Spatial Analysis and Decision Assistance (SADA) Version 4.1

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PERFORMANCE BASED RADIOACTIVE MATERIALS CONTROL (MEASUREMENT)

Improve the process of determining the presence or absence of radioactive material for the requirements and conditions present.

- ***Planning***
- ***Instrumentation***
- ***Sampling***
- ***Analysis***

Instrumentation

- Selecting the proper instrument for surveys
- Advances and improvement
- Exploiting field analytical capabilities
  - Data logging
  - Live Time analysis
  - GPS
- Integration of instrumentation to analytical software

Analysis

- Parametric to non-parametric
- When is enough, enough?
- Iterative Methods - SADA
  - Infill
  - Adaptive Sampling and Analysis Program (ASAP)
  - Markov/Bayes
  - Co-Variance/Co-Kriging
  - Minimize Uncertainty of Exceedence
  - Minimize risk of misclassification

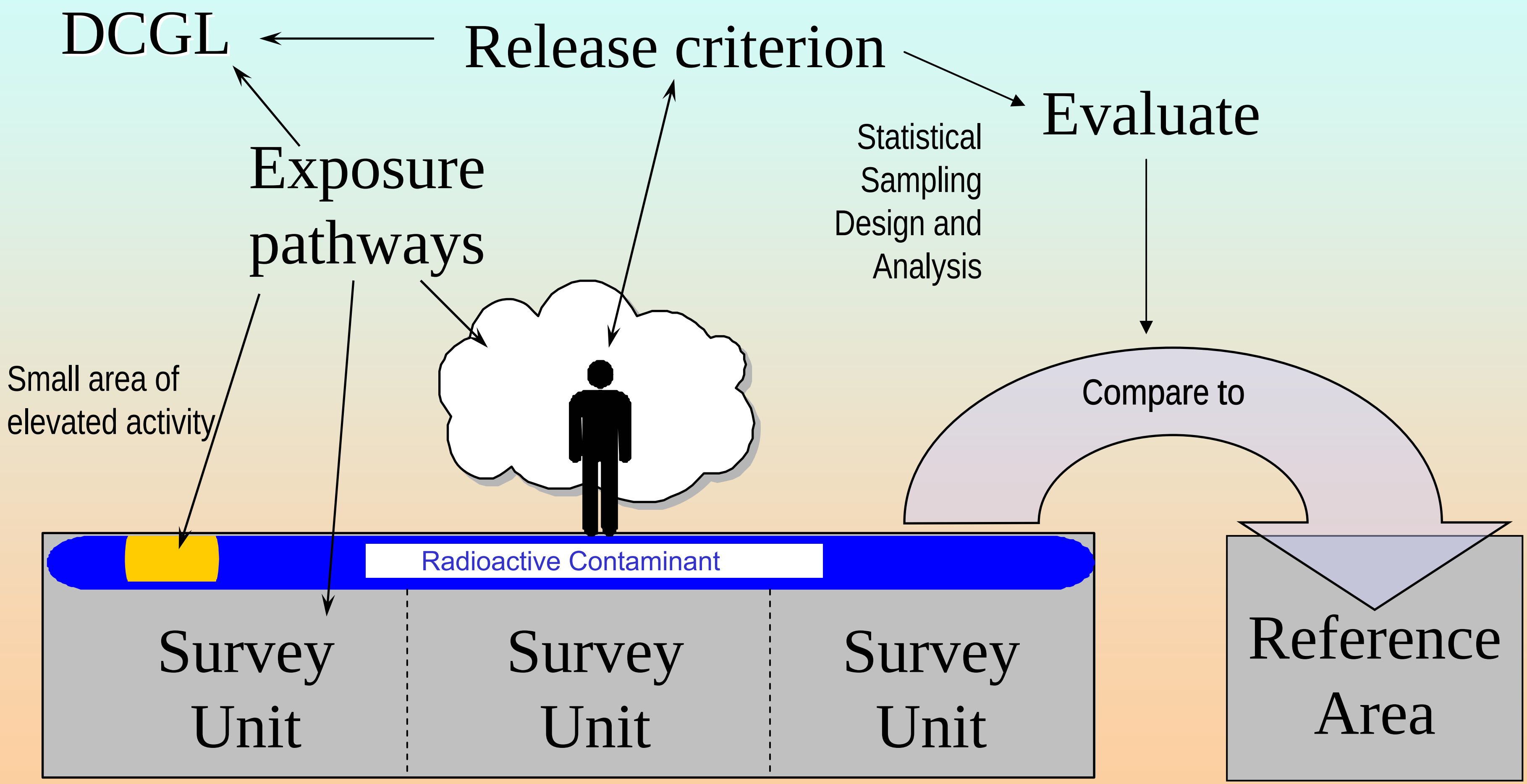
Research Objective Dealing with Subsurface Radionuclides

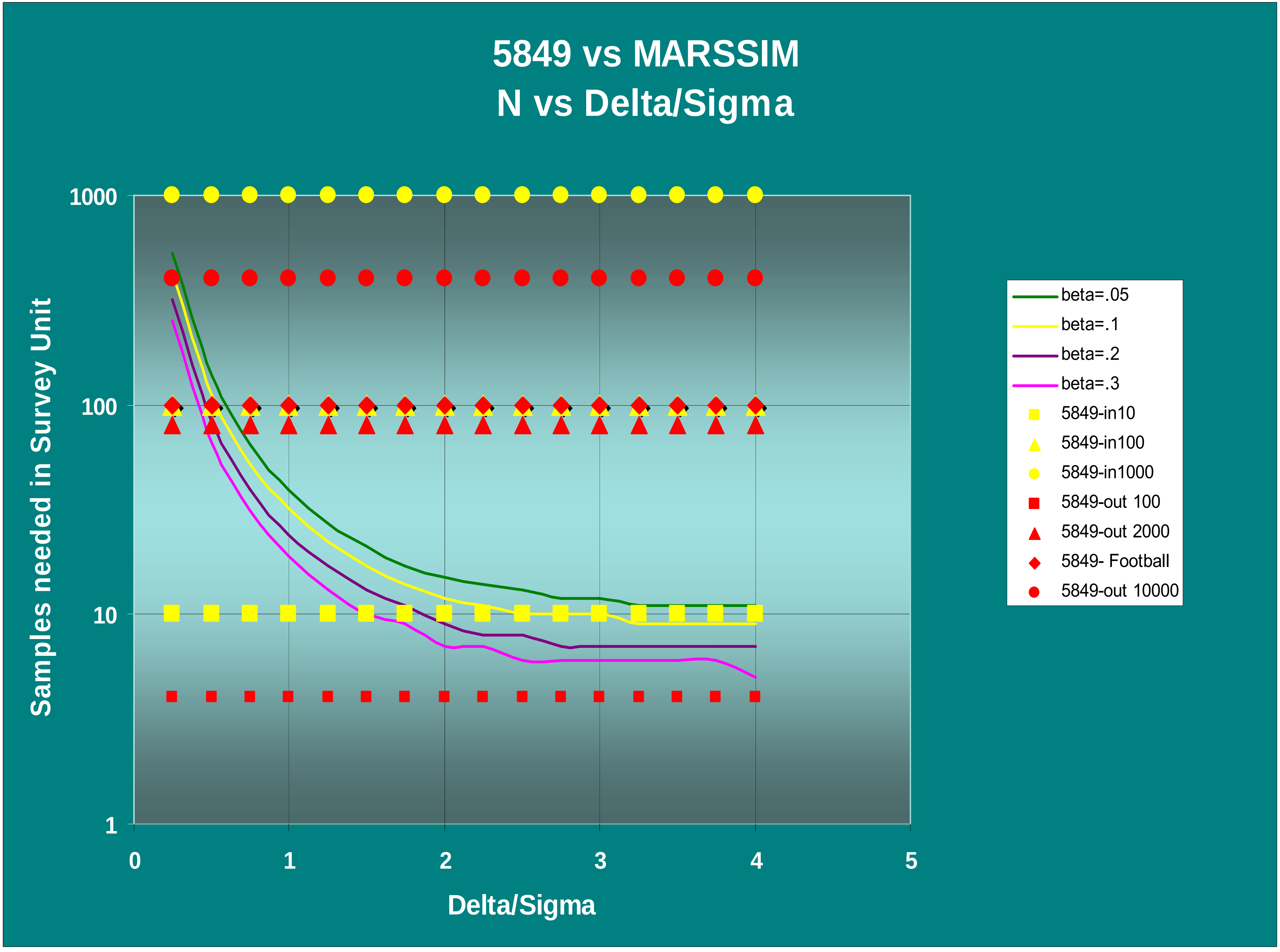
Pursue more realistic and defensible estimates of exposure of the public to radiation from radionuclides released from contaminated sites through optimization of sampling and analysis

Planning (Multi Agency)

- Understand requirements of pending decisions
- Explicitly identify and manage uncertainties that could lead to decision errors
  - Sampling uncertainties - MARSSIM (Aug 2000)
  - Analytical uncertainties - MARLAP (Dec 2003)
  - Materials specific – MARSAME (Target 2007)
  - Subsurface specific – MARSSub (TBD)
- Implementing the intent of “performance based” (surface/subsurface sampling & analysis) − **SADA**

MARSSIM *DQO/DQA* Process




5849 vs MARSSIM
N vs Delta/Sigma
Samples needed in Survey Unit
1000
100
10
1
0
1
2
3
4
5
Delta/Sigma
beta=.05
beta=.1
beta=.2
beta=.3
5849-in10
5849-in100
5849-in1000
5849-out 100
5849-out 2000
5849- Football
5849-out 10000

Sampling the Subsurface

- How is designing a sampling survey for subsurface materials different from designing a sampling survey for surface materials within the first 15 cm of soil?
- At issue is **how to design the survey more efficiently**, because the sampling effort is considerably higher for subsurface sampling than it is for surface soil sampling.
- The approach needs to be better than what we are doing now, with a justifiable technical basis and **no hidden assumptions**.

Design More Efficient Surveys

Reduce required number of samples by increasing the information available by other means than simply taking more direct measurements. This can be done in two ways:

- 1) **increase the information** available from professional knowledge of site processes, historical data, pollutant transport etc.
- 2) make **more efficient use of the hard data** that is already available by the use of more advanced statistical methods.

Develop further design efficiency

- Incorporate prior information quantitatively as “soft data” that can be combined with hard concentration data from samples- **Bayesian Statistics**
- Sampling design based on maximizing the information that will be added - **not all locations are equally informative**
- **Geostatistical** data analysis that incorporates known spatial relationships among data locations
- **Geophysical** data may be used for scanning - Bayesian extensions to estimate volume (volume factor)

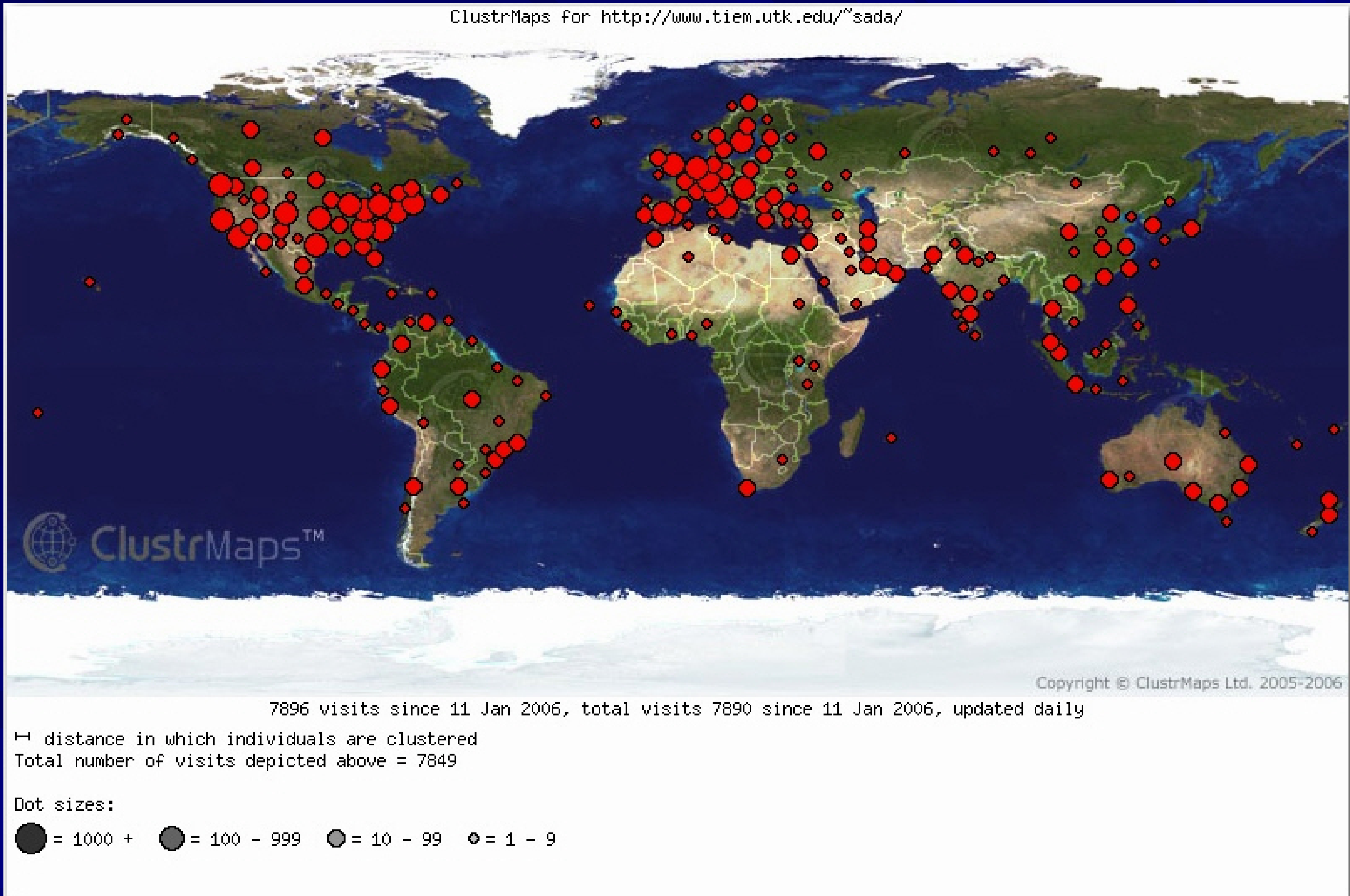
SADA Overview

Windows--based freeware designed to integrate scientific models with decision and cost analysis frameworks in a seamless, easy to use environment.

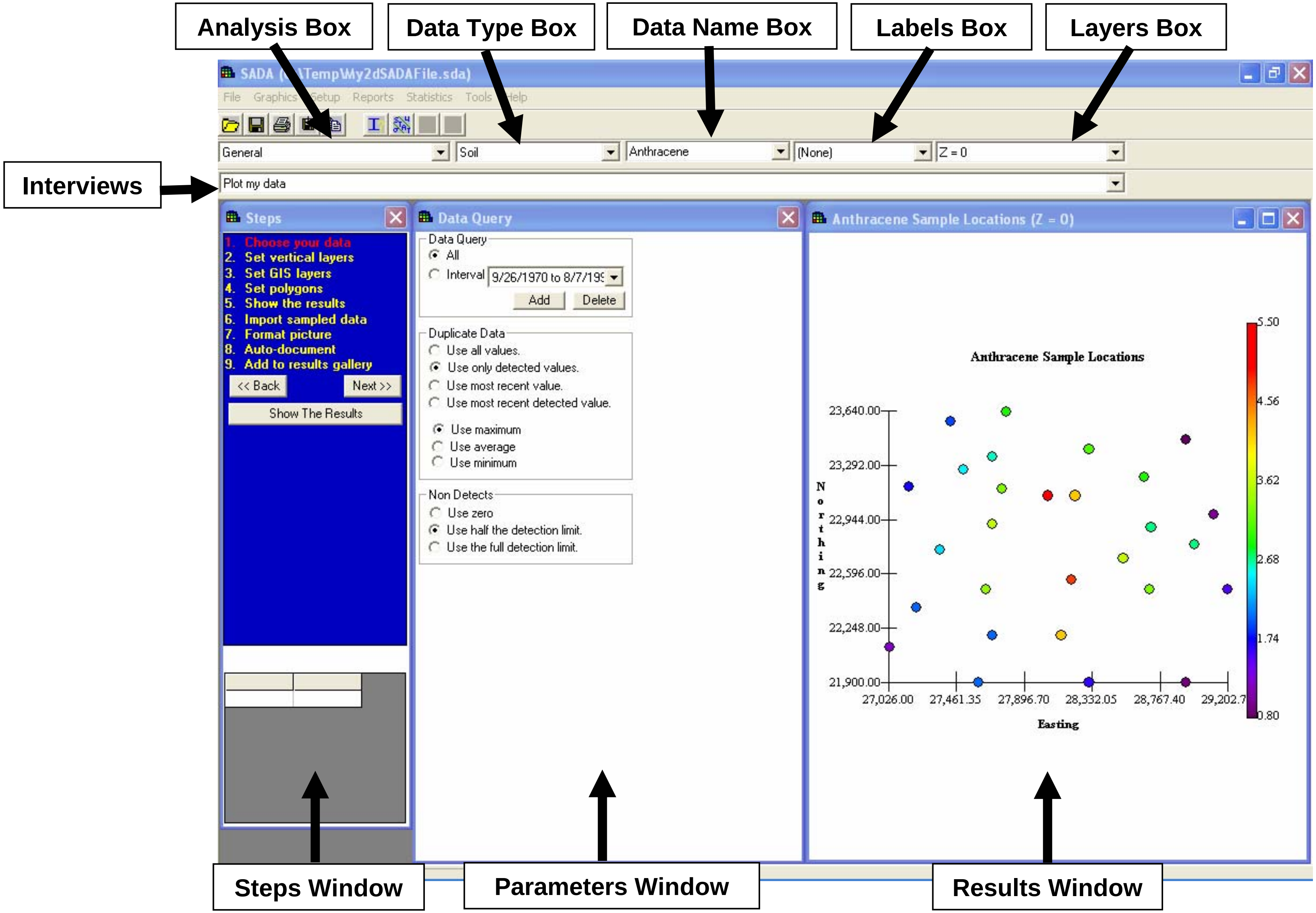
- Visualization/GIS
- Statistical Analysis
- MARSSIM Module
- Geospatial Uncertainty Analysis
- Sampling Designs
- Custom Analysis
- Geospatial Interpolation
- Area of Concern Frameworks
- Human Health Risk Assessment
- Ecological Risk Assessment
- Cost Benefit Analysis
- Export to Arcview/Earthvision

SADA has been supported by both the DOE, EPA, and the NRC. SADA Version 3.0 had about 11000 downloads. Version 4.0/4.1 has had about 4000 since January, 2005.

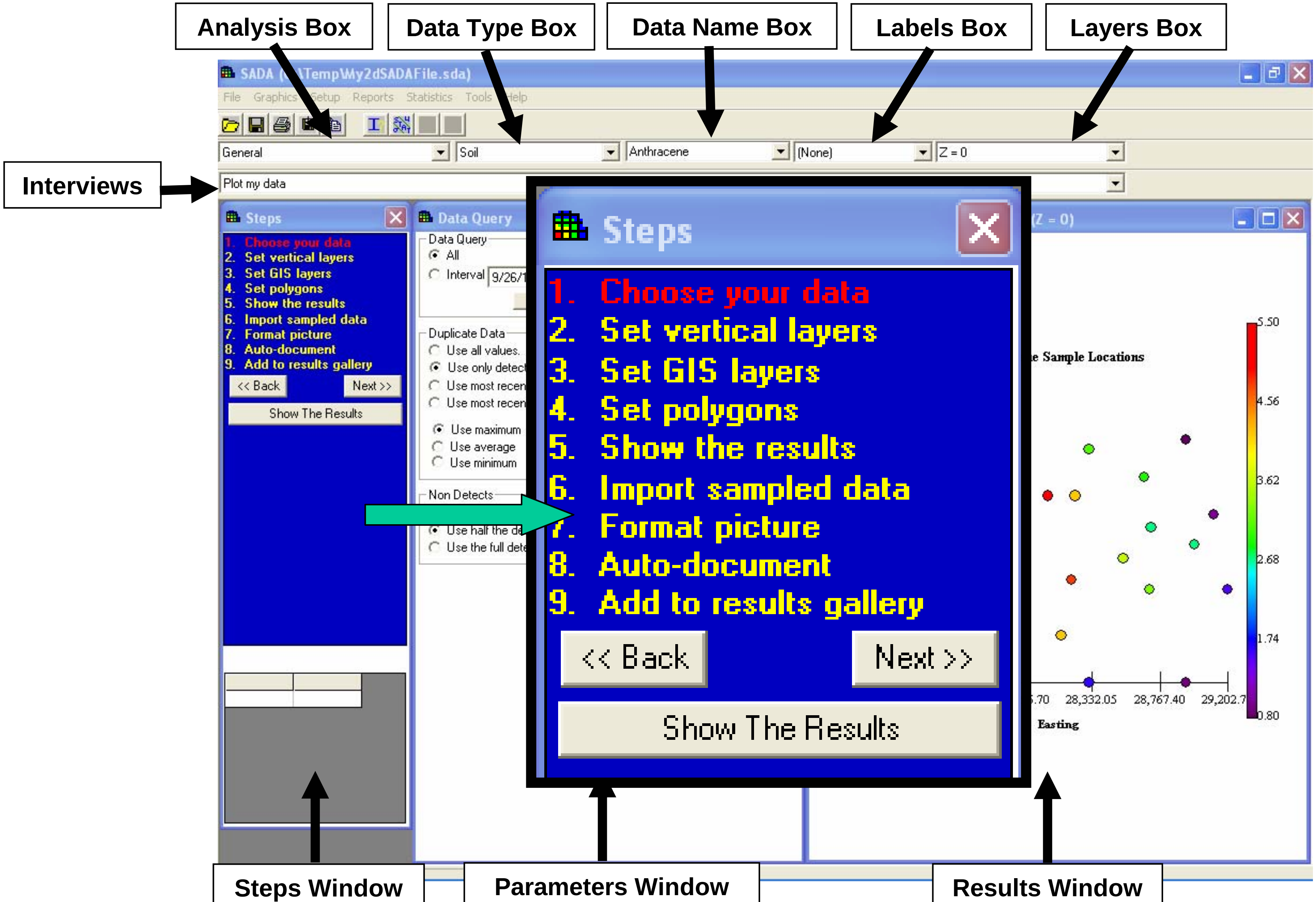
Domestic and Foreign Collaboration/Interest



The New SADA Look: Scaleable Interfacing



The New SADA Look



Sample Laboratory Data

PROJECT NAME	PROJECT #	SAMPLEI	SAMPLE ID	DATE COLL	DATE RECD	ANALYZED	TAI LAB #	ANALYTE	RESULT	PQL	UNITS	METHOD
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Aldrin	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	a-BHC	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	b-BHC	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	d-BHC	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	g-BHC, Lindane	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	4,4'-DDD	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	4,4'-DDE	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	4,4'DDT	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Dieldrin	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endosulfan I	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endosulfan II	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endosulfan Sulfate	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endrin	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endrin Aldehyde	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Endrin Ketone	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Heptachlor	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Heptachlor Epoxide	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Methoxychlor	< 0.00010	0.0001	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	Toxaphene	< 0.00500	0.005	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	alpha-Chlordane	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/7/2002	02-A162603	gamma-Chlordane	< 0.00005	5E-05	mg/l	8081A
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1016	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1221	< 0.00100	0.001	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1232	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1242	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1248	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1254	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/6/2002	02-A162603	Aroclor 1260	< 0.00050	0.0005	mg/l	8082
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/5/2002	02-A162603	Arsenic	< 0.0050	0.005	mg/l	6010B
I-40/I-640 SINKHOLE	4969.013	BW/JO	HSSW1	10/1/2002	10/3/2002	10/5/2002	02-A162603	Barium	0.08	0.01	mg/l	6010B

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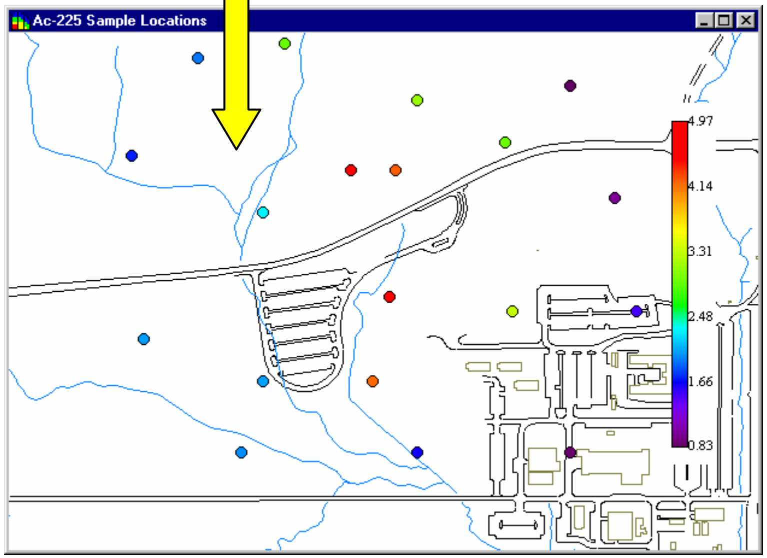
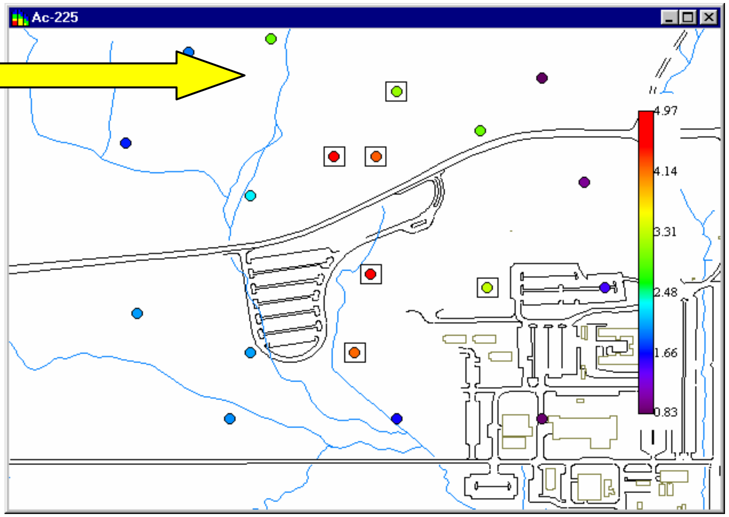
Spatial Analysis and Decision Assistance

Data Exploration

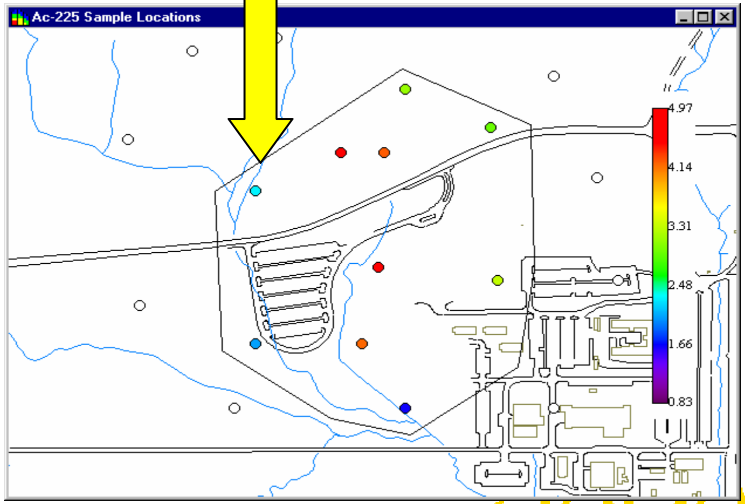
Spatial Data Screens

Data Plot/GIS Overlays





Polygon Selection/Cutaways



Statistics

Statistics

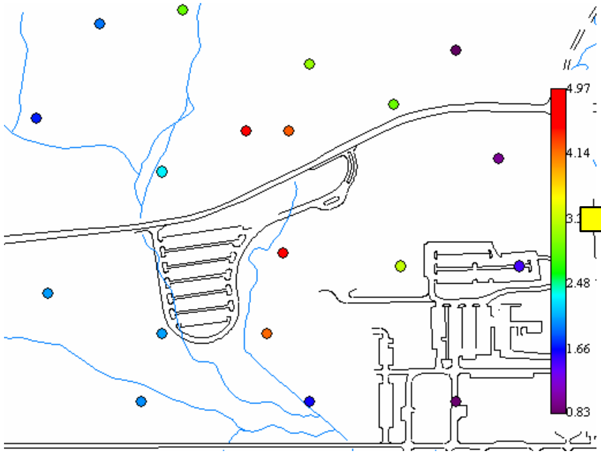
Options Format

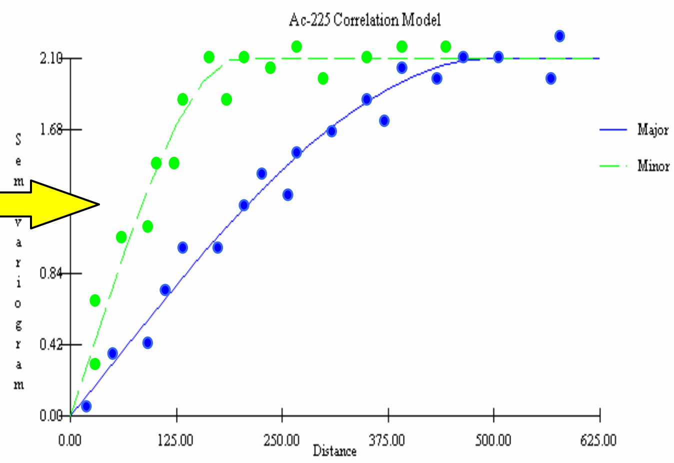
Name	CAS Number	Mean	Variance	Number of Data
Ac-225	14265851	3.4	1.3	10
Beryllium and compou	7440417	75.6	640.9	10
Arsenic, Inorganic	7440382	8.3	6.	10

TM

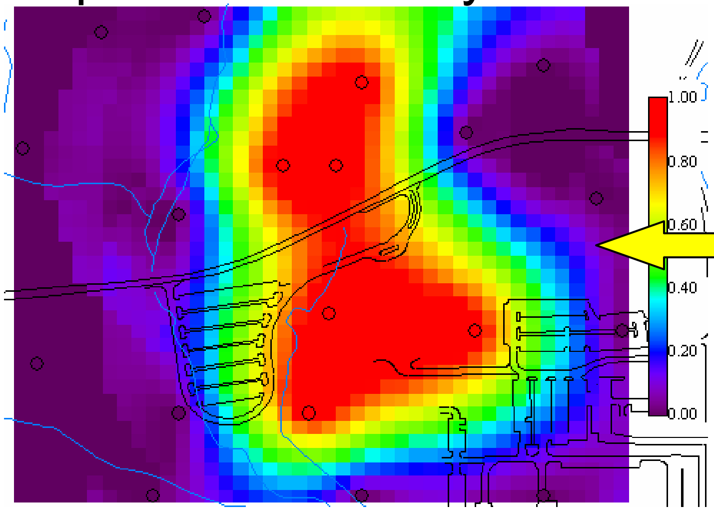
Spatial Analysis and Decision Assistance

Spatial Analysis

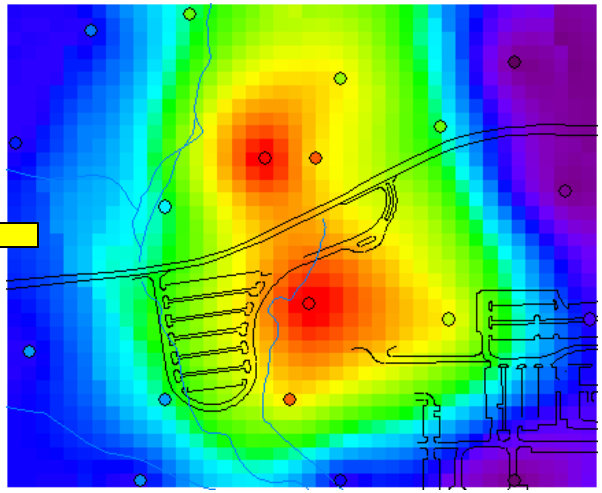




Spatial Uncertainty



Spatial Estimation



Accounting for Local Uncertainty in Decision-making

Why do we model uncertainty?

Usually to make decisions such as:

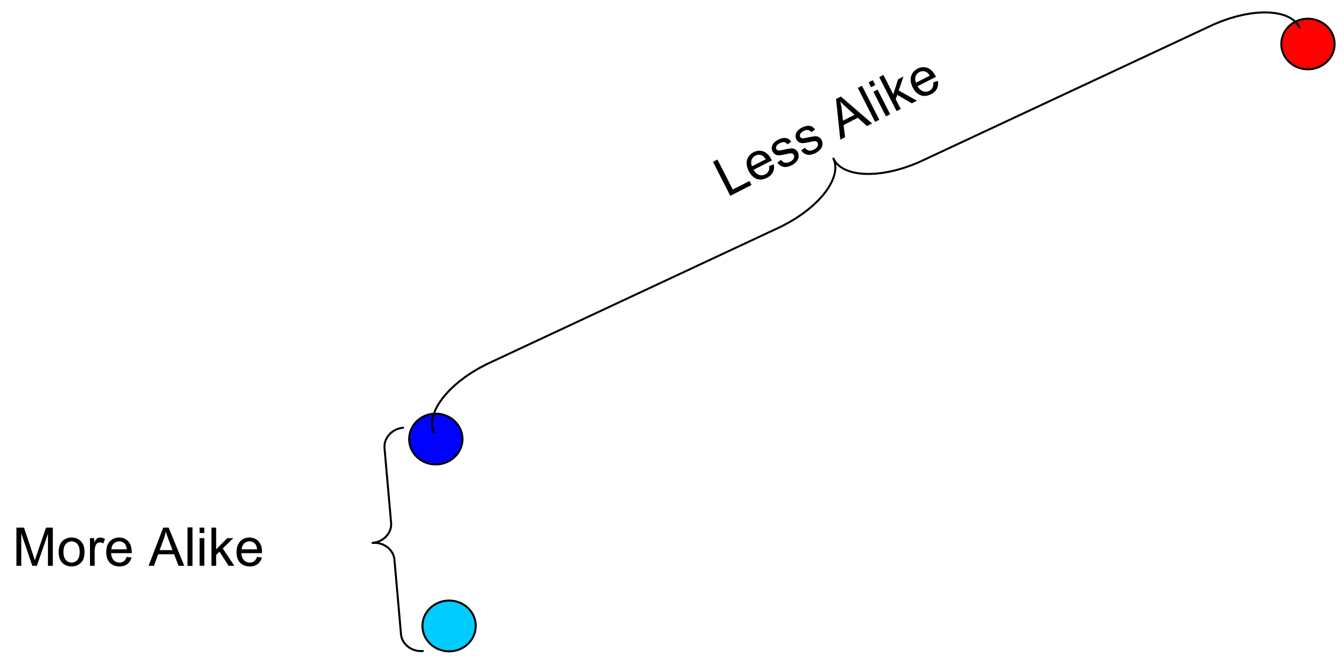
- Which remediation units should be cleaned
- Where should additional samples be collected

Criteria for cleaning of remediation units

1. Exceeding a probability threshold
2. Exceeding a physical threshold
3. Minimization of expected costs

Spatial Correlation

If data are spatially correlated, then on average, sample points that are close to each other are more alike than sample points further away. (More complex spatial correlations exist but this type is the most common).



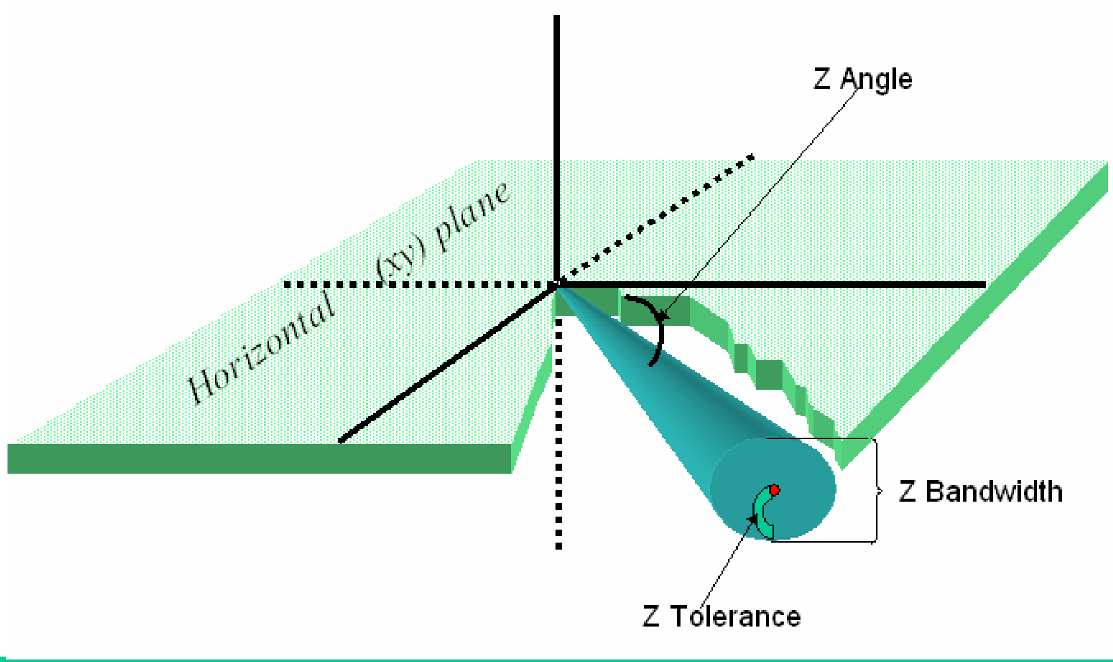
Three-Dimensional Variography

Three-dimensional semi-variogram calculation is the same approach as in the two-dimensional case. In addition to the previously defined parameters, a z angle (dip), z tolerance, and z bandwidth must be specified.

Z Angle (Dip) – The angle below the horizontal plane that the cone should dip.

Z Tolerance – The tolerance on this dip angle.

Z Bandwidth – The maximum distance the vertical component of the cone is permitted to go.



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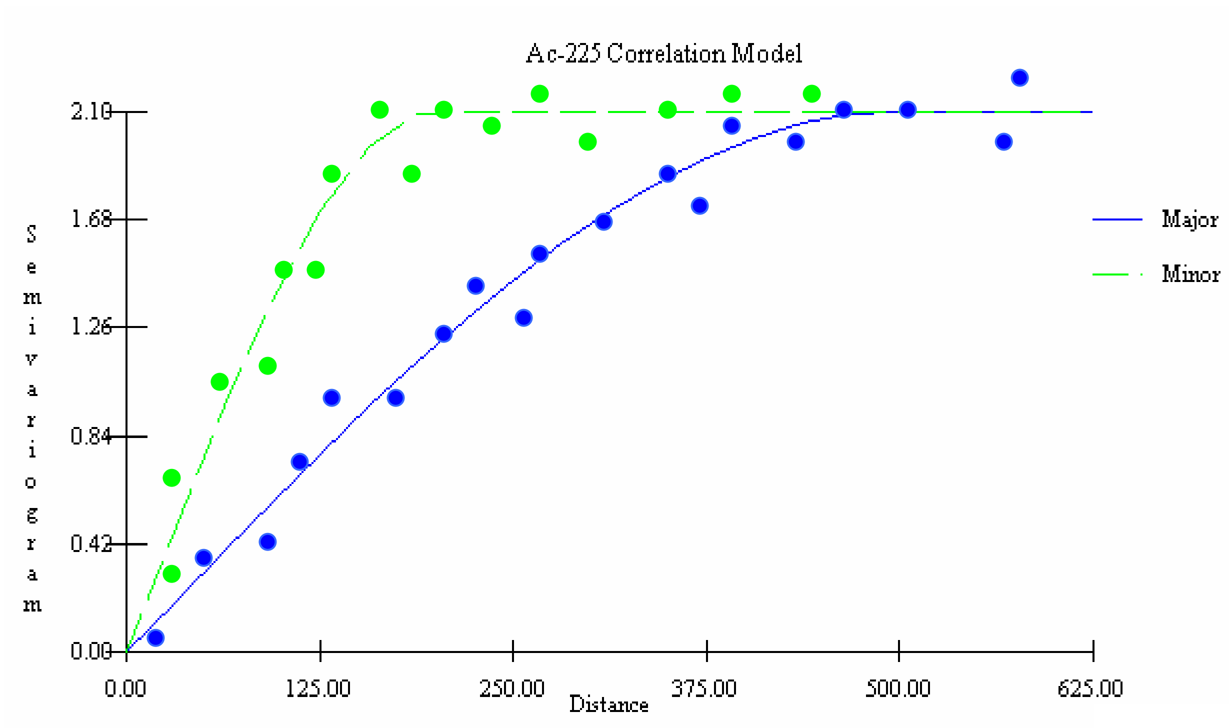
Spatial Covariance

When the kriging models are used, they will require that the semi-variogram values are known for any distance **h**. At this point, we only have these values for a few discrete distances. Therefore, we need to fit a model to the data so that a semi-variogram value is available for every distance.



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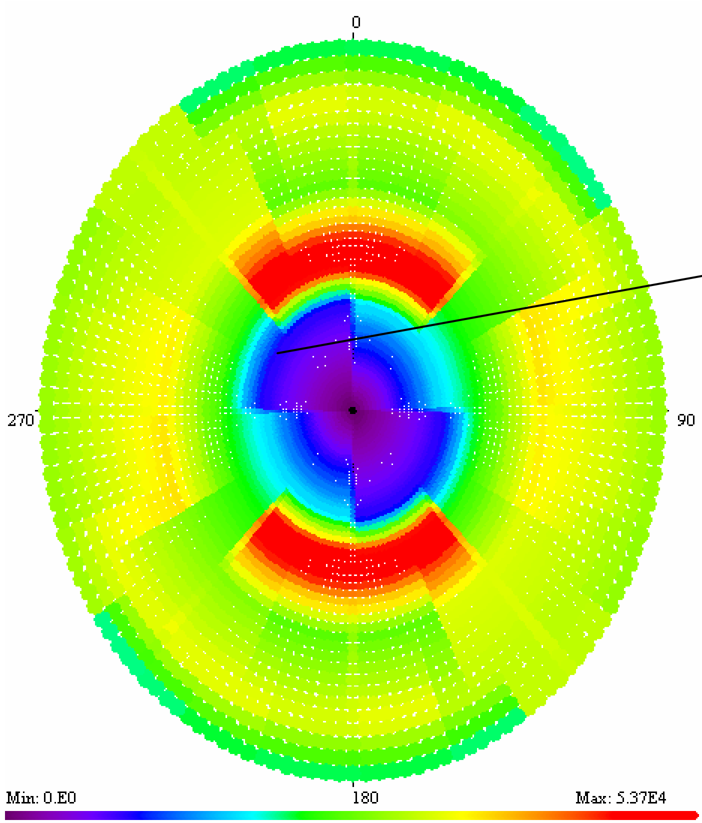
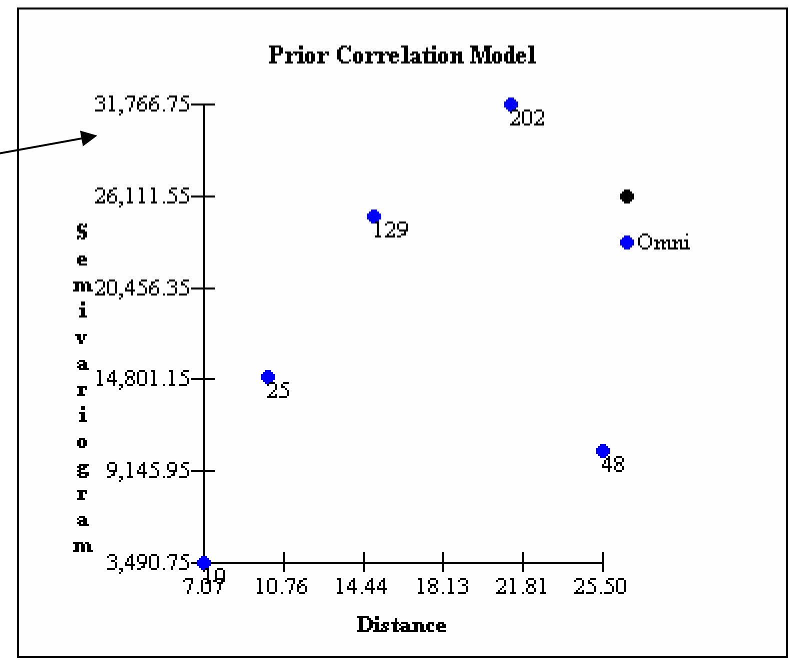
Rose Diagrams

Rather than viewing only on angle at a time, users can view semivariogram values in all directions at once. They can then choose an angle of interest by clicking on the rose diagram map. SADA will show the semivariogram values for that direction.





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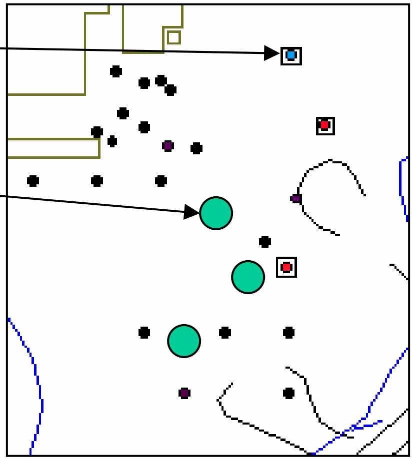
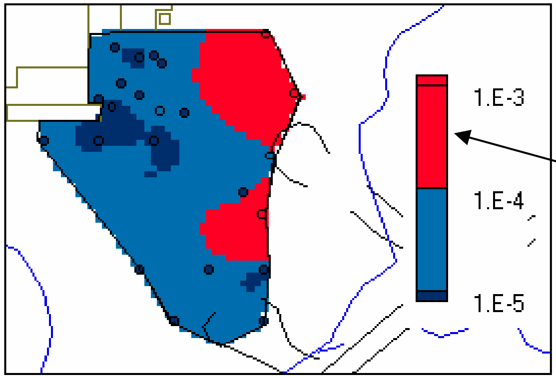
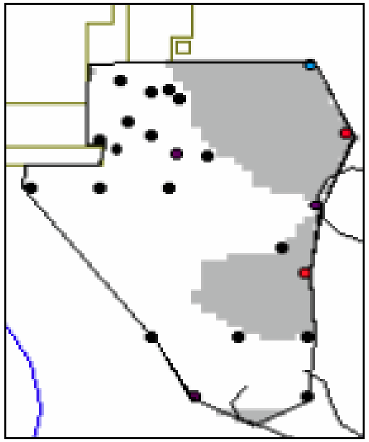
Decision Analysis

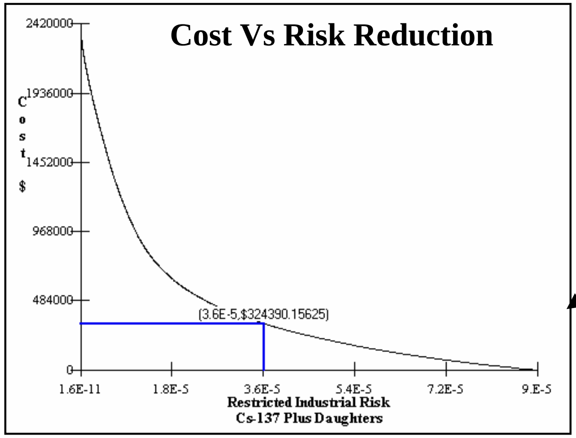
- Spatial Screens
- Sampling Strategies





- Spatial Risk
- Area of Concern
- Cost Benefit





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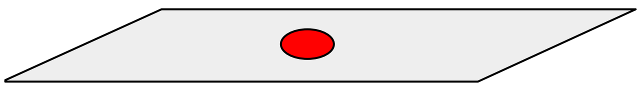
3 Types of Sample Designs: 2d, 3d, and 3d Core

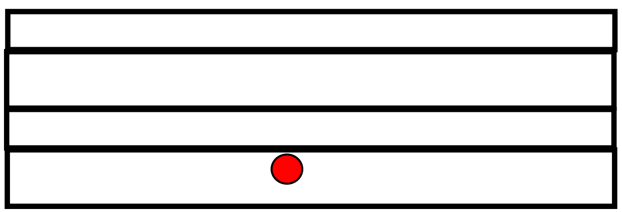
With all designs, SADA first identifies the location of the sample. Then, based on whether there are multiple layers and whether the user wishes to core, the following broad scenarios are possible for a single sample.

2d



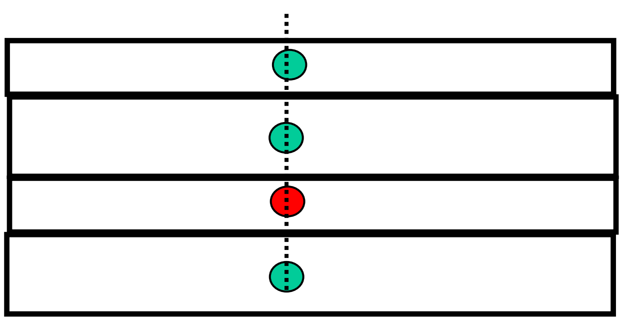
In a 2d application, the sample is placed on a single layer.

3d



In a 3d application, the sample is placed on a single layer at the depth required.

Core



In a core application, the sample is placed on a single layer at the depth required. Then all layers above and below are also sampled subject to polygon definitions.

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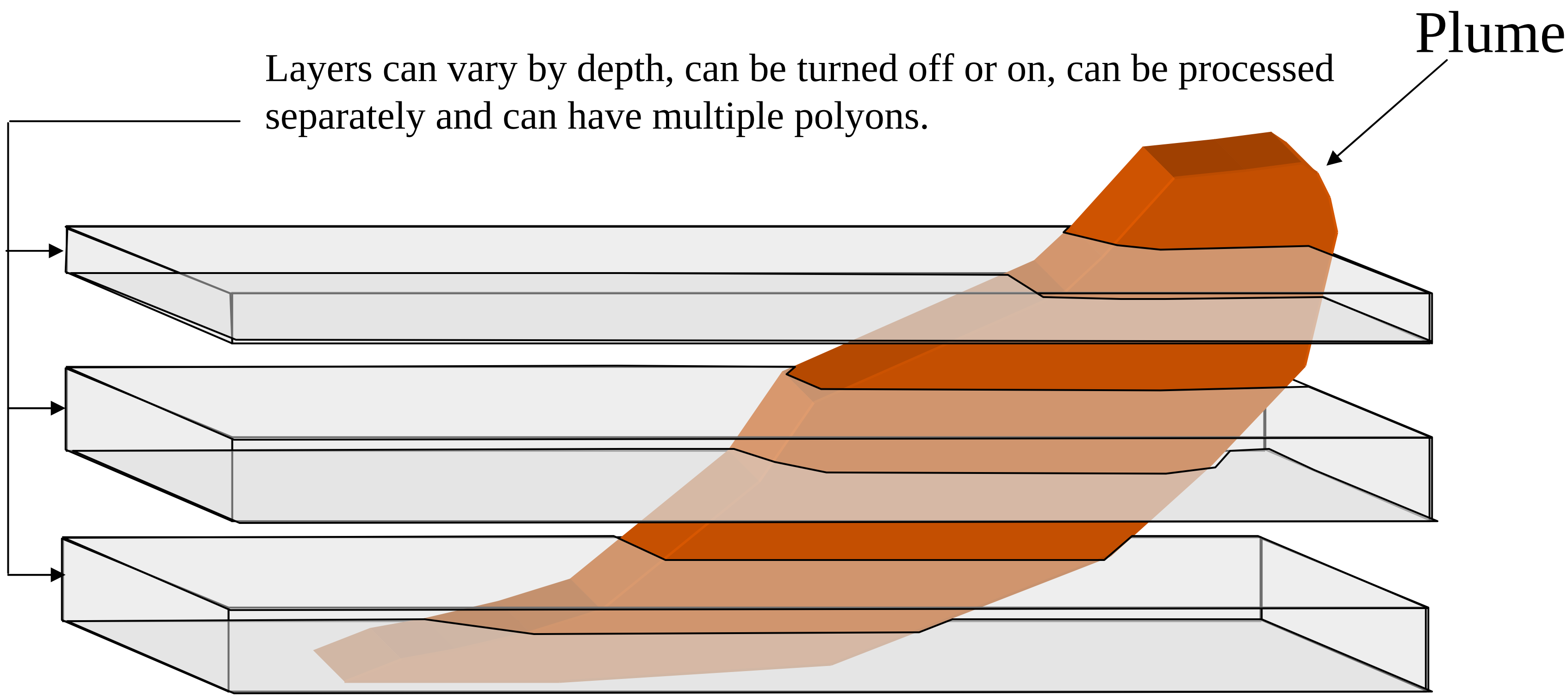
3d Layering/Polygons

SADA is now equipped to draw multiple polygons, on multiple layers and invoke a cookie cutter approach vs layer by layer approach to establishing the subsurface design.



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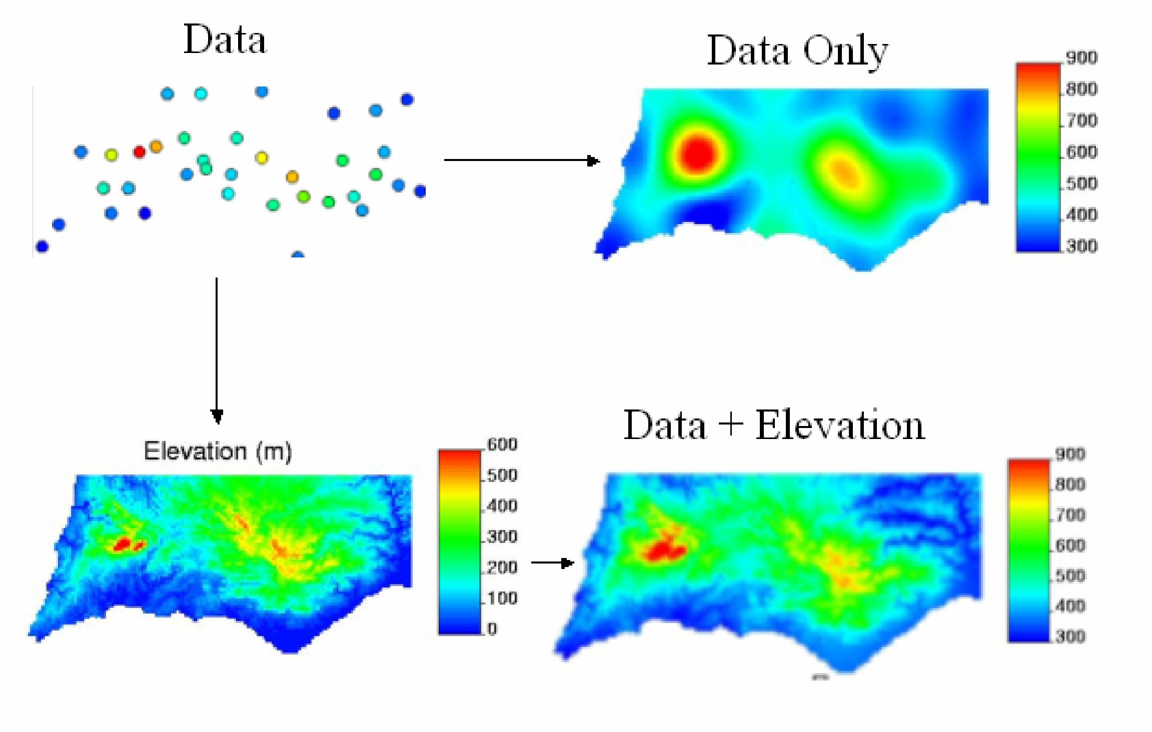
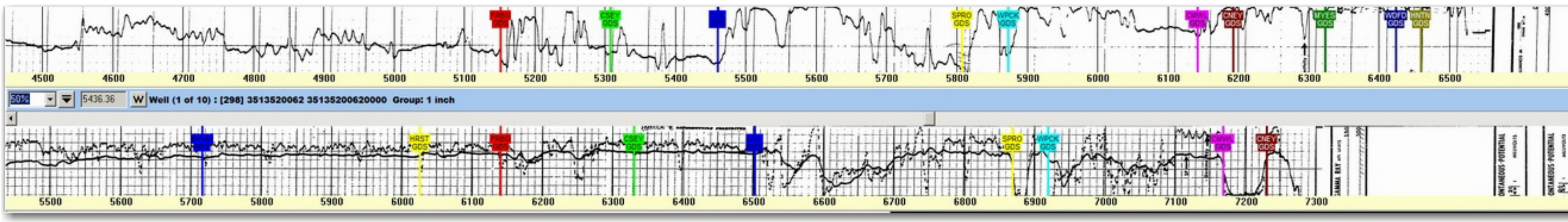
Markov Bayes II

- Explicitly incorporates soft information such as core hole scans, ground penetrating radar, etc into the model
- Can produce more realistic heterogeneous results
- Can support investigations that have sparse data sets
- Source code is available for implemenation in SADA



Well Logging Data



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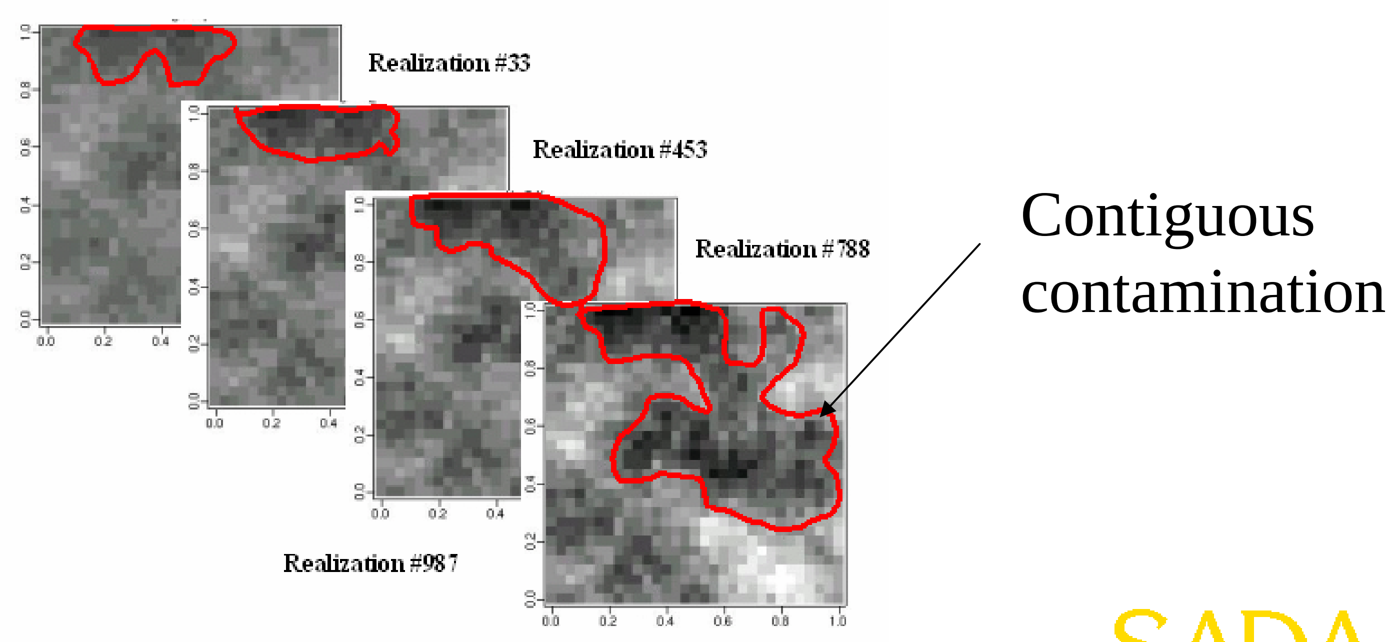
Geostatistical Simulation Cont

- Geostatistical simulation extends this idea by using the raw data values and spatial correlation structure to produce equiprobable realizations of what contamination could be given sample location and sample value.
- Simulations can then be used to predict probability of leaving behind a continugous area of any shape or size
- One can perform a simple count of those realizations that have meet the conditions of elevated and contiguous zone and determine the probability of leaving such a zone behind.



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Supporting tools: Incorporating Geophysical data

- In order to support such methods as bayesian ellipgrid and Markov Bayes, SADA needs to be able to import often dense forms of secondary information
- This information may come in the form of core hole scans, penetrating radar, stratigraphy, hydrostratigraphic units, hydraulic conductivity, porosity, seismic profiles.

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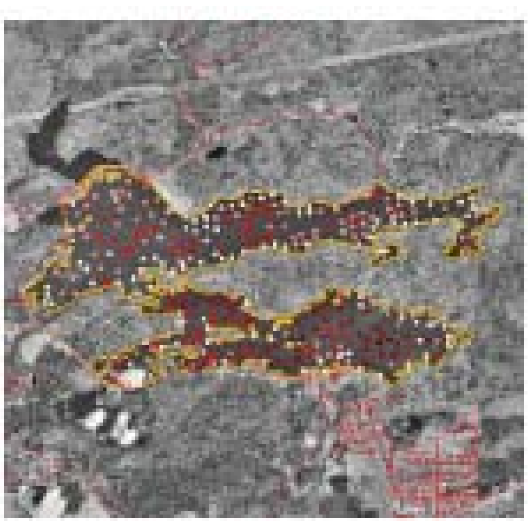
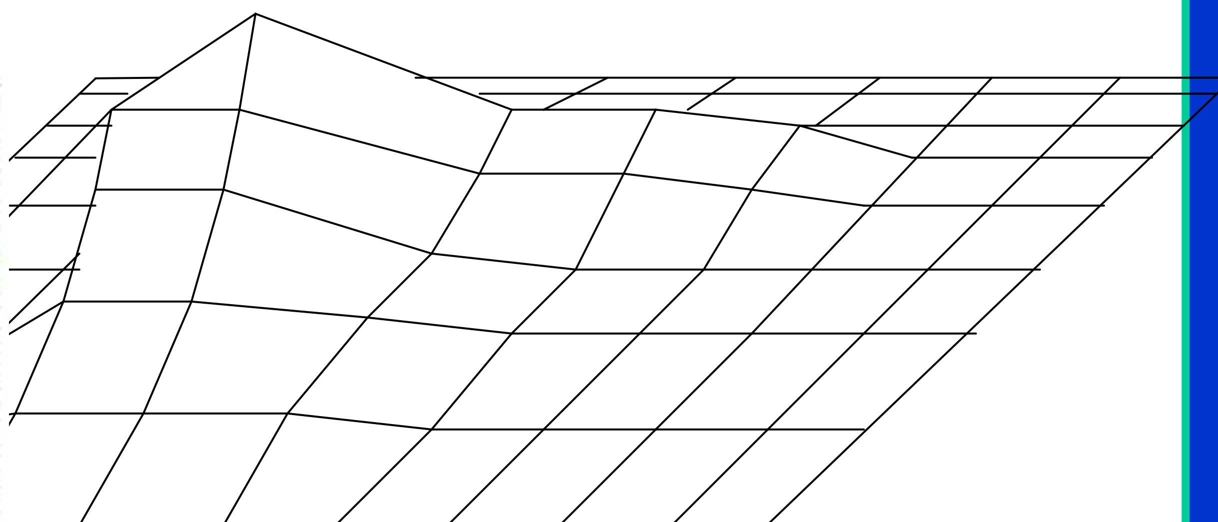
Elevation and Photo Draping

In the current version of SADA, elevation must be handled manually by users through a combination of layers and polygon tools. Since the release of 4.1, one method has been developed and is in an alpha state for incoporating elevation data directly into SADA and allowing SADA to shape layering systems according to elevation specifications. This work when finalized should solve the elevation problem.





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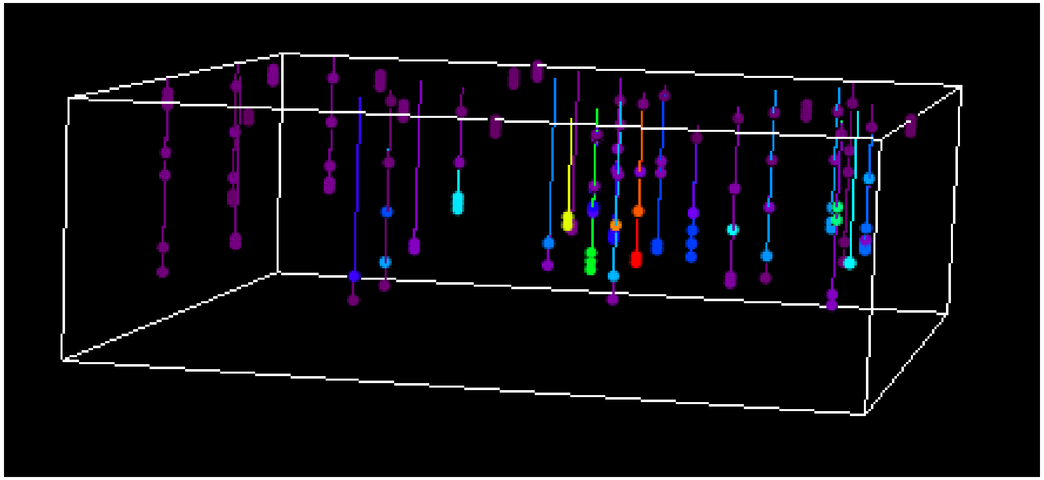
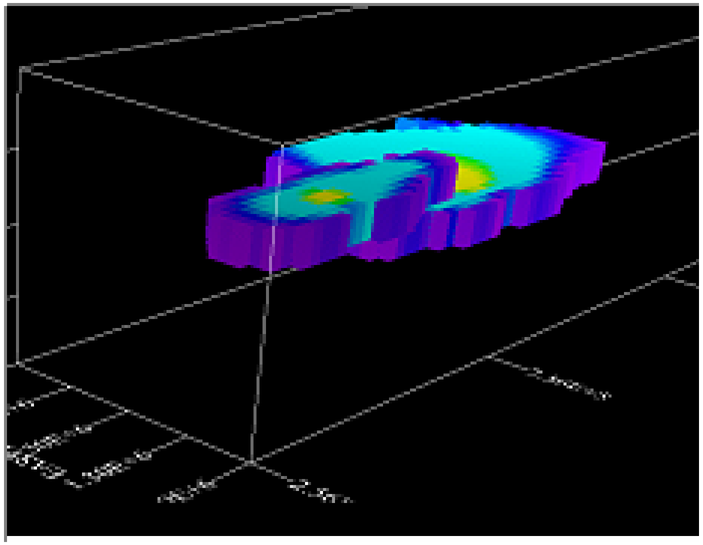
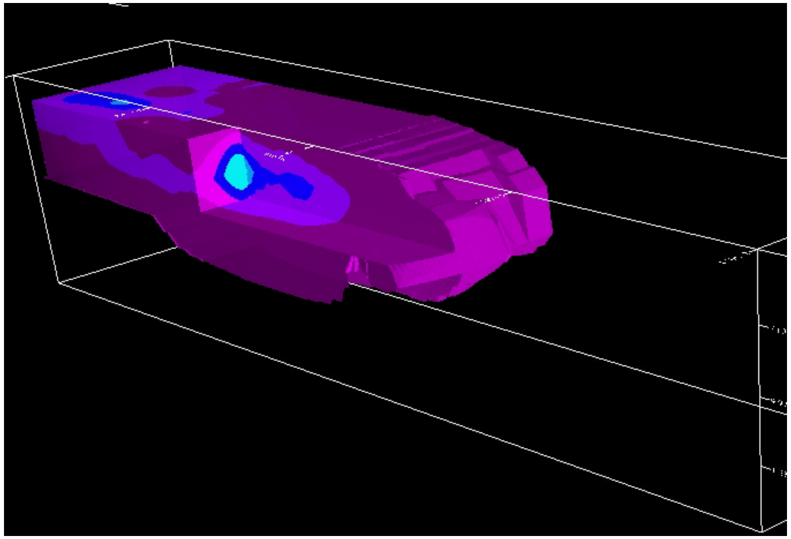
3D Visualization

True 3d Views: Points, Blocks, and Isosurfaces







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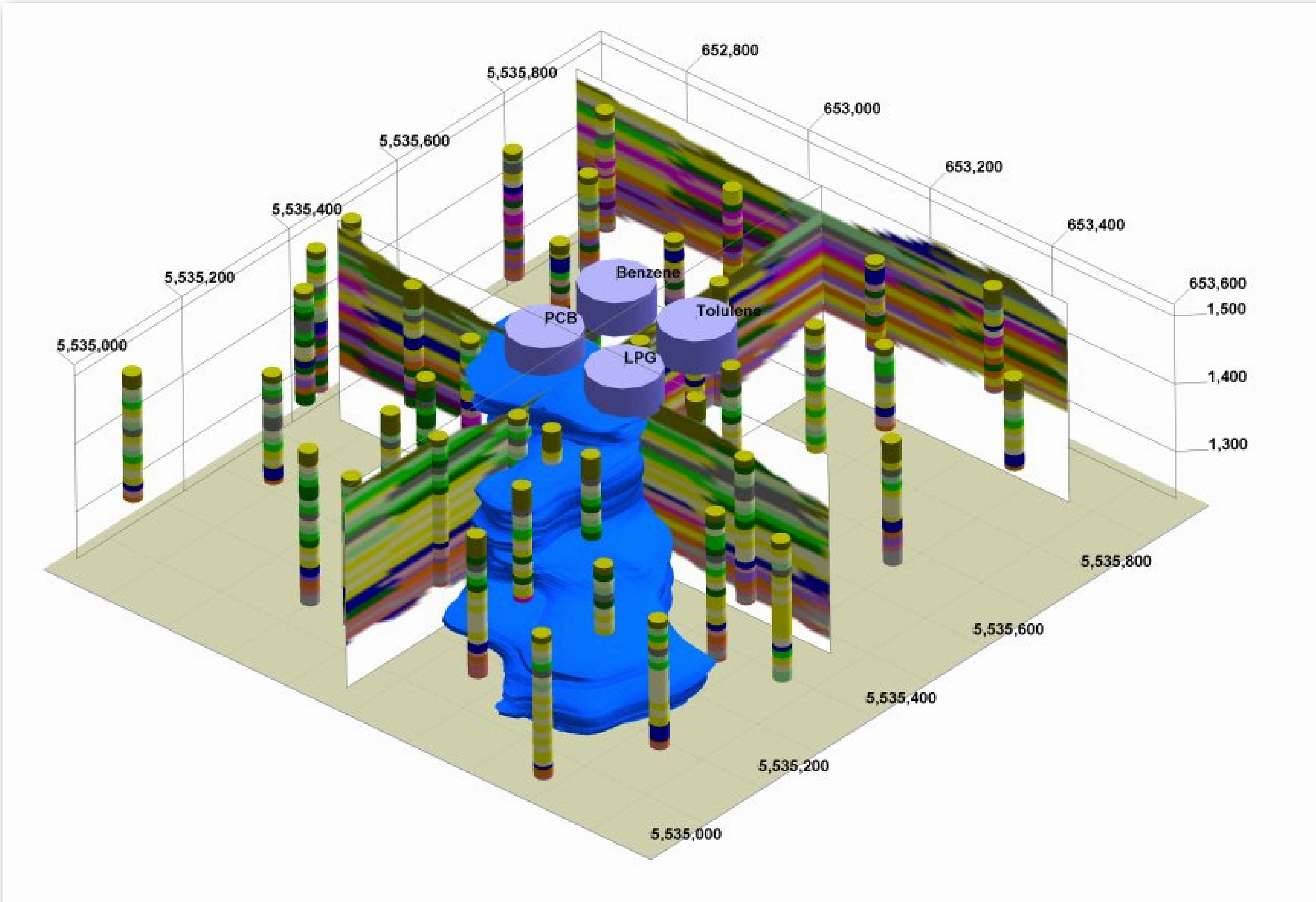
Spatial Analysis and Decision Assistance

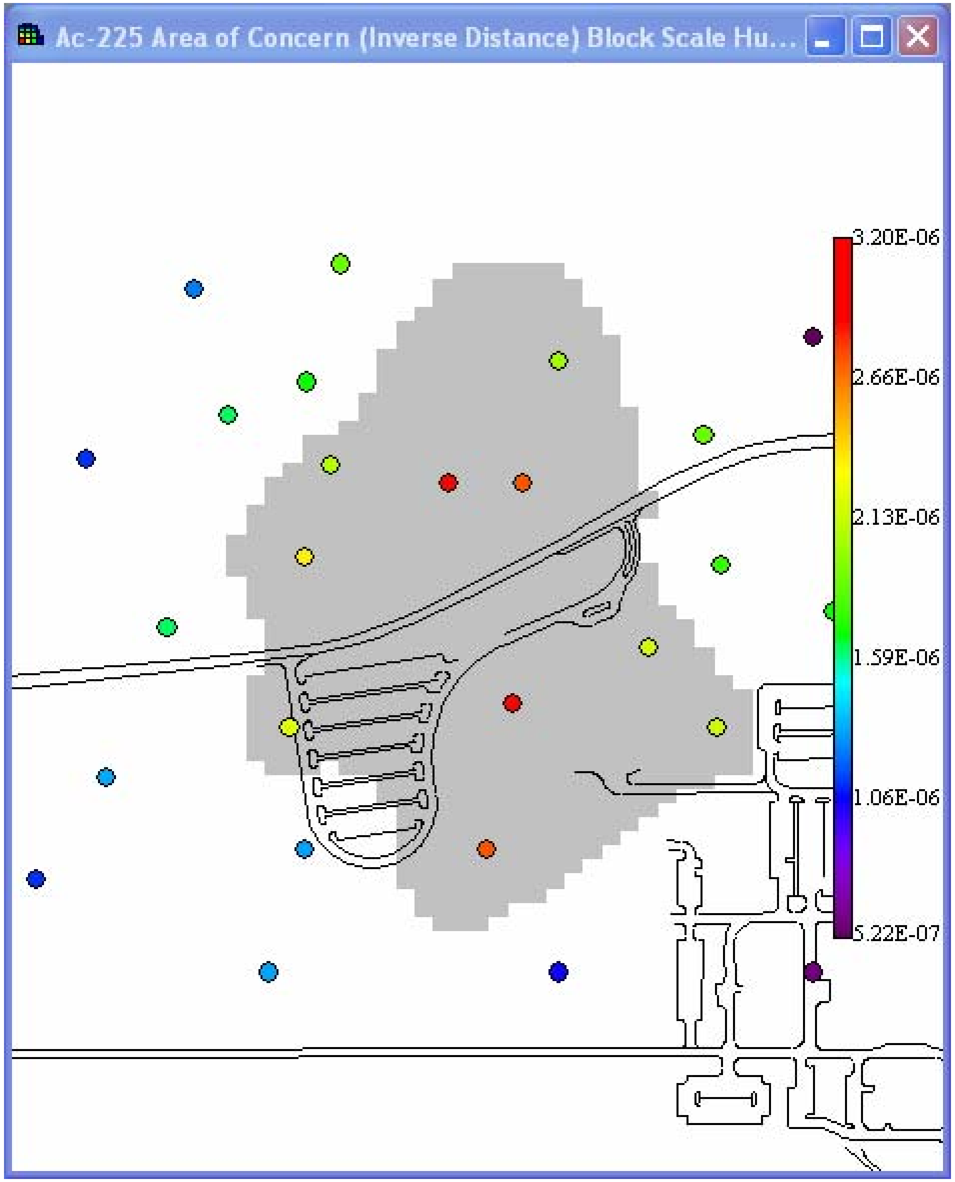
Radium Plume Display



* After ROCKWORKS

SADA Overview: Autodocumentation

- Area of concern map
- Based on HH Risk
- Utilized inverse distance as geospatial model
- Block based area of concern framework.



Ecological Dose Exposures

- SADA calculates dose (mg/kg BW d) from food ingestion, soil ingestion, dermal contact, and inhalation for terrestrial exposures
- SSL, Female, Male, or Juvenile
- Over 20 different species