Large Scale Groundwater Monitoring Program Optimization

Presented By
Eryn Torres
Geosyntec Consultants

Objective

Introduce Optimization and Plume Stability Methods:

- Plume Stability Characterization
- Groundwater Monitoring Program Optimization
  - Well Network Optimization
  - Sampling Frequency Optimization

Client Problem

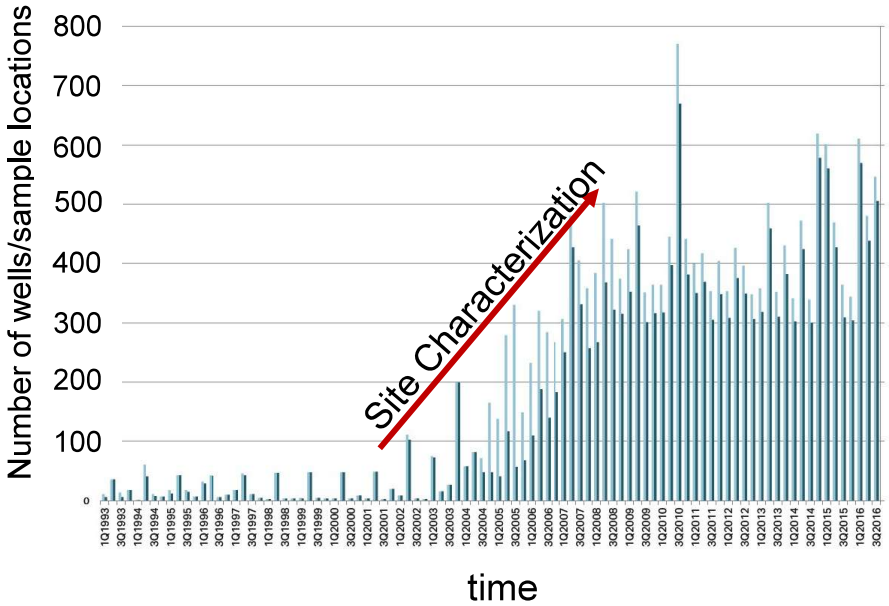
- 861 well network
- Quarterly Sampling and Reporting of ~450 wells
- ~$1M annually
  - Lab
  - Field
  - Data Management & Analysis
  - Report Figures
  - Report Writing

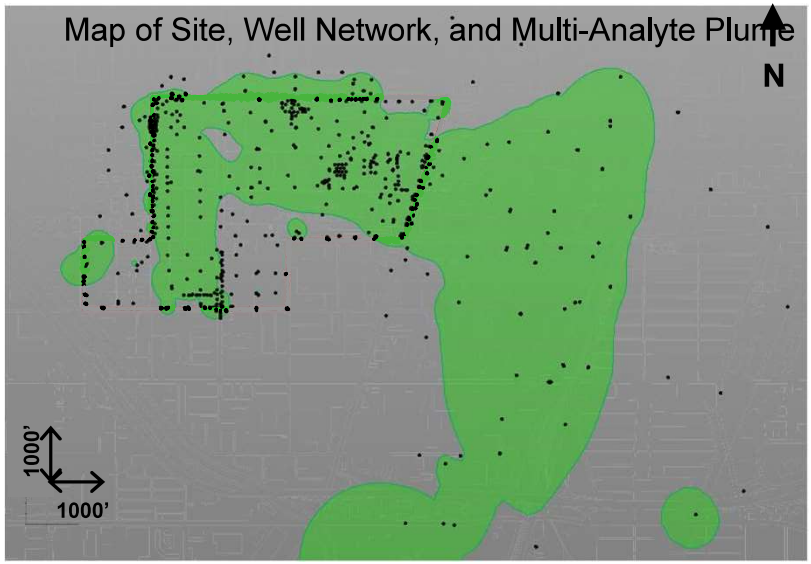
All depend on number of wells and sampling frequency

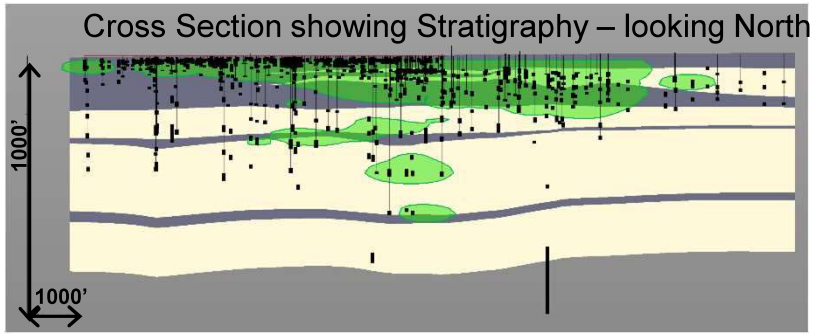
- How can we save money??
- Can we apply similar logic to other sites?

Case Study: Large Chemical Terminal Site

- **Site Area: 450 ac, Plume Area: 1,000 ac**
- **Network Coverage: >2,000 ac (861 wells)**
- **Frequency: quarterly sampling and reporting of ~450 wells**
- **Depth of impacts: 625 ft bgs**
- **7 aquifers**
- **COCs: 1,2-DCA, Benzene, DIPE, TBA**







Agency/Regulator Engagement

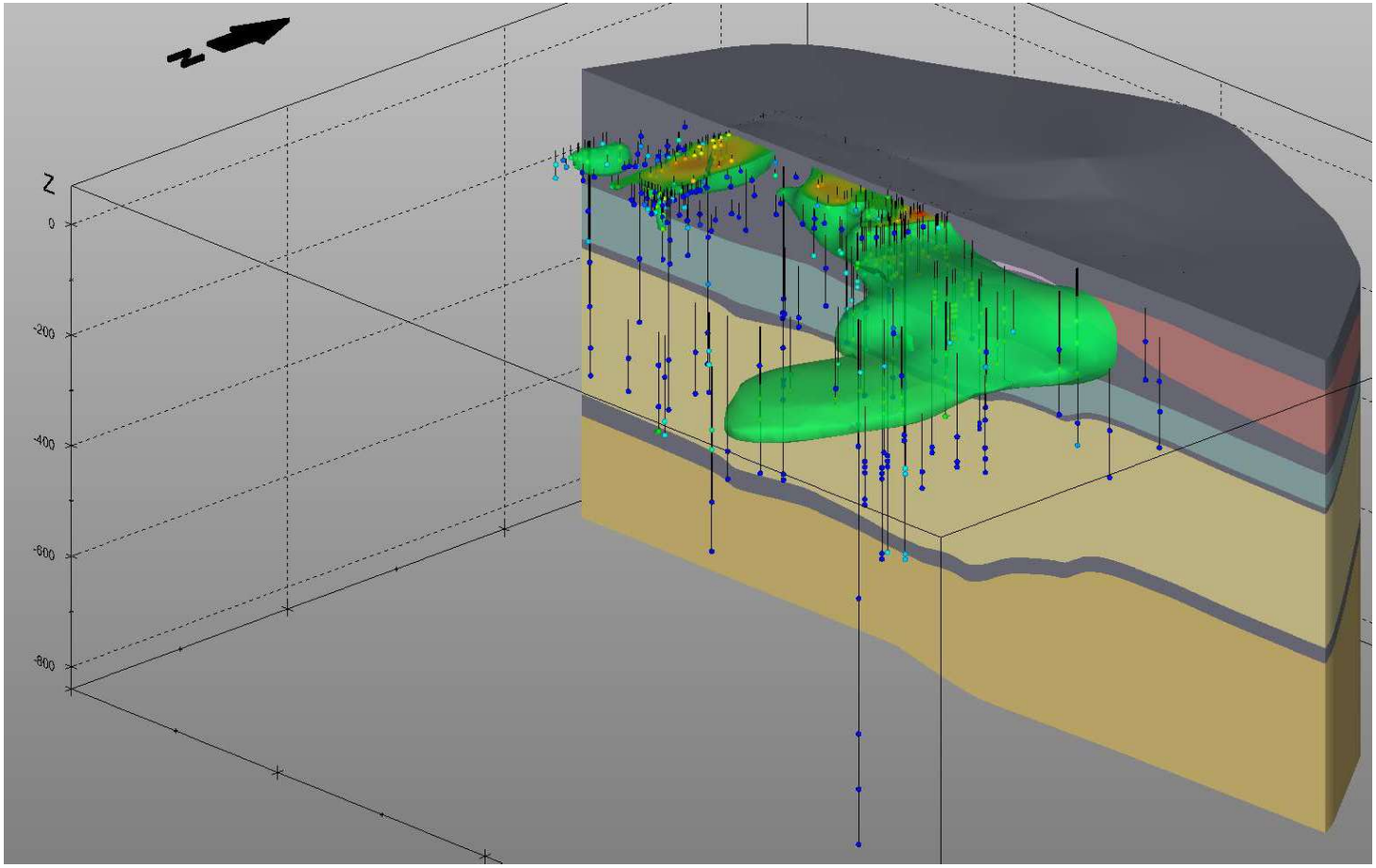
- **Build Credibility**
- **Establish Trust**
- **Incorporate Feedback**
- **Ensure Transparency**
- **Foster Open Dialogue**

Method

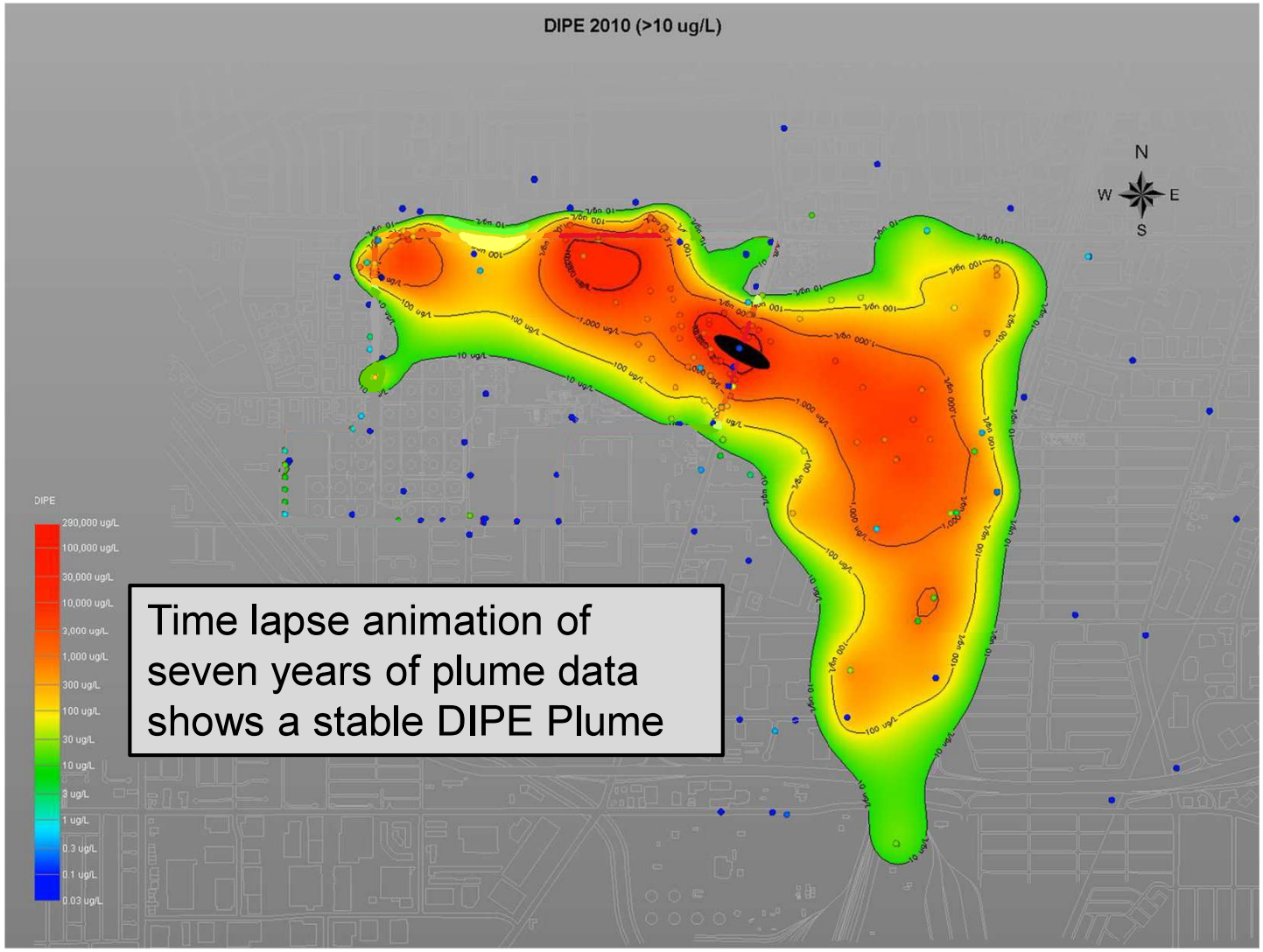
- **Plume Stability**
  - **EVS**
- **Well Network Optimization**
  - **Python and EVS**
- **Sampling Frequency Optimization**
  - **CES using MAROS**

Intro to EVS

EVS: powerful volumetric software used to create complex 3D geologic, chemical, and hydrogeologic models of the subsurface.



Plume Stability Maps – DIPE – 2010-2016



Time lapse animation of seven years of plume data shows a stable DIPE Plume

Techniques for Geospatial Optimization

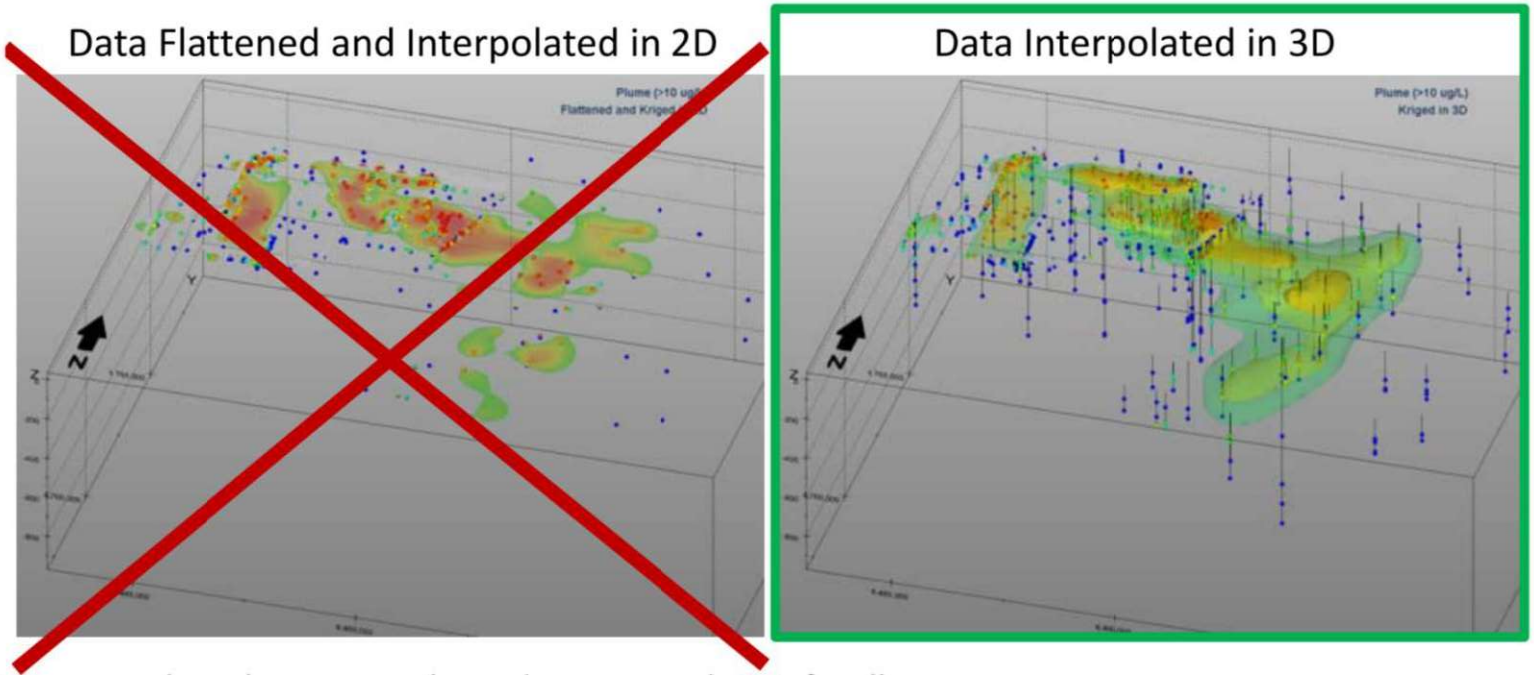
Spatial Uncertainty Analysis

- Uses uncertainty derived from standard deviation.
- Useful for adding wells.
- Criteria not clear – what uncertainty is tolerable?

Redundancy Analysis

- Replicates trends using subset
- Tests if sample point can be removed.
- Criteria can be tailored.

Out of the box tool: Runs in 2D



Exhaustive Search via Leave-One-Out Method

Complete Dataset
(**722** sample locations in 668 wells)

Final list is identified
(**306** sample locations in 299 wells)

Python Automated Process

Leave-One-Out (LOO):
find Least Significant Well

Criteria:

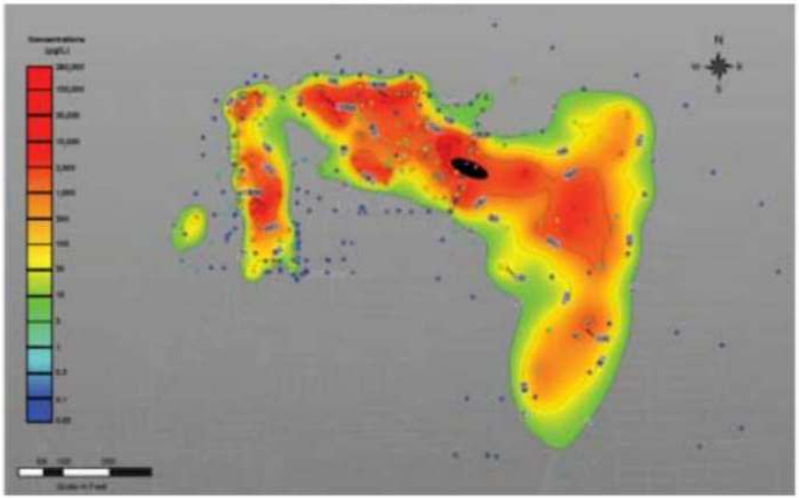
- Mass change < 25%
- Volume Change < 25%
- Boundary Moved? (yes/no)
- Minimum compound delta (μg/L)

Identify and Remove Least Significant Well

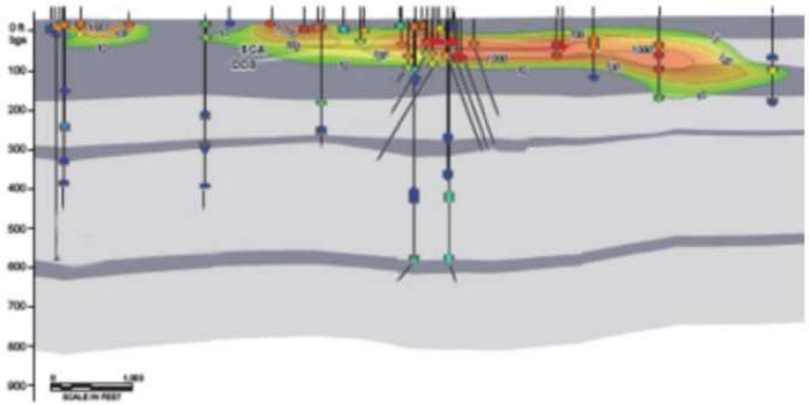
Create new Input file with X - Least Significant Well

Comparing DIPE Plumes - Full (722) vs. Optimized (306)

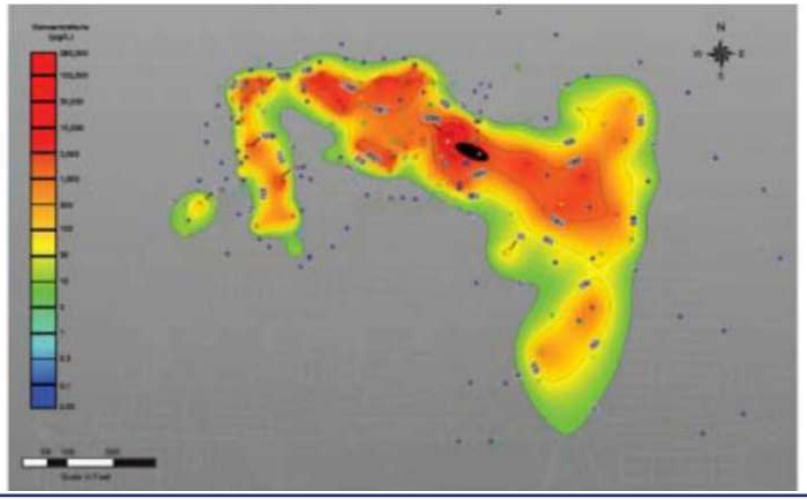
Full Network – Map View



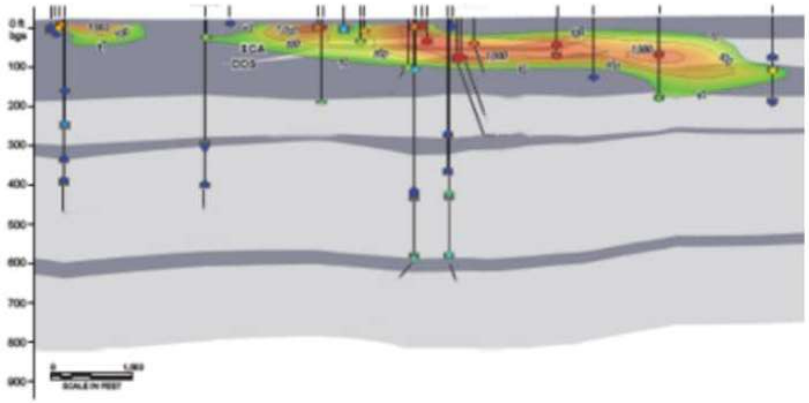
Full Network – Cross Section View



Optimized Network – Map View



Optimized Network – Cross Section View



Techniques for Sampling Frequency Optimization

Iterative Thinning

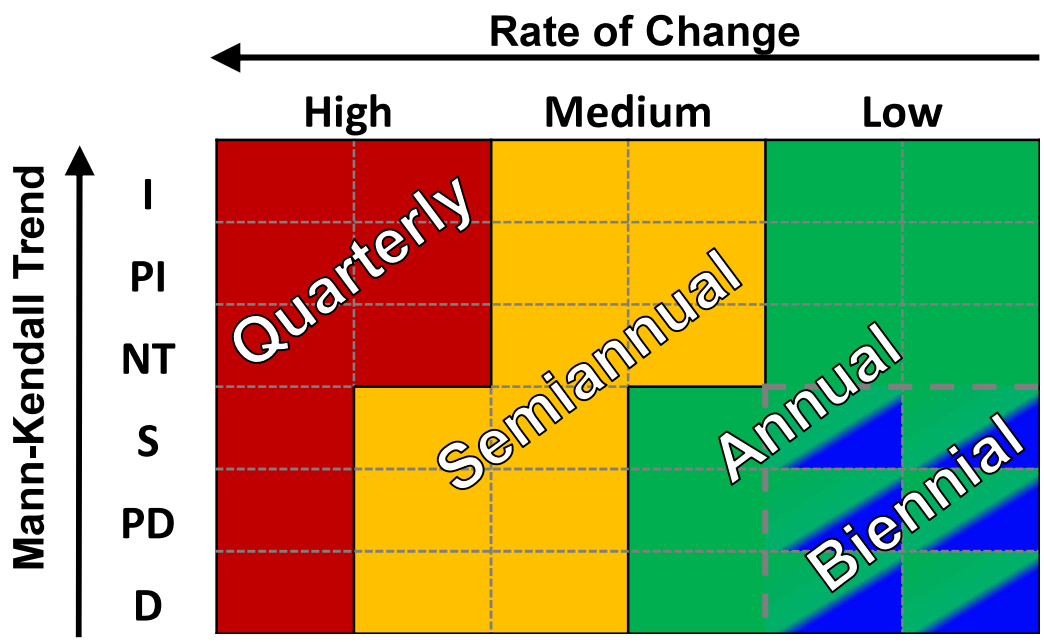
- Replicates trends using a subset.
- Difficult to defend if trends are not clear.
- Confidence level must be chosen.
- Difficult for frequent non-detects.

Cost Effective Sampling (CES)

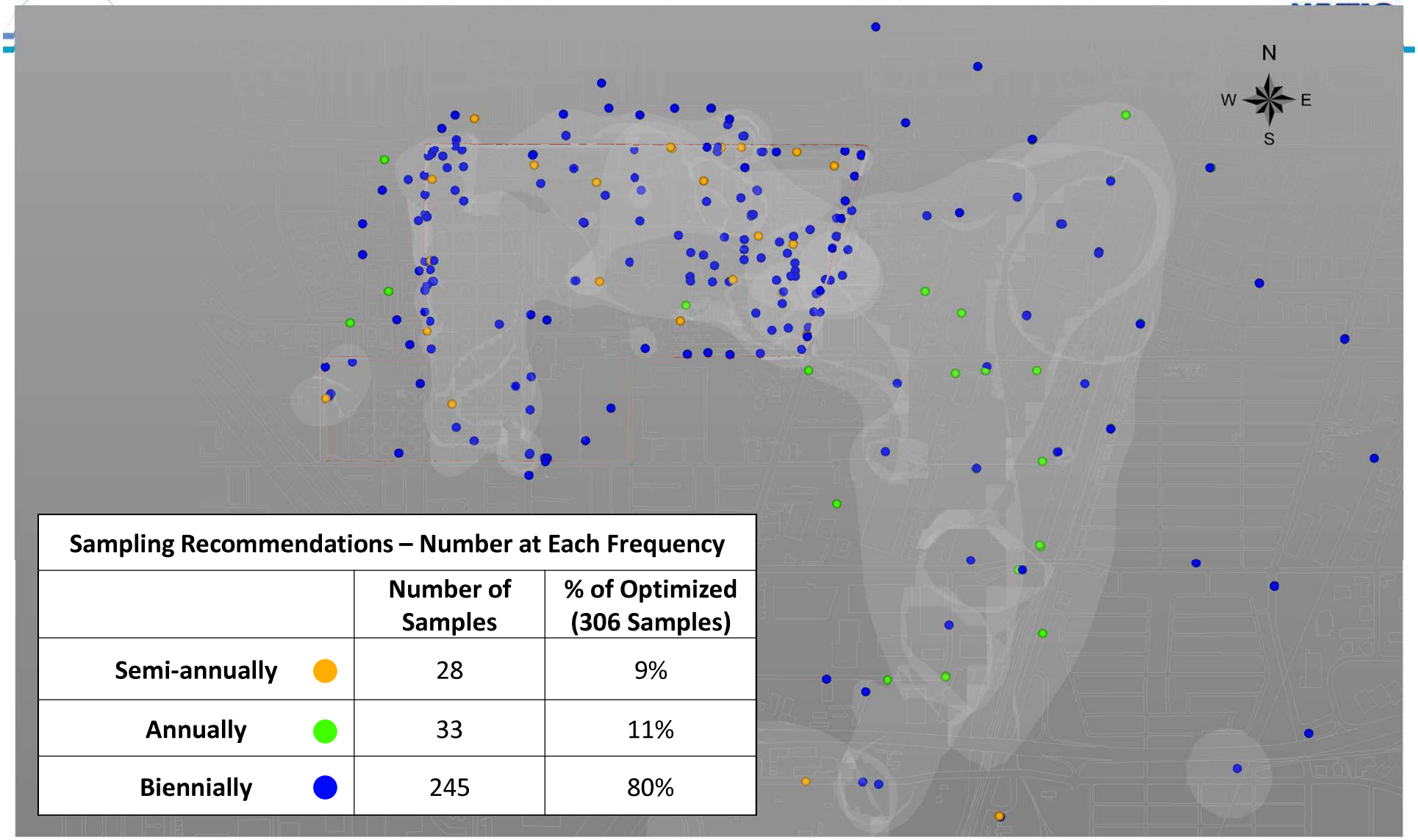
- Uses trends and Rates of Change
- Recommends minimal sampling
- If rates are low, or trends declining, less frequent sampling required.

MAROS CES Analysis

- Monitoring And Remediation Optimization Software (MAROS)
- CES Sampling Frequency Analysis
  - Linear Regression and Mann-Kendall Trends for each analyte, for each well
  - Long-term and recent
- Tools used on Optimized Dataset (306 samples)



CES Sampling Frequency Recommendations



Sampling Recommendations – Number at Each Frequency		
	Number of Samples	% of Optimized (306 Samples)
Semi-annually	28	9%
Annually	33	11%
Biennially	245	80%

Repeatability

- **Consistent communication and transparency with the Agency leads to credibility and trust.**

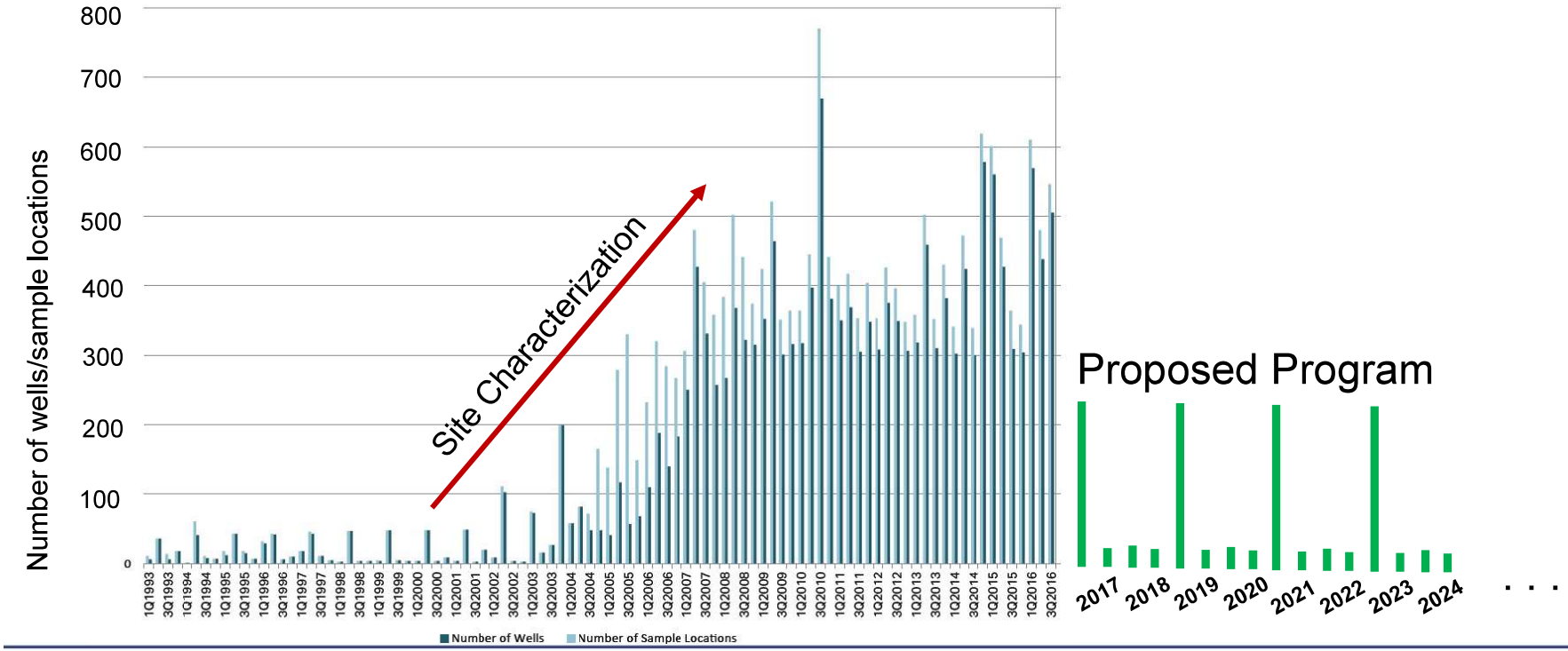
- **Automation of the decision algorithm and customization of decision points leads to flexibility to apply to other large sites.**

Knowledge Check

- **A 2D representation of a complex site is often appropriate.**
  a) **True**
  b) **False**
- **What is important about Agency/Regulator engagement?**
  a) **Builds trust and credibility.**
  b) **Ensures proposed program will be approved.**

Summary

- **Method customizable to sites and goals**
  - **Plume Stability Characterization**
  - **Well Network Optimization**
  - **Sampling Frequency Optimization**
- **Innovative Method, State of the Art Software**
- **Agency engagement leads to method buy-in**
- **Implementation saves client 65% of their $1M annual monitoring and reporting costs**



Contacts and Questions

Points of Contact

Eryn Torres

– etorres@Geosyntec.com

Questions ?