



# Passive Sampling for Soil Gas, Indoor Air, and Water

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US EPA Region III & States LUST Technical Conference  
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## Outline

- Introduction
- Passive Sampler
- Site Assessment Example
- Vapor Intrusion/Indoor Air Example
- Groundwater Example
- Conclusions





Do you prefer an informative picture before an operation?

Where's the problem?



## Passive Sampler - GORE™ Module

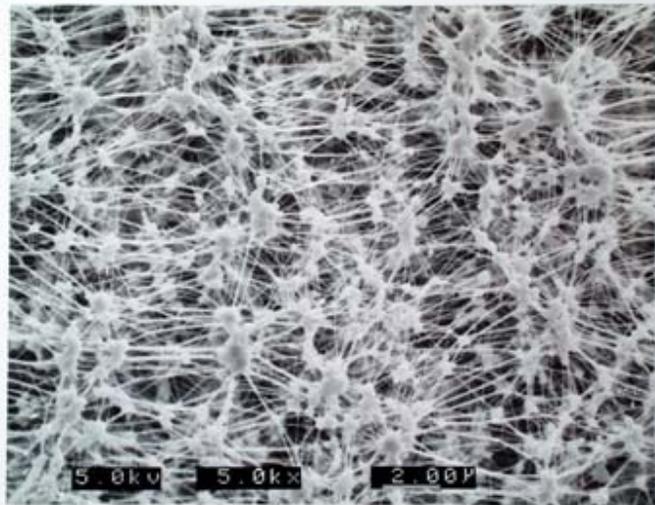


- Accurate
- Comprehensive
- Proven
- US EPA Verified
- Patented

- **Passive sampling for soil gas, air, and groundwater.**

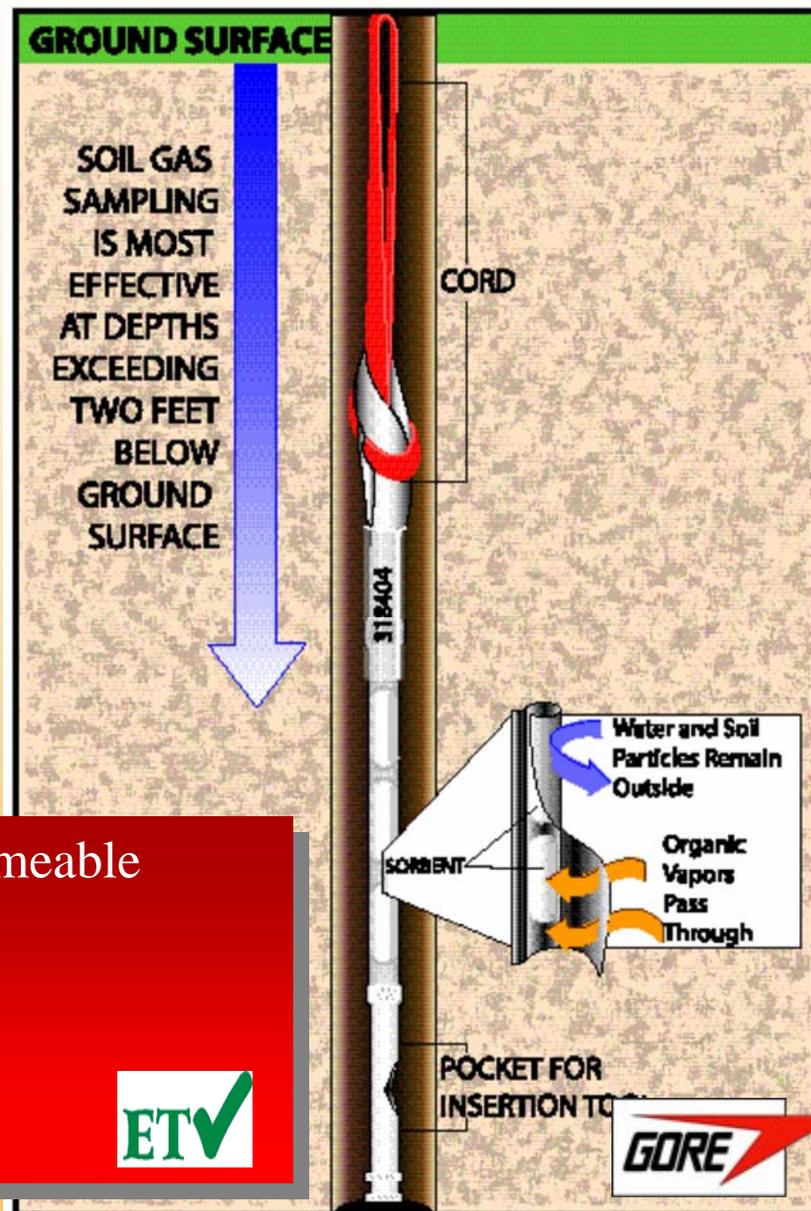


# Passive Sampler



GORE-TEX® Membrane

- Chemically-inert, waterproof, vapor permeable
  - Direct detection of organic compounds
  - Sample integrity protected
- Engineered sorbents
- Duplicate samples

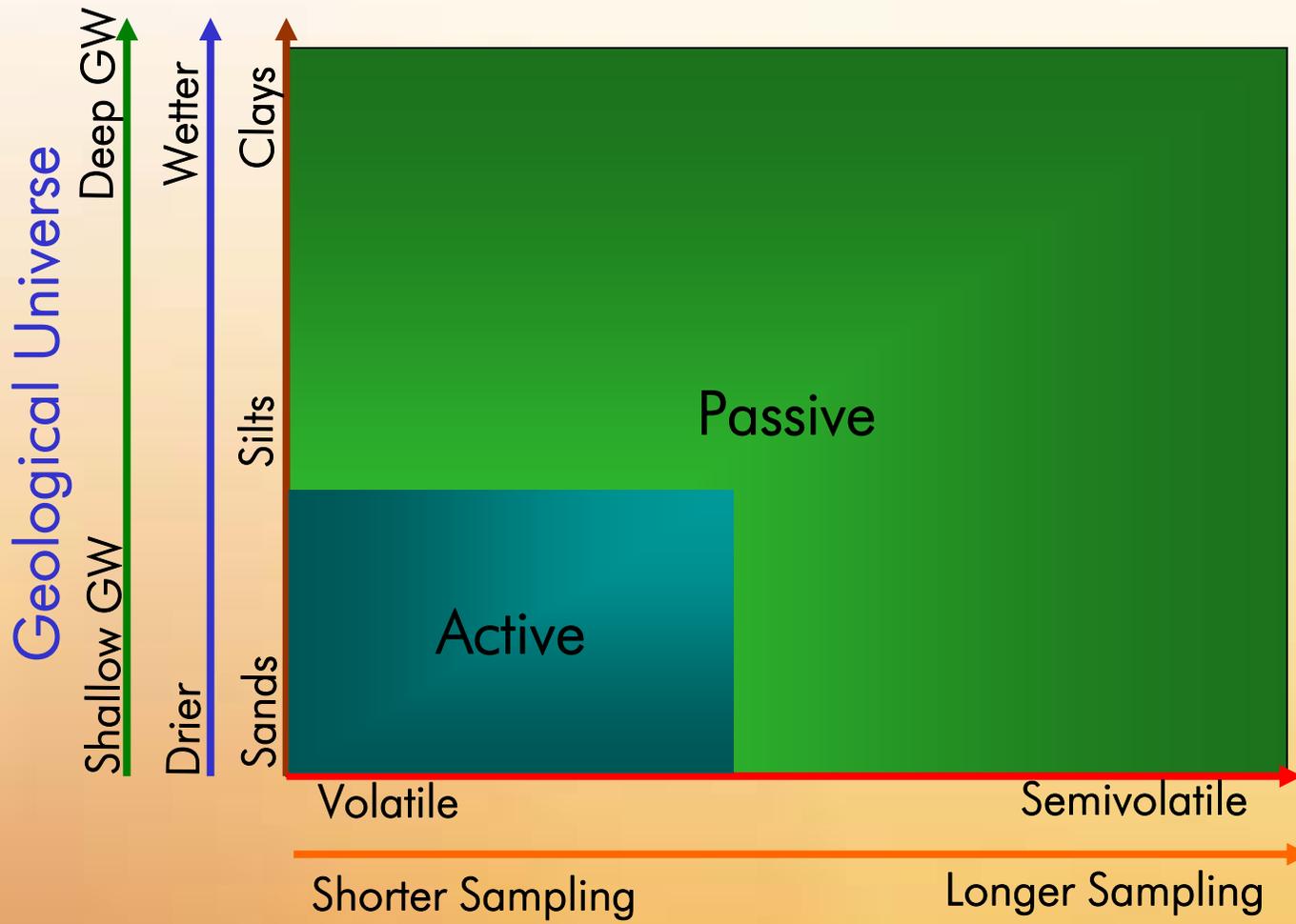


## Passive Sampling Benefits

- Rapid, inexpensive, unobtrusive installation & retrieval
  - Minimal operator & field sampling error
- No mechanical parts
- No energy required
- Virtually any sampling medium
  - Soil, air and water
- Time-integrated sampling
  - Sensitivity in ppt range
  - Sensitivity to broad range of compounds VOCs, SVOCs, PAHs



# Why Passive Vapor Sampling?



**Time-integrated:**  
Sensitive to a broader range of compounds, present in lower concentrations, in virtually any soil condition.

Organic Compound Universe



## Sampler Deployment



- Rapid, unobtrusive
- Hand tools
- Three-foot install depth

- 20 to 80 ft sample spacing
- 1-14 day exposure
- Unsaturated/saturated soil, subslab, indoor/outdoor, groundwater



# Sample Any Media



Soil Gas



Subslab Vapor



Indoor/Outdoor Air



Sediment



Ground & Surface Water



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## Volatiles

Vinyl Chloride  
Methyl t-butyl ether  
Benzene  
Toluene  
Ethylbenzene  
o-Xylene  
m,p-Xylene  
Octane  
1,1-Dichloroethane  
1,2-Dichloroethane  
1,1,1-Trichloroethane  
1,1,2-Trichloroethane  
1,1,1,2-Tetrachloroethane  
1,1,2,2-Tetrachloroethane  
1,1-Dichloroethene  
trans-1,2-Dichloroethene  
cis-1,2-Dichloroethene  
Trichloroethene  
Tetrachloroethene  
Chloroform  
Carbon Tetrachloride  
Chlorobenzene  
1,4-Dioxane  
Freons  
Fuel Oxygenates

## Semi-volatiles

1,3,5-Trimethylbenzene  
1,2,4-Trimethylbenzene  
1,2-Dichlorobenzene  
1,3-Dichlorobenzene  
1,4-Dichlorobenzene  
Undecane  
Tridecane  
Pentadecane  
Naphthalene  
2-Methylnaphthalene  
Acenaphthene  
Acenaphthylene  
Fluorene  
Phenanthrene  
Anthracene  
Fluoranthene  
Pyrene

**NOTE:**  
*This is not a comprehensive list  
of compound  
detection or analytical  
capabilities.*

## Explosives

Nitrobenzene  
2-Nitrotoluene  
3-Nitrotoluene  
4-Nitrotoluene  
1,3-Dinitrobenzene  
2,4-Dinitrotoluene  
2,6-Dinitrotoluene  
1,3,5-Trinitrobenzene  
2,4,6-Trinitrotoluene

## Chemical Agents/Breakdown Products

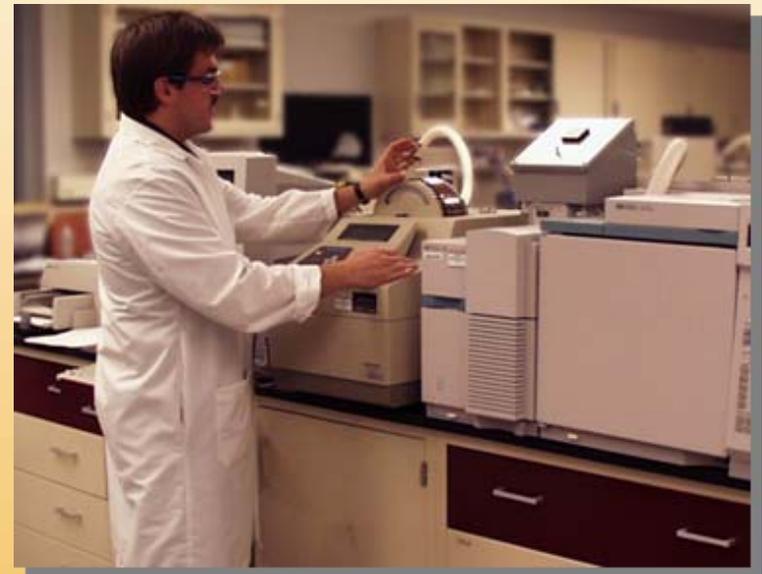
Mustard (as a TIC)  
1,4-dithiane  
1,4-oxathiane  
Benzothiazole  
p-Chlorophenylmethylsulfide  
p-Chlorophenylmethylsulfoxide  
p-Chlorophenylmethylsulfone  
Dimethyldisulfide  
DIMP (Diisopropyl methylphosphonate)  
DMMP (Dimethyl methylphosphonate)  
4-chloroacetophenone  
2-chloroacetophenone

**Mercury (elemental)**  
**Pesticides/Herbicides**  
**PCB Congeners**  
Capabilities demonstrated.



## Sampler Analysis

- Modified EPA method 8260/8270
  - TD/GC/MS
  - Compound specific
  - ppt sensitivity
- Rigorous QA/QC Program
  - QA Manual
- Mass & concentration data



## BRAC Assessment – Tooele Army Depot, UT

### Background

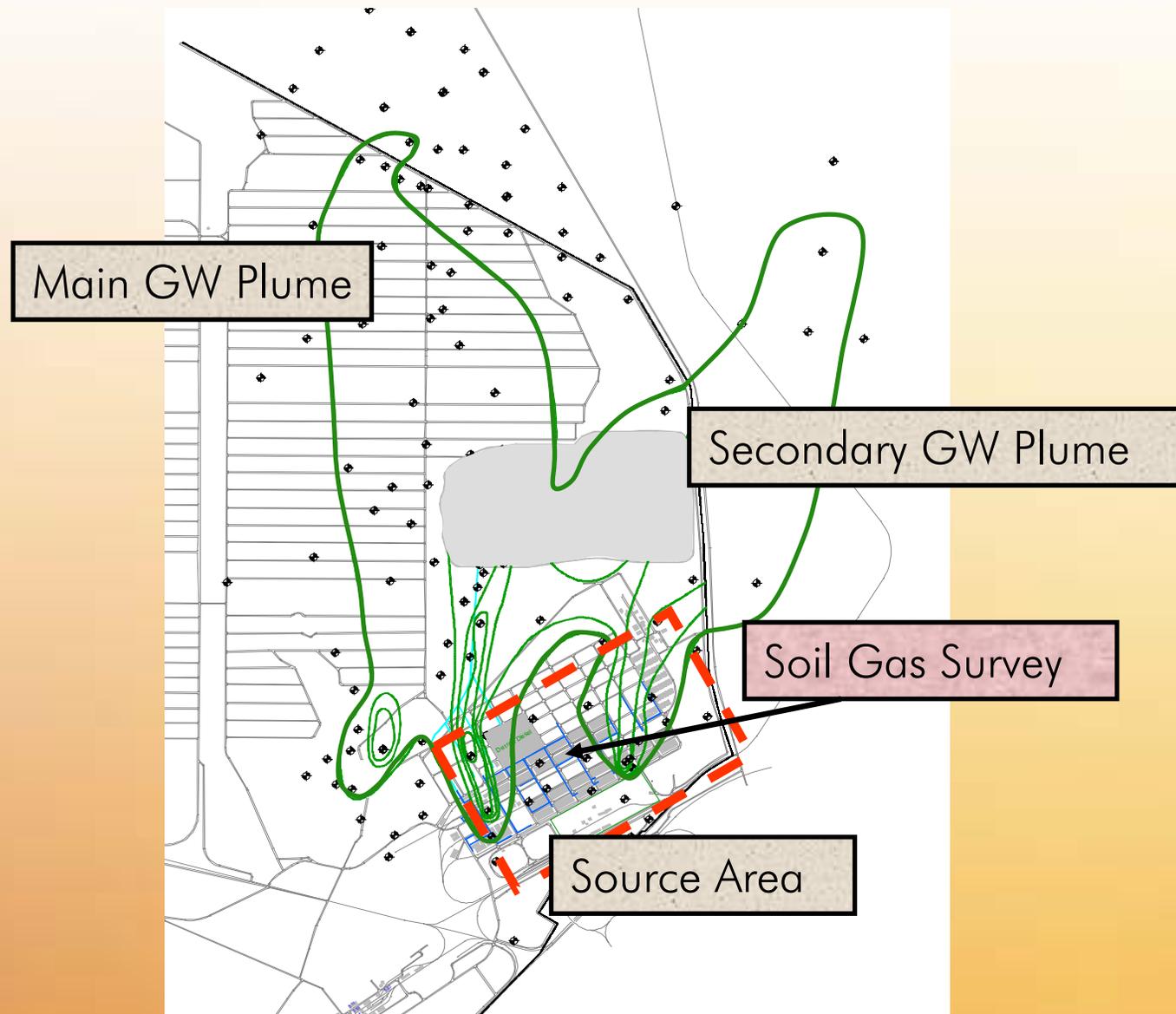
- Depth to gw, 100 to 400 ft bgs
- Poorly sorted silts, gravels, cobbles
  - Conventional subsurface investigation - difficult & expensive

### Current Remedy

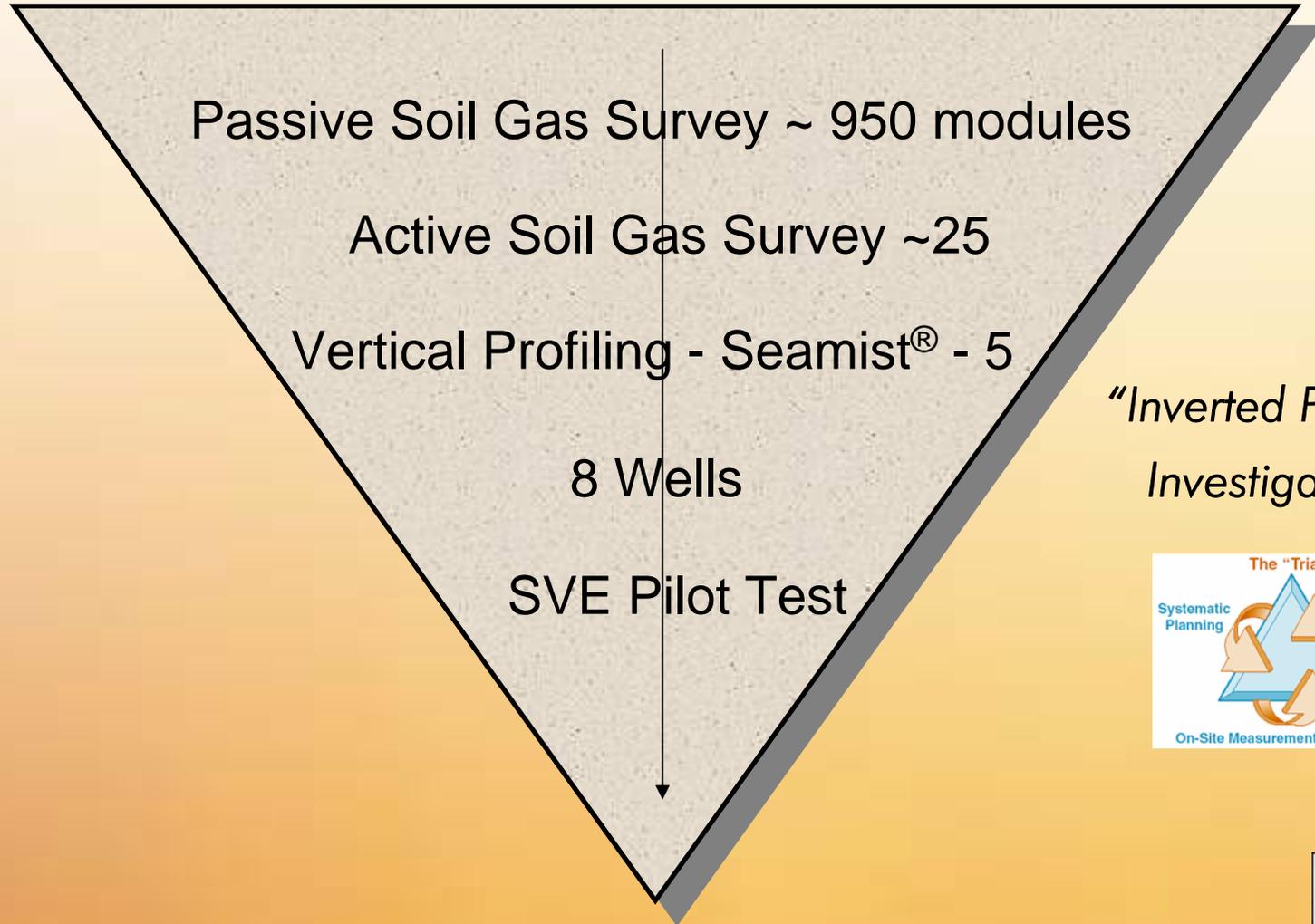
- Contaminant plume - ~40 billion gallons
  - TCE
- Current pump & treat system
  - \$2 million per year to operate
    - 30 years to remediate plume
- Plume stable
  - Need to locate unknown source areas



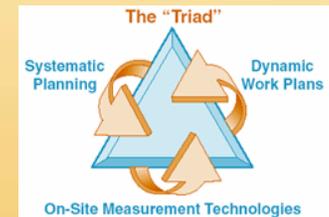
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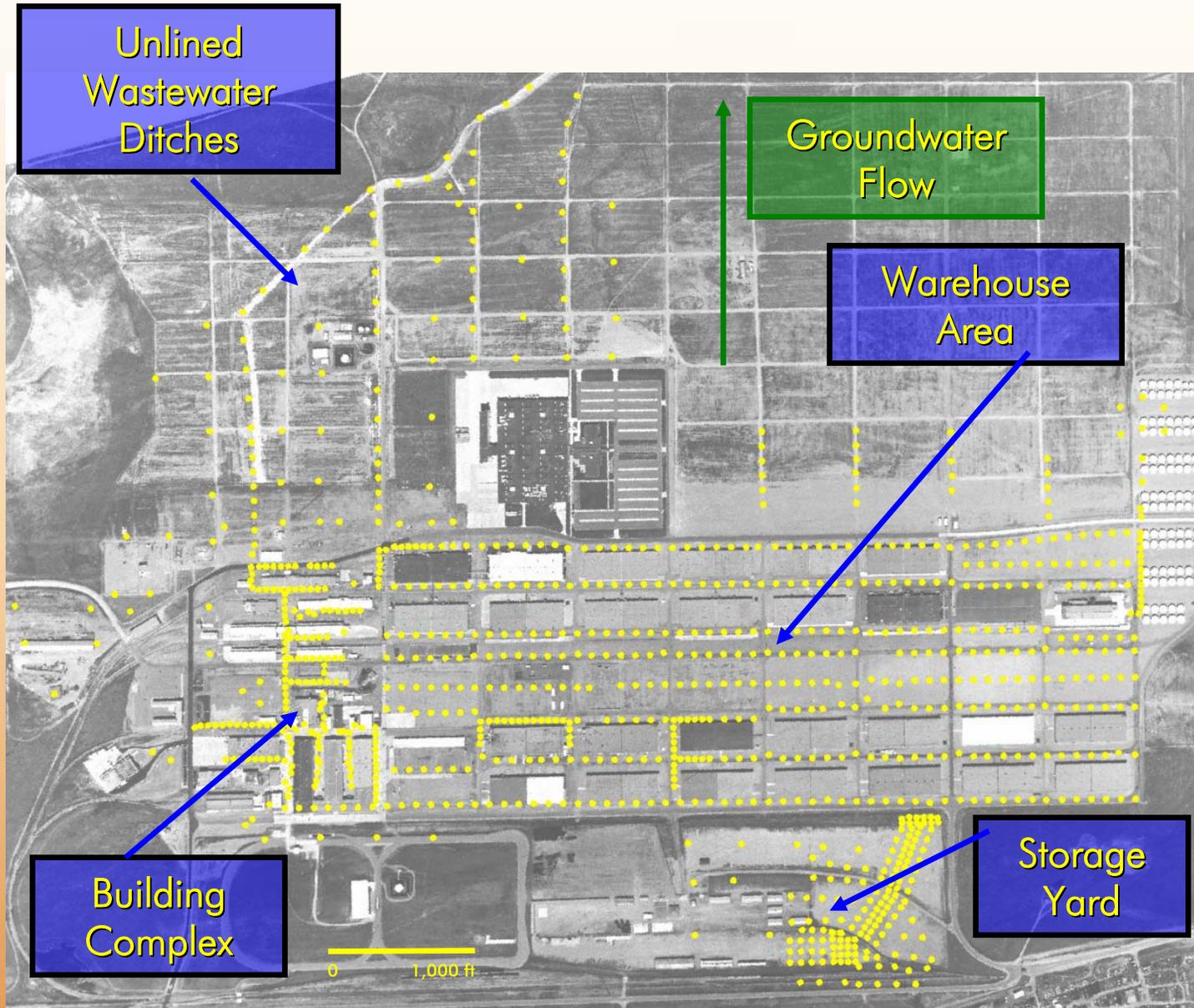
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*“Inverted Pyramid Investigation”*

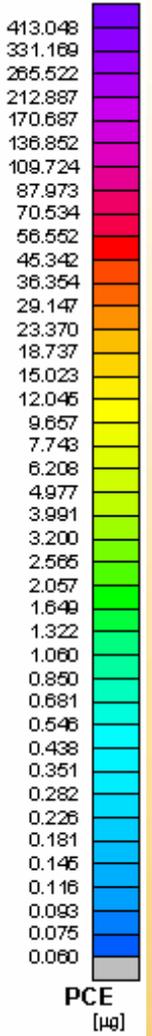
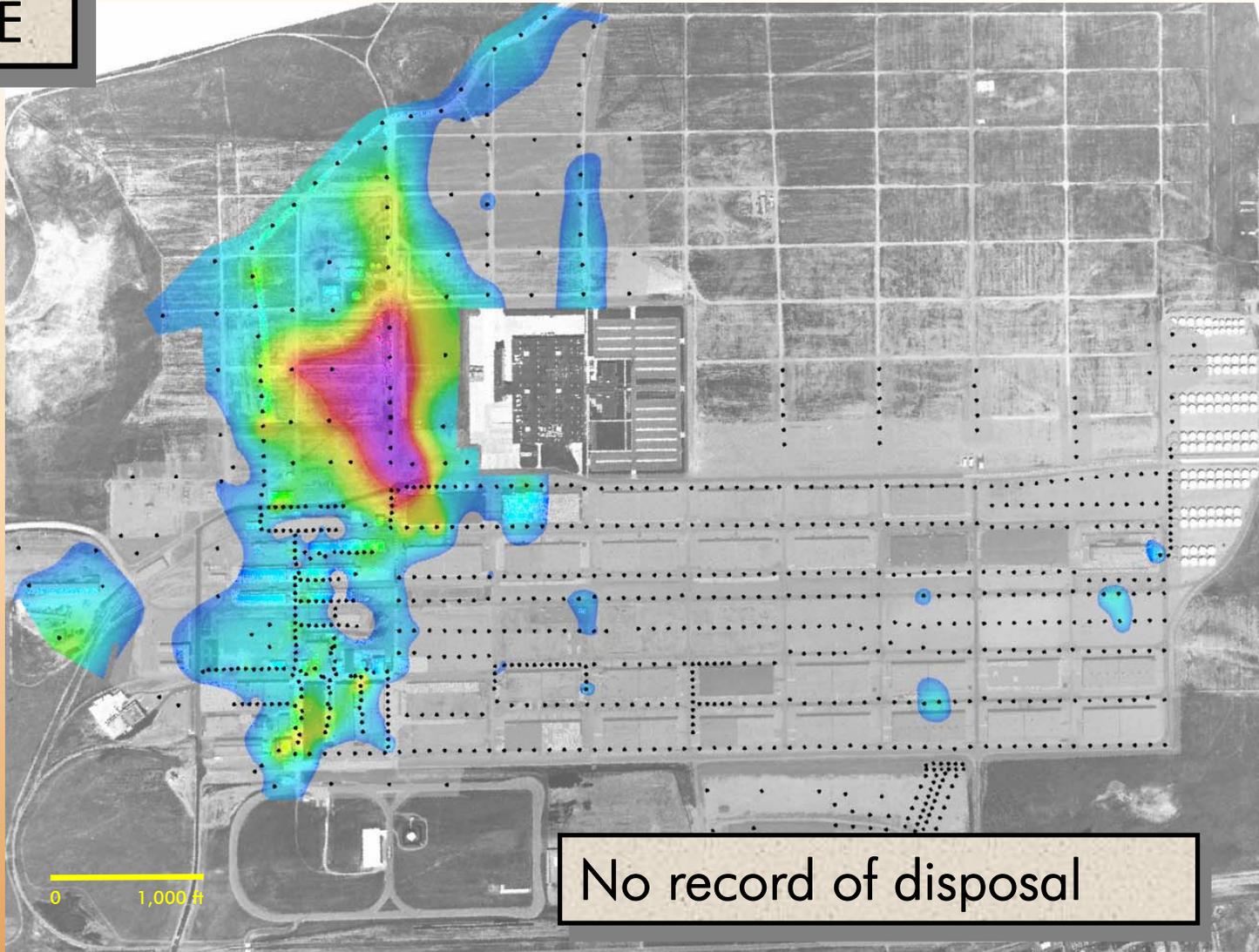


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PCE

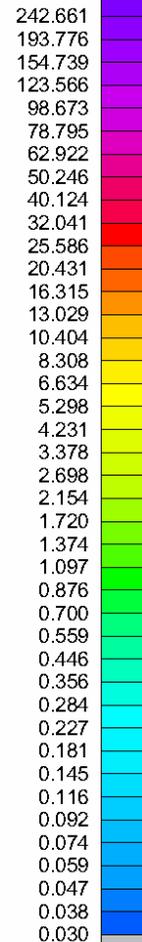
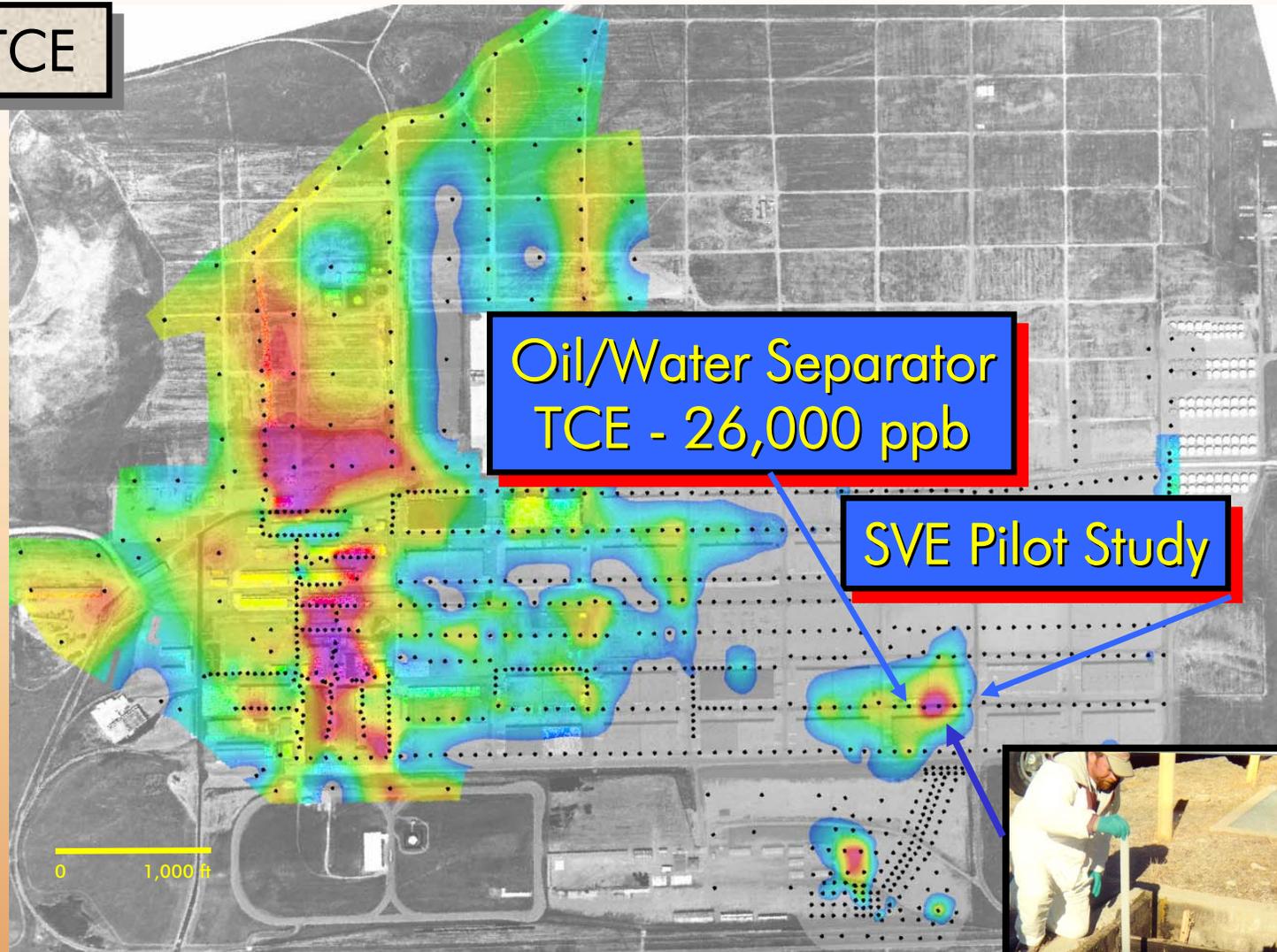


No record of disposal



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TCE



TCE  
[µg]



## Conclusions

- Passive soil gas survey confirmed known sources
  - Previous unidentified source(s) investigated
  - Contaminated soil below separator - major source
    - 6,000 lbs TCE in soil (estimated)
- Source removal most effective remedial action
  - SVE pilot test - 3,900 lbs of solvent - six months
- Monitoring well downgradient
  - TCE - decreased ~1,700 ug/l - six months
- Pump and treat turned off 20 years early
  - Cost savings of \$40,000,000



## Vapor Intrusion and Indoor Air Sampling

### Concentration Calculations - Organics in Air & Soil Gas



**AIR:**  $\text{ug} / \text{m}^3 = \text{Mass} / \text{System Factor} / [\text{Sampling Rate} \times \text{Exposure Time}]$

**SOIL GAS:**  $\text{ug} / \text{m}^3 = \text{Air} / \text{Soil Effectiveness Factor}$

**Mass** - GC/MS measured mass from the passive sampler

**System Factor** - Corrects for efficiency of adsorption & desorption as affected by adsorbent, compound & method

**Sampling Rate** - L/hr of contaminated air collected by the sampler  
(ANSI, ISO, NIOSH, ASTM -- Sample Chamber)

**Soil Effectiveness Factor (E)** -  $D_{\text{eff}} - f(\text{porosity, pore water content, H, } D_{\text{water}})$

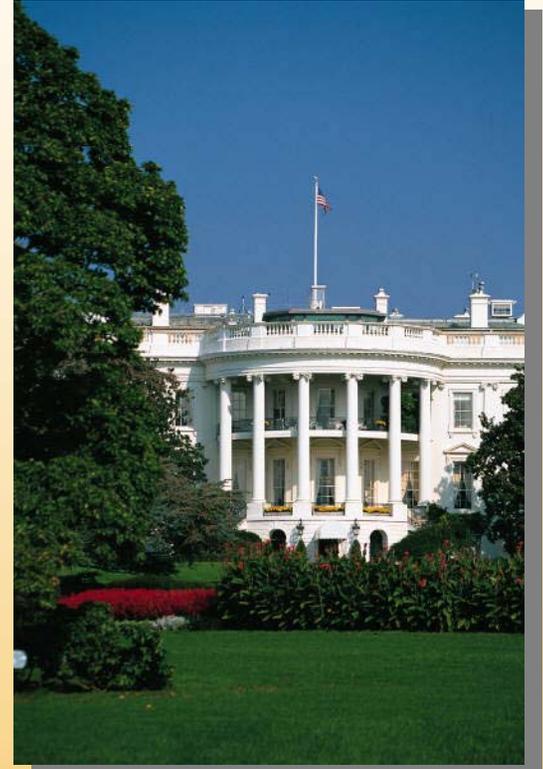
$$- E = D_{\text{eff}} / D_{\text{air}}$$

Willington, R.J. and J.M. Quirk. 1961  
Johnson and Ettinger 1991



## Case History

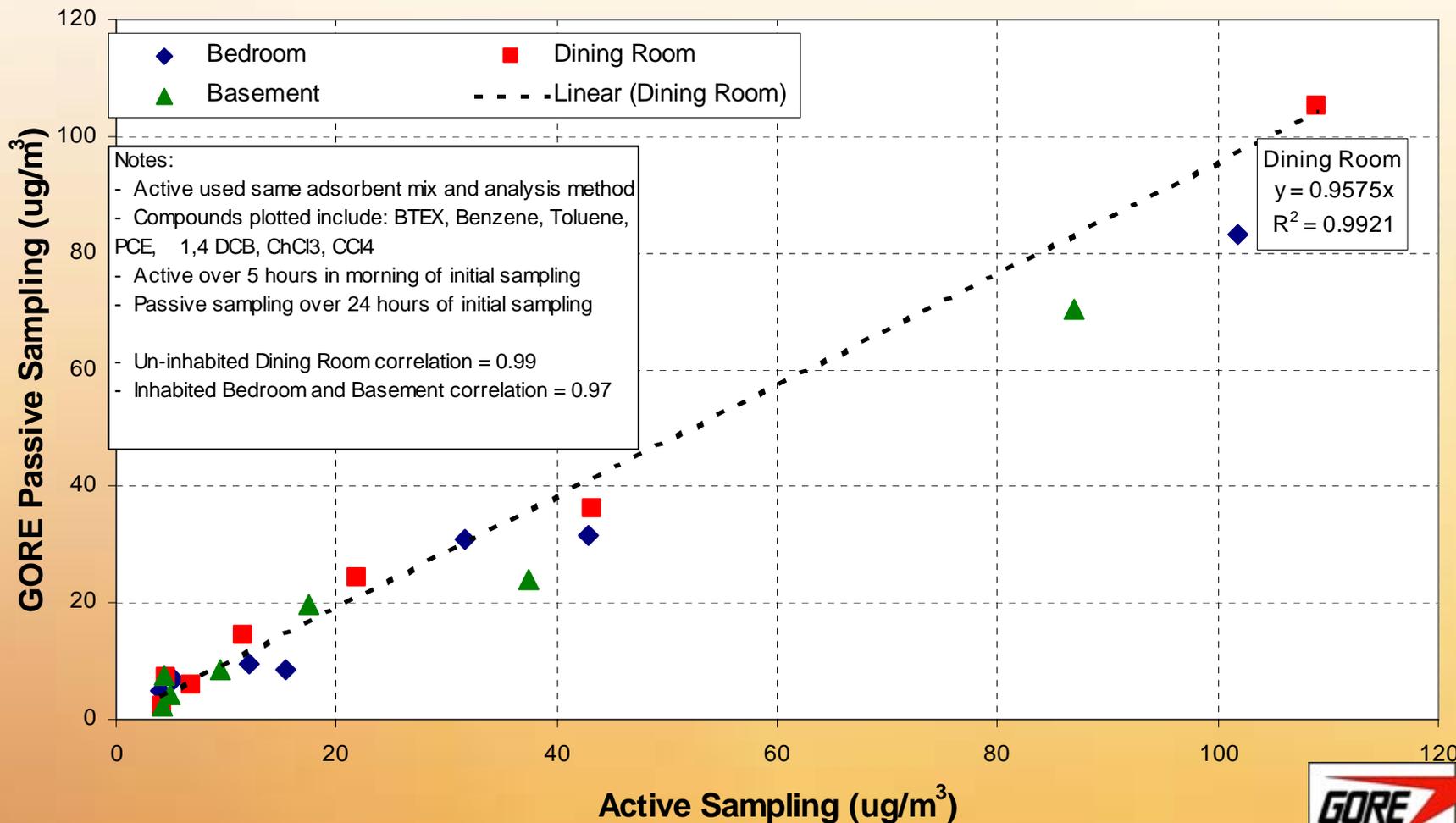
- Indoor Air Sampling
  - Home near Washington, DC
  - Three rooms
  - Nine passive samplers per room
    - Exposed for 1, 3, 7 days
  - Calibrated battery-powered pumps
    - Sorbent-filled tubes
    - Pumps operated ~ five hours



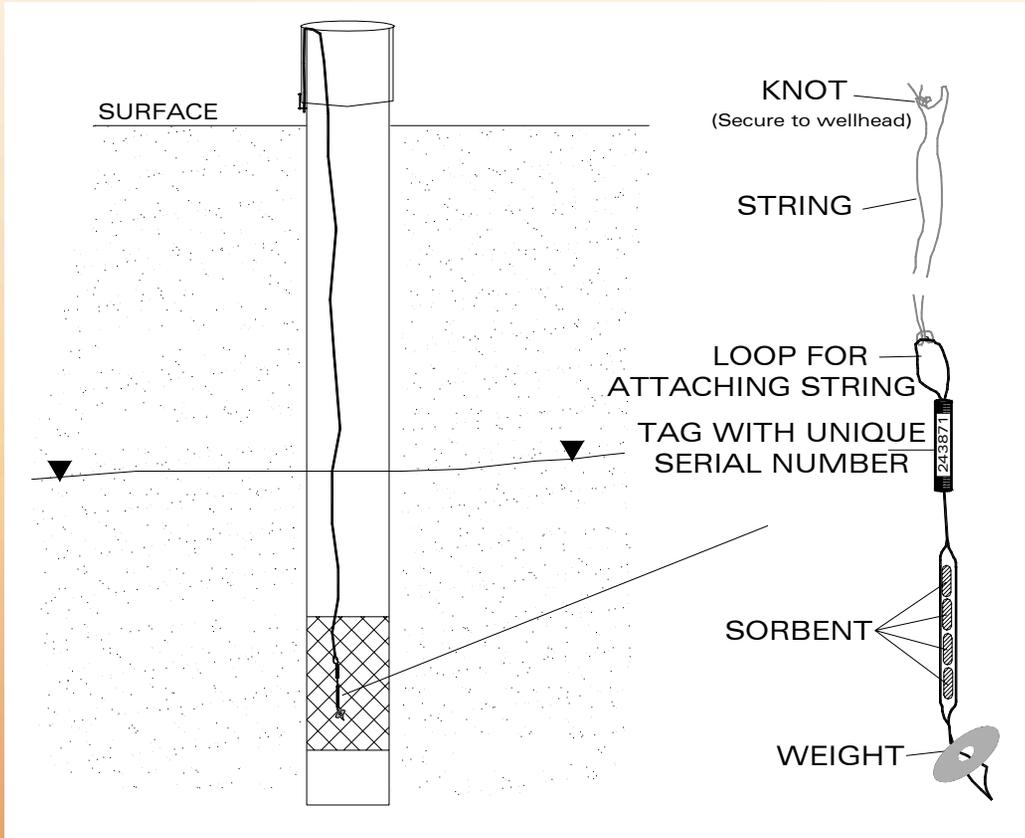
Passive sampling compared favorably to TO-17 active method.



# Comparison of Passive Data to TO-17 Active Sampling



## Groundwater Sampling

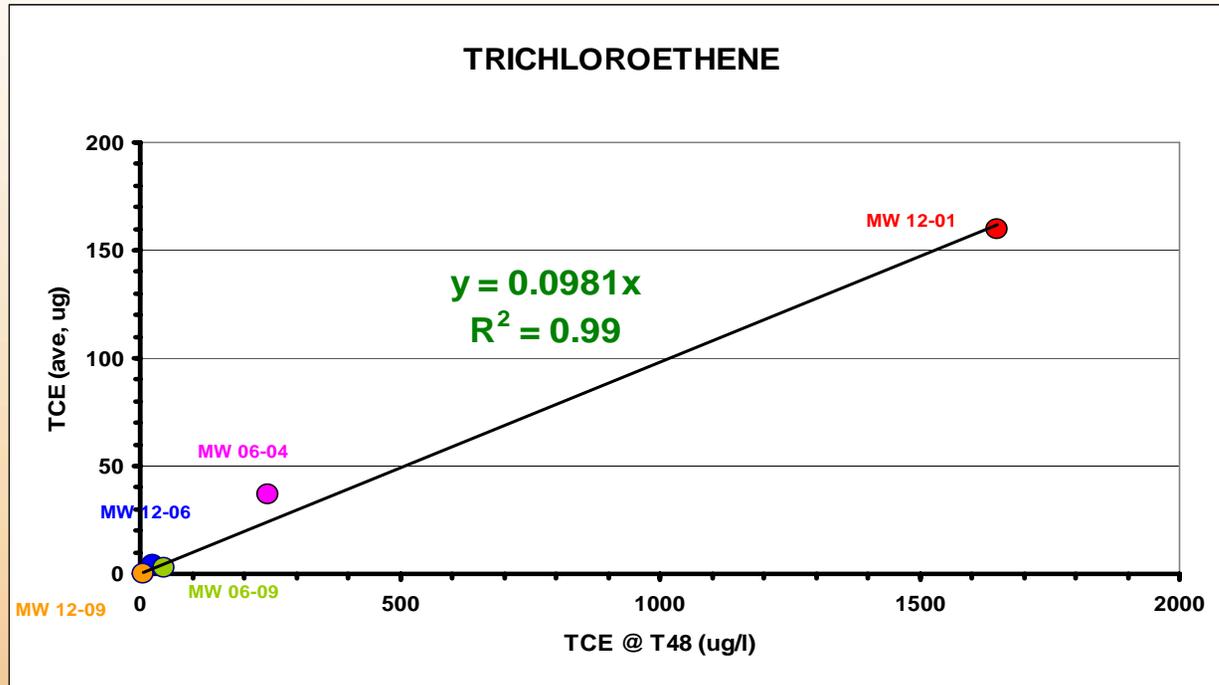


- Partitioning
  - Liquid to vapor phase
  - Henry's Law
- Diffusion
- Adsorption
- VOCs, SVOCs, PAHs, & Soluble Compounds



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US EPA

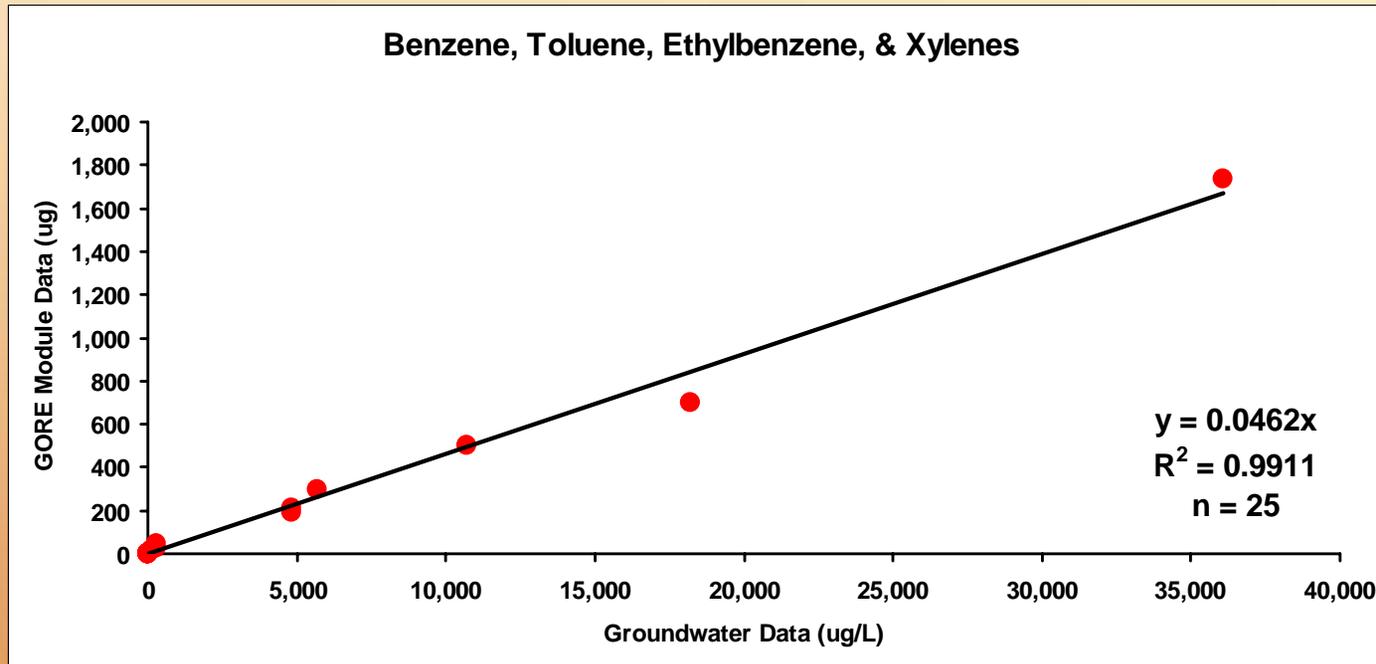
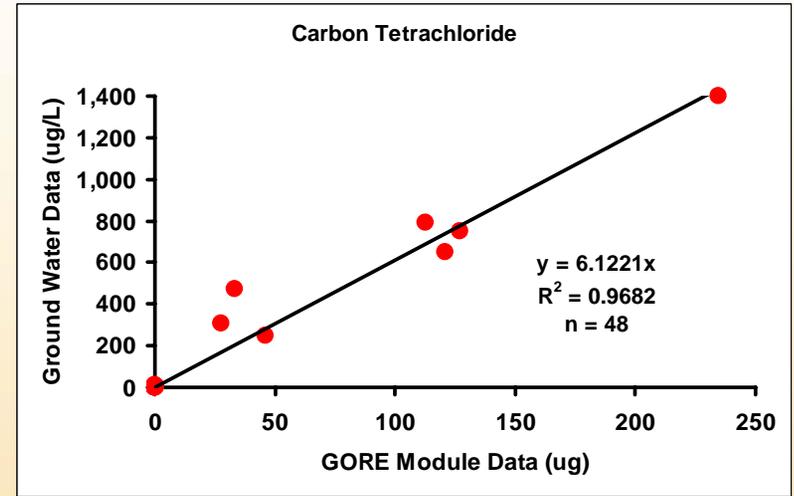
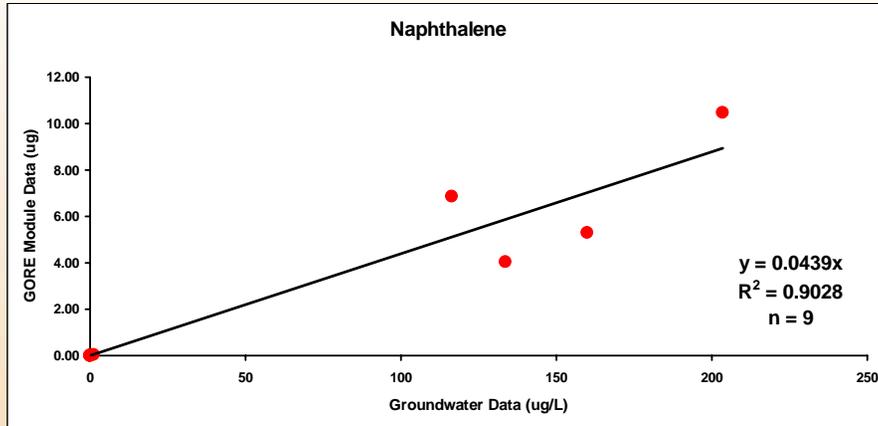


**“...results show that GORE-SORBER Water Quality Monitoring can be used to monitor long-term concentration trends...”**

**“...optimally suited for relatively low-cost concentration trend monitoring and screening.”**



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## Case Study

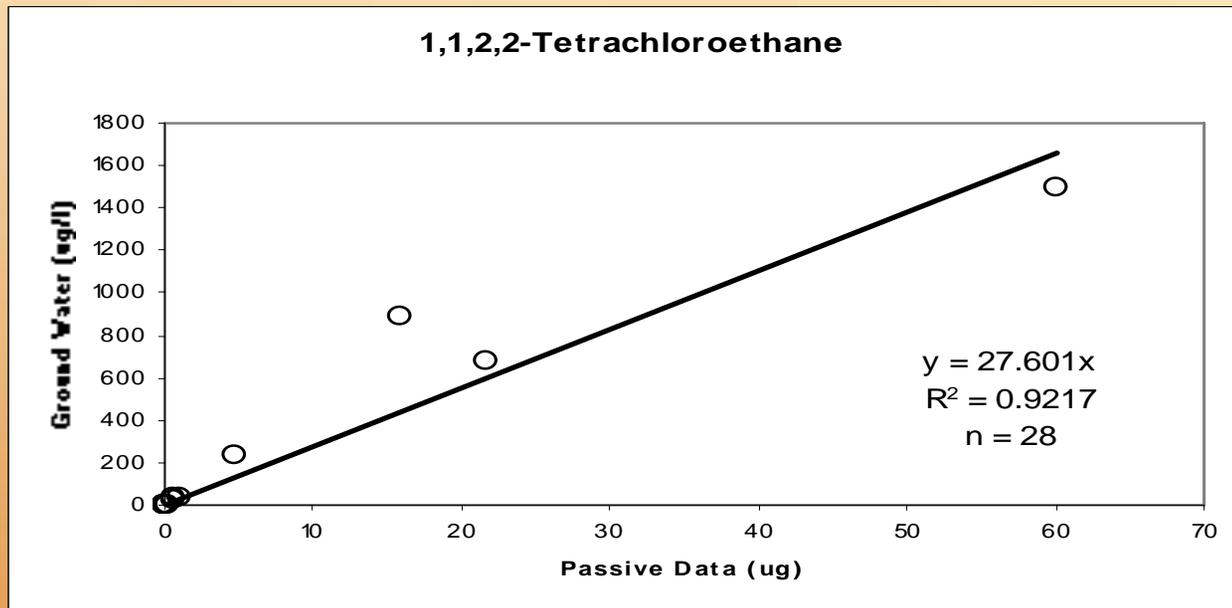
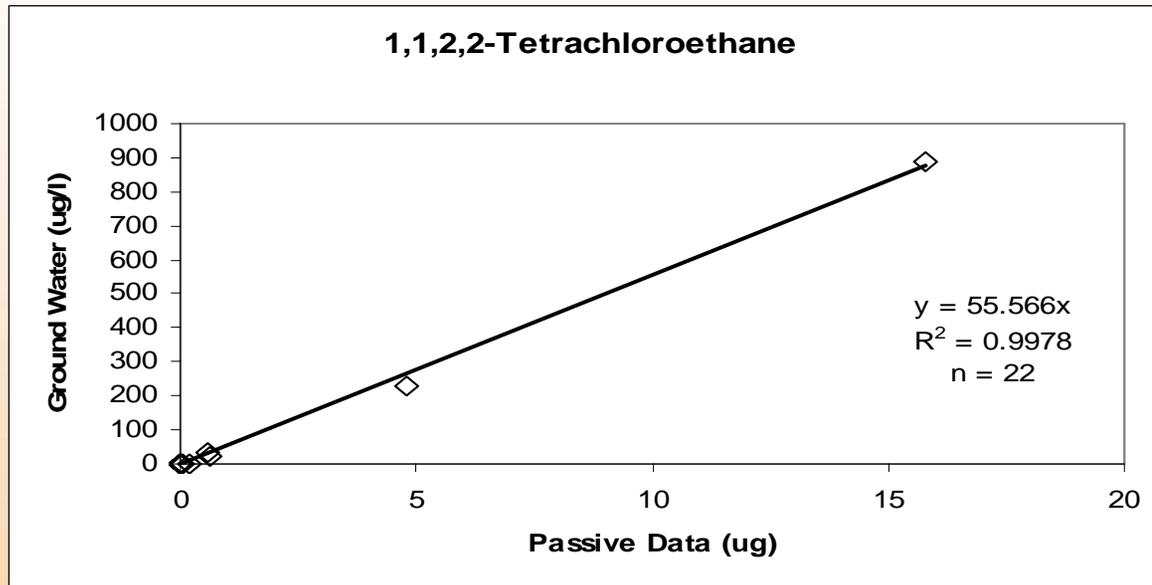
### Background

- Military facility
- 30+ years munitions testing
- Groundwater contaminated ~2,000 ug/l
- Groundwater depth up to 30 feet
- Unconsolidated alluvial deposits
- Large network of wells
- Two co-sampling phases since July 1997

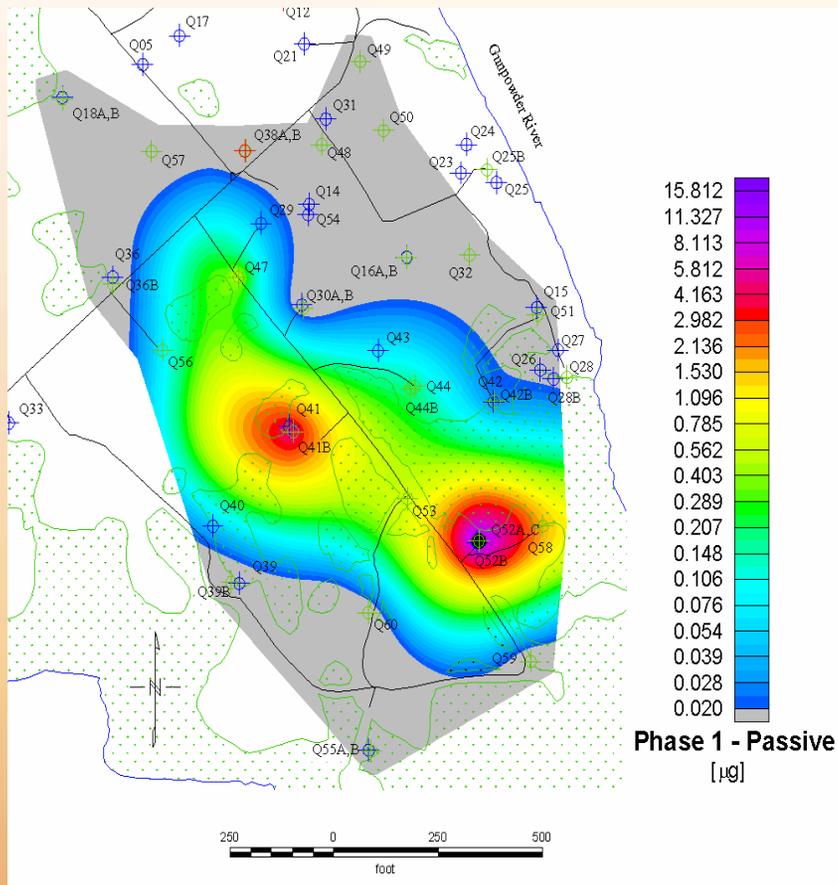


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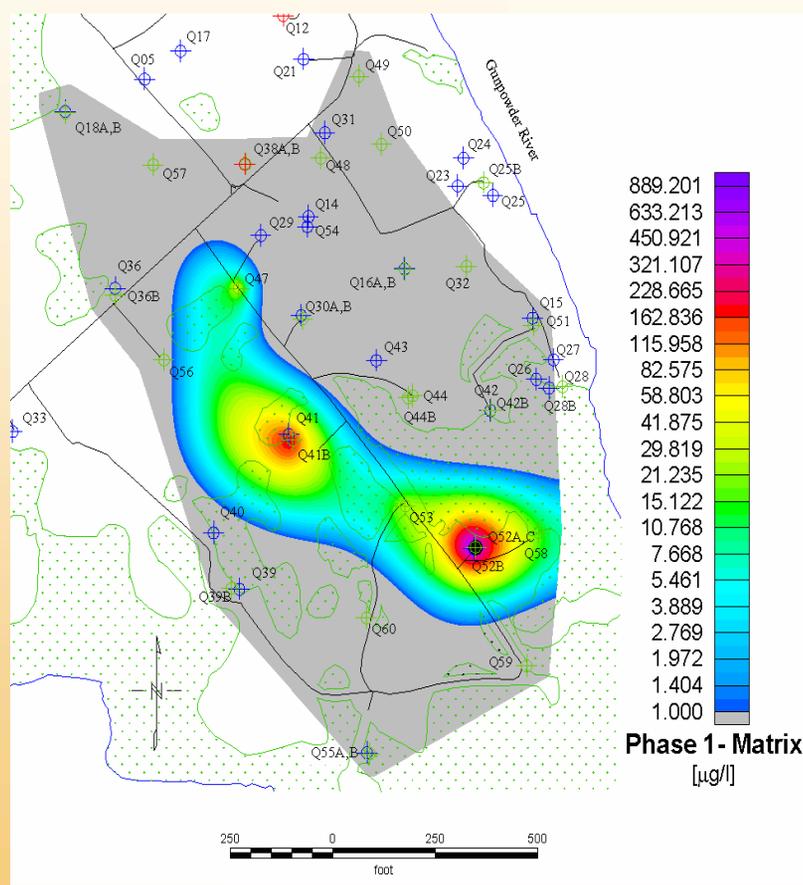
## 1,1,2,2-Tetrachloroethane



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Phase 1 - Passive Data



Phase 1 - Groundwater Data



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## Cost Comparison

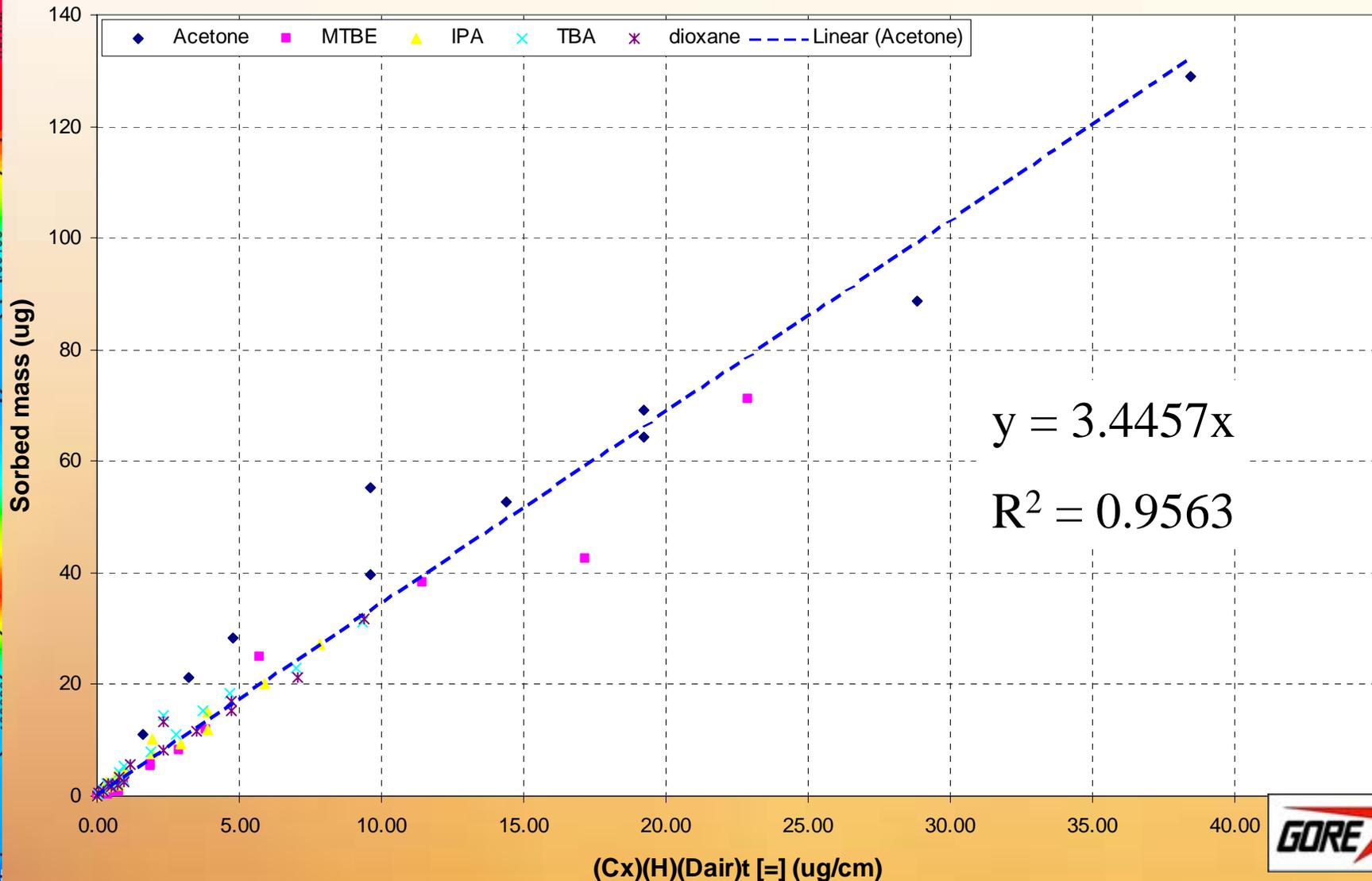
Item	Units	Unit Description	Extended Cost
<b>Traditional Groundwater Sampling</b>			
Project management	42	Hours	\$2,145
Field crew	235	Hours	\$12,993
Equipment – pump	1	Lump sum	\$1,765
Purge water disposal	0	Disposal fee	*
Laboratory costs	26	Samples	\$7,452
<b>TOTAL</b>			<b>\$24,355</b>
<b>Passive Groundwater Sampling</b>			
Project management	4	Hours	\$204
Field crew	31	Hours	\$1,324
Equipment – consumables	1	Lot charge	\$100
Laboratory costs	26	Samples	\$5,070
<b>TOTAL</b>			<b>\$6,698</b>

\* Note: Due to the availability of an on-site treatment system, purge water disposal costs are not included.

**\$24,355/\$6,698 = 72% cost savings**



# Water Soluble Compounds - Sampling Rate



## Conclusions

- Passive - effective in soil gas, air and water sampling
- Permeable, sorbent-based membrane sampler
  - Overcomes limitations with active vapor sampling
  - Overcomes limitations with other diffusion sampling devices
- Concentration capability research continues
- Field testing



# THANK YOU.

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