Overview of Air Force
Long-Term Monitoring Optimization
Programs and Case Studies

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AFCEE/BCE
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Overview

- Opportunities
- AFCEE optimization tools
- Process
- Resource requirements
- Case studies
- Outreach & training
Why Optimize?

- Air-Force wide network is about 35,000 Wells
- Corporately expensive to monitor
  - 35,000 wells x $1500 per event = $52.5M
  - Some installation O&M programs >$2M per year
- Most data is not used for decision support
- Data redundancy
  - Number of wells
  - Frequency of sampling events
- Need *formal* mechanism to reduce redundancy and identify essential data
Opportunities

- Reduction in monitoring 20 – 60%
- Reduces redundancy in data capture
- Provides independent analysis
- Supports & justifies O&M budget
- Reasonable costs to accomplish
- Proposal for stakeholders to improve sampling
Cumulative Monitoring Costs
$2M Annual Program Optimized to $1M

Air Force Base X

Year

$0
$5,000
$10,000
$15,000
$20,000
$25,000

$1000s


Redundant
Optimized
LTM Monitoring Goals

- Protect human health & the environment
- Sufficient data; avoid “nice to have” data
- More than adequate decision support
- Tolerable level of uncertainty in decision-making without significant information loss
LTM Optimization
AF Game Plan

- Develop *robust*, broad-application tools
- Rank & *prioritize* candidate facilities and sites
- *Implement* optimization process across AF
- Develop methods for post-optimization evaluation & validation
- Standardize reporting and output—-*keep it simple*
- Refine exit strategies
Optimization Identifies Sampling Redundancy & Essential Data

“Nice to have” All Data
Samples = 240

“Essential” 90% Reduction
Samples = 27
Components and General Process

- Validation & 3 Yr Review
- Decision Framework
- Data Mgmt (Legacy Data, Current Data)
- Tool Inventory
- Qualitative Analysis
- Temporal Analysis
- Spatial Analysis
- Network Expansion
- Network Reduction
- Regulatory Buy-in
- Cost Analysis
- Reporting

Optimized Network
LTM Optimization
Periodic Review, Adjustments, & Exit Strategy

- Characterization
- MW Sampling Network
- Remediation
- LTM Initial Design
- Validate
- Adjust
- Review 3–5 Yr
- LTM Optimized
- Site Closure
- Exit Strategy
  - DQOs Met
  - Goals Achieved
- LTM Complete

I n t e g r i t y  -  S e r v i c e  -  E x c e l l e n c e
Process

- RPO site visit; inventory of existing network
- Identify contaminants of concern (COCs)
  - Focus on 3 – 5 constituents
  - Need maximum coverage over time & space
- Regulatory framework
  - Permits
  - RODs
- Optimization tool selection
- GIS coverages
- Support from onsite contractors & web-enabled databases
Resource Requirements

- Electronic data
- Conceptual site model
- Contaminant hydrogeology
- Funding $10-35K per site
- Entire installation can be > $200K
- Typically < 15% annual O&M budget
Optimization Tools

Algorithm

GTS

Software

MAROS
Other Approaches Are Important

- Parson’s Three-Tiered approach
- Intelligent search algorithms and artificial intelligence (AI)
  - Genetic algorithms
  - Simulated annealing
  - Neural networks
- AI more practical with increasing computational power
Optimization Tools
What Do They do?

- Identify essential sampling locations
- Determine an optimal sampling frequency
- Assess relative importance of individual wells
- But, there is no *purely objective* solution or answer
Tool Selection

- **GTS**
  - Minimum no. wells > 30
  - Multiple sites and OUs, or individual sites
  - Need a geostatistician

- **MAROS**
  - Site modeled as a distinct plume
    - Source area known
    - Plume delineation
    - Well categories respective of plume
  - Handles large sites or networks < 40 wells
Information

- GTS and MAROS (Vers 2.0 downloads)
- [http://www.afcee.brooks.af.mil/er/rpo.htm](http://www.afcee.brooks.af.mil/er/rpo.htm)
GTS Optimization Algorithm
(translated to software, Dec 2004)

1. Identify Temporal Redundancy
2. Construct Temporal Variogram
3. Preprocess Data & Construct Indicators (A)
4. Compute Composite Temporal Variogram (B)
5. Perform Data Thinning (E)
6. Eliminate Wells With All NDs or With < 6-10 Distinct Sampling Dates
7. Iteratively Thin Selected Wells
8. Determine Variogram Sill (C)
9. Adjust Global Sampling Frequency
10. X2

- Set sampling intervals for eliminated wells using global sampling frequency from temporal variogram (X1)
- Adjust Individual Well Sampling Frequencies
- Global sampling frequency should be applied to all wells except for those adjusted individually (X2)
- Individual well sampling frequencies should take precedence over global frequency unless operationally impractical
- Monitoring and sampling wells on individually determined schedules could add undue operational costs. If so, just apply global sampling frequency to all wells

Finalize Degree of Temporal Redundancy
Adjust Individual Well Sampling Frequencies

- Initialize Thinning % Using C=5% or 10%
- Increase Thinning %
- Re-compute Slope & Assess Accuracy (F)
- Estimate Slope & Confidence Bounds for Each Remaining Well (D)
- Perform Data Thinning (E)
- Initialize Wells With All NDs or With < 6-10 Distinct Sampling Dates
- X
- X1
- X2
- Y
- N

P1

Monitoring and sampling wells on individually determined schedules could add undue operational costs. If so, just apply global sampling frequency to all wells.
Locally weighted quadratic regression (LWQR) replaces Kriging algorithm.

**LWQR**
- Smoothing technique, not an interpolator
- Robust; does not assume or require a spatial covariance model (variogram)
- Can estimate complex seasonal trends and nonlinear data
- Handles multiple values in time and space
- A less complex and flexible alternative for software development

GTS 2.0 coming July 2004
GTS Software December 2004
Enter Data, Reduce Data, Select Wells

1. Identify Site Constituents of Concern (COCs).

2. Analyze Lines of Evidence (LOEs) for Plume Stability (by well and by COC)
   - Increasing (I)
   - Probably Increasing (PI)
   - No Trend (NT)
   - Stable (S)
   - Probably Decreasing (PD)
   - Decreasing (D)
- Spatial moment analysis
  - Impacts total mass, center of mass, & spread of mass calculations
  - Estimation technique inaccurate in some cases
  - Programming fix is in process
- MAROS 2.1 coming August 2004
Products & Deliverables

- Decision framework & methodology
- Essential monitoring locations
- Redundant monitoring locations
- Optimized sampling frequency
- Expanded network in areas of uncertainty
- Cost benefit analysis & return on investment
Web-Enabled Data Resources
Great Asset for Facilitating Optimization

Tinker AFB Data Management Tools
Click on the tool you want to use.

DATA Wizard
View environmental data
on-line or export for analysis

© Science Applications International Corporation, 2003
Categories Based on:

- Semi-quantitative scheme
- Relative statistical importance
- Global regression weights or slope factors
- Temporal influence & coverage

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<td>MW-05</td>
<td>Low</td>
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<td>MW-13</td>
<td>Low</td>
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GTS Time Series Output with Confidence Bands
Manganese in Well JBW7317

Sampling Date

Concentration (ppb)

- Upper 90% Conf. Bnd.
- Lower 90% Conf. Bnd.
- Initial Fit
- Med. Fit (0.35)
- Med. Fit (0.40)
- UQ Fit (0.40)
- LQ Fit (0.40)
- Sample Conc.
TCE Spatial Comparison
All Wells vs Reduced Network

All Wells

Well Reduction 40%

Site 133: TCE Concentrations (ppb), 1999-2000, Base Map

Site 133: TCE Concentrations (ppb), 1999-2000, 40% Removal

Easting (10,000 ft)

Northing (10,000 ft)

Mean: Raw

3000
2000
1000
500
100
50
5

Easting (10,000 ft)

Northing (10,000 ft)

Mean: Raw

3000
2000
1000
500
100
50
5

Integrity - Service - Excellence
MAROS Well Sufficiency Analysis
(from Aziz, 2003)

Estimation Uncertainty plot based on Slope Factor (SF) values

High SF areas $\Rightarrow$ High estimation error $\Rightarrow$ Possible need for new locations

Low SF areas $\Rightarrow$ Low estimation error $\Rightarrow$ No need for new locations
### Optimized Semiannual Sampling

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Sampling events in color
Estimating Cost Savings
Baselined Against Current Monitoring

• Inputs
  – List of wells monitored
  – Annual samples collected (including QC samples)
  – Analytical costs (analyte and method used)
  – Materials and equipment costs (rentals & expendable items)
  – Shipping costs
  – Labor costs for ...
    • Field sample collection and field measurements
    • Chemistry data management
    • Meetings and preparing reports
    • Updating/revising documents/databases
    • Professional site visits and QA/QC audits
    • Project management and administration

• Cost of performing optimization
Case Studies

- **GTS**
  - MMR, FS-12 and Eastern Briarwood Plumes
  - AFP6
  - Loring, Pease, & Edwards AFBs
  - **Tinker AFB** (in process)

- **MAROS**
  - **Tinker** AFB, ST-40
  - Wurtsmith AFB, LF30-31
  - MMR, Ashumet Valley Plume
  - Homestead AFB, SS-2A (proposed)
  - McIlelan, Vandenberg, Dover, Edwards, Fort Lewis, Long Prairie Superfund Site (early studies)
# GTS Case Study Results

**Potential Savings at AF Installations**

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<thead>
<tr>
<th></th>
<th>Edwards</th>
<th>Loring</th>
<th>Pease</th>
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<tr>
<td><strong>Original Frequency</strong></td>
<td>Annual</td>
<td>Quarterly</td>
<td>Annual</td>
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<tr>
<td><strong>Optimized Interval</strong></td>
<td>Every 7 Qtrs</td>
<td>Every 2-3 Qtrs</td>
<td>Every 8 Qtrs</td>
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<tr>
<td><strong>Redundant Wells</strong></td>
<td>20-34%</td>
<td>20-30%</td>
<td>10-36%</td>
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<tr>
<td><strong>Cost Reduction</strong></td>
<td>54-62%</td>
<td>33-39%</td>
<td>49-52%</td>
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<tr>
<td><strong>Annual Cost Savings</strong></td>
<td>$230 K-$270 K</td>
<td>$300 K- $360 K</td>
<td>$85 K- $90 K</td>
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Training

- GTS & MAROS
- Brooks City-Base
- Before Dec 2004
LTM Optimization
Summary

- AF optimization tools are available
- Significant cost savings can be realized
- Case studies have matured technology
- Implementation should focus on priority sites
- Training to take place at AFCEE
Thanks

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