

Case Studies to Evaluate Hydrocarbon Vapor Attenuation in the Vadose Zone

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BP

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Attenuation Factors

Type of Data	U.S. EPA Attenuation Factor	
	2002 Guidance	2007 Guidance ^a
Shallow Soil Gas	0.1	0.02 (residential)
		0.002 (industrial)
Deep Soil Gas	0.01	--
Ground Water	0.001	--

^a Value expected to be included in revised U.S. EPA guidance due out in 2007.

An attenuation factor is simply the ratio of the two concentrations: the indoor air and the subsurface media. For soil gas, the relationship can be expressed as:

$$X_{\text{indoor}} = [X_{\text{soil-gas}}][\alpha] \quad (\text{Eq. 2-1})$$

Where:

X_{indoor} = Concentration of VOC in indoor air ($\mu\text{g}/\text{m}^3$);¹

$X_{\text{soil-gas}}$ = Concentration of VOC in soil gas ($\mu\text{g}/\text{m}^3$); and

α = Attenuation coefficient (unitless).

Case Study #1

Free Product Under Active Distribution Facility

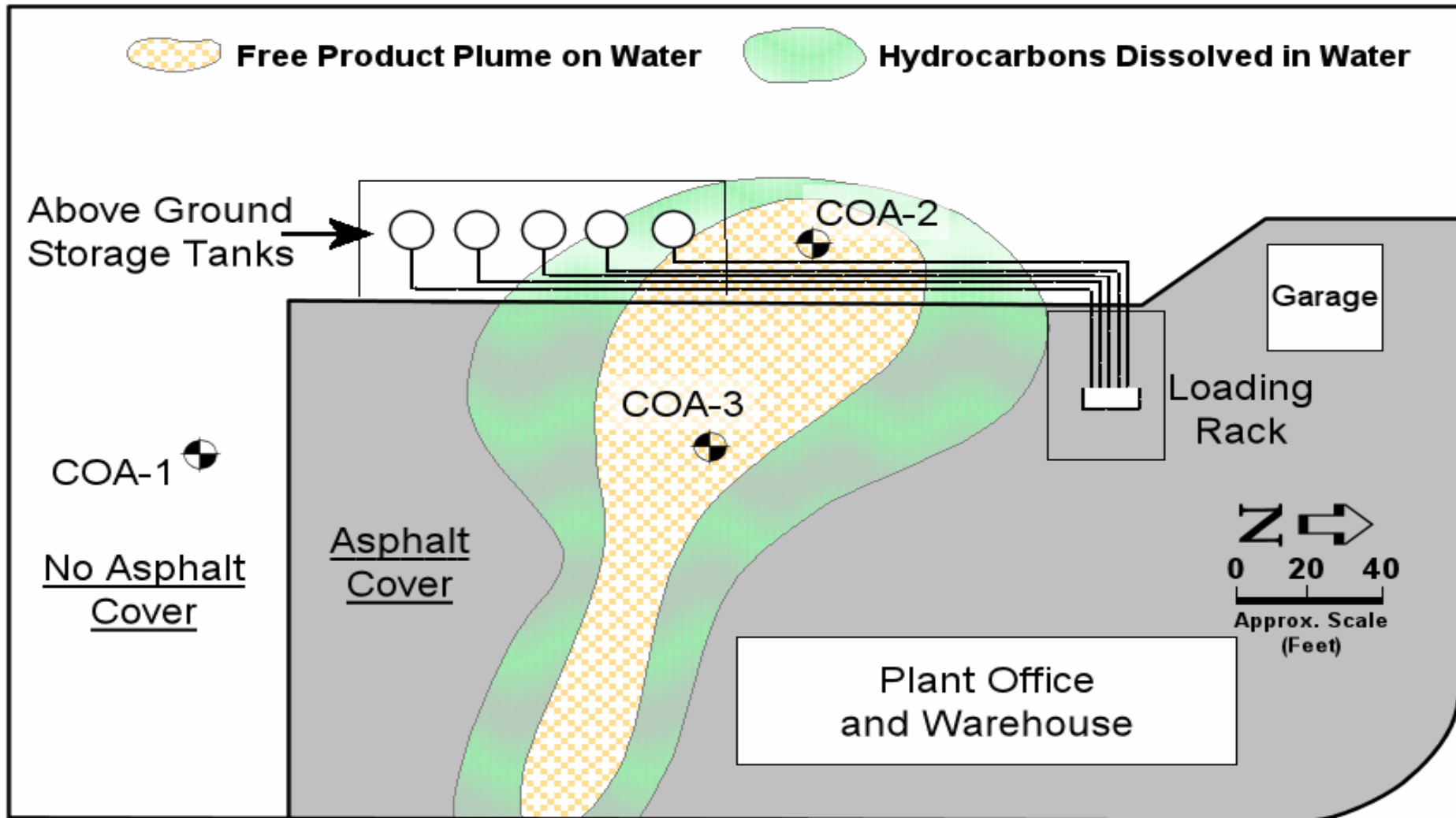
- Sandy Soil-Desert Area
- Groundwater at 10 feet
- Free Product (gasoline and diesel)
- Clean Soils (where soil gas collected)
- Large Asphalt Slab
- Non slab area little vegetation no irrigation



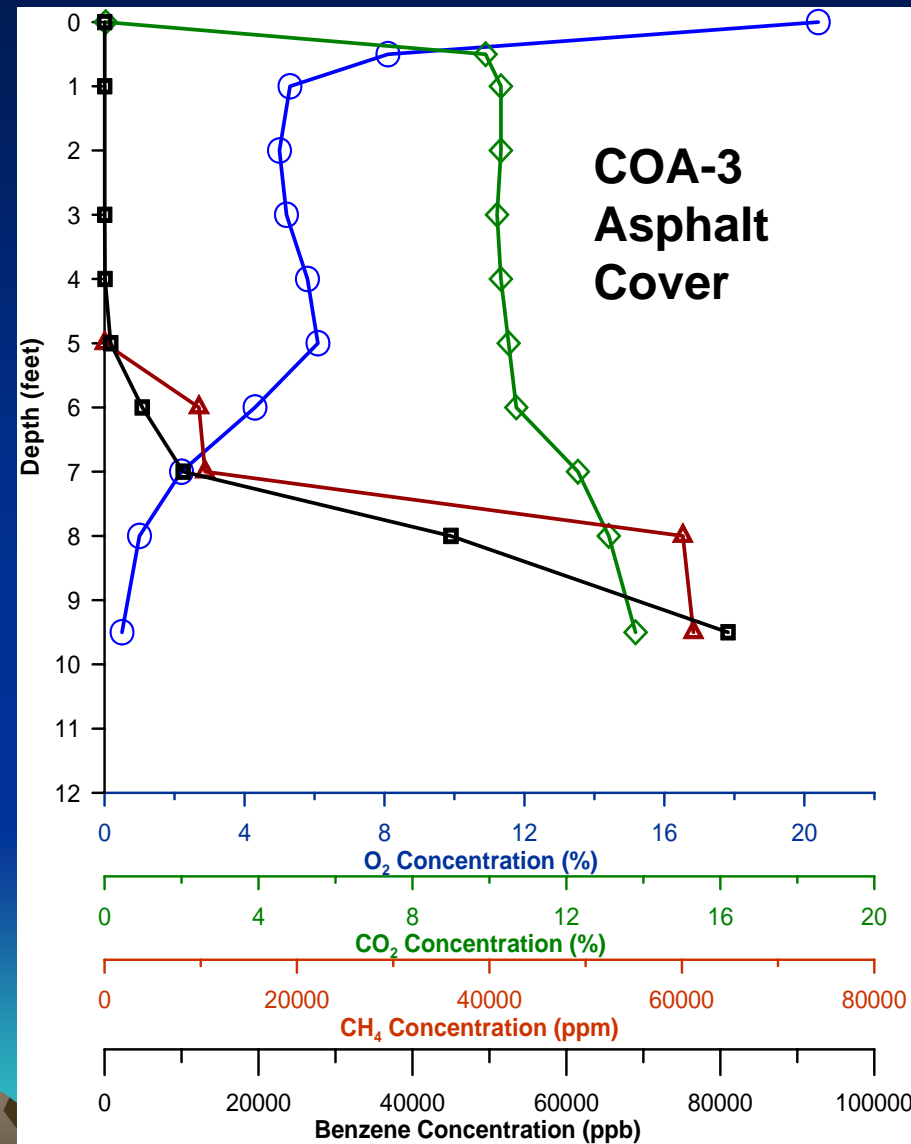
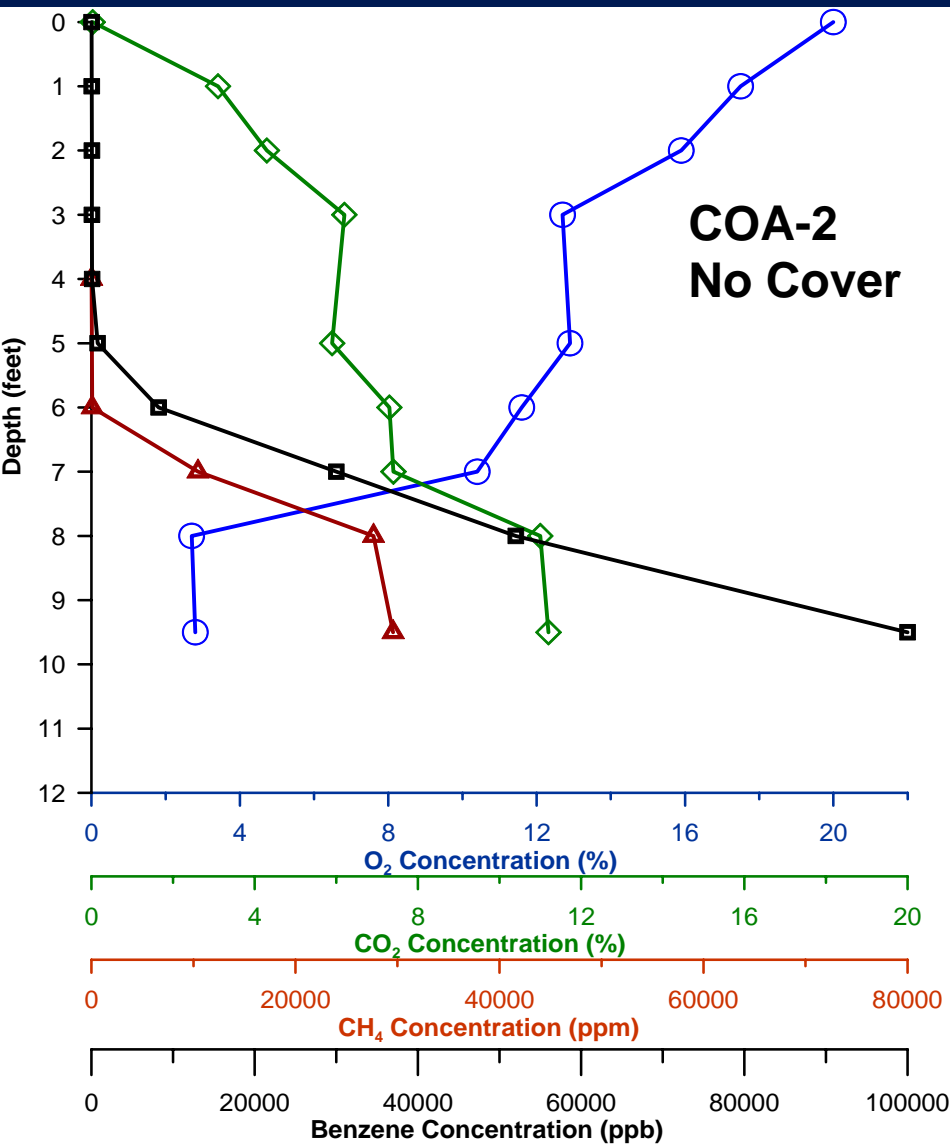
Distribution Facility Showing Slab and No Slab Areas



Case Study #1-Map of Distribution Facility

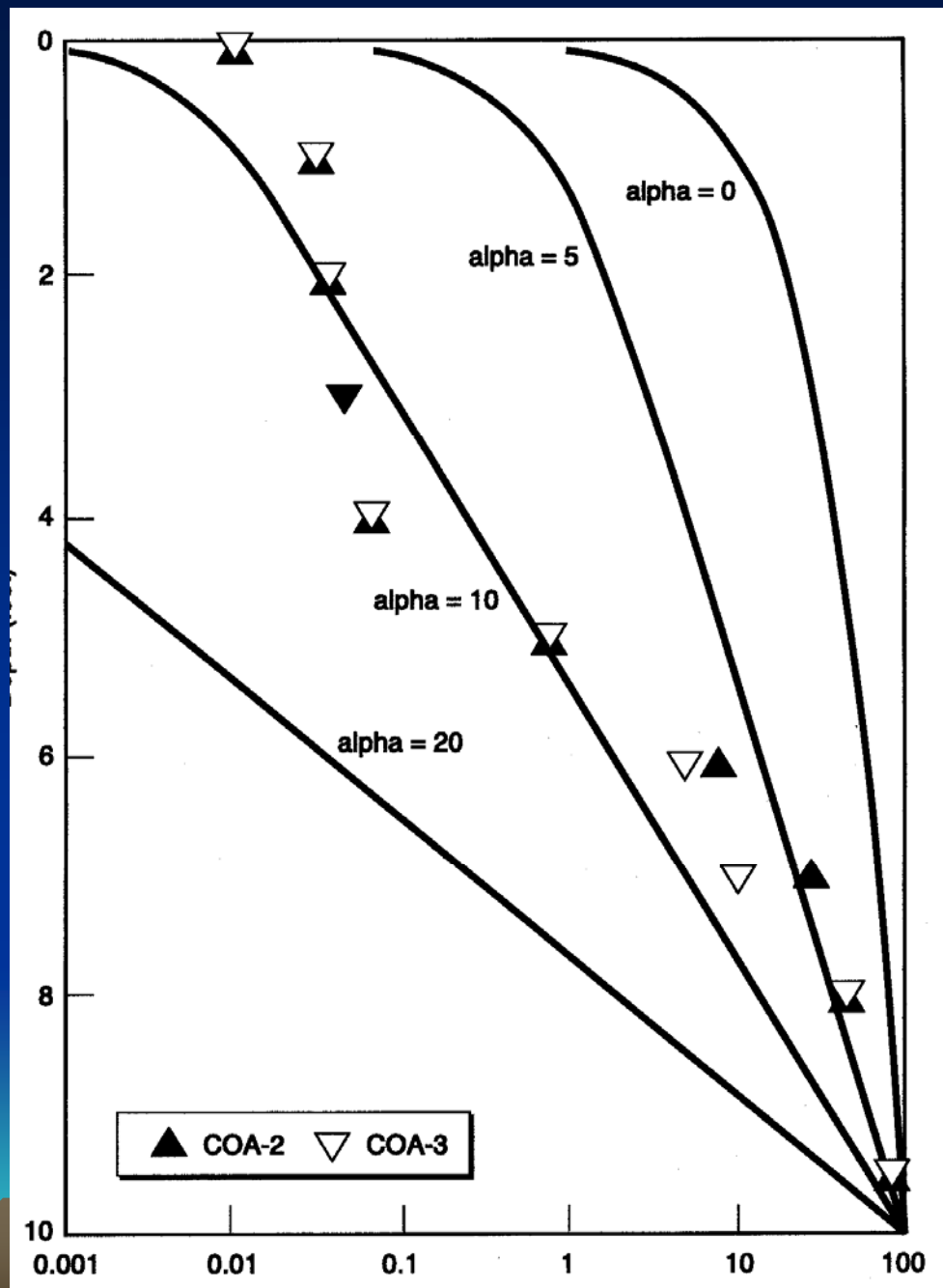


Vertical Profile of Soil Gases at Distribution Facility



Free product is at 10 feet

Depth
in feet

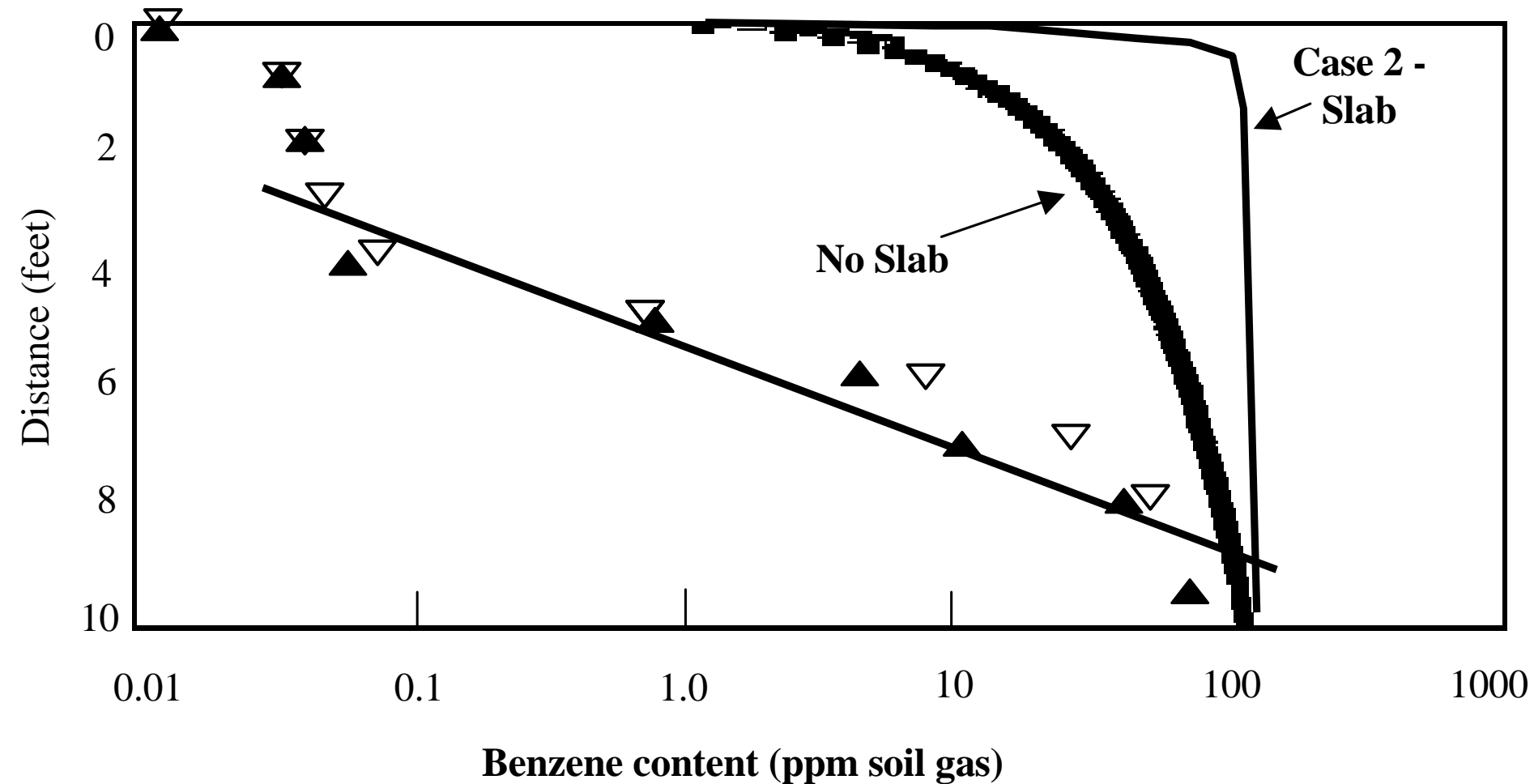


Benzene concentration in ppmv

Field Data vs
Alpha Values

Distribution
Facility

Comparison of model predictions with field data for distribution facility-semi-log plot of data.



▲ = field data COA-3 under asphalt

▽ = field data COA-2 no asphalt

Model Case 1 - No slab

Model Case 2 - With Slab

Case Study #2

Home Over Former Oil Field Sump

- Sandy to silty sandy soils-Central Coast
- Perched Water 4 ft (Groundwater >60 feet)
- Predominantly crude oil
- Affected soil 4-15 feet bgs
 - TPH 100 to 10000 mg/kg
 - Benzene < 0.1 mg/kg
 - BTEX < 30 mg/kg (mostly < 1 mg/kg)
- Slab under house
- Non-slab area formerly irrigated



One Way to Start Collecting Indoor Air Samples



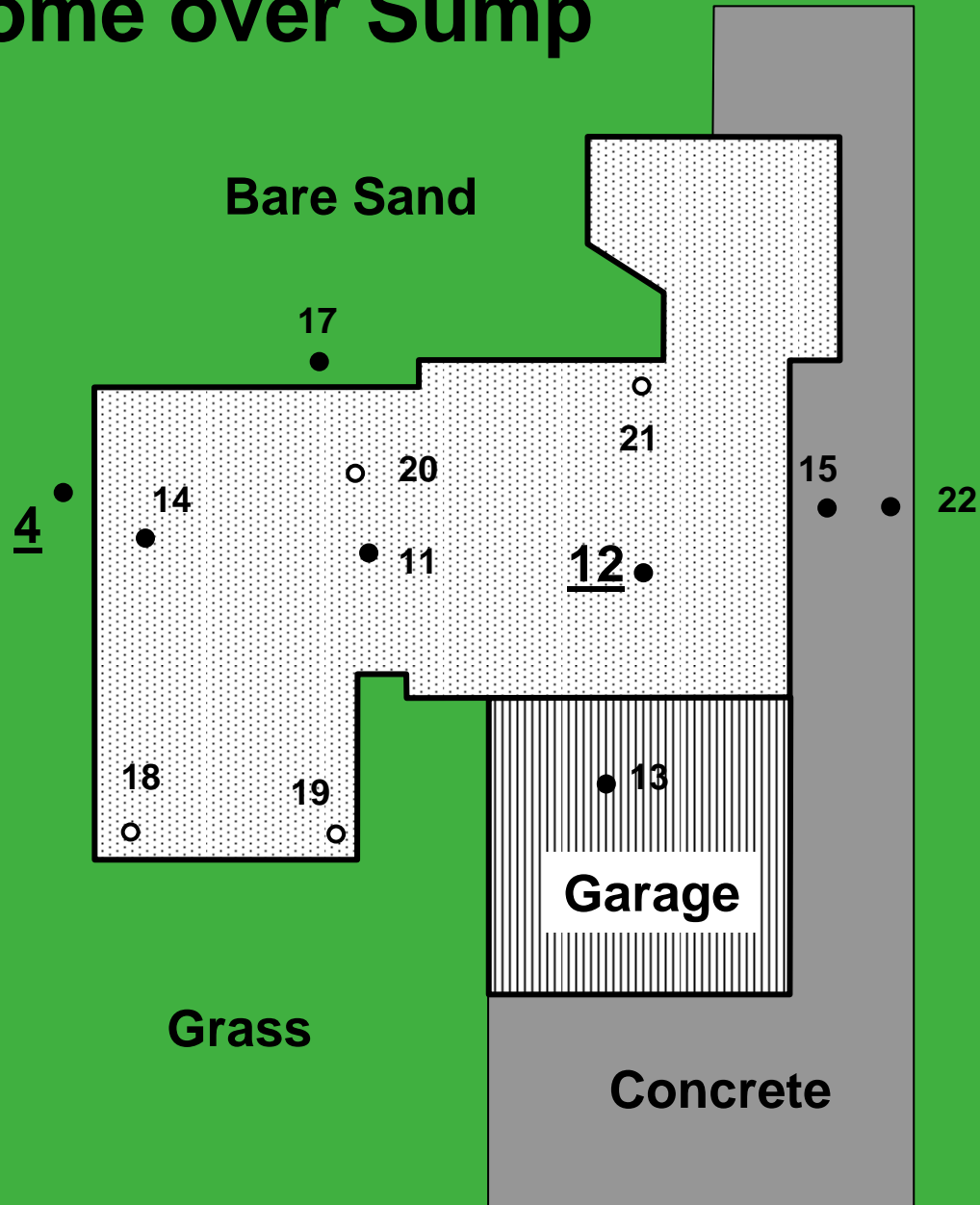
Soil Gas Samples Collected Adjacent to House



Subslab Sampling in Driveway- Better than in the House

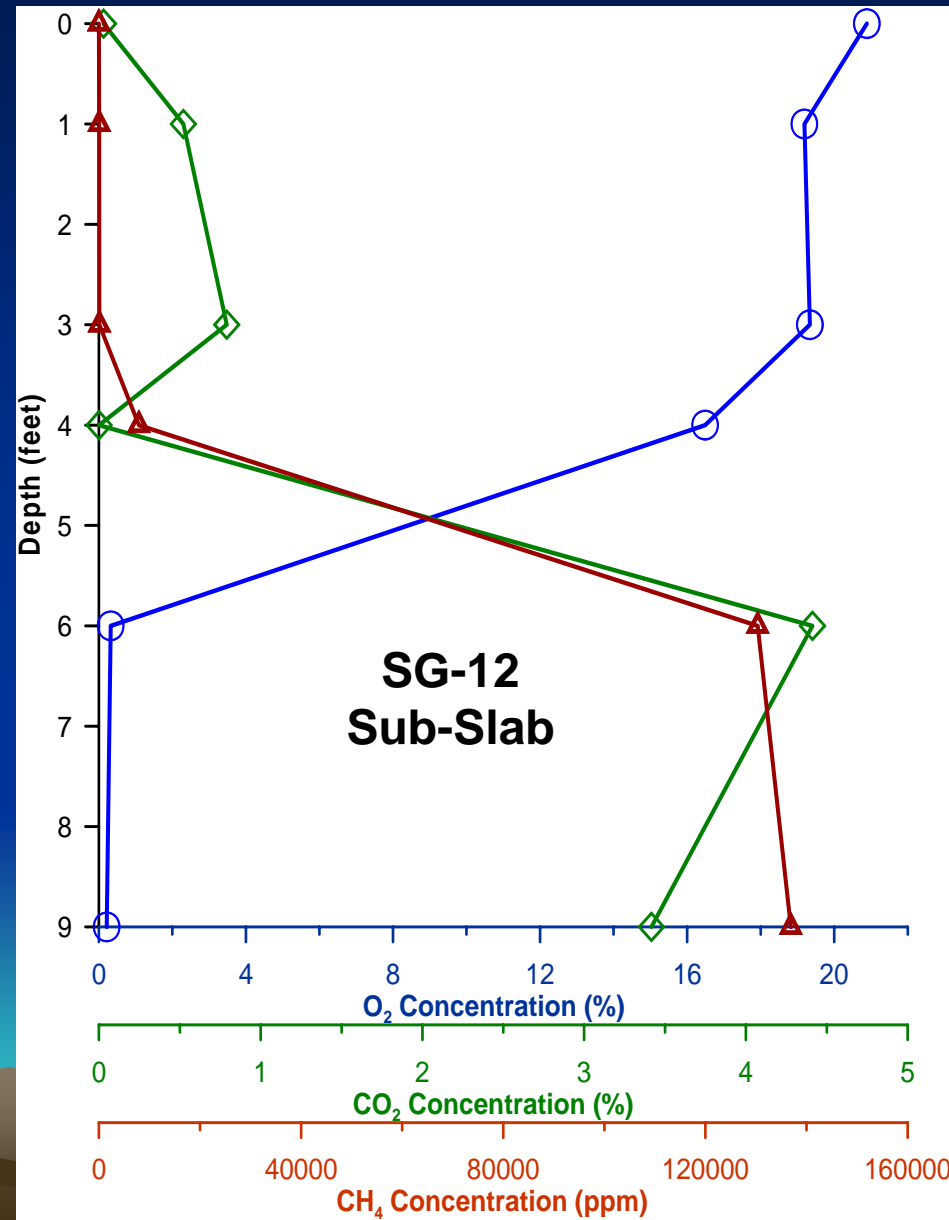
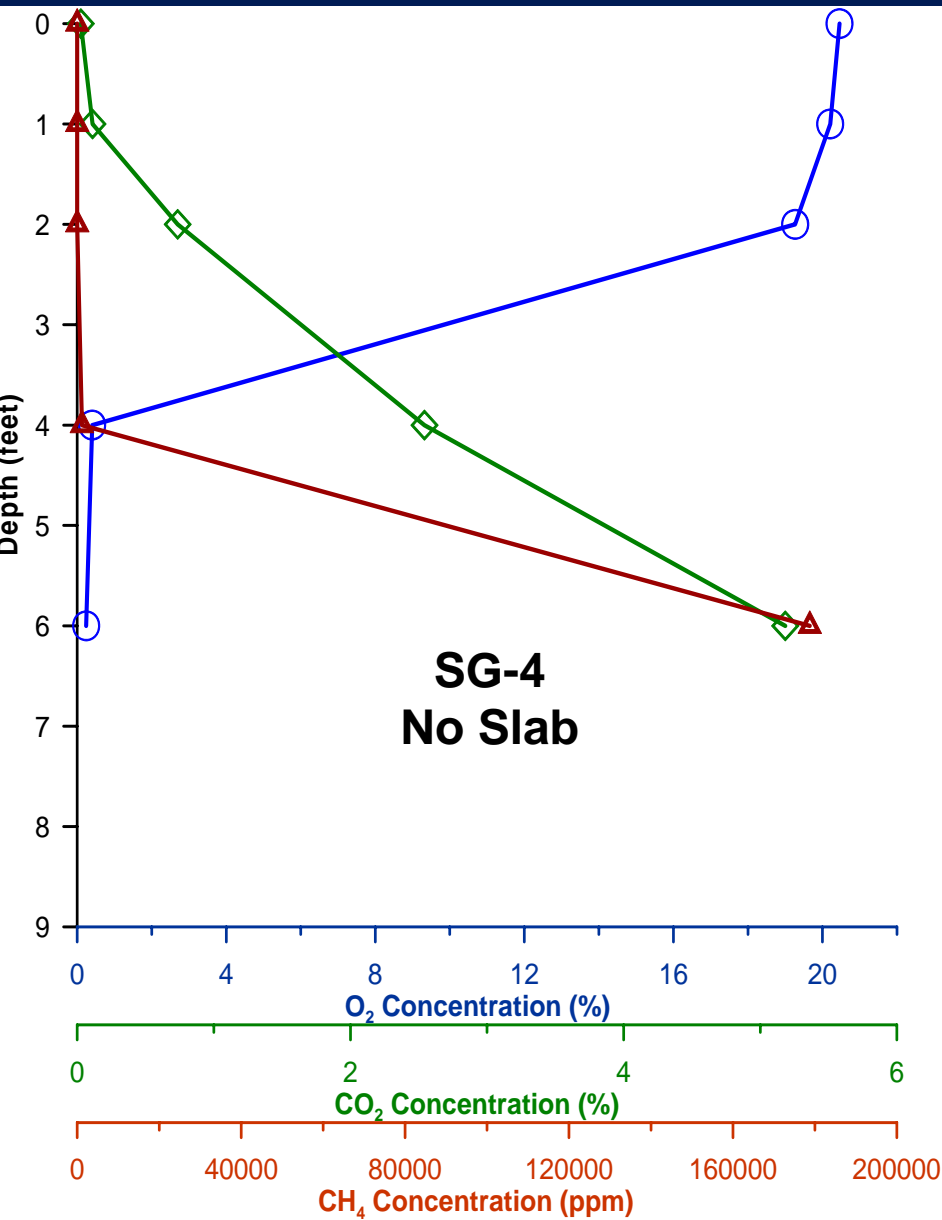


Home over Sump



- Single Story
- Slab on grade
- Heating only (no AC)

Vertical Profile of Soil Gases at House over Sump



Case Study #3

GW Plume Under Service Station

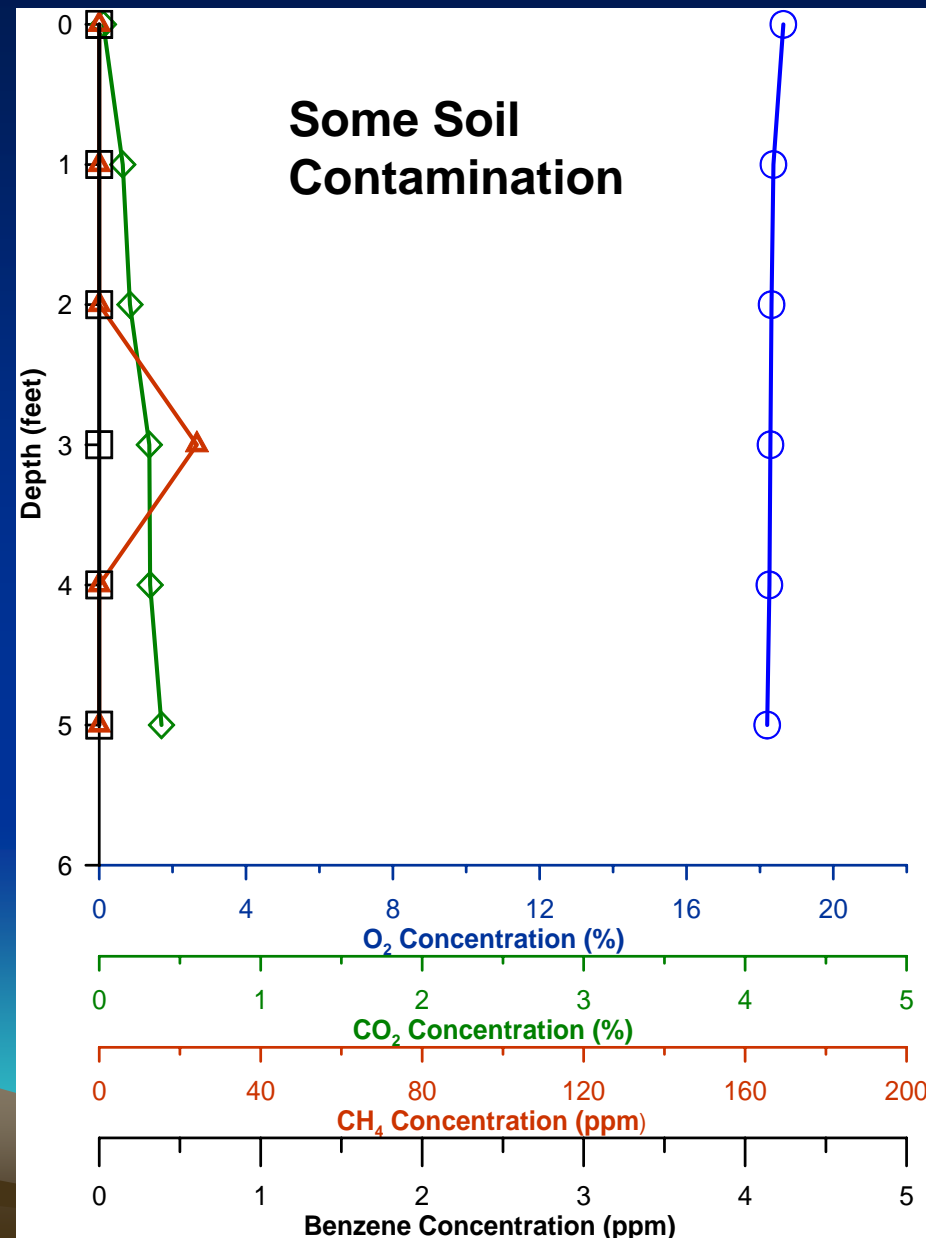
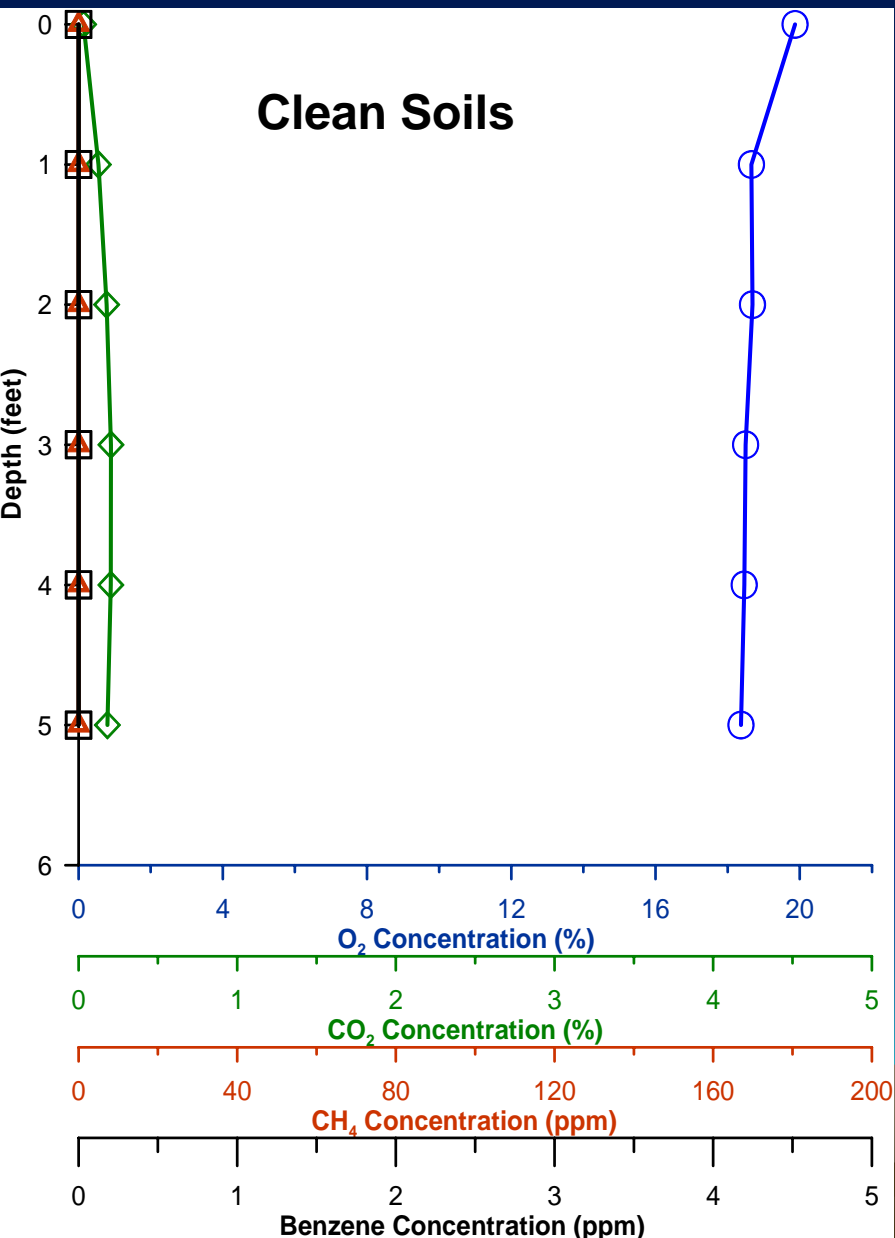
- Sandy Soils-S. CA beach area
- Groundwater at 5.5 feet
- Dissolved gasoline plume (1 to 3 ppm)
- Predominantly Clean Soils
- Former service station now demolished
- Bare ground, no irrigation
- No slab



Collecting Soil Gas as Service Station Site



Service Station-Sandy Soils over GW Plume



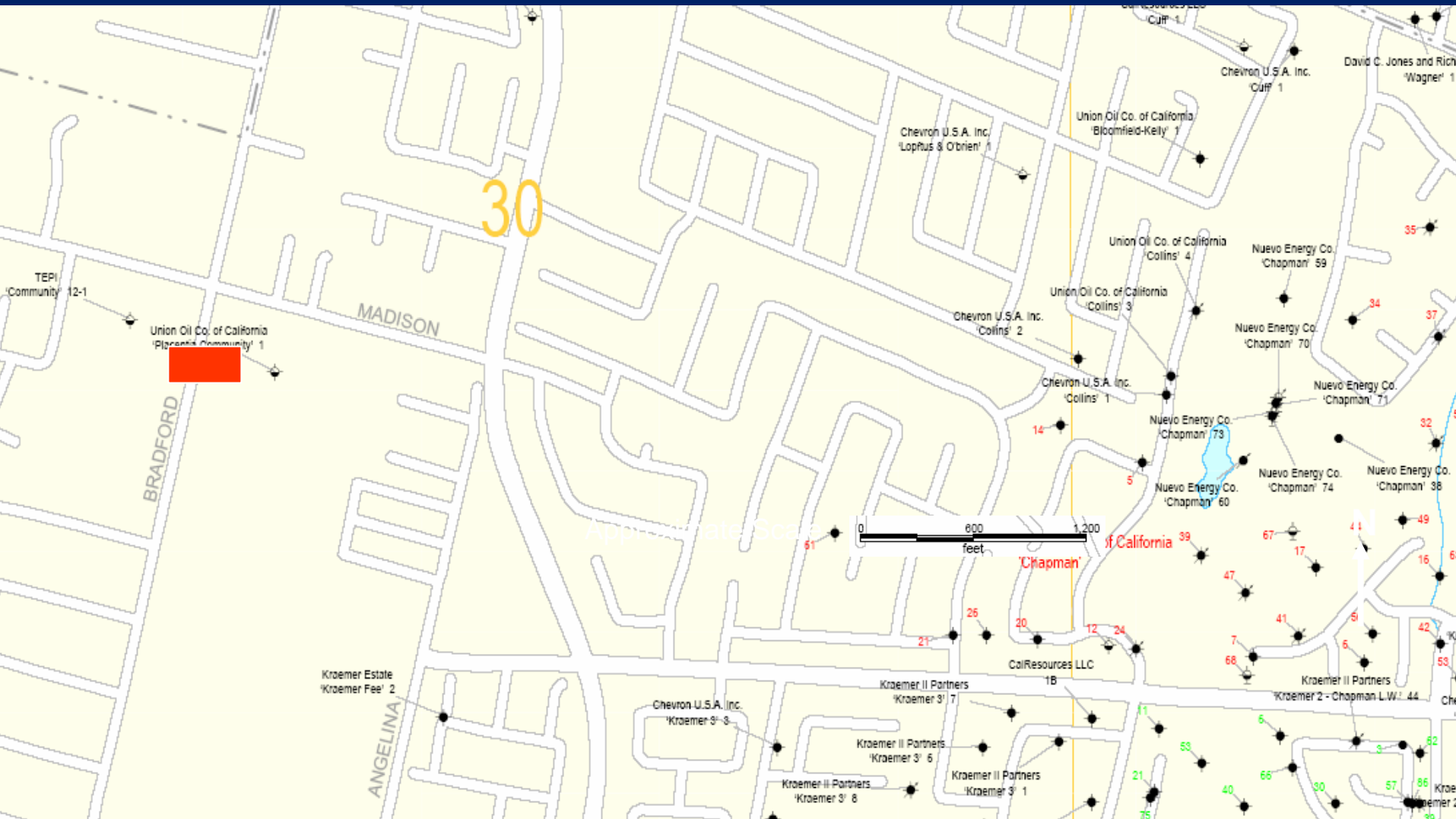
Case Study #4

Building Over Oil Field

- Clay-rich soils-Orange County
- Deep groundwater- 120 feet
- Clean Soils
- Shallow oil field (several thousand ft)
- New construction forced soil gas analysis
- Slab under buildings over 50 yrs old



Location of Building on Edge of Oil Field

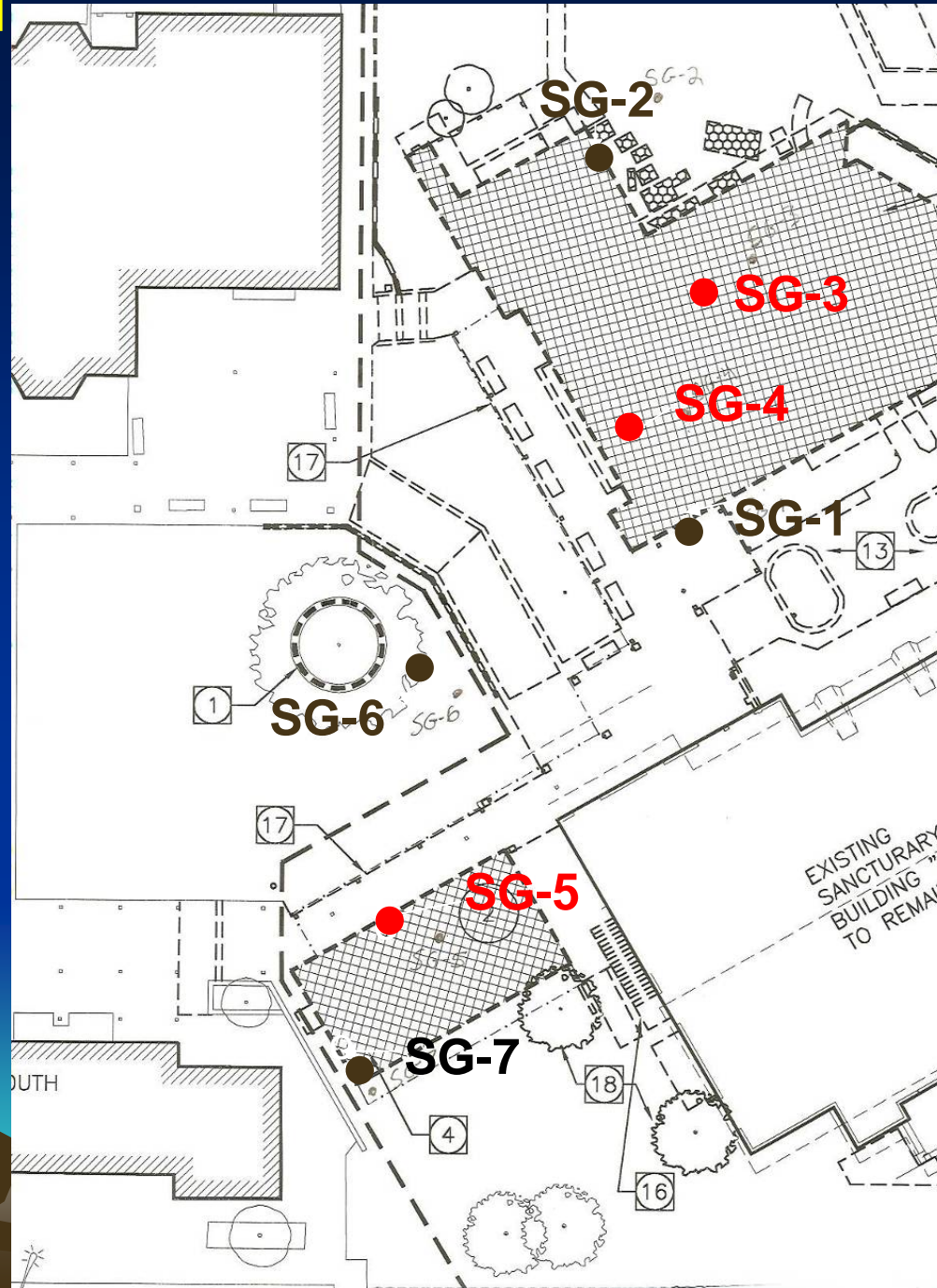


Building over Oil Field

Soil Gas Under Slab= **3, 4, and 5.**



Soil Gas Outside Slab= **1, 2, 6 and 7.**



Hand augering
outside building



Clayey soil at
5 to 10 feet
below surface



Drilling through
concrete slab



Augering below
slab



Outside of
mobile lab



On site
analysis with
mobile lab



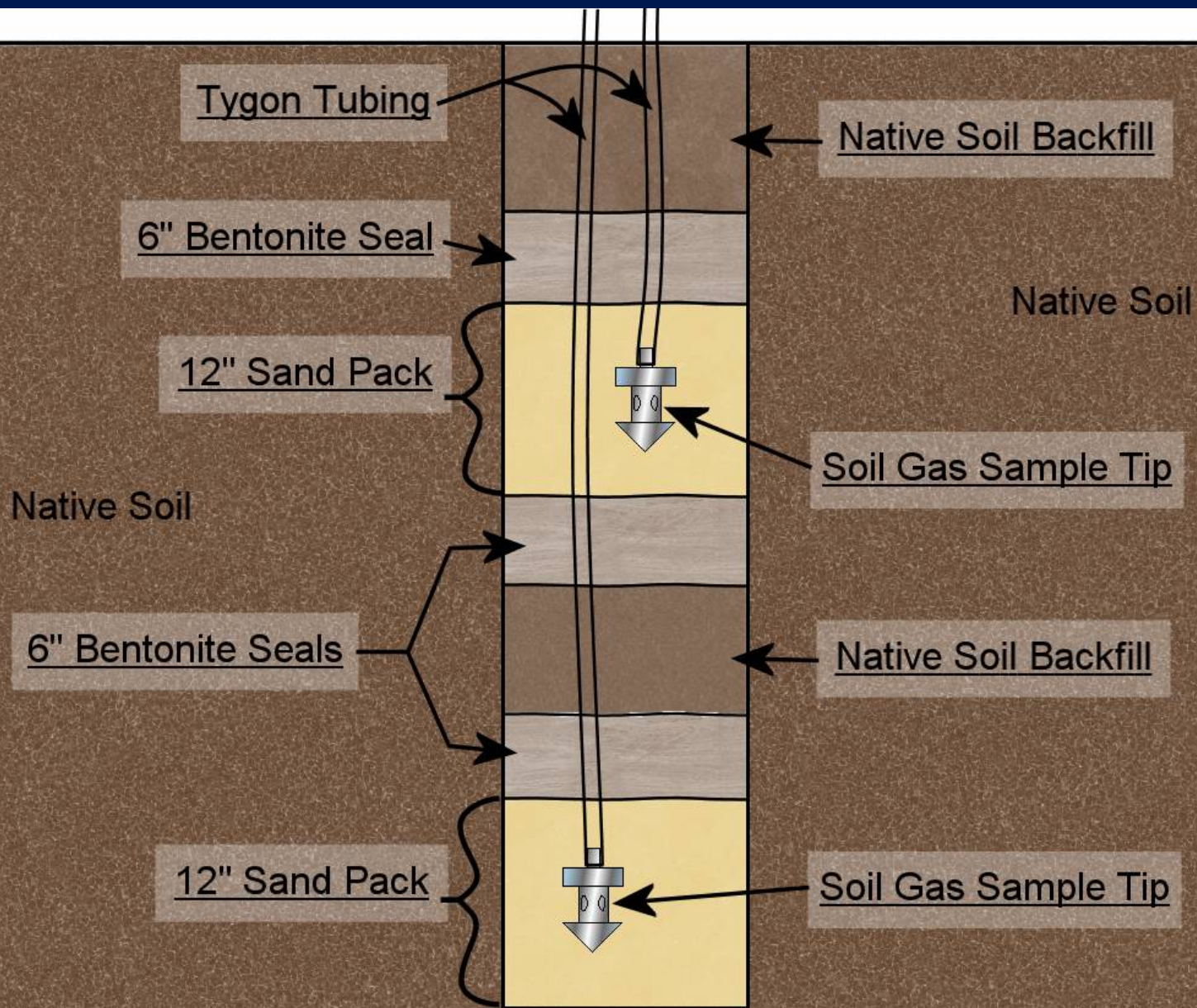
First set of
preview data
collected with
hand-driven
probe



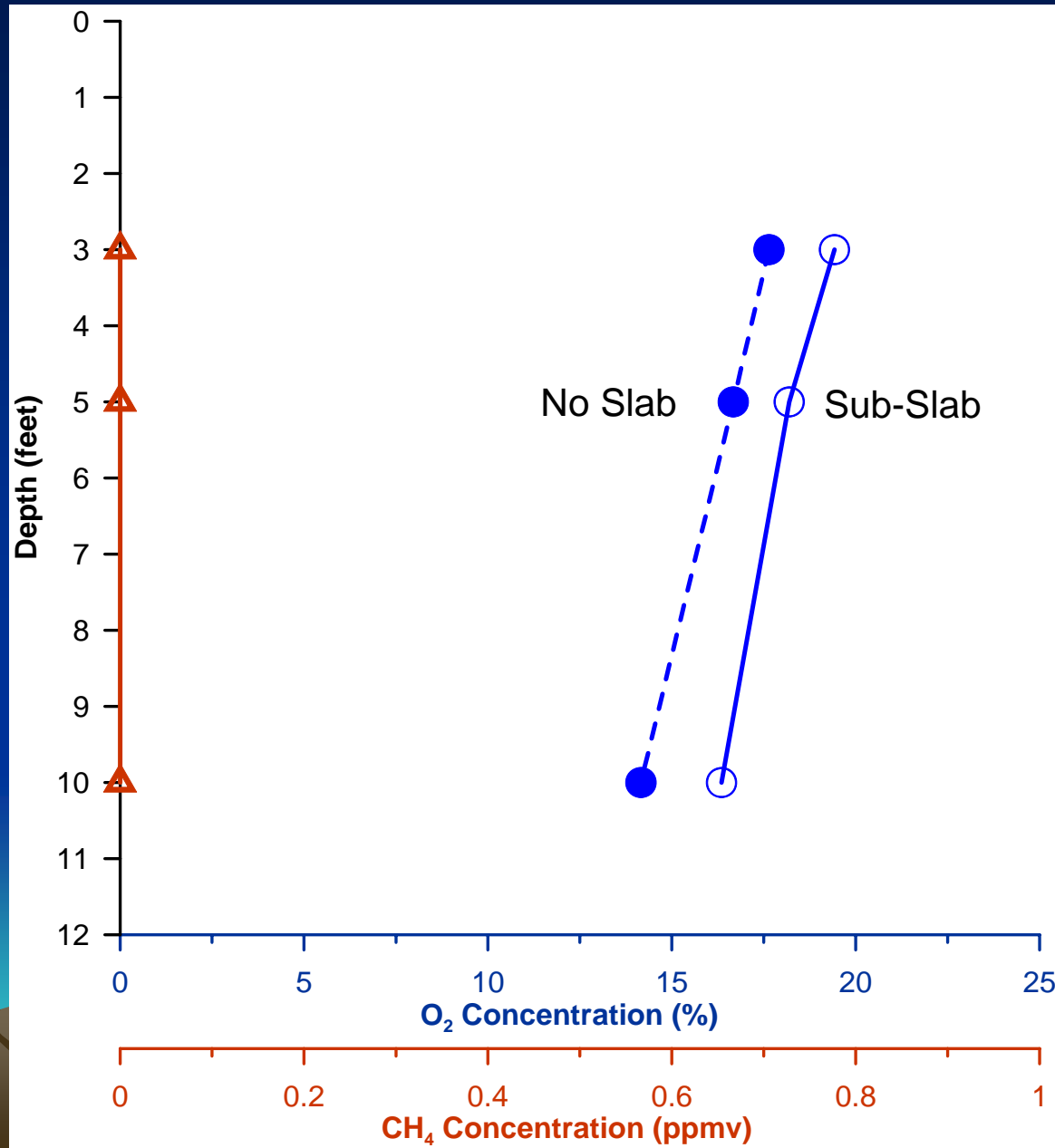
Constructing
dedicated
sample points



Dedicated Soil Gas Probes



Vertical Profile of Soil Gases-Building over Oil Field



SUMMARY

- Four case studies evaluated HC vapor migration using vertical profiles
- HC vapors showed attenuation when soils were clean
- Oxygen levels under slabs were greater than 5% in all cases examined
- Oxygen levels above 5% are a good barrier to upward migrating HC vapors
- Methane used as a surrogate for benzene

