Cost-Effective, Accurate Environmental Investigations Using Passive Soil Gas Sampling

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Intersol 2009 – 8th International Conference-Exhibition
Analysis, Treatment Methodologies and Remediation for Polluted Soils and Groundwater
Paris, France
March 24-27, 2009

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Outline

Part I

- Introduction
- Benefits of passive soil gas sampling
- Membrane-based passive sampler

Part II

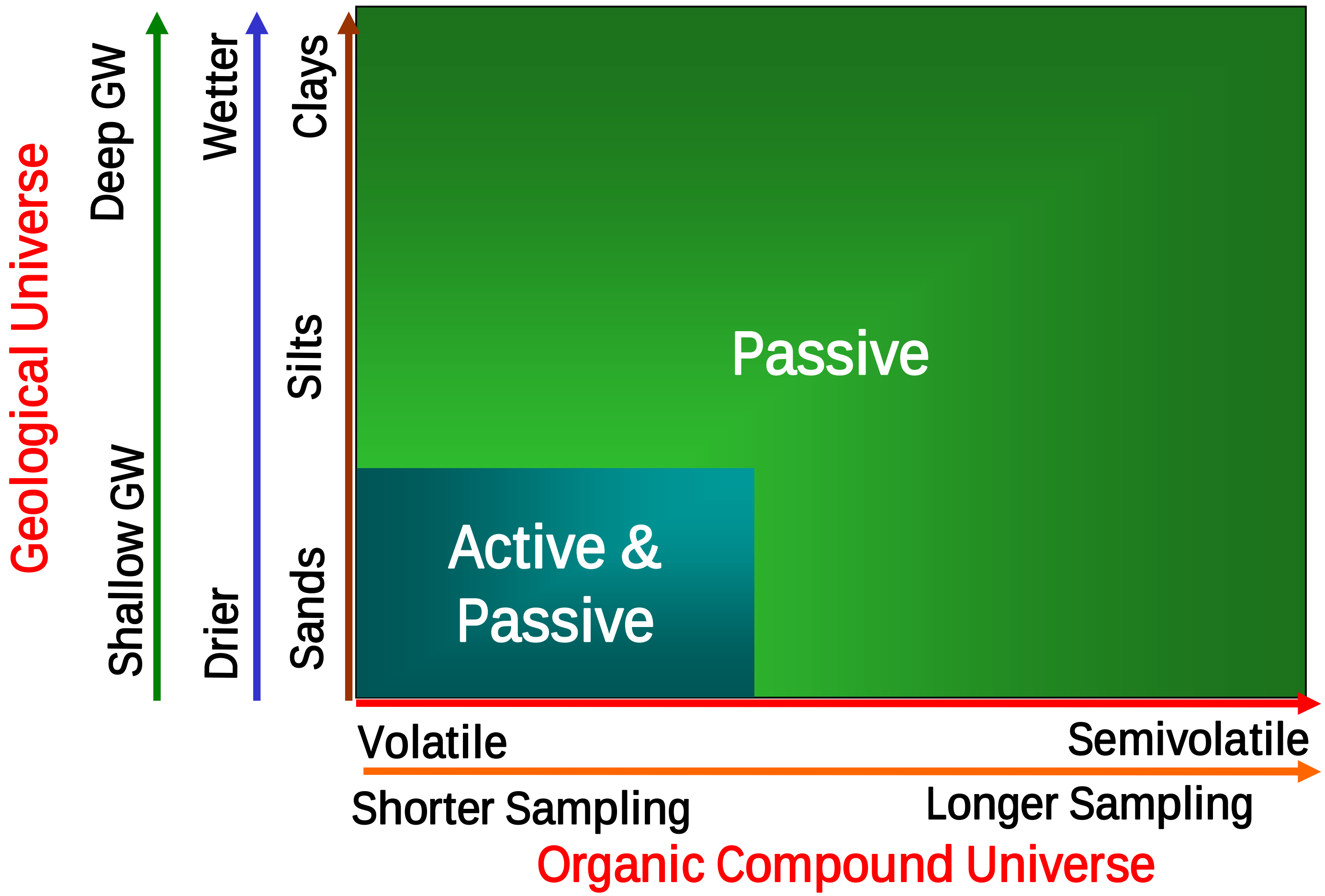
- Site characterization examples
- Conclusion

Benefits of Passive Soil Gas Sampling

- Rapid, inexpensive, unobtrusive installation & retrieval
  - Minimal operator & field sampling error
- Minimal access limitations
- Time-integrated sampling
  - Sensitivity to low concentrations (sub ppb-ppm)
  - Sensitivity to broad range of compounds: VOCs, SVOCs, PAHs
  - Minimizes sampling variability
- Virtually any soil and moisture condition
- No mechanical parts or connections
- No energy required

Why Passive Soil Gas Sampling?

Soil Gas Sampling



✓ Time integrated ✓ Works in virtually any soil condition

✓ Sensitive to a broader range of compounds at lower concentrations

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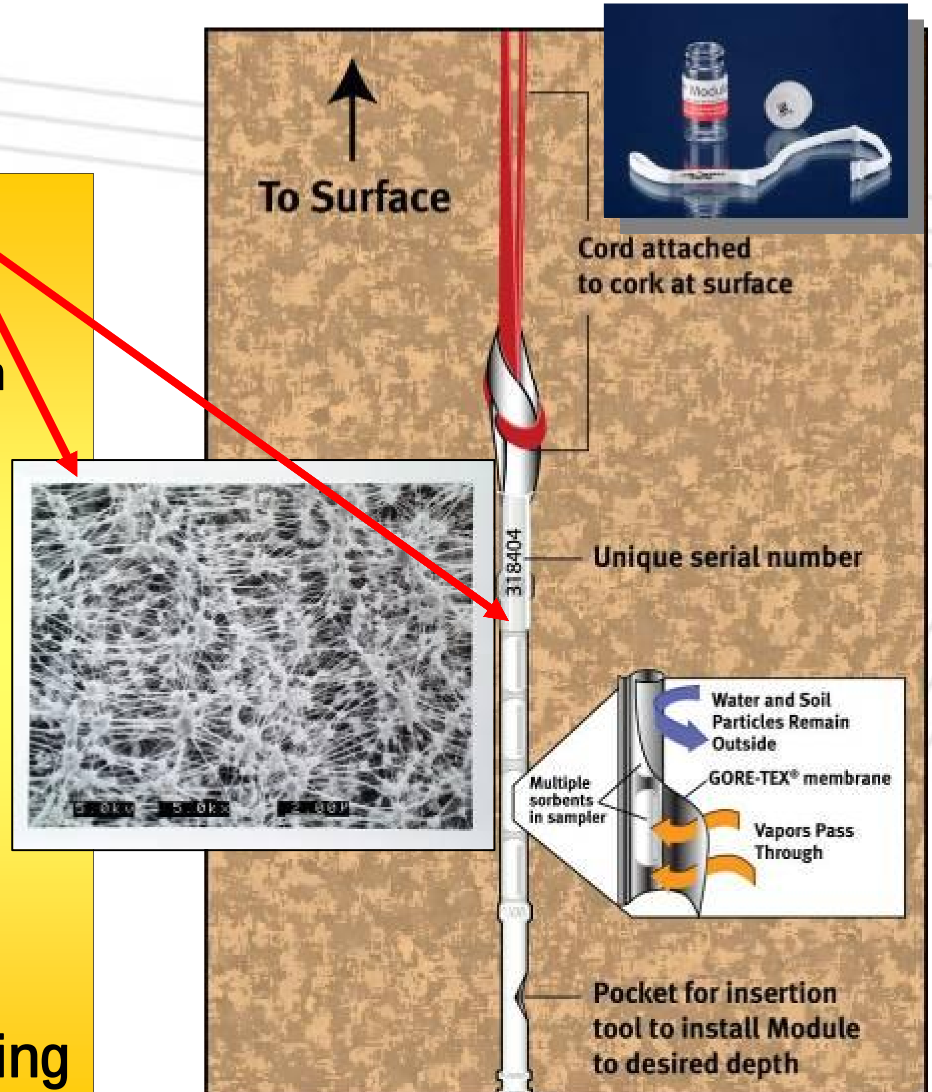
GORE™ Module

1) GORE-TEX® Membrane (ePTFE)
    - Waterproof, vapor permeable
    - Designed for diffusion - no adsorption
    - Chemically-inert – no off-gassing
    - Protects sample integrity
        - In air, water, soil

2) Engineered sorbents
    - Hydrophobic, VOCs, SVOCs, PAHs
    - Multiple samples

3) Sample analysis
    - US EPA 8260/8270

4) Concentration & mass data reporting



US EPA ETV (Aug 1998)
$R^2 = 0.82\text{-}0.99$

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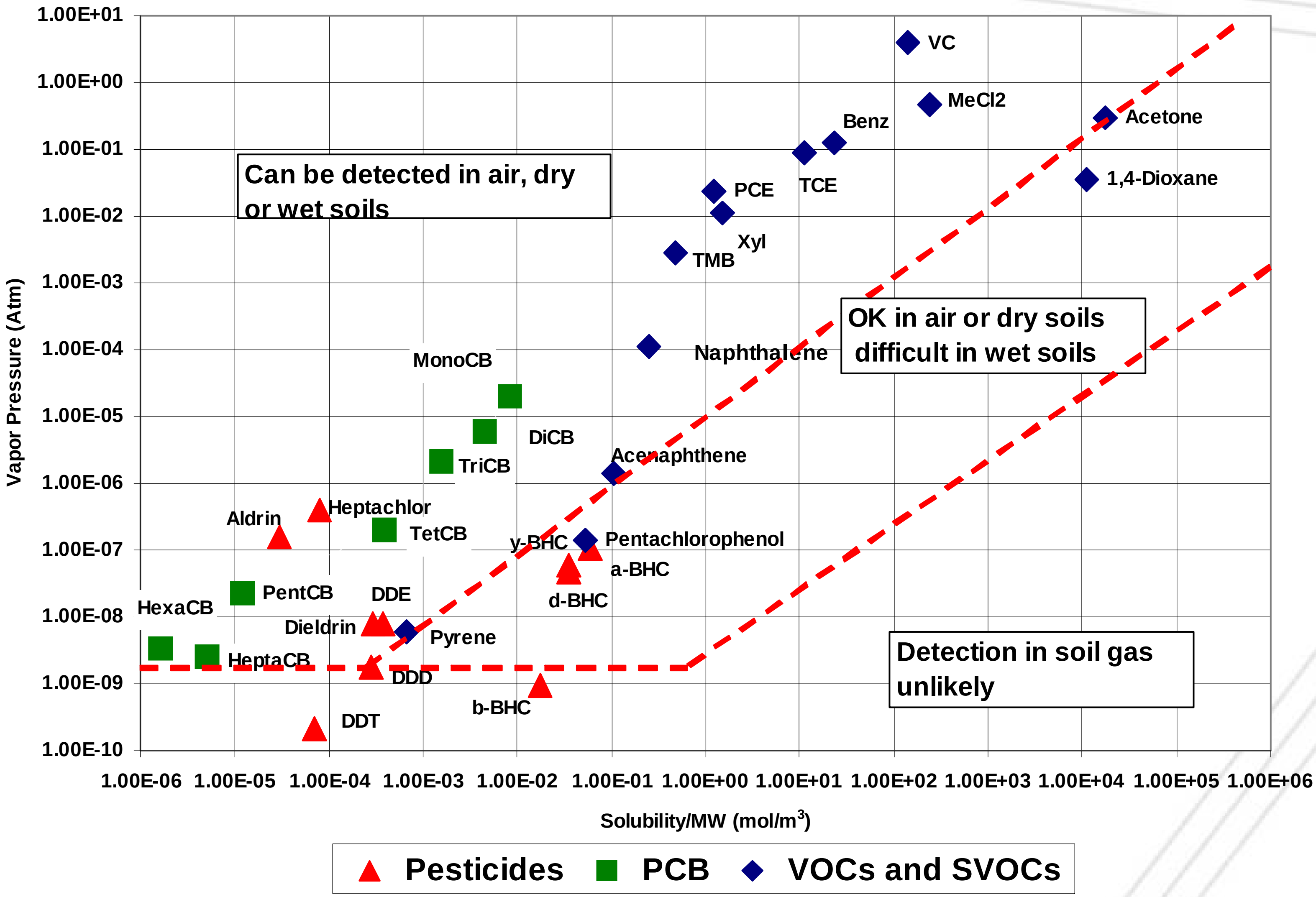
Detection Capabilities in Soil Gas



Soil Gas & Subslab Soil Gas

- Surface to any depth
- Sealed with impermeable cork
- Vertical profiling




Courtesy of LDD Advanced Technologies, Ltd.

Courtesy of AquAeTer

Courtesy of the Kansas Department of Health & Environment

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Air

- Indoor
- Outdoor
- Crawlspace

Indoor air

Crawlspace air

Groundwater/Sediment Porewater

Courtesy of Peregrine Ventures

Courtesy of Marion Environmental

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Site Background

- Department of Defense facility, southeastern US
- RCRA Facility Investigation
  - Two SWMUs (20+ hectares)
- Objectives
  - Identify unknown source areas and delineate extent
  - Presence of DNAPL
- Obstacles
  - Large, access-limited, industrialized area
    - Numerous surface, subsurface structures and utilities
  - Wide range of chemicals including mercury
- Need
  - Cost-effective, high-resolution contaminant delineation
  - Less labor, reduced utility risk, & data collection in limited access areas

Site Geology/Hydrogeology

- Weathered limestone
  - Shallow reworked surface soils
    - Site activities
- Three aquifers
  - 1) Silty sand/gravel = 3 m bgs
  - 2) Clayey gravel = 13 m bgs
    - Primary source of drinking water
  - 3) Limestone = 23 m bgs
  - Communication between aquifers
  - Shale – confining base unit

Soil Gas and Subslab Soil Gas Sampling

- Hand-held compression drill
- Two cm diameter, uncased, cork-sealed holes
  - 0,75 m depth bgs
- 5 to 15 m regular grid spacing
- 12-14 day exposure
- Multiple phases
  - SWMU 1 - 2004/2005 – 617 GORE™ Modules
  - SWMU 2 - 2006 sampling – 358 GORE™ Modules

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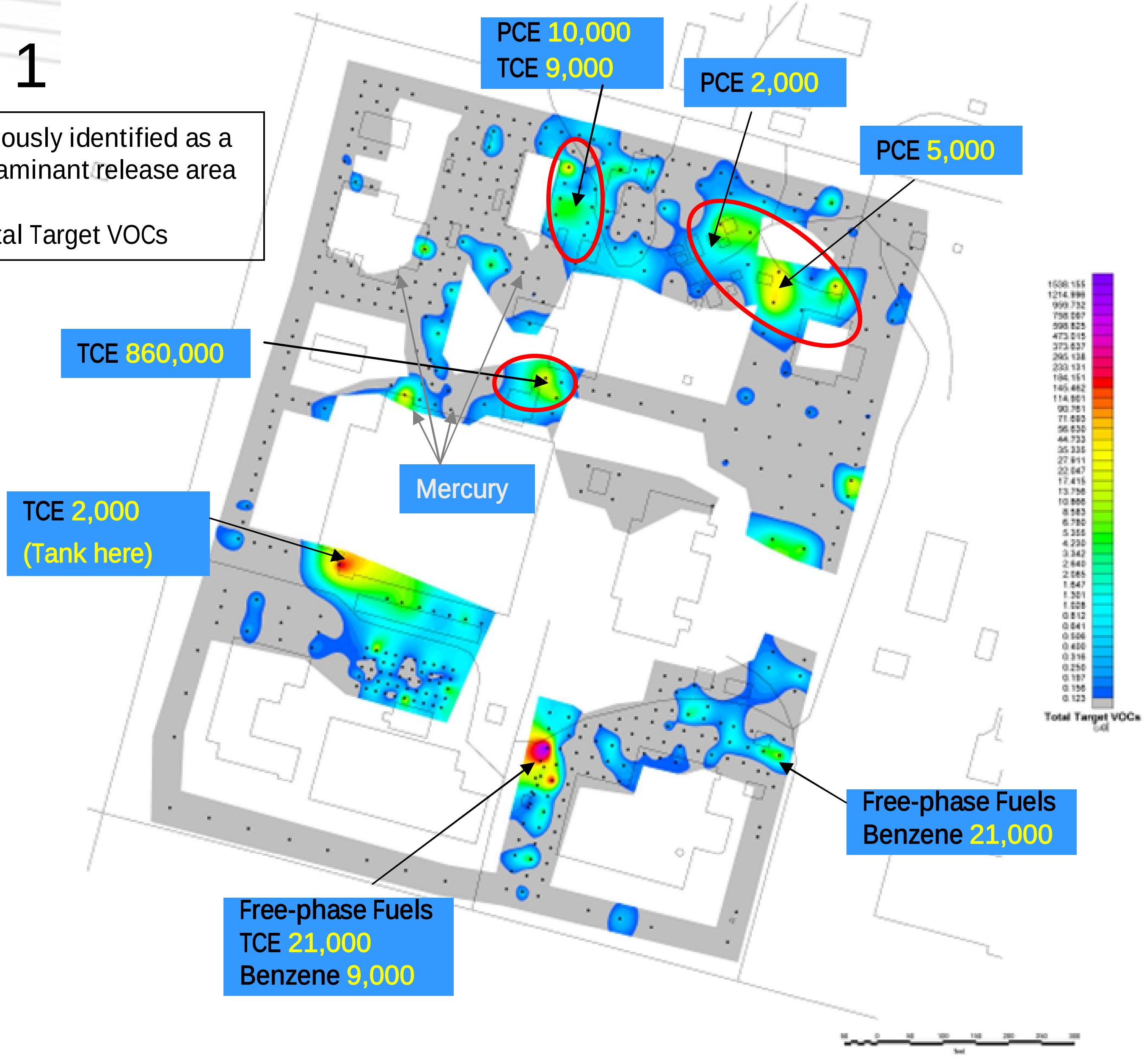
SWMU 1

Not previously identified as a potential contaminant release area
GW - ug/L
PSG – ug – Total Target VOCs



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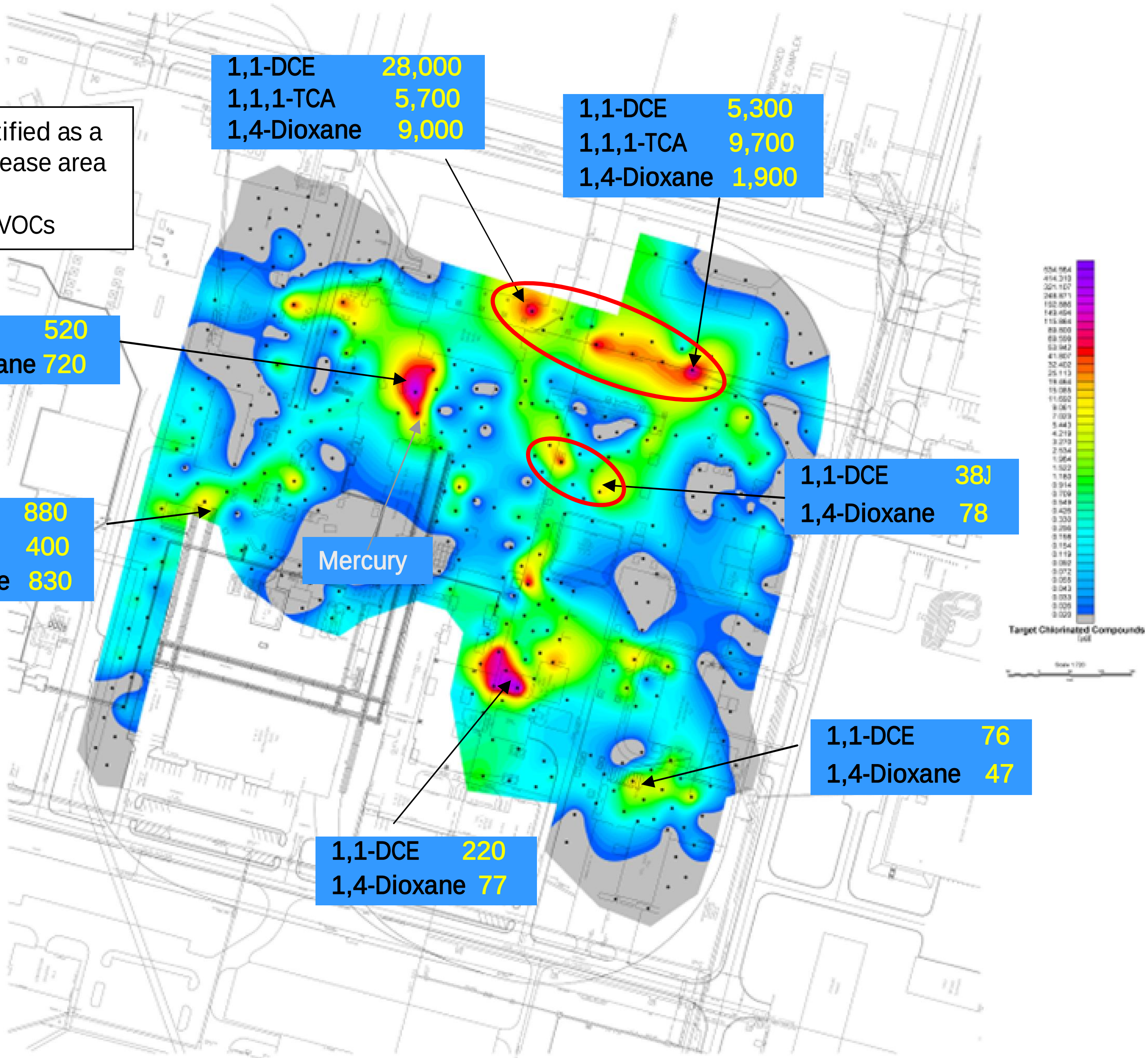
SWMU 2

Not previously identified as a potential contaminant release area
GW - ug/L
PSG – ug – Total Target CVOCs



Passive Soil Gas Survey – Follow-Up

- Potential VOC release areas investigated
- Correlated well with soil and groundwater data
- SWMU 1
  - Three separate areas identified as new potential release areas
    - Sampling revealed DNAPL likely
    - Free-phase jet fuel observed
    - GW conc. equal to nearly 80% of effective solubility of TCE
- SWMU 2
  - Previously unknown source area identified – 0.5 acres
    - mg/L concentrations – 111TCA, 11DCE
      - 1% solubility exceeded - DNAPL
    - 1,4-dioxane (ppm) in groundwater

Cost Savings

- >75% lower sampling costs
- Conventional soil/GW drilling program
  - ~600 locations proposed
  - Reduced to 38
- **> $1 million saved**

Conclusions

- Accurate, cost-effective, high-resolution image
- Identified previously unknown release areas
- Optimized RFI sampling
- Overcame access limitations
- Significant cost and time savings

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Optimize DNAPL Characterization

Objective

- Optimize source zone characterization
- Accurate plume delineation
- Use strengths of passive soil gas and MIPs

Background

- Former 1920s industrial zone in Western Europe
- 1995 characterization
  - Conventional soil borings, monitoring wells
  - Site poorly characterized
    - Few PCE source zones identified

Original Investigation Approach

Borings and existing monitoring wells from previous investigations:

- Borings
- Wells until 5 m-bgl
- Wells 6-10 m-bgl
- Wells 11-15 m-bgl
- Wells 16-20 m-bgl
- Wells >20 m-bgl

Proposed Next Steps:

- More wells…

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Proposed New Phased Approach

Phase	Action	Goal
1A	Passive Soil Gas Screening (*GORE™ Survey*)	Identify and delineate source zones Investigate potential for VI risks
1B	MIP Investigation (*Membrane Interface Probe*)	Characterize the vertical distribution and extent of the contaminants
1C	Installation of wells and analyses	Collecting analytical data
2	Groundwater modeling and risk assessment	Understanding plume migration and assessing potential risks
3	Data evaluation and reporting	Presenting results to Local Environmental Authorities
4	Communication with Stakeholders	Presenting results to other stakeholders

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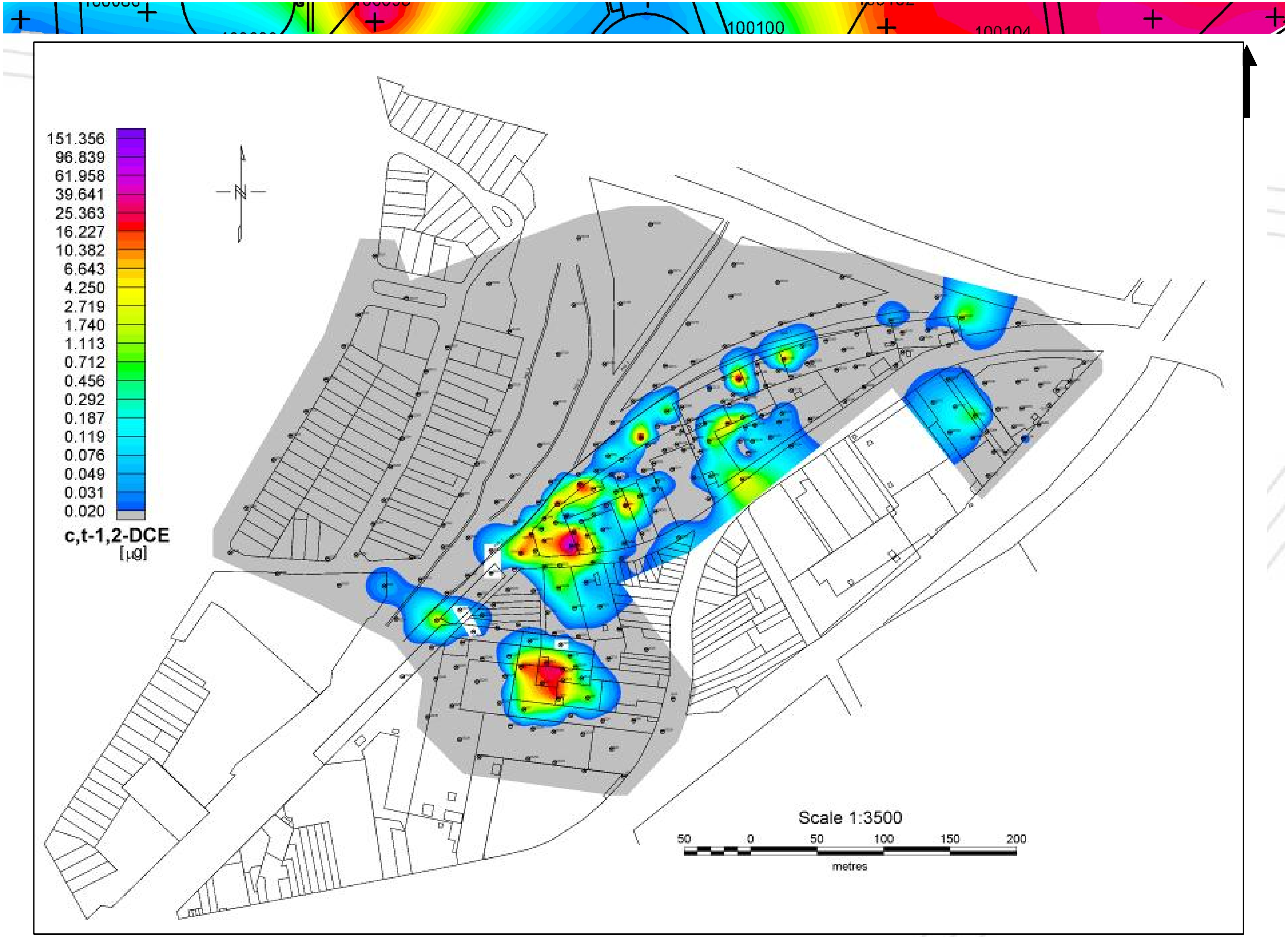
Optimize DNAPL Characterization

Phase 1A: GORE™ Survey

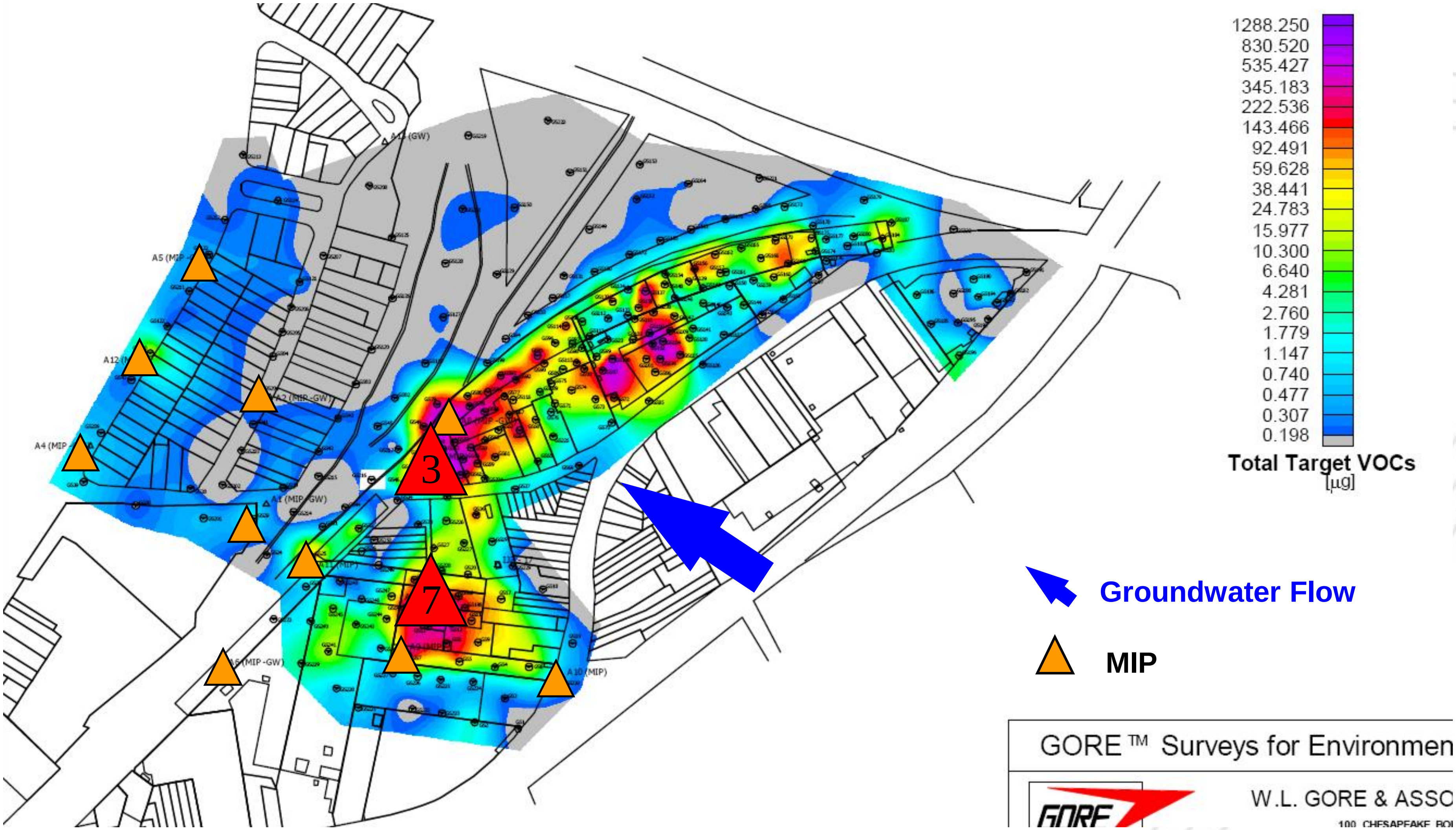
- 250 GORE™ Modules installed (2 phases)
  - 172 in industrial zone (~20 different companies)
  - 38 in nature park
  - 40 in streets
- Installation depth ~1,5 m
- Exposure time ~ 15 days

Passive soil gas results

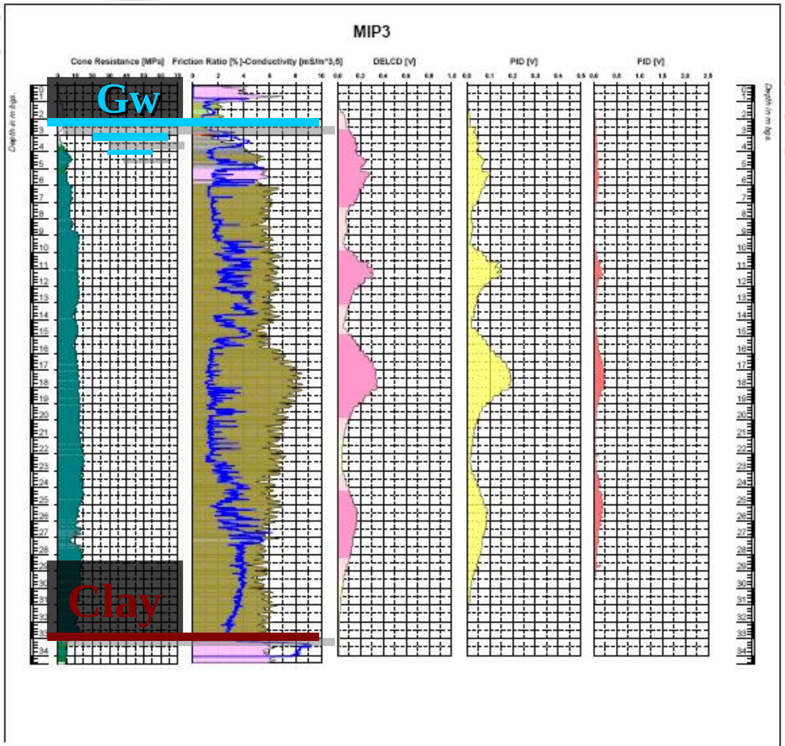
- Multiple source areas – 1,1,1-TCA, PCE, BTEX
- Horizontal extent delineated – on and off-site
- High concentrations and DNAPL likely
- Larger source areas than initially thought

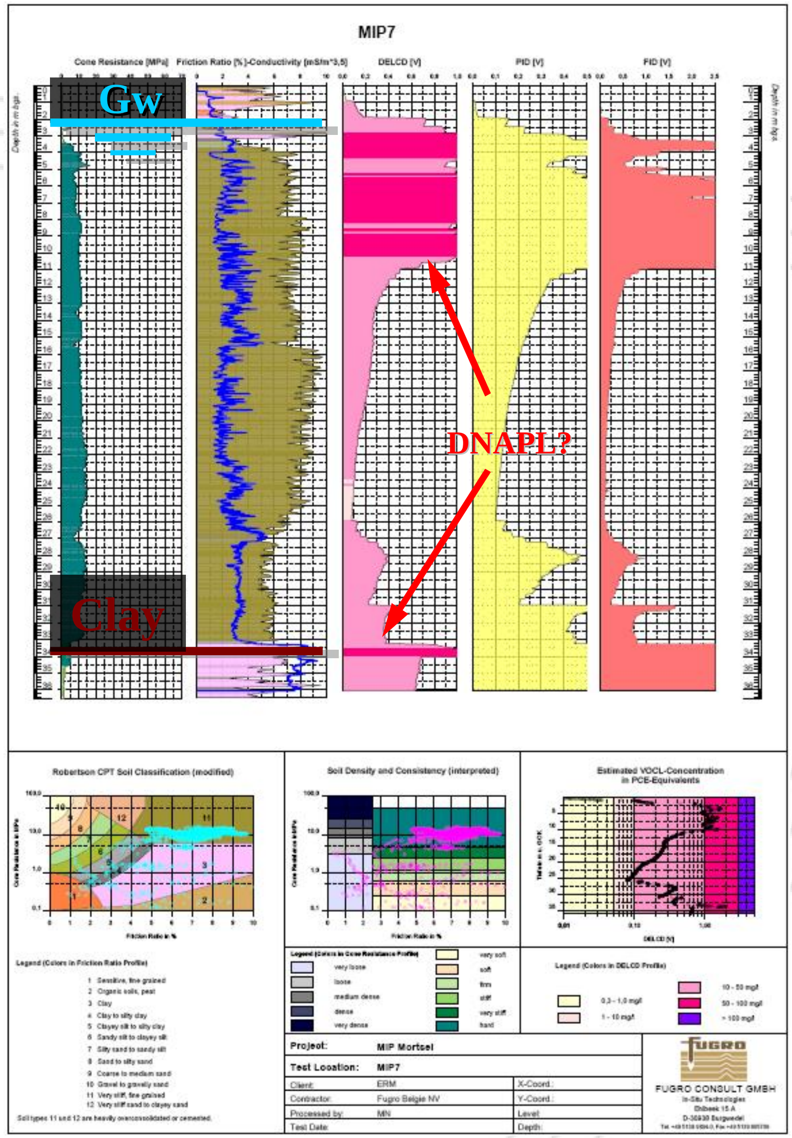

151.356
96.839
61.958
39.641
25.363
16.227
10.382
6.643
4.250
2.719
1.740
1.113
0.712
0.456
0.292
0.187
0.119
0.076
0.049
0.031
0.020
c,t-1,2-DCE
[µg]
Scale 1:3500
50 0 50 100 150 200
metres
100100

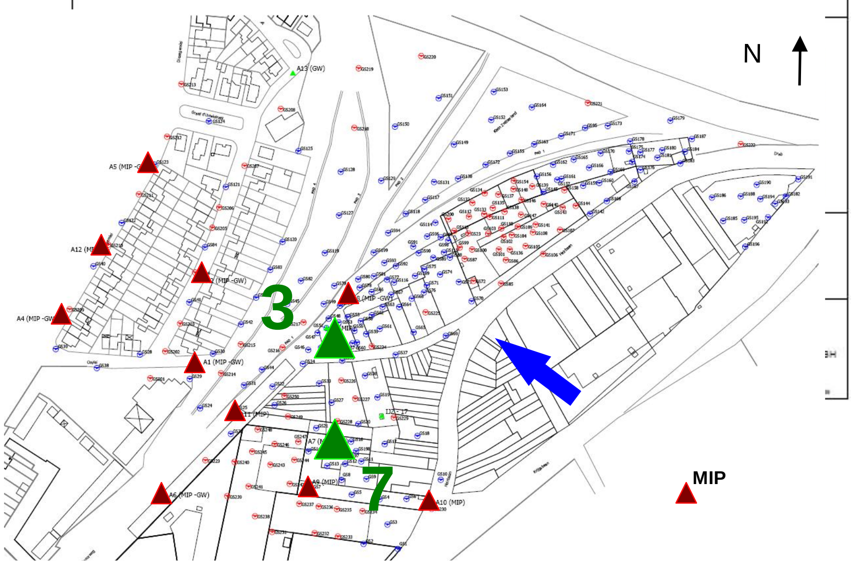
Optimize DNAPL Characterization



MIP and passive soil gas data correlated well







Source Areas

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Optimize DNAPL Characterization

Summary

- Known source zones CVOCs and fuels confirmed and delineated
- New source zones of CVOCs and fuels detected (on- and off-site)
- Extent of impacts in the source zones larger than initially identified
- Potential for free phase product (DNAPL) identified
- Plume width and length larger than initially identified
- DNAPL characterization optimized
  - Combination of passive soil gas and MIPs

Conclusions

Passive soil gas sampling....

- Provides a high resolution, accurate image of subsurface contamination
- Is an accurate, cost-effective, time-saving assessment tool
  - Lower field sampling costs (¢ vs $)
- Overcomes access limitations
- Focuses follow-on intrusive and expensive sampling
- Optimizes Conceptual Site Models, remedial design and long-term site monitoring

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THANK YOU!

W. L. Gore & Associates, Inc. thank

- **CH2M Hill**
- **ERM**

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PCBs – Landfill France

Objective:

- Locate and identify subsurface contaminants
- Focus human health risk assessment (HHRA)

PCBs – Landfill France

Geology

- 0-3m - fill materials
- 3-6m - sandy clay
- > 6m - sandy gravels
- Groundwater 3-5m
- White “paste” encountered 1-3m mixed with fill

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PCBs – Landfill France

Survey Design

- VOCs, SVOCs, PCBs
- ~0.5 hectare site
- 32 GORE™ Modules
  - 17 module subset for PCBs
  - Regular grid ~30m spacing
  - 1-2m depth, slide hammer, tile probe
- ~18-day exposure

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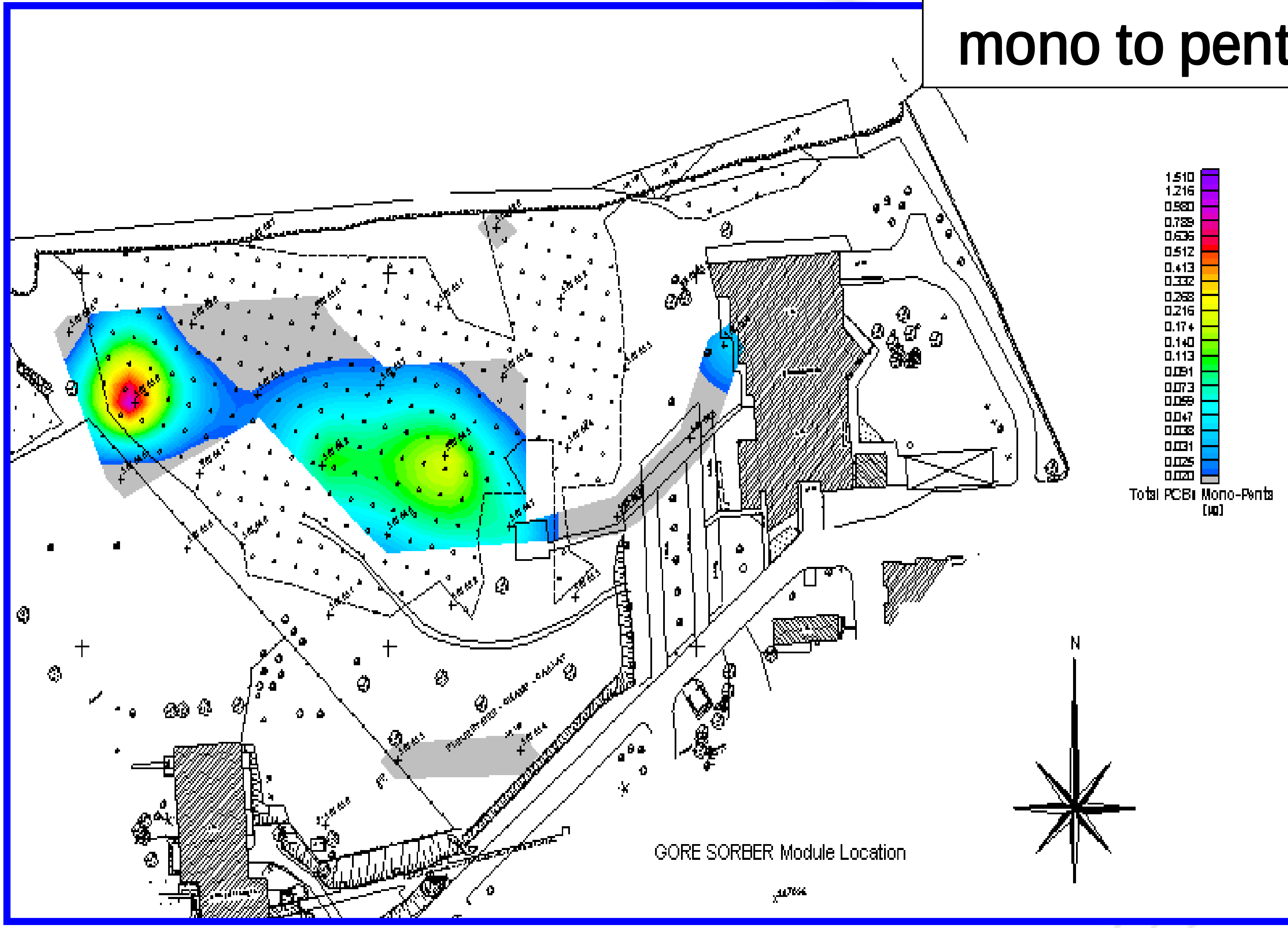
PCBs – Landfill France

Total PCBs – mono to penta



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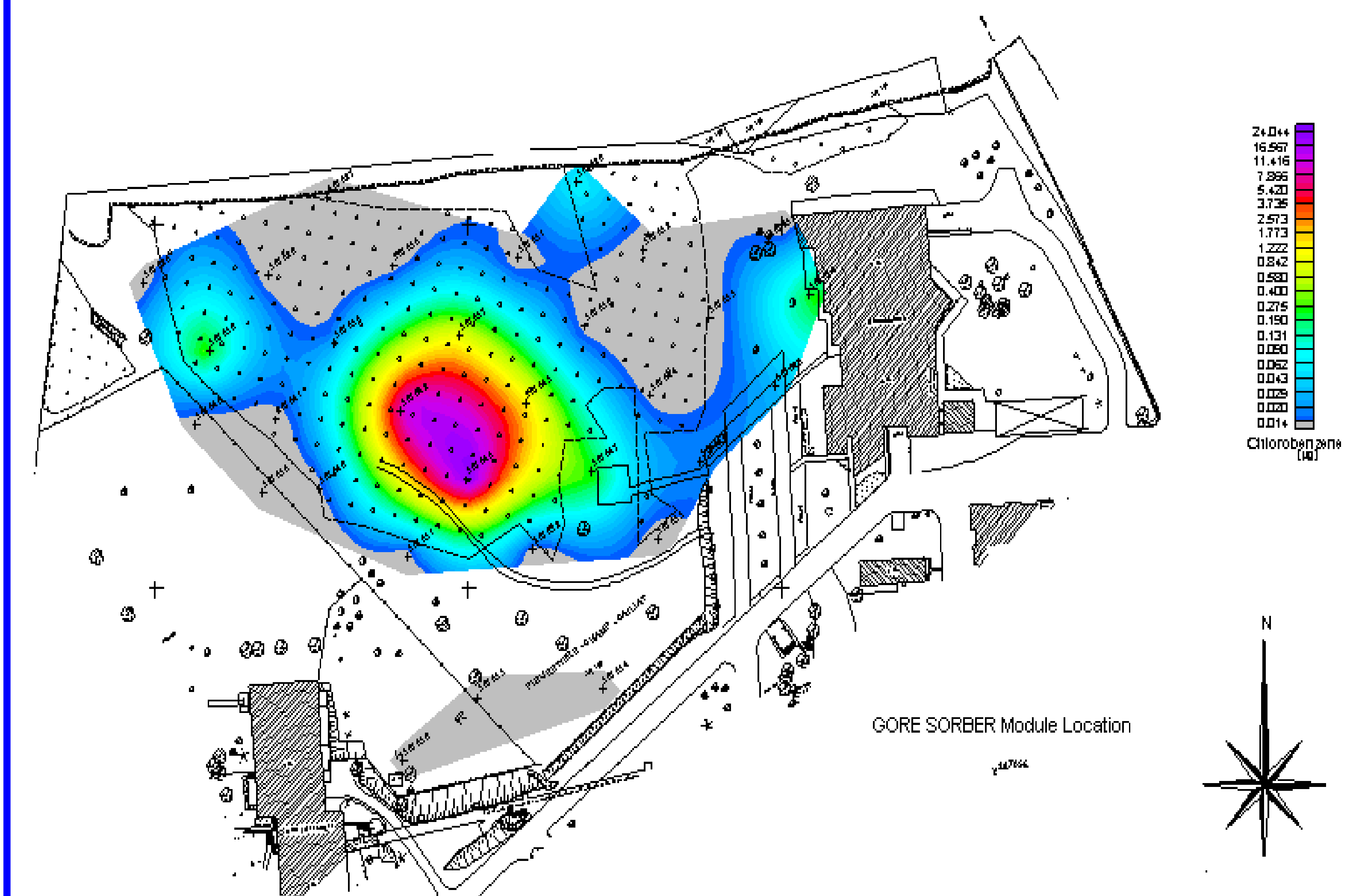
PCBs – Landfill France

Chlorobenzene



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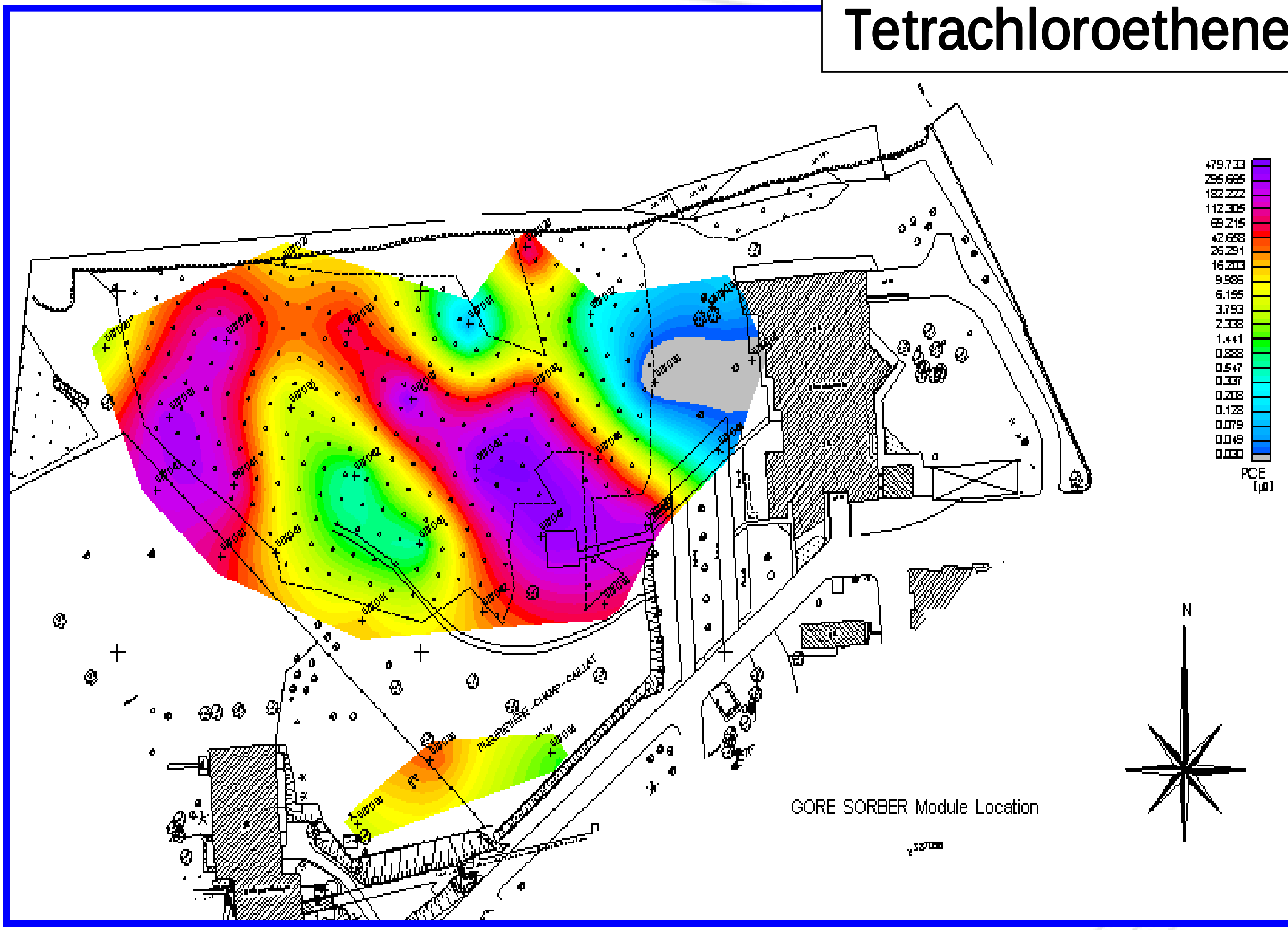
Tetrachloroethene



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PCBs – Landfill France

Survey Results

- Focused subsequent sampling
  - Soil, ground water, vapor flux data
- Reduced overall costs of sampling and analysis
- Guided sample analysis
- Increased accuracy of HHRA