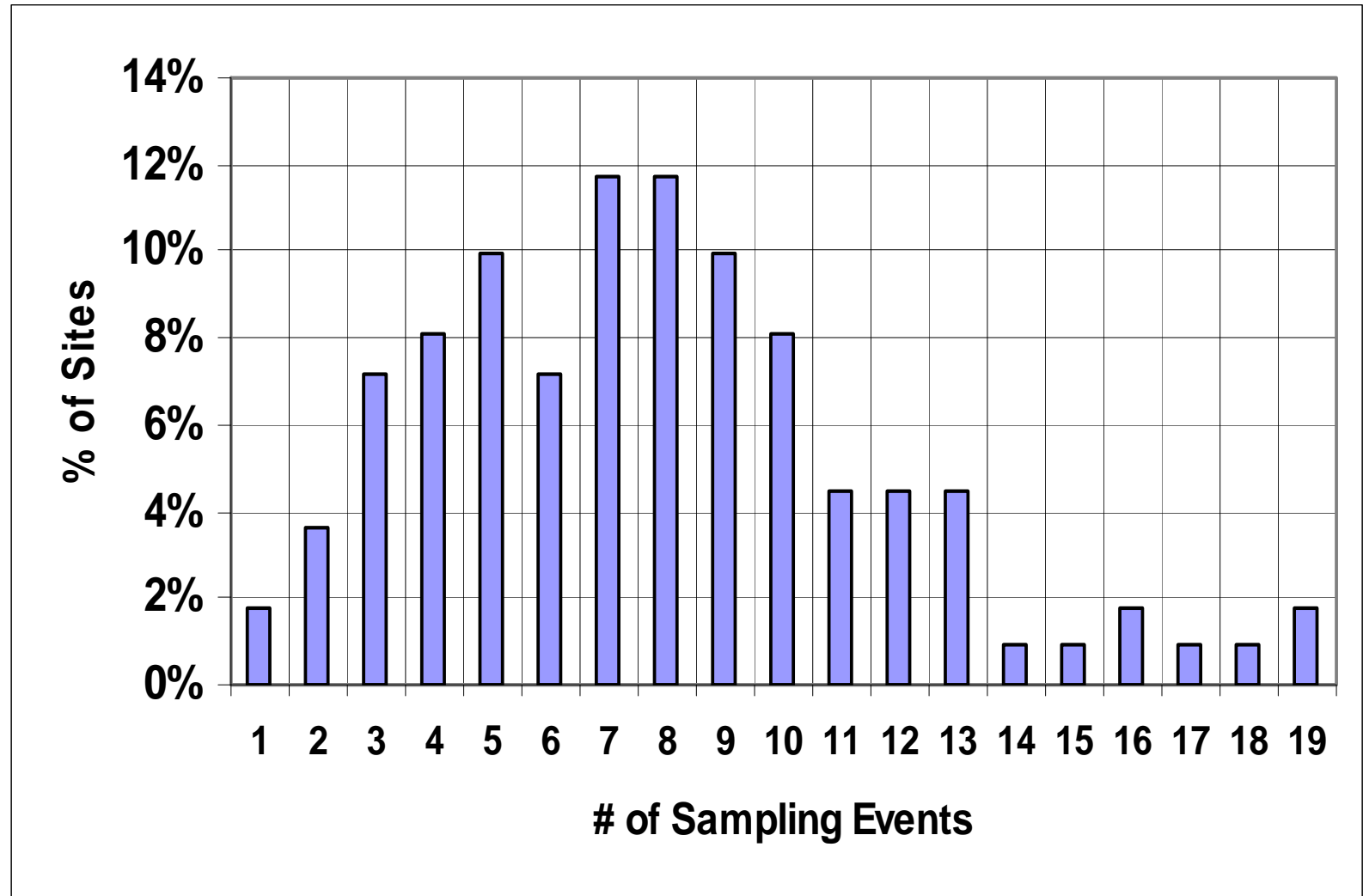
Total number of sites	109
Number of soil vapor wells	353
Number of sampling events at each site	Range 1 to 19 Average 7
Total number of samples collected	4025

# Distribution of Soil Vapor Well Screens

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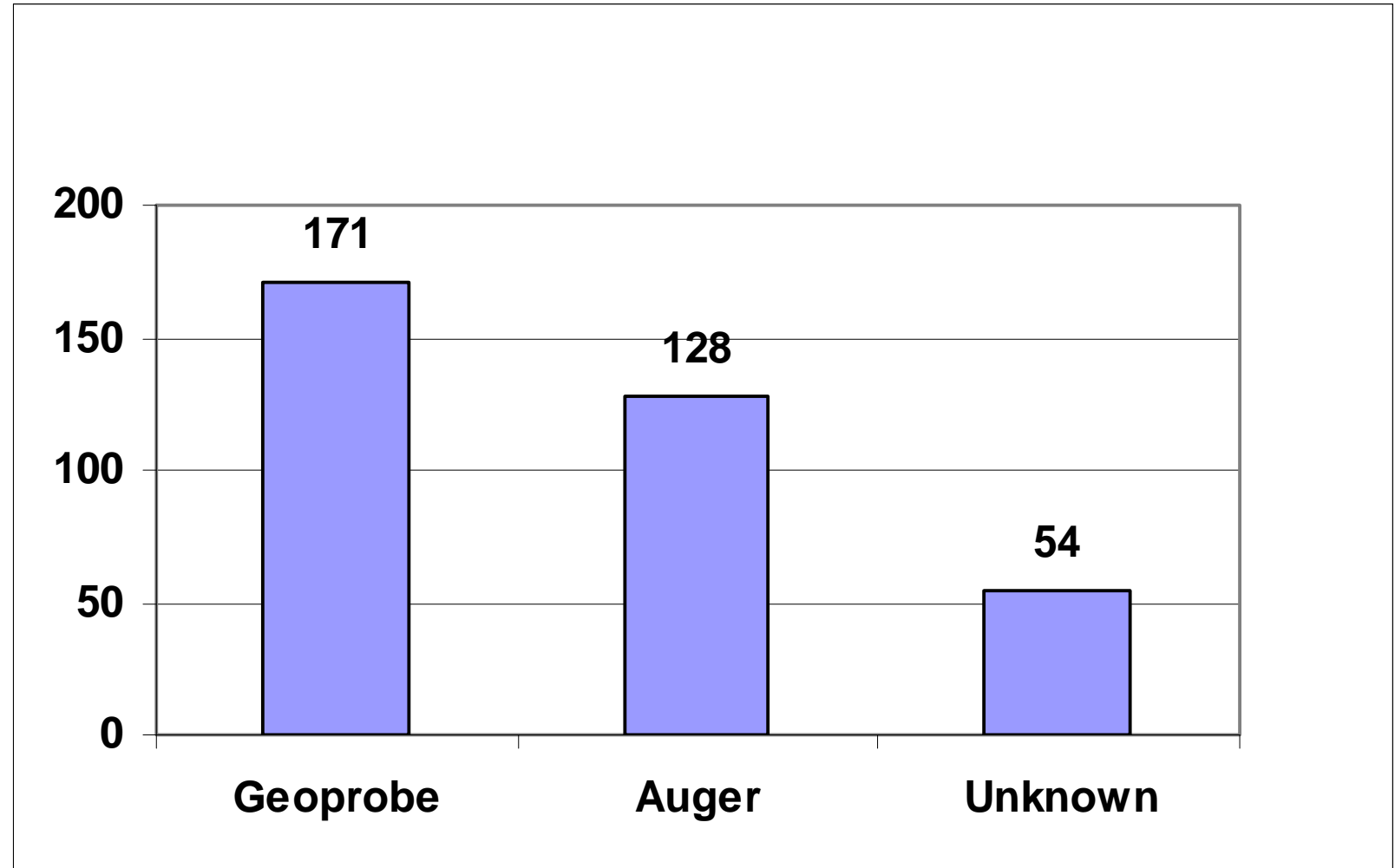


# Soil Vapor Sampling Events at Sites



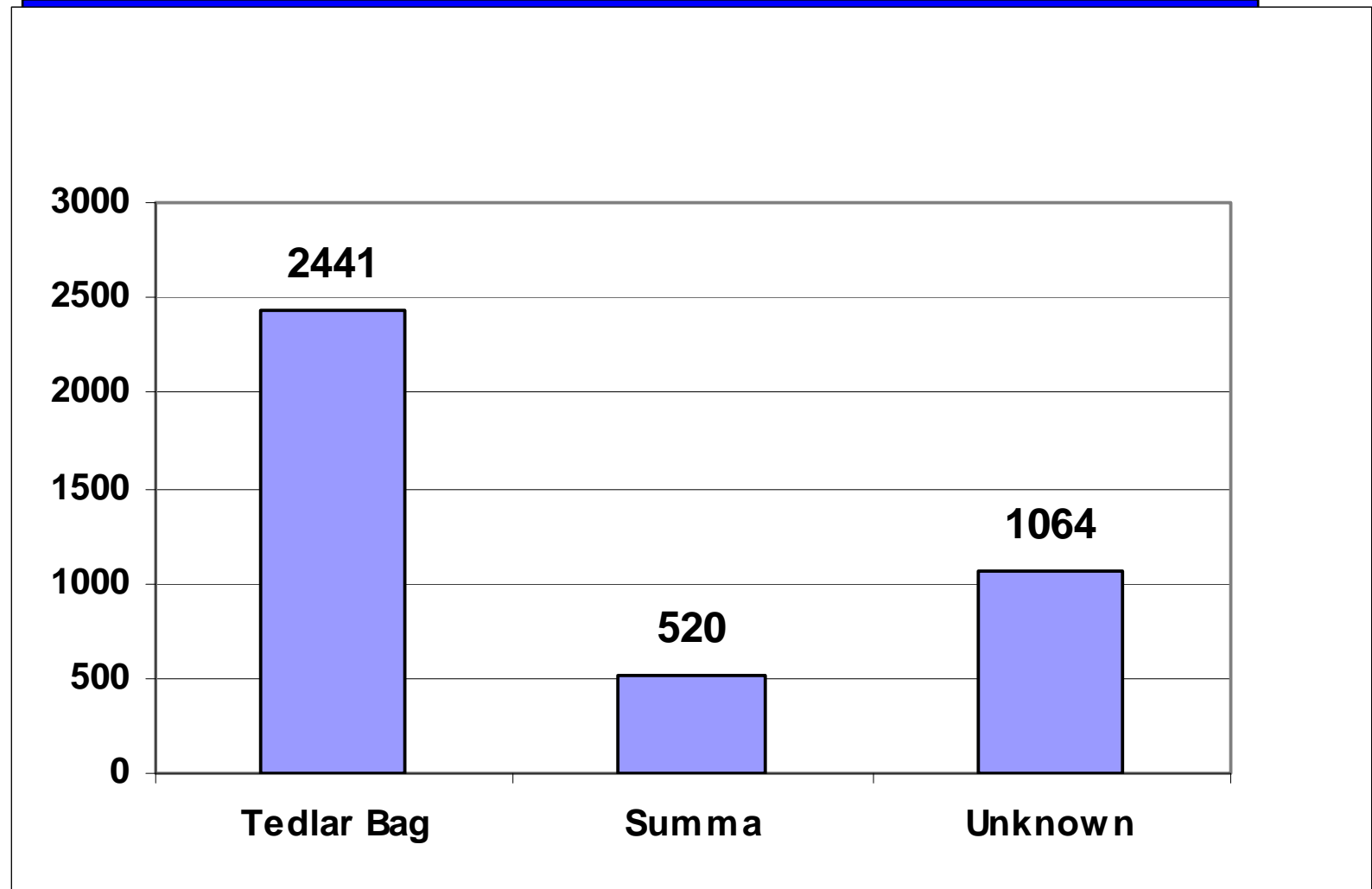
# Vapor Well Construction Methods

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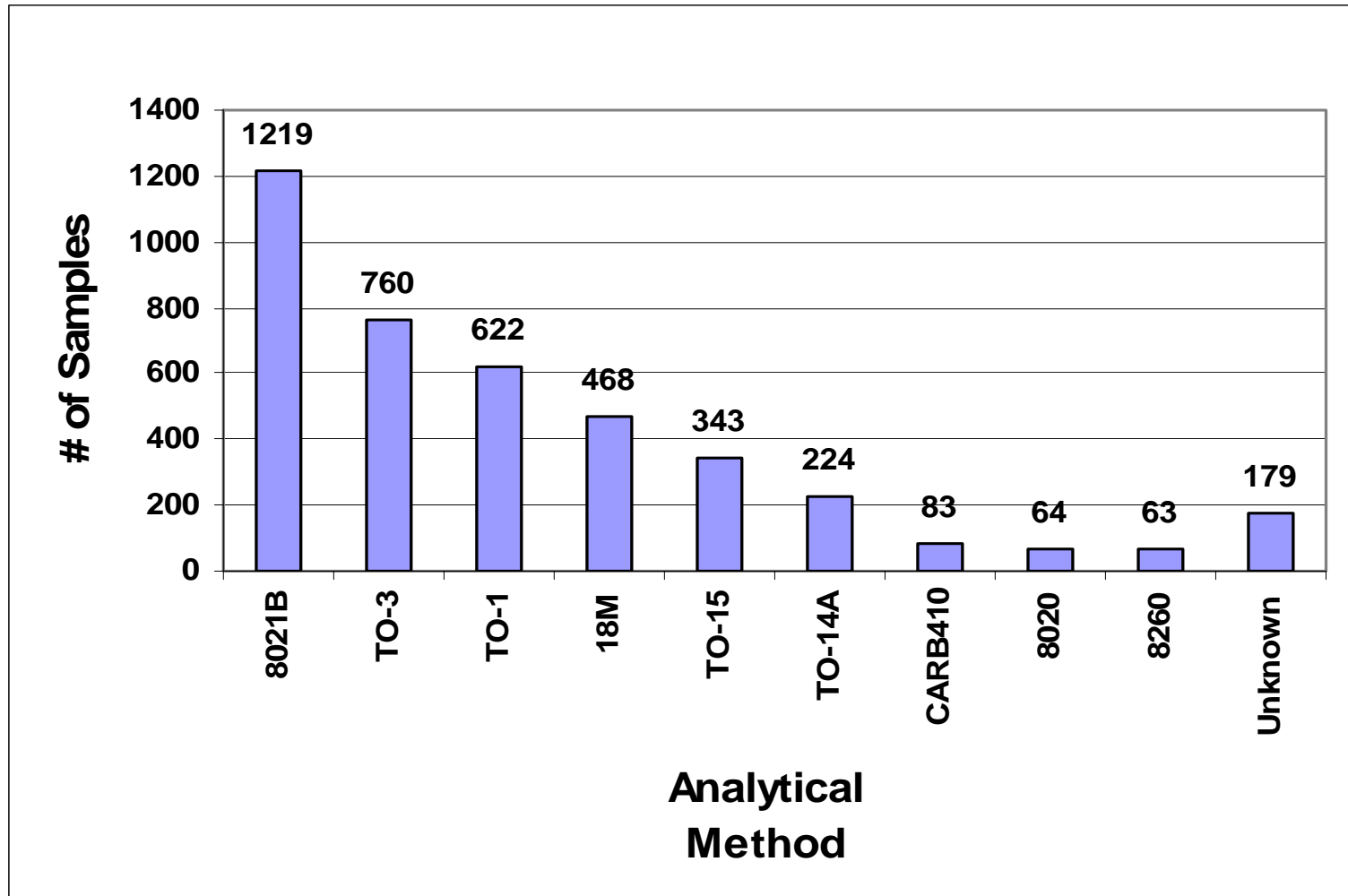


# Soil Vapor Sample Collection Methods



# Soil Vapor Analytical Methods

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# Air Samples

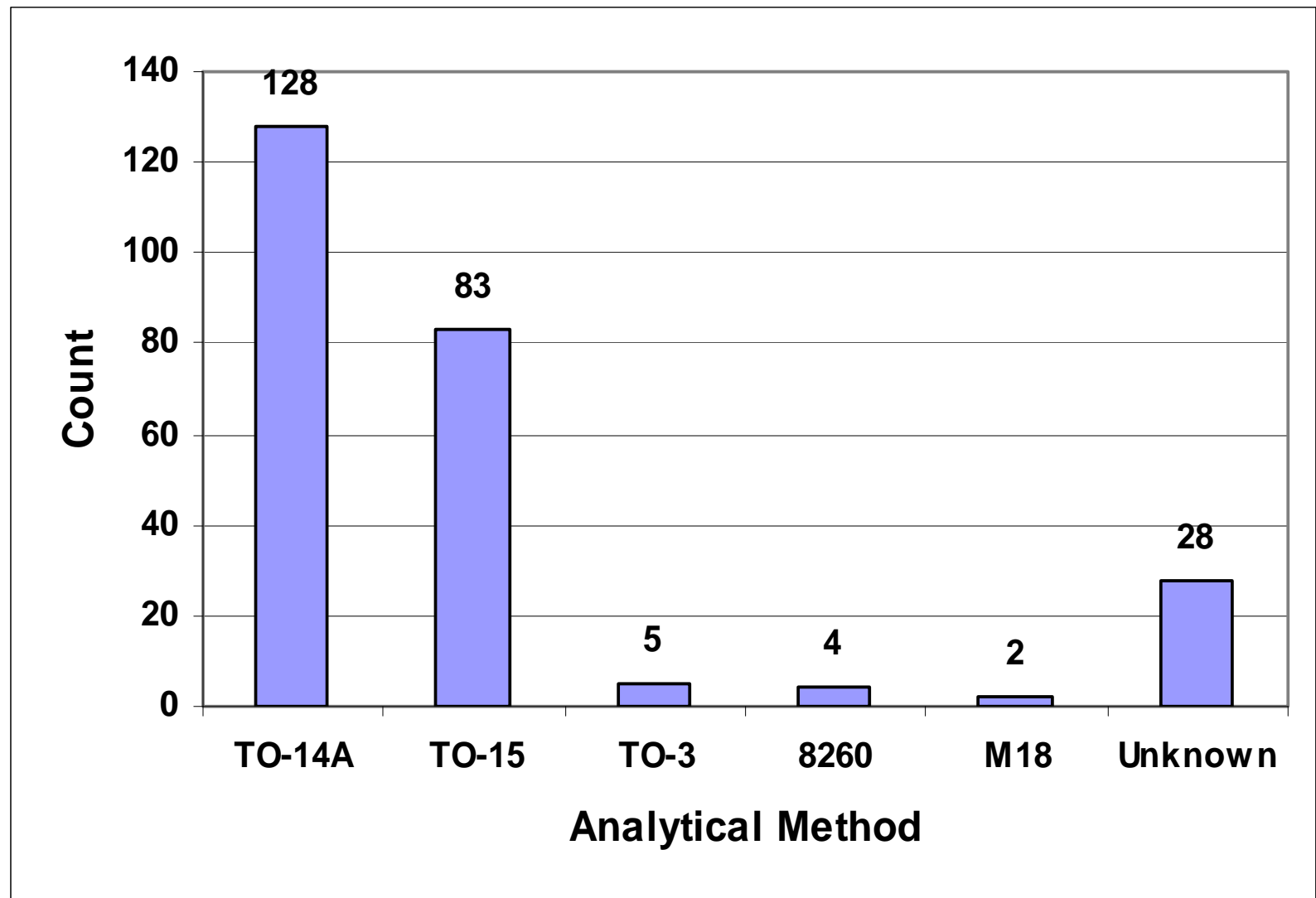
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Air Sample Location	Number of Sites
Indoor air (main level)	22
Basement	11
Outdoor air (ambient air)	21

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

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# Current Activities

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- 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

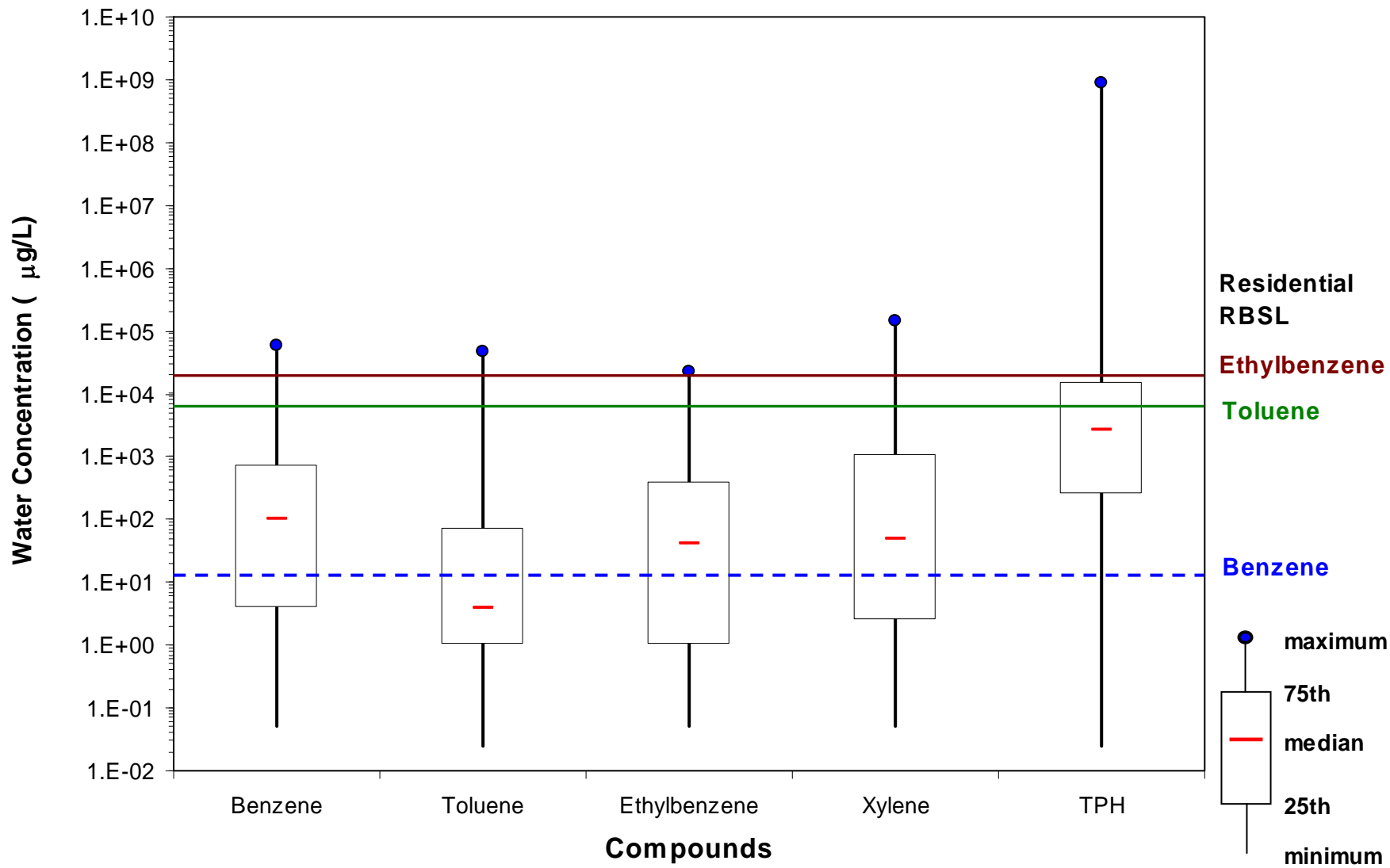
# Data Evaluation

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- 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)

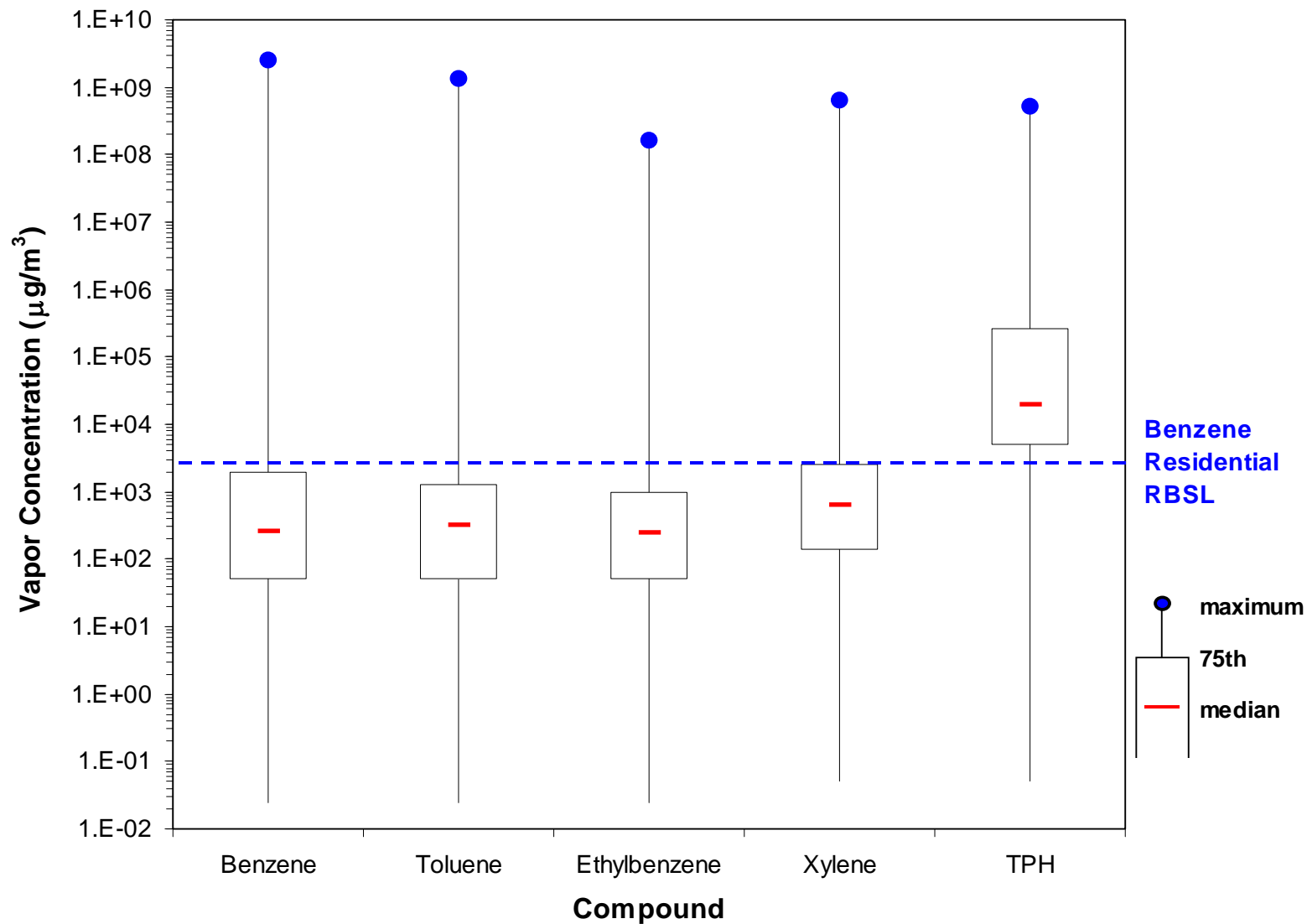
# BTEX in Groundwater by Site

## 109 Sites



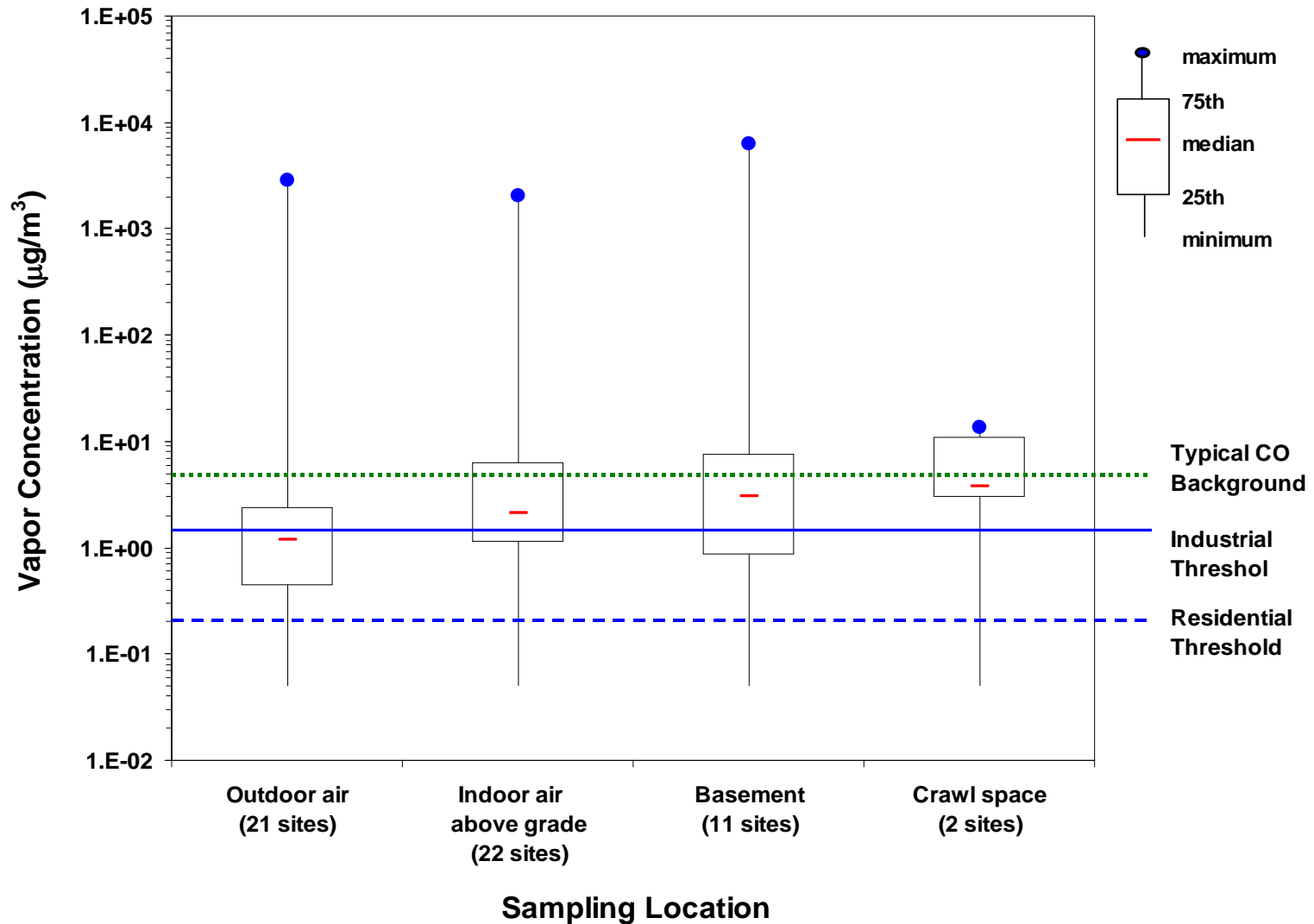
# BTEX in Soil Vapor by Site

## 109 Sites



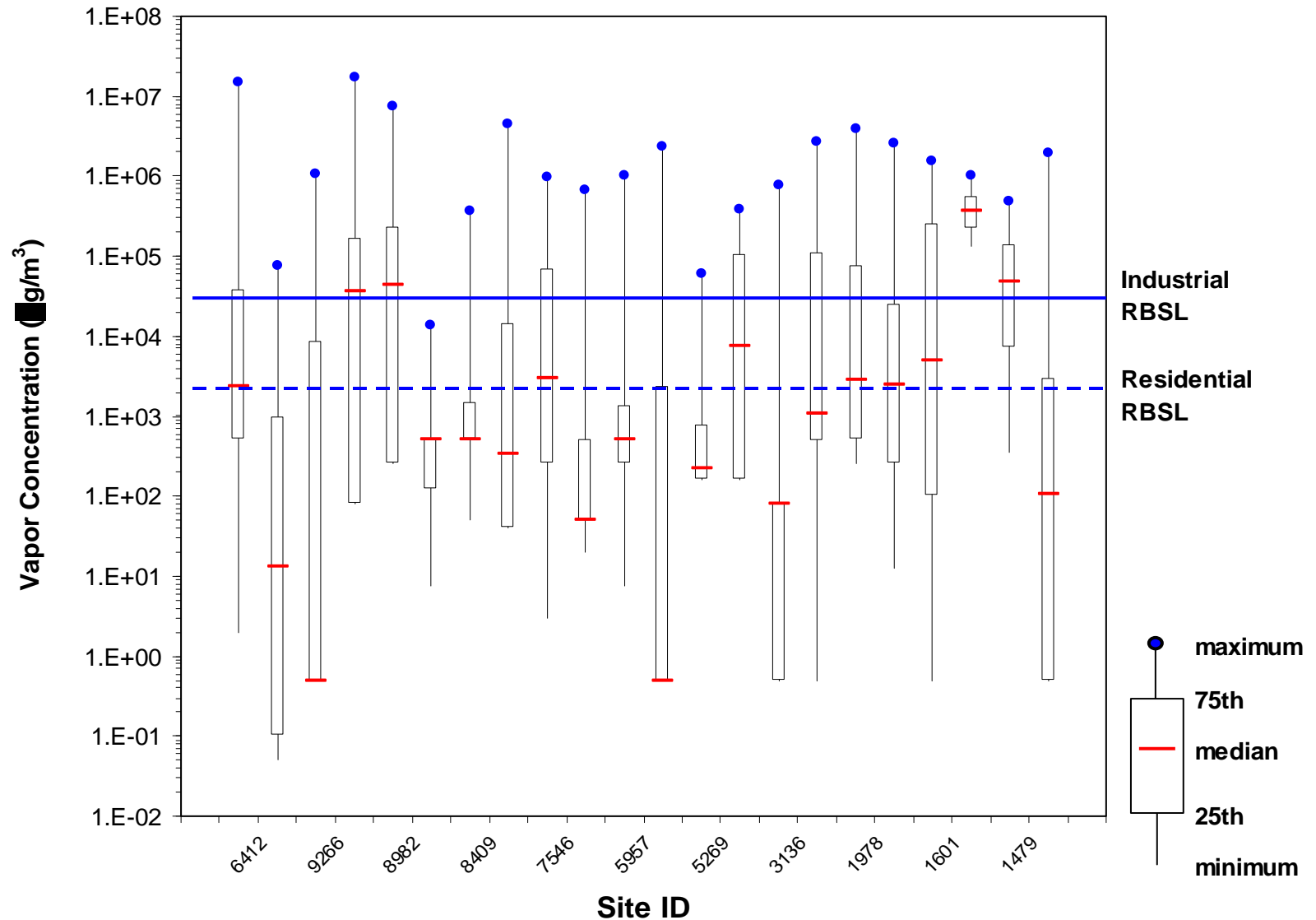


# Benzene Concentrations in Air

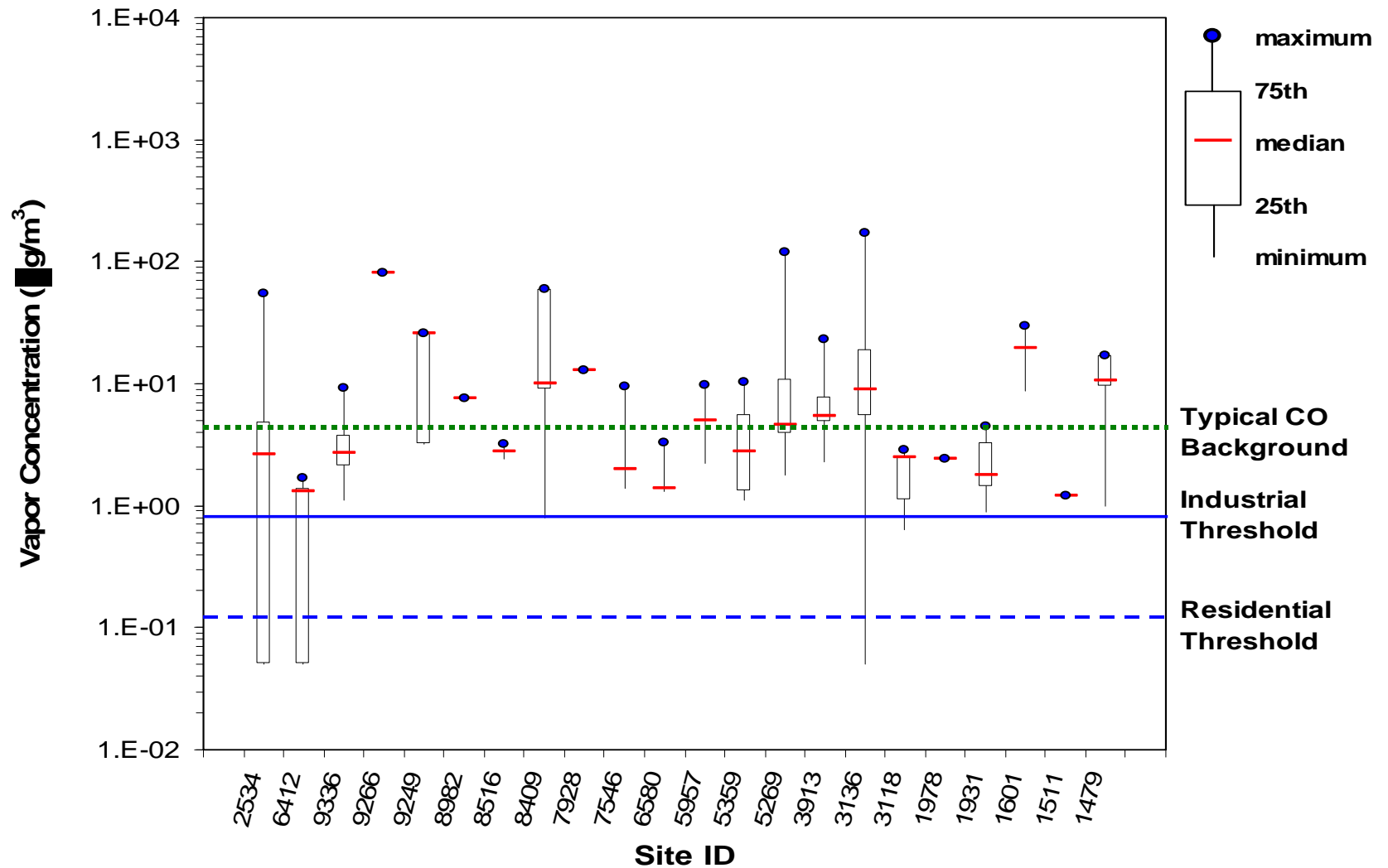


# Benzene in Soil Vapor

(from the 22 sites that had indoor air samples)



# Benzene in Indoor Air (22 Sites)



# Data Evaluation Conclusions

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- 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

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- 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

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- 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

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## 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

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- Toluene, ethylbenzene, xylenes, MTBE, and total volatile hydrocarbon analyses
- Measure radon at vapor intrusion sites
- Additional information regarding lithologic profile
- Measurement of O<sub>2</sub> and CO<sub>2</sub>
- Sub-slab sampling
- Measure pressure gradients