Agenda for Technical Interchange Meeting #1

Groundwater Monitoring - Delivery Order T0008

Long Term Monitoring Optimization Study

Date: Friday, November 12, 2004

Time: 10:00 am – 12:00 noon

Place: Camp Stanley Storage Activity - Boerne, Texas

Proposed Order of Discussion

Time	Topic
10:00 am	Introductions Presentation by Dr. Carolyn Nobel Discussion of LTMO study goals and issues Development of CSSA site-specific tool Schedule for LTMO study development
10:30 am	Question and answer session/further discussion
11:00 am	Site Tour

Identifying Opportunities for Cost Savings Applying Long Term Monitoring Optimization

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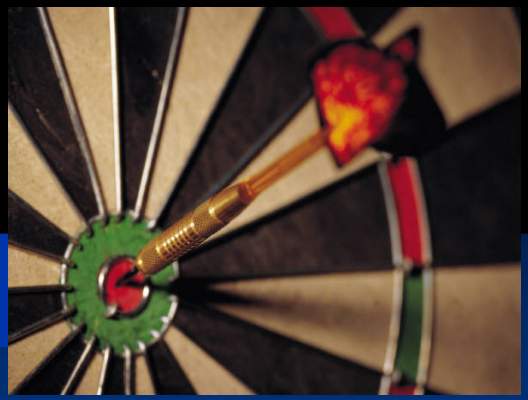
What's the Point?



Parsons' 3-Tiered LTMO Approach combines a qualitative evaluation with temporal and spatial statistics to evaluate the distribution and frequency of groundwater sampling.

The 3-Tiered LTMO approach has been applied at multiple sites and identified significant monitoring program reductions and potential cost savings.

Outline

- Background and Motivation
- Long Term Monitoring Optimization Steps
- 3-Tiered LTMO Analysis
- Applications
- On-Going & Future Projects
- Summary

Background and Motivation

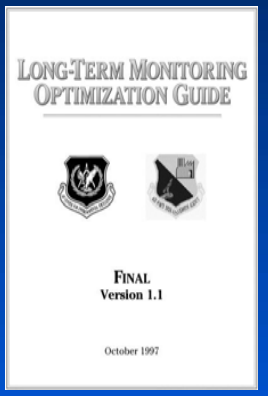
- Long term monitoring represents a significant, persistent, and growing burden
- Often yields “wrong” level of information
- LTMO provides opportunity to identify:
  - Substantial cost savings
  - Identify inadequacies & avoid inefficiencies
  - Prevent potential impacts to public & environment

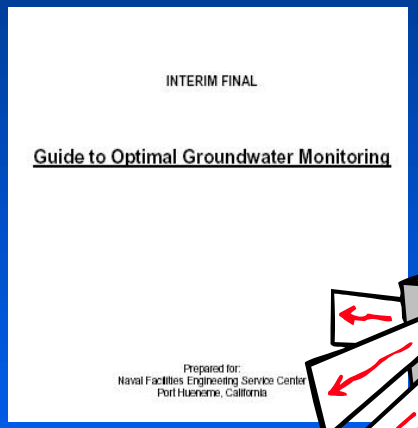
So, LTMO's the way to go… Now what?

- Is it a possibility for my site?
- How do I get started?

PARSONS
3-Tiered LTMO

MAROS Decision Support System
for Optimizing LTM Programs





Navy and Marine Corps Working Group

Optimizing Remedial Action Operations and Long Term Monitoring

Long-Term Monitoring (COMING SOON!!)
Cost-Effective Sampling (Subterranean Research,

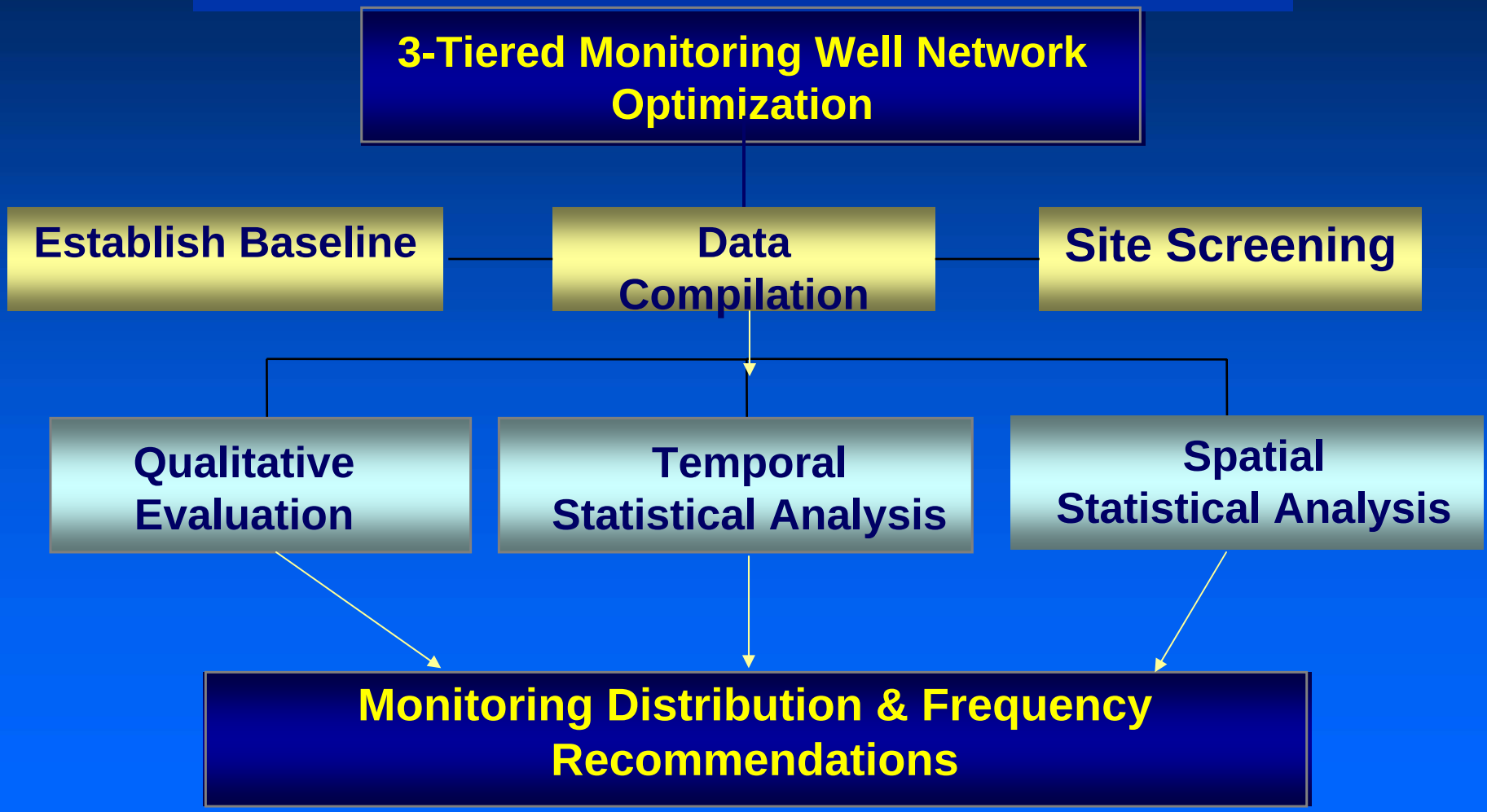
Geostatistical Temporal/Spatial (GTS) Optimization Algorithm

Long-Term Groundwater Monitoring: The State of the Art

Steps Involved in an LTMO

1. Review/Develop Objectives for Monitoring Program
2. Examine Existing Data
3. Determine if Site is a LTMO Candidate
4. Perform Optimization
5. Assess & Implement Results

3-Tiered LTMO At A Glance

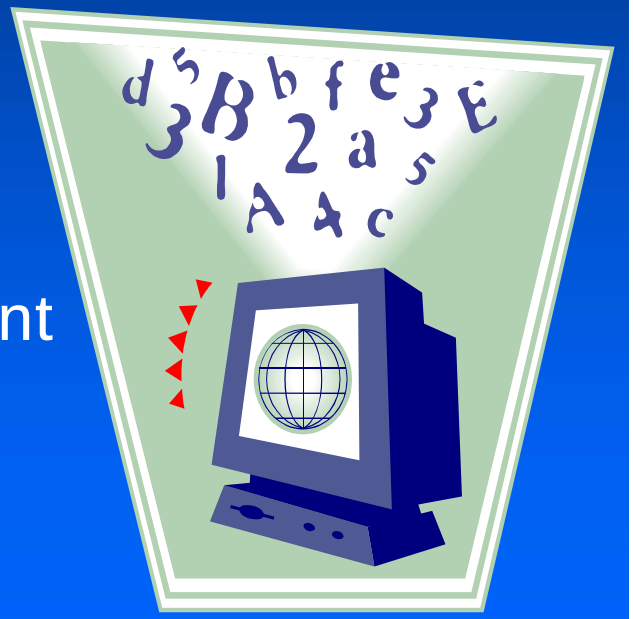


Review/Develop Objectives for Monitoring Program

- Establishing a Baseline…
  - What are you measuring?
  - How often and where?
    - What is the current monitoring program?
    - How much does it cost?
  - Why are you measuring?
    - Regulatory drivers?
    - Points of compliance?
    - Remedy performance evaluation?

Data Requirements

- Description of Current Monitoring Program & Sampling Rationale
- Historical monitoring results
- Well Information
- Plume Source, Nature, and Extent
- Hydrogeologic Conditions
- Groundwater Flow Direction & Gradient
- Site Features
- Cleanup Goals/Regulatory Limits
- Logistical/Policy Considerations



Site Screening: Don't Even Go There?

- Established Monitoring Objectives
- "Long Term Monitoring" Program & Adequately Characterized Site
- Status Quo for Next Few Years
- Flexible Regulatory Environment
- Adequate Data Availability & Format
  - Greater than 10 Wells (preferably > 30)
    - Same plume, aquifer/zone, and timeframe
  - At Least 4 Historical Sampling Events Over 2 Years or More

3-Tiered Analysis Methodology

- Qualitative Evaluation
- Temporal Evaluation
- Spatial Evaluation
- 3-Tiered Summary

Qualitative Evaluation Methodology

- DATA:
  - Site characterization
  - Monitoring results
  - Monitoring Network DQOs, etc.
- INFORMATION:
  - Value of each well in big picture context
- SOLUTION:
  - Recommend:
    - Well retention or removal
    - Optimal sampling frequency

Requires Experienced Hydrogeologist Familiar With Site

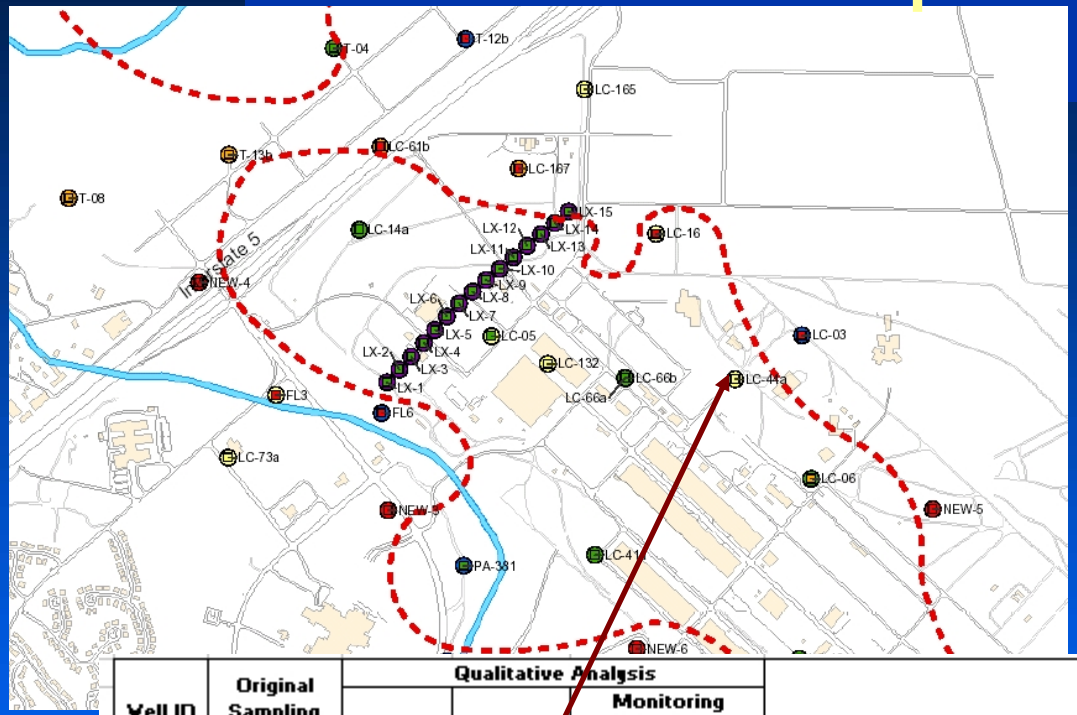
Qualitative Well Spatial Distribution Decision Logic

Reasons for Retaining a Well in Monitoring Network	Reasons for Removing a Well From Monitoring Network
Well is needed to further characterize the site or monitor changes in contaminant concentrations through time	Well provides spatially redundant information with a neighboring well (e.g., same constituents, and/or short distance between wells)
Well is important for defining the lateral or vertical extent of contaminants.	Well has been dry for more than 2 years
Well is needed to monitor water quality at compliance point or receptor exposure point (e.g., water supply well)	Contaminant concentrations are consistently below laboratory detection limits or cleanup goals
Well is important for defining background water quality	Well is completed in same water-bearing zone as nearby well(s)

Qualitative Monitoring Frequency Decision Logic

Reasons for Increasing Sampling Frequency	Reasons for Decreasing Sampling Frequency
Groundwater velocity is high	Groundwater velocity is low
Change in contaminant concentration would significantly alter a decision or course of action	Change in contaminant concentration would not significantly alter a decision or course of action
Well is necessary to monitor source area or operating remedial system	Well is distal from source area and remedial system
Cannot predict if concentrations will change significantly over time	Concentrations are not expected to change significantly over time, or contaminant levels have been below groundwater cleanup objectives for some prescribed period of time

Qualitative Evaluation Results Example

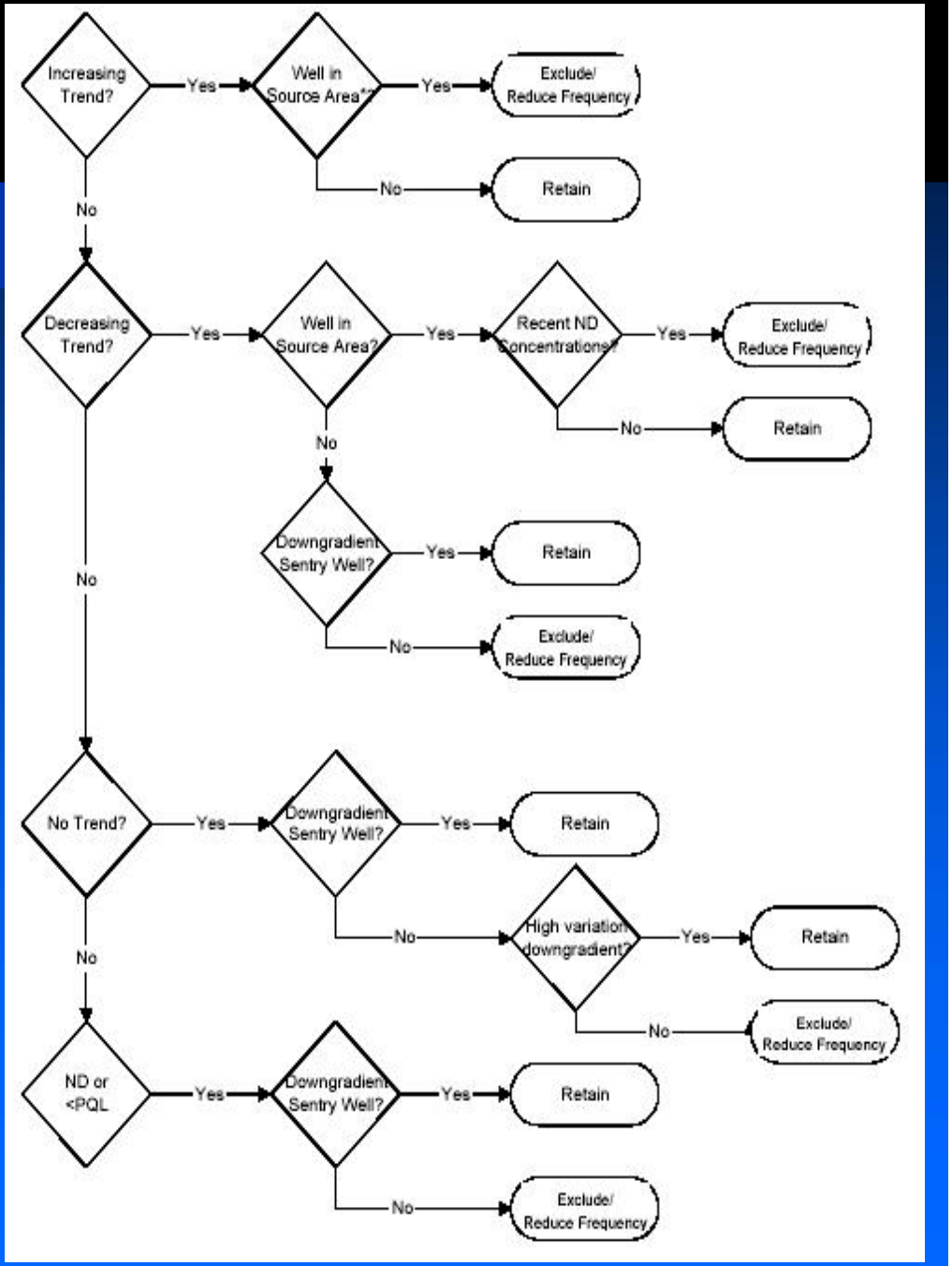


- Recommendation for each well:
  - Remove or retain
  - Sampling frequency
- Provide rationale for decision

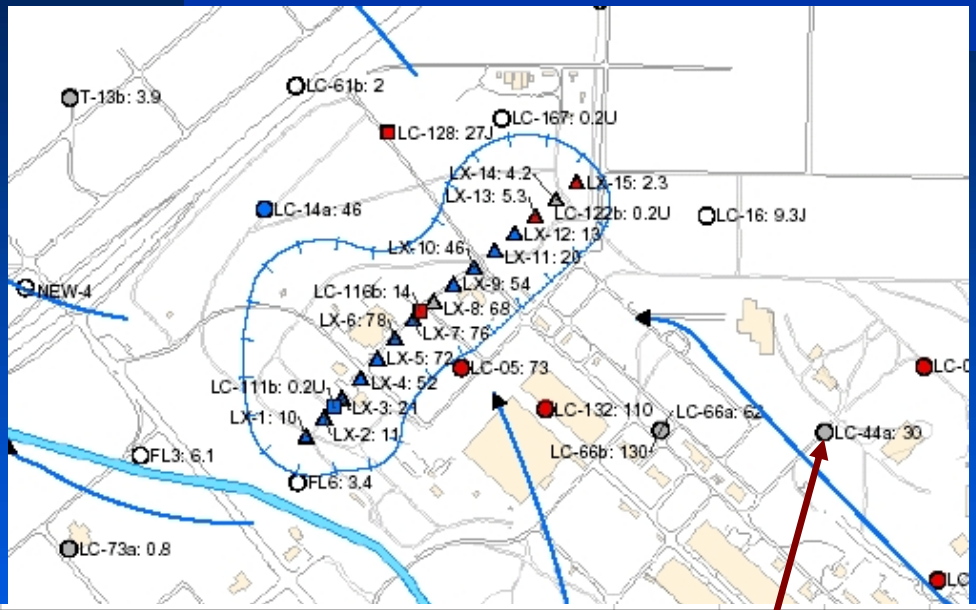
Well ID	Original Sampling Frequency	Qualitative Analysis			Rationale
		Remove	Retain	Monitoring Frequency Recommendation	
Plume Interior Wells					
FL2	None		✓	Annually	Monitors elevated TCE concentrations in southwesterly-migrating lobe of TCE plume.
LC-05	Quarterly	✓		--	Monitoring of this well is not necessary to define the extent and magnitude of the plume over time.
LC-06	Quarterly		✓	Annually	Plume interior well faciltates obtaining periodic snapshot of plume conditions.
LC-14a	Quarterly		✓	Annually	Monitors concentrations along plume axis downgradient of I-5 extraction system near plume toe.
LC-19a	Quarterly		✓	Annually	Monitors plume axis downgradient of source area.
LC-19b	Quarterly	✓		--	Monitors shallower, lower-concentration zone than LC-19a.
LC-19c	Quarterly	✓		--	Similar screen interval as LC-19a, and lower TCE concentrations.
LC-41a	Quarterly		✓	Annually	Monitors elevated TCE concentrations in portion of plume with low well density.
LC-44a	Quarterly	✓		--	Redundant with nearby well LC-66b, which monitors a higher-concentration zone.
LC-49	Quarterly		✓	Annually	Located along plume axis, relatively high TCE concentrations.
LC-51	Quarterly	✓		--	Redundant with LC-53 and FL2.

Temporal Statistical Evaluation Methodology

- DATA:
  - > 4 sampling results over time
  - Well/plume location & GW direction
  - Chemical concentration
- INFORMATION:
  - Mann-Kendall Trend analysis
  - Automated process
- SOLUTION:
  - Recommend retention or removal/reduction based on decision rationale



Temporal Evaluation Results Example



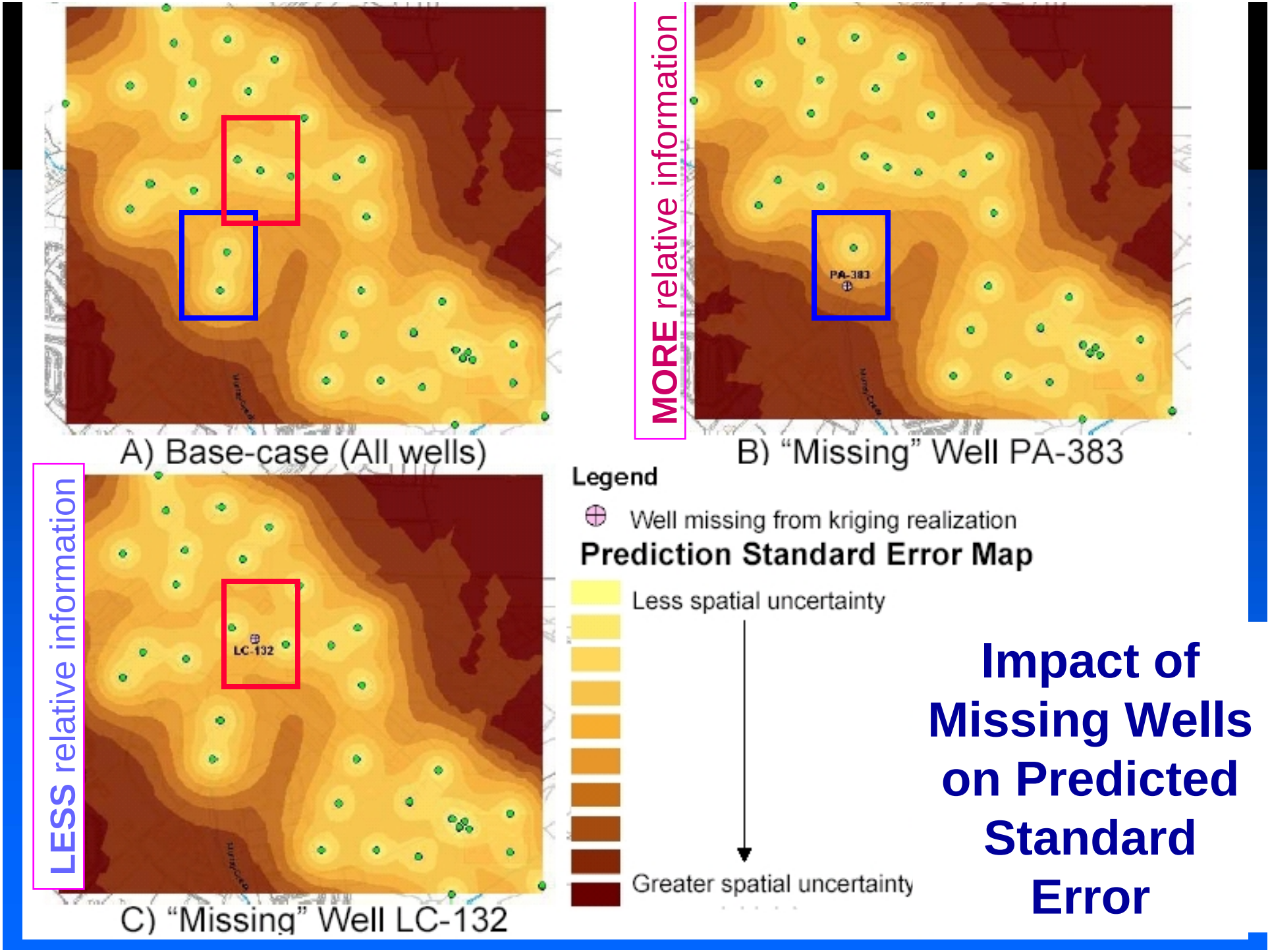
- Recommend Retain or Remove/Reduce
- Based SOLELY on value of temporal information
- Only wells with >4 results per chemical evaluated

Well ID	TCE	cis-1,2-DCE	PCE	VC	Rem/Red	Retain	Rationale
LC-03	Increasing	ND	ND	ND		√	Increasing down/cross gradient.
LC-05	Increasing	Increasing	Decreasing	ND		√	Increasing downgradient of source area.
LC-06	Increasing	No Trend	Decreasing	ND		√	Increasing downgradient of source area.
LC-14a	Decreasing	Decreasing	<PQL	ND	√		Decreasing downgradient of extraction system.
LC-19a	Decreasing	Decreasing	Decreasing	ND		√	Decreasing near extraction system, measure remediation.
LC-19b	No Trend	Decreasing	Increasing	ND	√		No trend TCE downgradient. cis-1,2 DCE and PCE at very low concentrations.
LC-19c	No Trend	No Trend	ND	ND	√		No trend downgradient.
LC-26	No Trend	No Trend	ND	ND	√		No trend slightly upgradient of source area.
LC-41a	No Trend	Decreasing	ND	ND	√		No trend in center of plume, low coefficient of variation (COV).
LC-44a	No Trend	No Trend	Decreasing	ND	√		No trend in center of plume, low coefficient of variation (COV).
LC-49	Increasing	No Trend	<PQL	ND		√	Increasing downgradient of source area.

Spatial Statistical Evaluation Methodology

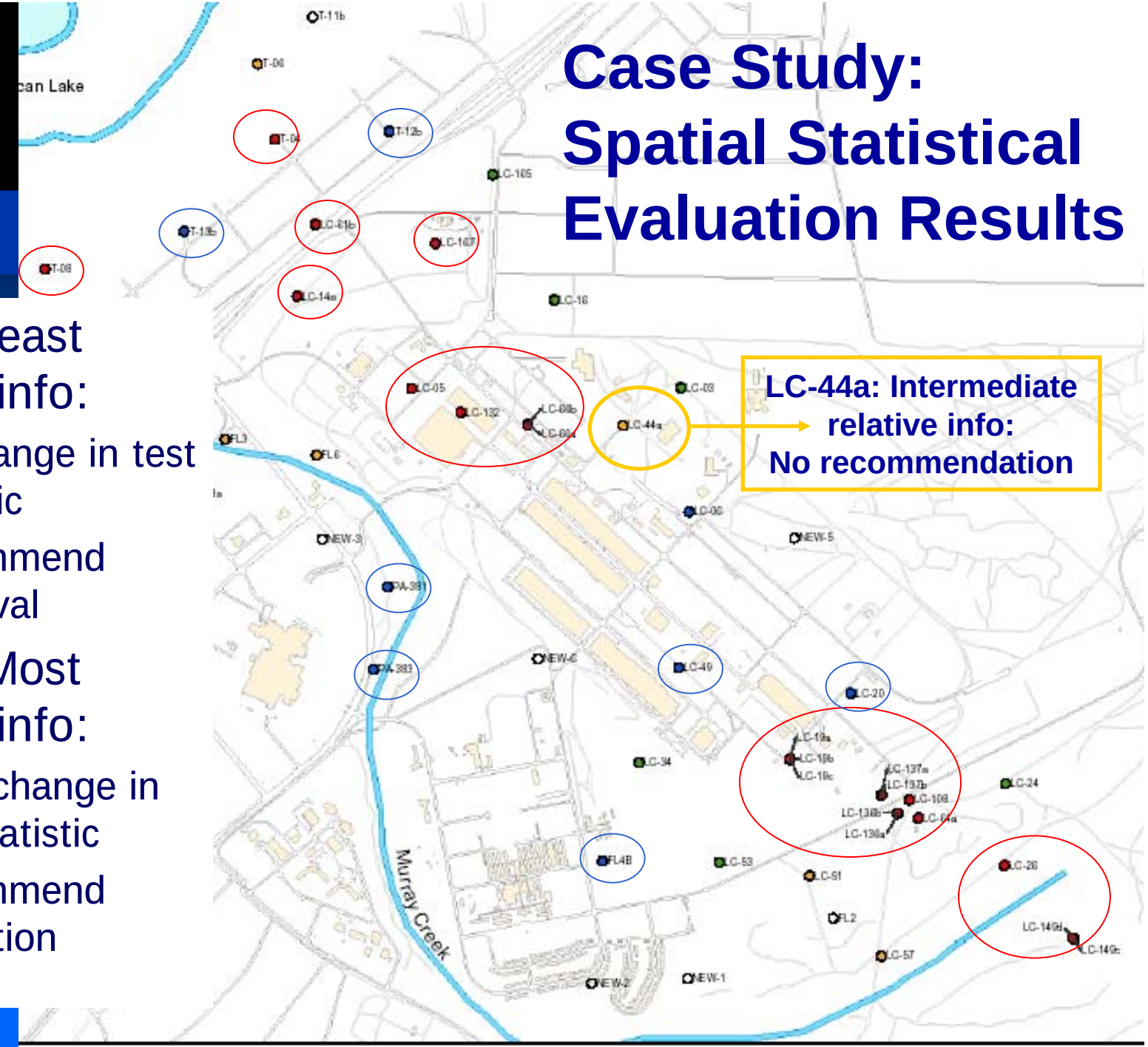
- DATA
  - Spatial “Snapshot” of Plume
    - Most recent chemical concentrations
    - Indicator chemical
    - Wells in same zone
- INFORMATION:
  - Geostatistical (Kriging) Evaluation
    - Develop spatial model (semivariogram)
    - Calculate Kriging predicted standard error metric for each well
  - Conducted Using ArcGIS Geostatistical Analyst Extension
- SOLUTION:
  - Recommend removal or retention based on relative value of spatial information of each well

Requires Experience with Geostatistics & Semivariogram Development

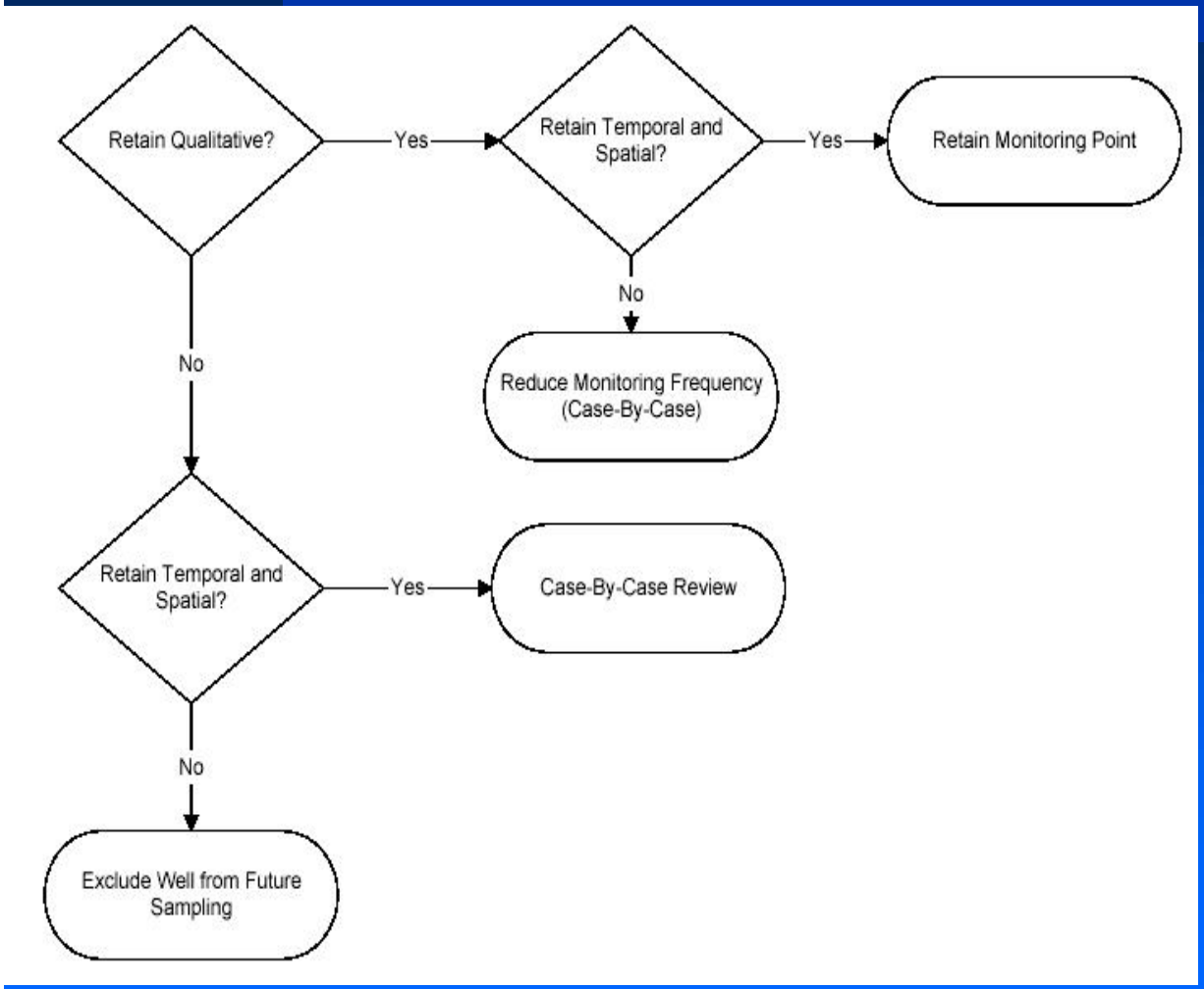

A) Base-case (All wells)
MORE relative information
PA-383
B) "Missing" Well PA-383
LESS relative information
LC-132
C) "Missing" Well LC-132
Legend
Well missing from kriging realization
Prediction Standard Error Map
Less spatial uncertainty
Greater spatial uncertainty
Impact of Missing Wells on Predicted Standard Error

Case Study: Spatial Statistical Evaluation Results

- Red = Least relative info:
  - No change in test statistic
  - Recommend Removal
- Blue = Most relative info:
  - >1% change in test statistic
  - Recommend Retention



3-Tiered Combined Evaluation Summary



- Combine 3 Analyses to Determine Final Distribution and Frequency Recommendation
- Qualitative Verified & Refined by Quantitative

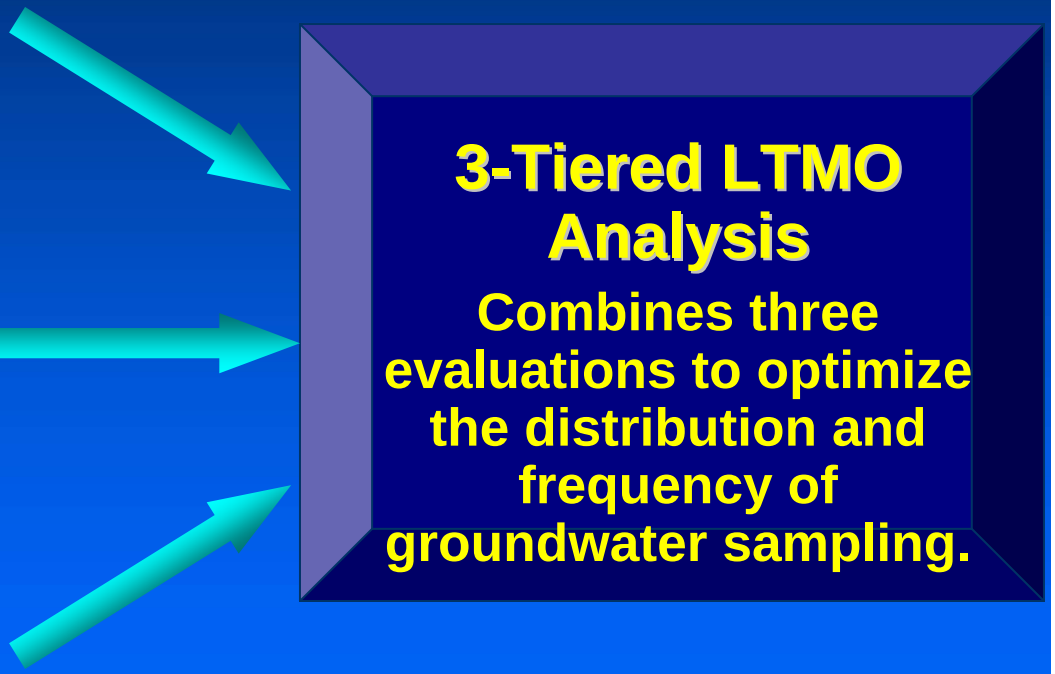
3-Tiered Summary Results Example

Well ID	Qualitative Evaluation		Temporal Evaluation		Spatial Evaluation		Summary		
	Remove	Retain	Remove	Retain	Remove	Retain	Remove	Retain	Recommended Monitoring Frequency
LC-03		√		√				√	Biennially
LC-05	√			√	√		√		--
LC-06		√		√		√		√	Annually
LC-14a		√	√		√			√	Annually
LC-19a		√		√	√			√	Annually
LC-19b	√		√		√		√		--
LC-19c	√		√		√		√		--
LC-26	√		√		√		√		--
LC-41a		√	√					√	Annually
LC-44a	√		√				√		--
LC-49		√		√		√		√	Annually
LC-51	√			√			√		--

- Combines Qualitative, Temporal and Spatial Results
- Case-by Case example:
  - **LC-14a** sampling frequency reduced based on temporal & spatial results

3-Tiered LTMO Analysis Summary

- Qualitative Evaluation
  - Experienced geologist big-picture analysis
- Temporal Statistical Evaluation
  - Mann Kendall trend analysis
- Spatial Statistical Evaluation
  - Geostatisical Kriging relative predicted error analysis



Applications

- 20+ Sites in Past 3 Years
- 10 to 300+ Well Monitoring Networks
- Identified 13% - 83% Reductions*
- On Average Identified Over 1/3 Reductions*
- Results Highly Dependant on Site Conditions
  - No recent optimization and more frequent current sampling → higher identified reductions
  - Sites with small number of wells can still lead to significant relative reductions

*Reduction in average sampling events per year

On-Going & Future Projects

- Evolving Method...
  - Automation of spatial evaluation
    - Multiple chemical & time period evaluation
- 3-Tiered/MAROS Demonstration Project
  - Sponsored EPA & AFCEE
  - Final report expected summer, 2004
- LTMO Roadmap
  - Sponsored by EPA & USACE
  - Draft in August

LTMO Roadmap

- **Audience:** managers, regulators, scientists and engineers tasked with reviewing monitoring programs
- **Goals:**
  - Understand the steps involved
  - Determine if a LTMO assessment is appropriate
  - Evaluate which LTMO methods and techniques are appropriate
  - Access more information and resources about LTMO tools

Summary

- Long Term Monitoring: essential & costly
- Long Term Monitoring Optimization
  - Potential cost savings
  - Improved understanding of site
- **Parsons is Leader in LTMO Analysis**
  - 3-Tiered LTMO Method combines qualitative & quantitative analysis
  - Method highlighted in EPA Demonstration/Roadmap

Thank you! Questions?

Identifying Opportunities for Cost Savings Applying Long Term Monitoring Optimization

For more information please contact:

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