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Strategies and Tools for Improved Management of Uncertainties at Contaminated Sites

Real-Time Remedial Demonstration Project Kickoff Meeting

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Experience Has Demonstrated That Cleanup Work Is Filled with Uncertainty

- Hog-and-haul for contaminated sediments and soils
  - Removed volumes always greater than those estimated during the design phase
- Pump and treat systems for contaminated groundwater
  - Rarely are original goals for these systems achieved
  - Never within the time frame originally envisioned by the designing engineers
  - Lots of surprises when work is underway
- Revisited sites
  - The Site A saga
  - Rattlesnake Creek experience

Work at Neighboring DOE Sites Underscore This Fact:

- ***Fernald***: Additional 625,000 m^3 of contaminated soil, with four trainloads requiring off-site disposal

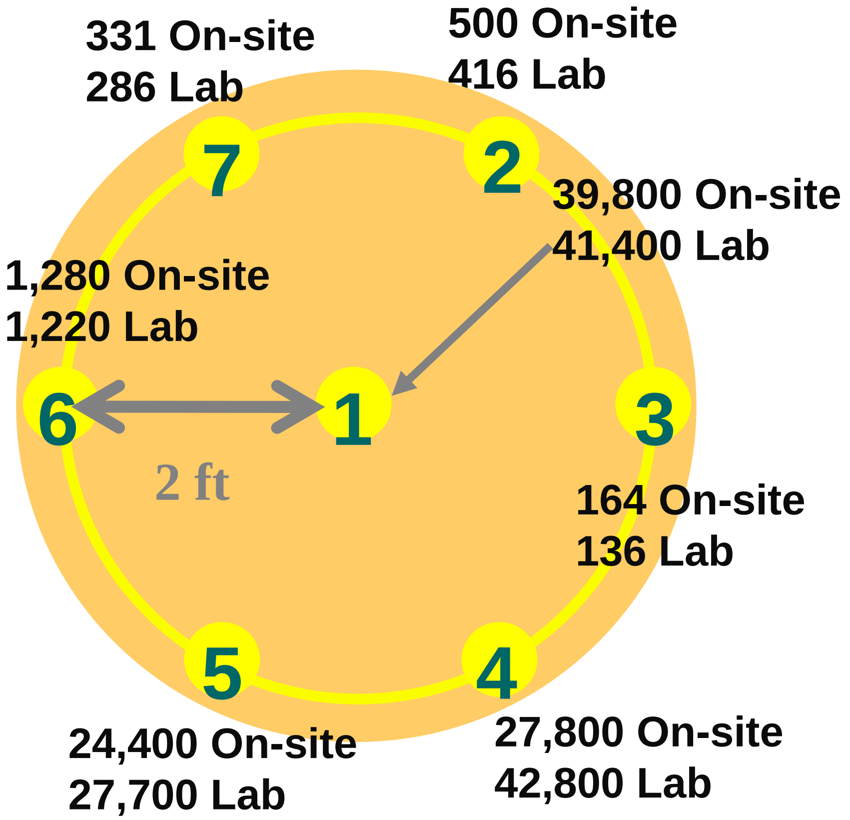
- ***Mound***: Double the amount of contaminated soil encountered by CH2M Hill than what was expected

- ***West Jefferson***: Three times the volume of contaminated soil, doubling costs and delaying schedules

(*Weapons Complex Monitor, October, 2006)*

Uncertainty Arises from Complexity and Heterogeneity of Natural Systems Combined with the Sparseness of Characterizing Data

- Spatial heterogeneity is the primary source of variability observed in environmental sample results
- Sample results can vary by orders of magnitude for proximal samples
- Historically the cost of collecting/analyzing samples has been significant, thereby limiting data
- The result—decision making takes place in a fog of uncertainty



Sampling Programs Are Key To Making the Correct Decisions

***CERCLA** (Comprehensive Environmental Response, Compensation and Liability Act*

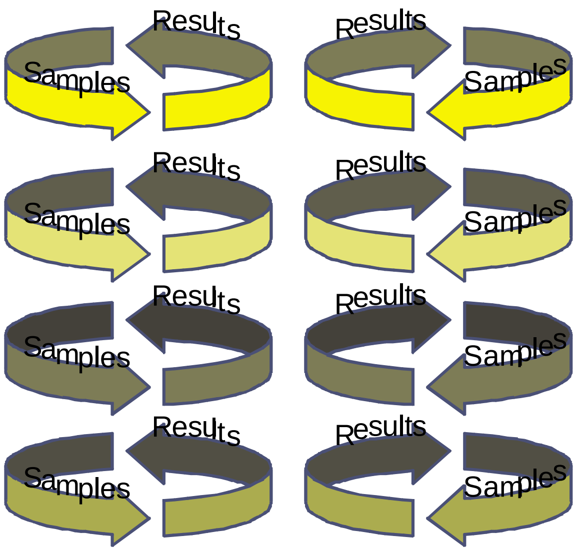
•Discovery; Preliminary Assessment (PA)

•Site Investigation (SI)

•Extended Site Investigation (ESI)

•Remedial Investigation/Feasibility Study (RI/FS)

•Remedial Action



***RCRA** (Resource Conservation and Recovery Act)*

•Discovery

•RCRA Facility Assessment (RFA)

•RCRA Facility Investigation (RFI)

•Corrective Measures Study (CMS)

•Corrective Measures Implementation (CMI)

Standard Sampling and Analysis Programs Are Expensive

Characteristics:

•**Preplanned Sampling;**

•**Off-Site Lab Analyses.**

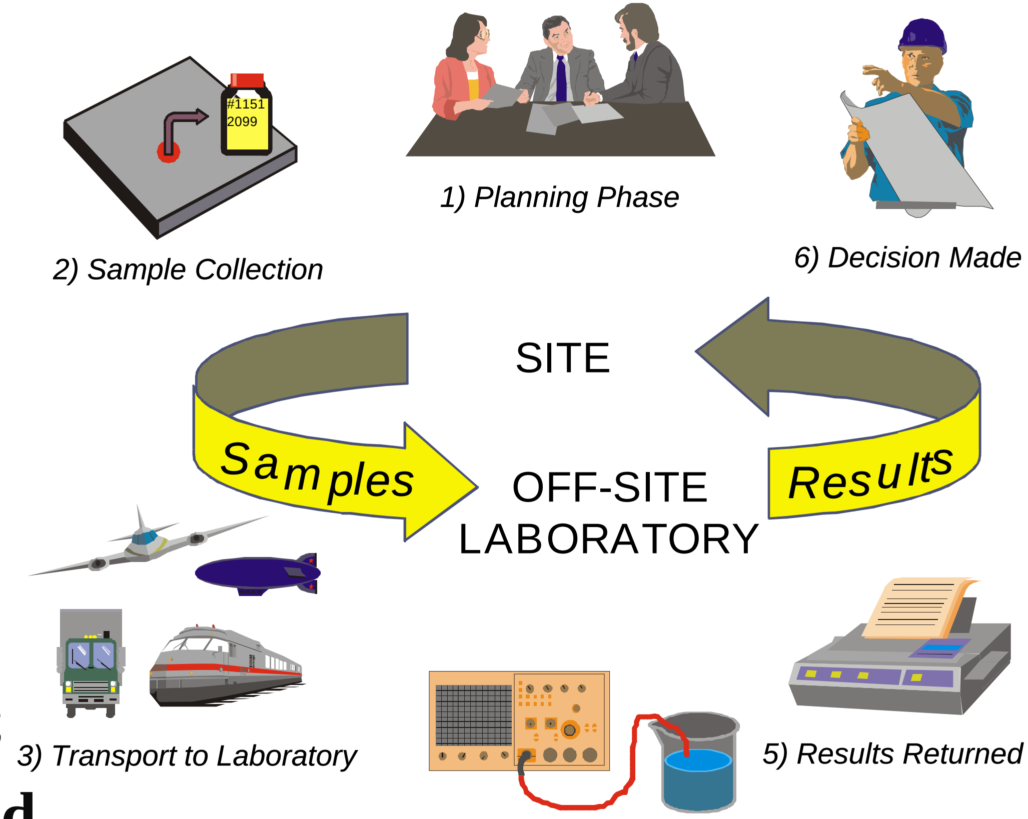
Problems:

•**High cost per sample;**

•**Surprise results;**

•**Pressure to oversample;**

•**Multiple trips to the field.**



The Alternatives Go by Many Names…

- Observational Approach (geotechnical engineering)
- Adaptive Sampling and Analysis Programs (ANL)
- Expedited Site Characterization (ANL)
- Sequential sampling programs
- Directed sampling programs
- EPA Technology Innovation Office’s Triad Approach

…But All Share Common Themes:

- **Systematic Planning** (pulling together all information for a site to influence sampling program design, including specification of exactly what decision needs to be made)
- **Dynamic Work Plans** (emphasis not on sample numbers and locations, but on how these decisions will be supported in the field)
- **“Real-Time” Methods** (providing data quickly enough to influence the outcome of the program)

Adaptive Sampling and Analysis Programs Can Cut Costs Significantly

Characteristics:

•Real-time sample analysis;

•Rapid field decision-making;

Advantages:

•Reduce cost per sample;

•Reduce # of samples;

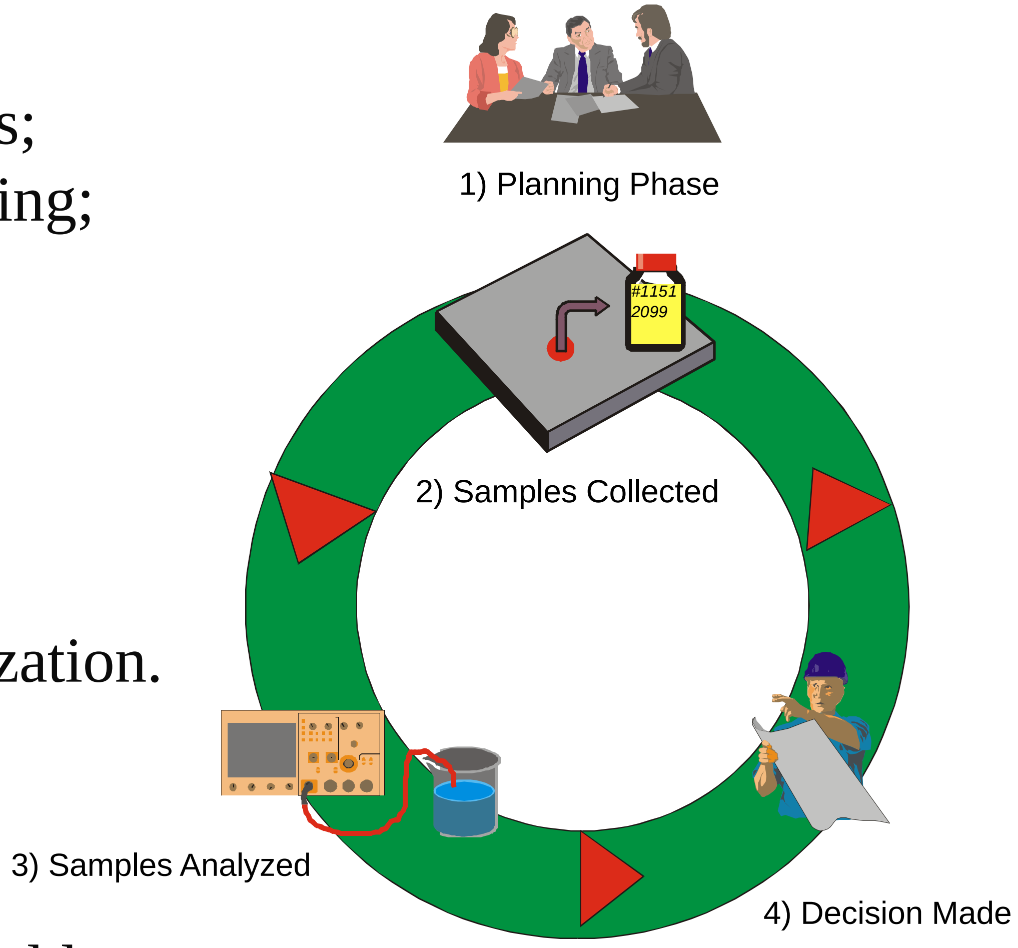
•Reduce # of programs;

•Achieve better characterization.

Requirements:

•Real-time method;

•Decision support in the field.



Real-Time Data Collection Methods are Becoming Increasingly Common





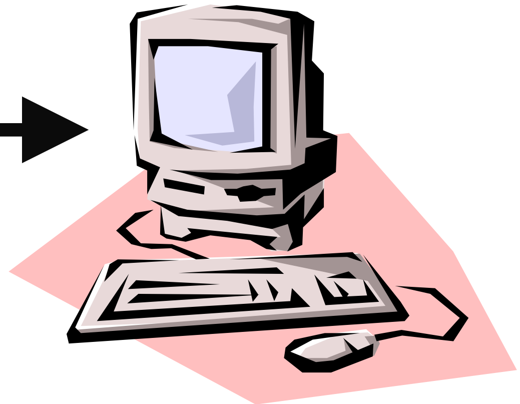


Argonne Focuses on the Decision-Making Process and Improving the Data That Feeds It

Base Maps

Geological Information

Sampling Data



Qualitative

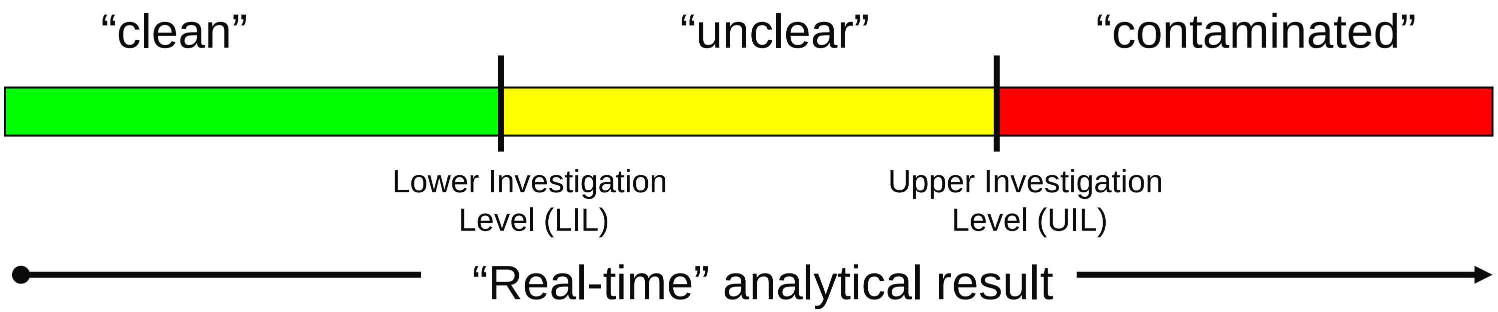
- **Data Integration**
- **Data Management**
- **Data Visualization**
- **Data Dissemination**

Quantitative

- **Contaminant Extent**
- **Where to Sample**
- **When to Stop**

Argonne Quantitative Methods

- BAASS (Bayesian Approaches to Adaptive Spatial Sampling)
  - Software based on Bayesian and spatial statistics
  - Used for guiding delineation sampling programs and estimating volumes
  - Assumes a real-time technique that can reliably identify the presence or absence of contamination above some action level
  - Selects sequential sampling locations to develop contamination footprints
- Non-Parametric Techniques for Collaborative Data Set Interpretation
  - Based on non-parametric statistical techniques
  - Identifies in-field investigation levels for interpreting real-time data sets



Argonne Partners with Others to Leverage Emerging Measurement/Analytical Hardware

- Tufts University (GC/MS technologies for explosives characterization)
- DOE Remote Sensing Laboratory (flyover remote sensing capabilities for surficial radiation and chemical contamination)
- DHS Environmental Measurements Laboratory (*in situ* measurement technologies for radioactive contamination)
- University of Ohio (nonintrusive geophysics for subsurface anomaly detection)
- Los Alamos National Laboratory (LIBS technologies for beryllium characterization)
- NORM ISI (NaI gamma spectroscopy for NORM contamination)
- Innov-X (XRF technologies applied to uranium characterization in environmental media)

Argonne's ASAP Approach Has Achieved Consistent Results across a Wide Range of Settings

Sandia National Laboratories

- Subsurface chromium contamination
- Estimation of contaminated soil volumes
- Number of bores reduced by 40%, samples by 80%

Kirtland Air Force Base

- Mixed waste burial trenches
- Estimation of contaminated soil volumes
- Number of bores reduced by 30%, samples by 50%

Argonne National Laboratory

- Near-surface VOC soil contamination
- Estimation of extent
- Number of samples reduced by 60%

Brookhaven National Laboratory

- Subsurface mixed waste contamination
- Estimation of contaminated soil volumes
- Cost estimates for removal action reduced from $40M to $8M

Fernald Site

- Radionuclide soil contamination
- Support excavation design and execution
- Expected to reduce $80M sampling to less than $40M

Joliet Army Ammunition Plant

- Surface TNT soil contamination
- Estimation of contaminated soil volumes
- Per sample costs reduced by 80%

FUSRAP Painesville Site

- Mixed waste soil contamination
- EE/CA support
- Overall project savings estimated at $10M

FUSRAP Ashland 2

- Radionuclide soil contamination
- Precise excavation support
- Overall project savings estimated at $10M

ASAP Approach Can Add Value at Several Points in the Cleanup Process

Process Point	*Problems with Traditional Approaches*	*Triad/ASAP Advantages*
Remedial Investigation	■ Expensive analytics limit sample numbers. ■ No mechanism for responding to surprise results.	■ Reductions in analytical costs. ■ Improved understanding of nature and extent. ■ Ability to address surprises while RI data collection is in progress.
Feasibility Study & Remedial Design	■ Data inadequate for accurate alternative evaluation. ■ Data inadequate for good design.	■ Selectively address data gaps and issues unresolved by RI datasets. ■ Provide improved estimates of contaminant volumes and footprints.
Remediation	■ Fixed, inaccurate excavation or dredging footprints. ■ Missed contamination and subsequent closure problems. ■ Inadvertent removal of “clean” material.	■ Allows dynamic work plans that can be adjusted based on data. ■ Waste stream minimization. ■ Ability to balance investments in data with expected cost reductions.
Long Term Monitoring & Closure	■ Either too much or not enough sampling. ■ Expensive analytics. ■ Limited flexibility to address unexpected outcomes.	■ Adjust data collection to meet the specific needs of individual areas. ■ Reductions in analytical costs. ■ Flexibility to modify monitoring on-the-fly in response to surprises.

For Contaminated Soils, Two Separate Issues

- **Are the contaminated soil volumes estimates right?**
  - Budget implications
  - Schedule implications
  - Remedial design implications

- **Is the remedial action as cost-effective as possible?**
  - Budget implications
  - For soils, usually equates with keeping excavation as precise as possible (i.e., waste minimization)