Site Characterization for Improved Remediation

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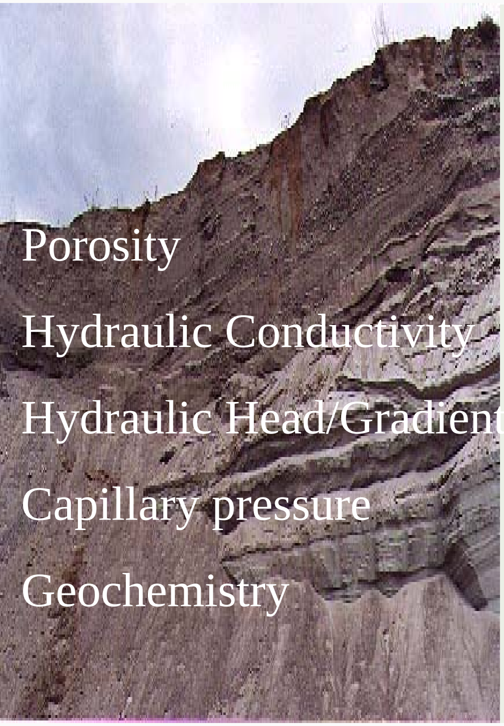
Recent Experience Leads to New Thinking

Optimization and Technical Support → Identify challenges and opportunities

Good characterization- series of best practices → A set of methods or techniques found to be the most effective and practical means in achieving an objective while making the optimum use of resources



- **Historical perspective**
  - Soil- EPA Superfund has historically focused on high quality analytical samples collected at discrete soil locations
  - Groundwater- EPA has historically used monitoring wells, pump tests, etc. to characterize and monitor sites
- **Challenges encountered**
  - Discrete soil sampling designs do not address matrix variability/heterogeneity- resulting in highly variable or statistically uncertain decision making
  - Large scale averages of aquifer materials obscure primary contaminant transport and mass storage areas
- **New thinking**
  - Soil- Incremental and composite techniques that provide large scale averages are better suited to represent exposure scenarios, control matrix variability/ sample heterogeneity, and make statistically confident decisions
  - Groundwater- large scale averages derived from aquifer materials can be misleading resulting in poorly performing or applied remedies. HRSC techniques provide measurements at scales more appropriate for remedy design.



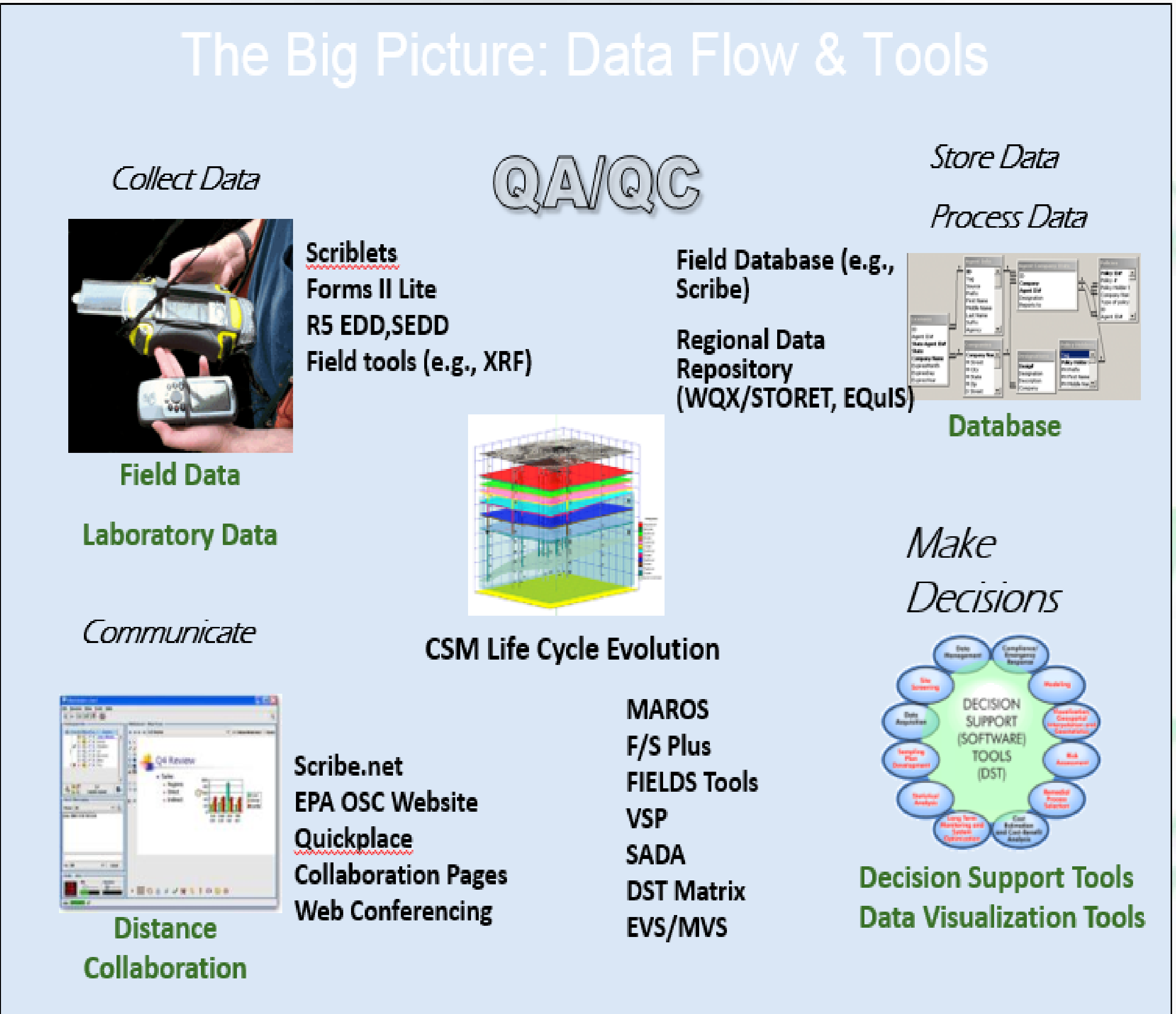

Recent Successes Highlight Focus Areas

Comprehensive team formation	Adaptive site management	Project life cycle CSM	Stakeholder outreach
Systematic planning	Dynamic work strategies	Real-time measurement technologies	Demonstration of method applicability
High resolution collaborative data	3-D visualization and analysis	Data management and communication	Optimization

- **Data management**
  - Historically reports as mechanism to exchange information, now data as deliverable, active data management
  - Data warehouse, data interoperability, economies of scale
- **High Resolution Site Characterization**
  - Direct sensing tools, scale appropriate measurements
  - Collaborative data approaches
- **Real-time data visualization**
  - Conceptual Site Model (CSM) lifecycle management

Data Management is Key

Plans required- Region, Site, Project



- **Data acquisition**
  - Occurs quickly, involves large amounts of data
  - Data must be integrated into CSM quickly to inform continued data acquisition while mobilized
- **Data input**
  - Automatic/manual systems to QC at point of generation accurately transfer to databases
- **Decision Support**
  - Statistical, visualization, modeling
- **Communicate**
  - Force interpretation, compress timeframes

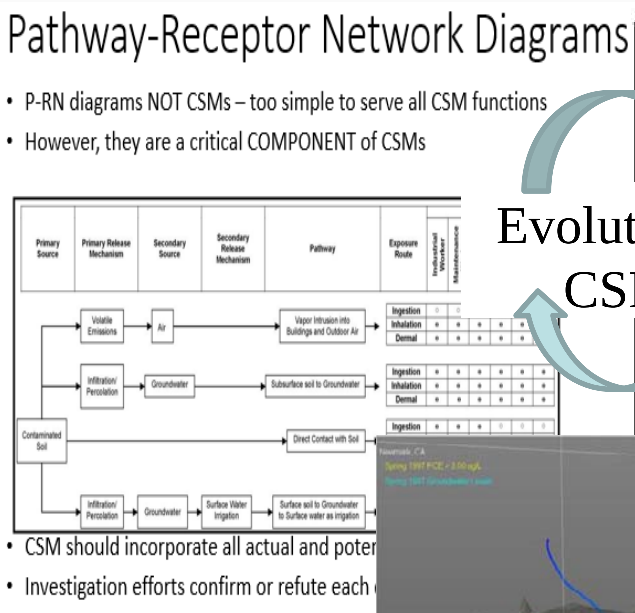
Data Management Leads to A Robust Conceptual Site Model

"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."

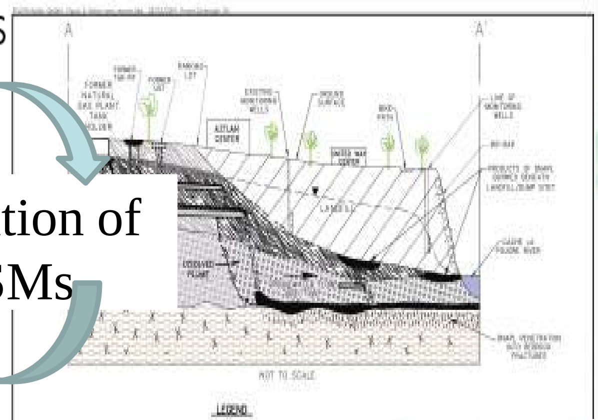
Donald Rumsfeld,

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

1980's—1990s

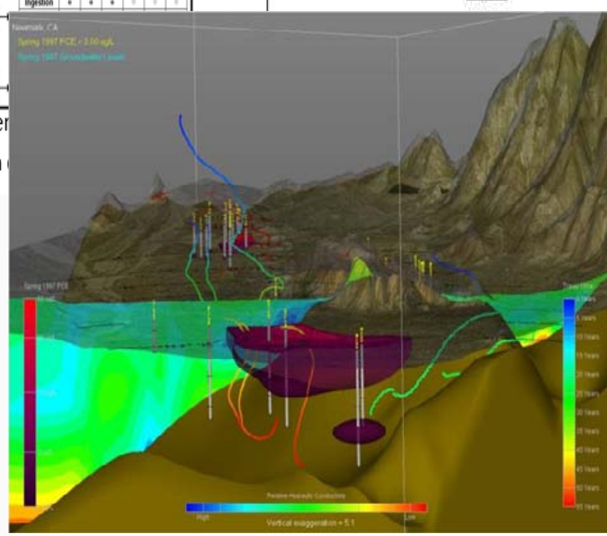


2000's



Evolution of CSMs

2010 to present



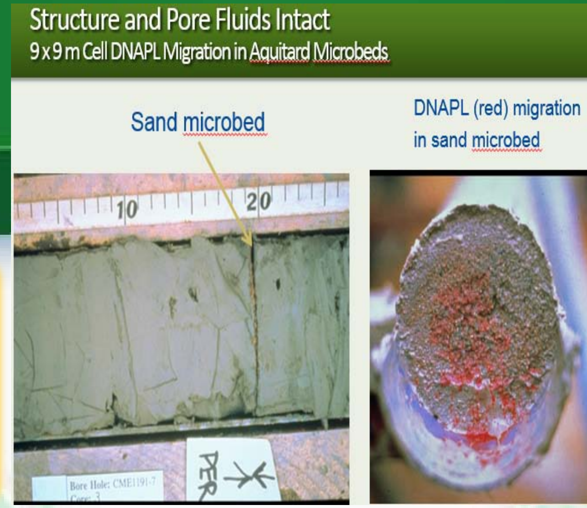
General Environmental Cleanup Steps	CSM Life Cycle	Best Management Practices SPP / DWS/RTMT	CERCLA - Superfund	RCRA	Brownfields	UST	VCUP Varies by State	IRP/ERP	MMRP
Site Assessment	Preliminary CSM → Baseline CSM (Conceptual)		Preliminary Assessment (PA) Site Inspection (SI) National Priorities List (NPL) No Further Remedial Action Planned (NFRAP)	Facility Assessment (RFA)	Phase I Environmental Site Assessment (ESA)	Initial Site Characterization Initial Response	PA SI	PA SI	PA SI MR Site Prioritization Protocol (MRSPP)
Site Investigation and Alternatives Evaluation	Characterization CSM Stage		Remedial Investigation/ Feasibility Study (RI/FS) Removal Actions - Emergency/ Time Critical/Non-Time-Critical	Facility Investigation (RFI) Corrective Measures Study (CMS)	Phase II ESA	SI Corrective Action Plan (CAP)	RI/FS	RI/FS NFRAP	RI/FS
Remedy Selection	Design CSM Stage		Proposed Plan Record of Decision (ROD)	Statement of Basis (SB) Final Decision and Response to Comments	Remedial Action Plan (RAP)	Cleanup Selection	ROD	Proposed Plan ROD	Remedy Selection
Remedy Implementation	Remediation/ Mitigation CSM Stage		Remedial Design (RD) Remedial Action (RA) – Interim and Final	Corrective Measure Implementation (CMI)	Cleanup and Development	Corrective Action - Low-impact site cleanup - Risk-based remediation - Generic remedies - Soil matrix cleanup	RD RA	RD RA – Interim and Final Remedy in Place (RIP)	RD Time Critical Removal Action (TCRA) RA RIP
Post-Construction Activities	Post-Remedy CSM Stage		Operational & Functional Period Operation & Maintenance (O&M) Long term monitoring (LTM) Optimization Long Term Response Action (Fund-lead groundwater/surface water restoration)	O&M On-site inspections and oversight	Property Management Long-term O&M Redevelopment Activities (Private- and Public-led)	LTM	O&M LTM	Shakedown period Operating Property and Successfully O&M LTM	Shakedown period Long Term Management
Site Completion	(Quantitative)		Construction Complete (CC) Preliminary or Final Close Out Report (PCOR/FCOR) Site Completion - FCOR Site Deletion O&M as appropriate	Certification of Completion Corrective Action Complete with Controls or without Controls	CC Property Management	No Further Action (NFA)	CC	Response Complete (RC) NFA	RC NFA

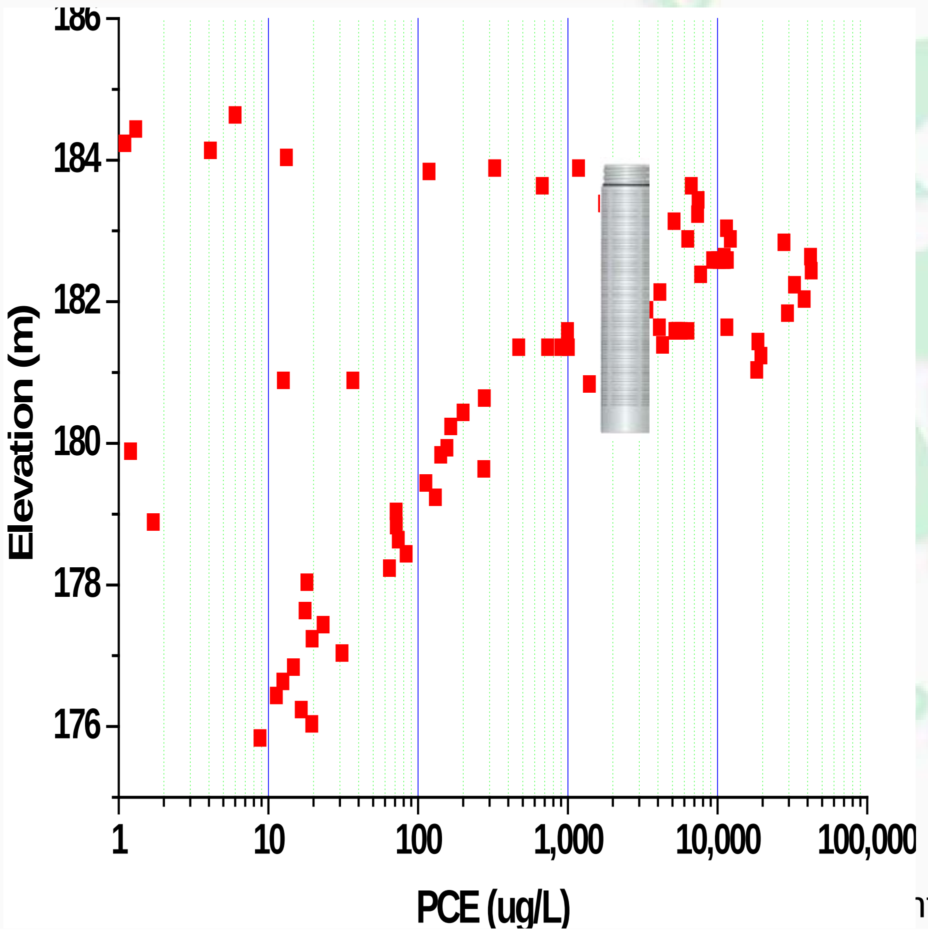
Abbreviations:
SPP = Systematic Project Planning
DWS = Dynamic Work Strategies
RTMT = Real Time Measurement Technologies
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
RCRA = Resource Conservation and Recovery Act
UST = Underground Storage Tanks
VCUP = Voluntarily Clean Up Programs
IRP/ERP = Installation Restoration Program/ Environmental Restoration Program
MMRP = Military Munitions Response Program

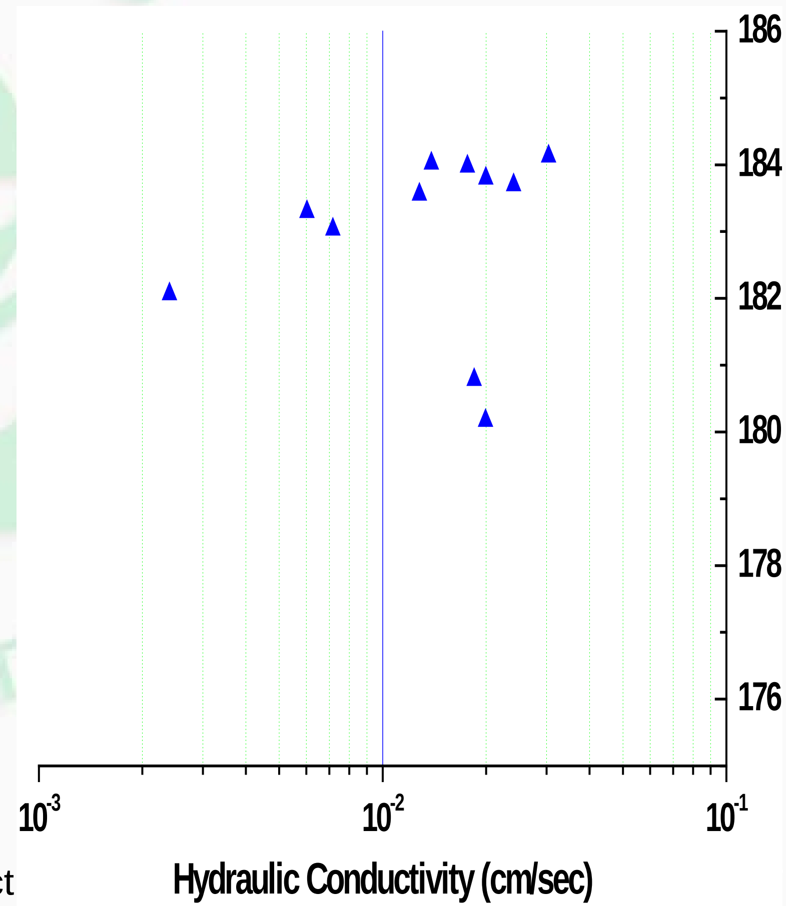
Environmental Cleanup Best Management Practices: Effective Use Of The Project Life Cycle Conceptual Site Model. EPA 542-F-11-011

Sampling Scale and Averaging

Monitoring wells yield a depth integrated flow weighted average

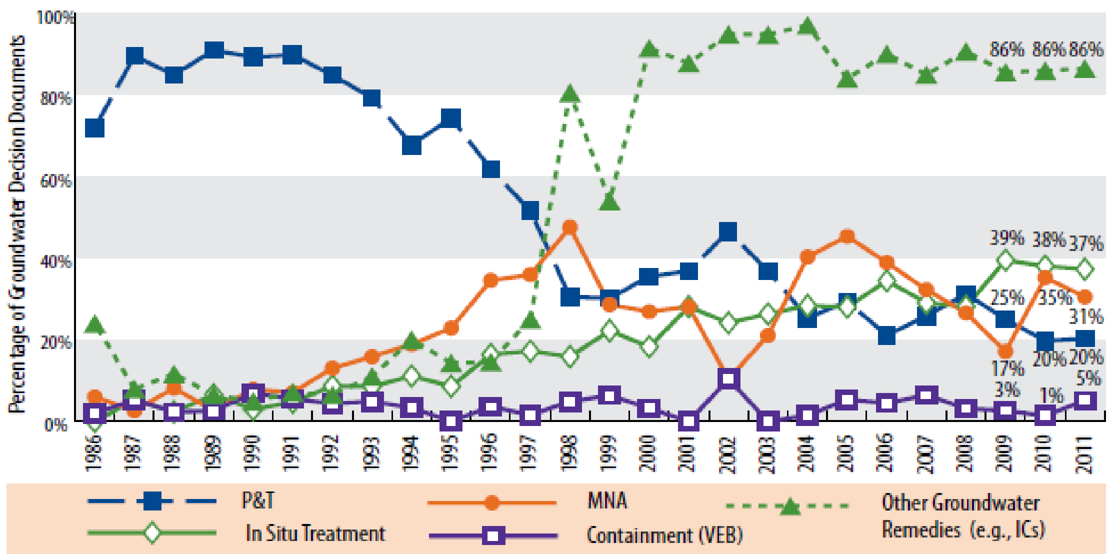






Mass Flux Distribution-
The Rise of In-Situ Remedies

Figure 11: Selection Trends for Groundwater Remedies (FY 1986-2011)



Superfund Remedy Report 14th edition

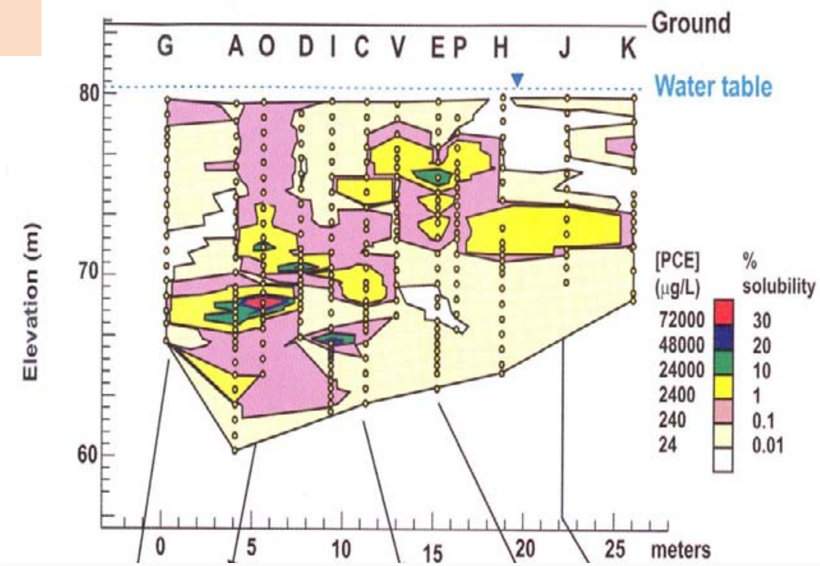
- 1980's- Pump and Treat 90% of GW remedies, no in-situ remedies
- 2011- Pump and Treat 30%, In-situ almost 40%

Guilbeault et al., 2005

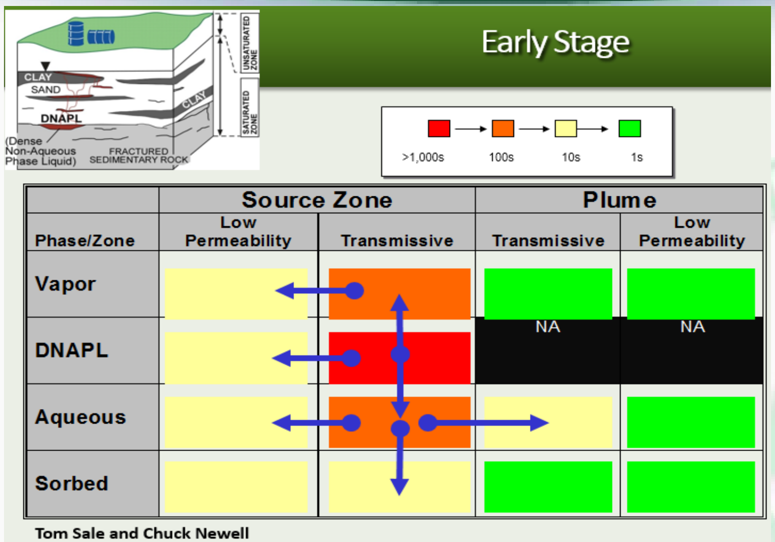
75% of mass discharge occurs through 5% to 10% of the plume cross sectional area

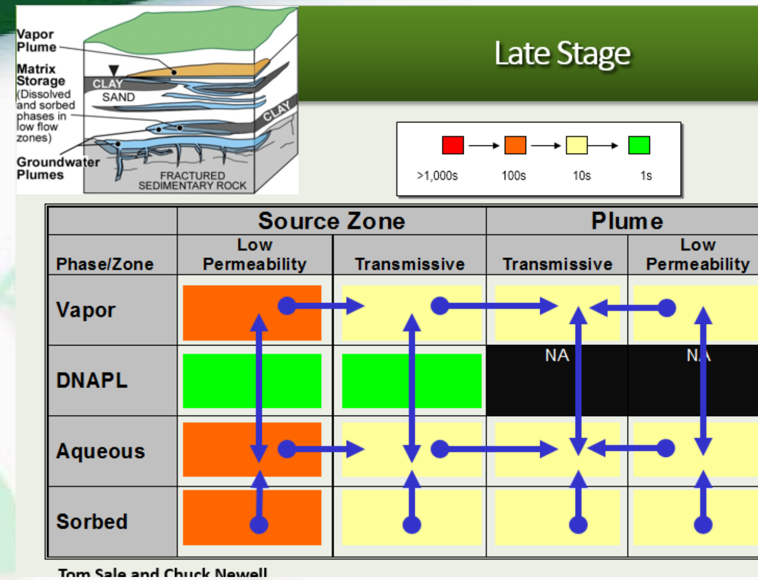
Optimal Spacing is ~0.5 m

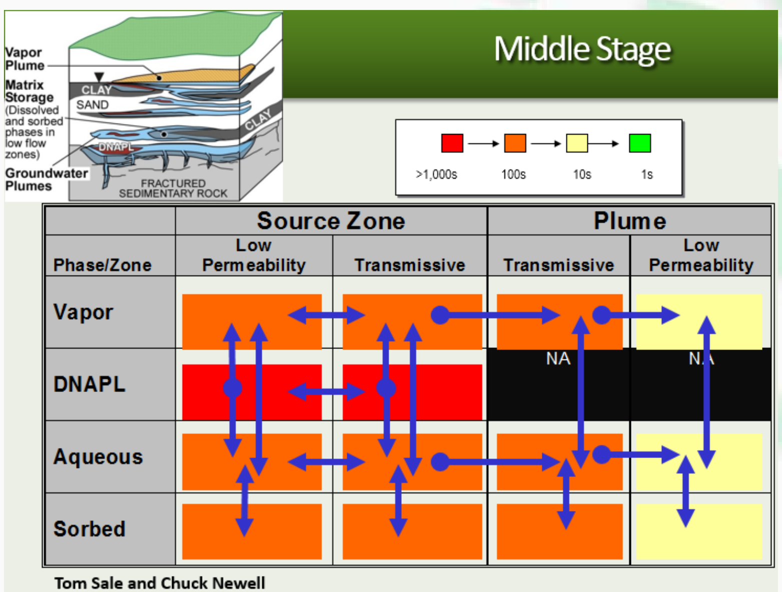
New Hampshire PCE Site

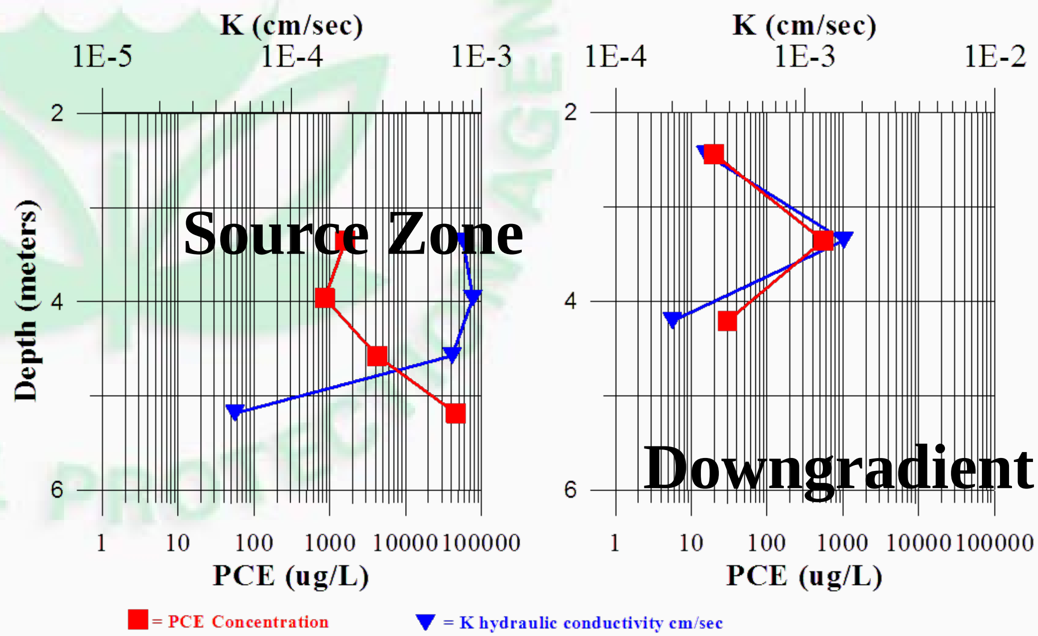


Spatial Variability In Flux……
But Also Temporal

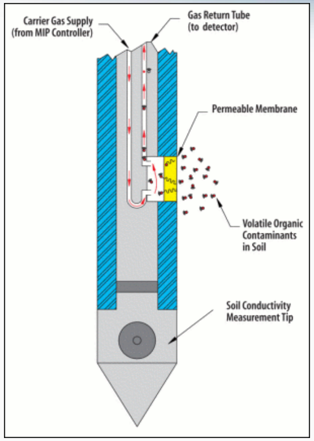


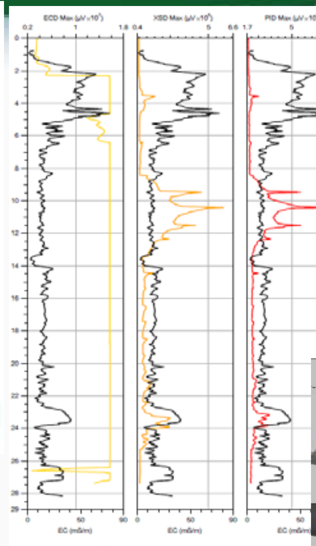


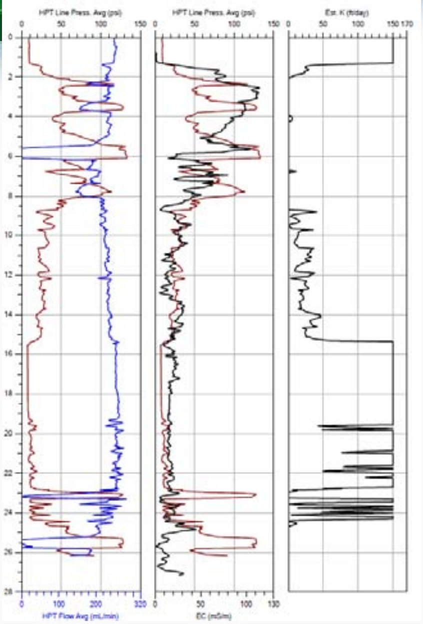


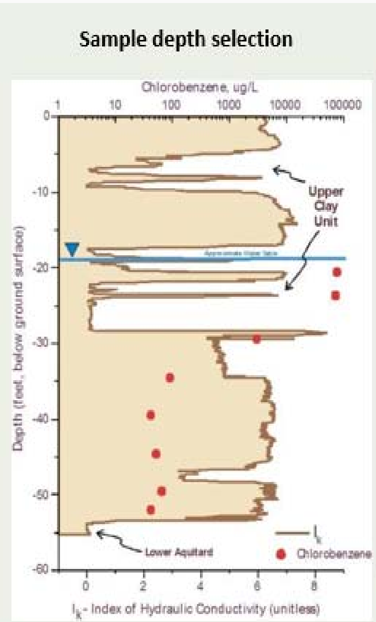


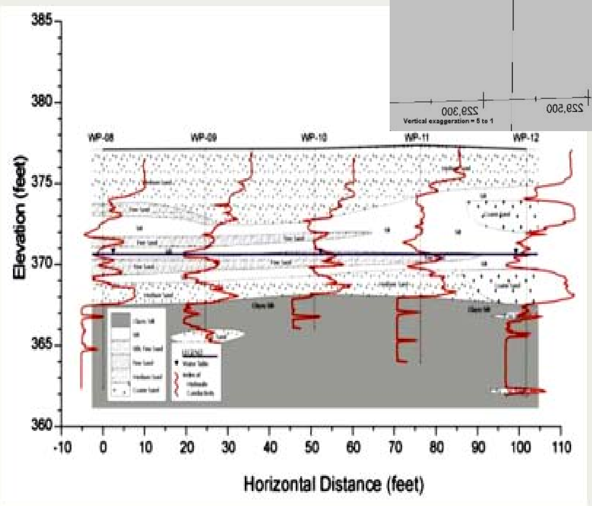
Hail to the Tools!

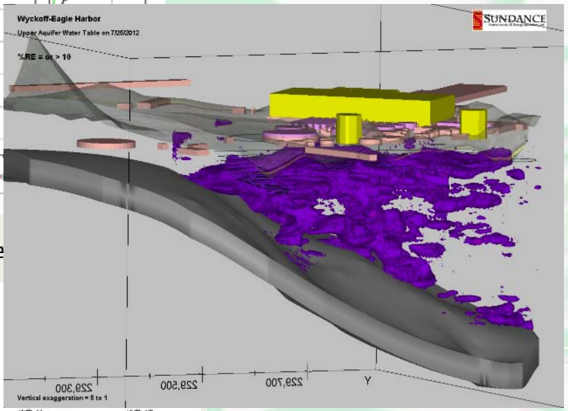


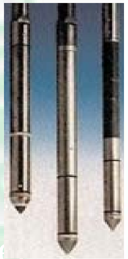


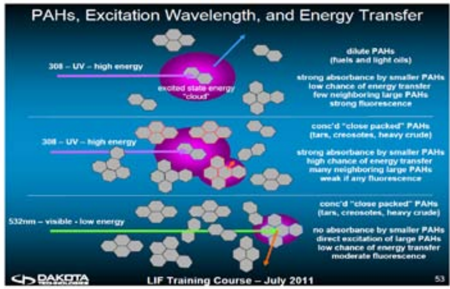


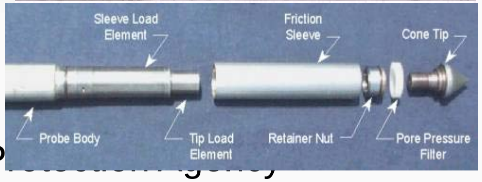


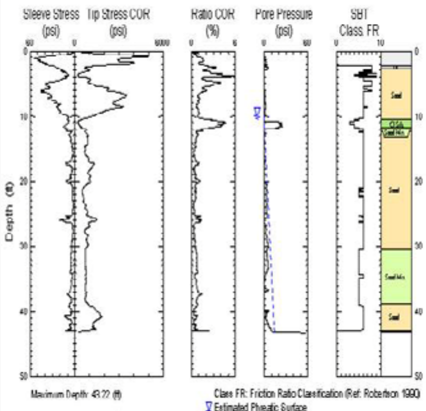


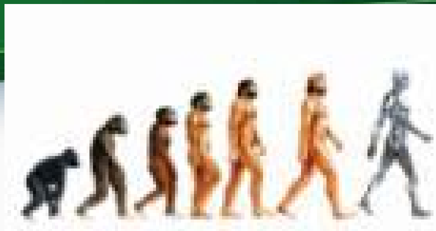












Addressing Uncertainty and Matrix Heterogeneity

The Missing Link

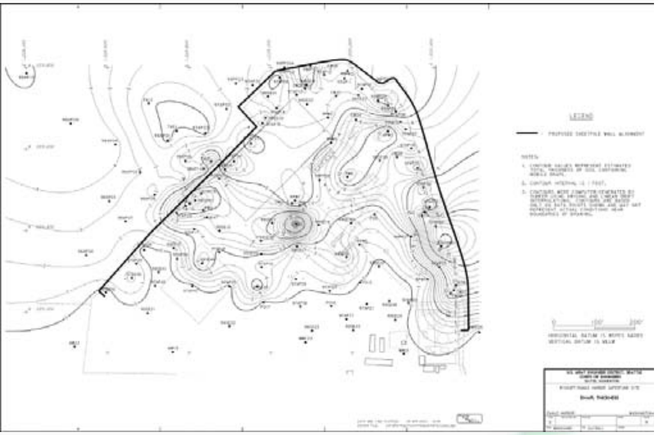
Collaborative data sets and high-resolution also critical for geologic / hydrogeologic information.

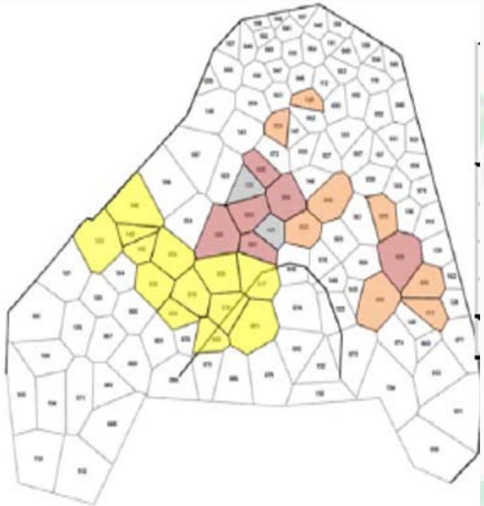
• Not just analytical concept.

• In many cases, geologic / hydrogeologic context may be more critical for effective remedy design.

Example 1- Wyckoff Region 10

Existing Work Products



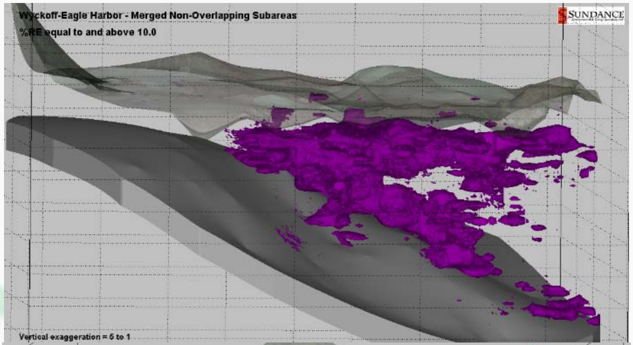


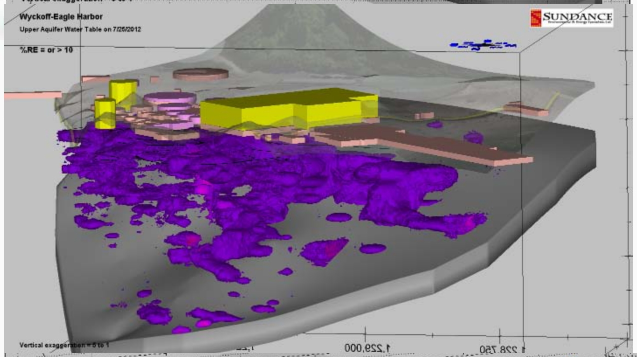
Wyckoff Geology

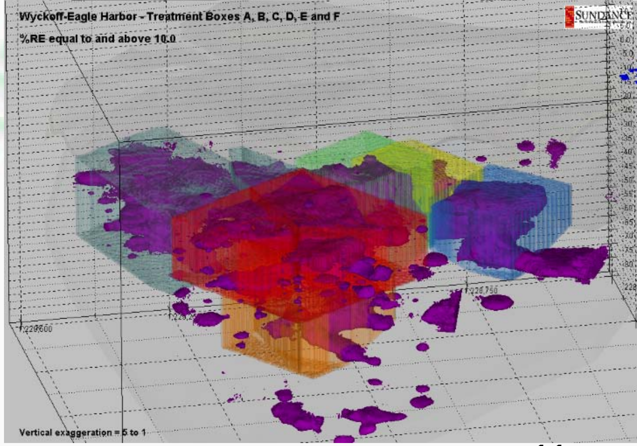
Wyckoff TarGOST

Wyckoff Treatment

FFS- TarGOST® and 3D Visualization





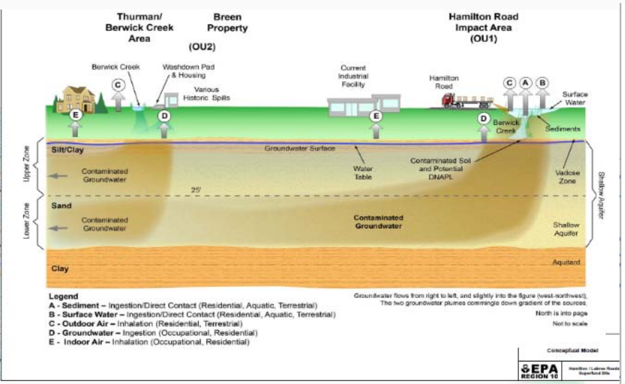


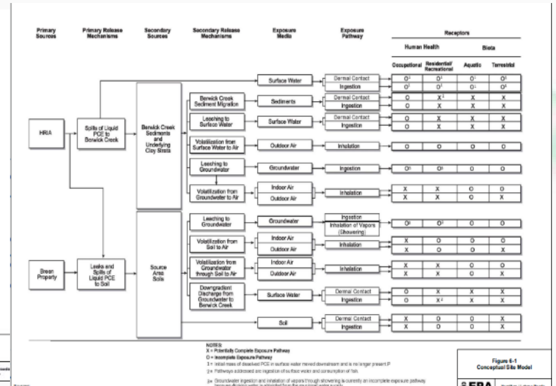
	Y-Length, ft	X-Width, ft	Z-Height, ft	Treatment Box Soil Volume, cu. yds.	TarGOST Impacted Soil Volume @ 10 %RE in Treatment Box, cu. yds.	TarGOST 10 %RE Percent of Treatment Box Volume, cu. yds.	TarGOST 20 %RE Percent of Treatment Box Volume, cu. yds.	TarGOST 50 %RE Percent of Treatment Box Volume, cu. yds.	TarGOST 100 %RE Percent of Treatment Box Volume, cu. yds.
Box A	160.00	170.00	45.00	33,836	12,883	38%	9%	0%	0%
Box B	200.00	210.00	30.00	38,538	5,524	14%	7%	1%	0%
Box C	180.00	165.00	23.00	18,302	6,491	35%	19%	5%	1%
Box D	180.00	132.00	10.00	5,861	2,253	38%	15%	0%	0%
Box E	305.00	300.00	28.00	77,146	13,371	17%	3%	0%	0%
Box F	300.00	300.00	22.00	72,706	14,734	20%	7%	1%	0%
TOTAL				246,389	55,255	22%			
				Total 10 %RE TarGOST Impacted Soil Volume Inside Wall	59,489				
				% Captured in Boxes	93%				

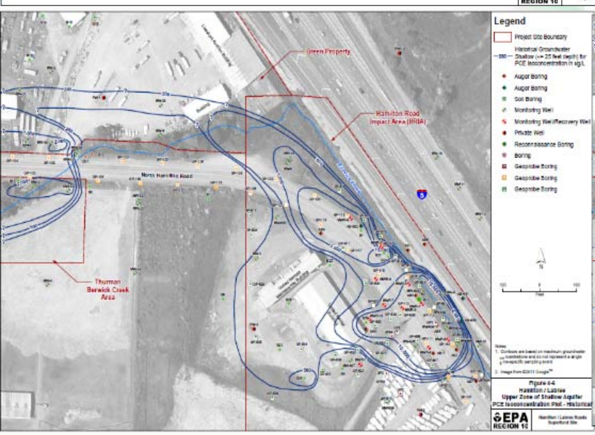
Example 2- Hamilton Labree Region 10

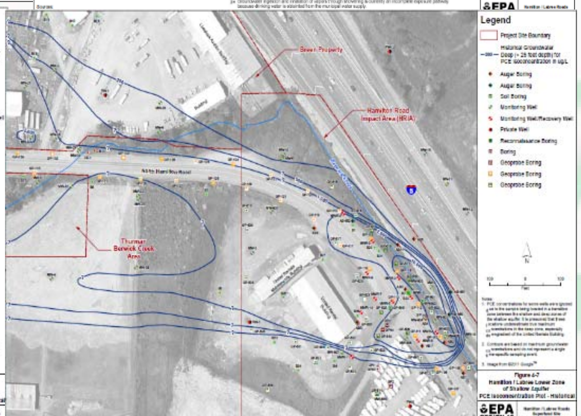
PDI- MIP, HPT, 3D

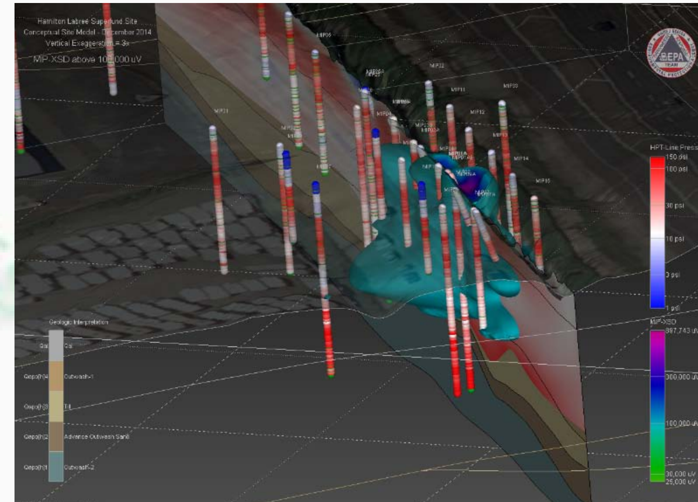
HRIA RI work products

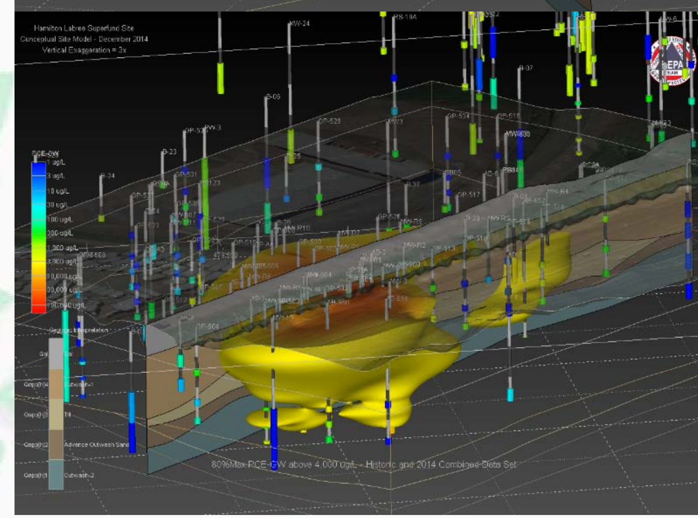












HRIA MIPHPT Geology

HRIA PCE GW

HRIA PCE Soil

Conclusions

HRSC and Incremental Sampling Translated for Remedial Designs

- **In Groundwater**
  - Limit large scale averaging, use scale appropriate measurements
  - Use transects and multi-level sampling
  - Use direct sensing and collaborative data sets
- **In Soil**
  - Use incremental and compositing techniques to control matrix variability, reasonably represent exposure and decision units
  - Many increments and replicate samples provide- good estimate of mean, and ability to calculate UCL/LCL and statistical confidence
- **Real-time CSM Updates/Data Visualization**
  - Forces interpretation not just presentation
  - Includes all decision makers in the process- consensus, streamline
  - Save time and money- fewer repeat mobilizations, early ID of data collection errors
  - Keeps focus on root causes not symptoms- High mass footprint (where to remediate), Matrix distribution (how to remediate)