Using Monitoring Data to Assess Remedy Progress: Using Temporal Changes in Plume Metrics

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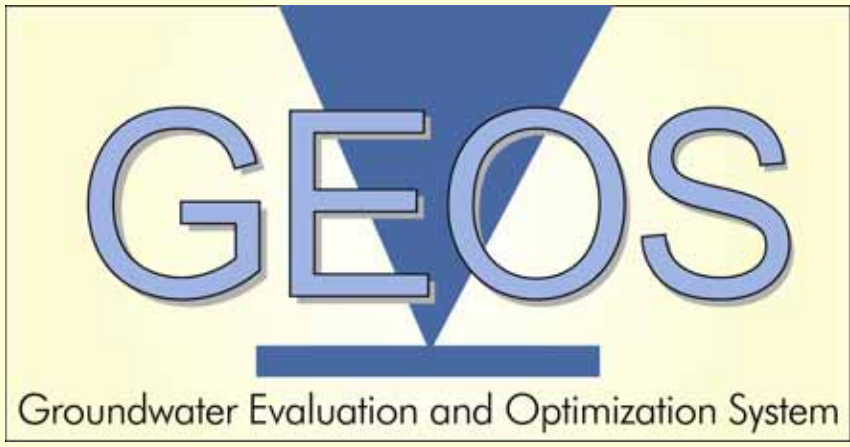

Problem

-How to evaluate the effectiveness or progress of a clean-up?

-How to process and understand the voluminous amount of monitoring data that increases with each passing year?

GEOS Solution

-Collection: Obtain data in a standardized electronic format (Region 5 EDD, Multimedia EDD)

-Assembly: Assemble all info relevant to site cleanup in a "Remedy Performance and Compliance (RPC) Report"

-Analysis: Perform standardized and normalized analyses that management and staff can use to evaluate Superfund remedy progress and cleanup effectiveness

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Remedy Performance Issues

- No standard EPA method for determining if contaminant plumes have gotten better

- No standard EPA method for determining if progress of long-term cleanups are progressing as planed

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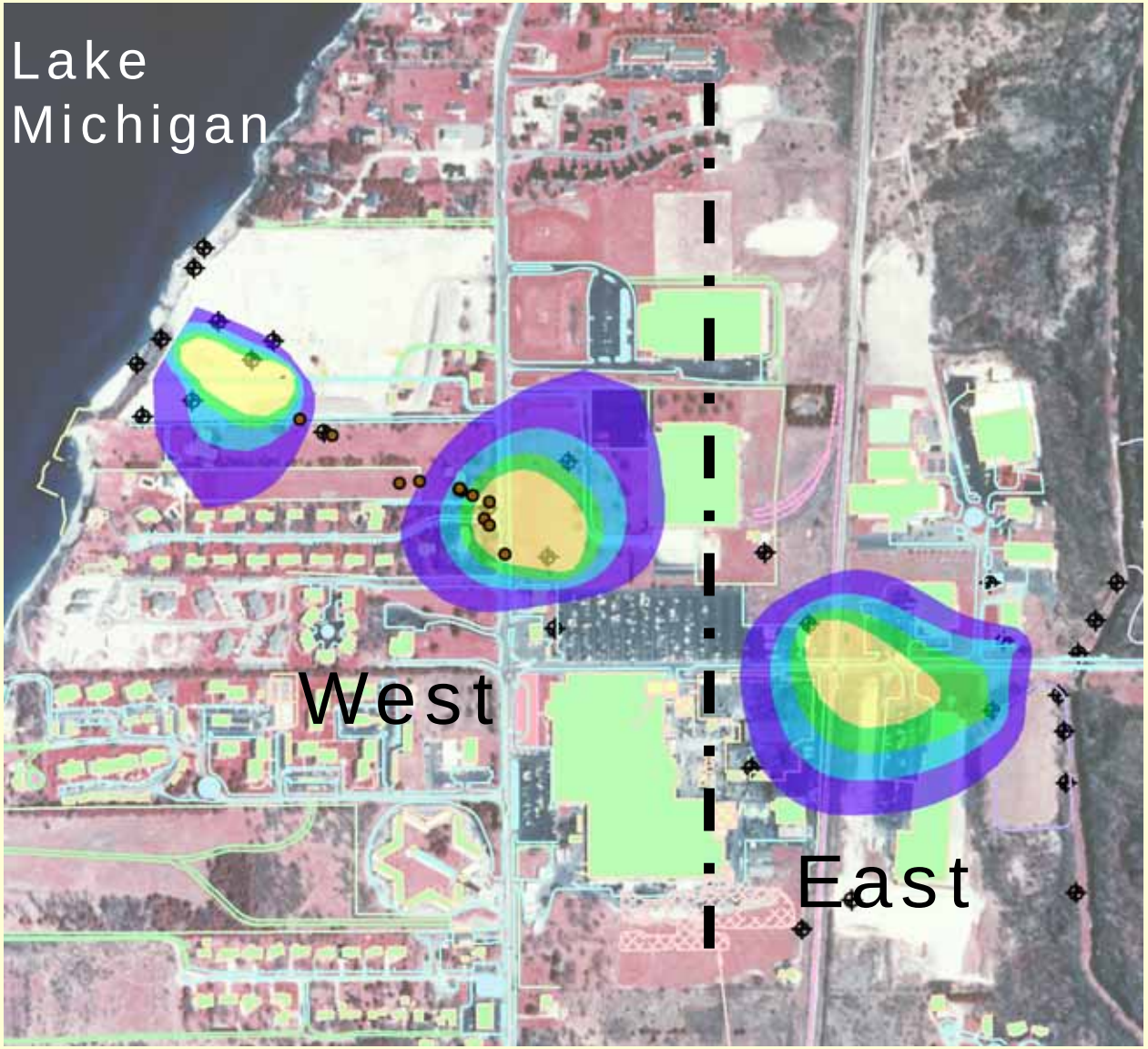
Remedy Performance Issues

TCE East & West Plume at Bendix Superfund Site
St. Joseph, MI



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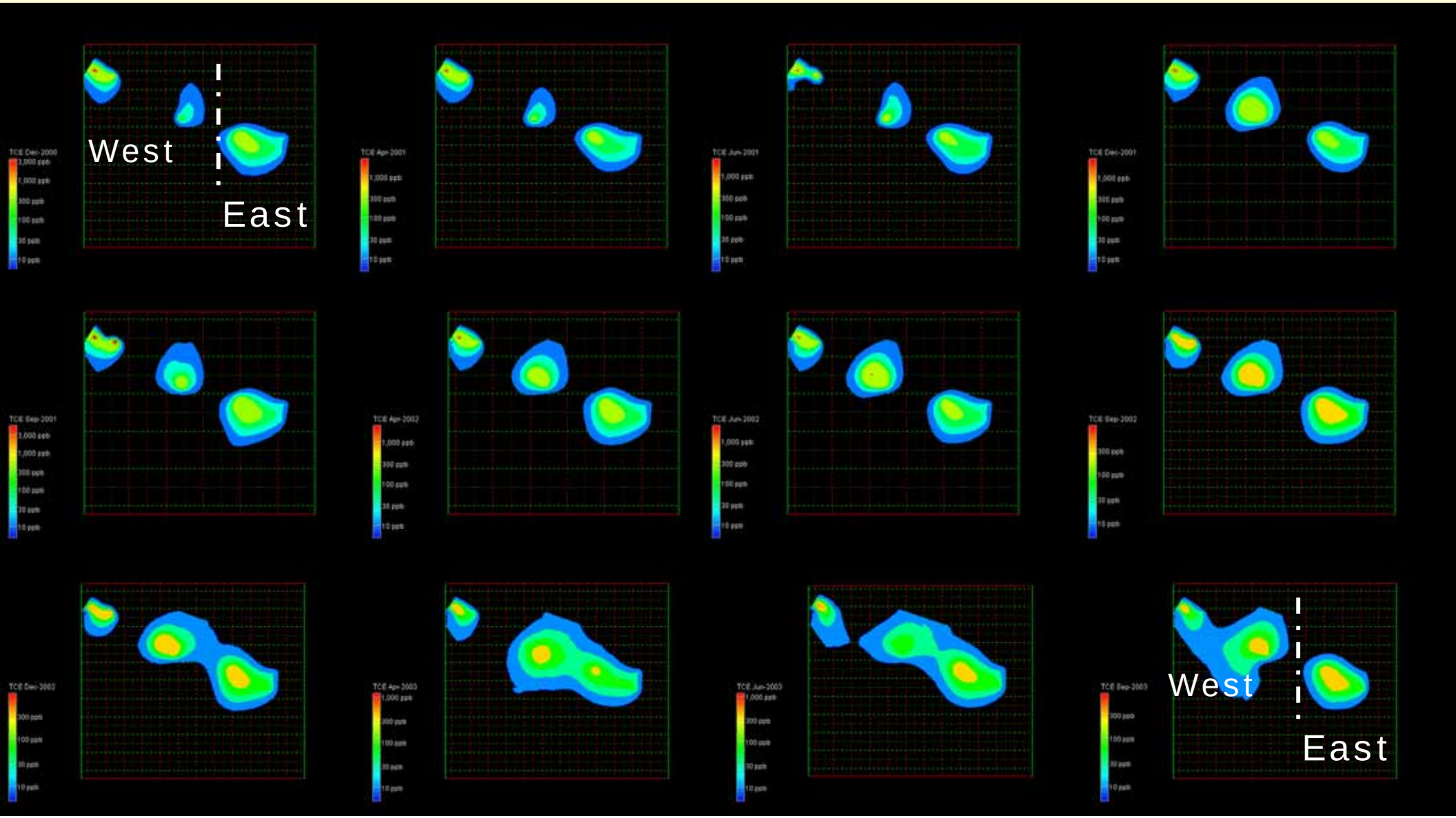
Remedy Performance Issues

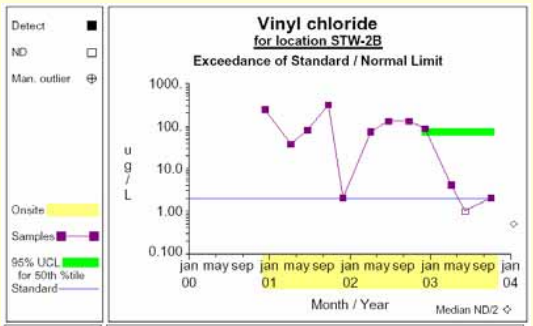
What is happing here?

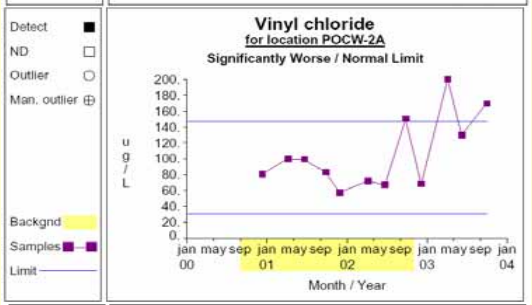
12 snapshots of a TCE East & West Plume at Bendix Superfund Site St. Joseph, MI from 2000 to 2003

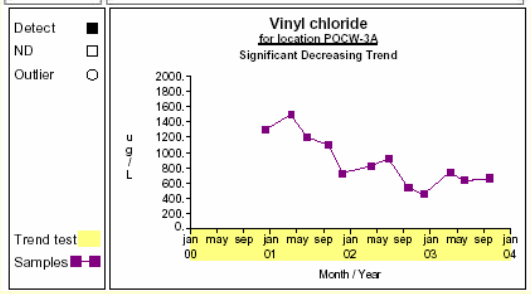


Traditional Method

- Perform a variety of statistical methods on individual monitoring wells







Contaminants and Wells	Well Location	UCL	Standard (MDEQ Residential Criteria)	Exceed Standrd	Worse or Better?	Trend
1,1,1-Trichloroethane			200 ug/L			
1,1-Dichloroethane			---			
MWE-1	Center line of East Plume				Worse	
POCE-3	Upgradient of discharge point of East Plume				Worse	
BDW-1	West Plume boundary				Worse	Increasing
BDW-2	West Plume boundary				Worse	
MWW-1	Center line of West Plume					Decreasing
POCW-1A	Upgradient of discharge point of West Plume				Worse	
POCW-3B	Upgradient of discharge point of West Plume				Worse	
1,1-Dichloroethene			7 ug/L			
MWE-1	Center line of East Plume	27.367		Yes		
STE-2	Upgradient of East Plume POC wells	10.000		Yes		
MWW-2	Center line of West Plume	287.196		Yes		

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Emerging Complementary Method

Analyze the contaminant plume as a whole

- Translate the data-driven estimate of a plume into metrics
- Tracked and compared metrics over time

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Metrics Include:

- Size of the plume (plume mass and volume)
- Distribution of areas of high or low concentration
- Location of the plume (center of plume mass)
- Shape of the plume (plume spread)
- Plume orientation (center line of plume)

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Metrics Include:

Determining Moments above Specified Cutoff Concentration Value

n porosity

$c(x, y, z, t)$ concentration at point in space, time

$\gamma(c-\hat{c})$ = 1 if concentration > cutoff value
= 0 if concentration < cutoff value

$$V_{c>\hat{c}} = \iiint_{V_{aquifer}} n\,\gamma\,dx\,dy\,dz \qquad Volume$$

$$M_{c>\hat{c}} = \iiint_{V_{aquifer}} c\,n\,\gamma\,dx\,dy\,dz \qquad Mass$$

$$\bar{x}_{c>\hat{c}} = \frac{\iiint_{V_{aquifer}} x\,c\,n\,\gamma\,dx\,dy\,dz}{M_{c>\hat{c}}} \qquad Center\ of\ Mass$$

$$S_{xx|c>\hat{c}} = \left[\frac{\iiint_{V_{aquifer}} (x-\bar{x})^2\,c\,n\,\gamma\,dx\,dy\,dz}{M_{c>\hat{c}}}\right]^{1/2} \qquad Spread(xx)$$

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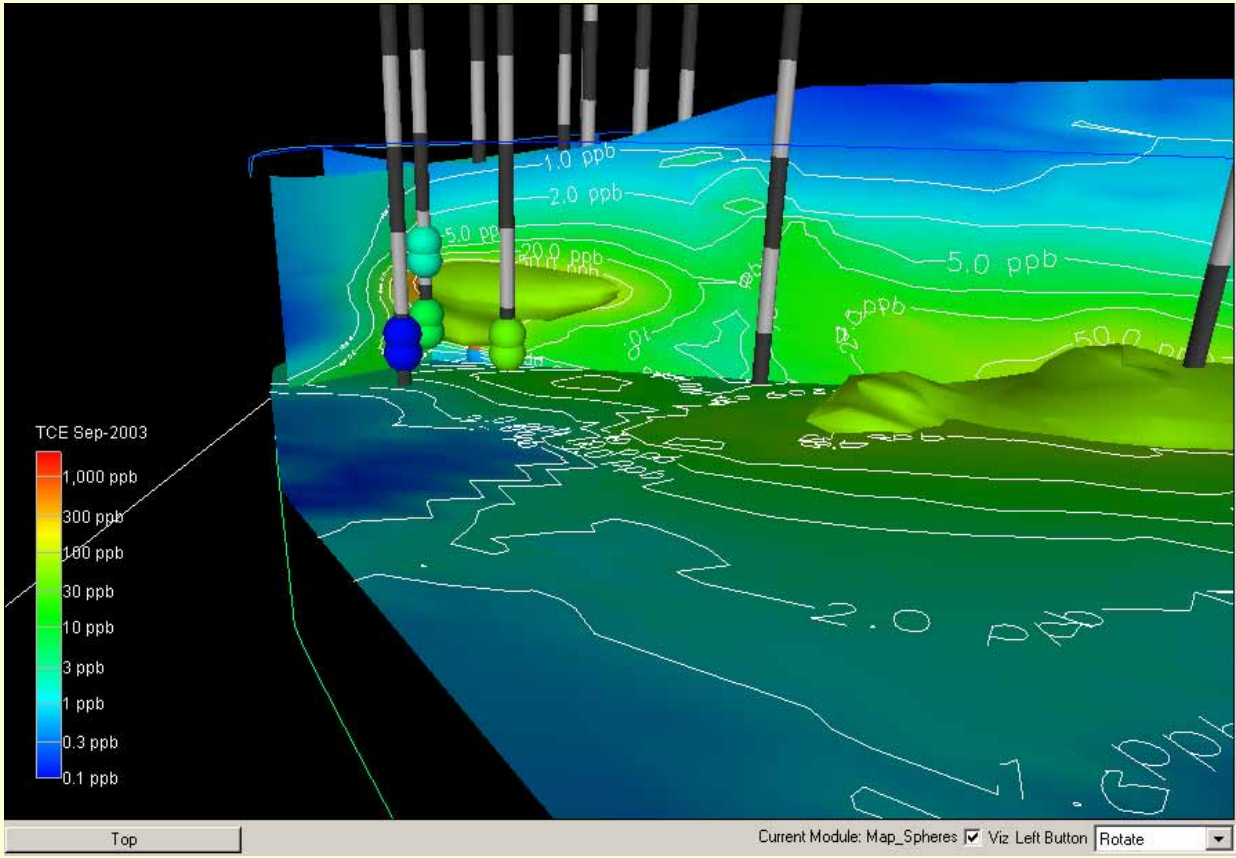
Metrics Include:

- Size of the plume (plume mass and volume)

Determine the 3D mass/volume of target contaminants for each round of data



Amount of dissolved contaminant is indicator of

- Initial problem
- Current problem
- Cleanup progress
- Risk Reduction

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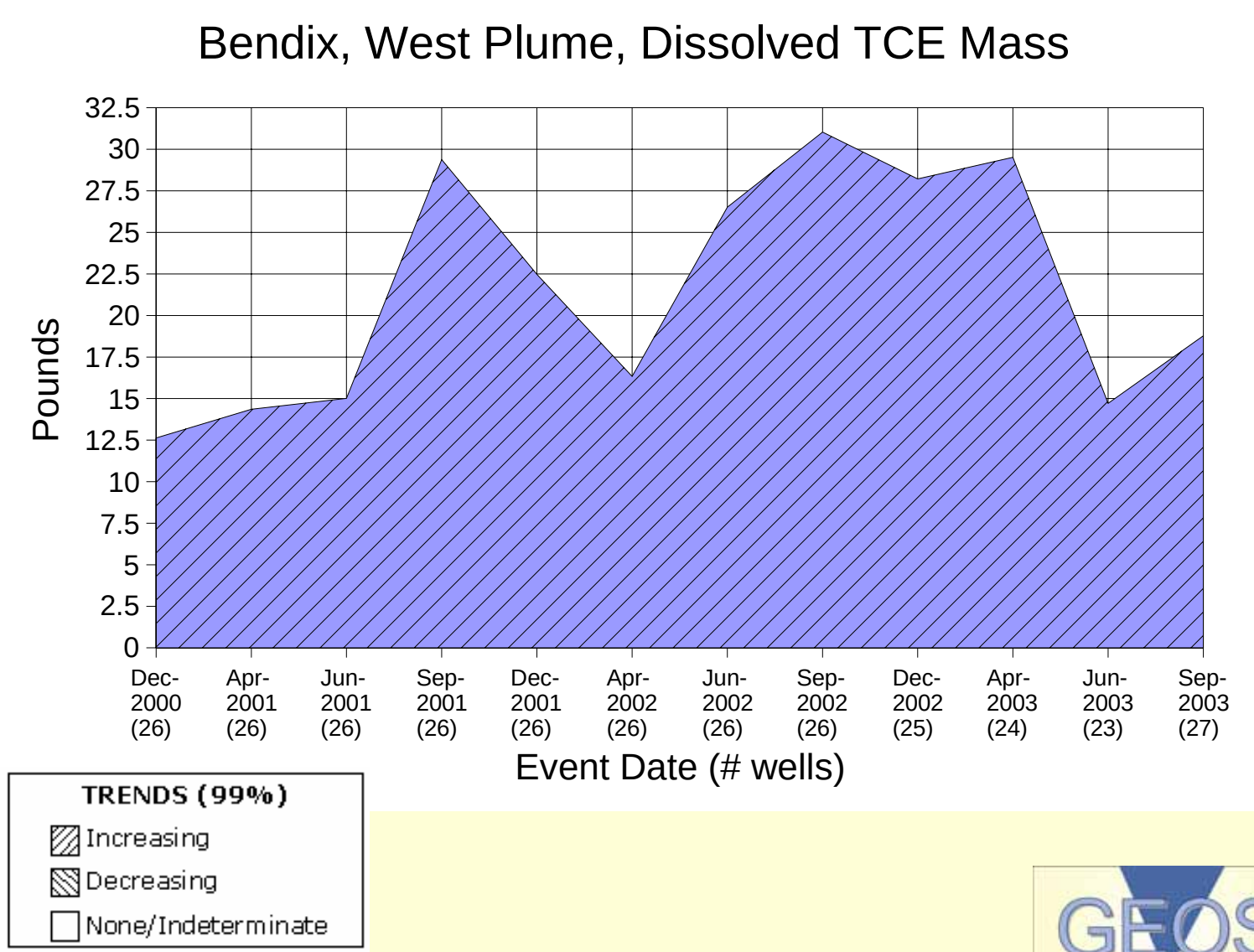
Trends present in metric?

- Is plume *mass* trending up or down over time?

Issues:
Number of well sampled can effect mass/volume



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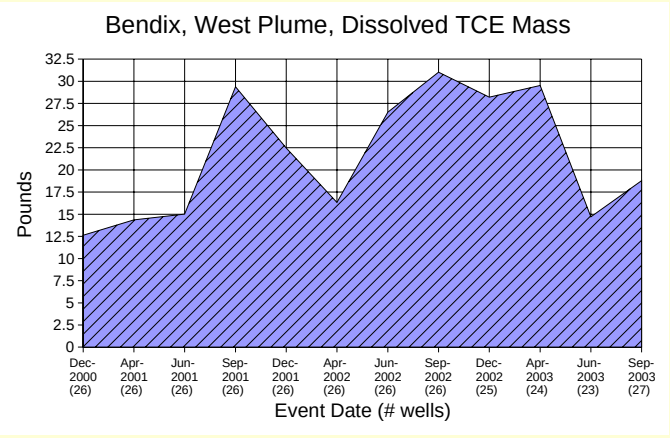
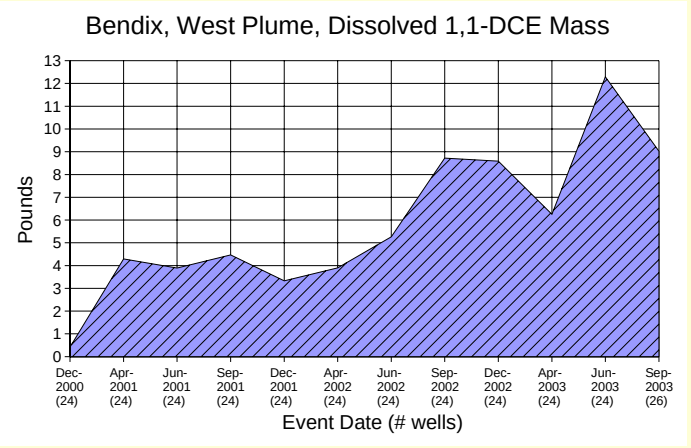
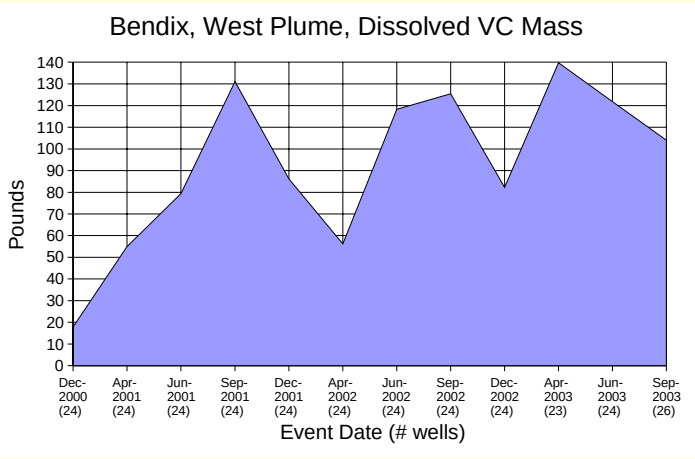
Trends present in metric?

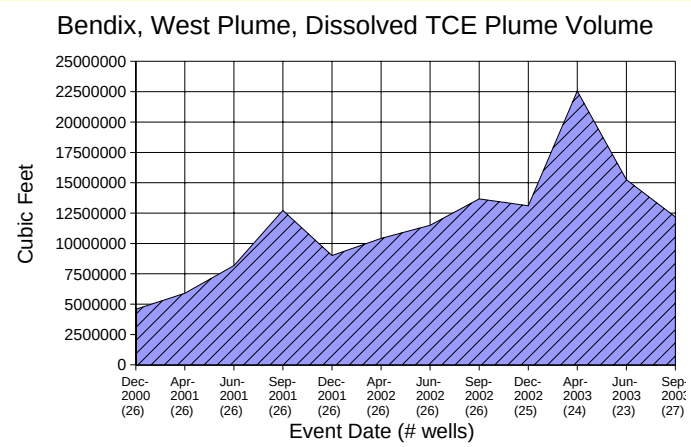
➢Is plume *mass* trending up or down over time?

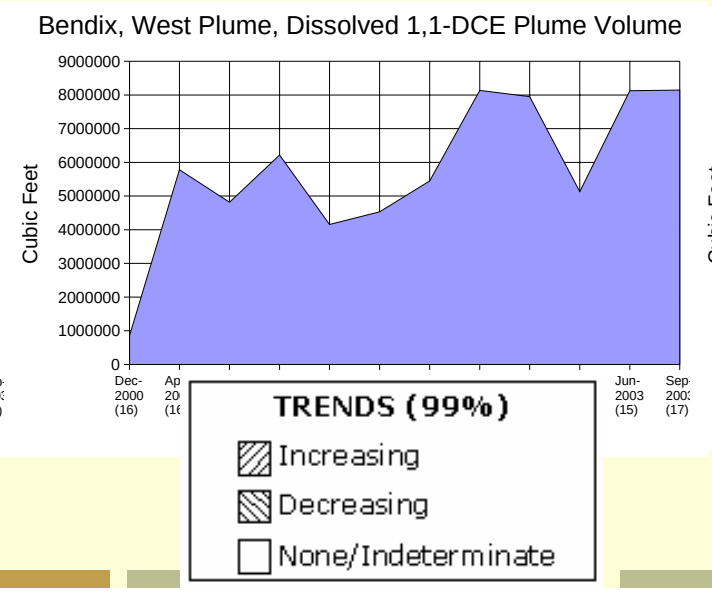


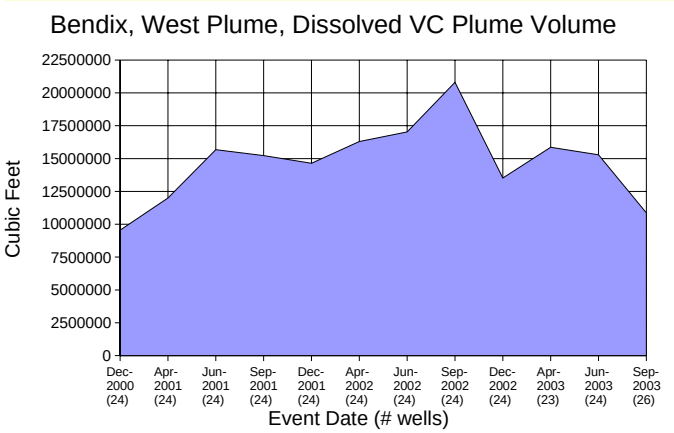




➢Is plume *volume* trending up or down over time?



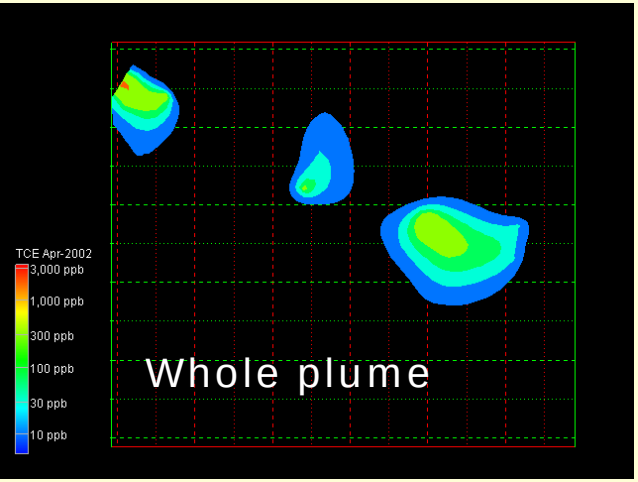


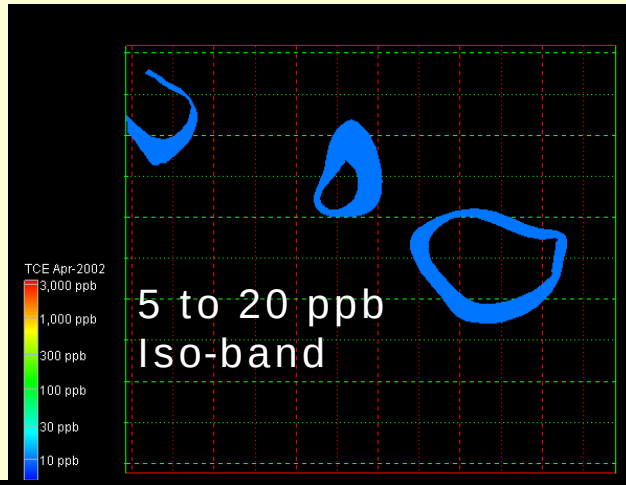


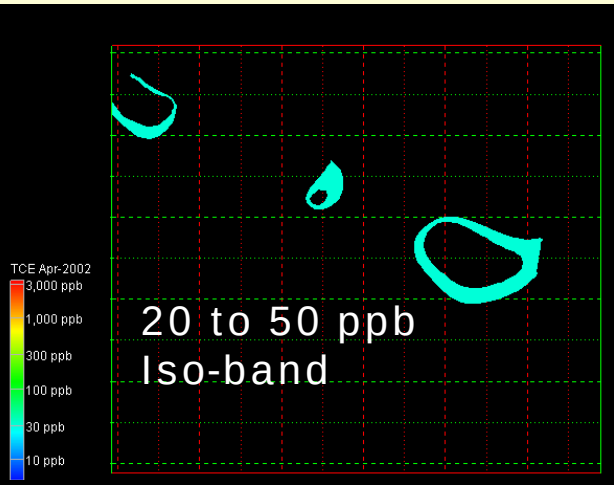
Metrics Include:

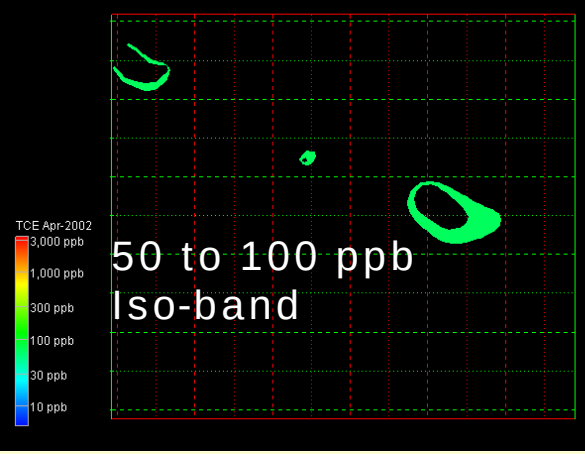
- Distribution of areas of high or low concentration

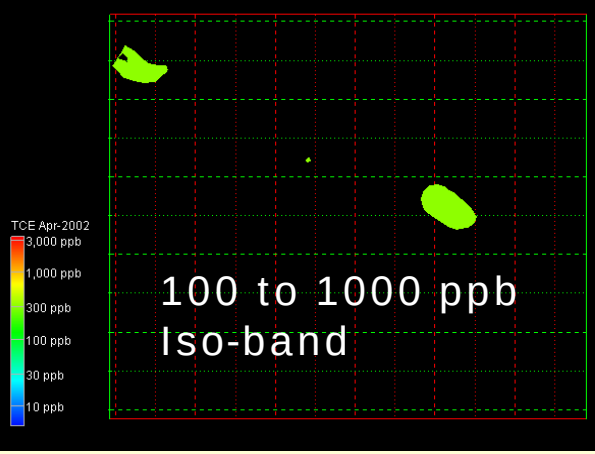
What is 3D mass/volume within each 3D Iso-concentration band?

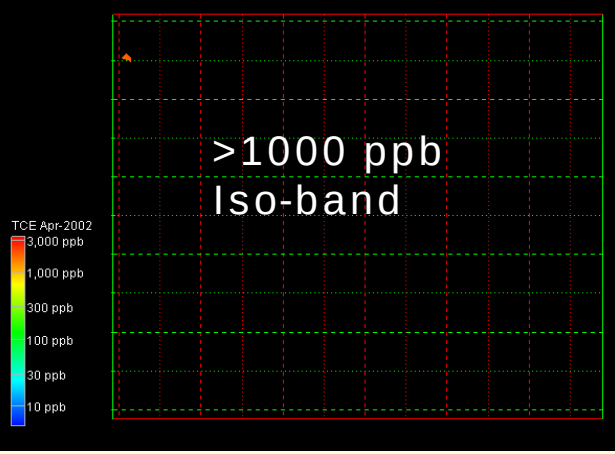












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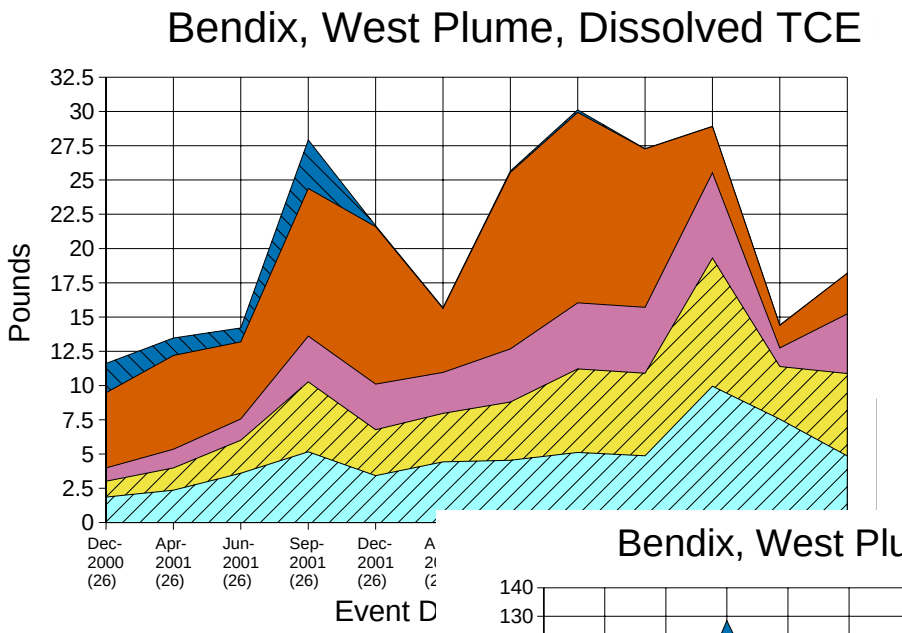
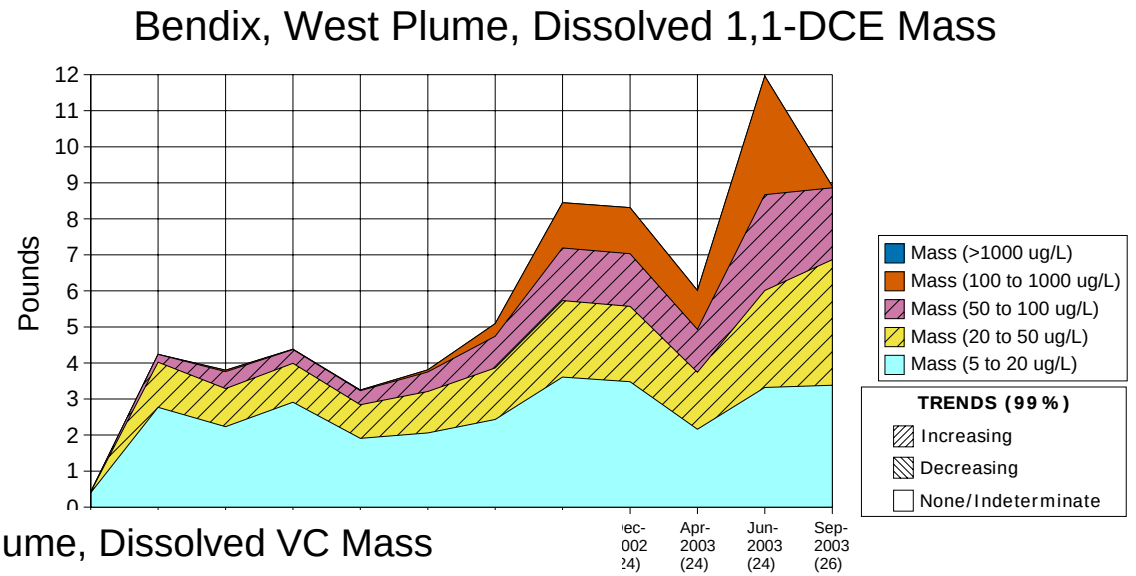
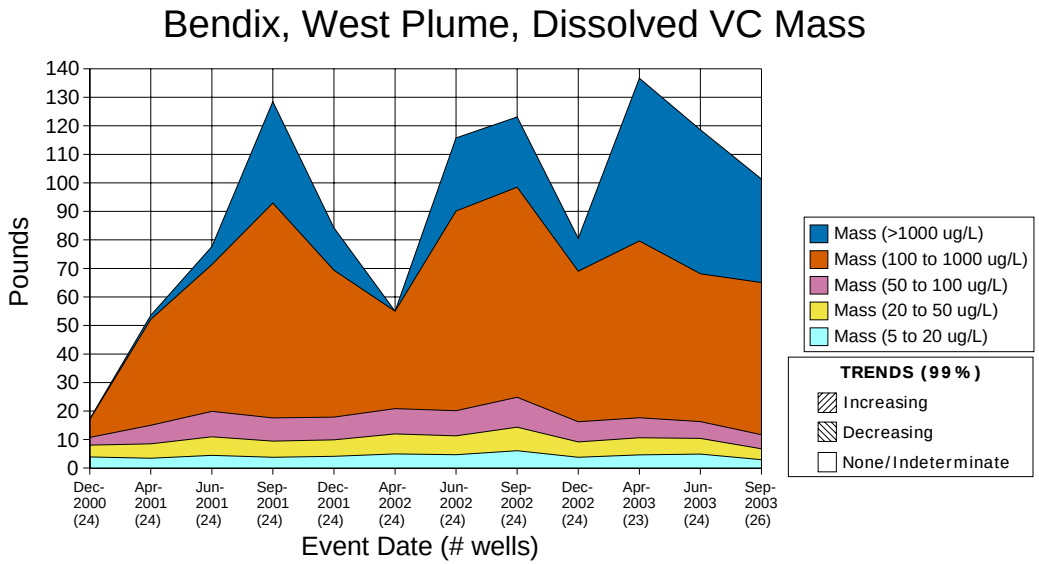
Trends present in metric?

- Trend in *mass* distribution within areas of high or low concentration (Iso-bands)







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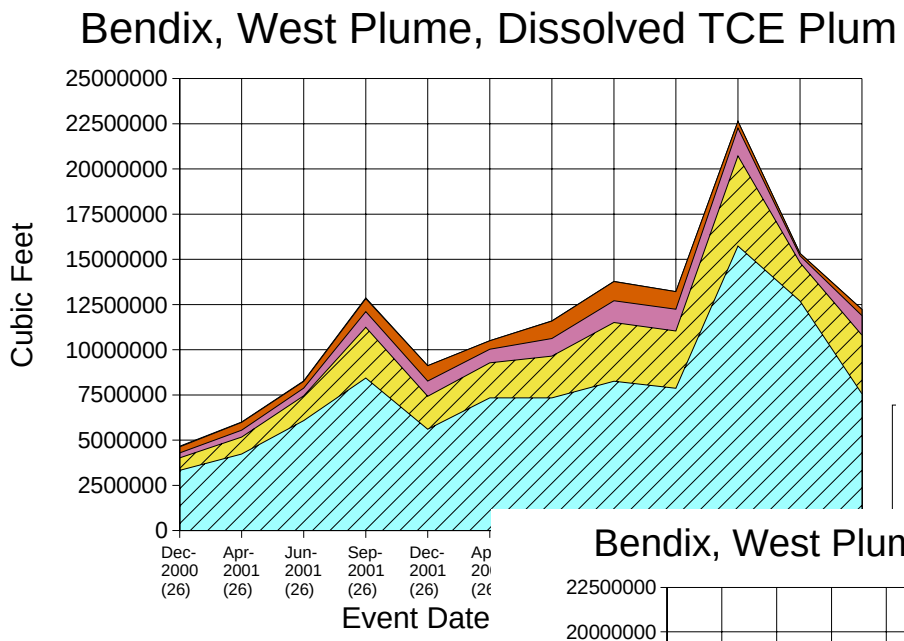
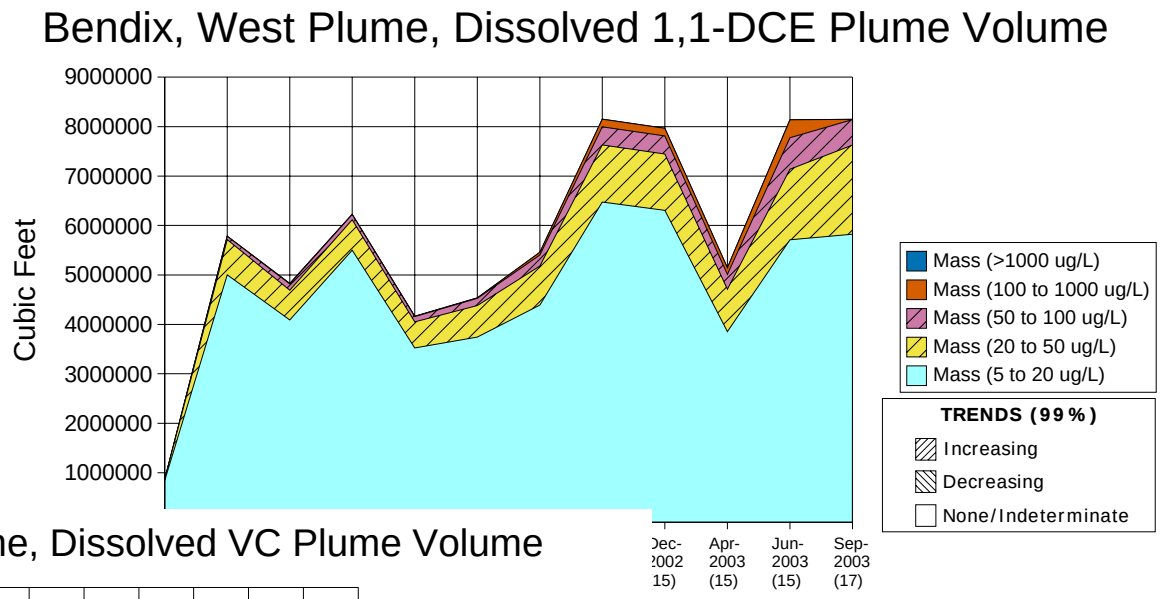
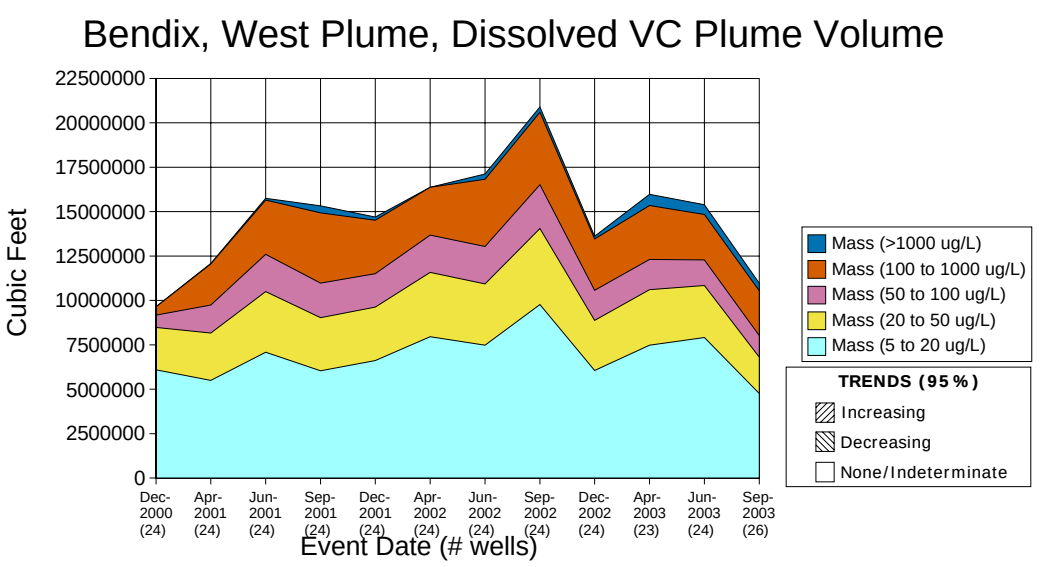
Trends present in metrics?

- Trend in *volume* distribution within areas of high or low concentration (Iso-bands)







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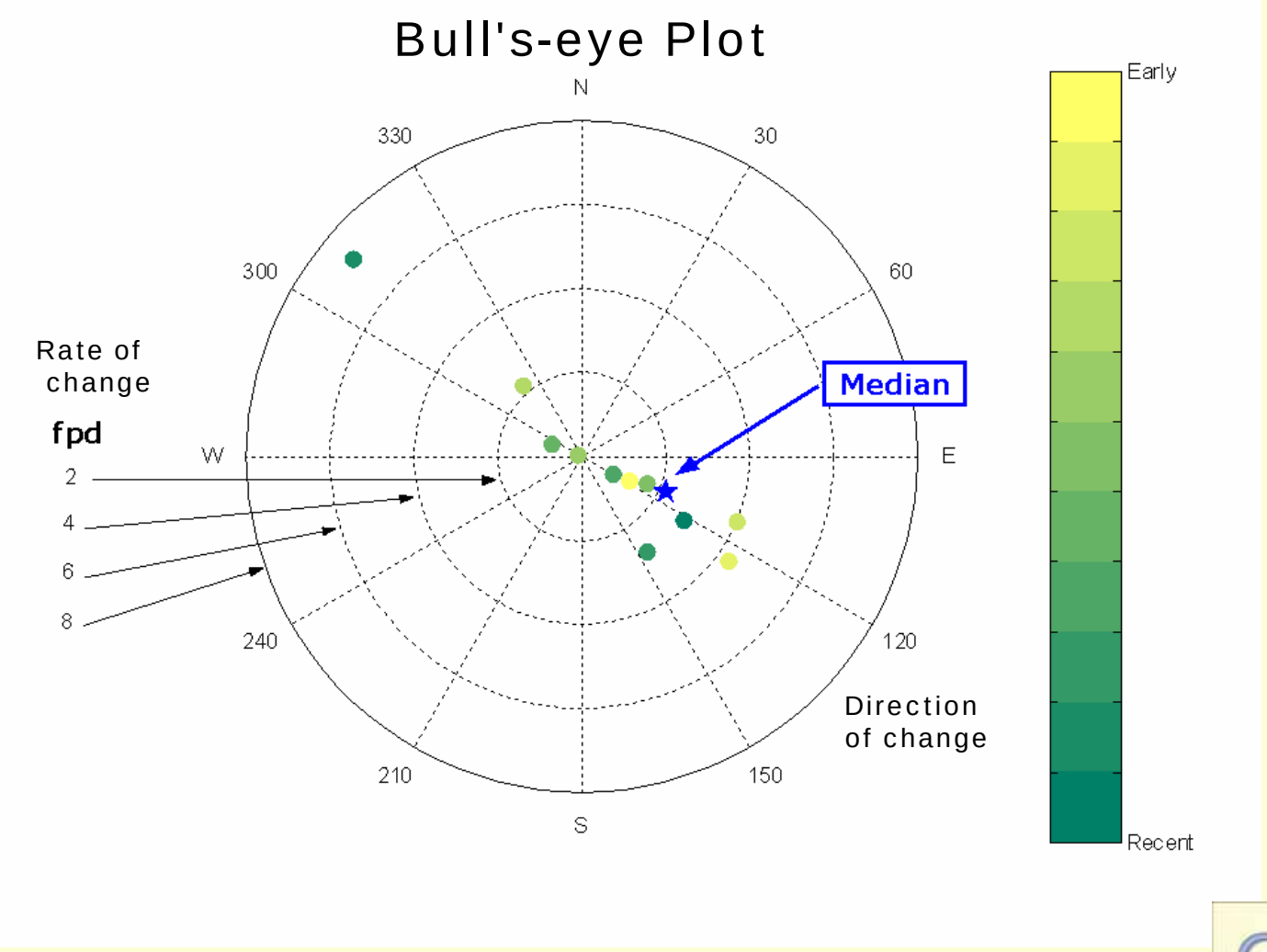
Metrics Include: Trends present in metric?

- Center of plume mass. Is plume migrating?

This plot is obtained by comparing centers of mass in 2 consecutive sampling events, and dividing by the number of days between them.

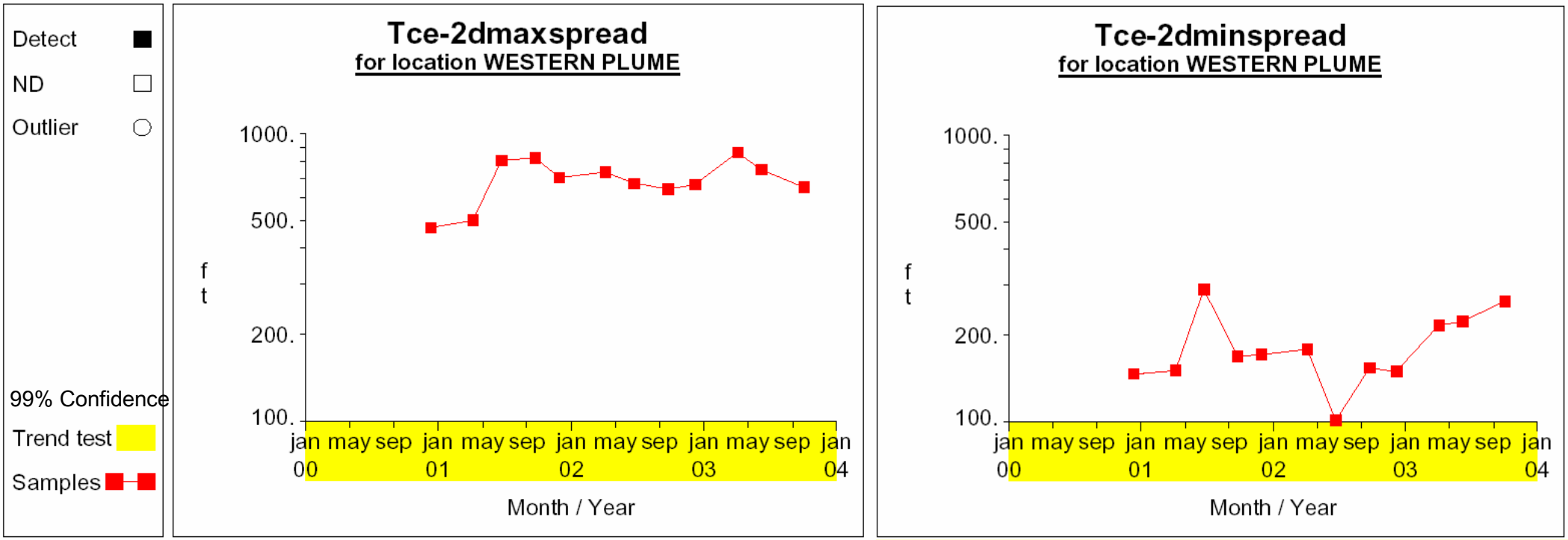
The blue star is the median of those values (of both magnitude and direction).



Metrics Include

Trends present in metrics?

- Shape of the plume or plume spread (Max and min axis of the second moment ellipsoid)



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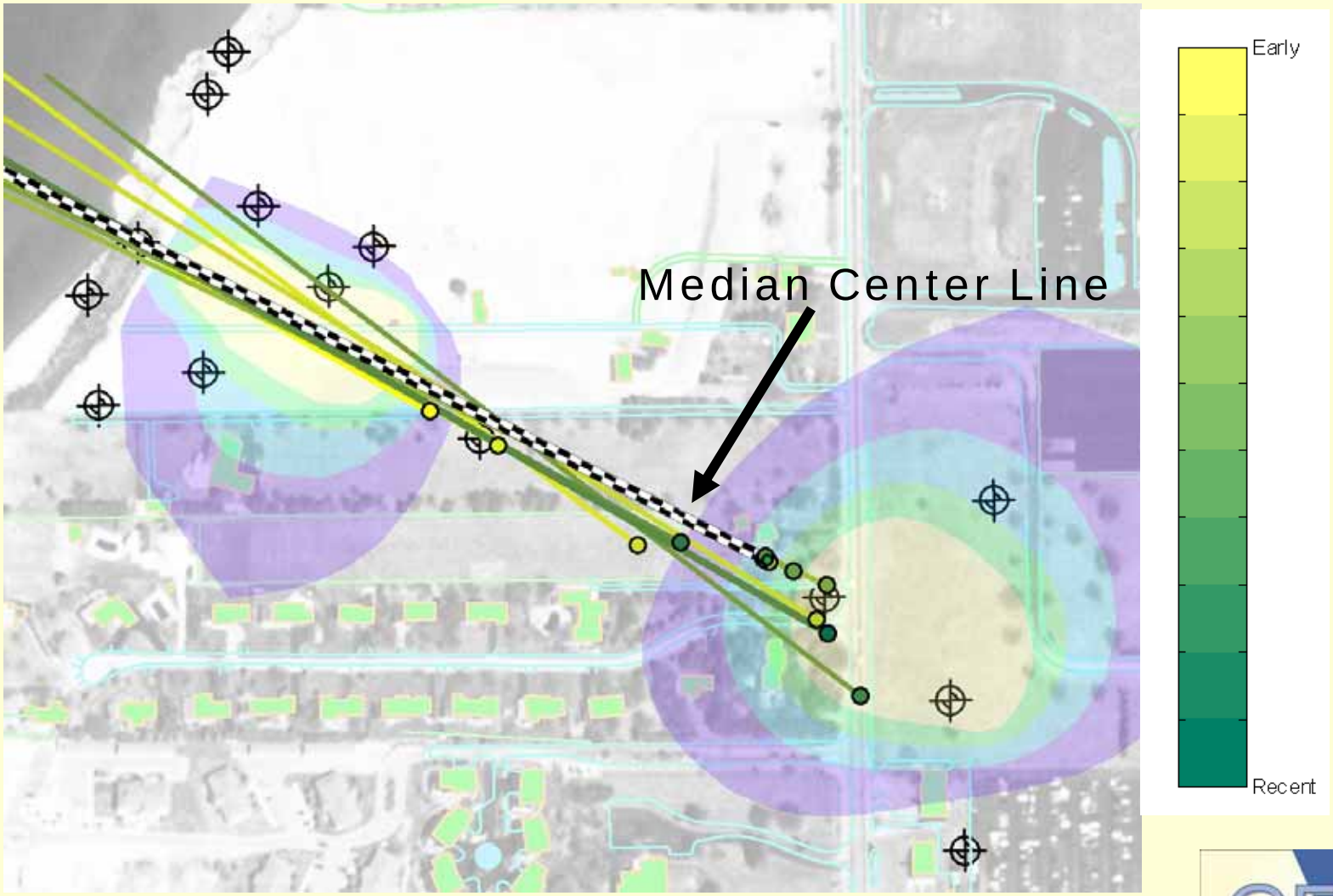
Metrics Include

- Plume orientation/center line (Bearing of max axis of the second moment ellipsoid)



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Tools to used to determine and analyze metrics

EVS/MVS by CTech
Used for: 3D mass/volume, iso-volumes, and center of mass

CarStat by Discerning Systems
Used to: calculate the presence of trends

PAM (Plume Assessment Metrics) by Subterranean Research
Used to determine: a trend's rate of change, plume spread and center line of plume

MAROS By USAF-Groundwater Services
Can determine: trends in changes over time for mass, center of mass, and plume spread,

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Groundwater Monitoring Optimization Objectives Issues

Objective should include effect on

- Plume mass
- Plume volume
- Plume rotations/shifting
- Outer perimeter of plume edge “foot print ” (size above cleanup standard) need non-detects to help define the edge

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Conclusions

Moving to Post-construction/Long-term monitoring stage

Managing periodic or episodic data sets

- Collection—move to standards-based electronic reporting
- Assembly---ensure reports are sufficiently comprehensive
- Analysis---investigate *performance* with compliance
  - What is current state of system? What was anticipated state of system? What is anticipated end-point and "roadmap"? Is current state compatible with these?

New tools leverage characterization/design work products

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