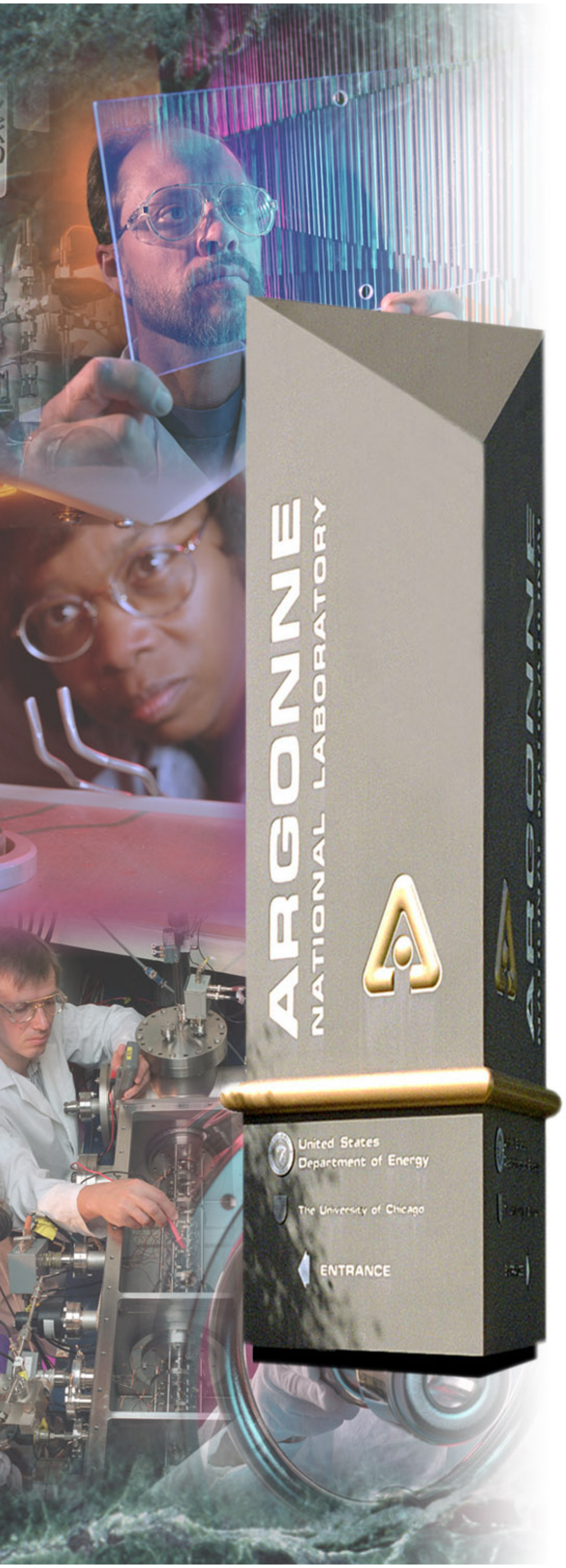


Triad for Managing Data Uncertainty for Cleanup (Argonne Examples)

Jack Ditmars & Robert Johnson
Environmental Assessment Division

December 1, 2003 FRTR General Meeting

Argonne National Laboratory

Office of Science
U.S. Department of Energy

A U.S. Department of Energy
Office of Science Laboratory
Operated by The University of Chicago

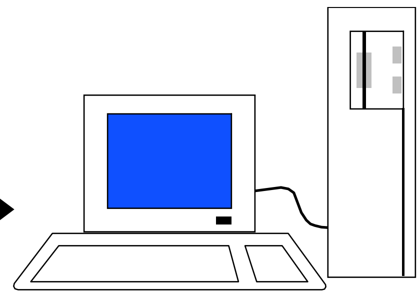
Argonne Has Had an Abiding Interest in Sampling Strategies/Decision Uncertainty

- **Adaptive Sampling and Analysis Programs (ASAPs)**
  - DOE Innovative Technology Summary Report (2001)
  - EPA Technology Innovation Office (TIO) develops Triad Program with similarity to ASAP principles (2001)
- **EPA TIO invites Argonne to:**
  - Support Triad Program Campaign (2002)
  - Assist in preparation of “Triad Handbook” now “Triad Resource Center” (2003)
- **Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)**
  - Applications/training for site cleanup verification
- **Argonne’s work focuses on quantitative basis for decisions**

ASAP Emphasizes Real-Time Decisions

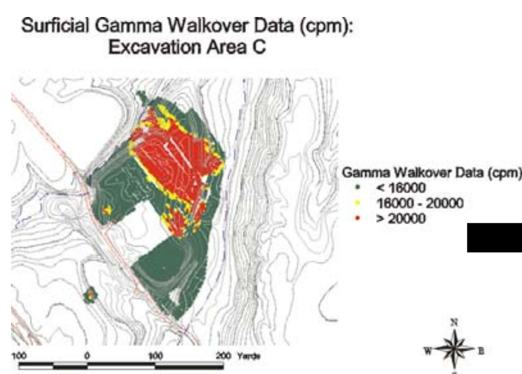
Existing Information

- Base maps
- Geology
- Boring samples
- ……..



Results on Web

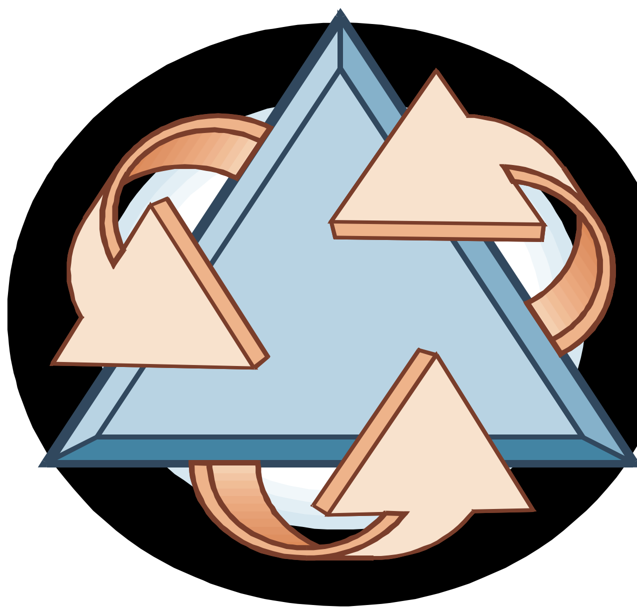
Rapid field data acquisition



Decision makers, stakeholders, ...

EPA's Triad Approach Similar to ASAP

Systematic Planning



Dynamic Work Strategies

Real-Time Measurements

Changes focus from lab analysis uncertainty to decision uncertainty

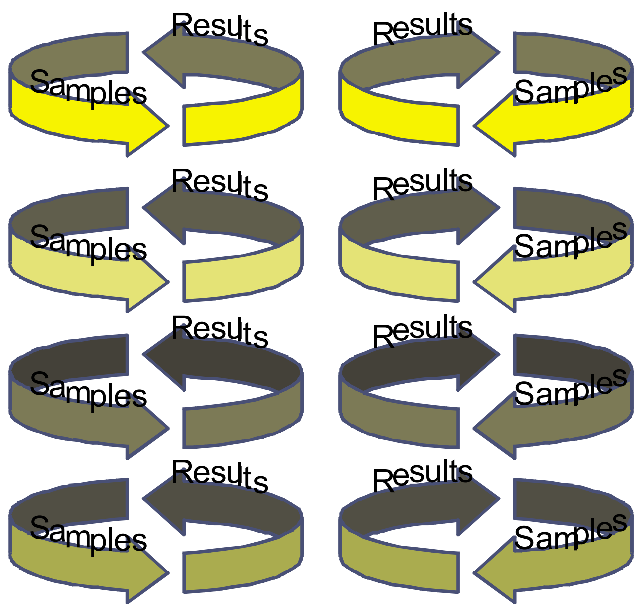
Argonne's Experience Demonstrates Benefits of Triad Approach

- **Why and how Argonne developed ASAP**
- **Examples of Argonne experiences at federal cleanup sites**
  - How ASAP/Triad approaches were employed
  - Range of situations addressed
  - What benefits were realized
- **While ASAP involves some quantitative tools, the examples emphasize the importance of employing each of the Triad components:**
  - Systematic planning
  - Dynamic work strategies
  - Real-time measurements

Sampling Programs Are Key Components of the Entire Environmental Restoration Process

***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)

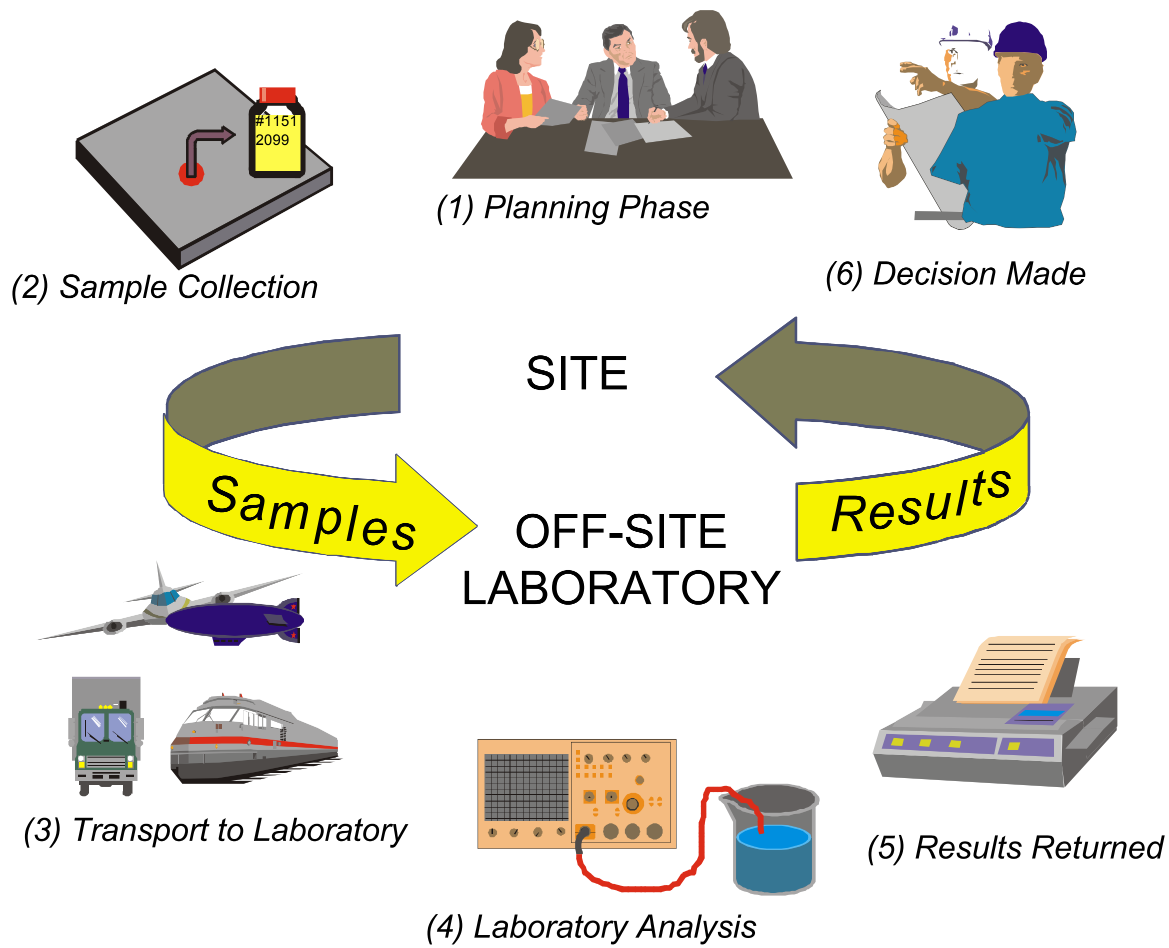
Standard Sampling and Analysis Programs Are Expensive

Characteristics:

- **Preplanned sampling**
- **Off-Site laboratory 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 Strategies/Plans** (emphasis not on sample numbers and locations, but on how these decisions will be supported in the field)
- **Real-Time Measurement Systems** (provide data quickly enough to influence subsequent sampling)

Adaptive Sampling and Analysis Programs Can Cut Costs Significantly

Characteristics:

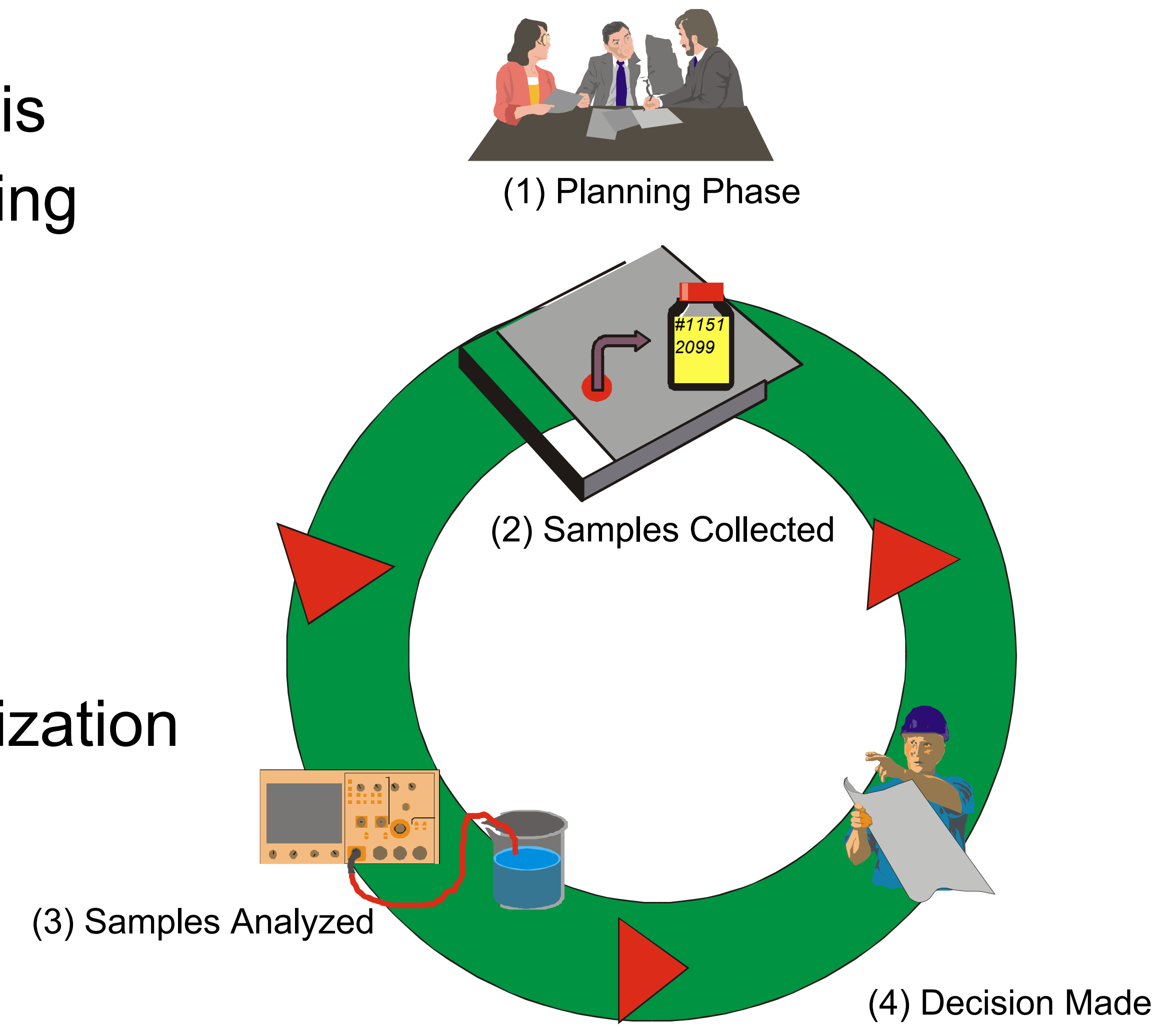
- Real-time sample analysis
- Rapid field decision making

Advantages:

- Reduce cost per sample
- Reduce no. of samples
- Reduce no. of programs
- Achieve better characterization

Requirements:

- Field analytical method
- Decision support in the field



Field Analytical Methodologies are Becoming Increasingly Common







Discrete Samples
Direct Measurements

Scanning

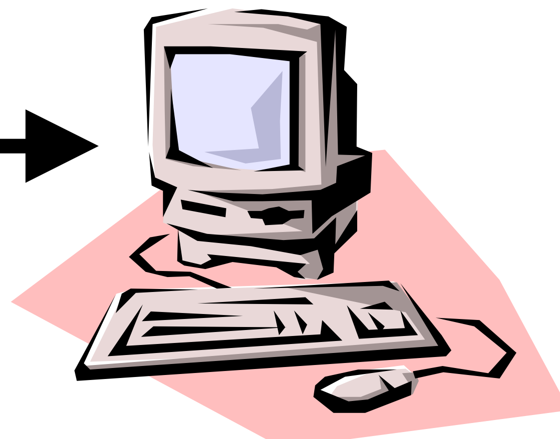
Interpolation…………………………………………….Interpretation

Adaptive Sampling and Analysis Program Decision Support

Base Maps

Geological Information

Sampling Data



Qualitative

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

Quantitative

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

Contaminated Soils Characterization Programs Have Three Attributes

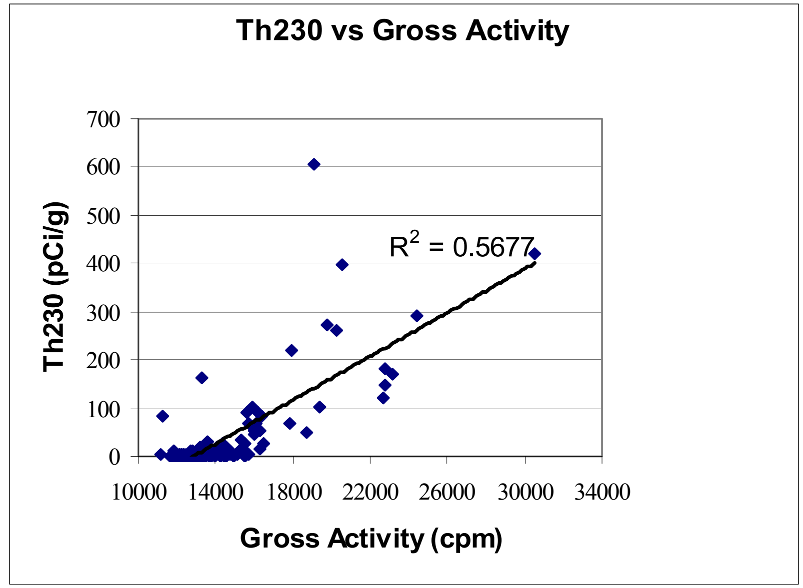
- The decisions that need to be made are often binary (e.g., does this unit of soil exceed cleanup guidelines or not?).
- Sample results display a spatial autocorrelation with a significant range as well as significant short-scale heterogeneity.
- "Soft" information is critical to designing effective sampling programs. Soft information refers to historical information, experience with similar events at other sites, stressed vegetation, anecdotal information, etc.

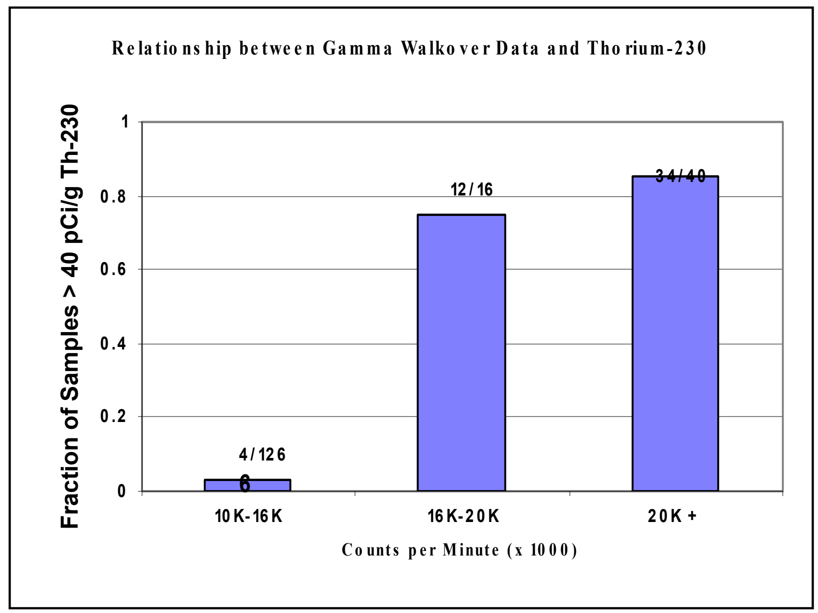
Joint Bayesian/Geostatistical Methods Provide One Approach for Guiding Discrete Sample Collection

- **A Bayesian approach is used to combine "soft" and "hard" data (Beta priors and posteriors for the probability of contamination being present above guidelines);**
- **Indicator geostatistics is used to interpolate from locations where samples have been taken to places where data are unavailable;**
- **Uncertainty is handled in the context of the EPA's Data Quality Objectives (DQOs) and the probability of making Type I and II errors.**

Nonparametric Techniques Are of Particular Value for Scanning Technologies

- Scanning technologies can provide 100% coverage of a site's surface/subsurface. Interpretation is key.
- Linear regression analysis is not particularly useful, often resulting in a poor "fit."
- Nonparametric techniques focus on the decision to be made and associated decision errors.
- Nonparametric techniques are relatively immune to problems that plague linear regressions.





Adaptive Sampling Techniques Have Been Successfully Applied at a Number of Federal Sites

Sandia National Laboratories

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

Kirtland Air Force Base

- RB-11 (Haliburton)
- Mixed waste burial trenches
- Estimation of contaminated soil volumes
- Number of bores reduced by 30%, samples by 50%

Argonne National Laboratory

- 317 Area (Weston)
- Near surface VOC soil contamination
- Estimation of extent
- Number of samples reduced by 60%

Brookhaven National Laboratory

- Glass Holes Area (CDM Federal)
- Subsurface mixed waste contamination
- Estimation of contaminated soil volumes
- Cost estimates for removal action reduced from $40M to $8M

Fernald Site

- Soils program (Fluor Daniel Fernald)
- Radionuclide soil contamination
- Support excavation design and execution
- Expected to reduce $80M sampling to less than $40M

Joliet Army Ammunition Plant

- TNT Production Lines (OHM)
- Surface TNT soil contamination
- Estimation of contaminated soil volumes
- Per sample costs reduced by 80%

FUSRAP Painesville Site

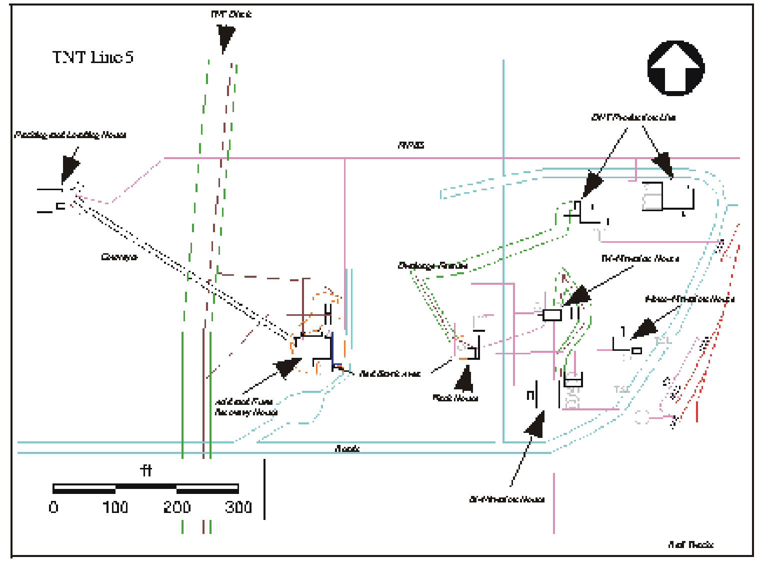
- Whole site (BNI and SAIC)
- Mixed waste soil contamination
- EE/CA support
- Overall project savings estimated at $10M

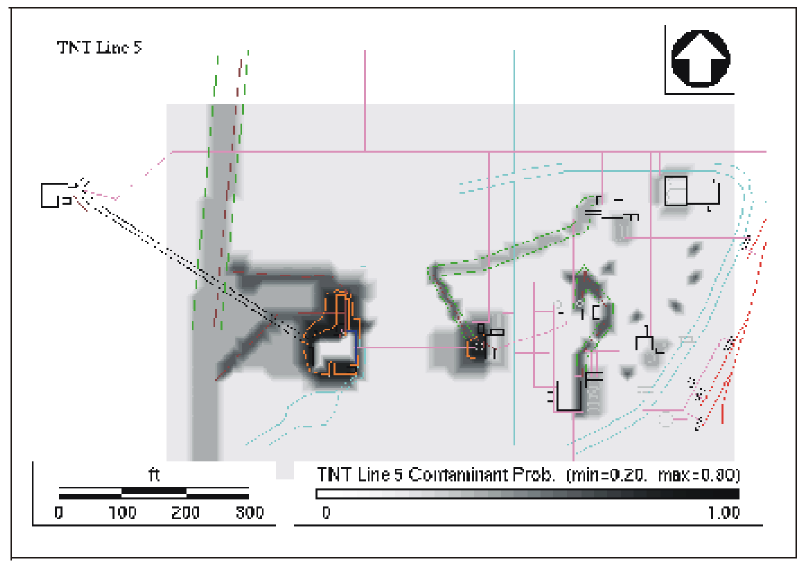
FUSRAP Ashland 2

- Whole site (ICF Kaiser)
- Radionuclide soil contamination
- Precise excavation support
- Overall project savings estimated at $18M

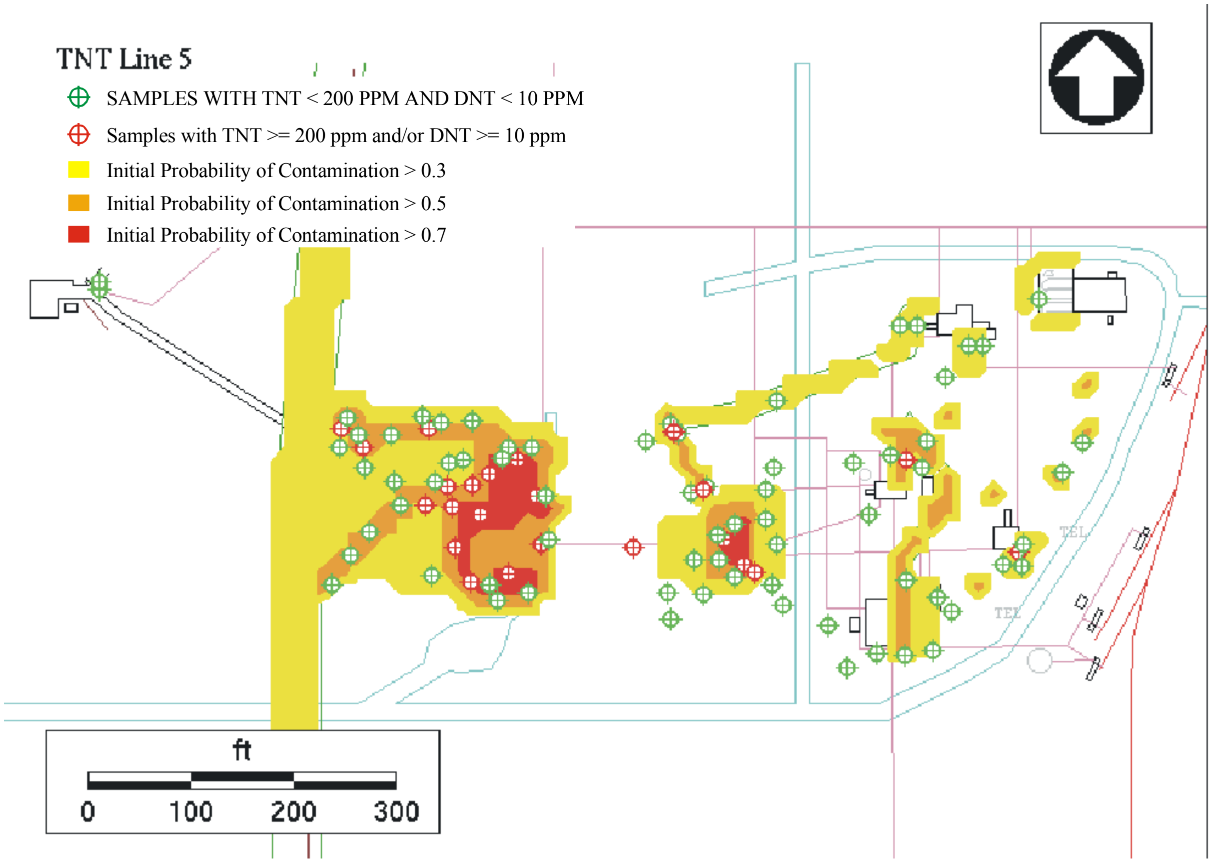
Joliet Army Ammunition Plant (JAAP) ASAP Demonstrates Discrete Sampling

- **Existing pertinent site information is compiled and integrated;**
- **This information is used to develop a quantitative conceptual image of where contamination is likely to be found;**
- **The conceptual image is broken into three regions: “clean”, “dirty”, and “uncertain”;**
- **ASAP sampling programs are developed pertinent to the needs of each region.**





Sampling Progresses to Refine Conceptual Model



Ashland 2 Site Demonstrates Scanning Linked to Remediation & Systematic Planning

- “Peeling” a site back in lifts is guided by field screening data for each lift during the remediation [Precise Excavation]
- Thickness of each lift ranges from 6 inches to several feet and the footprint shifts to follow the contamination
- Each lift is characterized using Argonne’s adaptive sampling and analysis program (ASAP) techniques (real-time data collection and decision support)
- Screening/removal process continues with depth until the site has achieved remediation levels
- Reduces potential for removing “clean material” and leaving material above clean-up guidelines (in-situ soil sorting)

Ashland 2 Site Benefits from Linking ASAP to Remediation

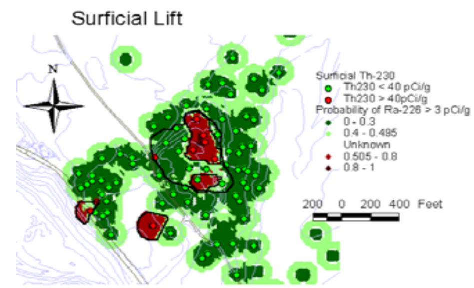
- Argonne collaborated the U.S. Army Corps of Engineers to replace “block excavation” with “precision excavation” at the FUSRAP Ashland 2 site

- Buffalo District undertook an independent cost analysis of Ashland 2 project

  - **Project records indicate a minor cost increase of $200,000 for “precise excavation” components (gamma walkover data and data analysis) compared with:**

  - **Major cost savings that were achieved by avoiding unnecessary disposal costs**

- **Total project savings exceeded $10 million**



Additional Information

- **Argonne's experiences have been documented**
  - Papers and articles in ASTM book, *Remediation*, The Military Engineer, The Corps Environment, …
  - DOE Innovative Technology Summary Reports, brochures
  - Conferences – NDIA, Waste Management, …
  - EPA Triad Resource Center

- **Contact:**

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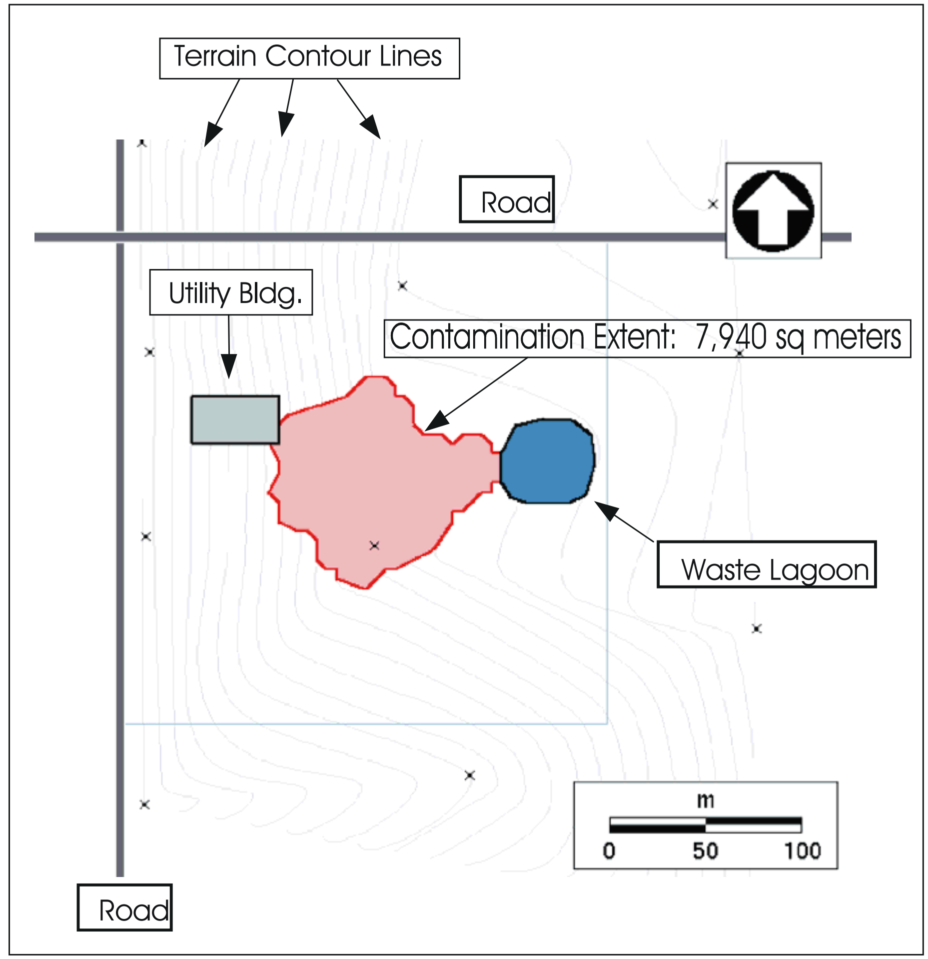
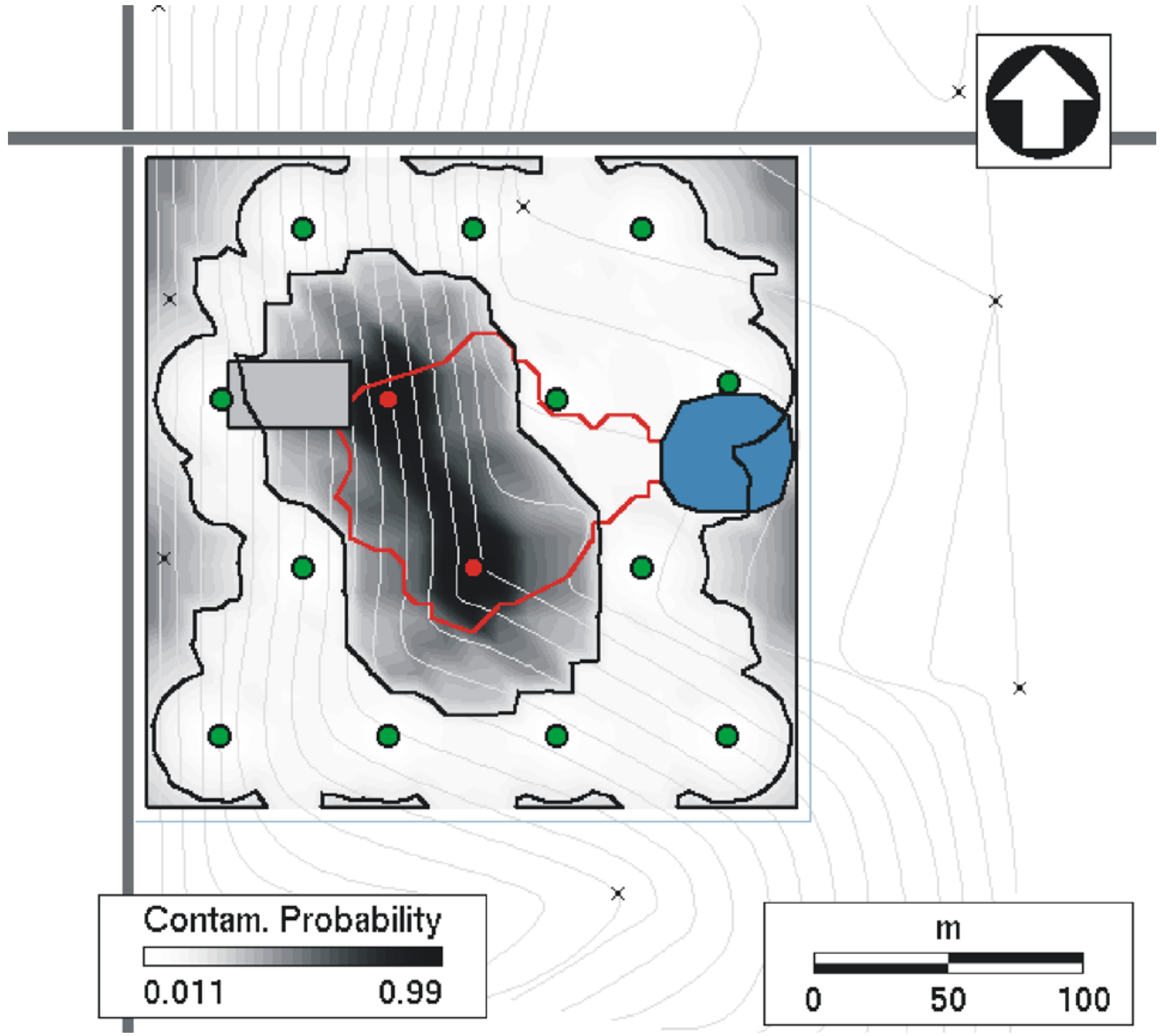
Example Site: Surface Contamination Event

- **Surface soil contamination as the result of spillage from the lagoon.**
- **7,940 m^2 actually contaminated, an area unknown to the responsible party.**
- **Soft information available for the site includes:**
  - Slope of land
  - Location of barriers to flow
  - Location of source
- **Owner will remediate anything with a greater than 20% chance of being contaminated.**

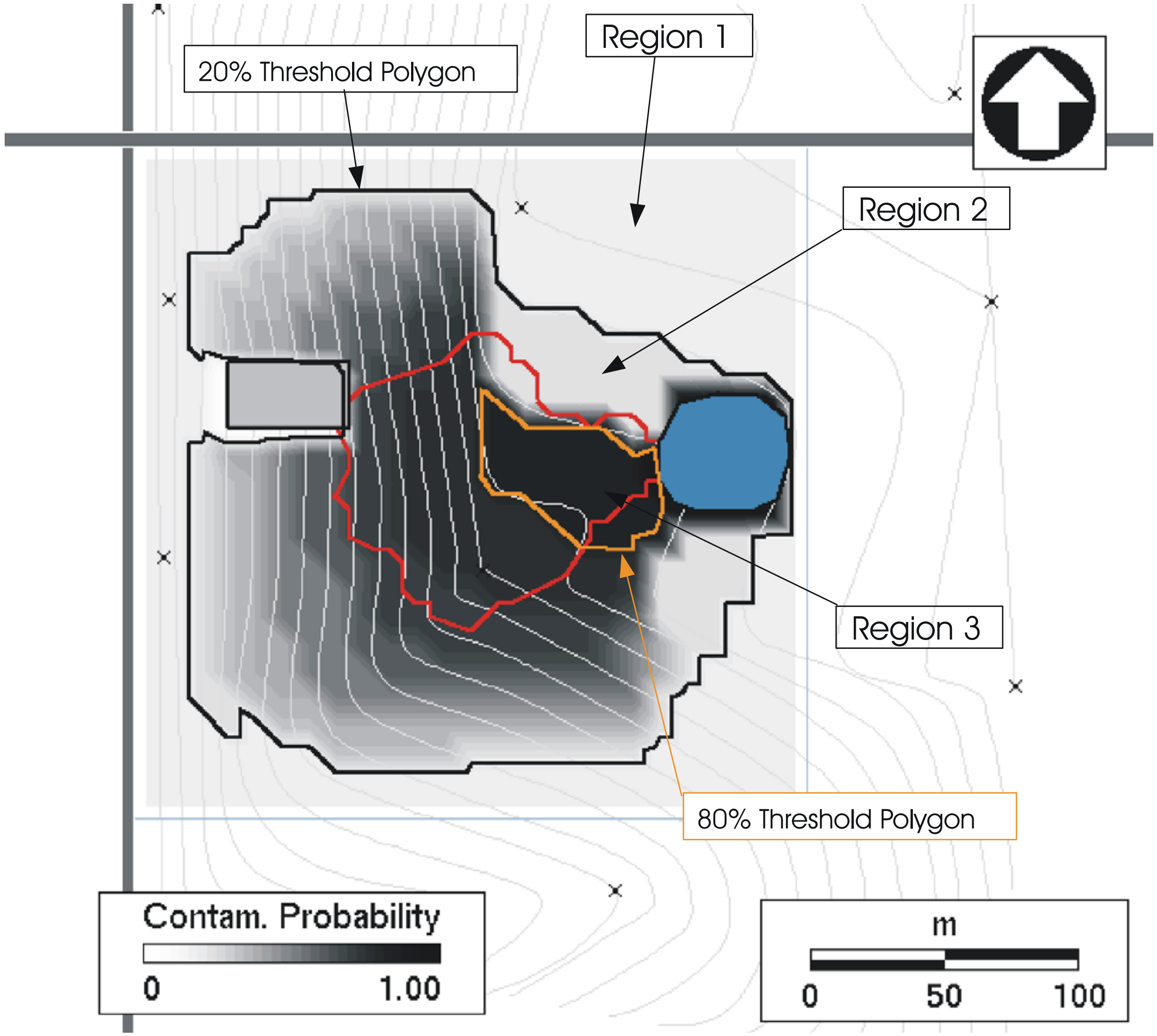


Standard Approach

- **Determine sample numbers**
- **Layout systematic grid**
- **Sample all at once, send to a laboratory for analysis**
- **Interpolate based on results**

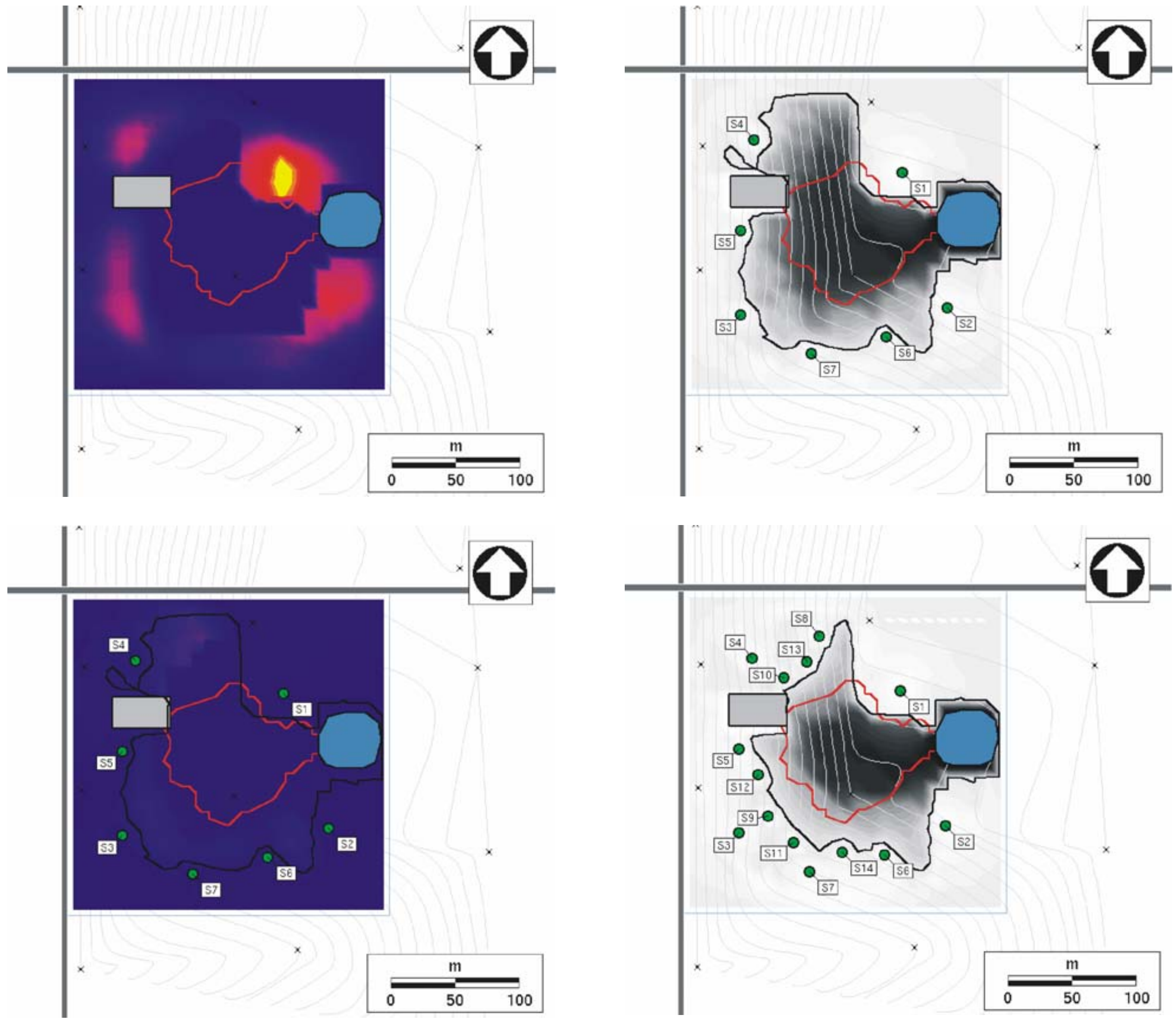


Adaptive Approach: Initial Conceptual Model



Sampling Progression with Adaptive Alternative

- **Samples are collected sequentially, with an appropriate Functioning Area Monitor providing “real-time” data.**
- **New sample locations selected on the basis of the initial conceptual model, updated with current sampling results.**
- **In this example, locations are selected to maximize the area with a less than 0.2 probability of contamination.**



Sampling Can Continue until Goals are Achieved