What is HRSC?


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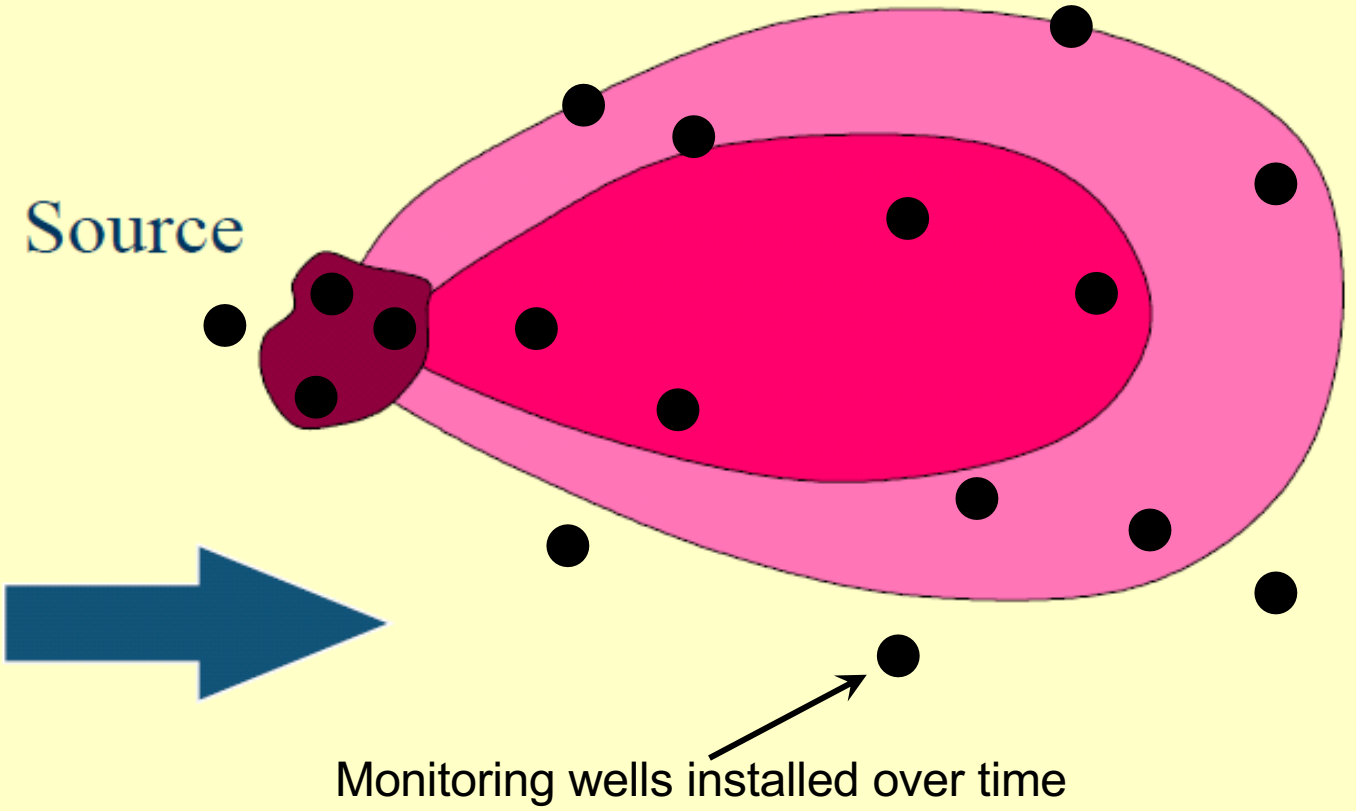
What Type of Investigation is HRSC ?

- **Subsurface investigation appropriate to the scale of heterogeneities in the subsurface which control contaminant distribution, transport and fate, and that provides degree of detail needed to understand:**
  - » Exposure pathways
  - » Processes affecting fate of contaminants
  - » Contaminant mass distribution and flux by phase and by media (mobile and immobile)
  - » How remedial measures will affect the problem

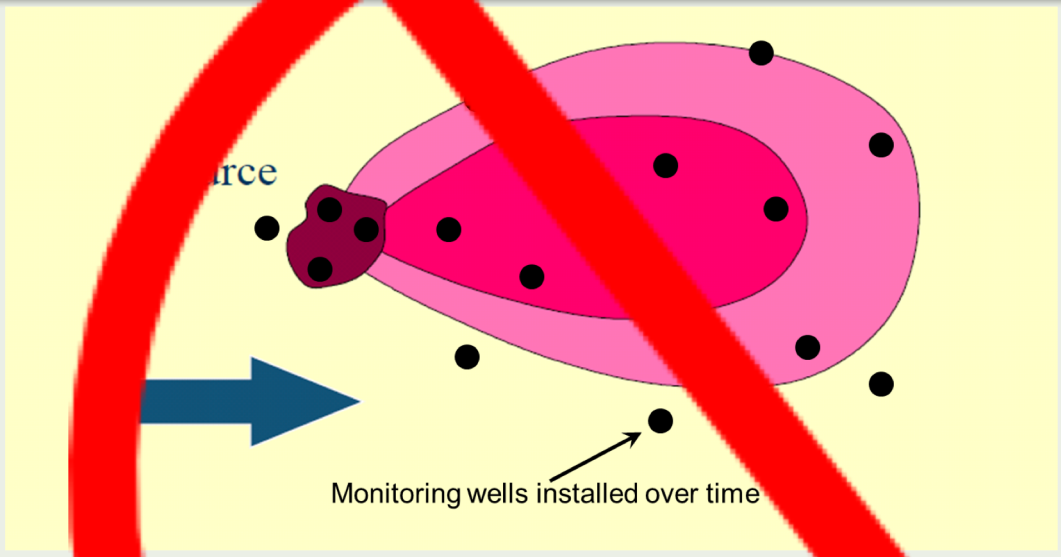
HRSC Addresses "Scale"

Matches the scale of measurement with the scale of the variability of the property being measured

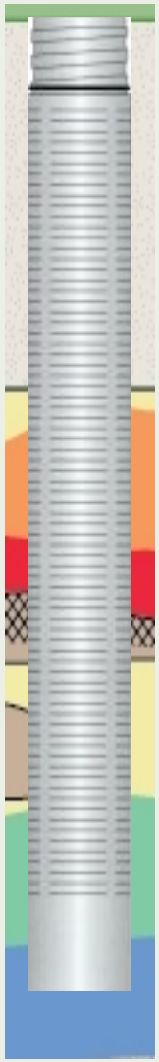
1980's Conception of Plumes



Conventional M[illegible]oring Well Placem[illegible]t Strategy



How "Well" Do You Understand Your Site Conditions?



- **The technology used influences the understanding you develop**
  - » Sample water and it's natural to think you have a water problem
  - » Solubility of non-aqueous compounds is less than 1/10 of 1%
  - » Do you have a water problem in the soil or a soil problem in the water?
  - » Do you have a dissolved phase plume moving with the groundwater (< 0.1%) or a diffusion plume emanating from stationary or sorbed mass (>99.9%)
- **The scale of measurement must be appropriate for the scale of the heterogeneity**
  - » Variability in hydraulic conductivity and sorption capacity
  - » Lenses of silts, clays and peats (nature's filters)
  - » Discrete preferential pathways

How "Well" Do You Understand Your Site Conditions?

- **Conventional monitoring wells are not optimal investigation tools**
  - » Wells yield depth-integrated, flow-weighted average data
  - » Cannot discern small scale heterogeneities controlling contaminant transport in groundwater
  - » Monitoring wells are good for ***monitoring***
- **Monitoring wells have significant life cycle costs**
  - » Routine sampling, analytical, data evaluation, reports
  - » Maintenance, property devaluation, trip/fall hazards

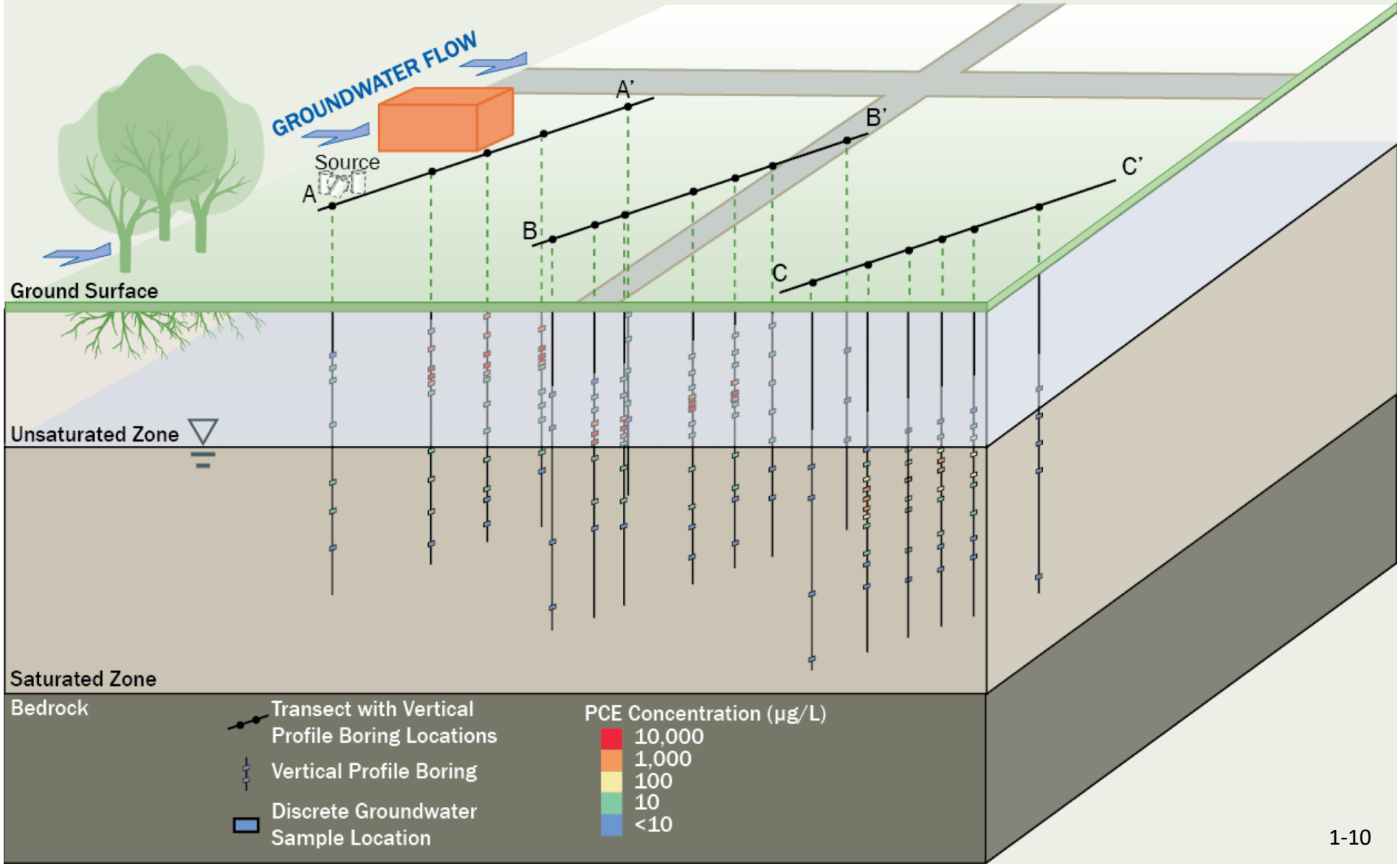
HRSC Addresses Two Critical Issues – Cost Effectively

- **Sampling Scale and Data Averaging**
  - » Measurements must be made at a scale that is meaningful with respect to the variability of the quantity being measured
    - › High percentages of mass released (90% - 99%+)
    - › Often hiding in small footprints and thin lenses
- **Coverage**
  - » Enough measurements at the right locations
    - › Horizontal spacing
    - › Vertical spacing

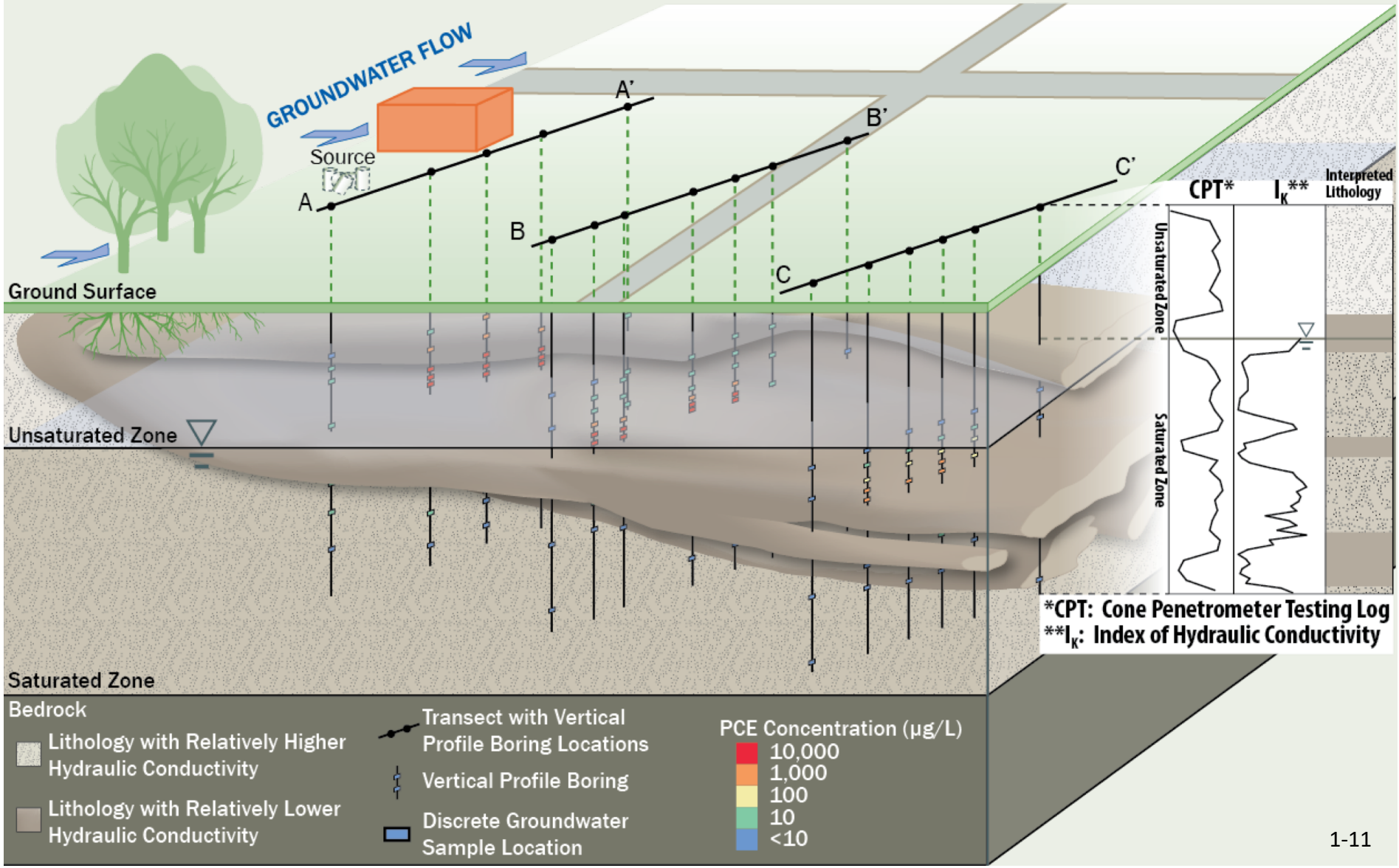
Tools for Obtaining Vertical Profiles in Unconsolidated Environments

- **Qualitative contaminant data:**
  - » MIP – LIF – PID – FID – Immunoassay – Colorimetric
- **Hydrostratigraphic measurements:**
  - » Electrical conductivity meter – Cone penetrometer – Hydraulic profiling tool
- **Soil coring:**
  - » Direct push – Sonic – Auger and Rotary
- **Direct push groundwater sampling devices:**
  - » Various grab sample devices
- **Quantitative contaminant data:**
  - » Mobile laboratory – Fixed laboratory

Step 1 – High-confidence spatial distribution of COCs



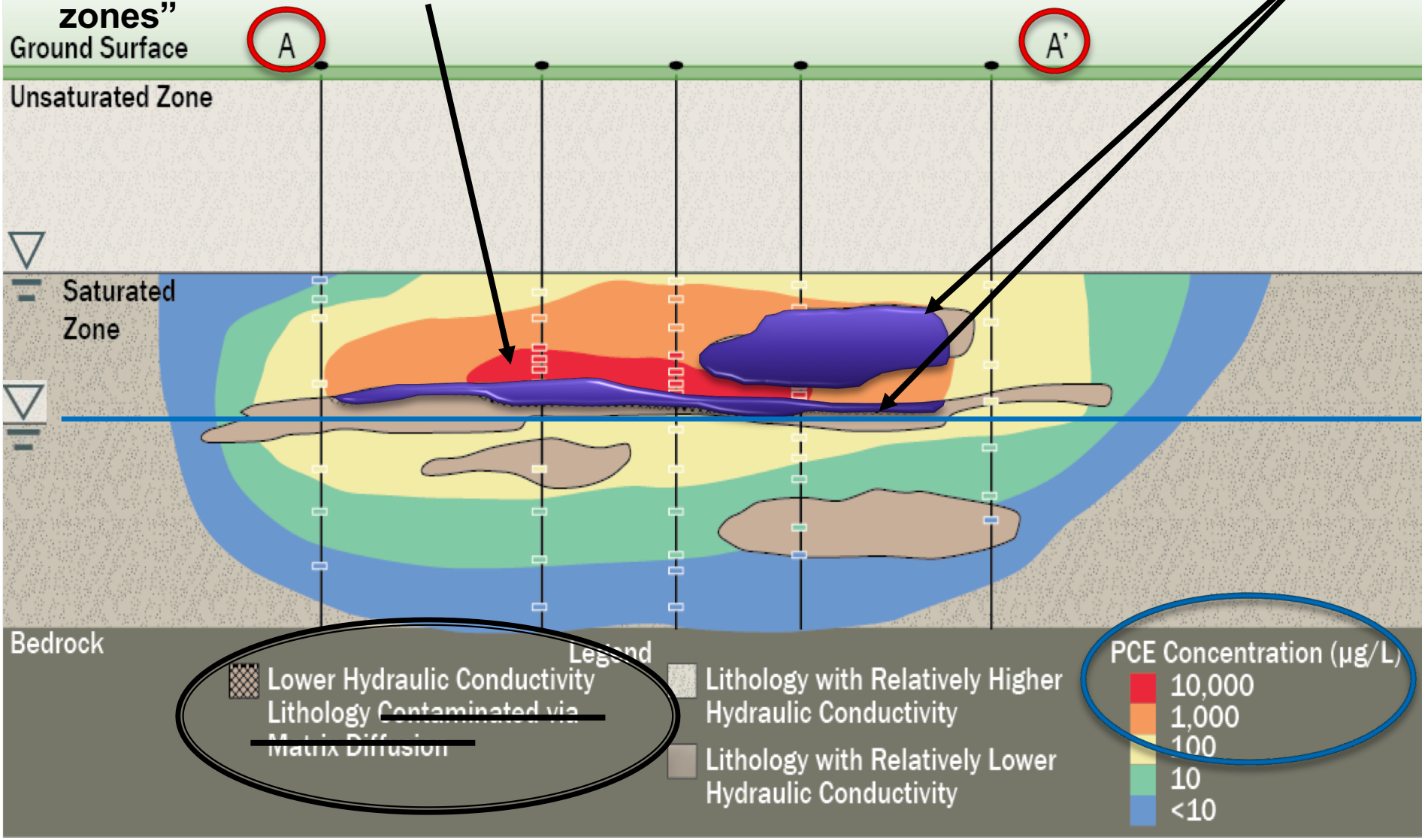
Step 2 – High-confidence matrix distribution of COCs



An HRSC Aha Moment – Root Causes vs. Symptoms

HRSC often indicates high mass resides in low-permeability "storage zones"

Matrix diffusion is out of storage zones and into higher permeability "transport zones"



Why HRSC?

What are the Benefits of HRSC?

- **Overall cost and time savings:**
  - **Differentiates root causes from symptoms**
  - Provides real-time results to guide the investigation
  - Reduces data gaps and remobilizations
  - Enables targeted sampling and monitoring locations
  - Reduces lifecycle analytical and reporting costs
  - Enables targeted remedial footprints
  - Increases remedial efficiency
  - **Reduces overall lifecycle costs and project durations**

HRSC Cost-Effectiveness

- **Do it right once**
  - » Fast and accurate characterization
  - » Selection of appropriate remedy
  - » Effective remedial design
  - » Targeted and efficient remedial action
  - » Optimized long-term actions and monitoring
- **HRSC facilitates use of targeted remedies**
  - » *In situ* actions such as chemical oxidation, resistive heating and bioremediation
  - » *Ex situ* actions such as pump and treat

An HRSC Aha Moment – Root Causes vs. Symptoms

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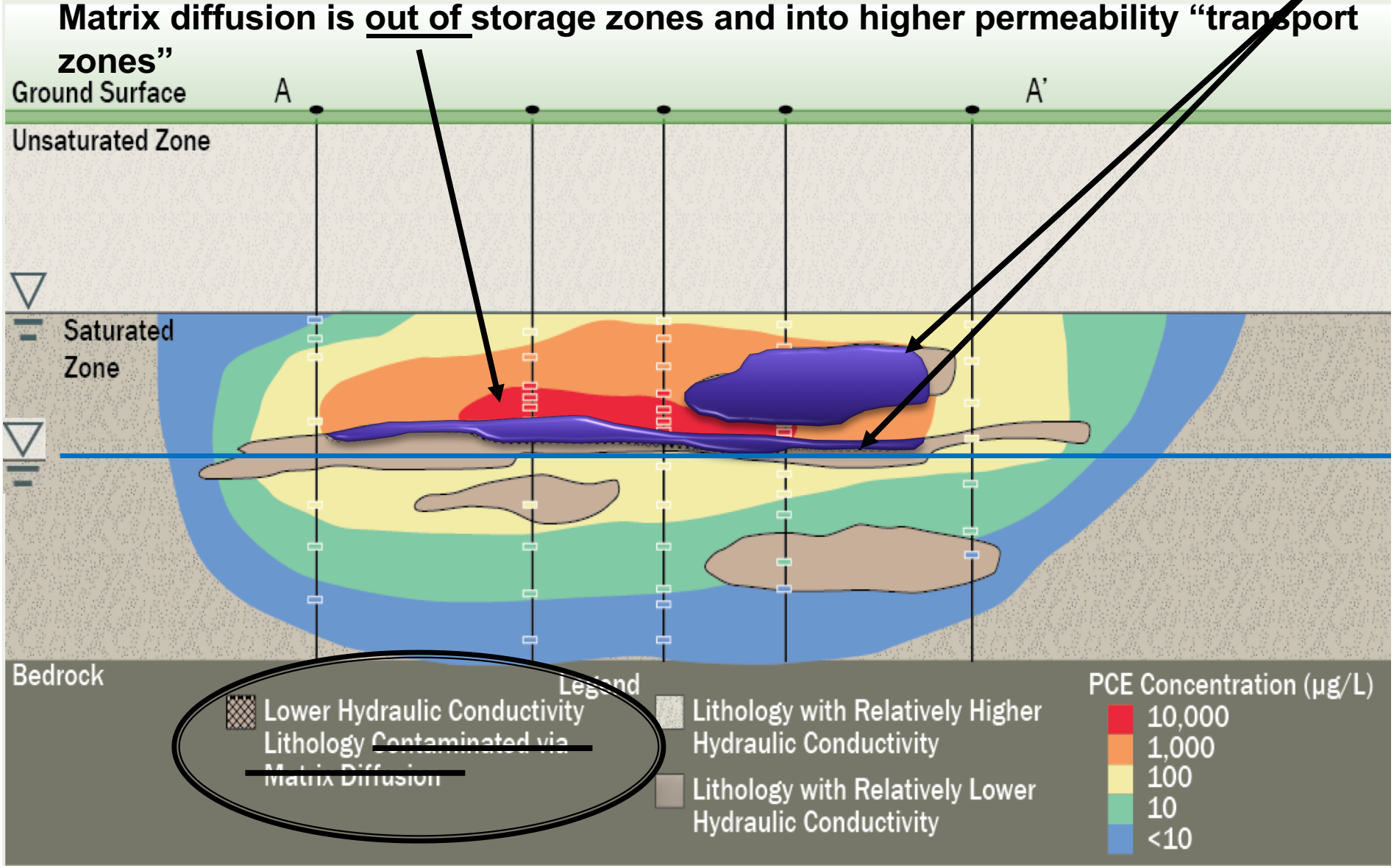


Cost of Remedies vs. Cost of Characterization

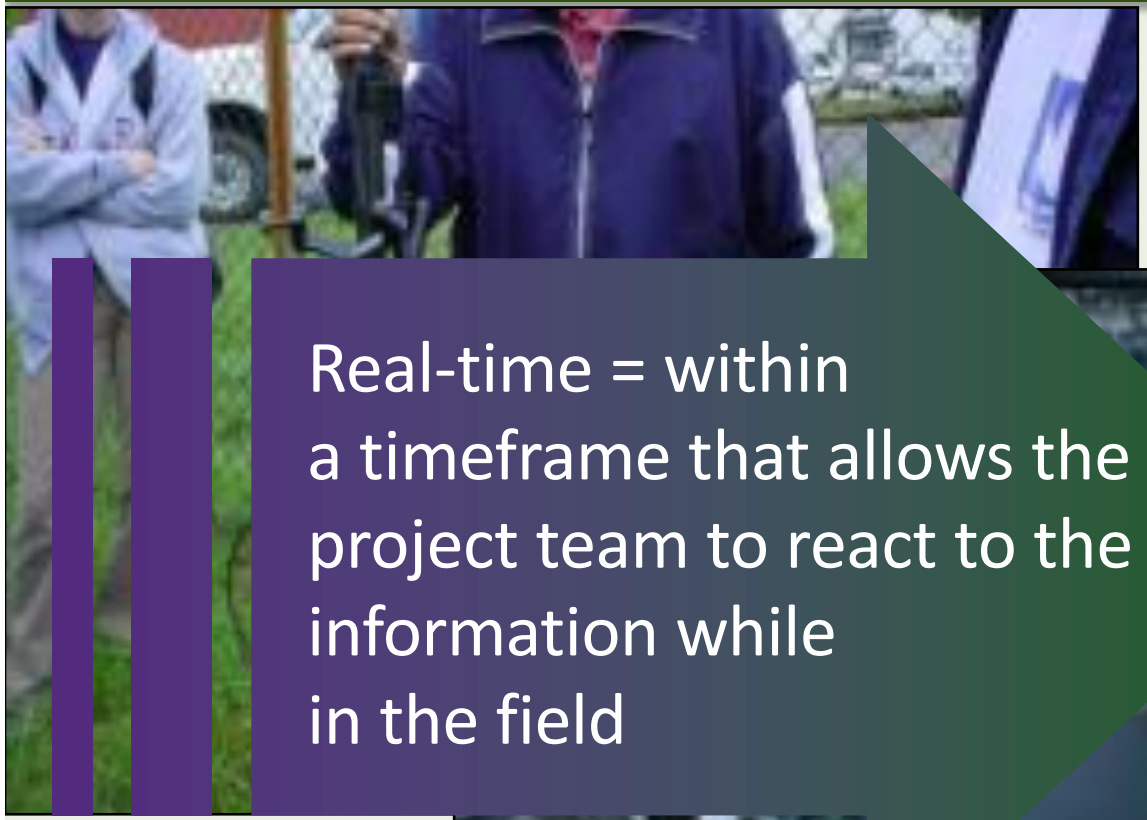
- **Remedies based on a flawed CSM may not perform as expected, increasing the time it takes to achieve remedial action objectives, and the overall cost**
- **HRSC makes the investment upfront to obtain a more complete and realistic CSM**
- **Pay a little more now to avoid paying a lot more later**
  - » Until the CSM reflects reality, investigation and cleanup will be costly – pay the costs upfront and get the CSM right the first time in order to avoid paying more later

How is HRSC Implemented?

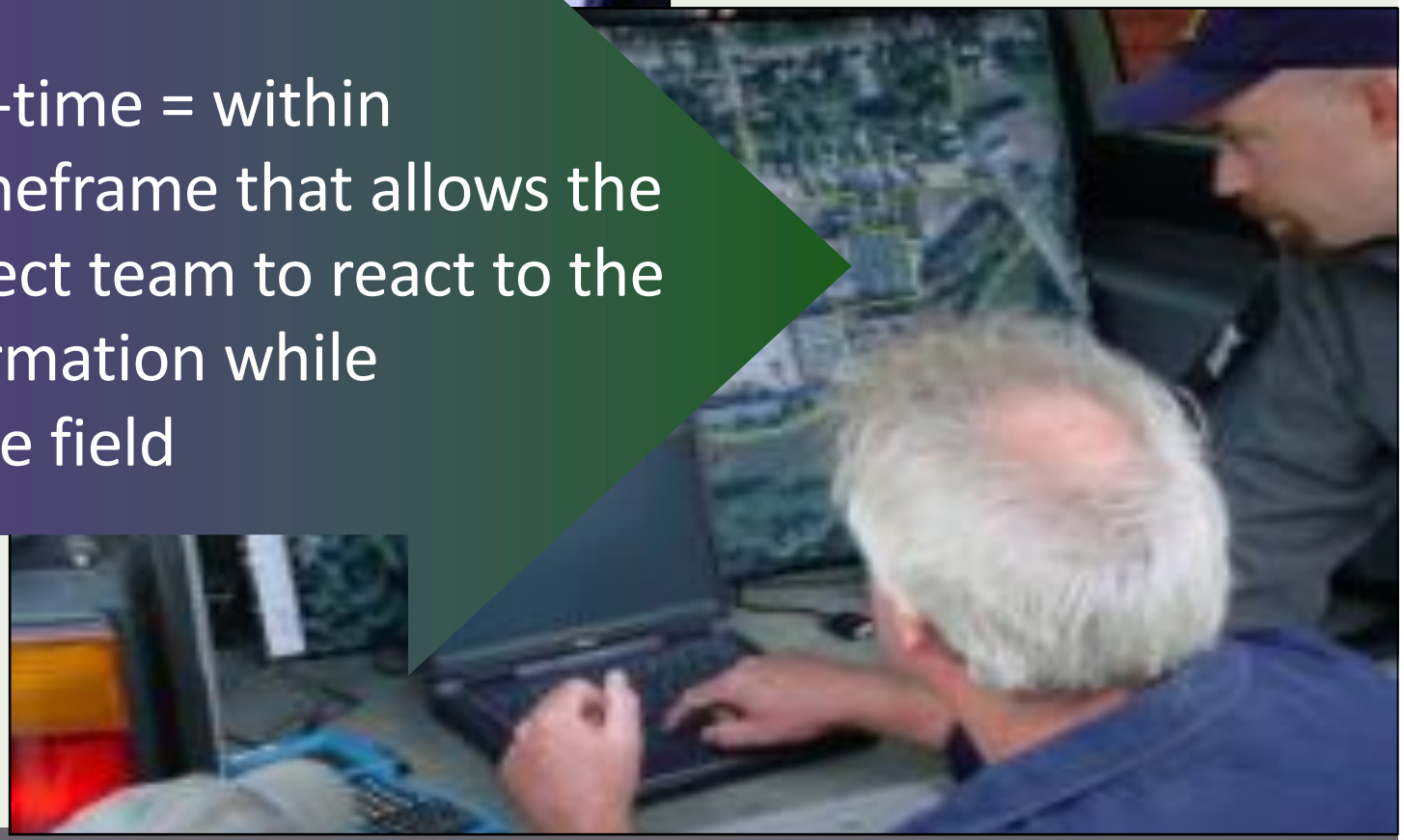
Dynamic Approaches to Site Characterization?

- **Uses streamlined work plans with decision logic diagrams**
- **Sequences activities based on decisions to be made and a continuously updated CSM**
- **Generates collaborative data sets for multiple lines of evidence and controls uncertainties**
- **Provides real-time data management and communication**
- **Considers potential remedies and reuse**

What is Meant by "Real-Time?"



Real-time = within
a timeframe that allows the
project team to react to the
information while
in the field



How Is HRSC Data Collection Different?

- **Provides a greater density of measurements**
- **Uses collaborative data sets**
- **Employs strict field QA/QC**
  - » Maximize usefulness of data
  - » Target confirmatory or collaborative sample analysis where needed
- **Often uses field-based action levels or response factors with a margin of safety**
- **Uses real-time data management and communication strategies**
  - » High volume of data gathered to capture, process, format for stakeholder decision-making

In Review

- **What**
  - HRSC is a methodology for understanding and properly accounting for the affects of subsurface heterogeneity
  - HRSC uses scale-appropriate measurements and sample spacing consistent with the scale of variability of the property being measured
- **Why**
  - Better defined mass distribution – spatial and matrix distribution
  - More realistic, intuitive and useful CSM
  - Targeted and more efficient remedies
- **How**
  - High-density vertical profiling to account for heterogeneity
  - Dense horizontal transects to reduce interpolation and extrapolation error
  - Direct sensing technologies to enable real-time decision-making

Credits and Contact Information

- **Much of the information in this presentation comes from the two-day HRSC course developed and taught by US EPA, Office of Superfund Remediation and Technology Innovation (OSRTI)**

- **Contact Information:**

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US EPA, Environmental Response Team

OSRTI, Technical Innovation and Field Services Division

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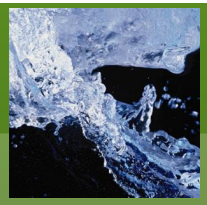
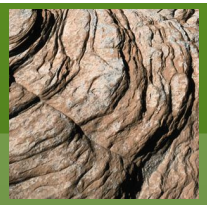
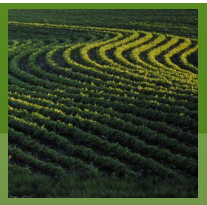
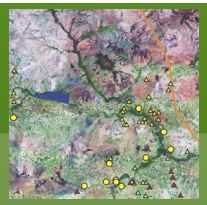
732-735-5822

Questions?

Data Use and Management

EPA United States Environmental Protection Agency

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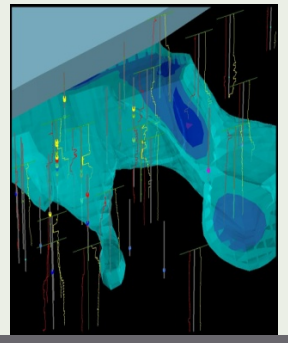
Overview

- **Maximizing the use of existing data**
- **Obtaining direct sensing data through HRSC**
- **Visualizing and interpreting the data**
- **Collaborating in real time with project stakeholders**
- **Decision-making in real time – data gaps and next actions**



Historical Information Compilation and Evaluation

- **Develop Preliminary CSM**
  - Geologic, hydrogeologic, and analytical data
  - Media of interest, contaminants of concern (COC)
  - "Think like a chemical"

- **Begin with the End in Mind**
  - Identify viable technologies for COCs, impacted media and geologic matrix
  - Identify factors critical to success of each technology (feasibility study data needs)
  - Ensure HRSC scale is commensurate with practical aspects of viable remediation technologies

Historical Information Compilation and Evaluation

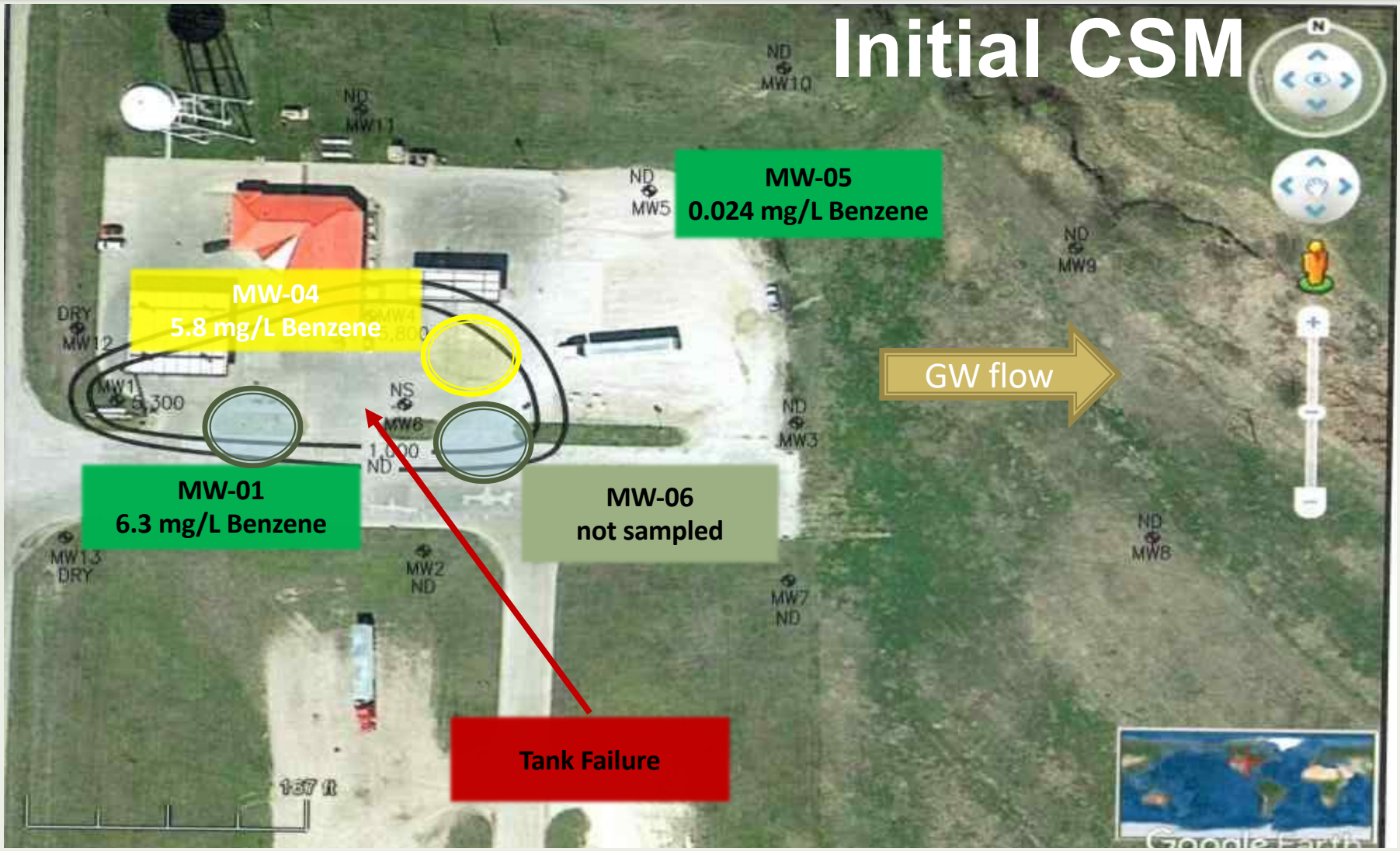
- **Review existing site investigation work plans, reports, data**
  - » Effectively support decision-making (Rumsfeld Principle)?
  - » Data type and quality, measurement scale vs. heterogeneity?
- **Evaluate historical and regional information**
  - » Facility operations, online data reports, aerial photos
  - » USGS topographic maps, meteorological data
  - » Nearby sites, wells, borings

"As we know, there are known knowns. There are things we know we know. We also know there are known unknowns. That is to say we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know."

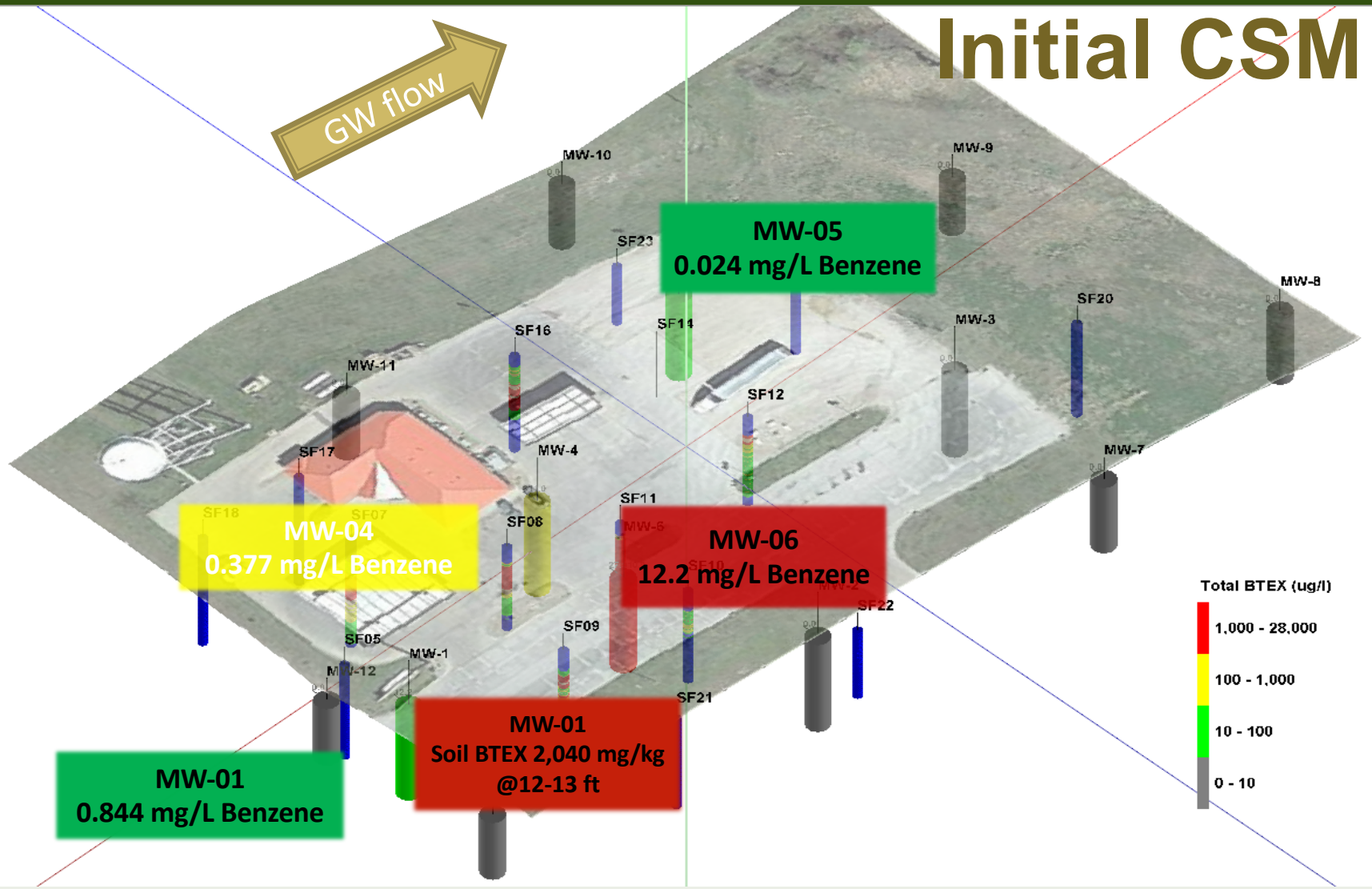
Donald Rumsfeld,

Feb. 12, 2002
U.S. Department of Defense

What is known/unknown? What do we need to know?



What is known/unknown? What do we still need to know?



Things we need to know -- Migration/Receptor Issues

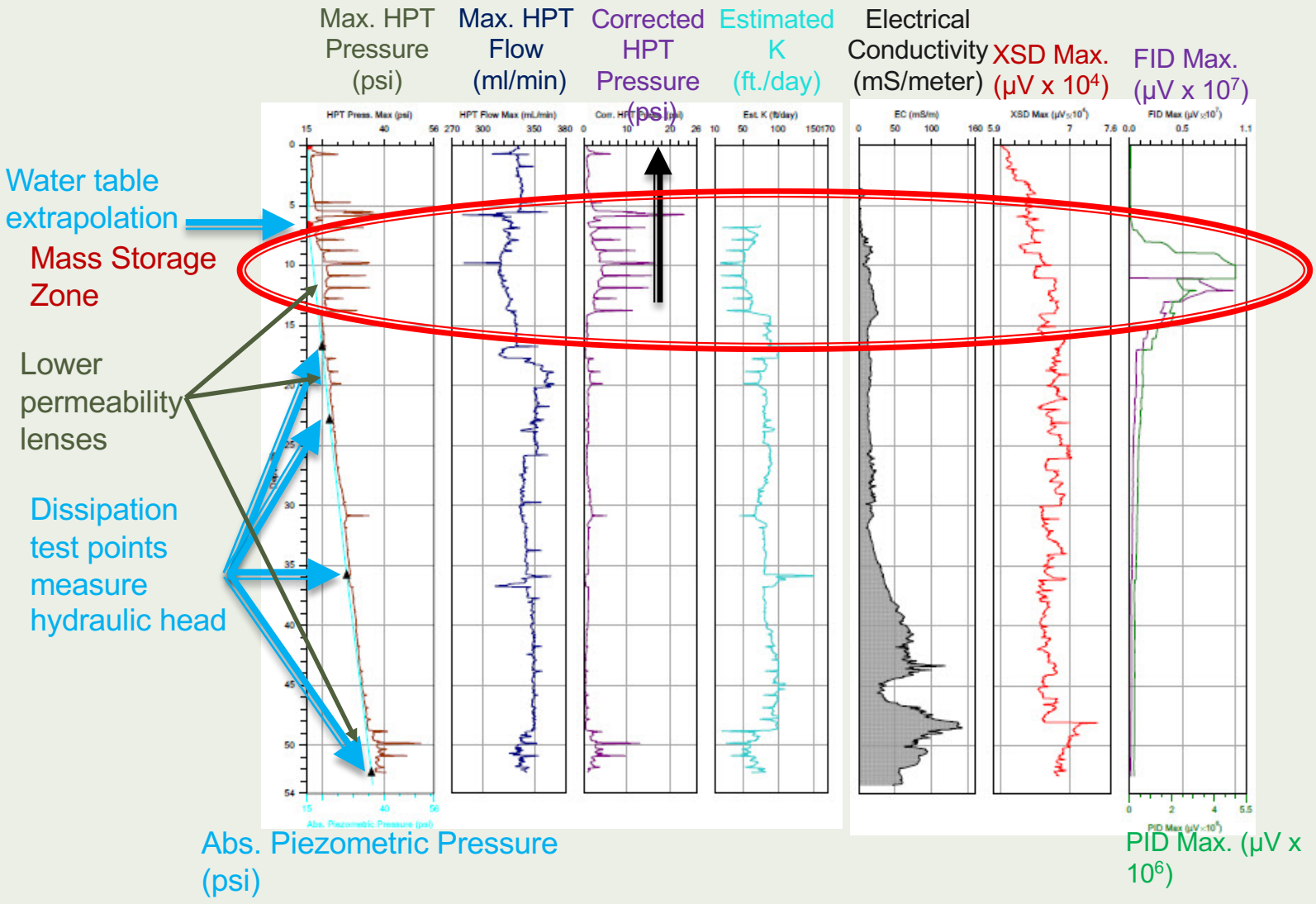
- **Vapor sources**
  - Pathways
  - Capture zones
- **LNAPL**
  - Where is it
  - Path to groundwater
  - Adsorption/absorption lens
  - Preferential pathways (natural and man-made)
- **Groundwater impact**
  - Hydraulic conductivity zones (transport zones)
  - Direction, flux and potential capture/treatment zones
  - Mass storage zones (future matrix diffusion sources)

Things we need to know -- Remediation Evaluation Needs

- **Mass distribution**
  - » Percentages, orders of magnitude, not ppb and ppm
  - » Spatial distribution – remediation footprints
  - » Matrix distribution – effective technologies

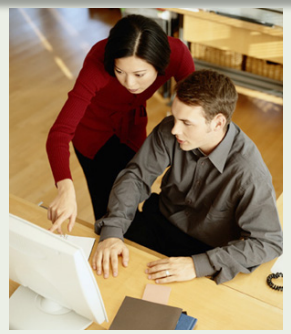
- **Capture zones**
  - » Cut-off trench, skimmer pumps, adsorption zones
- **Treatment zones**
  - » Contact, residence time, appropriate conditions
- **Mass transfer zones**
  - » Contact, appropriate conditions, driving forces, capture zones
- **Containment/immobilization**

What if we put in a transect of borings, each of which tells us all of this?



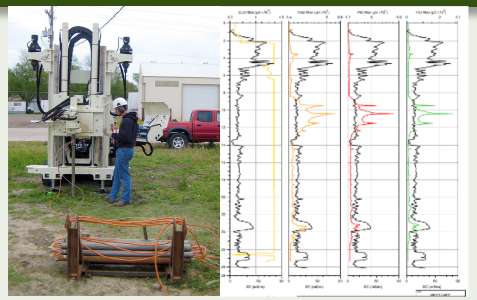
The practical realities placing boring transects across gas station sites

Real-Time Collaboration Process



Project team determines next boring locations

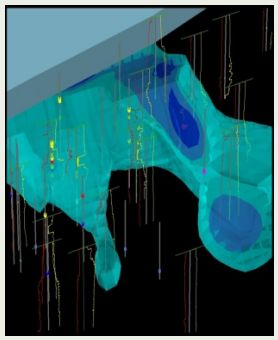
Data collected by direct sensing field team



End of day upload of raw data to shared database

Evening download by data vis. team

Morning upload of data visualization to SharePoint site



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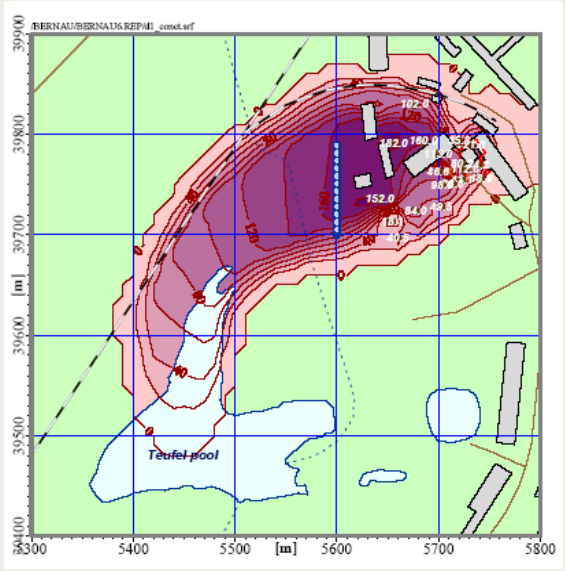
Data Management, Assessment, and Visualization Process

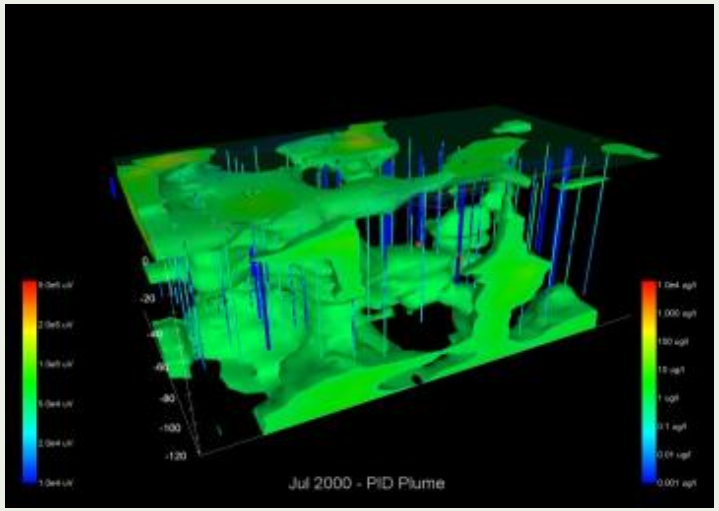
- **Tool Export Format**
  - » Database Programs with Real-Time QC
- **Visualization and Decision Support Tools**
  - » 3- and 4-D mapping
  - » Dense 2-D cross-section transects
- **Interpretation**
  - » Communication
  - » Decision-Making

Data Visualization Tools

- **Tools are available for visualizing and evaluating subsurface data in 2-D and 3-D**

Typical 2-D map of plume based on 7 wells

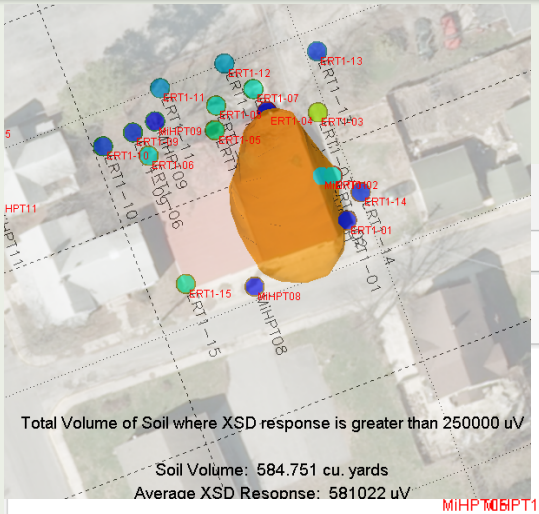




3-D plume visualization based on over 50 sampling locations

- **Is it flowing or is it sorbed?**
- **Where is the mass?**
- **Which gives more accurate remediation footprints?**

Data Visualization Tools



MVS Data Visualization
"Root Cause" Plume Core

MIP-XSD_Volumetric_Analysis_CSM2016b.4dm - 4DIM Player

Current State: 5 of 7 FPS Target: 15.00

Playback

Author: Jason C. Ruf
Organization: S2C2 Inc.
Description: This 4Dim is an attachment t...

File Info

Vertical Exaggeration = 2X

Mass Storage Zone

Geologic Interp
Sand
Clay
Silt and Clay
Clay Lenses

Corr. HPT Pressure
100 psi
88 psi
75 psi
63 psi
51 psi
38 psi
26 psi
13 psi
1 psi

Baseline Corr. XSD
2,000,000 uV
1,000,000 uV
100,000 uV
30,000 uV
10,000 uV
3,000 uV
1,000 uV
500 uV

Total Volume of Soil where XSD response is greater than 250000 uV

Soil Volume: 584.751 cu. yards
Average XSD Resopnse: 581022 uV

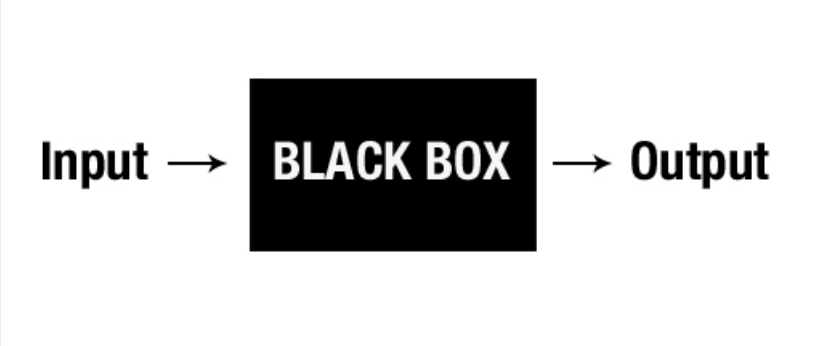
290,400
290,600

NOTES:
Data visualization completed by S2C2
and Data Visualization for the Delmar
Superfund Site, Delmar, Maryland Re

EPA

Understanding Limitations on 3D Interpolations

- **Need to use constraining points to make image conform to user's belief in what image should be**
- **May be difficult for user to check validity of interpolation**
- **Potential for a degree of "black box" operation**
- **Potential danger of outputting "garbage" unless operators are sophisticated and experienced**



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