



**Environmental Investigations Using
Versatile, Vapor-Permeable,
Adsorbent-based Passive Samplers**

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W. L. Gore & Associates, Inc.**

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GORE™ Surveys: Investigating Air, Soil, and Water

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Outline



- Introduction
- Environmental investigations
 - Passive sampling – soil gas, subslab soil gas, air
 - Common applications
 - Benefits
- GORE™ Module
 - What it is and how it works
- Example
- New advances
 - Concentration reporting – air, water
- Examples

Do you prefer an informative picture before an operation?

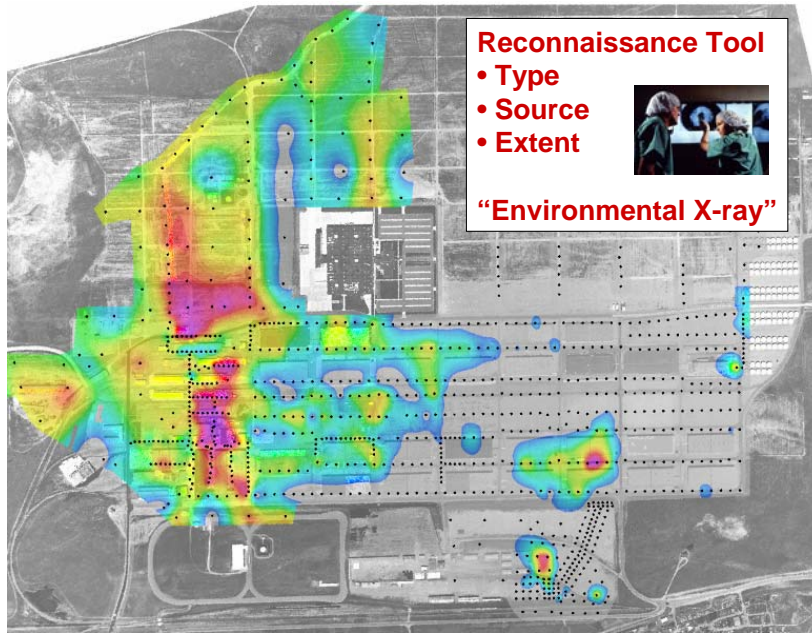


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Do you prefer an informative picture before remediating?



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Common Applications – Passive Sampling



- Site assessment (Conceptual Site Models)
- Vapor intrusion
- Remedial optimization
- Property transfer - Brownfields
- Monitoring
 - Long-term GW
 - Remediation
- Pipeline integrity



* - partial list

Benefits – Passive Sampling



- Rapid, inexpensive, unobtrusive installation & retrieval
 - Minimal operator & field sampling error
- Time-integrated sampling
 - ppt sensitivity
 - Sensitivity to broad range of compounds VOCs, SVOCs, PAHs
 - Minimizes sampling variability
- Virtually any soil and moisture condition
- No forced extraction of vapor
- No mechanical parts
- No energy required

Limitations

Mercury and vapor concentration, no longer a limitation.

Comparison



- **Active** soil gas and subslab soil gas
 - Forced withdrawal of vapor
 - Complex setup
 - Potential for error



Courtesy of ZEBRA Environmental Corporation

- **Passive** soil gas and subslab soil gas
 - No forced withdrawal of vapor
 - Simple setup
 - Minimal error



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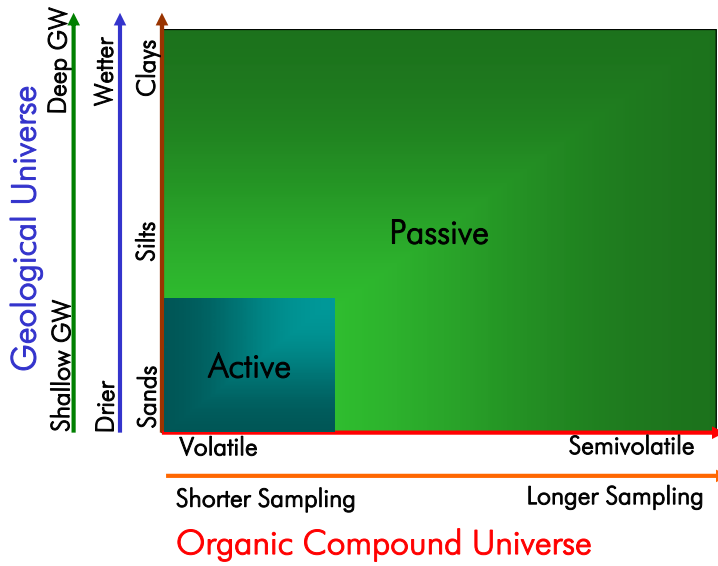
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Limitations

Mercury and vapor concentration, no longer a limitation.

Why Passive Sampling?

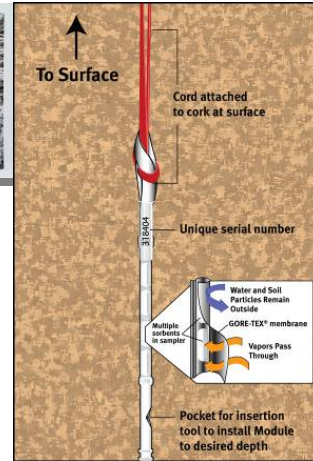
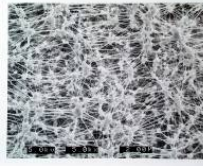


Time-integrated:
Sensitive to a broader range of compounds, present in lower concentrations, in virtually any soil condition.

GORE™ Modules

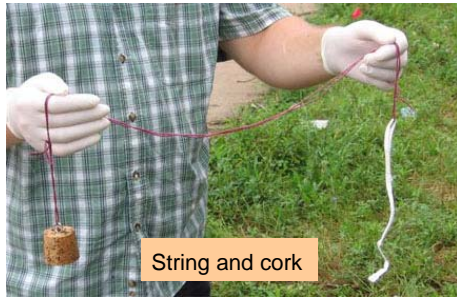


GORE-TEX® Membrane

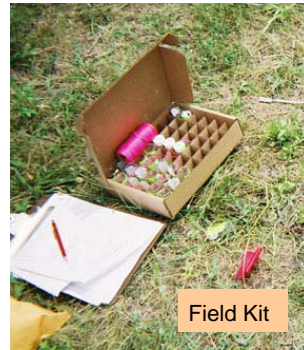


- 1) GORE-TEX® Membrane
 - Chemically-inert, waterproof, vapor permeable
- 2) Engineered sorbents
 - Hydrophobic
 - VOCs, SVOCs, PAHs
- 3) Sample analysis
 - EPA 8260/8270 or TO-15
 - Duplicate samples
 - **Direct detection of organic compounds**
 - **Sample integrity protected**

GORE™ Module



String and cork



Field Kit



Insertion rod

Subsurface Installation

Installation - Soil Gas, Subslab Soil Gas and Air



Soil Gas



Slam bar

Hammer drill



Module insertion

Subslab Soil Gas



Angle beneath slab



Air



Crawlspace air



Indoor air

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Installation – Sediment and Groundwater



Sediment

To Surface

Cord attached to float or insertion probe.

GORE[®] Module can be inserted directly into sediment.

- Water and Sol. Containing Resins
- GORE-TEX[®] membrane
- Organic vapors Pass through

Water

Sediment

Flag

Come Pole Notched at Bottom

GORE[®] Module

Groundwater



Vertical Profiling in Wells

Remedial Optimization Example

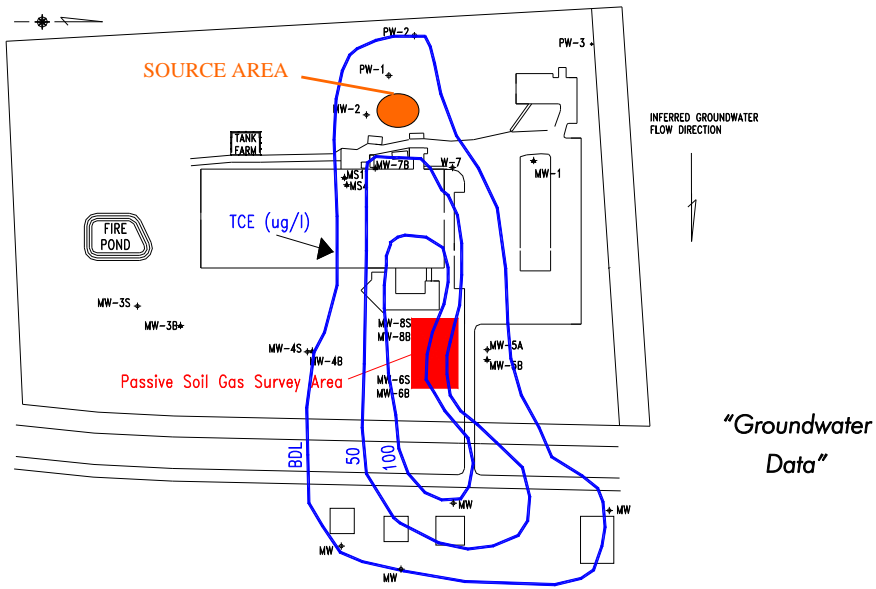


Manufacturing Facility

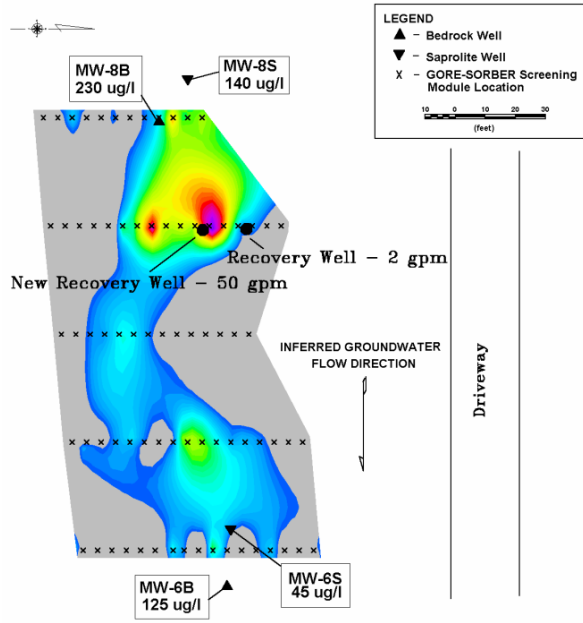
Objective: optimize recovery well placement

- Chlorinated compounds in groundwater
- 30ft weathered, "tight" clay (10^{-8}), fractured bedrock
- Groundwater ~30ft depth
- Geophysical survey lacked resolution
- Active soil gas survey failed
- PETREX survey performed poorly
- 77 GORE™ Modules, 30 x 4ft sample spacing

Remedial Optimization Example



Remedial Optimization Example



"Soil Gas Data & New Recovery Well"

Remedial Optimization Example

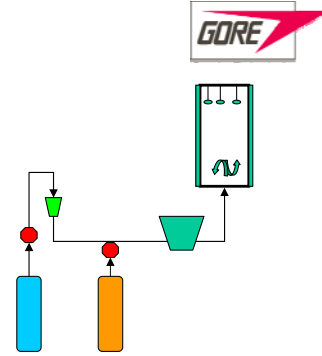


Conclusions

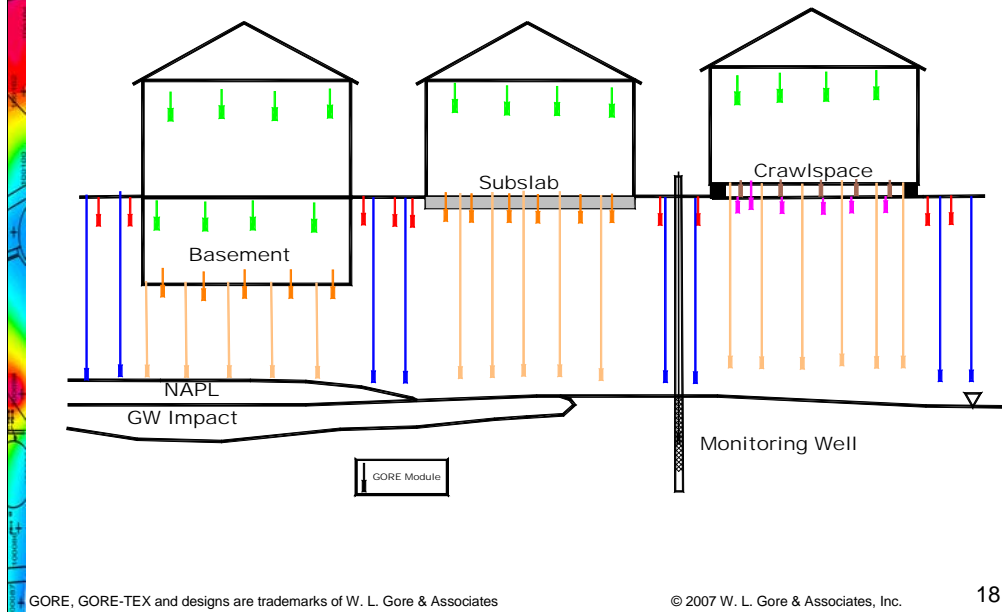
- Sample spacing delineated suspect fracture
- TCE in groundwater detected in soil gas
 - Challenging site geology
- Recovery well location optimized
- 25x increase in fluid removal
- 75% increase in TCE removal

Calculating Concentrations

- **Quantify (measure) uptake rate**
 - Experimental conditions
 - Varying concentrations, conditions
 - Air, water
- **Exposure period**
- **Quantify (measure) mass desorbed**
- **Soil gas**
 - Eff. Diff. = f [total porosity, water-filled porosity]*
 - Johnson-Ettinger VI model terms
 - Millington-Quirk
- **Conc = f [volume = f (uptake rate, time), mass, soil*]**
- **Approach** – IH methods-solid, sorbent-based diffusion samplers
 - ASTM 6306 (1998); 6246 (1998); 4597 (1987)
 - MDHS 70 (1990); 80 (1995); 27 (1983)



Vapor Intrusion Investigation



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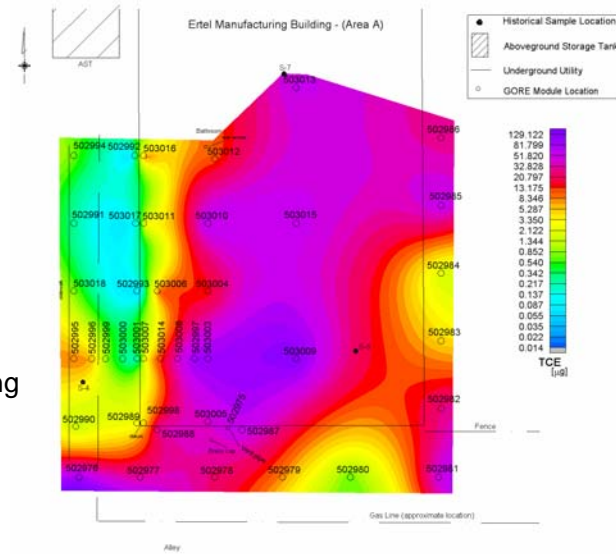
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Vapor Intrusion Concentration Example

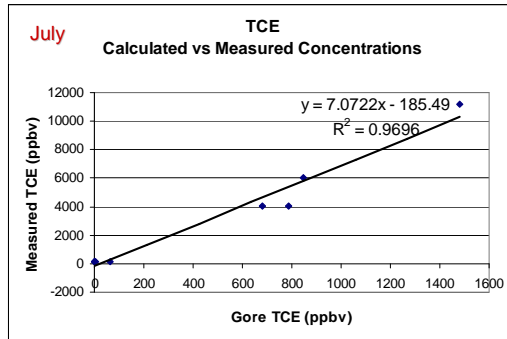


Indianapolis site

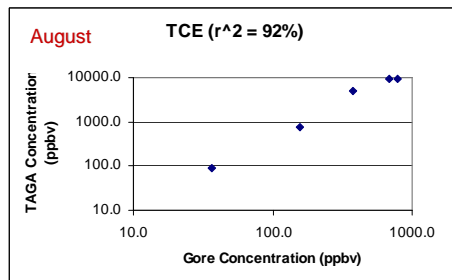
- US EPA - IDEM
- Objective:
 - “First look”
 - July
 - VOCs, SVOCs, PAHs
 - Guide next sampling
 - July, August
 - “sampling boot camp”



Vapor Intrusion Concentration Example



- 3 ft sample depth
- Excellent correlation

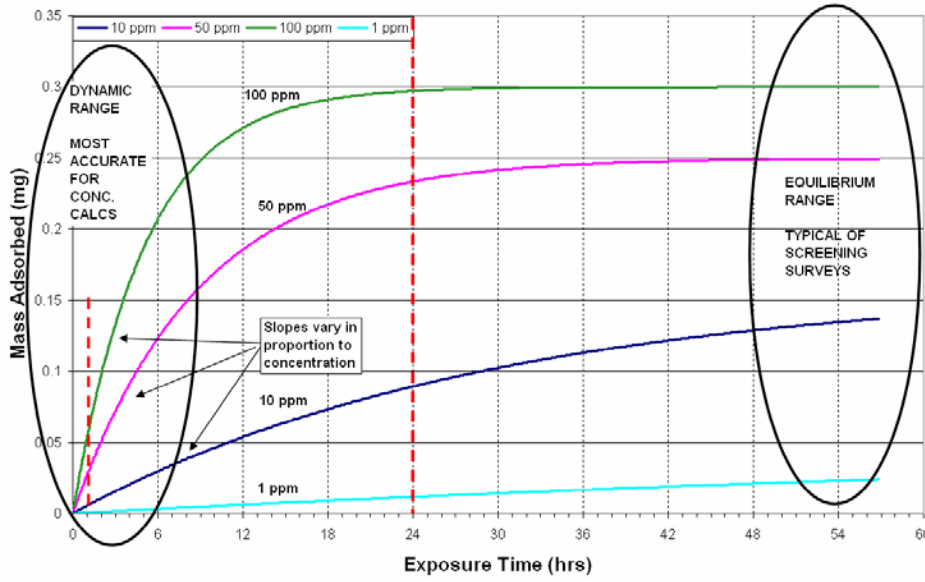


Courtesy of Todd McAlary, GeoSyntec Consultants

Vapor Intrusion Concentration Example



Example Adsorption Curves



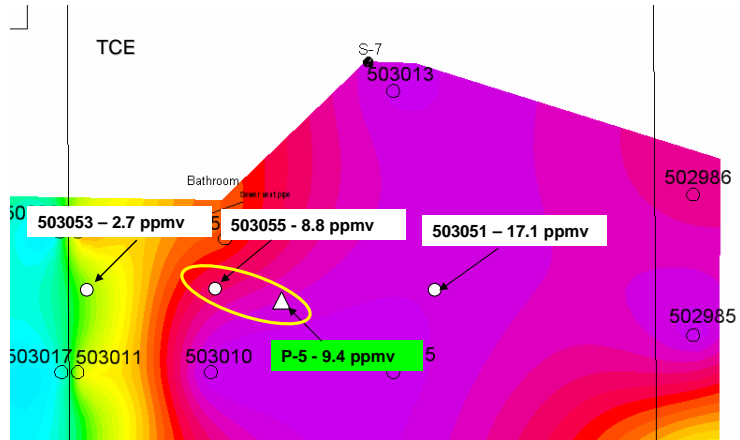
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Vapor Intrusion Concentration Example



- 3 ft sample depth
- One hour exposure
- Correlates spatially
- Matches P5



Groundwater Sampling Example

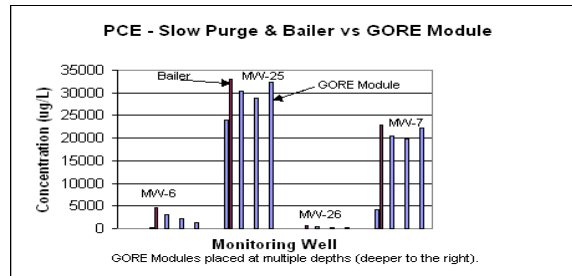
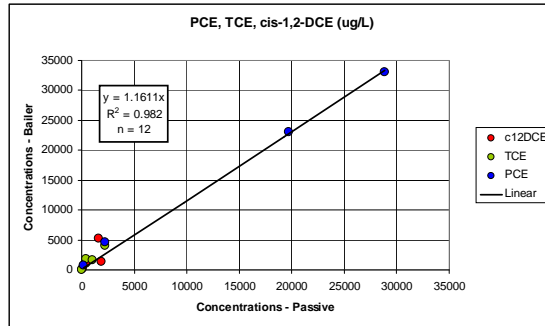


Dry cleaner site – southeast US

- Chlorinated solvents in groundwater
- Shallow water table ~ 8ft.
- Up to four GORE™ Modules per four wells
 - Vertical profile
 - One hour exposure
- Slow purge (peristaltic pump); disposable bailer



Groundwater Sampling Example



Conclusions



GORE™ Module - versatile, membrane-based passive sampler

- Effective in broad scope of environmental investigations
- Sample virtually any media
 - Air, soil gas, water
- Inexpensive installation, retrieval & operation
 - Minimizes sampling error
- **Concentration reporting**
 - Relatively new capability
 - Sound science
 - Favorable data comparisons



THANK YOU!



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