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# Spatial Analysis and Decision Assistance (SADA)

Version 4.1

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## User Guide

May 2005

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<http://www.tiem.utk.edu/~sada/>

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## Getting Started

This chapter provides:

- An overview of SADA;
- Installation instructions; and
- A description of the SADA layout, including windows, buttons, menus, and interviews.

### SADA Overview

Spatial Analysis and Decision Assistance (SADA) addresses common environmental assessment issues by integrating and streamlining methods from several fields of study. These studies include:

- Data Exploration and Visualization
- Geographic Information System
- Statistical Analysis
- Human Health Risk Assessment
- Ecological Risk Assessment
- Data Screening and Decision Criteria
- Geospatial Interpolation
- Uncertainty Analysis
- Decision Analysis
- Sample Design
- Utilizing Soft Information
- MARSSIM module

While SADA was written within the context of environmental analysis, many of the processes were broadly constructed to deal with a wide array of problems concerning spatially distributed information. For simplicity, this manual will be written in the language of environmental assessment.

This manual assumes that the reader is familiar with the Windows environment and comfortable with the topics covered in this manual. References are made to other resources outside of the manual for topics that may not be familiar to all users. While some concepts may be discussed briefly, the manual is written primarily to show how to implement these concepts within the software.

A number of files have been included on the distribution disks to help the user get started. They include comma-delimited data files (.csv), example SADA files (.sada), and some GIS layer files (.dxf). The data sets contained in these files are intended for demonstration purposes only; they were not originally sampled at the locations seen in the GIS overlays and have been altered. ToxicologicalDatabases.mdb and ScenarioDatabases.mdb are also included for setting up the human health risk module in SADA while a benchmark database is included for ecological risk assessment setup and a custom database is included for the custom analysis setup. These file types will be discussed and demonstrated throughout the manual.

### Installing SADA

Before installing SADA, check for the following minimal requirements:

- CPU: Pentium II
- Disk Space: 400 MB

RAM: 64 MB  
OS: Windows 98, 98 Second Edition, NT 4.0 (SP4 and higher), 2000, ME, XP  
Clock: 200 MHz

These requirements, however, are recommended to enhance performance of geospatial analyses:

CPU: Pentium IV or higher  
Disk Space: 1 GB  
RAM: 256 MB or higher  
OS: Windows 2000, XP  
Clock: 1 GHz

To install SADA from a disk or CD:

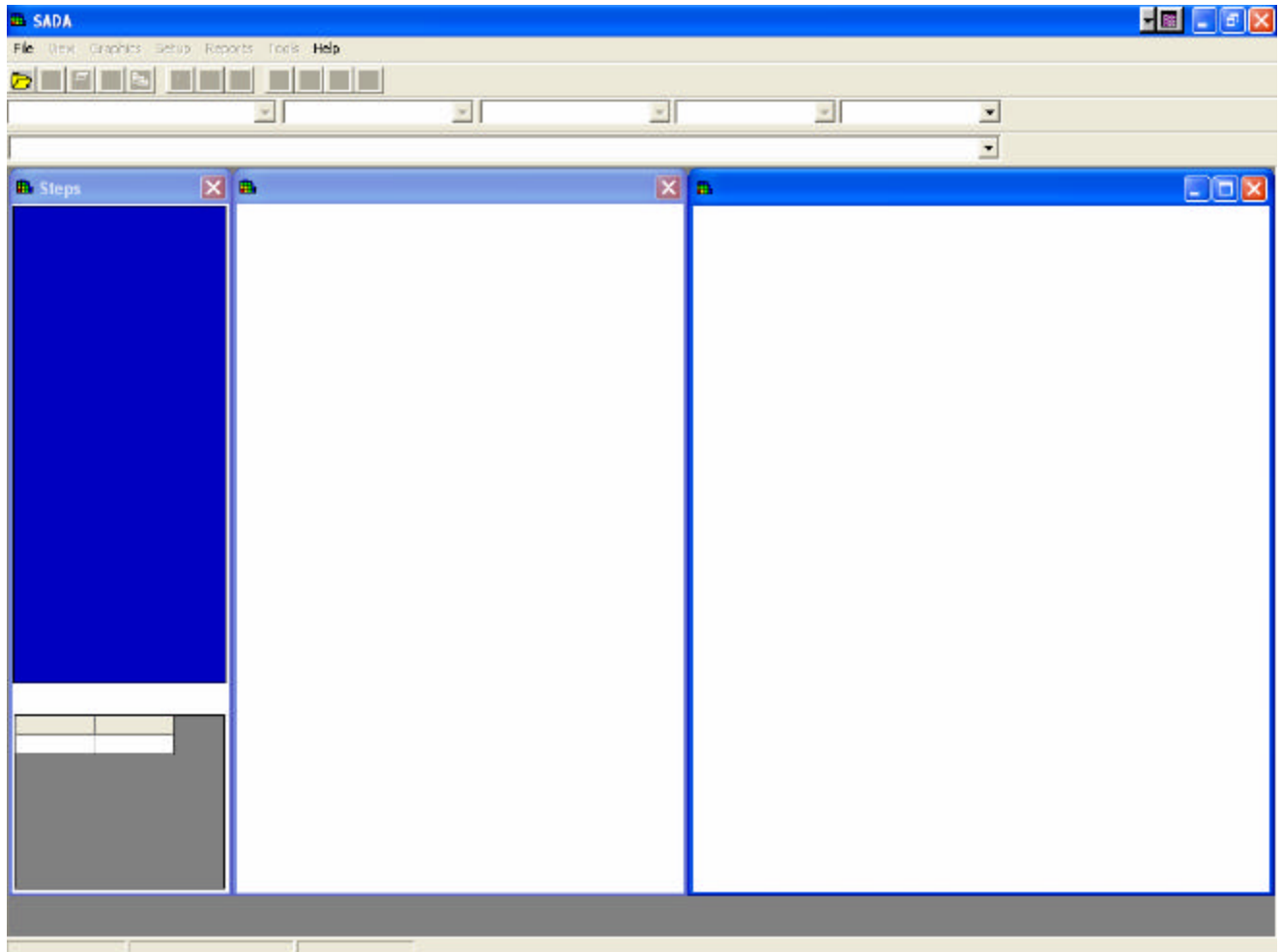
1. Place disk 1 (or CDROM) into the drive.
2. Press the Start Button on the Windows bar and select Run . . .
3. In the run box, type a:\setup (note your drive may have a different specification than "a:", particularly for the CDROM drive).
4. Follow the directions in the setup program.

To install SADA from the web download, double click the setup executable file in windows explorer and follow the directions.

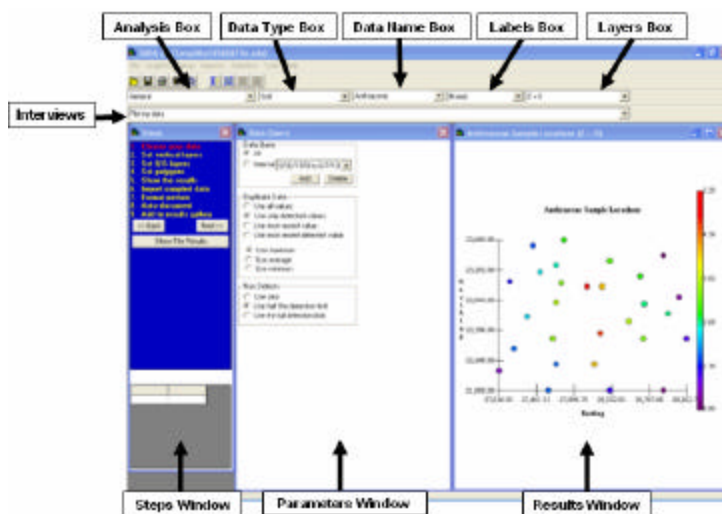
## **SADA Layout**

Before implementing methodologies in SADA, it is important to understand the main components that make up the software: list boxes, interviews, windows, buttons, and menus. When SADA is first opened, a welcome screen will appear.

Behind the welcome screen are three empty windows. Only the **Open** button and the **File** and **Help** menus will be enabled.

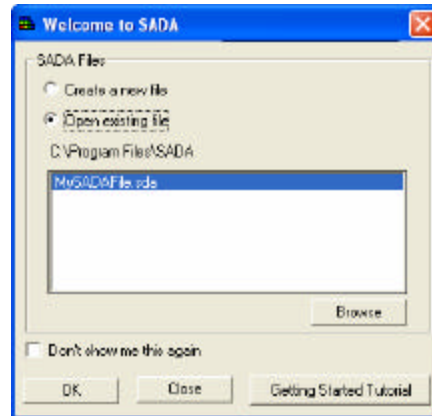


After a SADA file is created, the menus and buttons will be enabled and the windows and list boxes will display the corresponding data. In the following image, the file ThreeDimensional.sda, which is distributed with SADA, has been opened.



## Welcome Screen

The welcome screen appears when SADA is first opened.



At this screen, users have the option of creating a new SADA file or opening an existing file. All existing files will appear in the test box. **Note:** SADA is shipped with several test files that will appear here.

There is also a link here for the Quick Start Tutorial. This tutorial provides a basic introduction to SADA Version 4.

## List Boxes

**Analysis Box:** This box displays the type of analysis (e.g., general, human health, etc.). For a new file, only **General** is available. General is the default choice and simply means that the data will be used in a straightforward way without applying any other framework or models, such as risk. To use other analyses, set up human health, ecological, MARSSIM, or custom. After selecting an analysis, the interviews will change to display the appropriate actions for that analysis and the windows will change to reflect the data.

**Data Type Box:** This box displays the type of data. These can be media (e.g., soil, sediment, groundwater, etc.), Basic (when media is unimportant to the user or unspecified during file setup), Geobayesian, or Results Gallery (where the user dynamically saves spatial models). When a new data type is selected, the Data Name box changes to reflect the data for that data type. The interviews may also change depending on the data type selected.

**Data Name Box:** This box displays the name of the data. When the data type is Media, this box will list available analytes. When the data type is Basic, this box may list analytes and/or other information about the data (e.g., density). When the data type is Geobayesian, this box will display any professional judgment data names defined by the user. The Graphics Window will change when a new data name is selected.

**Labels Box:** This box displays information about the data set (e.g., depth, name, casnumber, etc.). When a label is selected, the Graphics Window will display the selected labels next to every data point. Note that the default setting for this box is [none]. If there is more than one value for a particular data point (due to duplicate or pooled data) and the values differ, SADA will display the following \*\*\*. To search for a particular label within the dataset, use the **Search Labels** function.

**Layers Box:** This box displays the different layers for data set, if the data set is three-dimensional.

## Interviews

Interviews are an important component of SADA Version 4. This list box displays all the functions that can be performed on a data set based on the analysis, data type, and data name combination. Note that the interviews listed will change when a different analysis or data type is selected.

The following list represents all the possible interviews in SADA. See the chapter associated with a particular interview for more specific information.



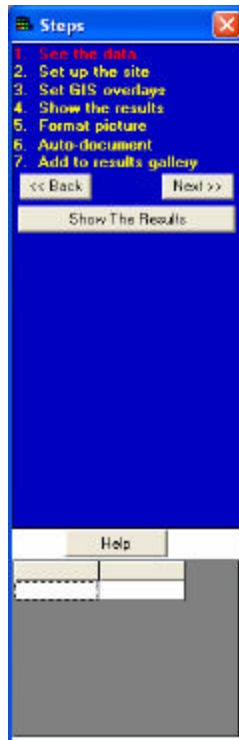
- Calculate Cost Versus Cleanup
- Calculate Cost vs. Cleanup Based on soft Data Only
- Develop a Sample Design
- Develop a MARSSIM Sample Design
- Display Empty Plot
- Draw a Contoured Eco Dose Map
- Draw a Contoured Risk Map
- Draw a Data Screen Map
- Draw a LISA Map
- Draw a Point Risk Map
- Draw a Probability Map
- Draw a Variance Map
- Draw an AOC Map Based on Soft Data Only
- Draw an Area of Concern Map
- Draw an Eco Point Dose Map
- Interpolate My Data
- Model Spatial Correlation
- Plot My Data
- Update My Prior Probability Map
- Update My Prior Variance Map
- View My Initial Probability Map
- View My Initial Variance Map

## **Windows**

There are 3 important windows in SADA Version 4: the Steps Window, the Parameters Window, and the Graphics Window.

### **Steps Window**

This window displays all the steps that need to be performed for a particular interview. When a step is selected, the parameters window displays the associated parameters.



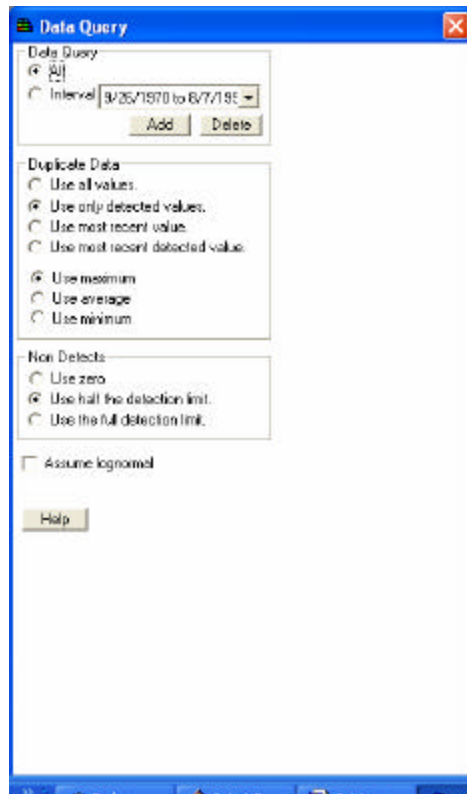
The following list represents all the possible steps in SADA. See the chapter associated with a particular step for more detailed information.

- Add to results gallery
- Auto-document
- Correlation modeling
- Cross validation
- Display empty plot
- Draw/Edit prior
- Format picture
- Import sampled data
- Interpolation methods
- MARSSIM Parameters
- Search neighborhood
- See the data
- Set background data
- Set cost information
- Set GIS overlays
- Set grid specs
- Set LISA parameters
- Set sampling parameters

- Set up the site
- Set update data
- Show the results
- Specify decision criteria

### Parameters Window

This window (which replaces the Control Panel of SADA Version 3) contains the parameters related to each interview step.



### Graphics Window

This window displays the graphical results based on the list box selections and the Steps and Parameter windows. The main toolbar provides different interactive functions for the graphics window.

Functions are enabled or disabled depending on the current plot configuration.

For all graphics, the **Print** function prints the current graphic to the printer.

The **Zoom In**, **Zoom Out**, **Restore**, and **Shift Picture** buttons will be available on all graphics except for cost curves. See the chapter on **Zooming, Shifting, and Restoring**.

The **Line Pointer** and **Line Query** buttons are available for reading cost graph information when that option has been chosen.

## Buttons

The following buttons are available on the toolbar:



**Open** – Opens SADA.



**Save** – Saves SADA files.



**Print** – Prints the currently displayed information.



**Copy to File** – Copies Ascii results to a file.



**Copy to Clipboard** – Copies current image to the clipboard. It can then be pasted into most Window Packages.



**Information** – Displays relevant information on the current graphic.



**Statistics** – Displays statistical information on the current graphic.



**Risk Screen Table**– Displays results of screening data against risk-based screening criteria. Only enabled for human health, ecological, or custom analyses.



**Risk Table** – Displays results of calculating risk. Only available for human health or ecological analyses.



**Measures Button** – Measures the distance between two points on the graphics window.



**Zoom In** – Zooms in an area on the graphics window.



**Zoom Out** – Zooms out an area on the graphics window.



**Shift Picture** – Shifts the picture on the graphics window.



**Restore Picture** – Restores the graphics window to the default view.



**Line Pointer** – The line pointer button is used to define the coordinates of a line on the graphics window.



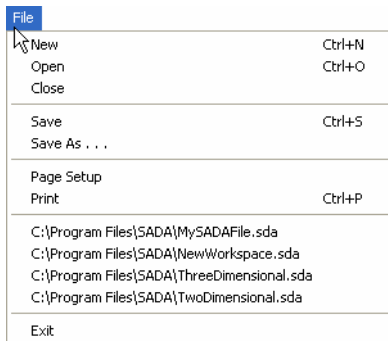
**Line Query** – The line query button is used to type in the value of one coordinate for a line in the graphics window and find the value for the other coordinate.

## Menus

The following menu items are available in SADA: File, Graphics, Setup, Reports, Statistics, Tools, and Help.

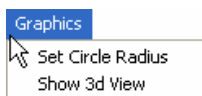
In addition to the standard menus, new menus will appear when Human Health, Ecological, or Custom are selected as the analysis type or Geobayesian is selected as the data type.

### File Menu



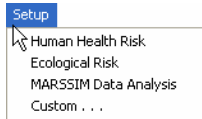
- New** Creates a new SADA file.
- Open** Opens a new SADA file.
- Close** Closes current SADA file.
- Save** Saves current SADA file.
- Save As** Saves current SADA file as another name.
- Page Setup** Changes the look of the printed page and chooses the printer.
- Print** Prints currently visible graphic.
- C:\ . . .** Opens most recently used SADA files directly.
- Exit** Exits SADA.

### Graphics Menu



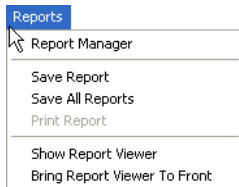
- Set Circle Radius** Sets the plot radius for plotted data values.
- Show 3d View** Opens the three-dimensional volume rendering window.

## Setup Menu



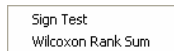
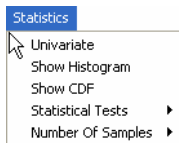
- Human Health Risk** Takes the user through the human health risk assessment setup wizard.
- Ecological Risk** Takes the user through the ecological risk assessment setup wizard.
- MARSSIM** Takes the user through the MARSSIM setup.
- Custom...** Takes the user through the custom analysis wizard in order to import external information into SADA.

## Reports Menu



- Report Manager** Opens the report viewer.
- Edit Active Report** Allows the user to edit the current report.
- Save Report** Saves the currently selected report (only when report viewer is visible)
- Save All Reports** Saves all reports currently associated with the project (only when report viewer is visible)
- Print Report** Prints current report (only when report viewer is visible)
- Show Report Viewer** Shows the HTML Report viewer where your reports can be viewed and edited.
- Bring Report Viewer to Front** Opens the report viewer on top of all other windows.  
Last five opened report can be easily accessed from the bottom section of this menu.

## Statistics Menu



- Univariate** Displays a table of one variable statistics for the selected data name.
- Show Histogram** Shows histogram of values for currently visible plot (not available for cost plots).
- Show CDF** Displays the cumulative distribution function (CDF) in the graphics window.

## Statistical Tests

**Sign Test vs. Decision Criteria** Uses the sign test to compare sampled data set to user-specified decision criteria.

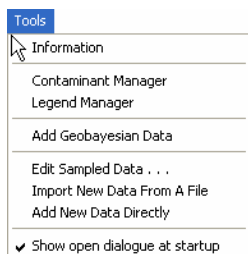
**Wilcoxon Rank Sum Test** Uses the Wilcoxon Rank Sum test to compare to data sets (e.g., sampled data to background).

## Number of Samples

**Sign Test** Uses the sign test to determine the number of sampled needed based on user-specified decision criteria.

**Wilcoxon Rank Sum** Uses the Wilcoxon Rank Sum test to determine the number of sampled needed based on user-specified decision criteria.

## Tools Menu



### Information

Produces the database fields from the SADA file for the currently selected data or modeling results.

### Search Labels

This function allows the user to search labels for particular information.

### Contaminant Manager

Allows the user to access the Contaminant Manager.

### Legend Manager

Provides access to the legend manager for legend creation and control.

### Add Geobayesian Data

Takes the user through the Geobayesian setup wizard in order to combine prior site information with hard sampled values.

### Edit Sampled Data

Allows the user to edit data properties in the Data Editor window.

### Import New Data From a File

Allows the user to import data to the current SADA file.

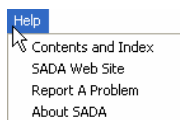
### Add New Data Directly

Allows the user to manually add a new contaminant to the data set.

### Show open dialogue at startup

Check this option for SADA to present the welcome screen each time it is started.

## Help Menu

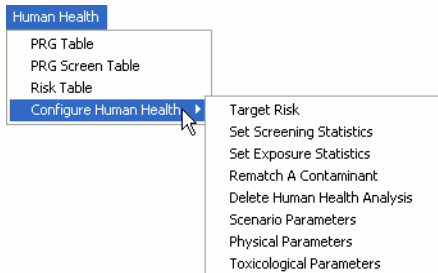


**Contents and Index** Gives the user access to the SADA Help system.

**SADA Web Site** Opens the SADA website in the default internet browser.

- Report a Problem** Opens the bug report page of the SADA website, which provides an e-mail link to SADA developers.
- About SADA** Provides information about the SADA software.

### Human Health Menu

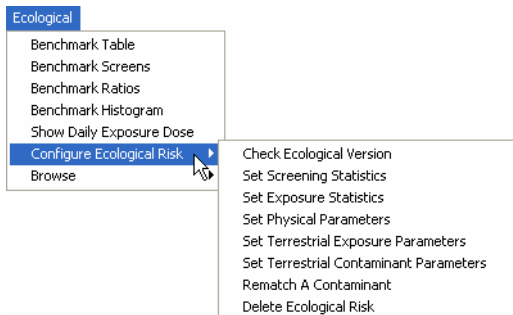


- PRG Table** Allows the user to view the table of Preliminary Remediation Goals (PRGs).
- PRG Screen Table** Presents the table of PRG screening results.
- Risk Table** Presents the table of human health risk results.

**Configure Human Health** Provides a list of the following options:

- Target Risk** Allows the user to view or edit the target health index and the target risk values.
- Set Screening Statistics** Allows the user to select a statistical approach for calculating representative screening values.
- Set Exposure Statistics** Allows the user to select a statistical approach for calculating exposure concentrations.
- Rematch A Contaminant** Allows the user to rematch a single contaminant with one in the toxicological database.
- Delete Human Health Analysis** Allows the user to delete the current human health analysis.
- Scenario Parameters** Presents the Scenario Parameters Window for viewing parameter settings.
- Physical Parameters** Presents the Physical Parameters Window for viewing parameter settings.
- Toxicological Parameters** Presents the Toxicological Parameters Window for viewing toxicological values.

### Ecological Menu

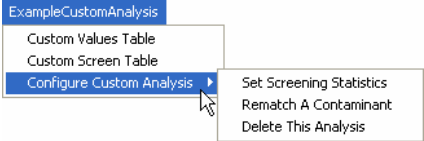




Benchmark Table From ...  
Benchmark Histogram From ...

<b>Benchmark Table</b>	Presents a table of ecological benchmarks for the selected media.
<b>Benchmark Screens</b>	Presents a table of ecological benchmark screening results for the selected media.
<b>Benchmark Ratios</b>	Presents a table of ecological benchmark ratios for the selected media.
<b>Benchmark Histogram</b>	Displays a histogram for the selected media in a new window.
<b>Show Daily Exposure Dose</b>	Presents a table of daily exposure doses for soil contaminants.
<b>Configure Ecological Risk</b>	Provides a list of the following options:
<b>Check Ecological Version</b>	Provides a list of the information for the selected file.
<b>Set Screening Statistics</b>	Allows the user to select a statistical approach for calculating representative screening values.
<b>Set Exposure Statistics</b>	Allows the user to select a statistical approach for calculating exposure concentrations.
<b>Set Physical Parameters</b>	Allows the user to view and set physical parameters for the analysis.
<b>Set Terrestrial Exposure Parameters</b>	Allows the user to view and set terrestrial exposure parameters for specific species.
<b>Set Terrestrial Contaminant Parameters</b>	Allows the user to view and set terrestrial contaminant parameters for specific contaminants.
<b>Rematch A Contaminant</b>	Allows the user to rematch a single contaminant with one in the ecological benchmark database.
<b>Delete Ecological Risk</b>	Allows the user to delete the current ecological analysis.
<b>Browse</b>	Provides a list of the following options:
<b>Benchmark Table From...</b>	Allows the user to view benchmarks from any valid SADA benchmark database.
<b>Benchmark Histogram From...</b>	Allows the user to view histograms of benchmark values from any valid SADA benchmark database.

**Custom Menu**



<b>Custom Values Table</b>	Allows user to see the set of custom values for the current contaminant(s)
<b>Custom Screen Table</b>	Screens current contaminant against the set of custom values.
<b>Configure Custom Analysis</b>	Provides a list of the following options:
<b>Set Screening Statistics</b>	Allows the user to select a statistical approach for calculating representative screening values.
<b>Rematch A Contaminant</b>	Allows the user to rematch a single contaminant to a contaminant in a custom database of the same data structure.

### **Delete This Analysis**

Deletes the current custom analysis.

### **Geobayesian Menu**



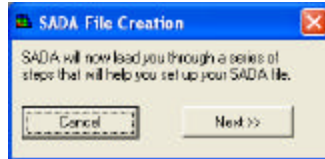
### **Create a New Prior**

Allows the user to setup another Geobayesian model.

## SADA Files

SADA Version 4 allows users to import data or create an empty SADA file. An empty file is useful if the user wants to use SADA to decide where to take initial samples.

To begin the creation sequence, open **SADA**, select **File**, and from the menu bar choose **New**. The following window will appear.



Press **Next >>** to continue.

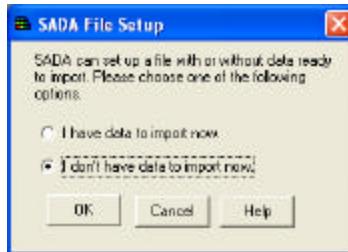
Select one of the choices from the SADA File Setup window and press **OK**.

Note: files may also be created with the welcome screen, which appears when SADA is opened.

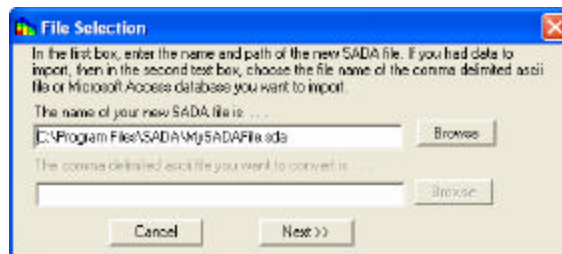
### Creating an Empty SADA File

A SADA file may be created without sampled data in an empty file. An empty file can be useful for determining where to take initial samples. Additionally, the user can develop an applicable environment (by setting vertical layers, GIS Overlays, polygons, and site boundaries) before importing sampled data.

At the SADA File Setup window, select "**I don't have data to import now**" and press **OK**.



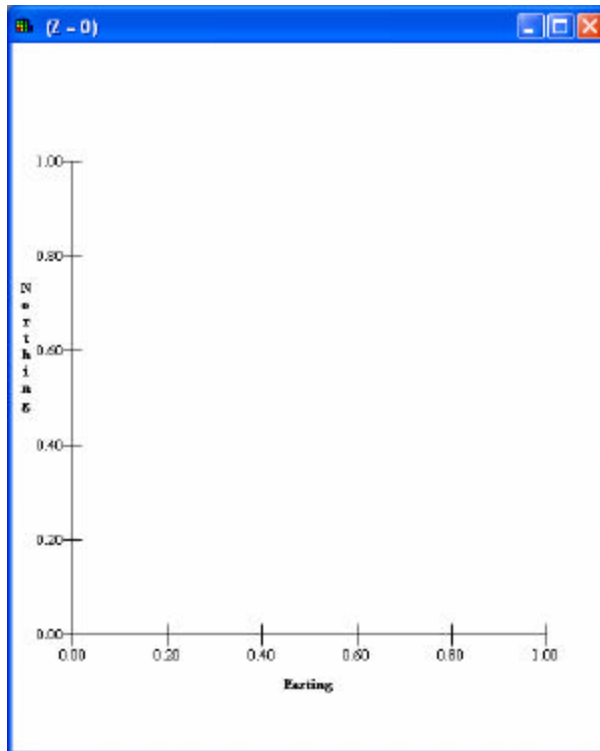
SADA opens the File Selection window.



Enter the name of the SADA file in the space provided. As a default, SADA will automatically enter MySADAFile.sda. Then press **Next>>**.

**Note:** the second line is disabled since there is no data to import.

After creating an empty file, SADA will display an empty plot in the Graphics Window.

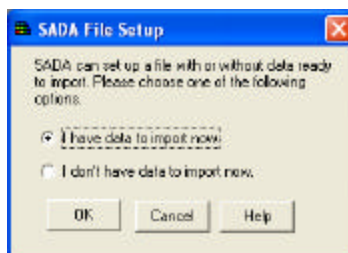


The only Interviews that are available are Develop sample design and Develop MARSSIM Sample Design. Select one of these Interviews and follow the steps that appear in the Steps Window.

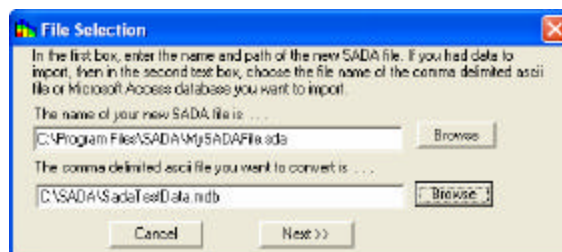
### Creating a SADA File with Sampled Data

At the SADA File Setup window, select "I have data to import now" and press **OK**.

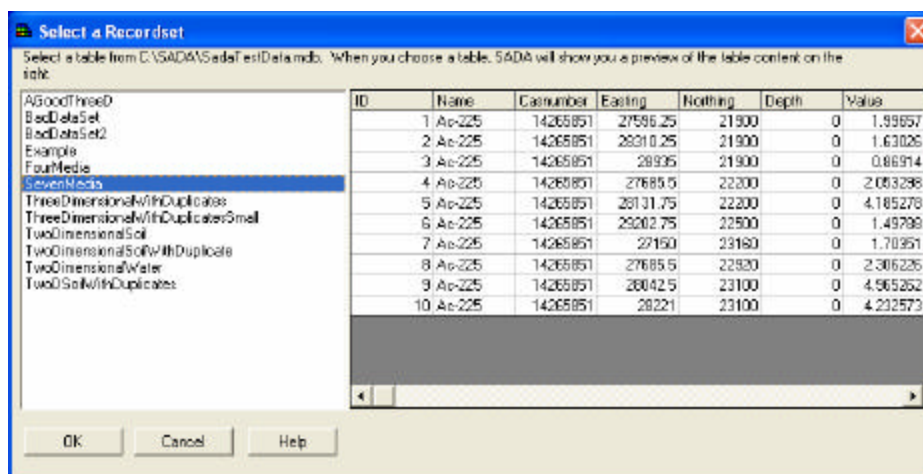
**Note:** SADA accepts a valid comma delimited ASCII text file or a Microsoft Access Office file containing appropriate sampling information to establish a SADA file.



SADA opens the File Selection window. At this point, enter the name of your new SADA file into the first textbox. Then, enter the name of the comma-delimited ASCII file or Access database that contains your data SADA into the second textbox (or press the **Browse** button to select). Press **Next>>** for SADA to convert your data file into this new SADA file. **Note:** the external file itself is not affected by the conversion process.



If your input file is an Access database, the following window will appear.



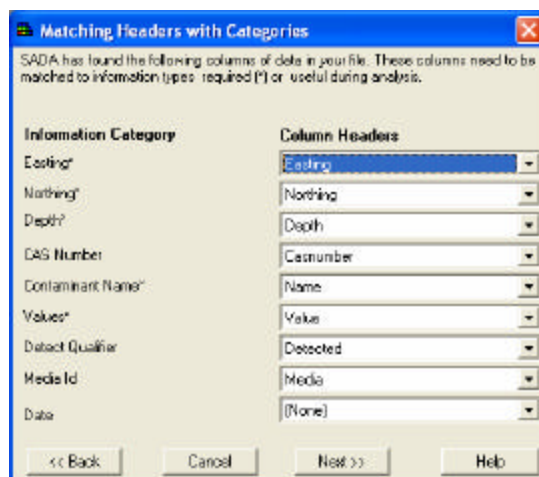
The pane on the left shows all the available tables in your database. Select the table with the needed information and press **OK**.

The next step in the process, or the first step if your dataset is a .csv file, is to identify the columns of information in the ASCII data file and match these columns of information to information categories that are required or may be useful in SADA. SADA scans the text file for column headers and applies default matches to these information categories. The results are shown in the **Matching Headers with Categories** window. If a column is mismatched with an information category type, then you can select a new column header by pressing the down arrows and highlighting the new column header.

Required information categories are followed by an (\*) and must be assigned to a column in the ASCII data file. A category is not assigned if the (none) option is selected in the drop down box. The **Depth** category is required only when data exist at varying depths. If the **Detect Qualifier** is not assigned, the data are assumed to be all detects. If the media column is not assigned, SADA adds an artificial media column titled 'Basic'.

**WARNING:**

If Media ID, which denotes the type of media the contaminants are sampled in (e.g. soil or groundwater) is not defined, then the human health risk and/or ecological risk modules cannot be setup later. The media is a critical information category to the risk modules. Also, SADA expects certain units for measured values in the risk modules.



After the columns have been set, press **Next>>**. SADA begins the conversion process and presents the data as it will be imported into the Data Editor.

Nothing coordinates has a non-numerical or empty value.

Eastings	Northing	Depth	Casnumber	Name	Value	Detected	Media	Date	SampleID
27595.25	21900	0	14265961	Ac-225	2	1	SD	9/26/1970	1
28910.25	21900	0	14265961	Ac-225	1.6	1	SD	9/26/1970	2
28935	21900	0	14265961	Ac-225	0.9	1	SD	9/26/1970	3
27685.5	22200	0	14265961	Ac-225	2	1	SD	9/26/1970	4
28131.75	22200	0	14265961	Ac-225	4.2	1	SD	9/26/1970	5
29202.75	22500	0	14265961	Ac-225	1.5	1	SD	9/26/1970	6
27150	23160	0	14265961	Ac-225	1.7	1	SD	9/26/1970	7
27685.5	22920	0	14265961	Ac-225	3.6	1	SD	9/26/1970	8
29042.5	23100	0	14265961	Ac-225	4.9	1	SD	9/26/1970	9
28221	23100	0	14265961	Ac-225	4.2	1	SD	9/26/1970	10
28667.25	23220	0	14265961	Ac-225	2.9	1	SD	9/26/1970	11
29113.5	22980	0	14265961	Ac-225	1	1	SD	9/26/1970	12
27417.75	23580	0	14265961	Ac-225	1.9	1	SD	9/26/1970	13
27774.75	23640	0	14265961	Ac-225	2.9	1	SD	9/26/1970	14
28310.25	23400	0	14265961	Ac-225	3.1	1	SD	3/22/1993	15
28935	NA	0	14265961	Ac-225	0.9	1	SD	3/22/1993	16
28200	22560	0	14265961	Ac-225	4.8	1	SD	3/22/1993	17
28700	22500	0	14265961	Ac-225	3.3	1	SD	3/22/1993	18
27200	22380	0	14265961	Ac-225	2.03	1	SD	3/22/1993	19
28884	22787	0	14265961	Ac-225	2.6	1	SD	3/22/1993	4
27350	22750	0	14265961	Ac-225	2.5	1	SD	3/22/1993	3
27026	22129	0	14265961	Ac-225	1.7	1	SD	3/22/1993	2

Buttons: Submit, Check Errors, Find next error, Delete Record, Cancel, Help

Finished

The **Data Editor** is a simple spreadsheet that shows how SADA views the data as it is being imported. It provides the user a chance to identify errors in the data set and correct them during the import process. At this point, the **Data Editor** is very simple in functionality and is designed to correct minor errors in the data. If for some reason the data import appears to be largely different than the user intended, the exact cause should be identified outside of SADA and the setup repeated.

SADA highlights cells with red if they contain an unacceptable value for SADA. In the example above, the northing column contains a value of "NA". Since SADA requires numerical values for every northing entry, the cell is now red. To determine the exact error, place the mouse over the red cell and the yellow text box near the top explains the problem with the entry.

Once the spreadsheet contains no red cells, the process may continue. Near the top is a checkbox called **Automatic Error Checking**. It is recommended that this box remain checked. When unchecked, SADA is no longer looking for mistakes as you type. Under these conditions, you must press the **Check Errors** button at the bottom of the page to run the check. It may be preferable to uncheck the **Automatic Error Checking** box and use **Check Errors** later when the user is entering or pasting large amounts of data and does not wish the process to be slowed by SADA checking values as they are entered. However, generally during the import process it should remain checked. If there are many errors or the file is large, use the **Find Next Error** button for SADA to locate the next error.

After scanning in the contaminants, SADA checks for duplicate values. Duplicate values are resolved based on the criteria defined on for the data query parameters, visible when **See the data** is selected from the **Steps Window**.

Click **Submit** after all errors have been corrected. The SADA file is now successfully created and is automatically opened.

## Data Requirements

Before a data set can be converted into a SADA file, it must adhere to the following requirements:

1. The data set must be in comma delimited text or in Microsoft Access.

2. The file must include at least four columns, in any order, that contain the analyte name, easting coordinate, northing coordinate, and sample value. If the data are taken over depth, an additional column with the depth value is required. No empty values are allowed for any of these columns, and non-numerical values are not permitted for any coordinate or sample value.
3. Columns containing CAS Numbers, Detect Qualifiers, Media Identification, and date are optional. Additional columns are accepted; however, the total number of columns may not exceed 250. CAS Numbers are accepted with or without dashes and without trailing or leading zero values. Valid detection qualifiers consist of only 0 and 1, non-detect and detect respectively. Proper media identification qualifiers are as follows: Soil – SO, Sediment – SD, Groundwater – GW, Surface water – SW, Air – AIR, Biota – BIO, and Background – Background. Proper date format is mm/dd/yy.
4. All columns must have a title row. Punctuation is not allowed in the title names.
5. If risk assessments are part of the analysis (either human health or ecological), then the concentration values are expected to be:  
 Soil, Sediment, and Biota: mg/kg for nonradionuclides, pCi/g for radionuclides  
 Surface/Groundwater: mg/L for nonradionuclides, pCi/L for radionuclides  
 In addition, a Media Identification column is required for setting up the human health risk or ecological risk modules.
6. Quotation marks are located only around items that contain a comma. SADA accepts quotations as field delimiters and may get fields out of order. For example, the value *Sample located on "C" Street* is accepted as three column values: *Sample located*, *C*, and *Street*. Conversely, *Arsenic, Inorganic* must be enclosed in quotes or SADA will read it as two field values: *Arsenic* and *Inorganic*. The proper way to store the field value is *"Arsenic, Inorganic"*.

If your data set is an Access File, it is likely that SADA will have no problems with data requirements.

## Opening/Saving a SADA File

### Open

To open a SADA file, select **Open** from the **File** menu or press the **Open** button located on the main toolbar.

### Save

To save a file, select **Save** under the **File** menu. You can also save a file by pressing the **Save** button located on many toolbars throughout SADA.

### Close

To close the current file, select the **File** menu and choose **Close**.

### New

To convert an ASCII text file into a SADA file or create an empty file, select **New** from the **File** menu. This begins the SADA file creation sequence.

## Basic Functions

This chapter displays some basic interviews, steps, and options in SADA.

Basic Interviews:

- Plot my Data
- Draw a Data Screen Map

Basic Steps:

- Display empty plot
- Set up the site
- Import sampled data
- See the data
- Set GIS overlays
- Format picture
- Auto-document
- Results Gallery
- Show results

Basic functions:

- Graphical displays
- Legend Manager
- Zooming, Shifting, and Restoring
- Pooling data
- Contaminant Manager
- Data Editor
- Add a contaminant
- Information
- Statistical Information

## Plot My Data - Interview

This interview, which is the default for a new SADA file with sampled data, displays the sampled data and any graphical additions (e.g., vertical layers, polygons, etc.) in the Graphics Window.

### Availability

This interview is available for all analyses that have sampled data, with all data types except Geobayesian.

### Steps

These are the steps that display in the Steps Window when this interview is selected. See the corresponding chapters for more information about each step.

1. See the data
2. Set up the site



3. Set GIS Overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

## Draw a Data Screen Map - Interview

In SADA, you can screen data against a user-defined concentration value, a human or ecological risk-based value, or custom criteria you may have brought into SADA, such as state soil screening values.

### Availability

This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian.

### Steps

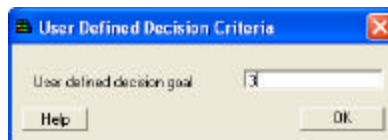
These are the steps that display in the Steps Window when this interview is selected. See the corresponding chapters for more information about each step.

1. See the data
2. Set up the site
3. Set GIS Overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

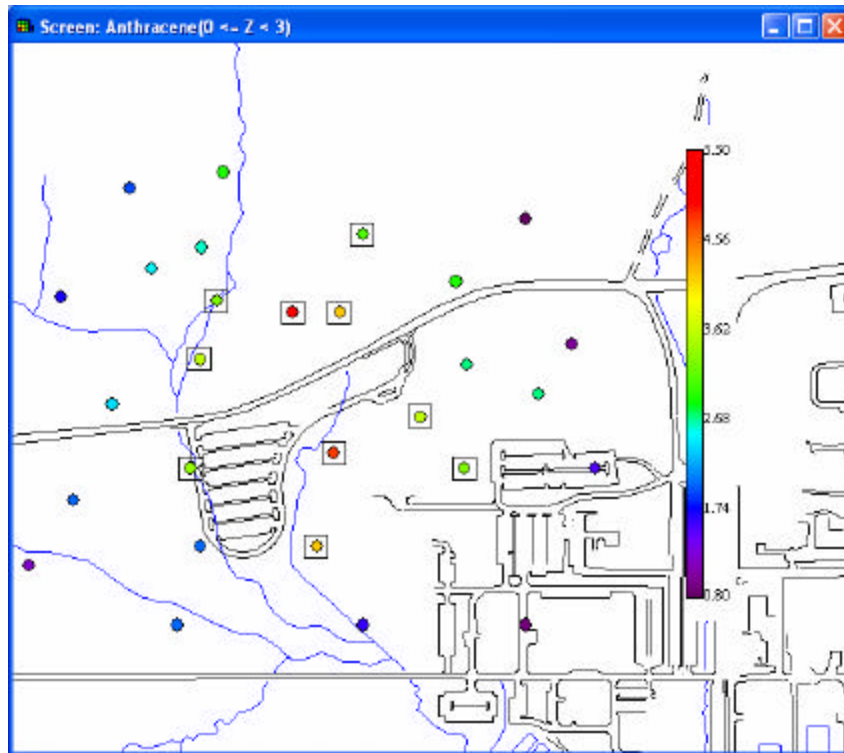
When **Show the results** is selected from the Steps Window, SADA will ask for the decision criteria. The decision criteria depend on the type of analysis.

### General Analyses

After selecting **Show the Results**, SADA asks the user for the decision criteria.



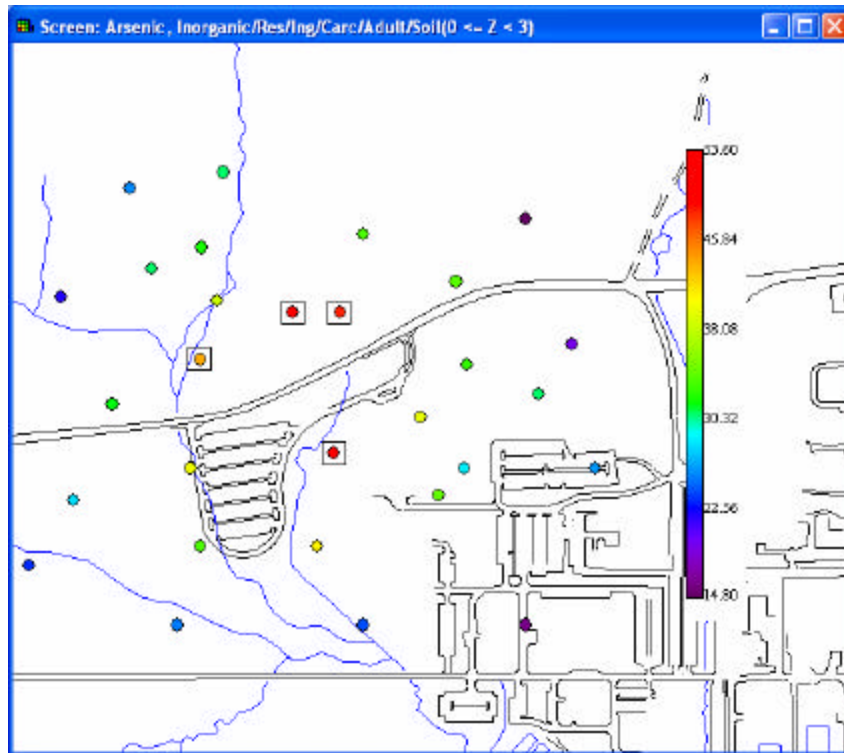
In the text box, enter a concentration value. Then, press **OK**. SADA highlights those sample points that exceed the specified concentration value.



*Human Health*

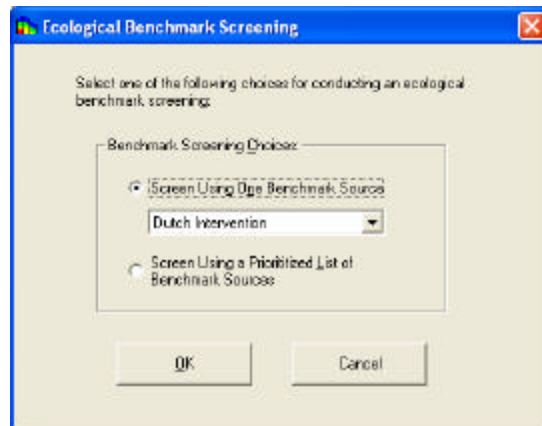
After selecting **Show the Results**, SADA presents the risk scenario selection window.

Select the risk scenario of interest and press **OK**. SADA screens the data against Preliminary Remediation Goals (PRGs) for the specified scenario.

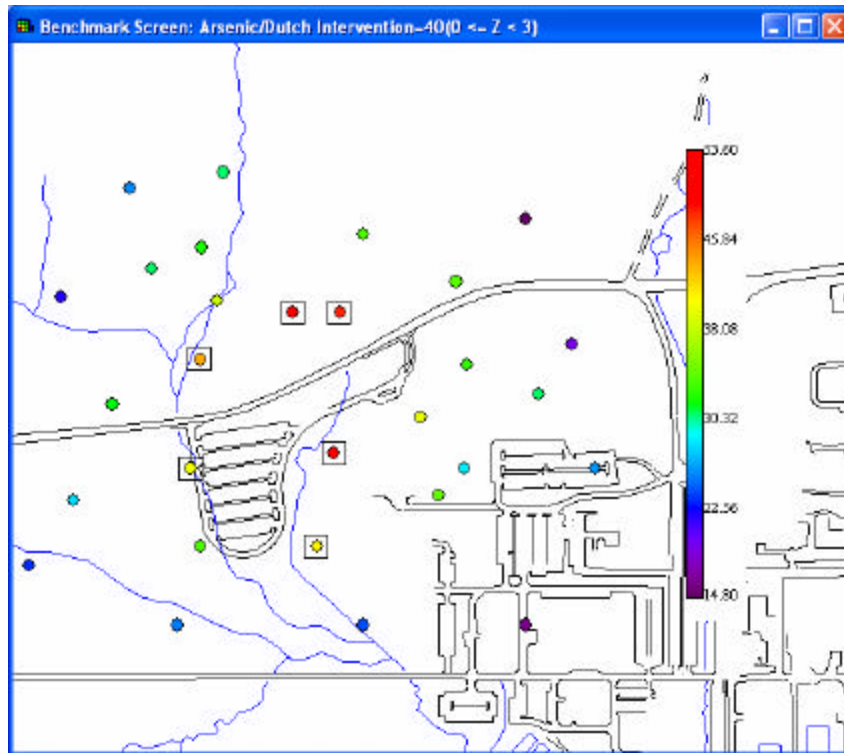


*Ecological*

After selecting **Show the Results**, SADA presents the ecological benchmark screening window.

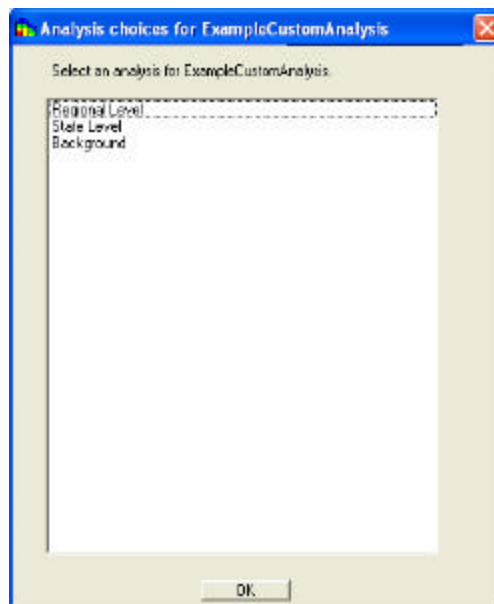


Select the screening option (screen against one benchmark source or a prioritized list) and press **OK**. SADA screens the data against the selected benchmark(s).



*Custom*

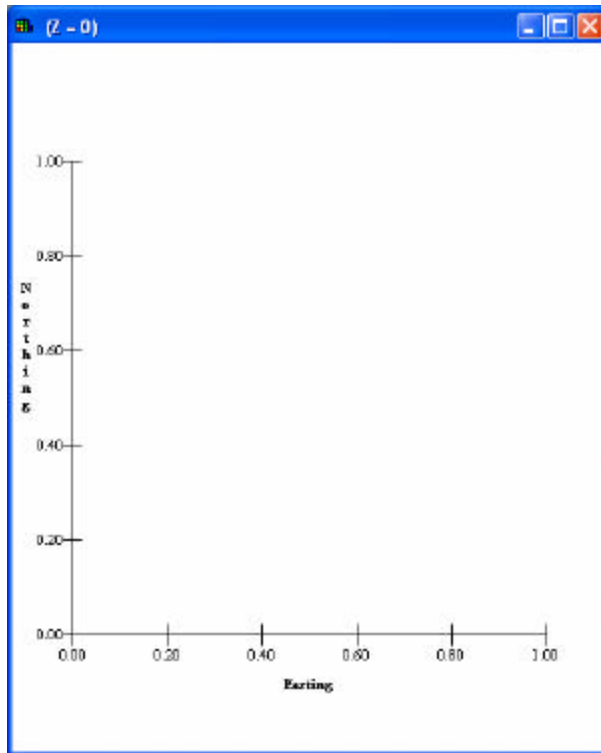
After selecting **Show the Results**, SADA asks the user for the decision criteria.



Select the screening criteria of interest and press **OK**. SADA screens the data against the specified Criteria.

### **Display Empty Plot - Step**

This step is only available for an empty data set. When this step is selected, there are no parameters displayed in the Parameters Window and the Graphics Window displays the empty plot.



### Set up the Site - Step

This step is available for all interviews. When this step is selected, the parameters window will display the following information:

**Setup the site**

Site Boundary

	Minimum	Maximum	
Easting	26500	29202.75	Apply
Northing	21900	23640	Draw
			Snap

Set Vertical Layers

All [v] Add

Layers (Double click to edit) Delete

0-0 (Active with no polygons)

Interpolate and Place New Samples

At the top  In the middle

Current Layer Polygons

Layer range: (Z = 0.1)

(None) [v] Add

Drawing Tools

Polygon  Ellipse  Rectangle

Delete Draw

Polygon names (Double click to edit)

Use only selected data during interpolation

Show only included polygons

Help


The window is divided into 3 sections: Site Boundary, Set Vertical Layers, and Polygons.

## Site Boundary

The site boundary determines the easting and northing coordinates that will be used in all SADA functions. (The vertical component is determined by the Set Vertical Layers step.) **Note:** *Even if a polygon extends outside of the site boundary, the site boundary still determines the data extends, and the points within the polygon outside of the boundary are ignored.*

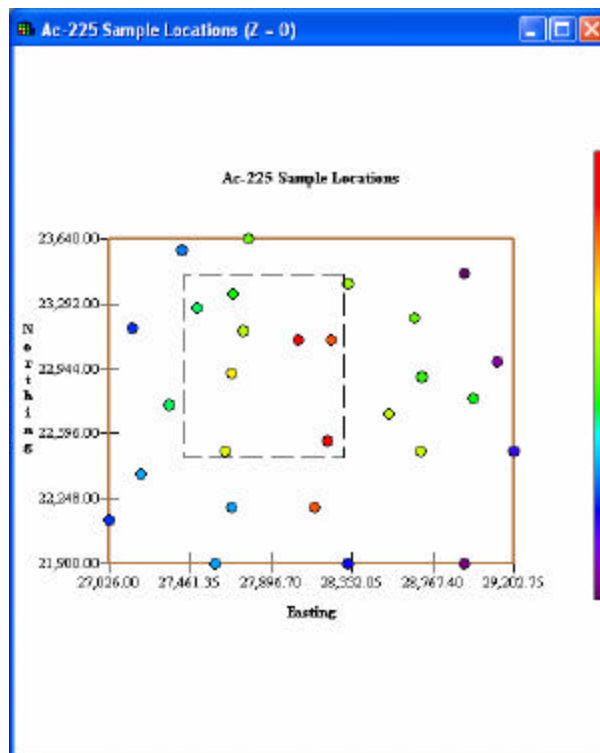
When **Set up the site** is selected in the Steps Window, the Parameters Window displays the site boundary information.

Site Boundary			
	Minimum	Maximum	
Easting	26900	29202.75	Apply
Northing	21900	23640	Draw
			Snap



Default easting and northing minimum and maximum coordinates are determined by SADA based on the data upon file creation. For an empty sada file, SADA sets both minimum values to zero and maximum values to 1.

To adjust these coordinates, manually enter appropriate values in the text boxes and press the **Apply** button. Alternatively, select the **Draw** button and use the mouse to select a rectangular area of interest in the Graphics Window. Press the **Apply** button to view the full effect.



Use the **Snap** button for SADA to snap the site boundary back to the full data or model extents. Then press **Apply** to view the full effect.

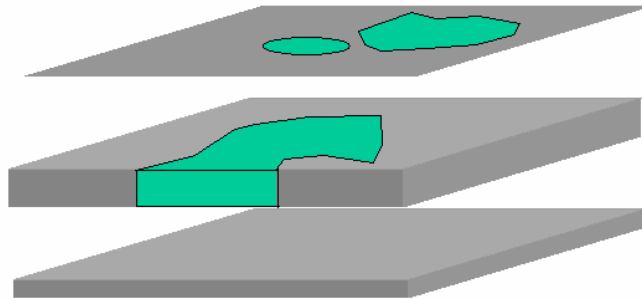
**Note:** *If site boundaries are set before GIS overlays are imported, SADA will ask the user if boundaries should be adjusted to incorporate the layers during their import.*

## Overview of Vertical Layers and Polygons

SADA 4 permits users to create layering schemes, name them, and recall them at any time. Within these layering schemes, users can specify multiple layers of regular or varying thicknesses. Unlike Version 3, these layering schemes now are used freely in both the data analysis and geospatial modeling realms, since the revised spatial models can now handle irregular depth layers.



Polygons have also undergone a similar change. As before, polygons can be created and named. However, now polygon designs (sets of polygons) are associated with one or more layers within a layering scheme. Furthermore, a polygon design can be used in multiple layering schemes. It can be helpful to think of polygons as being a form of a GIS layer that can be shown under a number of circumstances. It is important to understand, however, that if the polygon design is edited, the change will occur throughout every layer design that uses that polygon design. Polygon designs are always 2d in the sense that they only apply to one layer at a time. In other words, they don't "cut through" a set of layers unless requested by the user.



After a layering design has been created, a polygon scheme can be associated with each layer, and layers can be turned on and off. If a layer is turned off, then anything in that layer is treated as "unincluded" in exactly the same way that a data point that falls outside of a polygon is unincluded. In the case of geospatial analysis (kriging, correlation modeling, etc), however, those data are still used unless the box next to **Use only included data during interpolation** is checked on the Parameters window for the Step Set up the site.

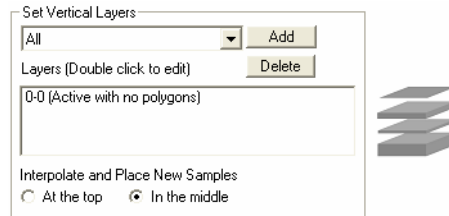
### Set Vertical Layers

For more information about vertical layers in SADA Version 4, see the chapters **Overview of Vertical Layers** and **Polygons**.

Layers apply to both data and modeling plots. They can have irregular depths and be with or without polygons. Users can design and save multiple layering schemes. For 3d data, modeling is always performed in true 3d dimension but shown one layer at a time in a 2d view.

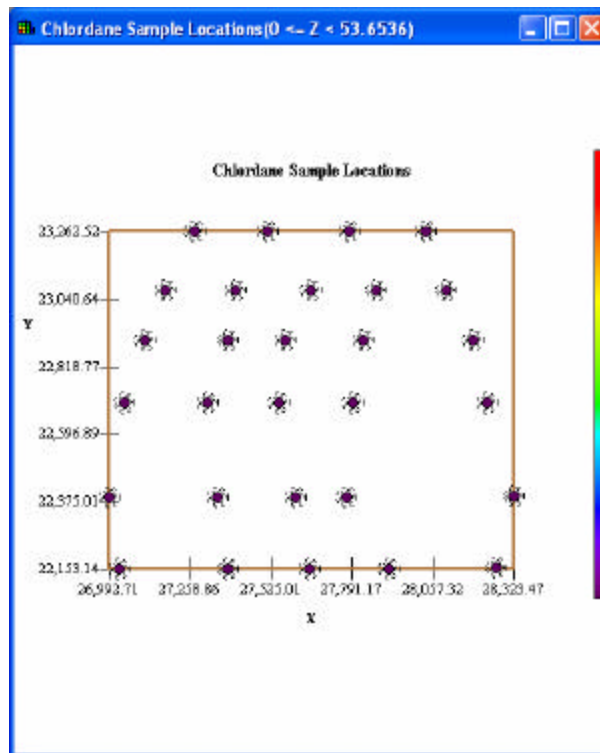
This step is available for all interviews, unless Geobayesian is the selected media type. Layers may also be added to empty SADA files.

Select the **Set up the Site** step from the Steps Window. The Parameters Window displays the following under the Set Vertical Layers heading.



At the top of the section, the vertical layers dropdown list contains all available Layer designs. Use the arrow to select a design from the list. The definition of each layer in the current layer design will then be visible in the box below. SADA comes with 3 default layering schemes: All, Surface Only, and 5 Layer Design. The user can also create layer designs.

- All: SADA displays the data as if there was one large layer and all data points are included in the analysis. Since many data points will be on top of each other or overlapping, they will be portrayed by hatched circles around the data point in the Graphics Window.

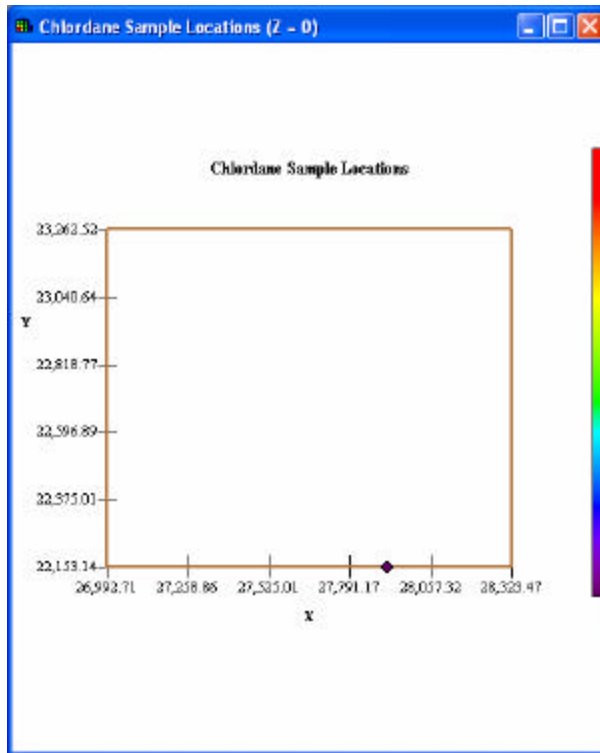


Click on any of the points, and all the data points over all depths within the layer will be displayed at the bottom of the steps window.

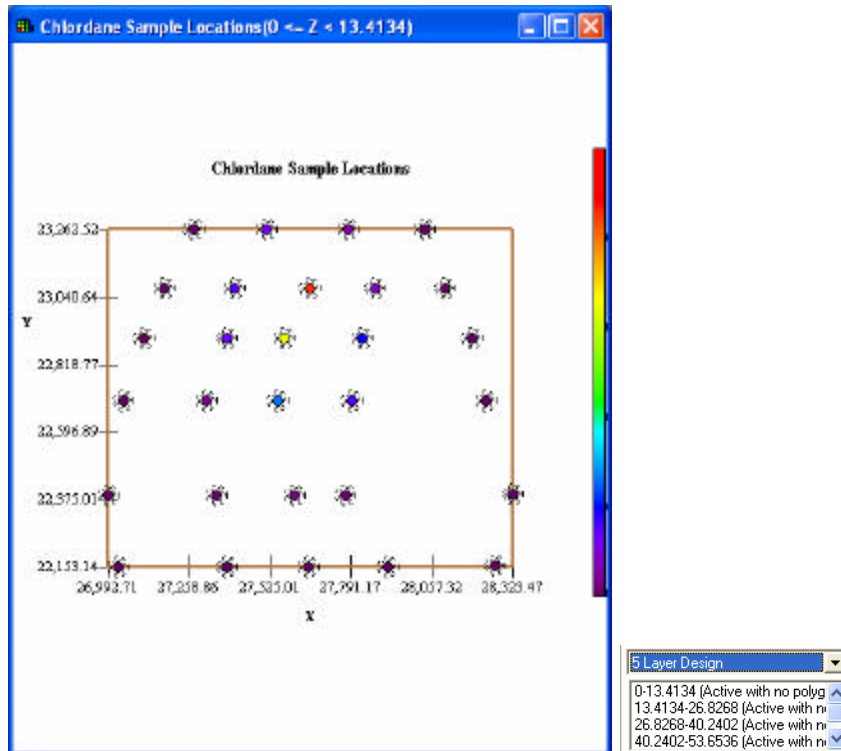


Field	Value
X	27383.71
Y	22904.309
Z	2.184
CAS	1234123
Names	Chlordane
Values	0.00784
Detect	1
Media	GW

- Surface Only: Only the data points at the surface (depth=0) are displayed in the Graphics Window and are included in the analysis.



- 5 Layer Design: SADA divides the data into 5 equal-sized layers depending on the minimum and maximum vertical data values.



- User-defined Layer design

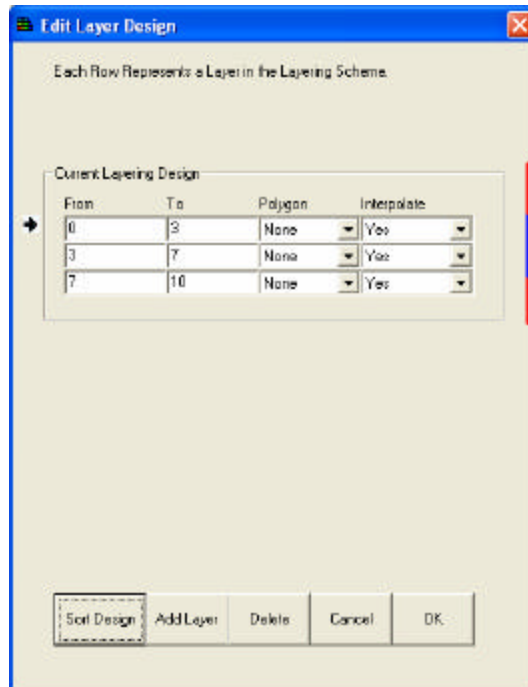
To add a new layer design, press the **Add** button. The following window will appear.

The "Create New" dialog box contains the following fields and buttons:

- Field: "Name of the New Layering Scheme:" with the text "test layer" entered.
- Field: "Based On:" with a dropdown menu showing "New Layer Design".
- Buttons: "Create" and "Cancel".

Enter a name for the new Layering design in the space provided. The new layering design can be based on a previously developed layering design, the default, or a new design. Press **Create**.

SADA opens the **Edit Layer Design** window.

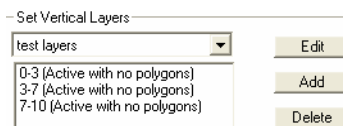


Enter values in the **From** and **To** columns to define each layer depth. Press **Add Layer** to add a blank layer to the layer scheme. If polygons have already been created, select the applicable polygon layer to display in each vertical layer. SADA will associate a polygon with the layer until otherwise notified. In the final column, choose whether a layer is turned on or off. If a layer is turned off, then model results from that layer are not included in any analysis or while creating new sample designs. Data are still included, however, during geospatial analyses unless the user clicks the box next to **Use only selected data during interpolation** on the Parameters Window.

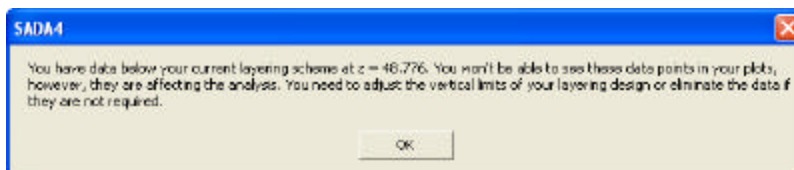
**Note:** All layers must be contiguous and non-overlapping. A layer can be a single value.

To delete a layer, select that layer (note that an arrow will now point to that layer) and press **Delete**. The Red & Blue line is a visual representation of the layers and how the depth of each layer relates to the overall depth of the layering scheme. The portion of the line that is highlighted is equivalent to the layer that is pointed to by the arrow. To sort the layers by depth, press **Sort Design**.

To cancel the layering scheme edit, press **Cancel**. Otherwise, once all the layers are entered, press **OK**. The layer design is now available in the Parameters Window.



**Note:** If you select a layering scheme that does not include all the data, SADA will provide a warning that points outside of the scheme may affect the analysis.



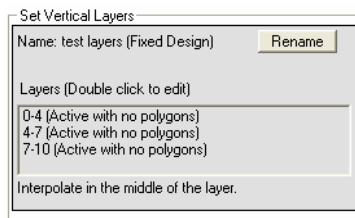
To edit any of the layer designs, select the layer design name from the drop down list and then double click on the layer in the **Layers** box.

At the bottom of the section under **Interpolate and Place New Samples** are two buttons: **At the top** and **In the middle**. Since each layer in a layering design is a range of depth, this section allows the user to set the depth of the interpolation point for each layer to be used in geospatial modeling. The default is "In the middle".

- At the top – the interpolation point will be the minimum depth for each layer.
- In the middle – the interpolation point will be halfway between the minimum and maximum depth for each layer

### Fixed or Locked Designs

Further advances in SADA's capabilities now include Geobayesian models, result galleries, and MARSSIM sample designs. These three types of features affect both layer and polygon designs by relying on layer and/or polygon configurations that are unchanging or fixed. The user does not have to worry about fixing designs, as SADA takes care of this. When each of these features is created, SADA will automatically create a copy of the current layer/polygon combination and lock or fix its design. The original layer/polygon combination remains fully editable as always while the copy receives the same name as the original but is denoted as fixed (e.g. Fixed Design) and is presented with varying levels of flexibility. When a layer becomes fixed, it will appear in a grey box and say Fixed Design in parentheses next to the design name.



When a layer is used in a MARSSIM design, no aspect of the layer can be changed, including the polygons. If a layer is used in a Results Gallery or a Geobayesian model, the polygons may be altered, but the layers can only be turned on and off. Double click to edit appears in parentheses next to Layers in the gray box. When you double click on a layer, the normal layer editing window will appear; however, most functions will be disabled.

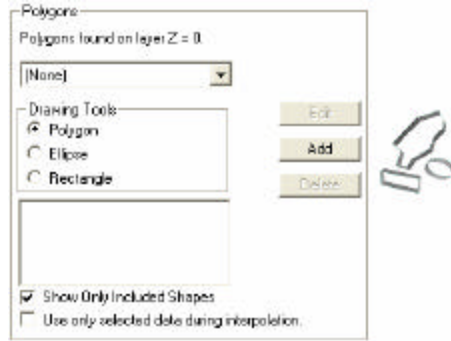
### Polygons

Within a spatial framework, it is often necessary to select certain items or identify a particular area in space. SADA allows the user to draw various shapes for defining areas and selecting items in space. These include ellipses, rectangles, and polygons. While it would be more accurate to refer to these as shape tools, they have been historically referred to as polygon tools and will therefore remain with this nomenclature. Polygons are very flexible and can be used for defining irregularly shaped spaces. When a polygon is drawn, items or space located inside the polygon is selected. While the polygon is present, only the items or space within the polygon will be utilized in the analysis. **Note:** the only exception is if the polygon area extends beyond the site boundary. Then only data within the polygon area that is within the boundary will be included.

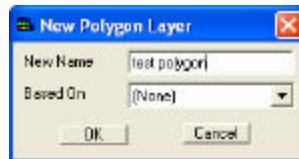
### Create a Polygon Collection

Polygons are created and maintained as layers. They can be assigned to one or more vertical layers. A polygon layer is "embedded" into a vertical layer and cuts through the entire layer.

Select **Set up the site** from the **Steps Window**. (Note that this step is available for all interviews in SADA.) The **Parameters Window** displays the following under the Polygons Heading.

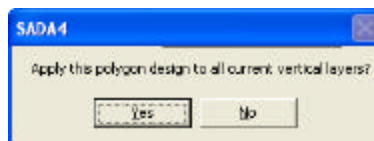


Press the **Add** button to add a new polygon layer.



Enter a name for the scheme and what the polygon(s) will be based on (if other polygon layers have already been created). Then press **OK**.

Note: If vertical layers have already been set, SADA will ask if the new polygon should be applied to all layers. To apply a polygon to selected layers, see the section **Set vertical layers**.



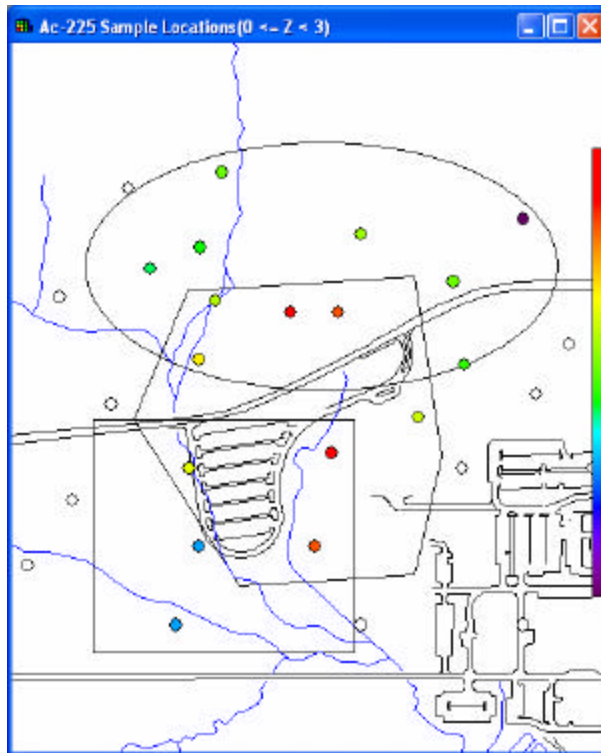
This polygon will now be active in the list of polygons. Notice that there are 3 drawing tools on the Parameters Window. To draw a polygon, select the appropriate tool.

- Polygon – Allows the user to create a many-sided polygon to partition the data.
- Ellipse – Allows the user to create an ellipse to partition the data.
- Rectangle – Allows the user to create a rectangle to partition the data.

Then press the **Edit** button. Notice that everything becomes disabled in SADA during polygon creation.

For the polygon tool, move the mouse over the Graphics Window and note that the coordinates appear on the status bar at the bottom of the screen. Each time the left mouse button is clicked, a new vertex is added. To complete the polygon, double click the left mouse button. For the other two tools, hold the mouse button down and drag the mouse to create the ellipse or rectangle.

After each polygon has been created, press the **Done** button. The polygon(s) will now display in the **Graphics Window**.



Add as many polygons per layer as desired. To change the layer, select the new layer from the Layers box and add polygons to that layer in the same manner.

### **Edit Polygons**

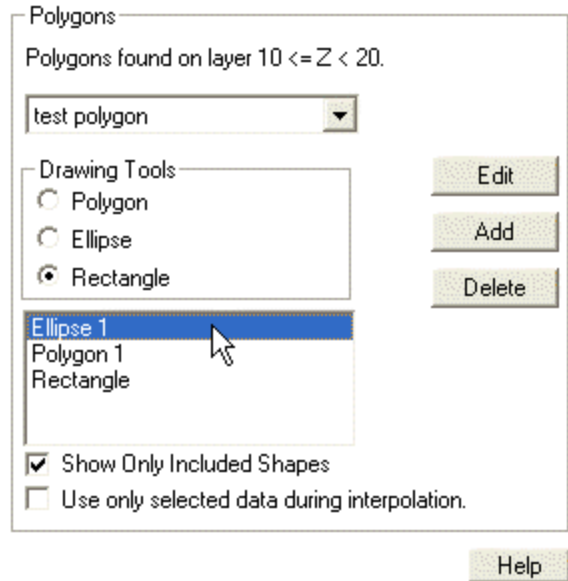
After a polygon has been drawn, vertices can be removed, added, or moved to another location. Similarly, an entire polygon can be moved to a new location or deleted entirely. To edit a polygon, left-click the mouse to highlight the vertices blue. The following conditions assume that the vertices have been highlighted.

To select a particular vertex, left click inside the vertex and it will turn red. To delete the vertex, press the Delete button. To move the vertex, hold the left mouse button down inside the vertex, move to the desired location, and release. To add a new vertex, click anywhere on a line between two vertices.

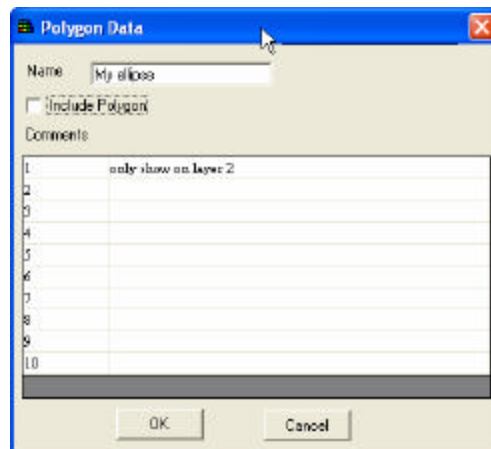
To select an entire polygon, right click inside any vertex and the entire polygon will turn red. To delete the polygon, press the Delete button. To move the entire polygon, hold the right mouse button down inside any vertex, move to the desired location, and release.

To copy or paste polygons, simply right mouse click and a popup menu containing the copy and paste options will become visible. When a polygon is copied, the location of the defining vertex points are preserved in the XY plane such that when the polygon is pasted onto another level, the location (and size) of the polygon is preserved.

To change the names of the polygons included in a collection or to display only some of the polygons, use the **Polygon Data window**. Select the polygon collection from the drop-down box on the Parameters window and double-click on the polygon name that appears in the list box below.



The **Polygon Data** window will appear.



In this window, the user can change the names of polygons and add comments about the polygon. Users can also choose to include or exclude a polygon with the **Include Polygon** check box. If a polygon is excluded, it is not used in any analysis; however, it is not deleted. This feature allows users to easily turn polygons on and off within the same layer. Click the **OK** button to close the window.

If the “Show Only Included Shapes” option on the Parameters window is checked, then SADA will remove all un-included polygons from both the graphics window and the list box for the polygon collection. If this option is unchecked, all un-included polygon names will still appear in the list box and a gray outline of the polygon shapes will be displayed in the graphics window. These polygons, however, will not be included in any analyses and only remind users of where the un-included polygons are located.

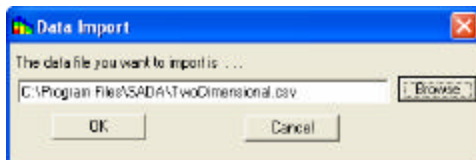
To turn off the polygon collection, select **Set up the site** from the **Steps Window** and select **[None]** from the Polygon Layer list in the **Parameters Window**.

Continuing the discussion of locked layer/polygon combinations initiated in the Set Vertical Layers chapter, polygons involved in the creation of a MARSSIM design, a geobayesian prior, or in a results gallery will be locked. When these results are created, SADA will automatically create a copy of the current layer/polygon combination and lock or fix its design. If a polygon is involved in a MARSSIM design, then it remains uneditable. If the polygon is involved in a Results Gallery or geobayesian prior, then it is fully editable.

## Import Sampled Data - Step

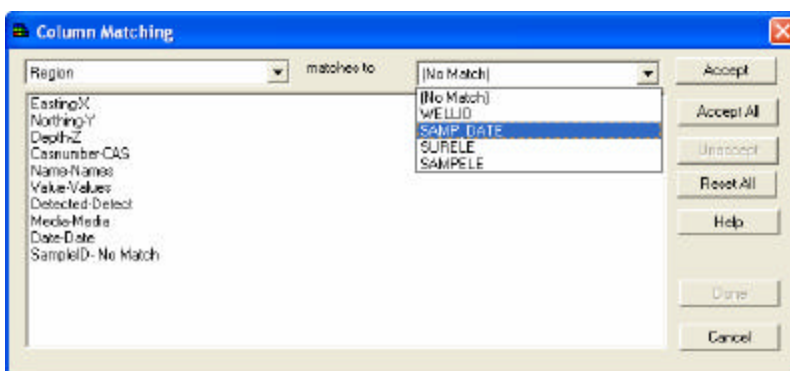
Data may be imported into any SADA file.

For an empty SADA file or a file that only contains Geobayesian model data, select **Import sampled data** from the Steps Window. For files with sampled data, however, select **Import New Data From A File** from the **Tools** menu. The following window appears.



Enter the name of the file to import or select the **Browse** button to search on the computer. Then press **OK**.

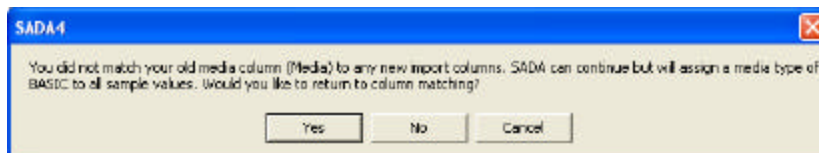
SADA opens the **Column Matching** window.



Match the columns in the current dataset to the columns of the new file using the drop down arrows. To accept a match, press **Accept**, and the match will appear in the window below. To accept all the matches (if you know that the columns are lined up), press **Accept All**. Select **Unaccept** to remove one match or **Reset All** to return all matches back to their respective lists.

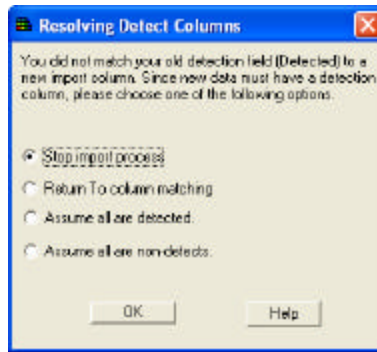
### WARNING:

If Media ID, which denotes the type of media the contaminants are sampled in (e.g. soil or groundwater) is not defined, then the human health risk and/or ecological risk modules cannot be setup later. The media is a critical information category to the risk modules. Also, SADA expects certain units for measured values in the risk modules. If media is not matched, SADA will present the following message.



Additionally, detect columns have to be matched or SADA will present the following message.





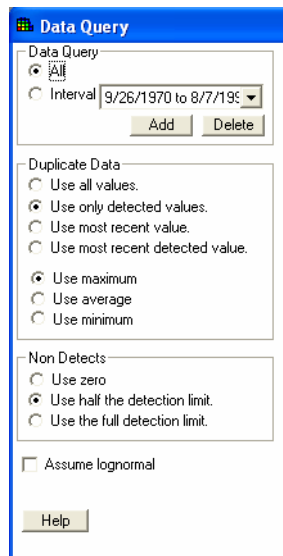
After the columns have been set, press **Done**. SADA begins the conversion process and presents the data as it will be imported into the Data Editor.

After submitting data through the Data Editor, SADA displays the imported data in the Graphics Window.

**Note:** The site boundary set by the user may change to reflect the boundaries of the imported data set.

## See the Data - Step

This is always the first step in the Steps Window for any interview using sampled data. As a default, when a new interview is selected, this step will be highlighted in the Steps Window and the associated parameters will appear in the Parameters Window.



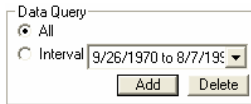
The parameters are divided into three sections: Data Query, Duplicate Data, and Non Detects.

At the bottom of the window is the **Assume Lognormal** button. Select this button for SADA to assume a lognormal distribution of data for statistics, risk assessment, and ordinary kriging. **Note:** This is only possible if all data are greater than 0.

## Data Query

SADA Version 4 permits users to specify a date field when creating a SADA file. If a date field is specified, then users may parse the data set by date and perform SADA functions on a portion of the data set.

When **See the data** is selected in the Steps Window, the Parameters Window displays two radio buttons under **Data Query**: All and Interval. (All is the default option.) Select 'All' in order to use all points for a given contaminant. In order to parse the data, select the interval option.



To add date intervals, press the **Add** button. SADA presents the **Set Date Range** window.



Add as many date ranges as necessary in the format mm/dd/yy. Each new range will now be visible in the drop down box next to **Interval**. (**Note:** SADA will create a default entry comprised of the entire date range for the file.)

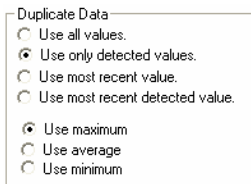
To perform a function on a date range, select the Interval radio button. Then, select the appropriate date range from the drop down box. The Graphics Window will only display the data points for the specified date range and all SADA functions will be performed on those points only.

**Note:** If a date range does not contain any data, the Graphics Window presents an empty plot screen.

To delete a date range, select that range from the drop down box and press the **Delete** button.

## Duplicate Resolution

The duplicate data options appear on the Parameters Window when **See the data** is selected in the Steps Window. These options determine the methods SADA will use to resolve duplicate values at a specific point.



The first four radio buttons under **Duplicate Data** determine what type of duplicates will be used.

- Use All Values – all duplicate values will be considered for future modeling
- Use Only Detected Values – only detected duplicate values will be considered for future modeling
- Use Most Recent Value – only the most recent duplicate value for a specific location will be considered for future modeling
- Use Most Recent Detected Value – Only the most recent detected duplicate value will be considered for future modeling

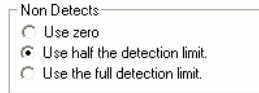
The last two are disabled if a date field was not specified for the data upon setup. If a detect field was not specified during setup, the second and fourth options above are disabled.

Three more radio buttons further define the duplicate resolution. If more than one point still exists, SADA will use the Maximum, Minimum, or Average value, depending on the user's selection. For example, a user selects "Use Only Detected Values" for the first four criteria and "Use Maximum" for the last three. If there are 3 detected values at a specific point, only the maximum value at that point will be used for future modeling.

Labels may be viewed with duplicate data by selecting the appropriate label from the Labels Box. Note that labels will only appear in the graphics window if they are the same value for all the data points at a particular location. Otherwise, the following symbol indicates different values: \*\*\*.

## Non Detects

The non detect options appear on the Parameters Window when **See the data** is selected in the Steps Window. These options determine the methods SADA will use to resolve non detects. Data reported as non-detect can have different statistical techniques applied to account for the uncertainty in the concentration.



The radio buttons under **Non Detects** determine how SADA will handle non detects.

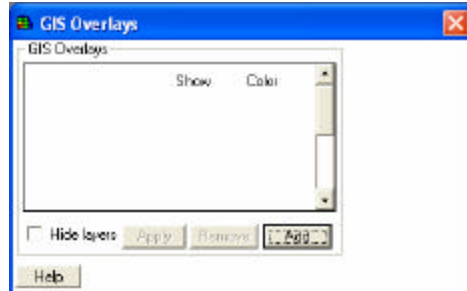
- Use zero – SADA treats non detects as a zero value when calculating the UCL 95.
- Use half the detection limit – SADA treats non detects as half of the detection limit when calculating the UCL 95.
- Use the full detection limit – SADA treats non detects at the full detection limit when calculating the UCL 95.

Other methods, such as regression techniques or bootstrapping, must be implemented before importing data.

## Set GIS Overlays - Step

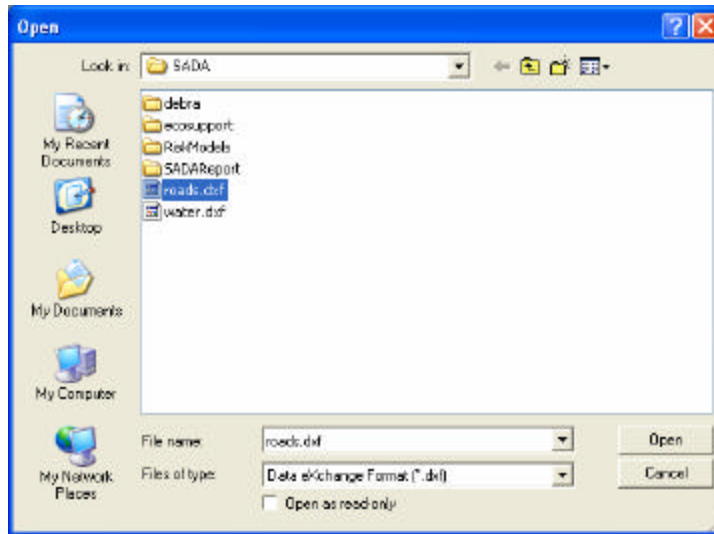
SADA can read and overlay pictures that has been produced by a Geographic Information System (GIS) and saved in a Data eXchange Format (.dxf) or Arc View Shape File (.shp). This step is available for all interviews. GIS overlays may also be added to empty SADA files.

Choose **Set GIS overlays** from the Steps Window. The Parameters Window displays the following.

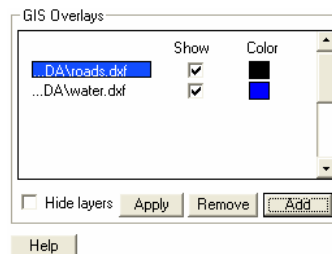


To add an overlay, press the **Add** button. Select the appropriate .dxf or .shp file and press **Open**.

**Note:** SADA comes with two sample .dxf files: roads.dxf and water.dxf.

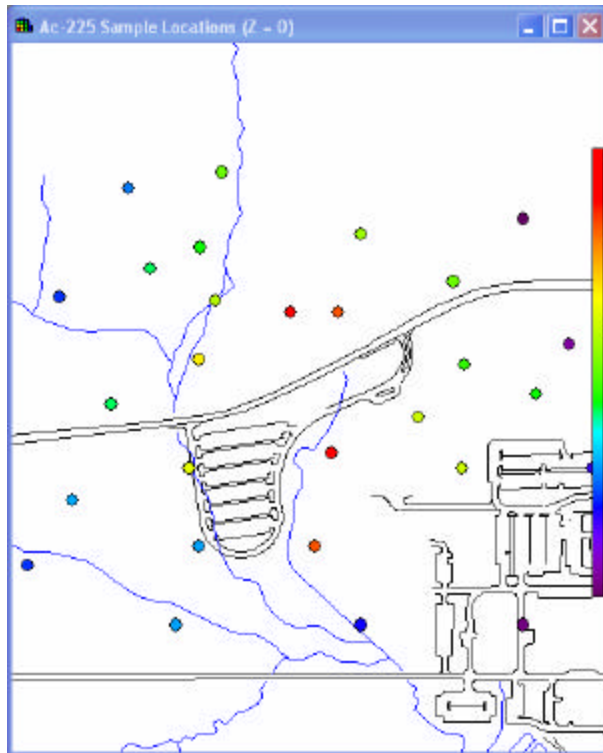


After adding overlays, the Parameters Window will look like the following.



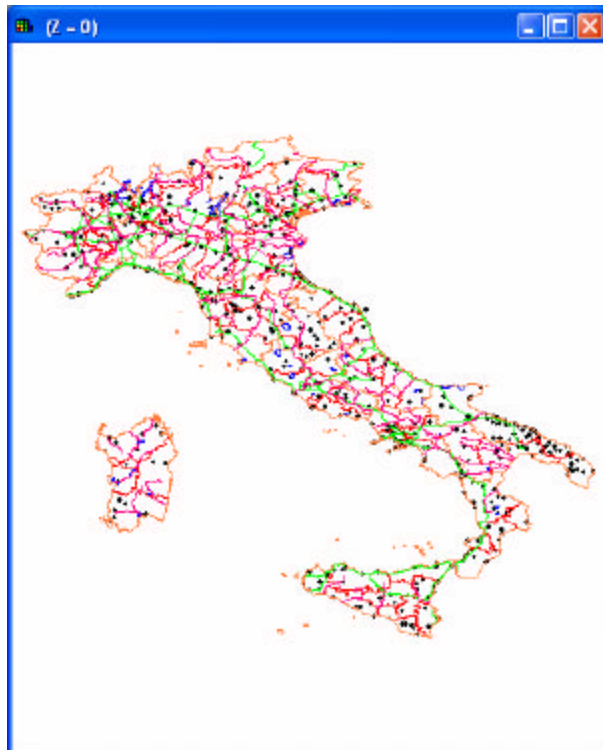
To close an overlay, select the overlay and press the **Remove** button. To make an overlay visible, check the box next to the name under the **Show** column. To change the color of an overlay, click the corresponding **Color** box and choose a color from the Palette window. To view your changes, press the **Apply** button.

To turn off the GIS overlay system, click in the box next to **Hide Layers**. Repeat this process to turn the GIS back on (**Hide Layers** will be unchecked). In the following image, the sample overlays in SADA are displayed.



For three-dimensional applications, the GIS image is available only for the Easting-Northing layer.

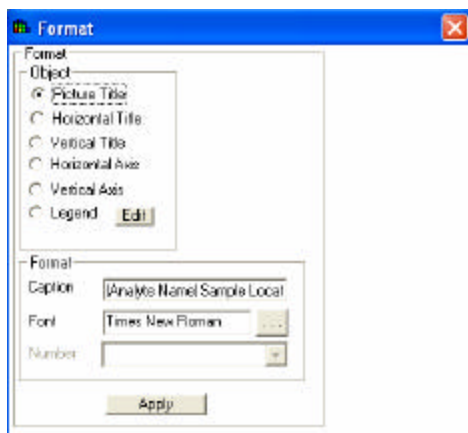
GIS overlays may also be imported for empty SADA files. In the following image, .shp files for Italy have been imported to an empty file.



## Format Picture - Step

The format option is available on the Steps Window for all interviews. The exception to this function is when polygons are being edited.

Select the **Format Picture** and the Parameters Window will display the following.



Select the portion of the picture you wish to format under **Object**. The current formatting scheme will appear under **Format**.

### *Caption*

The text associated with the selected object. See the chapter **Caption Formulas** for more information.

### *Font*

The font for the selected object.

### *Number*

A list of formatted number types.

After making all the changes, press the **Apply** button.

**Note:** Click on the *Edit* button next to *Legend* to open the *Legend Manager*.

## Caption Formulas

A caption formula is a string enclosed by the Pipe symbol (|) that will evaluate a text value during the plotting process. To begin a caption formula, place your cursor in the Caption entry box and type in a (|) symbol. Type in the name of one of these formula strings and complete with a (|) symbol again. Only one formula string per (|) enclosure is allowed.

The type of formula strings available depend on the type of graphic that is displayed. For example, a risk formula string would not be available for formatting probability maps.

The following is a list of formula strings and what they will evaluate.

Benchmark Name	The currently selected ecological benchmark name
Benchmark Value	The currently selected ecological benchmark value
Custom Criteria Name	The currently selected custom criteria name
Custom Criteria Value	The currently selected custom criteria value
Layer Value	The current layer (3D only)
Database Direction headers	The easting, northing, and depth titles as defined by the import column headers

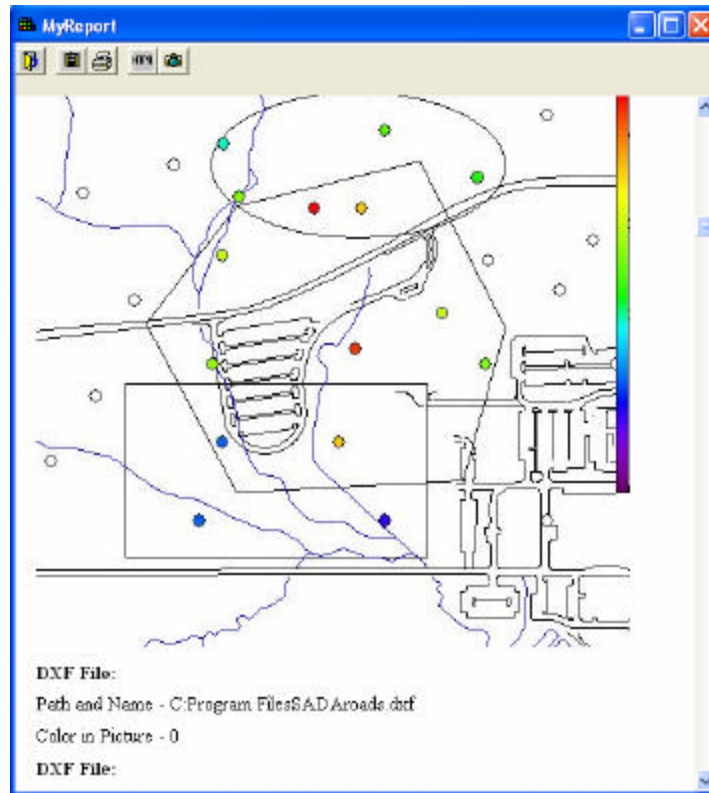
SADA Direction	SADA's titles for easting, northing, and depth
Analyte Name	The current contaminant name
Interpolant	The current interpolation scheme
Media	The current media type
Date	The date
Time	The system time plus the date
CAS Number	The current contaminant CAS number
Scenario	The current risk scenario
Pathway	The current risk pathway
Carc/Noncarc	"Carc" if carcinogen, "Noncarc" if noncarcinogen
Age	The receptor's age (Child, Adult, or Both)
Decision Scale	Block scale or site scale
Decision Basis	Analysis Based Option or Concentration Option
IK Cutoff Value	The current Indicator Kriging cutoff threshold
Sample Scheme	The current Sampling Scheme that exists in the Graphics Window

### **Auto Document - Step**

SADA allows the user to create a report and automatically add results and supporting information. The report is written in HTML format and can be read by a variety of products, including **Word**, **Word Perfect**, **Netscape**, and **Internet Explorer**.

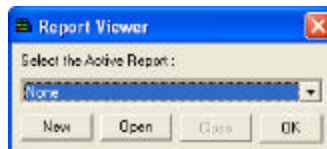
Reports are managed from the **Reports** menu and are viewable in the Report Viewer. The report viewer can be activated by selecting **Show Report Viewer** from the **Reports** menu.

The following functions are available with reports: create new reports, save reports, switch between reports, print reports, close the report viewer, add information to a report, and edit the report.

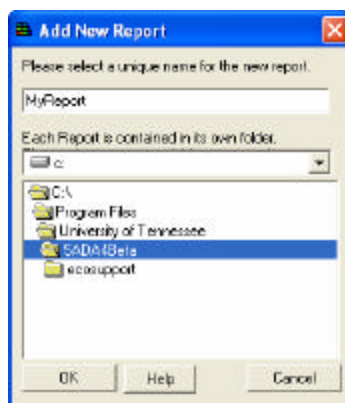


## Creating New Reports

Select **Reports** then **Report Manager**.



At the **Report Viewer** window, select the **New** button. SADA responds with the **Add New Report** window.



In the top entry box, enter the name of the report. SADA will automatically add .html to the end of the report title. In the directory box, select the directory where a sub-directory named after the report will be created. This new sub-directory will contain the html report as well as any pictures needed by the report.



For the above example, the selected directory is c:\Program Files\University of Tennessee\SADA4Beta and the name of the report is MyReport.html. SADA will create a directory called c:\Program Files\University of Tennessee\SADA4Beta\MyReport and place all report information in this directory. Click **OK**. Then select this report from the **Report Viewer window** and press **OK**.

## Saving Reports

To save the active report, select **Reports**, then **Save ActiveReportName.html** (with the **HTML Report Viewer** active). To save all reports associated with the project, select **Reports**, then **Save All Reports** (with the **HTML Report Viewer** active).

To undo the changes since the last save, select **Reports**, **Revert Active Reports** (with the **HTML Report Viewer** active).

For more information, see the chapter **Auto-Document**.


## Switching Between Reports

All open report names can be viewed under the **Reports** menu. Click on the desired report for display. To open another report, Click on **Report Manager**. Then use the **Open** button to open the desired file.

## Printing Report

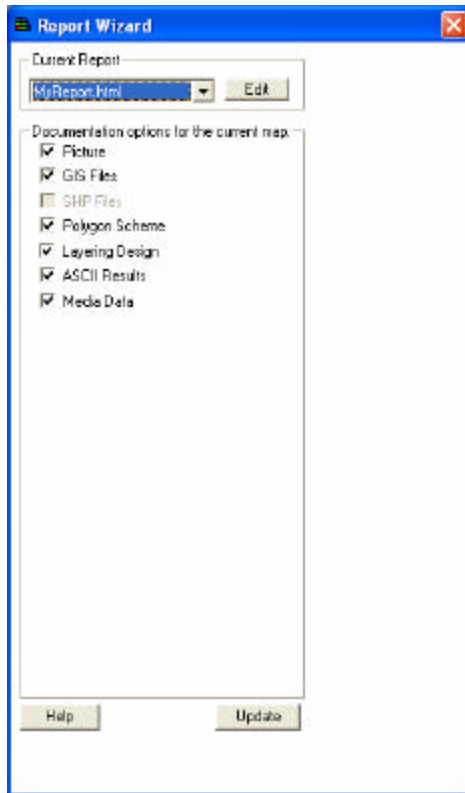
Select **Reports** and then **Print Report** from the menu bar (with the **Report Viewer** active) or press the **Print** button (on the **Report Viewer** only).

## Closing the Report Viewer

Deselect **Show Report Viewer** under the **Reports** menu or click on the **Close Viewer Button** on the Report Viewer's toolbar .

## Adding Information to a Report

For any given result, whether it is a graphical or tabular result, the result and all supporting information may be added to the report automatically by pressing the **Auto Document** step on the Steps Window. SADA presents the **Reports wizard** on the Parameters Window.



The top of this window will display the current report. To change this report, use the drop-down arrow to display other opened documents.

**Note:** If a report has not been opened yet, the current report box will list [none]. The user will then have to click on the **Edit** button to create a report or open a previously created report in the Report Manager.

Below the Report name is a list of the factors used in producing the current result. Desired items may be selected for inclusion in the report. When finished, press the **Update** button and the report is automatically updated.

### Editing the Report

SADA permits users to directly add their own input to a report. Open the Report Viewer, if not already opened, by selecting **Show Report Viewer** from the **Reports** menu.

Then select the HTML button  on the **Report Viewer**.

```

<html>
<head>
<title>C:\Program Files\University of Tennessee\SDA4Beta\MyReport\MyReport.html</title>
<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1;" />
</head>
<body bgcolor="#FFFFFF">
<br><br>
<br> <br> 12/16/2004 11:21:30 AM <br>
<br> The Following Picture is the JPG file named: SADA0.jpg
<p>  </p>
<p> <br> DXF File: </p>
<br>
<br> <p> Path and Name - C:\Program Files\University of Tennessee\SDA4Beta </p> </br>
<br> <p> Color in Picture - 0 </p> </br>
<p> <br> DXF File: </p>
<br>
<br> <p> Path and Name - C:\Program Files\University of Tennessee\SDA4Beta </p> </br>
<br> <p> Content Color - 16711680 <br> Color in Picture - 16711680 </p> </br>
<p> <br> Active Polygon Scheme Definition - </p> </p>
<p> <br> Scheme Name: test </p> </br>
<br> <p> Polygon Name: Polygon1 </p>
<br> <p> Polygon </p>
<br> <p> Format: (X, Y) -> (X, Y) </p>
<br> <p> <br> [ 28396.90359375 , 23154.255625 ] -> [ 27748.19140625 , 23149.275390625 ] </p>
<br> <p> <br> [ 27748.19140625 , 23149.275390625 ] -> [ 27638.59765625 , 22784.962421875 ] </p>
<br> <p> <br> [ 27638.59765625 , 22784.962421875 ] -> [ 27833.02734375 , 22295.5296875 ] </p>
<br> <p> <br> [ 27833.02734375 , 22295.5296875 ] -> [ 28342.041015625 , 22295.5296875 ] </p>
<br> <p> <br> [ 28342.041015625 , 22295.5296875 ] -> [ 28401.537109375 , 22291.062890625 ] </p>

```

Users who are familiar with HTML may enter information here. For users not familiar with HTML, the following codes are used for basic text.

<br>Line break ( Simply striking Enter at the end of the line does not result in a line break in the HTML output.)

<p> Paragraph break

<b>Bold font</b>

<i>Italic font</i>

Press the **Apply**  button on the **HTML Viewer** to see the changes in the output.

Press the **Save** button to save the changes.

### Add To Results Gallery - Step

SADA Version 4 provides a results gallery. This gallery acts almost like a camera, providing is a way for users to save particular instances (modeled results, interpolation scheme parameters, GIS overlays, vertical layers, etc.) within a SADA file. These results may then be accessed at any time by selecting the results from the results gallery. This is available for all interviews with sampled data (it is not available for empty SADA files).

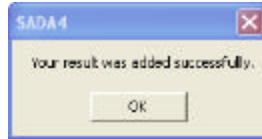
Select **Add to results gallery** from the Steps Window. SADA presents the following in the Parameters Window.



Enter a new name for the result and press **Add**.

**Note:** All previously created results will be listed in this window.

SADA will display a message that the result has been successfully added.



The result may now be viewed at any time in the Graphics Window by selecting Results gallery from the Data Type box and the applicable result from the Data Name box.



**Note:** When SADA stores the results it must also record the layer design and site boundary in place at the time. This is done by making a replica of the design and locking it for the Results Gallery. The layer design and site boundary are now fixed and cannot be edited (or minimally edited). Users can use this vertical design in other applications, but it is not recommended as it cannot be edited. For more information on layer designs and site boundaries see the chapters **Set Vertical Layers** or **Site Boundary**.

## Show Results - Interview

This interview, which is the only interview available when a result is selected from the results gallery, displays the previously created result in the Graphics Window.

### Availability

This interview is only available for the result gallery.

### Steps

These are the steps that display in the Steps Window when this interview is selected. See the corresponding chapters for more information about each step.

1. Show the results
2. Set up the site
3. Set GIS Overlays
4. Format picture

## Show Results - Step

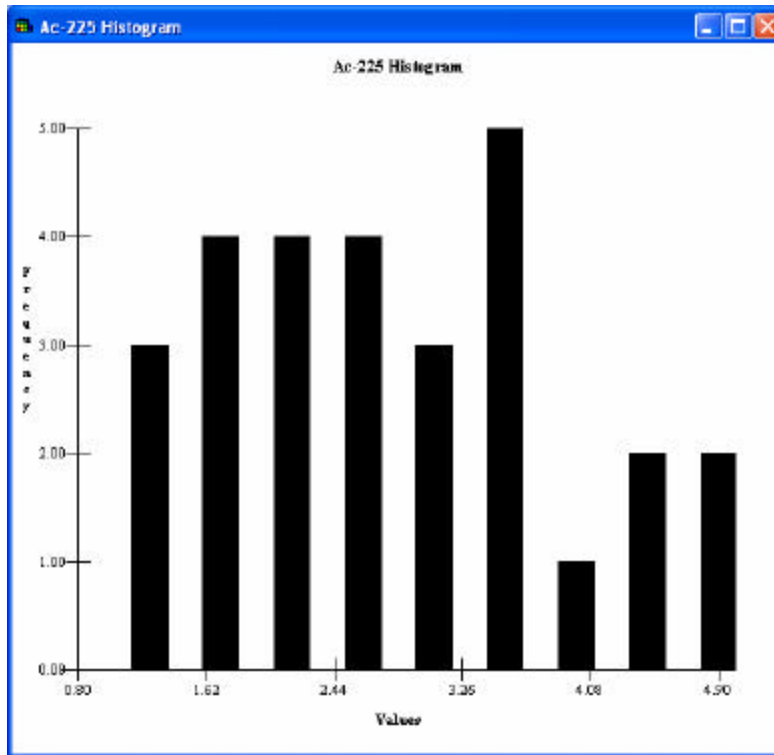
The **show results** step is available on the Steps Window for most interviews in SADA. Select this step to display the results of the other steps in the Graphics Window. This step may be selected at any time. The Graphics Window will only display what has been set up in the SADA file. For more information on what the results mean, see the particular interview.

## Graphical Displays

Throughout SADA, graphical images and associated summaries are easily accessible. Typically, these graphical components are interactive, providing links to databases, modeling frameworks, summaries, etc. SADA provides 4 types of graphical displays: histograms, data plots, geospatial model plots, and XY graphs.

### Histograms

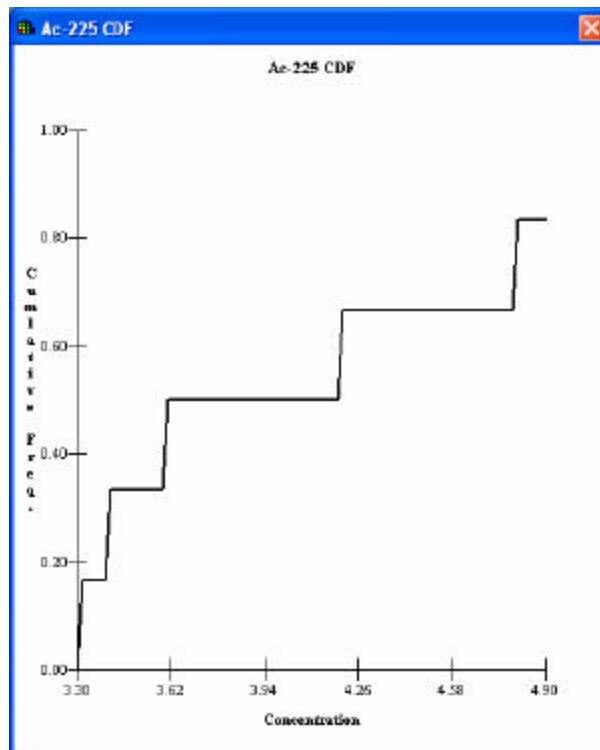
Histograms show the distribution of data across the range of values. The range of values is evenly divided into  $n$  classes, or intervals. For each class, the number of data values falling into that interval is tallied. The result is a bar graph that shows the number of items per class or interval. This is useful for identifying the distribution of the data (e.g. normal or lognormal). To view the histogram, press **Show Histogram** on the **Statistics** menu.



## CDFs

A new feature in SADA Version 4 is the Cumulative Distribution Function (CDF).

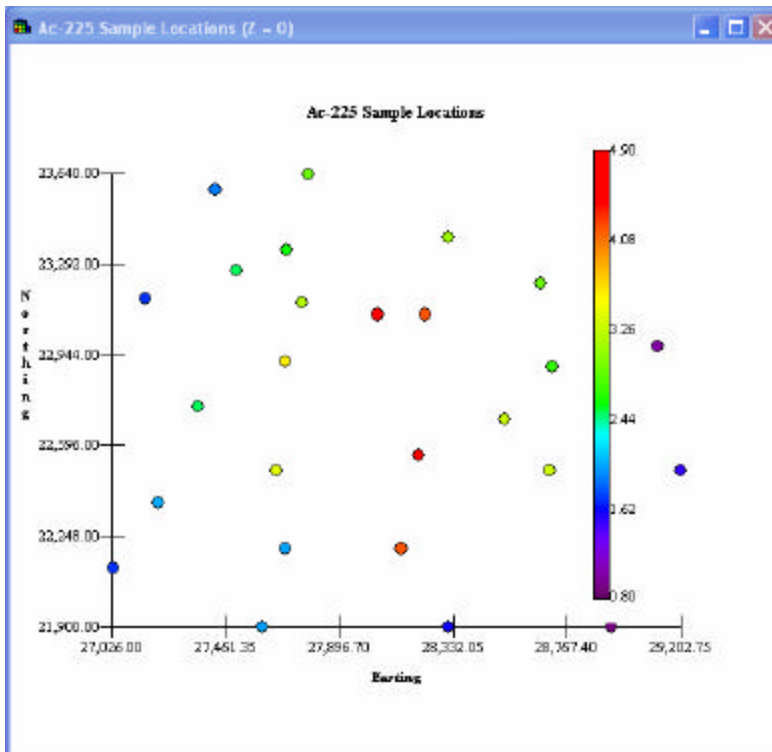
From the **Statistics Menu**, select **Show CDF**. The CDF is now displayed in the graphics window.



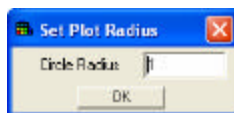
For any value on the x axis, this graph shows the percentage of data points falling below that value on the y axis. The Line Query button may be used to obtain accurate information.

### Data Plots

A data plot shows the location of data points relative to each other along with a color scale for noting relative magnitude. To construct a data plot, the spatial boundaries and the maximum and minimum sample values are calculated. The maximum and minimum sample values are used to construct the color scale where red denotes the highest value, black denotes the smallest value, and a spectrum of colors between identify the remaining values. A data plot is constructed by plotting a circle on the relative coordinate system and coloring it according to its magnitude.



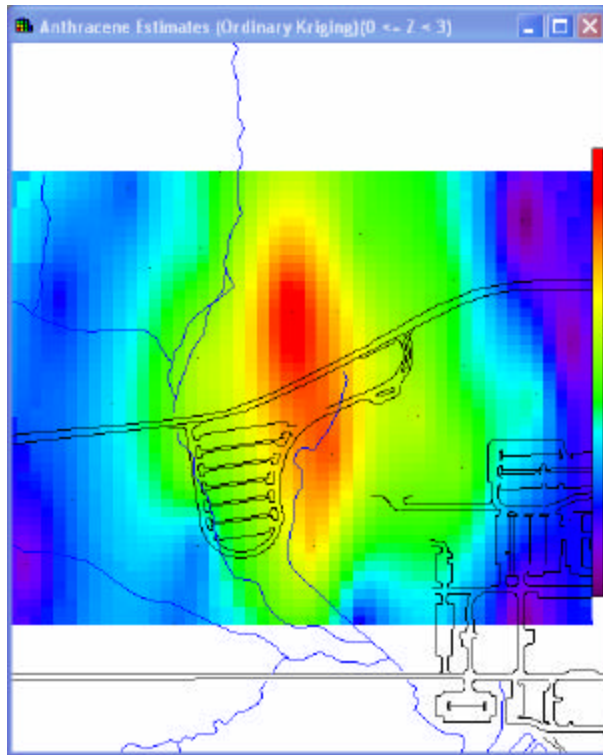
To change the radius of the circle, select **Set Circle Radius** from the **Graphics** menu. Enter the value of the radius and press **OK**.



For three-dimensional data, depth becomes a factor. SADA plots the data by layer in increasing depth values. To see these underlying layers, select the **Set up the Site** step in the **Steps Window**.

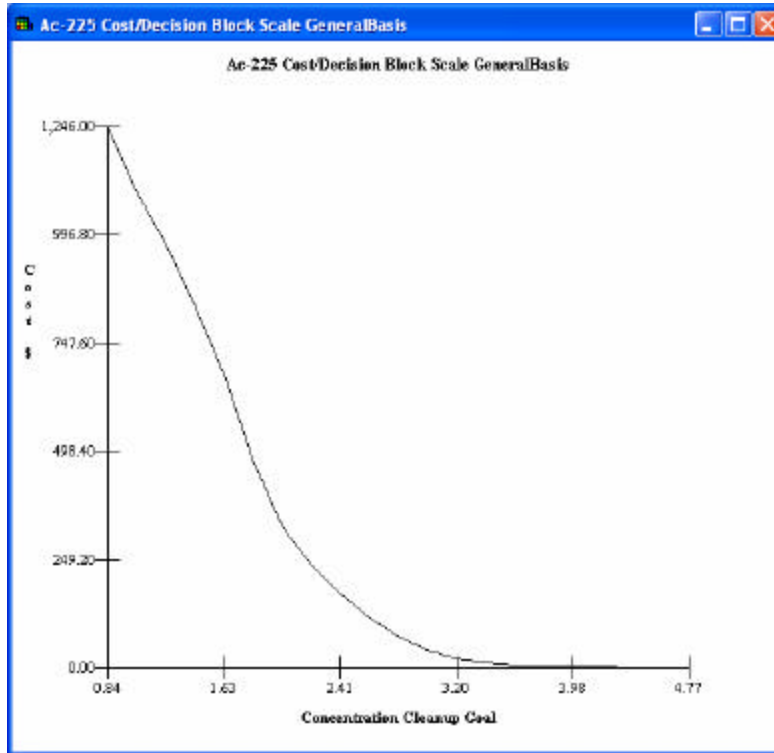
### Geospatial Model Plots

A model plot begins by partitioning the space into equally sized blocks. Geospatial modeling and any post processing occurs on each block. The resulting values are displayed with an associated color scale similar to the data plots. Instead of circles, blocks are used and there are no gaps between blocks.



## XY Graphs

XY graph refers to a simple two parameter plot where one value is associated with another. Cost versus Cleanup and correlation models are examples of simple XY graphs. Typically, if the value of one variable is a function of the value of the other variable, the independent variable is placed on the x axis and the dependent variable is placed on the y.



SADA also can overlay geospatial maps with layers from external GIS systems. See the section **Set GIS Overlays**.

## Legend Manager

SADA allows users to modify the legends that control the color range of data and result output. Two types of legends are permitted.

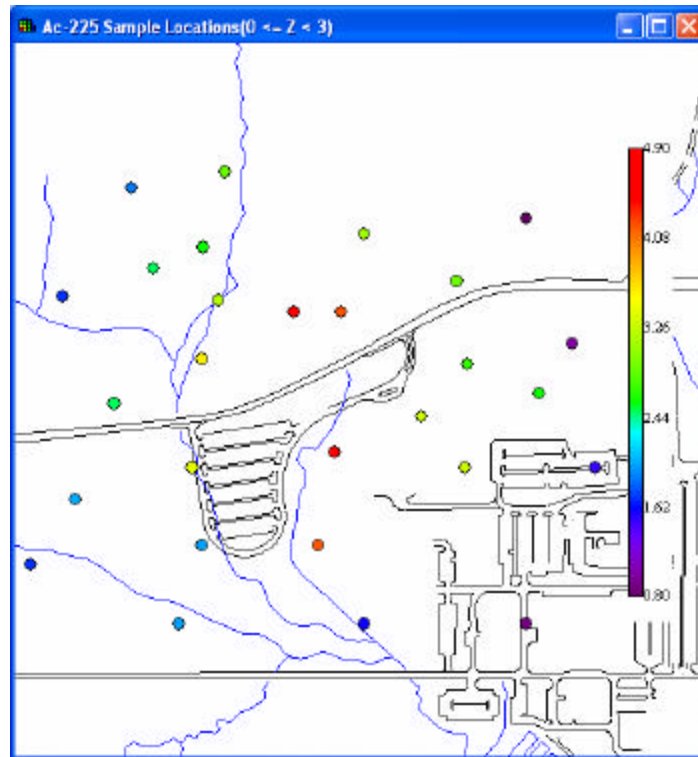
### *Continuous Color*

This legend is an unbroken color band that ranges through a spectrum from dark purple to bright red. Continuous color legends can be customized by manually stretching or compressing a subset of the color band.

### *Continuous Grayscale*

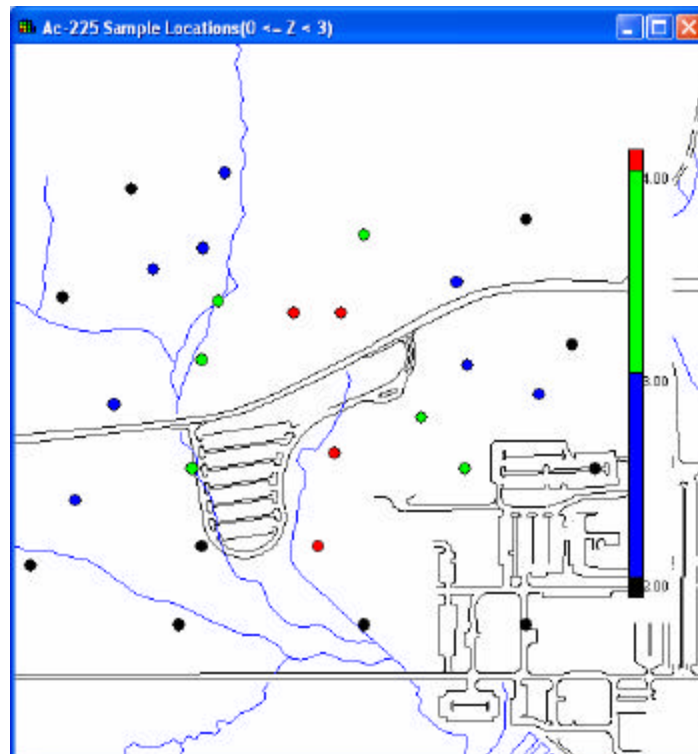
This legend is an unbroken gray scale band that ranges from near white to black. Continuous gray scale legends can be customized by manually stretching or compressing a subset of the band.





*Categorical*

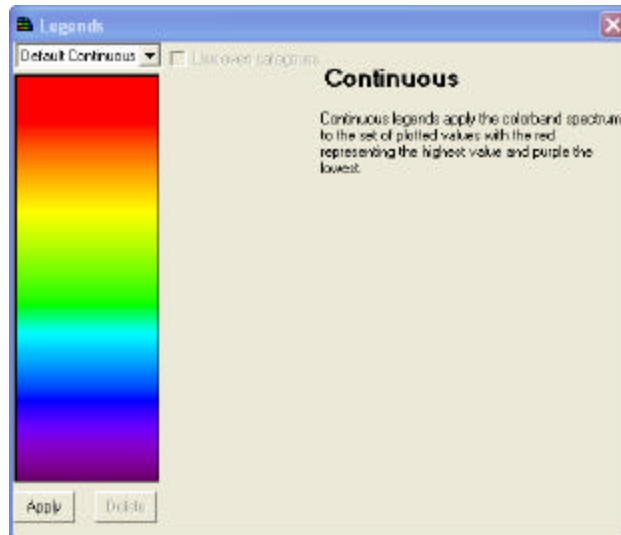
Categorical legends permit the user to break the legend into a series of ranges or categories with set names and colors. Note: SADA comes with 2 additional Categorical legends, Risk Scale and Geobayesian Scale. These are just samples of what may be created; they may be edited or deleted as necessary.



To control and create new legends, access the **Legend Manager** by one of these ways:

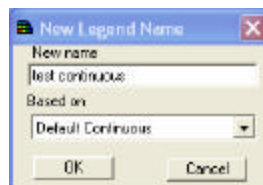
- Select the **Edit** button next to Legend Manger in the Parameters Window when **Format Picture** is selected in the Steps Window.
- Right mouse clicking on the legend itself.

The **Legend Manager** window appears.



At the top of the **Legends** window, a drop down box appears containing the default legend types and any user-defined types already created. Select a legend in this box and press the **Apply** button.

To create a legend, select **(New Continuous Palette)** or **(New Categorical)** from the drop down box. SADA responds with the following window.



All new legends are based on a existing legend. Type the name of the new legend in the top entry box and select the legend it will be based on in the lower drop down box.

## Customizing Continuous Legends

Only user-defined legends may be customized. Select a custom continuous legend or create one if none exists. Steps for customizing the continuous legend are included on the right side of the window for quick reference and are repeated here.

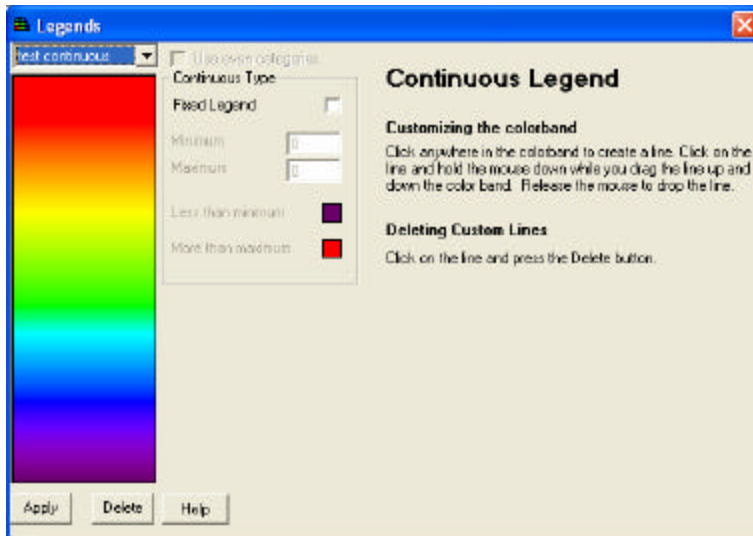
SADA Version 4 now allows the user to create a fixed or unfixed legend.

### Unfixed Legends

Unfixed legends work the same as in previous versions of SADA. To color band is stretched between the minimum and maximum values of the dataset.

To stretch or compress the color band, first click anywhere in the color band to create a new line. The line will be tagged at its endpoints with gray boxes. The boxes indicate that this is the active line. Click on the line and hold down the mouse while dragging it up or down the color band. The color band will respond by compressing or compacting the spectrum accordingly. You may create multiple lines.

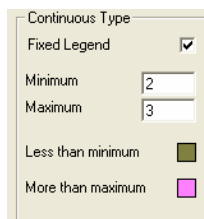
To remove a line, click on the line and press the **Delete** button in the window.



### Fixed Legends

Fixed legends are new to Version4. In a fixed legend the user determines the minimum and maximum values for the color band.

First click on the button next to **Fixed Legend** to activate this option.



Enter values for the minimum and maximum data. You can also click on the color box next to **Less than minimum** and **More than maximum** to change the colors. If your data set extends past your fixed legend, SADA will place a hatch mark on the scale and indicate the range of values above or below the legend with the colors chosen here. The following image shows a scale that does not encompass all the data in the dataset.



## Customizing Categorical Legends

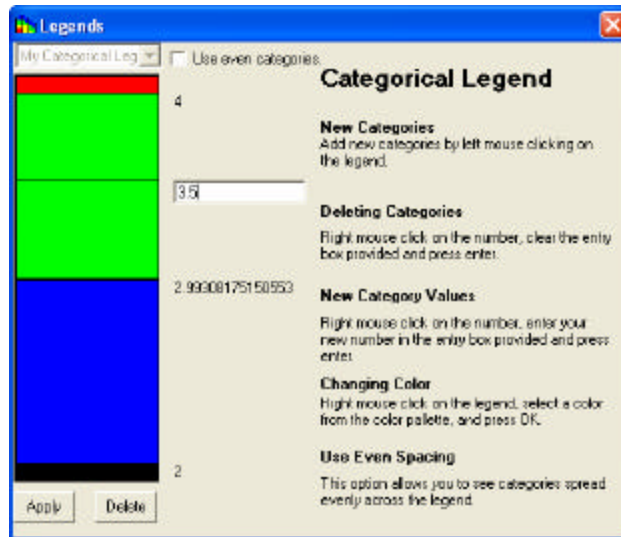
Only user-defined legends may be customized. Select a custom categorical legend or create one if none exists. Steps for customizing the categorical legend are included on the right side of the window for quick reference and are repeated here.

To create a new category, left mouse click on the legend. A new category is created.

To change category values, right mouse click on the category number and enter the new number. Press **Enter**.

To delete a category, right mouse click on the category number, clear the entry box, and press **Enter**.

To change the color of a category, right mouse click in the legend category, select a color from the color palette, and press **Enter**.



### Use Even Spacing

This option gives equal space on the legend to each category regardless of its relative numerical size.

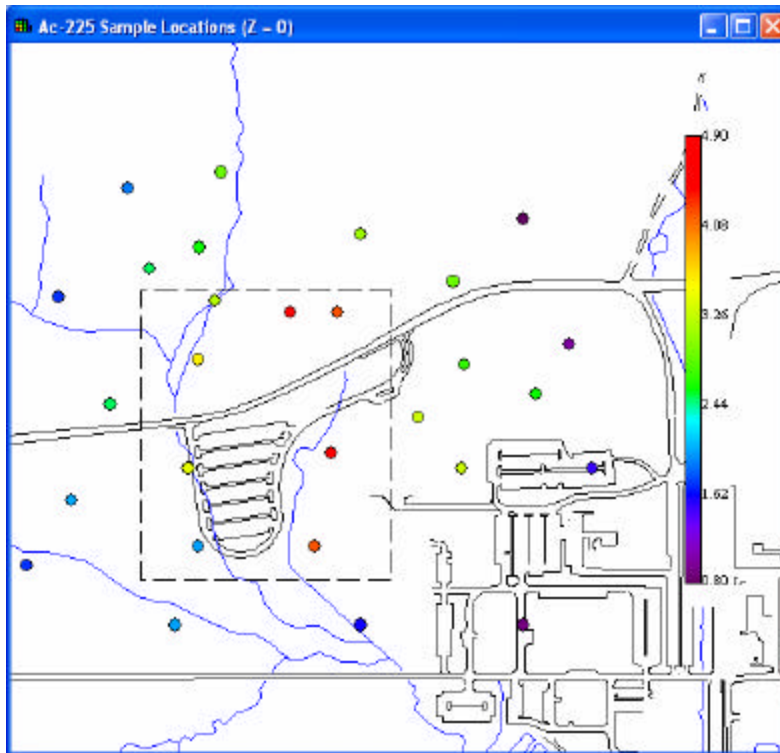
## Zooming, Shifting, and Restoring

This section covers zooming, shifting, and restoring the picture in the graphics window.

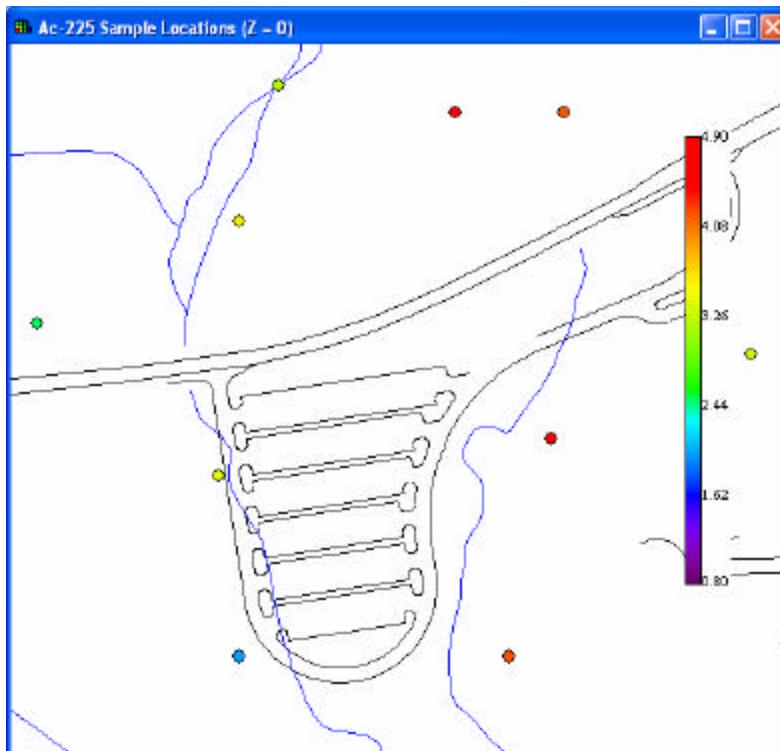
### Zooming

Zooming in and out are possible with geospatial maps. Select the **Zoom in** or **Zoom out** button from the main toolbar.

Using the left mouse button, select the region to zoom in on or out from.



Releasing the mouse button produces the zoom.



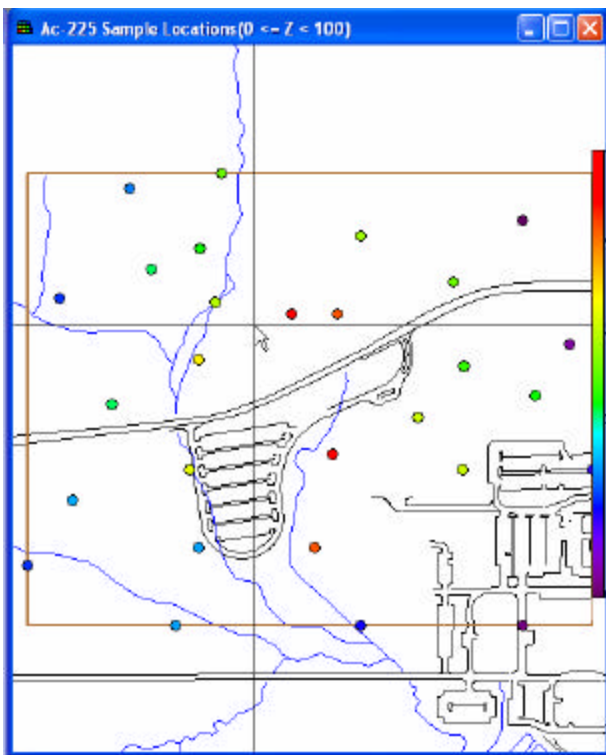
The area in the zoom box now fills the entire window. **Note:** SADA preserves the aspect ratio during zoom.

**Zoom Out** works similarly. Press **Zoom Out**, select the zoom area with the mouse, and the portion of the image that is visible is placed in the zoom box to cause the zoom out effect. Again the aspect ratio is preserved.

Select the **Restore picture** button to return the picture to its original scaling and position.

### Shifting the Picture

You may shift the image from side to side by selecting the **Shift Picture** button from the main toolbar. After selecting this option, click your mouse at any point in the picture and pull the mouse in the direction you wish to move the image. A line will appear demonstrating how far the picture will move. Release the mouse button and the picture will redraw.



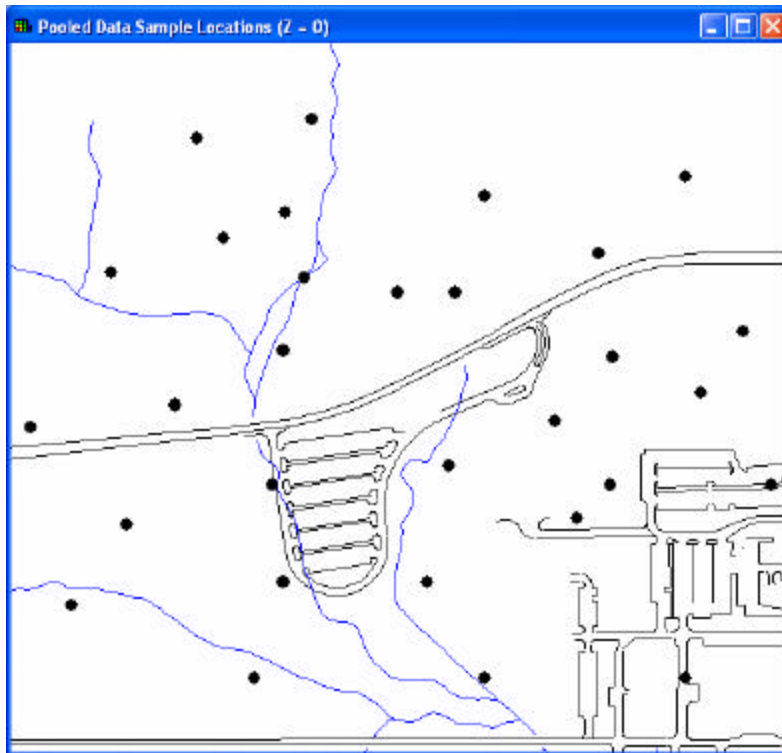
Select the **Restore picture** button to return the picture to its original scaling and position.

### Restoring the Picture

Select the **Restore picture** button to return the picture to its original scaling and position.

### Pooling Data

SADA provides a way for the user to apply modeling and summarization applications to all contaminants within a particular data type at once. This capability is available by selecting **Pooled Data** from the **Data Name box**. Pooled data produces a data plot that shows every sample location for every contaminant included in the analysis for the current data type. Notice that there is no legend associated with this plot. These data plots essentially demonstrate the distribution of information locations across space.



The Information and Statistics buttons are available and will produce tabular results for all contaminants; however, the user may not exclude any type of contaminant (rad, nonrad, unregistered) here without explicitly removing it from the list of included contaminants in Contaminant Manager. Labels may also be viewed with pooled data by selecting the appropriate label from the Labels Box. Note that labels will only appear in the graphics window if they are the same value for all the data points at a particular location. Otherwise, the following symbol indicates different values: \*\*\*.

The only interviews available for pooled data are **Plot my data** and **Develop a sample design**. Human health analyses offer a few more interviews.

Pooled data sources may extend over both radionuclides and nonradionuclides and may be modeled with varying interpolation schemes.

## Contaminant Manager

The **Contaminant Manager** provides the flexibility to remove or add contaminants to the analysis. Environmental assessments often result in a subset of contaminants identified as *contaminants of concern*, or COCs. These COCs become the focus of the analysis, and all other contaminants are given less attention. With the **Contaminant Manager**, non-COCs can be removed from further analysis, allowing the user to concentrate only on the COCs.

To access the **Contaminant Manager**, select **Contaminant Manager** from the **Tools** menu in the main SADA window. The following window appears.



Select the data type of interest from the drop down box in the upper left corner. Contaminants that are currently included in the analysis for this media appear in the left box and un-included contaminants appear in the right box. Select one or more contaminants from either box, and use the arrow buttons to move them between boxes. In the example above, Ac-225 will no longer be included in further analysis for soil data type. At any time, another data type choice can be made. When finished, press the **OK** button.

When a contaminant is excluded from further analysis, the following occurs:

- 1) Un-included contaminants no longer appear in the data name combo box in the main SADA window.
- 2) Data are re-pooled for this media and a new set of unique sampling points using all included contaminant samples is constructed. These can be viewed by selecting Pooled Data in the **Contaminant Selection** box of the secondary toolbar. Sampling locations that only contain data from un-included contaminants no longer appear.
- 3) Un-included contaminants will no longer affect or be included in any Pooled Data operations.

Contaminants can be returned to the analysis at any time by accessing the **Contaminant Manager** and moving them back into the **Included box**.

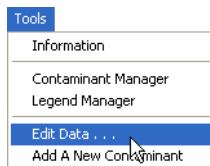
## Data Editor

The **Data Editor** is in the setup path for creating a SADA file. When setting up a new file, SADA places all the data into the **Data Editor** for a pre-check on the data. The **Data Editor** provides users with a chance to see how SADA is importing their data and any potential problems without terminating the process.

The **Data Editor** is also intended to be the primary way in which new data can be entered into SADA after a .sda file has already been set up. To add new contaminants after a file has been set up, refer to the Adding A New Contaminant chapter.

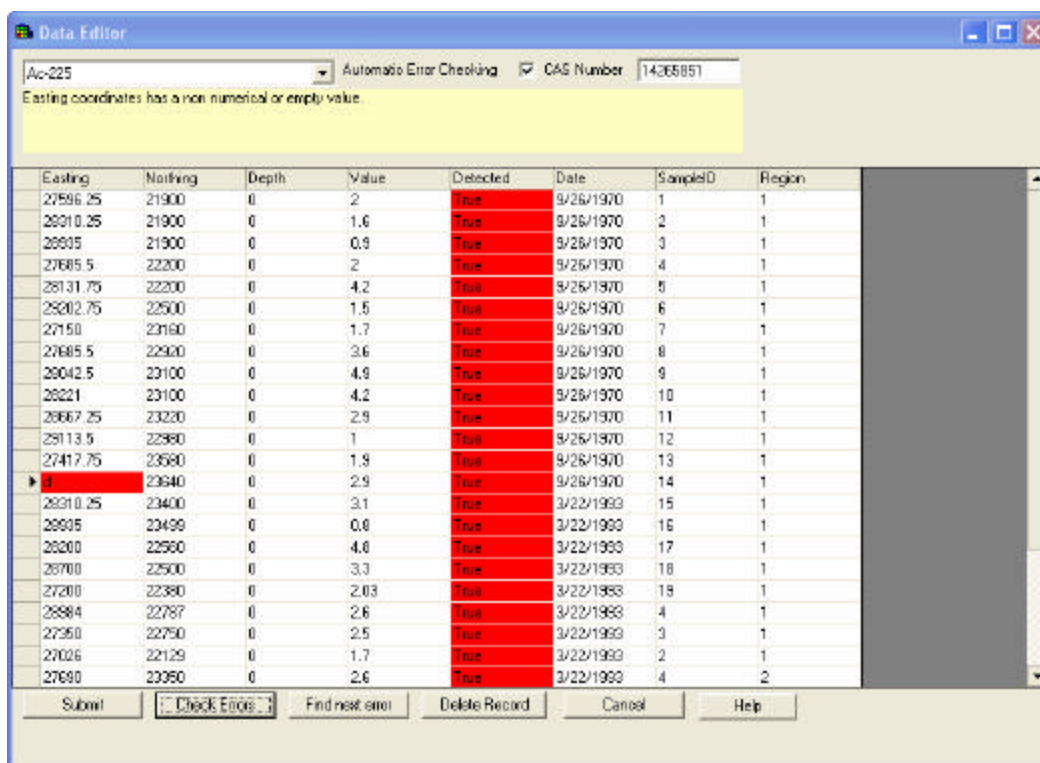
The **Data Editor** is a simple spreadsheet that allows data entry and copy and paste functions. In addition, the **Data Editor** highlights problem values in the data set by turning the cell value red.

To use the **Data Editor** after a .sda file has been created, select **Tools** from the main menu and then **Edit Data...**



If you are setting up a new file, the **Data Editor** will appear automatically.





The name of the current contaminant is in the upper left hand corner. To the right of this combo box is the **Automatic Error Checking** option and below is the error description and the contaminant CAS number.

In the snapshot above, two things are wrong with the data set. In the Easting column, there is a non-numerical value, and the entire Detected column contains the value True (0 and 1 are valid values). To determine what is wrong with a particular cell entry, hold the mouse over the red cell and the yellow error description box describes the problem.

When the **Data Editor** is initiated, the **Automatic Error Checking** box is automatically selected. With this selected, SADA is watching every entry and checking its validity. **Automatic Error Checking** is recommended for most operations. However, when entering or pasting large amounts of data into the editor, this feature can be annoying and may even slow down the process. Under these circumstances, unselect this option. When you wish to have your entries checked, press the **Check Errors** button at the bottom or reselect **Automatic Error Checking**. Use the **Find Next Error** button to have SADA automatically search for the next error.

### Copying Data from the Editor

To copy a block of data from the editor, select the region of interest and press CTRL+C (or right mouse click and select **Copy**). You can then paste this into another application, such as Excel.

### Pasting Data into the Editor

Under certain circumstances, it may be easier to prepare your data in another spreadsheet, such as Excel, and then paste them into the **Data Editor**. This is a likely case when new data has been taken and needs to be appended to the existing information. In this case, first copy the data from the external application. Then click in the (new) row at the appropriate place and type CTRL+V (or right mouse click and select **Paste**). Note that when **Automatic Error Checking** is on, you may see some red cells after you click in the (new) row. This is normal, and you should go ahead and complete the paste.

If you want to paste revised data over existing values, first copy the values in the external application. Next, select the appropriate cell where pasting should begin. Type CTRL+V (or right mouse click and select **Paste**).

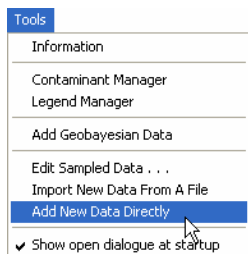
## Entering New Data into the Editor

You can enter new data into the **Data Editor** in one of two ways: by pasting data from another application or by hand entering the information. To hand enter data, click the mouse into the (new) row and enter the new information into each cell. Note that when **Automatic Error Checking** is on, you may see some red cells after you click in the (new) row. This is normal, and you may proceed with data entry.

When the data is complete and accurate, press the **Submit** button. SADA will perform a last check on the data before updating the file.

## Adding a New Contaminant

To add a new contaminant to an existing SADA file, select **Tools** and then **Add New Data Directly**.

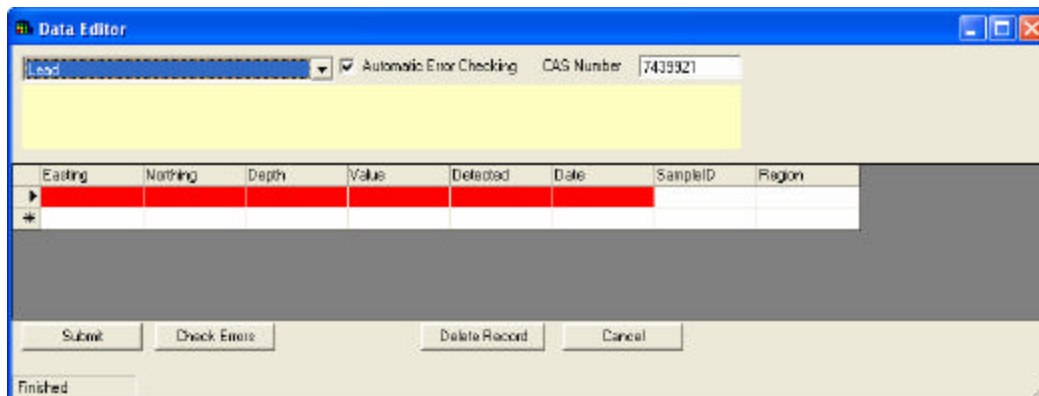


SADA responds with the following window.



Type the name of the new contaminant and CAS Number, if available. Select a media type from the drop down list and press **OK**. *Note: If you type a contaminant name that already exists within the specified media type, you will now have two instances of this contaminant and the data are treated separately. If you have new data for an existing contaminant you should add it to the existing data through the data editor.*

When you press **OK**, SADA will bring the data editor up. It will be empty, as there are no existing data for this contaminant. You must enter at least one sample value to successfully add a new contaminant.



After entering at least one sample value, press the **Submit** button. For more information on how to use this editor, see the section **Data Editor**. SADA will then add the contaminant and associated data to the existing file. As with all SADA results, you must save your SADA file to keep the new contaminant and data.

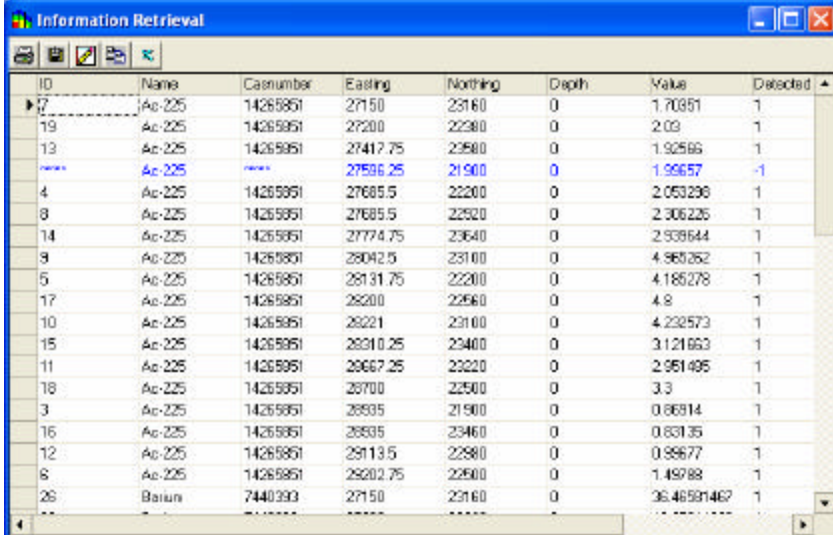
## Information

The user can access information about the current graphic in two ways: with the information button or the information table. Also, the user can search for a particular label contained in dataset by using the Search Labels function.

### Information Button

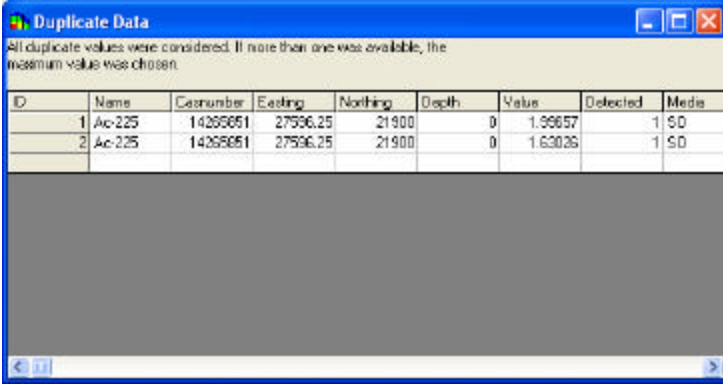
To retrieve information from the SADA file or from the modeling results, click the Information Button on the main toolbar while the image is in view. If you are interested in retrieving information about a selected region of the modeling results or data points, capture these points with polygons.

The following window shows the results of pressing the information button for a Pooled data set.



ID	Name	Casnumber	Easting	Northing	Depth	Value	Detected
17	Ac-225	14265861	27150	23160	0	1.70351	1
19	Ac-225	14265861	27200	22380	0	2.09	1
13	Ac-225	14265861	27417.75	22580	0	1.92566	1
	Ac-225		27536.25	21900	0	1.99657	-1
4	Ac-225	14265861	27685.5	22200	0	2.053296	1
8	Ac-225	14265861	27685.5	22520	0	2.306226	1
14	Ac-225	14265861	27774.75	23640	0	2.938644	1
9	Ac-225	14265861	28042.5	23100	0	4.965262	1
5	Ac-225	14265861	28131.75	22200	0	4.185278	1
17	Ac-225	14265861	28200	22560	0	4.8	1
10	Ac-225	14265861	28221	23100	0	4.232573	1
15	Ac-225	14265861	28210.25	23400	0	3.121663	1
11	Ac-225	14265861	28667.25	23220	0	2.951495	1
18	Ac-225	14265861	28700	22500	0	3.3	1
3	Ac-225	14265861	28935	21900	0	0.66914	1
16	Ac-225	14265861	28935	23460	0	0.63135	1
12	Ac-225	14265861	29113.5	22880	0	0.99677	1
6	Ac-225	14265861	29202.75	22500	0	1.49788	1
26	Barium	7440393	27150	23160	0	36.46591462	1

All field values not related to coordinate or value will contain asterisks. If there are resolved duplicated in the data set, the Information Retrieval window displays these points as blue entries. Click on a blue entry to display the Duplicate Data window.



ID	Name	Casnumber	Easting	Northing	Depth	Value	Detected	Media
1	Ac-225	14265861	27536.25	21900	0	1.99657	1	SD
2	Ac-225	14265861	27536.25	21900	0	1.63026	1	SD

This window displays the information for all duplicate values at that point and explains the method used to resolve them.

For modeling results, select the modeling region and press the Information Button. In this window, each row represents information about the modeled block. The first three columns show the row, column, and z layer position of the block. The next three columns show the location of the center of the block in coordinate values. The final column shows the modeled value for this block. For more information, see the section **Overview of Geospatial Modeling**.

Row	Column	Layer	Easting	Northing	Vertical	Value
1	1	1	27049.0275	21917.4	1.5	1.9016
1	2	1	27095.0625	21917.4	1.5	1.9219
1	3	1	27141.1375	21917.4	1.5	1.9869
1	4	1	27187.1925	21917.4	1.5	1.9085
1	5	1	27233.2475	21917.4	1.5	1.9106
1	6	1	27279.3025	21917.4	1.5	1.9297
1	7	1	27325.3575	21917.4	1.5	1.9297
1	8	1	27371.4125	21917.4	1.5	1.9297
1	9	1	27417.4675	21917.4	1.5	1.8869
1	10	1	27463.5225	21917.4	1.5	1.9089
1	11	1	27509.5775	21917.4	1.5	2
1	12	1	27555.6325	21917.4	1.5	2
1	13	1	27601.6875	21917.4	1.5	2
1	14	1	27647.7425	21917.4	1.5	2
1	15	1	27693.7975	21917.4	1.5	2
1	16	1	27739.8525	21917.4	1.5	2.9682
1	17	1	27785.9075	21917.4	1.5	2.7136
1	18	1	27831.9625	21917.4	1.5	2.4653
1	19	1	27878.0175	21917.4	1.5	2.4688
1	20	1	27924.0725	21917.4	1.5	2.4688

The following buttons appear in the **Information Retrieval** window.



**Print** – Prints the grid to the printer.



**Copy To File** – Copies grid contents to a comma delimited text file.



**Auto-Add Report** – Adds grid results to a report.



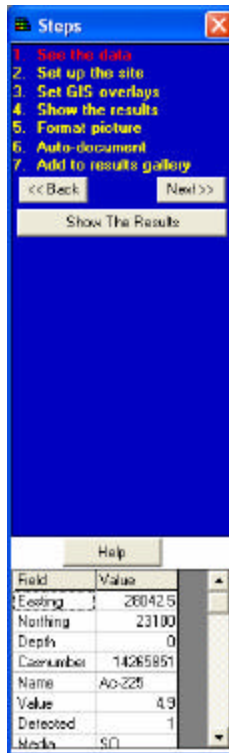
**Copy to Clipboard** – Copies the current image to the clipboard. It can then be pasted into most Windows packages.



**Export to Excel** – Automatically dumps the spreadsheet to an Excel file.

### Information Table

The Information Table is displayed at the bottom of the Steps Window. When the user selects a data point from the Graphics Window, this table is populated with specific information about that point (e.g., sample location, value, media, date, etc.).



If the data are pooled, field values appear blue and all fields not related to coordinate or value contain asterisks.

Field	Value
Name	Pooled Date
Casnumber	Pooled
Easting	27750
Northing	23145
Depth	0
Value	Pooled
Detected	Pooled
Media	Pooled

Click on a highlighted cell to open the **Pooled Data Point** window .

Name	Casnumber	Easting	Northing	Depth
Ac-225	14265851	27685.5	22900	0
Benzin	7440093	27685.5	22900	0
Arsenic	7440082	27685.5	22900	0
Anthracene	120127	27685.5	22900	0

This window displays all single contaminants and their represented values found at that point.

Similar to the Information button, duplicate values at one of the points will be blue and all fields not related to coordinate or value contain asterisks.

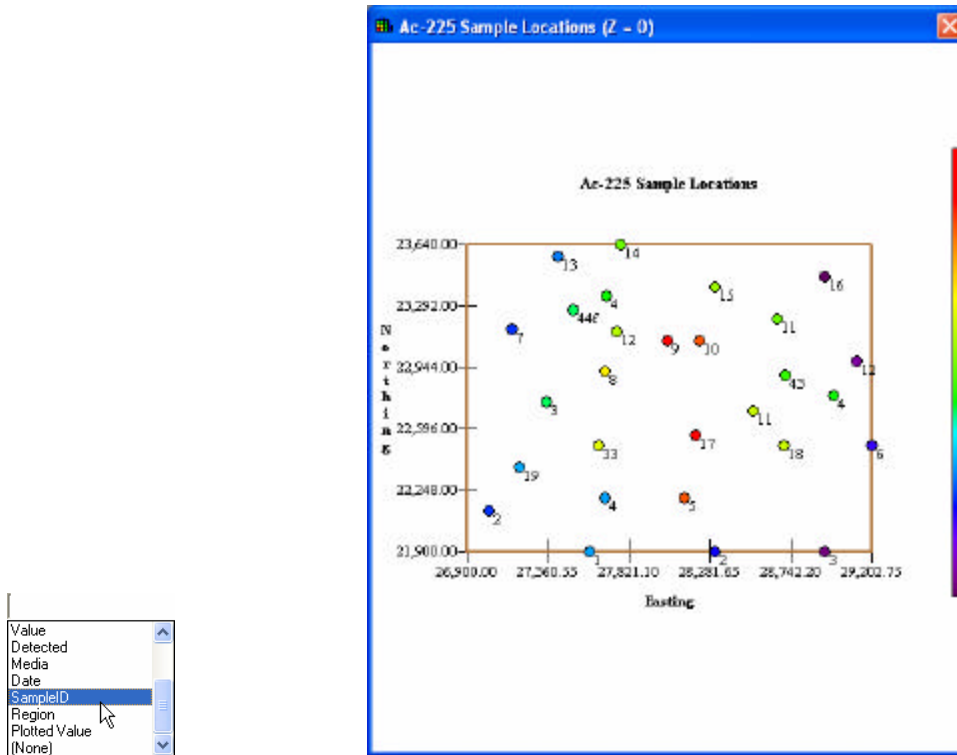
For 3d data, more than one point may exist at the same coordinate but at different depths. The information table reflects this by displaying information for each point within the same depth interval.

## Search Labels

SADA version 4 allows the user to search for a particular label associated with the dataset by using the search labels function. This is particularly useful for locating one data point out of a large dataset by a unique characteristic of that data point.

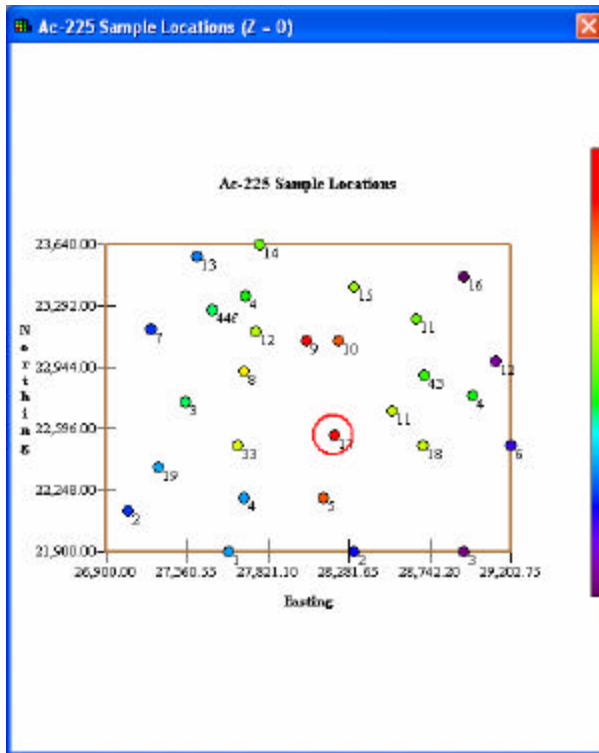
In order to use this function, make sure that the appropriate label type is selected in the **Labels box**. You will then see the applicable labels displayed for every data point in the graphics window.

In the following example, SampleID was selected from the labels box. Note that the graphics window displays the sample id associated with every sample point.



From the Tools menu, select **Search labels**.

In the **Current Label Search** box, enter the desired value. Click **Find** for SADA to place a red circle around the data point with that label. If there are more than one data point with that label, clicking **Find** again will go to the next point, and so on.



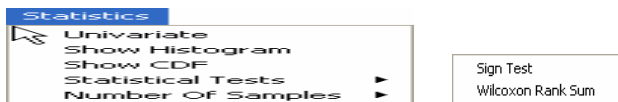
**Note:** For 3d data, SADA will search through all layers for the label and automatically change the layer to display the label for the user.

To remove the red circle, click on **Clear ID Circle**.

## Statistics

A statistical analysis summarizes a set of data or characterizes how the data are distributed. In addition, statistical values are often used in many modeling procedures within SADA (e.g. risk analysis).

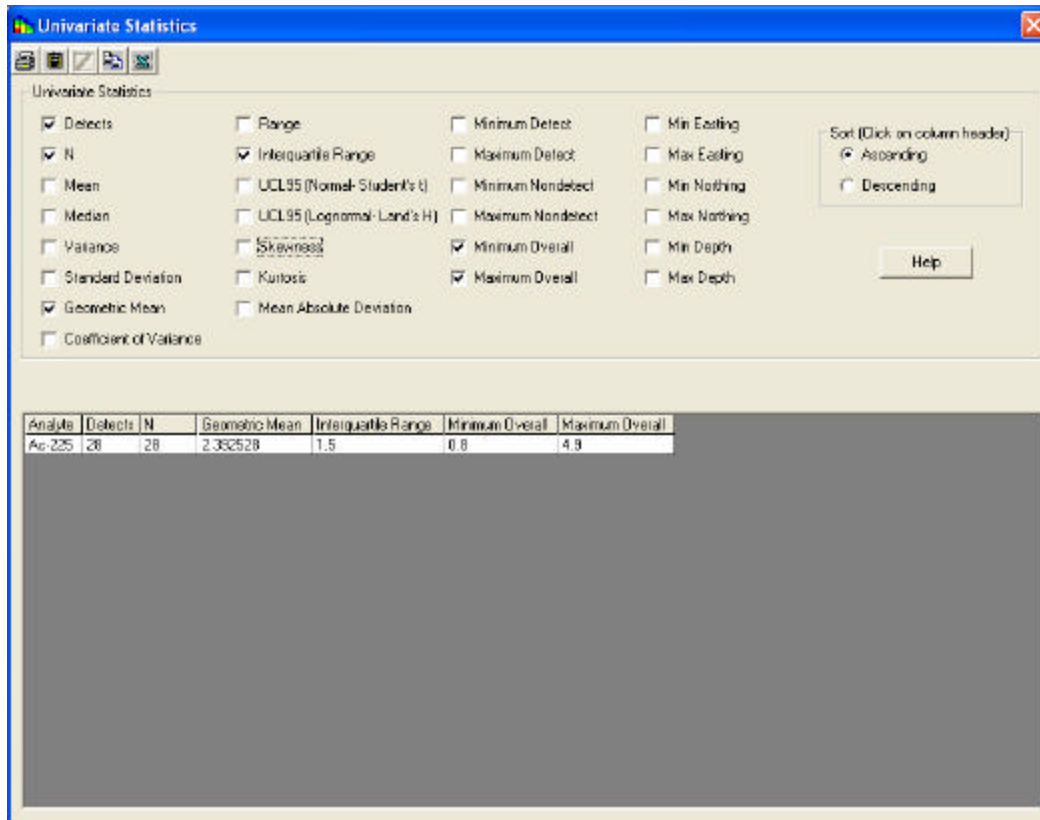
To view statistical summaries, select the appropriate type of statistics from the Statistics menu: univariate, statistical tests, or number of samples.



## Univariate Statistics

Use the **Statistics button** to calculate univariate statistics on every data point (or modeled value). When a polygon tool is on, this feature will return only those points found in the polygon. Select and deselect individual statistics to display them in the spreadsheet.





- **Detection Frequency**- the number of total samples that were detected, presented in the form (detected/total N)
- **Mean**- the sum of the values of a variable divided by the number of values
- **Median**- the value below which 50% of the data values fall
- **Variance**- a parameter that measures how dispersed a random variable's probability distribution is, the mean of the squares of the differences between the respective samples and their mean
- **Standard Deviation**- the positive square root of the variance
- **Mean Absolute Deviation**- the mean of the absolute values of the differences between the respective samples and their mean
- **Coefficient of Variance**- the ratio of the variance over the mean
- **Interquartile Range**- the central portion of a distribution, calculated as the difference between the third quartile and the first quartile; this range includes about one-half of the observations in the set
- **Range**- the difference between the lowest and highest values
- **UCL95 (Normal – Student's t)**- upper 95% confidence limit on the mean concentration of a normal distribution
- **Skewness**- is a measure of symmetry, skewness for a normal distribution is zero, and any symmetric data should have a skewness near zero. Negative values for the skewness indicate data that are skewed left and positive values for the skewness indicate data that are skewed right
- **Kurtosis**- Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. Data sets with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data sets with low kurtosis tend to have a flat top near the mean rather than a sharp peak.



- **Geometric Mean**- the mean of n numbers expressed as the nth root of their product
- **UCL95 (Lognormal – Land's H)**- upper 95% confidence limit on the mean concentration of a lognormal distribution
- **Minimum Detect**- the lowest detect value found in the dataset
- **Maximum Detect**- the highest detected value found in the dataset

## Statistical Tests

A statistical test is a procedure for deciding whether a hypothesis about a quantitative feature of a population is true or false. These tests are used to determine the statistical significance of a result. Statistical tests separate significant effects from mere luck or random chance.

All hypothesis tests have unavoidable, but quantifiable, risks of making the wrong conclusion. Two main types of errors can occur:

- A type I error occurs when a true hypothesis is rejected (a false negative in terms of the null hypothesis).
- A type II error occurs when a false hypothesis is accepted (a false positive in terms of the null hypothesis).

A null hypothesis ( $H_0$ ) is a statistical hypothesis that is tested for possible rejection under the assumption that it is true (usually that observations are the result of chance). The alternative hypothesis ( $H_a$ ) is the hypothesis contrary to the null hypothesis.

The null hypothesis is tested by:

- Drawing a random sample from the population
- Making a measurement of the feature
- Calculating an appropriate function of the data
- Comparing this statistic to a critical level

A parametric test makes an assumption about the underlying distribution of observed data. A non-parametric test makes no such assumption.

Non-parametric tests:

- Do not assume Normal distributions
- Can handle non-detects
- Are not sensitive to outliers
- Work nearly as well as parametric tests when data are normal

SADA currently implements two non-parametric tests used by the DQO and MARSSIM processes: Sign Test Wilcoxon Rank Sum test.

### Sign Test vs. Decision Criteria

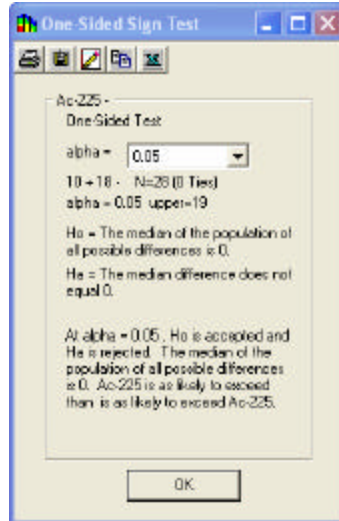
The Sign Test is a one-sided, nonparametric test that determines the probability of a sample median being equal to a hypothesized value. This test makes the basic assumption that there is information only in the signs of the differences between paired observations, not in the magnitudes of the differences.

A sign test is performed by comparing each value to the decision criterion. The number of exceedances, ties, and the number of sample values below the decision criterion are recorded and compared to a significance value that is dependent on the alpha.

After selecting **Sign Test vs. Decision Criteria**, SADA asks the user to define a decision criteria, depending on the analysis type.



Press **OK** and SADA presents the results of the one-sided sign test.

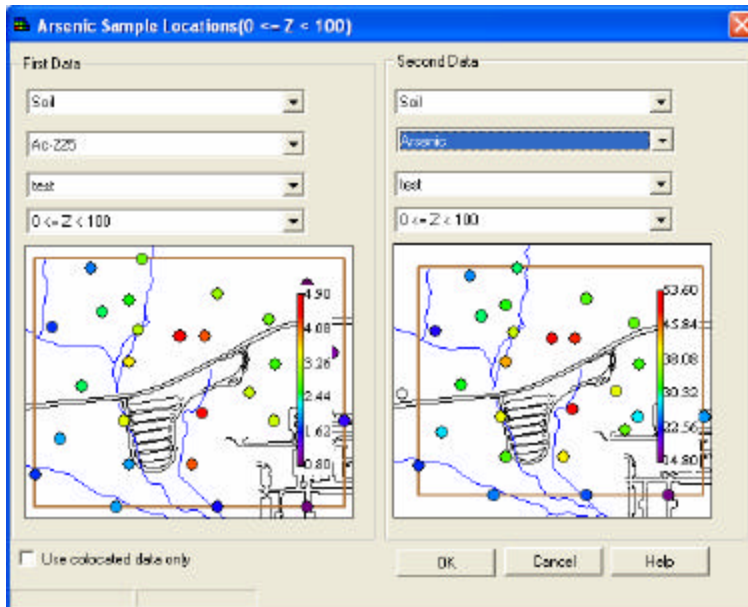


SADA will calculate the differences and count the number of positive differences for the test statistic beta. A critical value for a given alpha level or p-value is derived based on the binomial distribution or simply pulled from a table. Then the null hypothesis is either accepted or rejected.

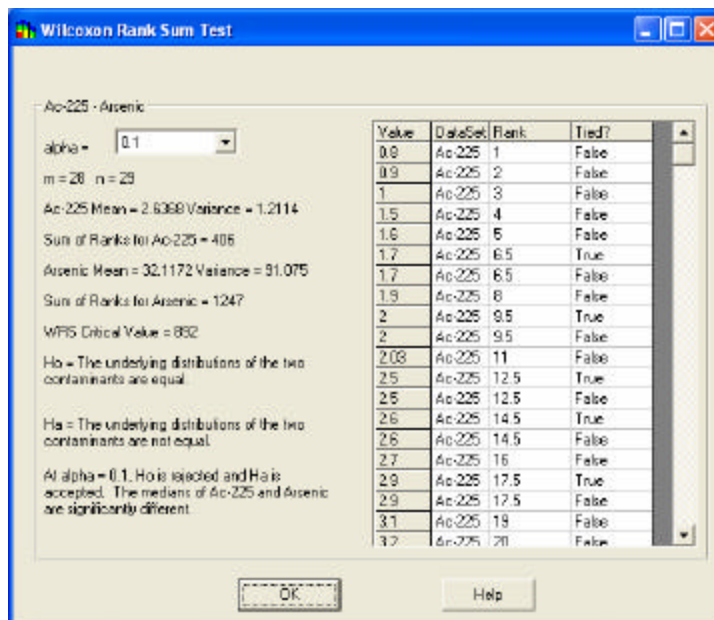
### **Wilcoxon Rank Sum Paired Test**

The Wilcoxon Rank Sum (WRS) Test is a nonparametric test used to determine compliance with the decision criterion when the contaminant of concern is also in background. It compares the locations of two populations, to determine if one population is shifted with respect to another. The method employed is a sum of ranks comparison which works by ranking the combined data sets and summing the ranks for each contaminant. The sum of the ranks is then compared to significance values based on the decision alpha.

Select **Wilcoxon Rank Sum Test** from the **Statistics menu -> Paired Statistics**. SADA presents the following window.



Select the appropriate information for each data set and press **OK**. SADA displays the results for the test.



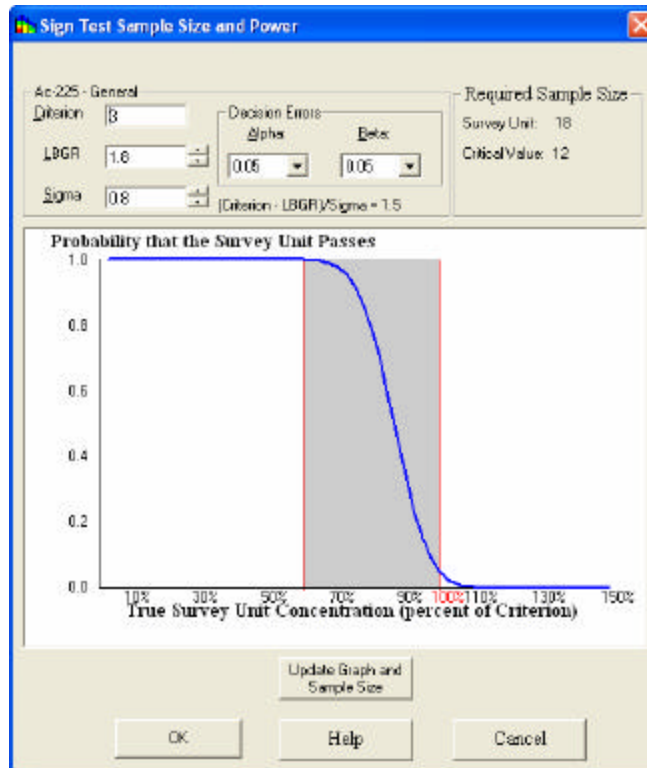
## Number of Samples

SADA has two types of statistics to determine number of samples: Sign test and Wilcoxon rank sum test. (Alternately, the user may also determine the number of samples based on some outside decision.)

### Sign Test

This statistic uses the sign test to determine the number of samples needed by evaluating whether the median of the data is above or below the DCGLW. This test is used when contamination is not present in the background and measurements are radionuclide-specific or if background levels are a small fraction of the DCGL.

Select Sign Test from the Statistics menu -> Number of Samples. SADA asks the user for a decision criteria, depending on the analysis type. Then, SADA presents the following window.

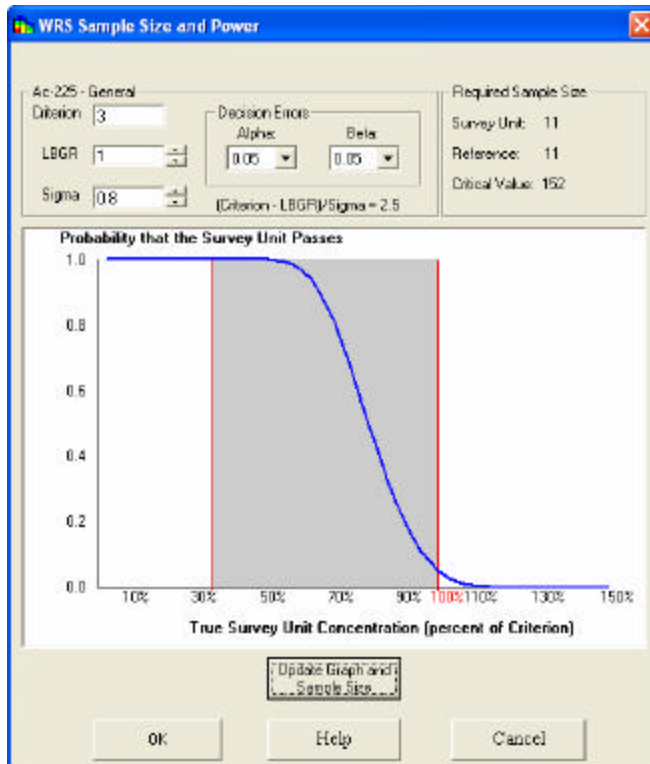


Compare contaminant levels with the DCGL levels. Each measurement below the DCGL contributes evidence that the survey unit is clean and the null hypothesis should be rejected.

### Wilcoxon Rank Sum

This statistic uses the Wilcoxon rank sum test to evaluate whether the difference between the median of the data in the survey unit and the median in the reference area is above or below the DCGLW. This test is used if contamination is present in the background.

Select **Wilcoxon Rank Sum** from the **Statistics** menu -> **Number of Samples**. SADA asks the user for a decision criteria, depending on the analysis type. Then, SADA presents the following window.



Compare survey unit concentration data with reference area data adjusted by adding the DCGL. Each survey unit measurement below an adjusted reference area measurement contributes evidence that the survey unit is clean and the null hypothesis should be rejected.

If the human health risk or ecological risk assessment module has been setup, then the table separates radionuclides, nonradionuclides, and unregistered contaminants.

## Geospatial Methods

This chapter includes an overview of geospatial modeling and the following interviews and steps:

- Set grid specs - step
- Interpolation method - interview
- Model spatial correlation - interview
- Correlation modeling - step
- Search neighborhood - step
- Cross validation - step
- Interpolate my data - interview
- Draw a variance map - interview
- Draw a LISA map - interview

### Overview of Geospatial Modeling

SADA provides a collection of methods to model contaminant behavior between sampled data points. These methods may estimate attribute values or quantify the uncertainty in estimation. The results serve as a foundation for secondary spatial modeling in human health risk assessment, ecological risk assessment, remedial design, and cost assessment applications. There are five geospatial interpolation methods currently available: Nearest Neighbor, Natural Neighbor, Inverse Distance, Ordinary Kriging, and Indicator Kriging.

The foundation for geospatial modeling in SADA is a choice of one of the five interpolants and a grid structure, which will partition the site. SADA will estimate the concentrations at the horizontal center of each block and use these values as an estimate for the block concentration. For 3d data, SADA also uses the vertical interpolation point to define block concentration. Block kriging is not currently available.

The premise for each of the available interpolants is that the concentration value at any location is a weighted average of the concentration values around it. Therefore, to estimate the concentration value at a given location requires averaging the weighted values of sampled locations in a nearby neighborhood. This idea can be mathematically expressed as

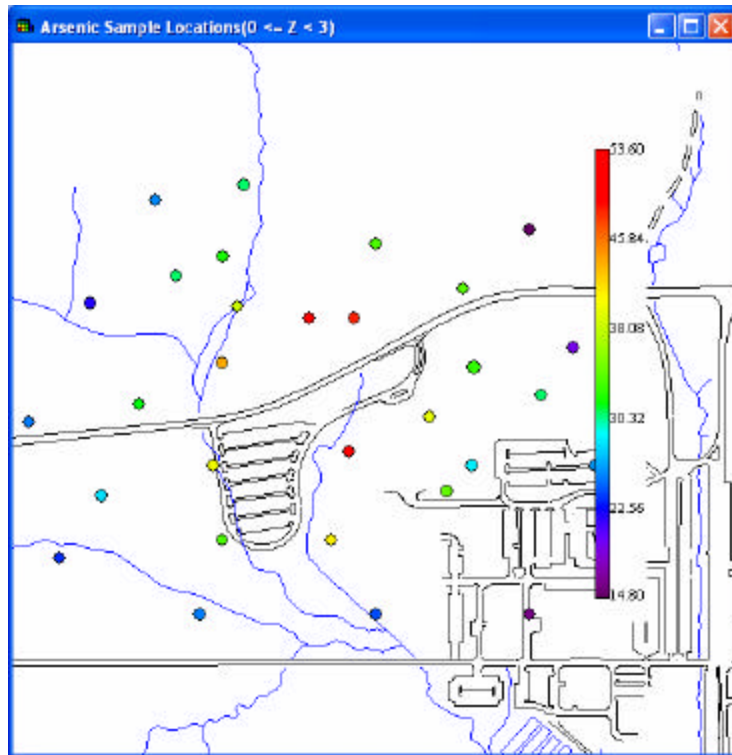
$$v_0 = \sum_{i=1}^{N(v_0)} w_i v_i$$

where  $v_0$  is the concentration to be estimated at  $(x_0, y_0, z_0)$ ,  $N(v_0)$  is the number of sample locations in the neighborhood of  $v_0$ ,  $v_i$  are the sample values, and  $w_i$  are the weights. Generally, the fundamental difference between the interpolation methods is how the weights are determined.

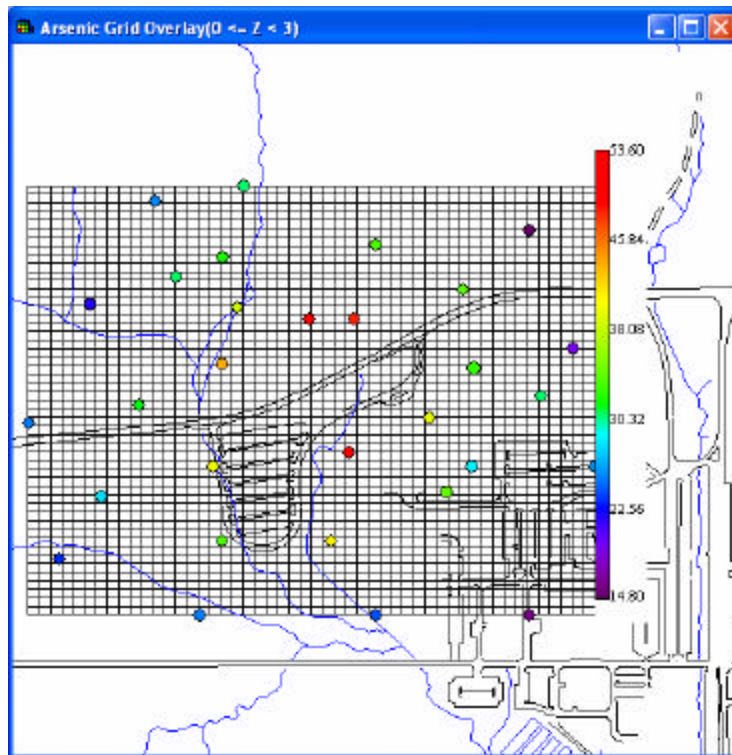
The mathematical basis and description of these methods is beyond the scope of this manual. For a more detailed explanation of these methods, see *GSLIB Geostatistical Software Library and User's Guide* by Deutsch and Journel (1992) or *An Introduction to Applied Statistics* by Isaaks and Srivastava.

The following examples demonstrate output from spatial models. In the first image, the user has provided a set of Arsenic data. With this data, the ordinary kriging model was used to produce the subsequent images.

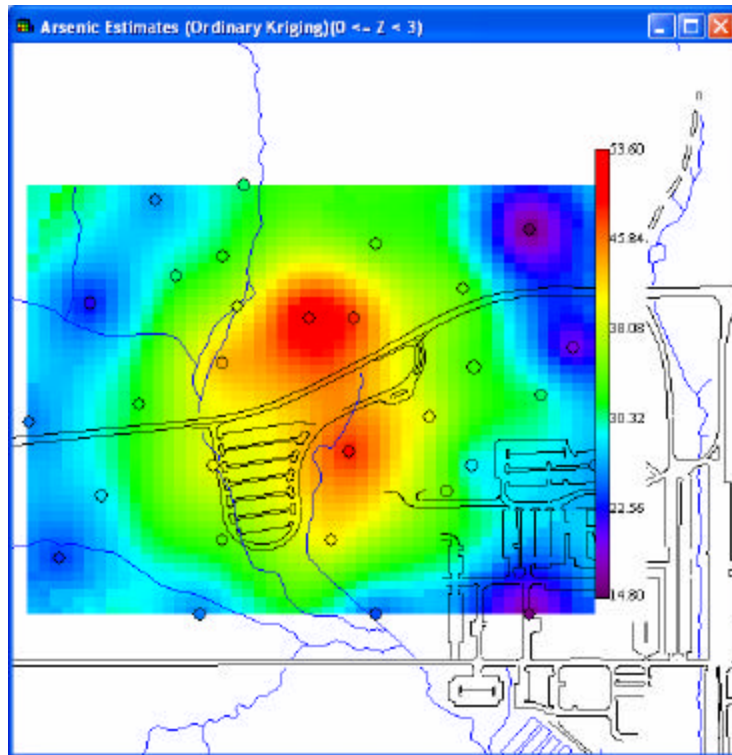
The supporting samples are distributed as follows:



The next step is to partition the space with a grid system.



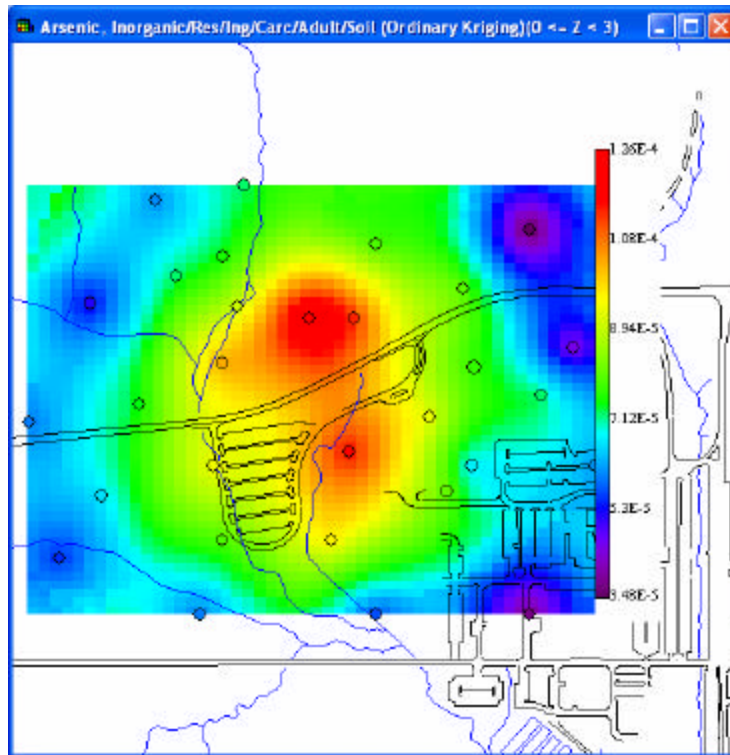
Once the grid has been established, each block in the grid becomes the focus of the geospatial model. The following image shows how the OK model estimates concentration values within each block to produce a map.



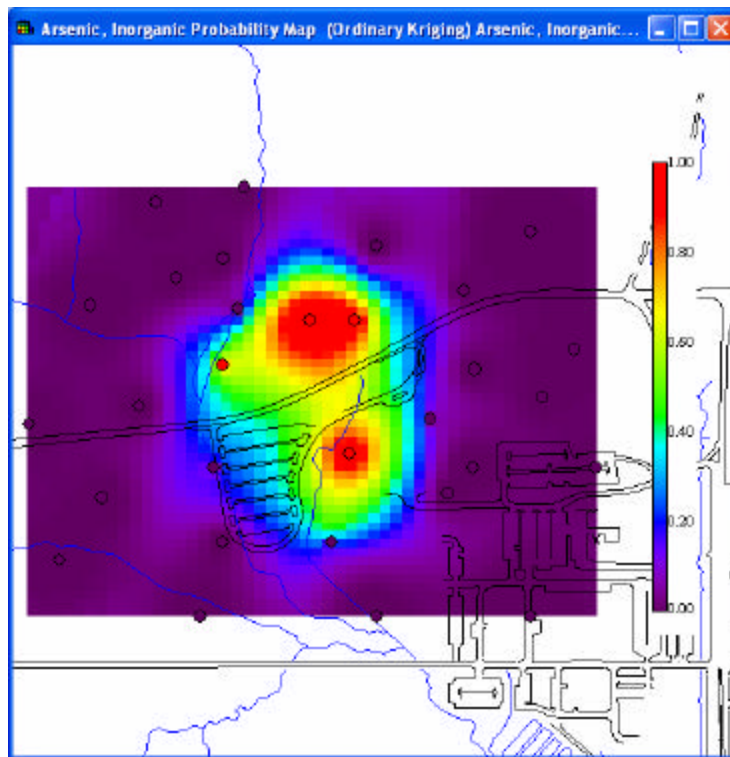
Using the concentration map as a basis, human health and ecological risk models may be added to transform the concentration map into a contoured risk map. Risk maps are useful for identifying areas that exceed established risk goals.

*Note: From a risk perspective, the exposure unit size may not be reasonable, especially for finely partitioned sites. However, once an area of interest is identified with the risk map, a polygon may be used to select the sub-region and define a new exposure area where risk models may be applied more appropriately.*

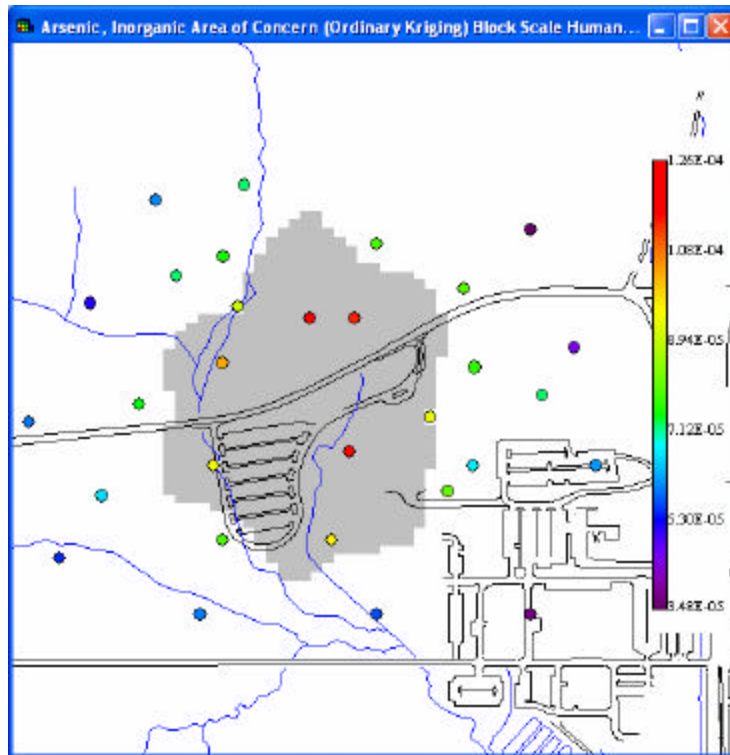




When using ordinary kriging or indicator kriging, uncertainty about site conditions can be quantified. For example, if a cleanup goal is specified, SADA can identify those areas that exceed this goal. Kriging adds another element to the modeling process by producing probability maps. For example, the following map demonstrates the probability of exceeding  $1E-6$  risk.



These modeling results can be extended to identify areas of concern or remedial boundaries.



Geospatial modeling also supports Cost Benefit Analysis and Sampling designs.

## Set Grid Specs - Step

Before any type of geospatial modeling or related decision analysis framework may be applied, the site must be partitioned into a grid or block system. Rather than estimate values at only a single point, we wish to estimate them at a number of points in order to fill in the picture of contamination. A grid definition simply describes the number, size, and location of a uniform set of blocks. These blocks will be the focus of the interpolation schemes. SADA's interpolation schemes will estimate the concentration value at the center of each block.

This step is available when one of the following interviews is selected: Interpolate my data, Draw a variance map, Draw a probability map, Draw an area of concern map, Calculate cost versus cleanup, Draw a LISA map, Draw a contoured risk map, Draw a contoured eco dose map, and sometimes Develop a sample design.

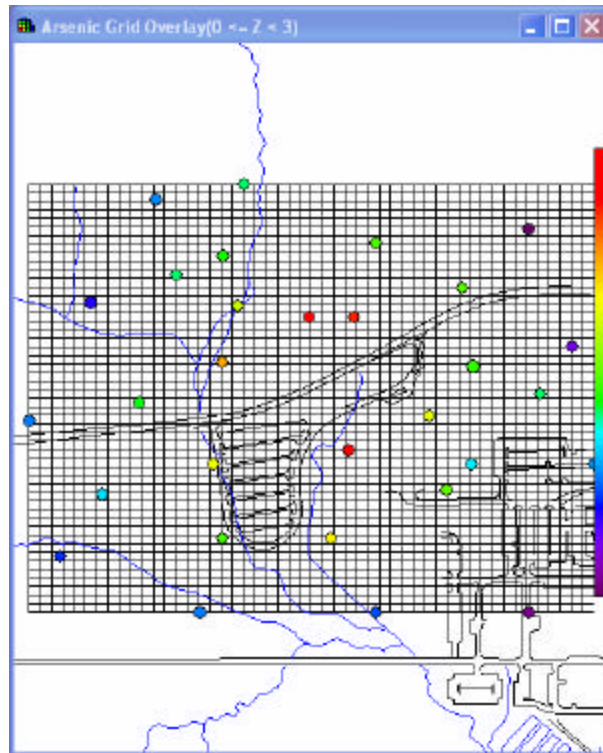
Select **Set grid specs** from the Steps Window. The following information is displayed in the Parameters Window.

	Easting	Nothing
<input type="radio"/> Number	50	50
<input checked="" type="radio"/> Size	46.065	34.0

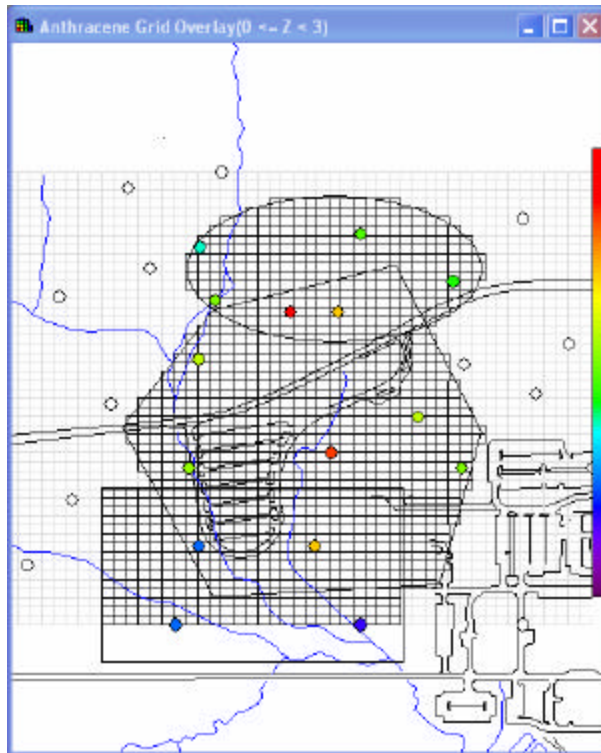
Grids may be developed based on number of blocks or size. To develop a grid based on number of blocks, click in the button next to **Number**. Then, specify the number of blocks in each direction. To develop a grid based on size of blocks, click in the button next to **Size**. Then, specify the size of blocks for each direction.

By default SADA calculates a global grid that extends to the minimum and maximum value taken over all data in the east and north coordinates. This allows the user to spatially sum risks over analytes easily and consistently. SADA then calculates the sub grid that encompasses all associated data points for the current analyte of interest.

To view the grid, press the **Show Grid** button.



Under the grid view, the user may then refine the spatial boundaries with the use of polygons to include or exclude blocks from analysis.



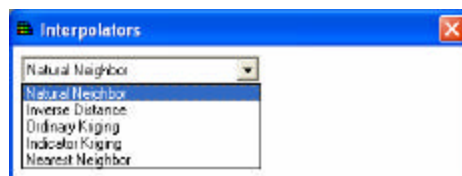
If the grid is three-dimensional, the user needs to define the vertical position in each box for interpolating the data (middle or top). See the section **Set Vertical Layers** to define this position. To view subsequent levels of the grid, use the layers box.

Once the site has been partitioned, a geospatial model may be applied.

### Interpolation Methods - Step

This step is available when one of the following interviews is selected: Interpolate my data, Draw a probability map, Draw an area of concern map, Calculate cost versus cleanup, Draw a contoured risk map, Draw a contoured eco dose map, and sometimes Develop a sample design.

Select **Interpolation methods** from the Steps Window. The following information is displayed in the Parameters Window.



Select the appropriate interpolation method from the list. There are five interpolation methods in SADA: Nearest neighbor, Natural Neighbor, Inverse Distance, Ordinary Kriging, and Indicator Kriging.

When ordinary or indicator kriging are chosen, options for the type of contours are available. Because we are within a geostatistical framework, it is possible not only to plot typical contours but also to evaluate spatial uncertainty by plotting certain percentile contours. For ordinary kriging, the mean and the percentile approach are the same when the percentile value is .5, which is the median. Because uncertainty assessment in ordinary kriging assumes that the point wise distribution is normally distributed with mean equal to the kriging mean and variance modeled by the kriging variance, then the mean and the median are equivalent.

In indicator kriging, the mean is actually the “E-Type Estimate”. The E-type estimate is the mean of the conditional cumulative distribution function and is calculated as

$$\approx \sum_{k=1}^{K+1} z'_k [F(u, z_k | (n)) - F(u, z_{k-1} | (n))]$$

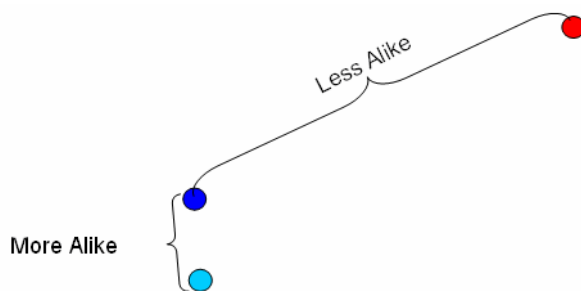
where  $z_k, k = 1, \dots, K$  are the  $K$  cutoffs,  $z_0 = z_{\min}, z_{K+1} = z_{\max}$  are the minimum and maximum of the  $z$  range and  $z'_k$  is the conditional mean within each class. (Deutsch and Journel, 1992).

Because of the non-parametric approach of indicator kriging and the application of its method to often highly skewed data sets, the 50<sup>th</sup> percentile of the indicator approach does not yield the same answer as the E-type estimate. This is similar in concept to the fact that the mean and median of a skewed distribution are not the same.

For the user with a knowledge of geostatistical simulation, note that percentile maps do not capture the same joint probability or joint uncertainty information as simulation. The likelihood that all points exceed their point-wise 95<sup>th</sup> percentiles is extraordinarily low, and it is therefore a highly conservative approach in the case of remedial design to use high percentile choices. However, these maps can be useful in such a conservative manner, since this is often the goal in protecting public health. They also are useful in identifying zones with wide distribution (variability) ranges.

**Note to Version 4 and earlier users:** the choice of kriging map (mean, 50<sup>th</sup> percentile, 75<sup>th</sup> percentile, etc.) will now serve as the basis for remedial designs and certain secondary sampling schemes. In earlier versions of SADA, the issue of spatial uncertainty in remedial designs was addressed using the remedial confidence parameter. For example, if one specified a confidence of 90%, SADA would identify all those zones where the probability of exceedance was at least 10%. To achieve this in Version 4.1, one would generate a 10<sup>th</sup> percentile map and identify those areas whose 10<sup>th</sup> percentile is greater than the specified value. Another way to think of this is to say “I want to identify those areas that have at least a 10% chance of exceeding the criteria”. That would be those places where 10<sup>th</sup> percentile is greater than the criteria. This is a subtle but important change in the way SADA handles uncertainty in the interface.

All of the methods presented here generally work on the principle that data points closer are more alike than data points farther away. This plays a key role in all of the approaches to weighting sample values.



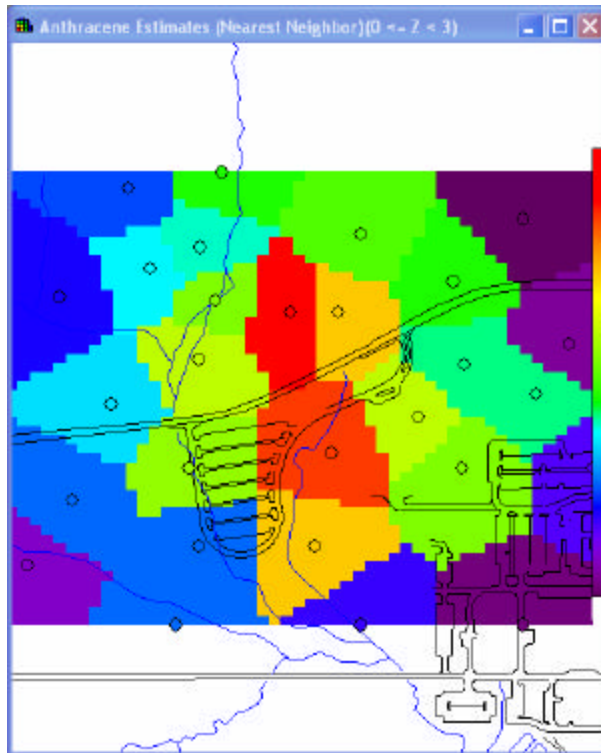
**Note:** for pooled data analyses, SADA uses the interpolant associated with the individual contaminants for contouring.

## Nearest Neighbor

In Nearest Neighbor, essentially each point of estimation (node) becomes equal in value to its nearest neighbor. It is not necessary to set up parameters with nearest neighbor.

Simply select **Nearest Neighbor** from the Parameters Window when the **Interpolation methods** step is selected. Then press **Show the results** on the Steps Window to display the applicable result in the Graphics Window.

The result of a nearest neighbor interpolation is a jigsaw puzzle pattern. Nearest neighbor is typically not satisfactory for most applications but can provide rough estimates for quick analytical purposes. The following image shows an estimates map for Anthracene.



## Natural Neighbor

Natural neighbor is as simple to use as Nearest Neighbor and provides more precise results; however, it is only available for two-dimensional interpolations. Natural neighbor requires that a grid be defined.

Once the grid has been defined, select **Nearest Neighbor** from the Parameters Window when the **Interpolation methods** step is selected. Then press **Show the results** on the Steps Window to display the applicable result in the Graphics Window.

Natural Neighbor interpolation is a weighted moving average technique that uses geometric relationships in order to choose and weight nearby points.

The equation for the Natural Neighbor (NN) interpolation is:

$$G(x, y) = \sum_{i=1}^n w_i f(x_i, y_i)$$

where:  $G(x,y)$  is the NN estimation at  $(x,y)$ ;

$n$  is the number of nearest neighbors used for interpolation;

$f(x_i,y_i)$  is the observed value at  $(x_i,y_i)$ ; and

$w_i$  is the weight associated with  $f(x_i,y_i)$ .

The number of natural neighbors is determined by constructing natural neighbor circles, called circumcircles. Two points are natural neighbors if they lie on the same natural neighbor circle. Delaunay triangulation is then used to determine the weights in order to interpolate. The weights ( $w_i$ ) depend on the area about each of the data points (Voronoi polygons) instead of the distance between data points, as with Inverse Distance Weighting (IDW).

The natural neighbor circles are constructed under the following constraints:

- No data are within a natural neighbor circle;



- No other datum is closer to the centroid of the circle;
- Smallest radius criterion for any group of three data; and
- Each natural neighbor circle passes through three data points.

For more detailed information about Natural Neighbor, refer to the following sources:

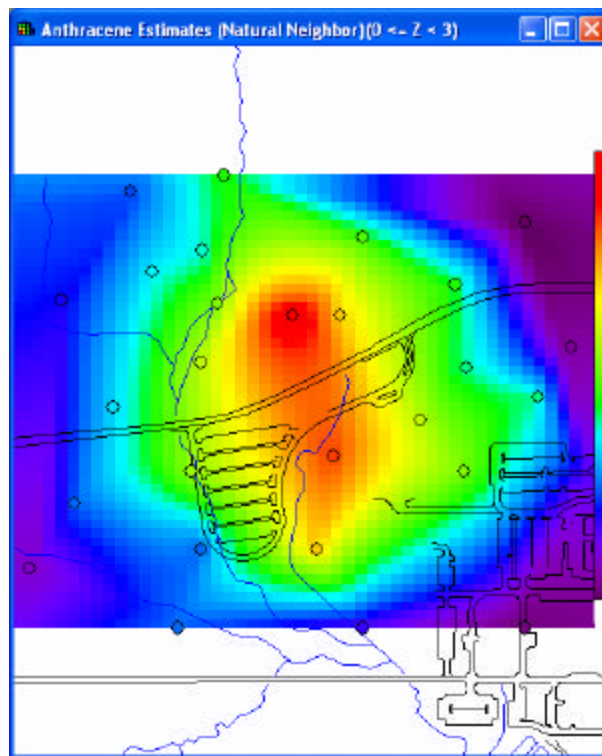
Owen, S.J., An Implementation of Natural Neighbor Interpolation in Three Dimensions, Thesis, Brigham Young University, 1992.

Sibson, R., "A Brief Description of Natural Neighbor Interpolation," Chapter 2 in Interpolating multivariate data, John Wiley & Sons, New York, 1981, pp. 21 - 36.

Watson, D.F., "Natural Neighbor Sorting," The Australian Computer Journal, vol. 17, no. 4, 1995.

Watson, D.F., nnggrid: An Implementation of Natural Neighbor Interpolation, published by David Watson, Australia, 1994.

The following image shows an estimates map for Anthracene.



## Inverse Distance

Inverse Distance is a simple interpolant that can often yield satisfactory results. The basic premise of inverse distance is that data points are weighted by the inverse of their distance to the estimation point. This approach has the effect of giving more influence to nearby data points than those farther away. Additionally, the inverted distance weight can be raised to further reduce the effect of data points located farther away. This approach is mathematically expressed as:

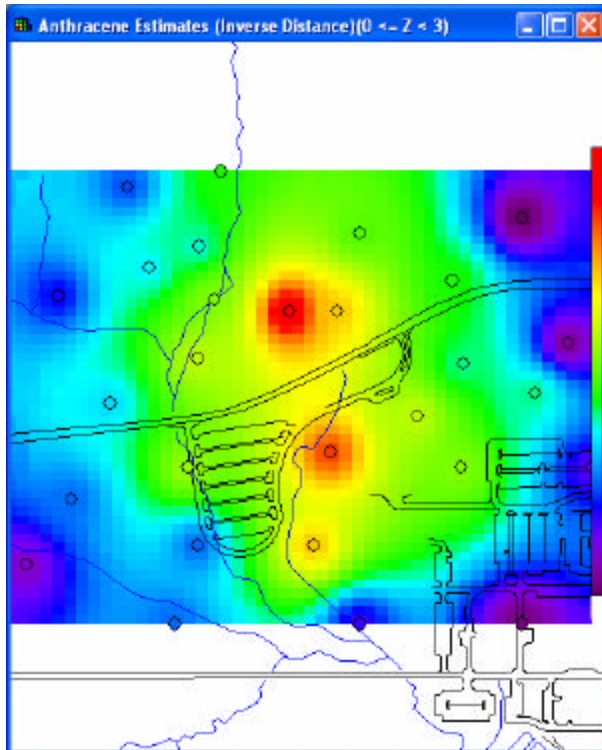
$$v_0 = \frac{\sum_{i=1}^{N(v_0)} \frac{1}{d_i^p} v_i}{\sum_{i=1}^{N(v_0)} \frac{1}{d_i^p}}$$

where  $v_0$  is the estimated concentration at  $(x_0, y_0, z_0)$ ,  $v_i$  is a neighboring data value at  $(x_i, y_i, z_i)$ ,  $DI$  is the distance between  $(x_0, y_0, z_0)$  and  $(x_i, y_i, z_i)$ ,  $P$  is the power, and  $N(v_0)$  is the number of data points in the neighborhood of  $v_0$ .

To utilize **Inverse Distance**, select **Inverse Distance** from the Parameters Window when the **Interpolation methods** step is selected. This interpolation method requires that a grid and search neighborhood be defined first.

Then, press **Show the results** on the Steps Window to display the applicable result in the Graphics Window.

The following image shows an estimates map for Anthracene.



## Ordinary Kriging

To utilize **Ordinary Kriging**, select **Ordinary Kriging** from the Parameters Window when the **Interpolation methods** step is selected. This interpolation method requires that a grid, a search neighborhood, and spatial correlation model be defined first.

Then, press **Show the results** on the Steps Window to display the applicable result in the Graphics Window.

Ordinary kriging (OK) is a geostatistical approach to modeling. Instead of weighting nearby data points by some power of their inverted distance, OK relies on the spatial correlation of the data to determine the weighting values. This is a more rigorous approach to modeling, as correlation between data points determines the estimated value at an unsampled point. The concept of spatial correlation and how to measure and model it in your data set is briefly described in the sections **Spatial Correlation** and **Modeling Spatial Correlation**. Furthermore, OK makes the assumption of normality among the data points.

In addition to the spatial correlation structure, SADA requires a definition of the neighborhood around estimation points. The issue of neighborhood definition is important to inverse distance and indicator kriging, as well. A discussion of neighborhood definitions is consolidated in the section **Defining A Neighborhood**.



Because OK is a statistical framework, a kriging variance is also produced for each block that can be viewed with the Draw a variance map interview. The OK estimate and OK variance are the parameters of a normal distribution located at the estimation point that can serve as a *measure* of uncertainty about the estimated value. This serves as an important foundation for decision frameworks that determine cost and boundaries of the remedial process.

A full explanation of ordinary kriging is beyond the scope of this manual. It is assumed that the reader is familiar with the process. For information on ordinary kriging see *GSLIB Geostatistical Software Library and User's Guide* by Deutsch and Journel (1992) or *An Introduction to Applied Statistics* by Isaaks and Srivastava.

## Indicator Kriging

To utilize **Indicator Kriging**, select **Indicator Kriging** from the Parameters Window when the **Interpolation methods** step is selected. This interpolation method requires a grid, a search neighborhood, and that a spatial correlation model be defined for each IK cutoff first.

Then, press **Show the results** on the Steps Window to display the applicable result in the Graphics Window.

Indicator kriging (IK) is a geostatistical approach to geospatial modeling. SADA uses IK in the same fashion as ordinary kriging (OK). Like OK, the correlation between data points determines model values. However, IK makes no assumption of normality and is essentially a non-parametric counterpart to OK.

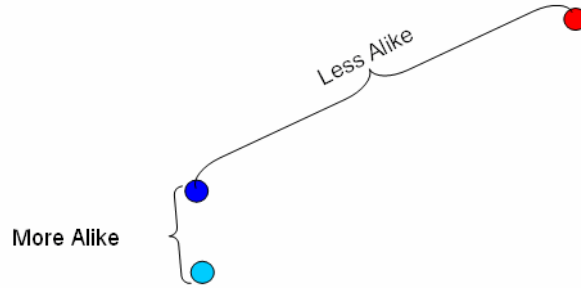
In addition to the indicator correlation structure, SADA requires a definition of the neighborhood around the estimation point. The issue of neighborhood definition is important to inverse distance and ordinary kriging, as well. A discussion of neighborhood definitions is consolidated in the section Defining A Neighborhood.

Instead of assuming a normal distribution at each estimate location, IK builds the cumulative distribution function (CDF) at each point based on the behavior and correlation structure of indicator transformed data points in the neighborhood. To achieve this, IK needs a series of threshold values between the smallest and largest data values in the set. These threshold values, referred to here as *IK cutoffs*, are used to numerically build the CDF of the estimation point. For each IK cutoff, data in the neighborhood are transformed into 0s and 1s: 0s if the data are greater than the threshold and 1s if they are less. IK then estimates the probability that the estimation point is less than the threshold value, given this neighborhood of transformed data and a model of the IK cutoff correlation structure. Performing this operation for each cutoff across the range of data approximates the CDF at the estimation point. After the CDF is built, it must be post processed to produce probability maps and E-Type values for estimation maps and risk maps.

The details of the IK process are beyond the scope of this book. It is assumed the reader is familiar with indicator kriging before attempting this process. For more information on indicator kriging, see *GSLIB Geostatistical Software Library and User's Guide* by Deutsch and Journel (1992).

## Spatial Correlation

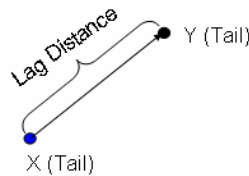
If data are spatially correlated, then on average, sample points that are close to each other are more alike than sample points further away. (More complex spatial correlations exist, but this type is the most common).



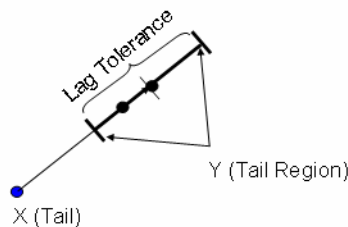
The degree to which data are more or less “alike” for any given distance can be calculated. SADA uses the semi-variogram method, which returns a measure of variance for any given distance of separation. This measure is defined as half of the average squared difference between values separated by distance **h**. The term **h** is referred to as the *lag* or *lag distance*. (Deutsch and Journel, *GSLIB Geostatistical Software Library and User’s Guide*, 1992)

$$\gamma(\mathbf{h}) = \frac{1}{2N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} (x_i - y_i)^2$$

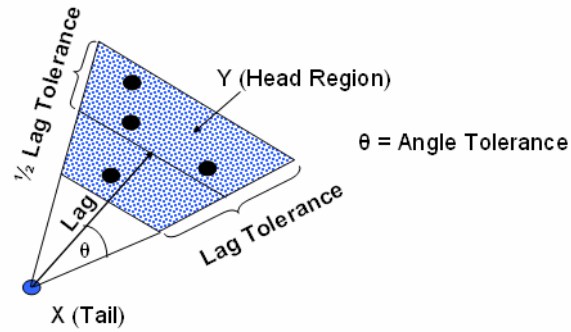
where  $N(\mathbf{h})$  is the number of pairs separated by vector **h**,  $x_i$  is the starting point (tail), and  $y_i$  is the ending point (head).



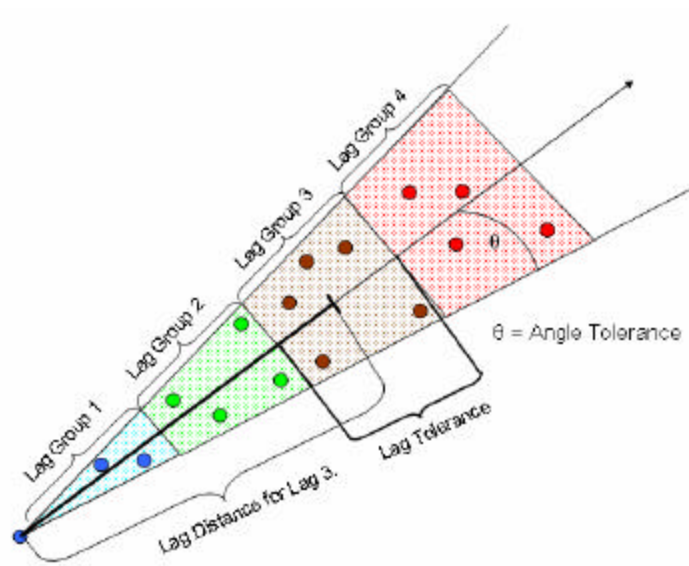
Rarely in practice will there ever be sample points separated by exactly a lag distance  $h$ . Therefore, a lag tolerance centered about the lag distance will permit a capture of more data points in the calculation of  $\gamma(\mathbf{h})$ . For example, to calculate the variance of all data points separated by 10 feet with a lag tolerance of 2 feet, the variance will actually be calculated for all pairs of data between 9 and 11 feet apart.



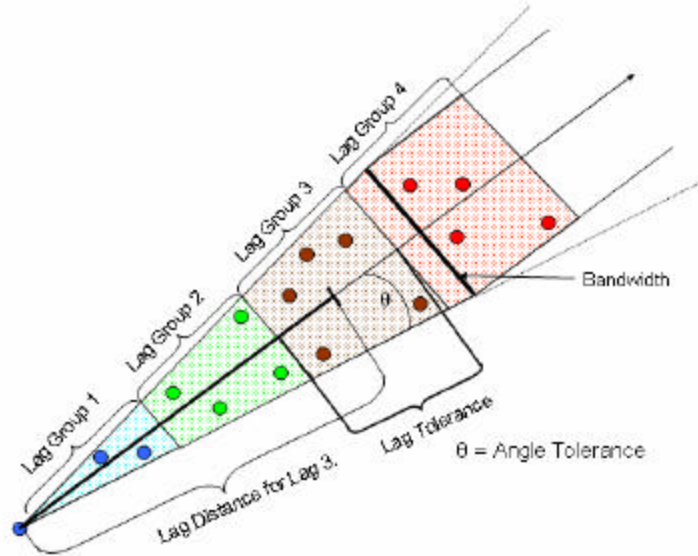
Although assigning a lag tolerance helps, most cases will never have enough samples separated by a lag - tol/2 to lag + tol/2 along a straight line to calculate the semivariogram value. Therefore, an angle tolerance,  $\theta$ , is also introduced to expand the region and to include more points in the calculation of the semivariogram value for the specified lag distance. In the figure below, all data points within the blue shaded area will be used.



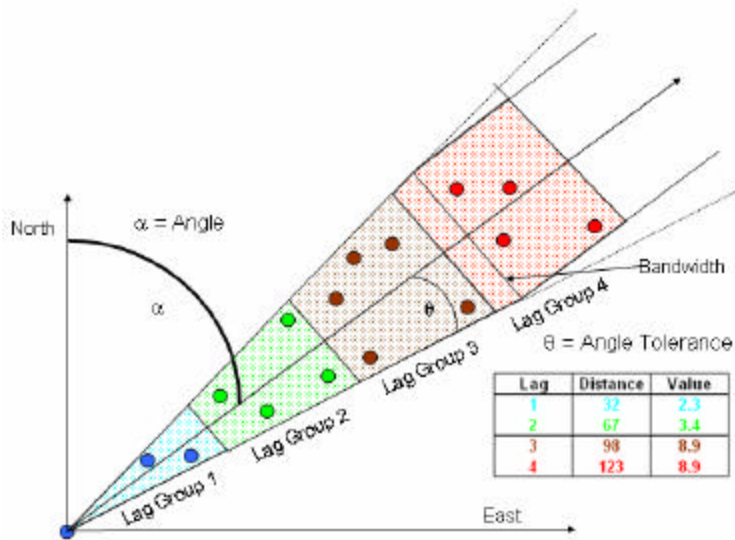
If this operation is repeated for a number of lag distances, a cone-shaped object would be generated that expands outward from the point of interest. This cone would be partitioned by lag groups centered about the lag distances.



As the cone stretches farther out, it opens up increasingly wide, capturing more and more data points. In practice, geostatisticians will often apply a constraint called the *bandwidth*. This bandwidth limits the expansion of the cone to a certain width. If you do not wish to constrain the cone's expansion, specify a very large bandwidth.



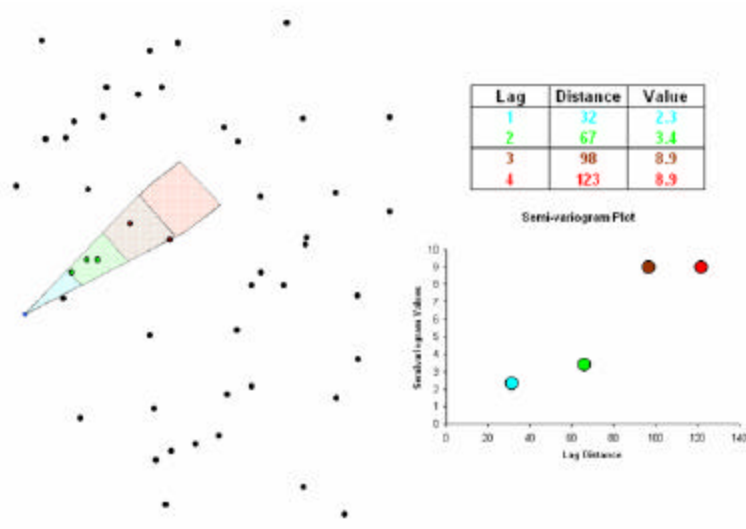
The final parameter is the angle. The angle specifies the direction for calculating the semi-variogram values. This is sometimes referred to as the angle of anisotropy and constrains the semi-variogram values to a certain direction.



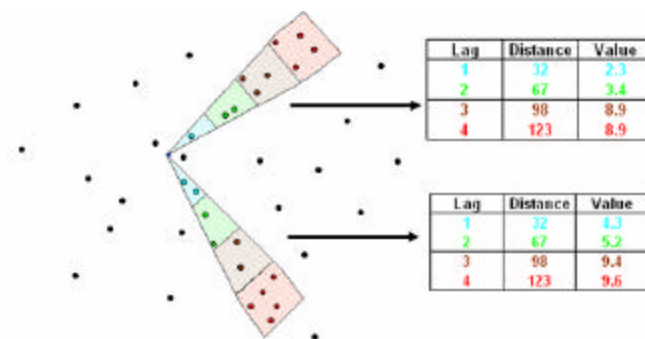
The semi-variogram calculation is performed for every sampled point.



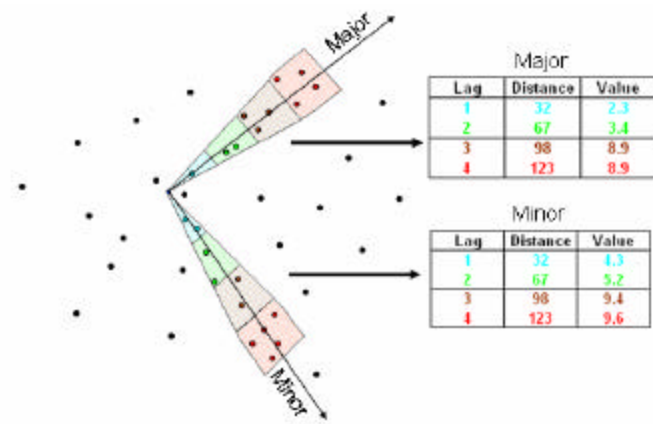
Then, the semi-variogram values are plotted.



Note though, by specifying an angle,  $\alpha$ , all those data points located outside of the cone from  $\alpha - ?$  degrees to  $\alpha + ?$  degrees are excluded. In other words, how data are correlated in a particular direction is being explored. If data are more correlated in one direction than another, the data are said to be *anisotropic*. This means that data in the direction  $\alpha$  are more alike than in other directions.



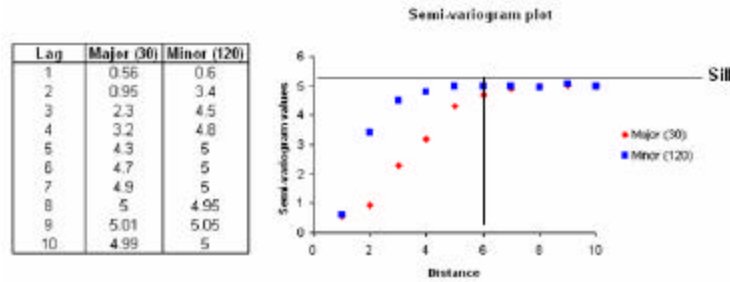
In fact, if anisotropic conditions exist, the direction of highest correlation is considered the *major direction* of anisotropy. The perpendicular direction is referred to as the *minor direction* of anisotropy. The *major direction* of correlation will exhibit semi-variogram values that increase at a slower rate than any other direction.



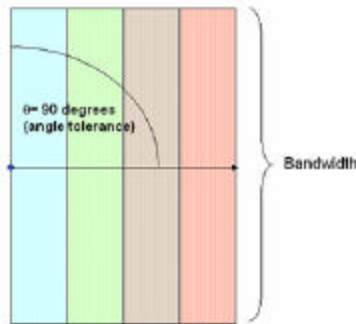
Theoretically, the semi-variogram values will continue to rise until they reach the *sill* value. The sill is the point at which the data are now far enough apart to be independent. The sill value should be roughly

equivalent to the variance of the data set. A *semi-variogram plot* is useful in detecting the sill value and location.

In the example below, there is a major direction at 30 degrees and the corresponding minor direction at 120 degrees. A sill value of approximately 5 is detected around 6 feet of separation.



In order to calculate an isotropic or *omni-directional* variogram, simply set the angle tolerance to 90 degrees and make the bandwidth significantly larger than the site. This will force the cone to consider the entire spectrum of data points.

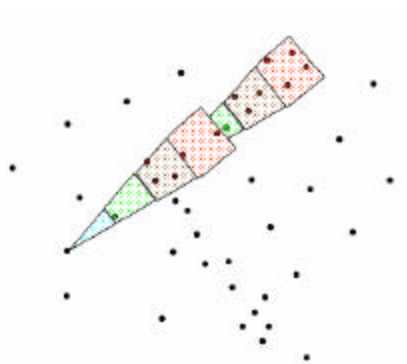


### What about in the opposite direction?

It is assumed that correlation is symmetrical. If data are varying a certain amount at 30 degrees, then they are varying the same amount at 120 degrees.

### Why aren't those sample points included in the 120 degrees direction to improve our semi-variogram calculation?

They are. The current point of interest will be captured by the cone of those points behind it.



### Direction of anisotropy

The direction of greatest correlation (direction of anisotropy) will produce semivariogram values that rise in value slower than the other directions. This is called the *major direction*. The *minor direction* is

perpendicular to the major direction (major direction + 90 degrees). The major and minor directions are used later in modeling spatial correlation for the purpose of ordinary kriging or indicator kriging.

### **Suggested Approach for Spatial Correlation**

Characterizing spatial correlation across the site through experimental variography can often be the most time consuming step in a geostatistical analysis. This is particularly true if the data are heterogeneous or limited in number. Without a rationale for identifying the major direction of anisotropy, the following steps might be useful in narrowing the focus of the exercise.

1. Begin with an omni-directional variogram with a bandwidth large enough to encompass all data points on the site.
2. Select the number of lags and lag distances sufficient to span a significant portion of the entire site, and choose the lag tolerance to be very close in value to the lag distance itself. In most cases, data become less correlated as the distance between them increases. Under these circumstances, the semivariogram values should produce a monotonic increasing function which approaches a maximal value called the *sill*. In practice, this may not be the case with variogram values that may begin high or jump around as distance increases.
3. Use the rose diagram to help determine the appropriate semivariogram values.
4. Adjust the number of lags and lag tolerances until, generally, a monotonic increasing trend is seen in the semivariogram values. If this cannot be achieved, it may be that a geostatistical approach is not viable or that more complicated trends are occurring than can be modeled within SADA. If a visual inspection of the data or knowledge about the dispersion of contamination indicates a direction of correlation, it may be more appropriate to first test this direction.
5. Assuming the omni-directional variogram is reasonable, add another direction to the plot with a smaller tolerance. You may have to adjust the bandwidth and angle tolerance to produce a reasonable semivariogram plot.
6. If the second direction rises slower to the sill or rises to a lower sill, then this is the major direction of anisotropy.
7. If neither direction produces significantly lower spatial correlation, it may be reasonable to assume an isotropic correlation structure.
8. Add a cone structure with direction equal to the major direction plus 90 degrees, and model the semivariogram results in this direction.
9. If the data are isotropic, choose the omni directional variogram as the major direction.

### **Spatial Correlation and Indicator Kriging**

Indicator kriging relies on models that quantify the spatial correlation among data values under the indicator transform. For a given threshold value, the indicator transform function assigns a value of 1 for data less than the threshold and 0 if it is greater. The semivariogram is then calculated using these transformed values.

In indicator kriging, the range of data values may be partitioned by a series of threshold values. For each one of these threshold values, the indicator transform is produced and a geospatial model of correlation must be available.

The indicator cutoffs are selected from the drop down box at the top of Parameters Window when **Correlation Modeling** is selected from the Steps Window.

Click on the **Edit** box next to **Variogram Type** to create new cutoff threshold values or to edit or delete existing values. SADA will open the **Indicator Cutoff** window.



To create a new value, select **New** and enter a new cutoff value. To edit a value, select the value in the Indicator Cutoffs window and press **Edit**. To delete a value, select the value and press **Delete**. Note that SADA displays how many data points are below the threshold in parentheses next to the cutoff value. The numbers in parentheses must be increasing in value to produce an increasing CDF. To check if the values are appropriate for the data set, select **Check CDF**. After making changes, press **OK**. The new set of indicator cutoffs will appear in the drop down box on the Parameters Window in ascending order.

For each cutoff threshold, define the major and minor parameters. The major direction is always highlighted in blue while the minor direction is green.

## Model Spatial Correlation - Interview

This interview presents the correlation model. SADA allows the user to only view the semivariogram results or to fit them with a correlation model.

### Availability

This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

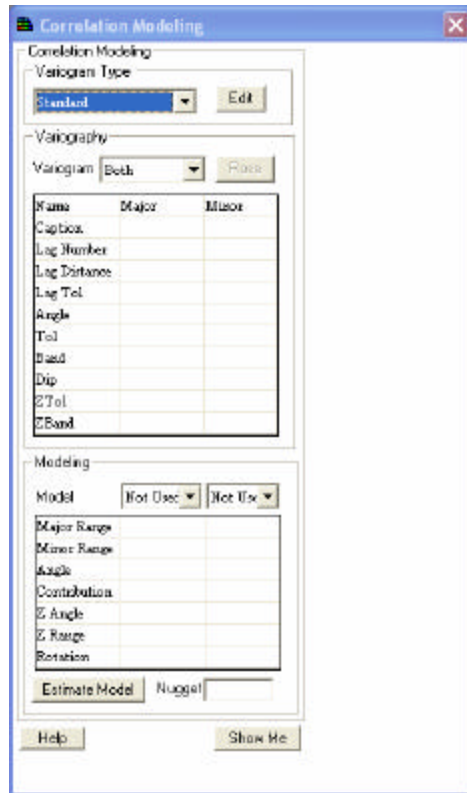
- See the data
- Set up the site
- Set GIS Overlays
- Correlation Modeling
- Show the results
- Format picture
- Auto-document
- Add to results gallery

## Correlation Modeling - Step

This step is available when one of the following interviews is selected: Model Spatial Correlation, Draw a Variance Map, Draw a probability map, Update My Prior Probability Map, Update My Prior Variance Map, and sometimes Interpolate my data, Draw an Area of Concern Map, Calculate Cost versus Cleanup, Draw a Contoured Risk Map, Draw a Contoured Eco Dose Map, and sometimes Develop a sample design.

Select **Correlation Modeling** from the Steps Window. SADA will display the following in the Parameters Window.



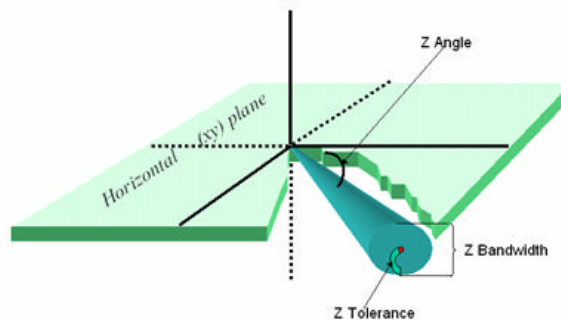


At the top of the tab in the drop down box under **Variogram Type**, select the default 'OK' option (for untransformed data) or create indicator cutoff threshold values.

SADA allows the results of two separate cones to be viewed at once to provide visual comparison and check for anisotropic correlation. (It is recommended that the user plot the major and minor axes; however, the cones do not need to be orthogonal to each other for simple viewing. If the model is used in OK or IK, they are considered orthogonal.)

Enter the appropriate parameters in the Variogram table. Each cone is identified by its **Caption**. The **Angle** parameter refers to the direction of the cone (measured clockwise from the positive y axis), the **Tol** parameter refers to the angle tolerance, and **Band** refers to the constraining bandwidth parameter.

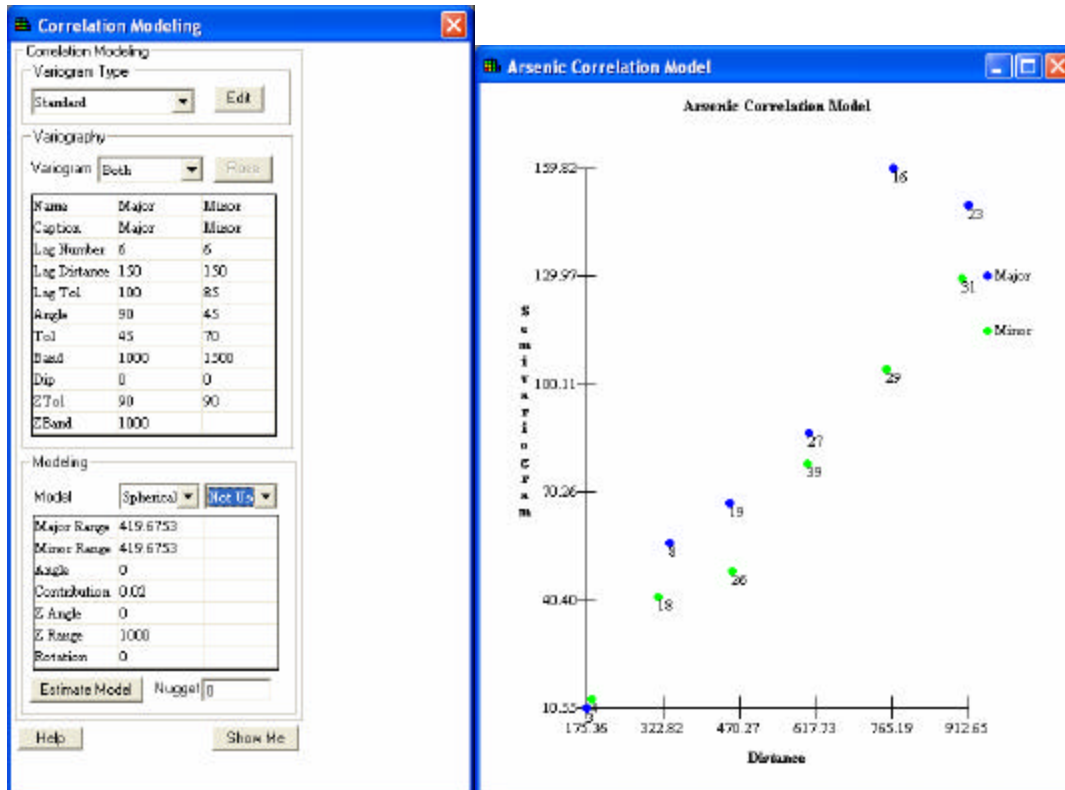
For the case of three dimensional data, the position of the cone in space is further specified by: **Dip** - the angle below the plane that the cone should dip (always negative), **ZTol** - the tolerance angle for the cone in the vertical direction. (*Note: the 3d parameters are disabled for 2d data.*)



In the drop down box next to **Variogram**, select 'Major', 'Minor', 'Both', or 'Nothing' to define the cones that are included in the graph of semivariogram results.

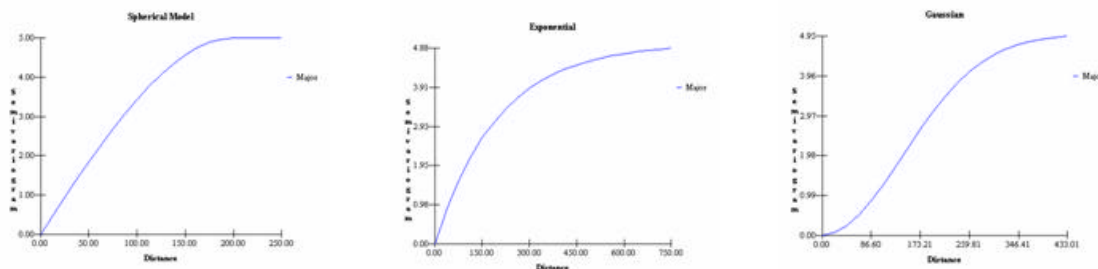
Select the **Rose** button to view the rose diagram for the data. This diagram can be used to set appropriate semivariogram parameters.

Press the **Show Me** button on the bottom of the window. The semivariogram results are calculated and plotted for each cone in the Graphics Window. The result of calculating the semivariogram for every lag is a series of semivariogram points. The major direction will appear blue while the minor direction is green. These variography results may be modeled separately or combined with a correlation model.



To fit a correlation model to the semivariogram results, enter the appropriate values in the second table on the Parameters Window.

The models are located in the drop down boxes next to **Model**; SADA provides 3 standard correlation models that provide a great deal of flexibility in semi-variogram data: Spherical, Exponential, and Gaussian.



Below each model are the parameters for fitting the semivariogram values.

Anisotropy in space is characterized by an ellipsoid model. This model is exactly the same as defining a neighborhood, which characterizes how points are estimated in space and is described by the following parameters.

Major Range – correlation length (or distance to the sill) along the major anisotropic axis.

Minor Range – correlation length (or distance to the sill) along the minor anisotropic axis.

Angle – The angle of anisotropy in the XY plane (equal to the major axis angle in experimental variography).

Contribution – The model's contribution to the sill (maximal model value).

Z Angle – The angle of anisotropy in the Z plane (equal to the Dip parameter in experimental variography).

Z Range – A value describing how anisotropy behaves in the z minor direction, relative to major axis.

Rotation – How the anisotropic ellipsoid is rotated about its major axis.

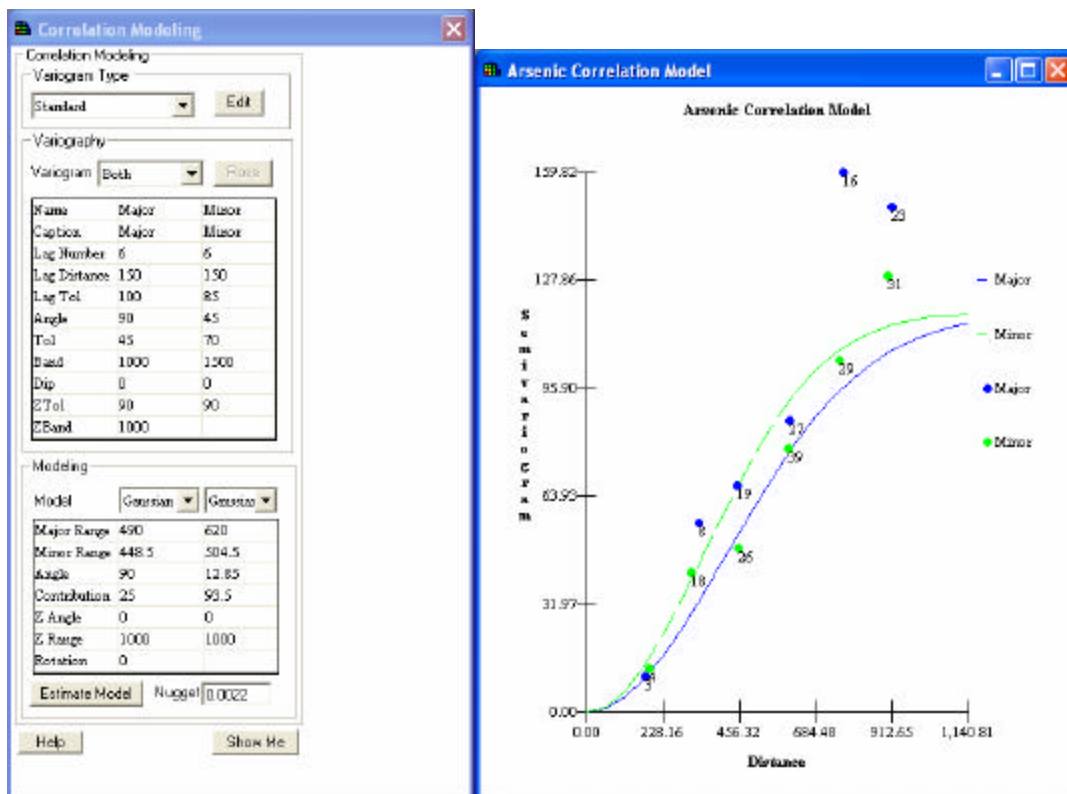
Nugget – the semi-variogram value as distance between points approaches zero; sometime referred to as noise effect.

To visualize how these parameters effect the ellipsoid, see the chapter on **Defining a Neighborhood**.

For more sophisticated modeling, the Angle and Z angle do not need to equal their experimental variography counter parts, Angle and Dip. *Note: this level of detail in fitting semivariogram models is not usually necessary.*

Use the **Estimate Model** button for SADA to help fit the correlation to the semivariogram values.


Press the **Show Me** button to view the results in the Graphics Window.



## Rose Diagram

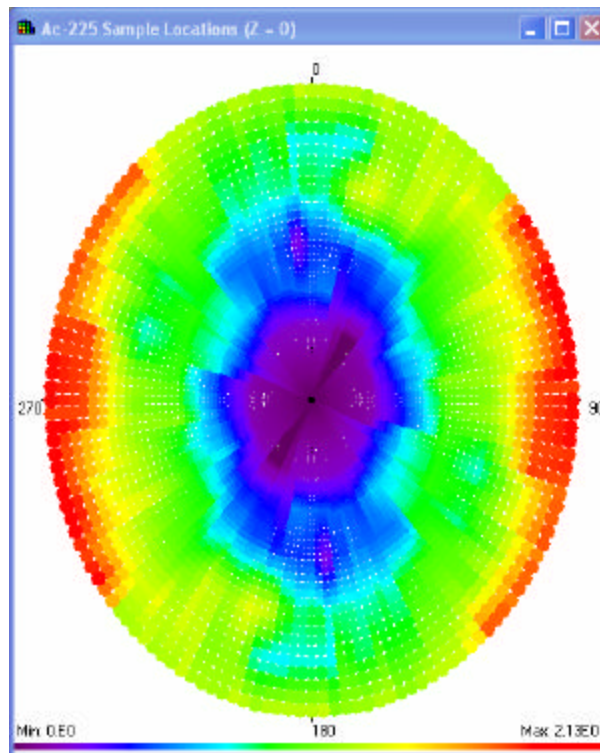
Rather than viewing only one angle at a time, users can view semi-variogram values in all directions at once with the rose diagram. A Rose Diagram is used to display correlation models for angles ranging from 1 through 180 degrees simultaneously. The semi-variogram magnitude is represented by a

continuous color legend. This legend is displayed on the bottom of the Graphics Window with the maximum and minimum value bounds.

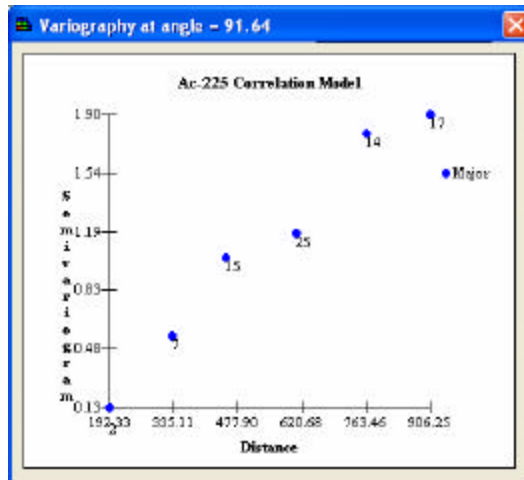
To draw a rose diagram press the rose button  on the Parameters Window when **correlation modeling** is selected in the Steps Window.



Use the slide bar to give a rose picture resolution. The higher the resolution, the longer it will take to calculate and draw the Rose Diagram. Press the **Estimate Time** button to estimate how long it will take to calculate the rose diagram. For large data sets, it may take an exceptionally long time to calculate the Rose diagram. Press **Cancel** in the Rose Diagram Window to stop the drawing of the rose diagram. Otherwise, press **Draw Rose**.



To see the individual angle variography model for any of the angles in the rose diagram, just click on the desired angle inside the Rose diagram. This launches the Rose Diagram Window.




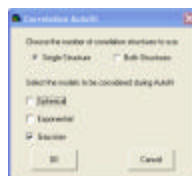
Invalid angles, or angles that don't produce lags, are shown as a black radial line inside the rose diagram. The angle that does not have extreme values and also has a smooth increase in value may be the direction of anisotropy.

**Note:** There are certain restrictions with rose diagrams: only one cone definition at a time can be used when creating a Rose diagram and at least 2 lags for each direction are required.

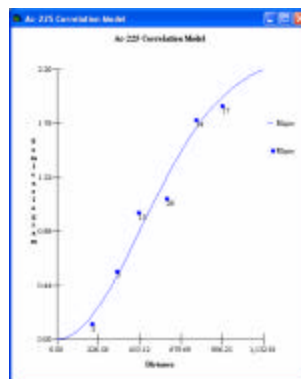
## Estimate Model

SADA will estimate the model and associated parameters for a given set of semi-variogram values with the **Estimate Model** button.

Press the **Estimate Model** button  on the Parameters Window when **Correlation Modeling** is selected on the Steps Window. SADA presents the following window.



Select the number of structures and the types of models to use and press **OK**. SADA will autofit a correlation model and display the results in the Graphics Window.



## Defining a Neighborhood

Inverse distance, ordinary kriging, and indicator kriging interpolation methods all require a neighborhood definition for estimating concentration values at a point. A neighborhood is defined as an area around the

point in which data values will be used to estimate the concentration value. Data values outside the neighborhood will be excluded.

The neighborhood is always defined by a *search ellipse* that can be manipulated in shape, size, and orientation to include or exclude various data. The parameters that control the shape and size of the search ellipse are found when selecting the **Search Neighborhood** step from the Steps Window.

The parameters Major Radius, Minor Radius, and XY Angle control the size and shape of the search ellipse.

### **XY Angle**

The angle or direction of the *major ellipse axis*. This angle is measured clockwise from the positive Y axis (0 deg is North). The *minor elliptical axis* is perpendicular to the major axis.

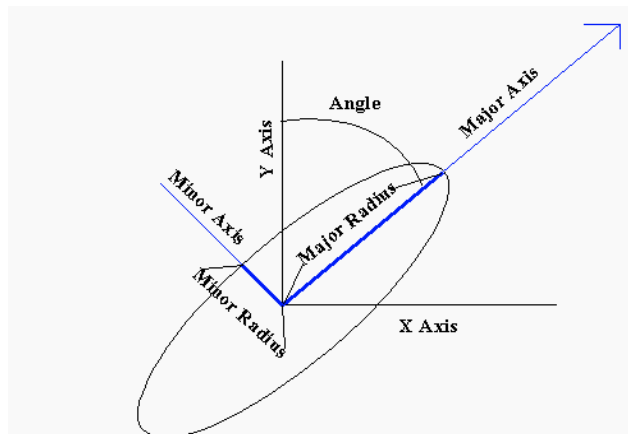
### **Major Radius**

The radius of the ellipse along the major axis.

### **Minor Radius**

The radius of the ellipse along the minor axis.

The following schematic demonstrates the roles of these parameters in the XY plane.



For three-dimensional data, the ellipse becomes an ellipsoid. The following parameters, in addition to those listed above, describe the search ellipsoid in 3D space.

### **Z Angle**

The angle or dip below the XY plane at the point of estimation. This angle is measured as negative degrees below the plane.

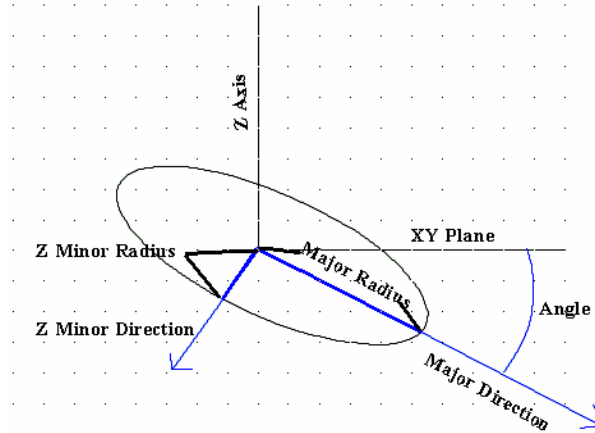
### **V Radius**

Often referred to as the Z minor radius, this is the radius of the ellipsoid in the minor direction.

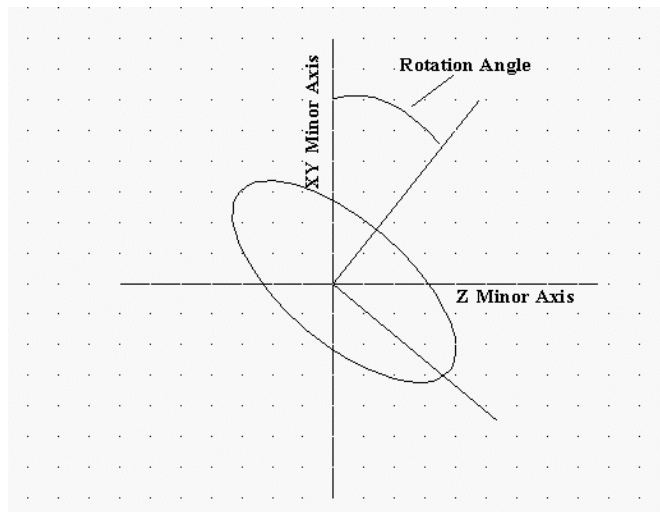
### **Rotation**

The parameters described to this point fully form the body of the ellipsoid in 3D space. The rotation parameter then rotates this ellipsoid about the major axis the specified number of degrees.

The following schematic shows how the ellipsoid is affected by the Z Angle and Vertical Radius parameters in a cross sectional view.



The following view shows the effect of the rotation parameter on the ellipsoid body. This view is along the major elliptical axis. The rotation angle rotates the two orthogonal directions clockwise relative to the major elliptical axis when looking toward the origin.



The following parameters define the search criteria within the search ellipse.

#### **Min Data**

The minimum number of data required before estimating the concentration. If this minimum is not met, SADA returns an un-estimated value. You will be notified of the number of un-estimated values. These values appear as empty spaces in the plot.

#### **Max Data**

The maximum number of data to use in estimating a point.

#### **Octant**

The ellipsoid is divided into quadrants, four if two dimensional, eight if three-dimensional. If the **Octant** value is greater than zero and there are fewer data points than the octant value in each quadrant of the ellipsoid, then the point will not be estimated.

#### **Power**

This parameter is associated with the Inverse Distance Method and has no bearing on the search scheme.



## Search Neighborhood - Step

This step is available when one of the following interviews is selected: Draw a variance map, Draw a probability map, Update My Prior Probability Map, Update my Prior Variance Map and sometimes Interpolate my data, Draw an area of concern map, Calculate cost versus cleanup, Draw a contoured risk map, Draw a contoured eco dose map, and Develop a sample design.

Select **Search Neighborhood** from the Steps Window. The following information is displayed in the Parameters Window.

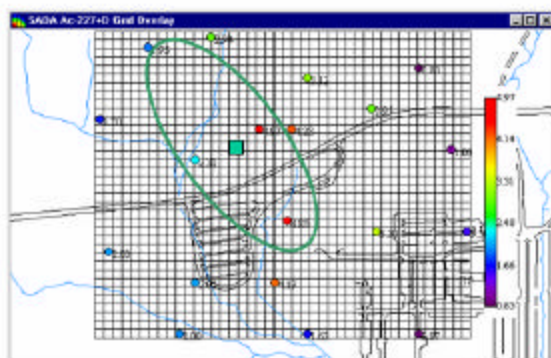


The screenshot shows a dialog box titled "Search Neighborhood" with a close button (X) in the top right corner. The dialog contains a section labeled "Geospatial Model Parameters" with the following fields:

Maj Radius:	1151.375	XY Angle:	0
Min Radius:	1151.375	Z Angle:	0
V Radius:	0	Rotation:	0
Min Data:	2	Order:	0
Max Data:	20	Power:	2

Enter appropriate values for the parameters in the spaces provided. For an explanation of each parameter, see the section on **Defining a Neighborhood**.

Neighborhoods allow the user to search for a single unsampled point.



## Cross Validation - Step

This step is available when one of the following interviews is selected: Interpolate my data, Draw an area of concern map, Draw a contoured risk map, and Draw a contoured eco dose map.

This step estimates the error in the value of existing data. Cross validation is performed on each existing data point by removing that data point from the available set of data points and estimating the value at the location of the removed point. The estimation uses the interpolation scheme, grid specs, and search neighborhood that were defined previously. The difference between the estimated value and the actual value at the removed data point is the error estimate. This error can be viewed as an actual error, absolute error, or a percentage error.

Select **Cross Validation** from the Steps Window. The following information is displayed in the Parameters Window.



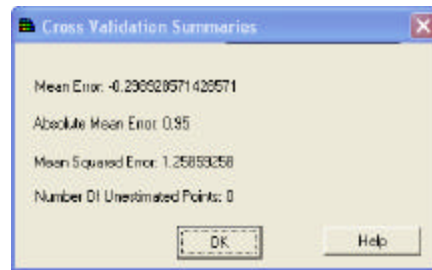
The screenshot shows a dialog box titled "Cross Validation" with a close button (X) in the top right corner. The dialog contains a section labeled "Cross Validation" with three radio button options:

- Plot error
- Plot absolute error
- Plot percentage error

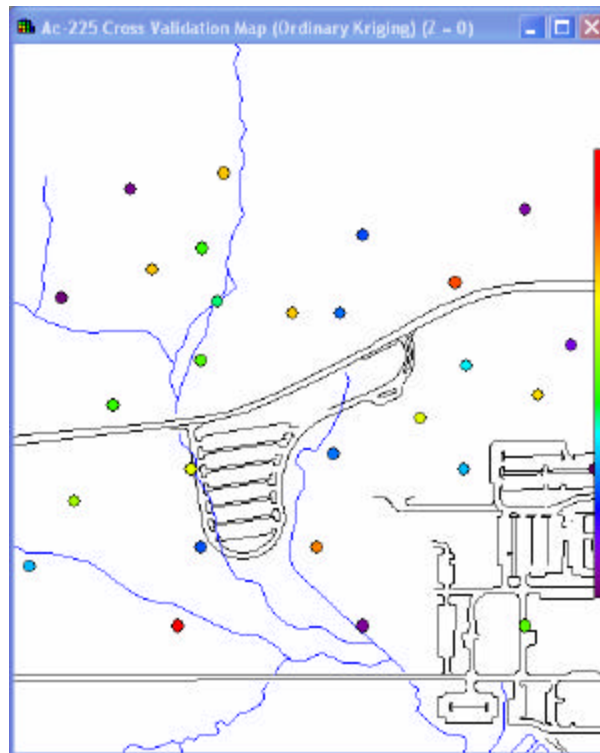
Below the options is a button labeled "Cross Validate".



Choose the type of error that should be displayed and press the **Cross Validate** button. SADA presents these site wide error statistics: Mean Error, Absolute Mean Error, and Mean Squared Error as well as the number of un-estimated data points.



Press **OK** to see the results in the Graphics Window.



Notice that cross validation changes the picture in the Graphics Window. The window now shows a data plot where the color of each data point corresponds to the error associated with that data point. If the legend is continuous, then the legend also changes to reflect the new range of values that is associated with the color scheme.

## Interpolate My Data - Interview

This interview presents the map of modeled concentration values for the selected contaminant based on the interpolation scheme selected in the Interpolation method step.

### Availability

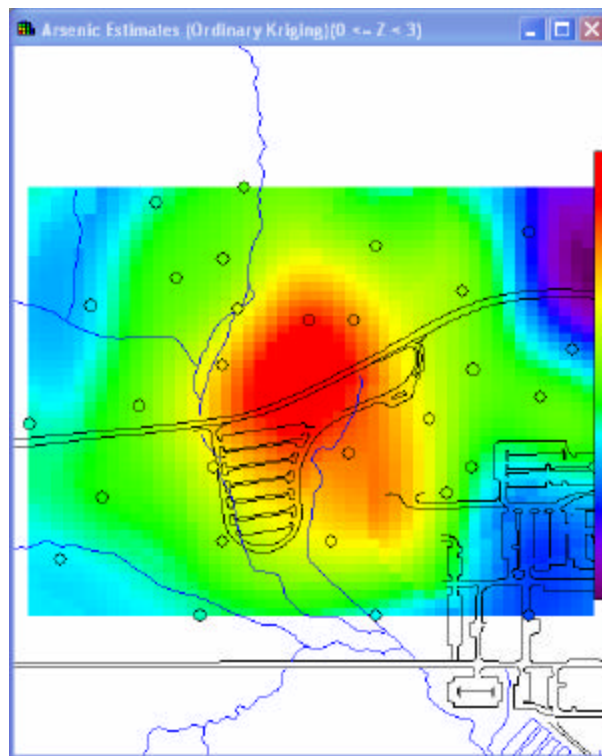
This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS Overlays
4. Set grid specs
5. Interpolation methods
6. Correlation Modeling\_(only available if OK or IK is selected under Interpolation method)
7. Search neighborhood\_(only available if OK, IK, or Inverse Distance is selected under Interpolation method)
8. Show the results
9. Cross validation
10. Format picture
11. Auto-document
12. Add to results gallery

After entering all the necessary parameters for each step, press **Show the Results**. The following image shows a sample estimates map for Arsenic.



### **Draw a Variance Map - Interview**

This interview produces the map of ordinary kriging variances for the selected contaminant. When this interview is selected, ordinary kriging (OK) is the only available interpolant in the Interpolation Methods step. If OK was not previously selected, SADA will warn the user and automatically change the interpolant to OK for the user.

## Availability

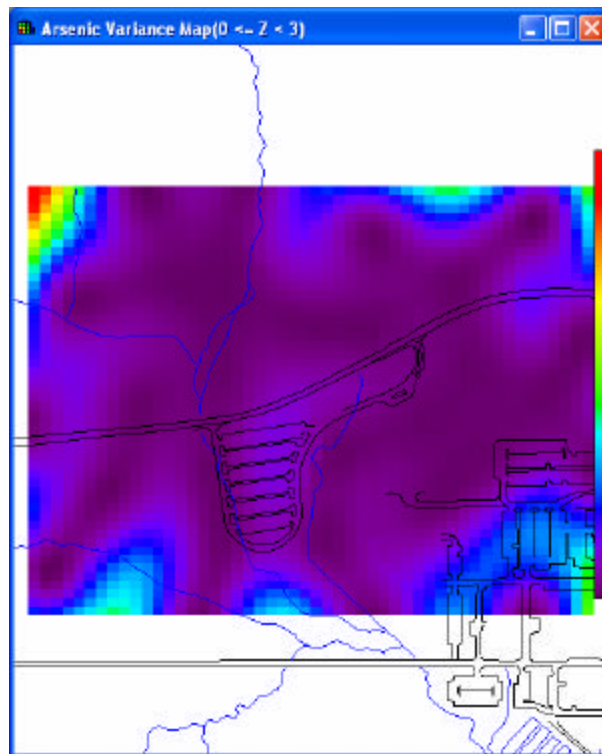
This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian. It is only available for the ordinary kriging interpolant.

## Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS Overlays
4. Set grid specs
5. Correlation Modeling
6. Search neighborhood
7. Show the results
8. Format picture
9. Auto-document

After entering all the necessary parameters for each step, press **Show the Results**. The following image shows a sample variance map for Arsenic.



## Draw a LISA Map - Interview

This interview produces the local index of spatial association (LISA) map for the selected contaminant. These maps show moving window statistics that are calculated at each grid node.

## Availability

This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS Overlays
4. Set grid specs
5. Set LISA parameters
6. Show the results
7. Format picture
8. Auto-document
9. Add to results gallery

After entering all the necessary parameters for each step, press **Show the Results**. The Graphics Window displays the map that was selected in the Set LISA Parameters step.

### Set LISA Parameters - Step

This step is available when the interview Draw a LISA Map is selected and sometimes for Develop a sample design.

Select **Set LISA parameters** from the Steps Window. The following information is displayed in the Parameters Window.



Select the **Local Index Approach** (Moran's I, Ripley's K, or Geary's C) and enter the **Search Radius**.

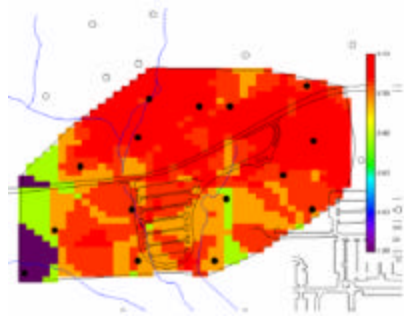
### Moran's I

This map is available after selecting the Draw a LISA Map Interview and the Set LISA Parameters step, and then selecting Moran's I from the Parameters Window.

This map computes the degree of correlation between the values of a variable as a function of spatial lags. This is similar to Pearson's correlation coefficient. It ranges from -1 (- correlation) to 1 (+ correlation), but the expected value is close to 0.

$$I(d) = \frac{\sum \sum w_{ij}(d)(x_i - \bar{x})(x_j - \bar{x})}{\frac{W(d)}{\sum (x_i - \bar{x})^2}}$$

where  $w_{ij}(d)$  indicates whether pairs are in the same distance class and  $w(d)$  is the sum of  $w_{ij}(d)$ .



## Ripley's K Map

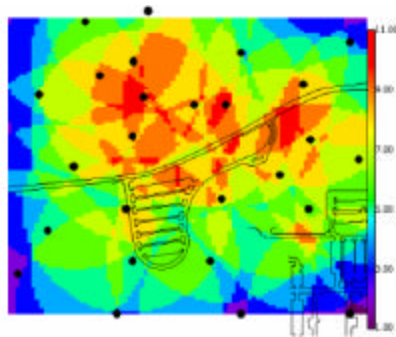
This map is available after selecting the Draw a LISA Map Interview and the Set LISA Parameters step, and then selecting Ripley's K from the Parameters Window.

This map quantifies the spatial pattern intensity of points for various sizes of a circular search window. IT computes the overall mean number of points located within a search window of radius  $t$ :

$$\hat{K}(t) = \frac{\lambda^{-1} \sum_{i=1}^n \sum_{j=1}^n I_i(e_i, e_j)}{n}$$

for  $i \neq j$  and  $t > 0$

where  $\gamma$  is point intensity ( $n/A$ ), which is an indicator of whether inside search window. There is an edge correction effect for grid areas on the fringe.

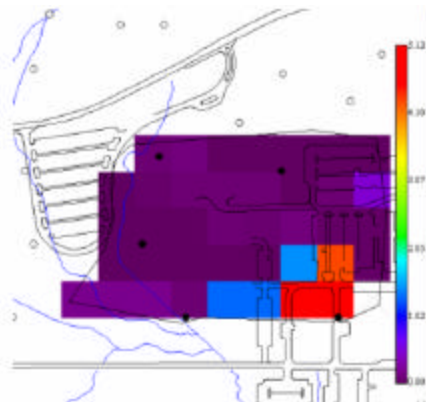


## Geary's C Map

This map is available after selecting the Draw a LISA Map Interview and the Set LISA Parameters step, and then selecting Geary's C from the Parameters Window.

This map measures the semivariance (average dissimilarity) among values of a variable at nearby locations

$$c(d) = \frac{\sum \sum w_{ij}(d) (x_i - x_j)^2}{2W(d)} \cdot \frac{1}{\sum (x_i - \bar{x})^2 / (n - 1)}$$



## Human Health Risk Assessment

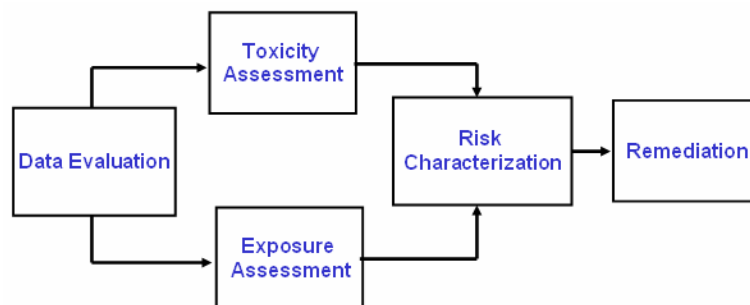
SADA provides a human health risk assessment module to calculate the risk of adverse health impacts on a population exposed to toxic chemicals found in groundwater, surface water, soil, and sediment. The human health risk models follow the EPA's Risk Assessment Guidance for Superfund (RAGS) and other related guidance. Exposure parameters can be customized to fit site specific exposure conditions and SADA will calculate risk-based screening values to quickly identify contaminants and areas of concern. These results are integrated into the other modules, such as cost benefit analysis, geospatial analysis, and sampling schemes.

While the risk modules are well integrated with the geospatial functions, they may also be used independently in a more traditional risk assessment. Human health risk output for SADA includes the calculation of site-specific preliminary remediation goals to identify contaminants of potential concern, exposure modeling for humans for five different land use scenarios, retrieval of toxicity information from IRIS/HEAST toxicity databases, and standard EPA exposure parameters for the risk models. Risk output includes tabular screening for identified areas, spatial point risk calculations, and maps of risk results which can be used to identify human health based areas of concern.

Before this module can be implemented, the user must provide the correct media identification for the data when creating a SADA file. Without media identification, SADA will not be able to setup this module. Furthermore, SADA expects the measurement units for radionuclides to be in pCi/g for Soil/Sediment and pCi/L for Surface water/Groundwater. Units for nonradionuclides must be in mg/kg for Soil/Sediment and mg/L for Surface water/Groundwater. In addition, the user must have a toxicological database and a scenario parameter database to associate with the data. SADA provides two such databases called ToxicologicalProfiles.mdb and ScenarioParameters.mdb; the user may customize these databases in Microsoft Access. During the risk module setup, SADA will extract relevant information from these databases to incorporate in the SADA file. SADA will not use the databases again unless prompted; however, the information extracted from the databases may be edited within SADA. **Note:** *this does not affect the external risk databases.*

### Overview of Human Health Risk Assessment

There are four main steps of a human health risk assessment: Data Evaluation, Toxicity Assessment, Exposure Assessment, and Risk Characterization. Provided here is only a brief overview of each step of the risk assessment process. This help file assumes that the user is familiar with the risk assessment process.



### Data Evaluation

This step consists of compiling all available data, sorting the data by media, and evaluating the data relative to established criteria in order to ensure that the data are appropriate for use and are considered to be representative of current conditions.

While SADA offers reliable and effective data storage, visual analysis, and synthesis that can enhance risk assessments, ultimately, the quality of the risk assessment is dependent upon the quality and quantity of the data.

## **Toxicity Assessment**

This step involves gathering toxicological information, such as identifying appropriate toxicity values, evaluating chemicals without toxicity values, and evaluating uncertainties of toxicity information.

### **Toxicity Value Classifications**

- Radionuclide - chemical that undergoes nuclear decay and emits radiation (e.g., Uranium-238)
- Nonradionuclide - chemical that does not undergo nuclear decay or emit radiation (e.g., Iron)
- Organic - chemical or compound that contains a carbon skeleton (e.g., Acetone)
- Inorganic - chemical or compound that does not contain a carbon skeleton (e.g., Mercury)
- Carcinogen - agent that may produce or incite cancer (e.g., Polychlorinated Biphenyls (PCBs), Vinyl Chloride)
- Noncarcinogen - agent that typically does not produce or incite cancer (e.g., Antimony, Beryllium)

### **Exposure Durations**

- Chronic - exposure lasting more than 7 years (“lifetime” exposures, typically low levels)
- Subchronic - exposures lasting from 2 weeks to 7 years (“limited occupational” or “event” exposures, e.g. remediation worker)

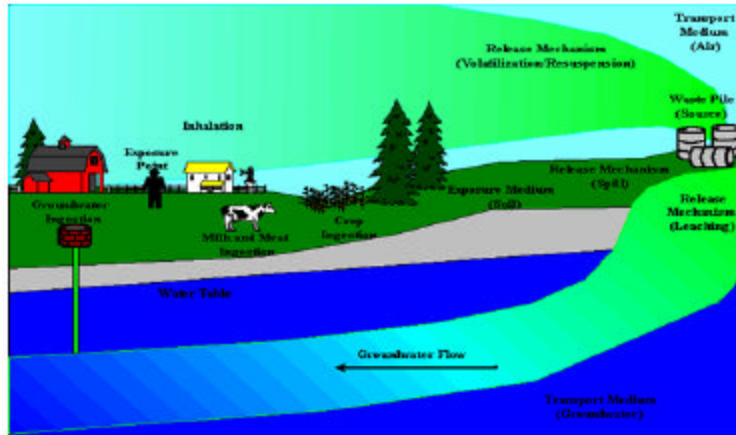
The toxicity values associated with SADA come from the [Risk Assessment Information System](#).

## **Exposure Assessment**

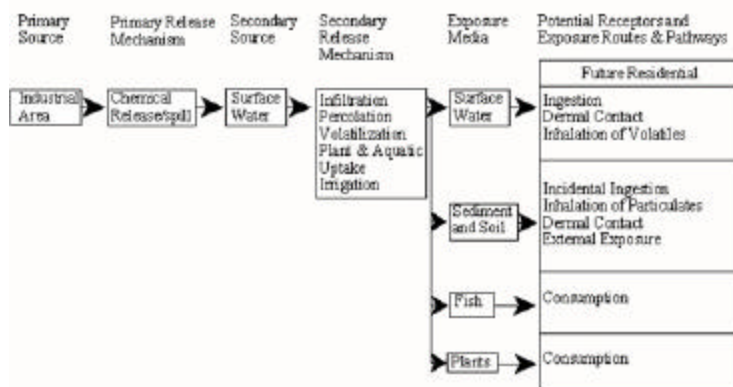
This step involves estimating the type and magnitude of exposures from the chemicals of potential concern that are present at or migrating from a site/facility. It includes the characterization of the exposure setting and identification of exposure pathways.

The characterization of the exposure setting may be accomplished with a Conceptual Site Model.





Site Conceptual Model For site A



## Risk Characterization

Risk Characterization incorporates the outcomes of the previous activities (Data Evaluation, Exposure Assessment, and Toxicity Assessment) and calculates the risk or hazard resulting from potential exposure to chemicals via the pathways and routes of exposure determined appropriate for a site.

- Calculate risks by media and land-use
  - Quantify risk for each chemical
  - Quantify risks from multiple chemicals
  - Combine risks across exposure pathways
  - Assess uncertainty
- Identify chemicals, media, and land-uses of concern
- Support development of cleanup goals

## Basic Risk and Hazard Equations

$$\text{Risk} = \text{CDI} \times \text{SF} \quad \text{HQ} = \text{CDI} / \text{RfD}$$

where:

Risk = unitless probability of individual developing cancer over lifetime

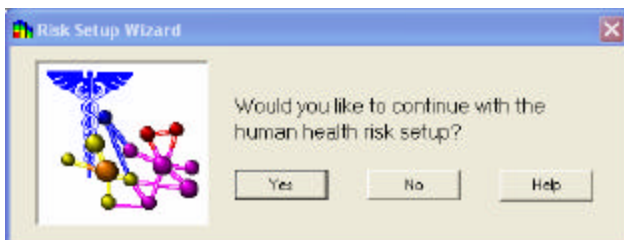
HQ = hazard quotient

CDI = chronic daily intake or dose [mg/kg-day; and risk/pCi]

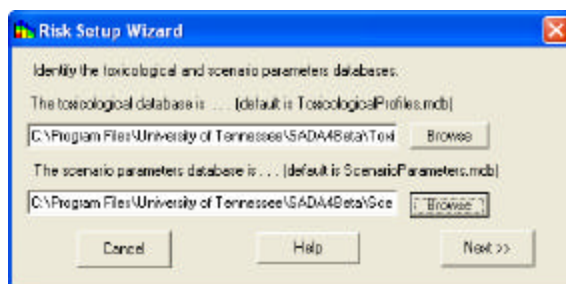
SF = slope factor, expressed in [(mg/kg-day)<sup>-1</sup>; pCi/risk]  
RfD = chronic reference dose

## Setting Up Risk

To initiate the **Risk Setup Wizard**, select **Human Health Risk** from the **Setup** menu of the main window.



Select **Yes**. (Select **No** to cancel the setup process.) In the next window, SADA needs the names of the supporting toxicological profiles and scenario parameters databases. Type the name of the corresponding databases or press **Browse** to select.



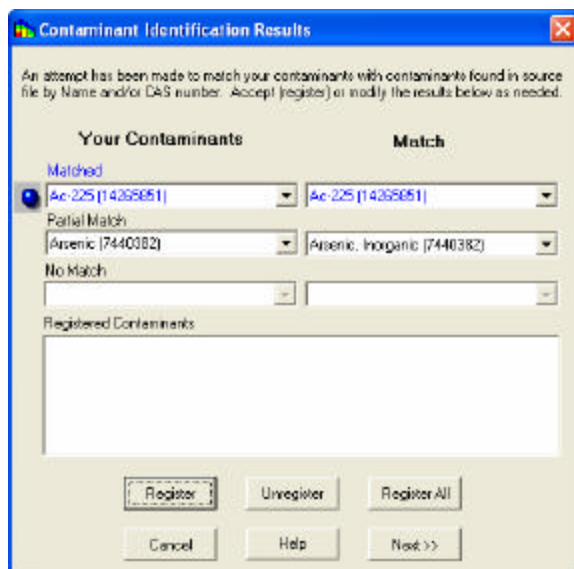
The toxicological database contains health related information about individual contaminants. The scenario database contains parameters regarding the human receptor exposure patterns.

SADA contains two default databases. The ToxicologicalProfiles.mdb comes from Oak Ridge National Laboratory's Risk Assessment Information System (RAIS - <http://rais.ornl.gov/>). This toxicological database is maintained regularly, and recent versions of the database can be downloaded from the SADA home page in a SADA compatible format. The toxicity values were compiled from EPA's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Tables (HEAST), derived from values found in these EPA sources, or provided after contacting EPA. After a risk module has been setup, errors or small updates to toxicity values can be handled through the Toxicological Links menu. In addition to toxicity information, this file contains physical parameters used in human health exposure modeling. These parameters include contaminant-specific Bioaccumulation Factors, Volatilization Factors, Particulate Emission Factors, Permeability Constants, Absorption Factors, Saturation Coefficients, and Radionuclide HalfLives.

The scenario parameters database, ScenarioParameters.mdb, contains default parameters from EPA guidance and local guidance for the Southeastern US; the parameters can be customized as necessary to account for local exposure conditions.

Once the databases have been selected, press **Next >>** to continue.

SADA now attempts to match each contaminant in your file with a contaminant found in the toxicological database. SADA searches by CAS number first (if available) and then by name. If the CAS number and name match exactly, SADA classifies it as **Matched**. If only the Name or the CAS number match, then the classification is **Partial Match**. Finally, if no match is found for either, the classification is **No Match**. These three classifications are presented in the **Contaminant Identification Results Window**.



On the left side of the window, your contaminants have been divided into the three categories. To view a resulting match for any contaminant, click on the down arrow and select your contaminant from the resulting drop down list. The corresponding selection on the right hand side will change to show SADA's match for your contaminant. If the match is acceptable, press the **Register** button. If all matches within a category are acceptable, press **Register All**. To unregister a matched pair(s), select the pair(s) in the registered contaminants box and press **Unregister**. Your contaminants will return to their original classification with their original match.

If no match is available for some of your contaminants, you may leave them as unregistered. Later, if the toxicological information becomes available, you may link these contaminants (or re-link registered contaminants) separately without setting up the entire risk module again.

Press **Next>>** to conclude setting up the risk module.

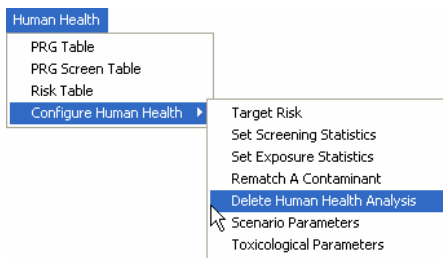
Once the module is complete, **Human Health** analysis will appear in the analysis type combo box on the secondary toolbar. Additionally, a **Human Health** menu will be visible in SADA when this analysis is selected from the combo box.

You may reset the Risk module at any time; simply select **Human Health Risk** under the **Setup** menu of the main window. The process is the same as before; however, SADA will give you the opportunity to reset or skip the toxicological and scenario parameter component identification.

## Delete Human Health Analysis

For various reasons, a user may decide to delete the human health analysis.

To delete the human health analysis, select **Human Health** in the combo box of the secondary toolbar. From the **Human Health** menu, select **Configure Human Health** and then **Delete Human Health Analysis**



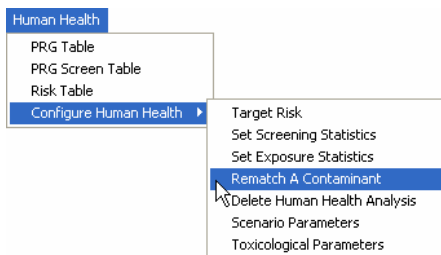
## WARNING

The user must be careful when using the delete analysis feature. Once an analysis has been removed, it cannot be re-established in SADA without Setting Up Risk again.

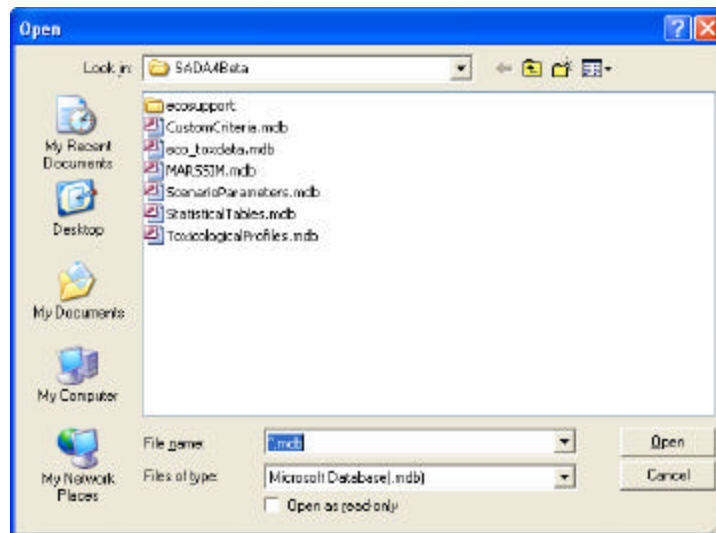
## Toxicological Links

After the risk module has been setup, you may revisit the originating toxicological database (e.g. ToxicologicalProfiles.mdb) or a second database in search of individual contaminant links. This utility is useful for correcting associations with the previously identified database or associating particular contaminants with another database. If the number of contaminants to relink is high, it may be more efficient to rerun the Setup Risk Assessment again.

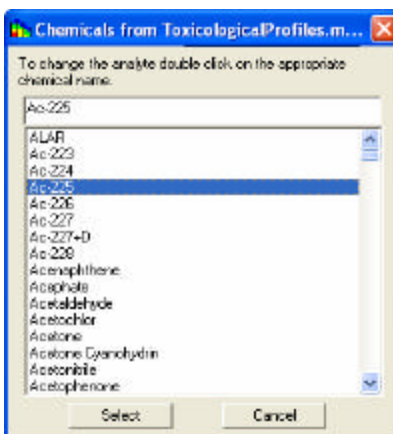
To link or relink a single contaminant, select the contaminant of interest from the **Data Name** box in the secondary toolbar. From the **Human Health** menu, select **Configure Human Health** and then **Rematch This Contaminant**.



SADA prompts for a toxicological database name.



After selecting a valid toxicological database and pressing **Open**, the following window appears.



The user's contaminant name appears in the top box. Contaminants available from the database appear in the list box. To associate the contaminant in the top box, select a contaminant in the list box and press the **Select** button. Information from the associated selection is then transferred to the internal database and all relevant options in SADA are updated for this particular contaminant. This update occurs for the selected contaminant across all media types (soil, surface water, etc.) automatically.

## Risk Parameters

SADA provides three databases with default information for human health risk: toxicological parameters, scenario parameters, and physical parameters. The toxicological and scenario databases are used during the human health risk module setup, where information is pulled into the SADA file. After the risk module is setup, these risk parameters can be customized within SADA. **Note:** *these changes do no affect the original source databases.*

## Toxicological Parameters

To view toxicological parameters, select **Configure Human Health** and then **Toxicological Parameters** from the **Human Health** menu in the main window. The **Set Human Health Contaminant Toxicity** window appears.

**Set Human Health Contaminant Toxicity**

Arsenic, Inorganic

General  
Inorganics  
CAS # = 7440382  
Volatile = ND  
Both

Noncarcinogenic Toxicity

	Water	Soil	Diet	
Oral Reference Dose	0.0003	0.0003	0.0003	(mg/kg-day)
Subchronic Oral Reference Dose	0.005	0.005	0.005	(mg/kg-day)
Inhalation Reference Concentration				mg/m <sup>3</sup>
Subchronic Inhalation Reference Concentration				mg/m <sup>3</sup>
Dermal Reference Dose	0.000123	0.000123		(mg/kg-day)
Subchronic Dermal Reference Dose	0.00205	0.00205		(mg/kg-day)

Carcinogenic Toxicity

	Water	Soil	Diet	
Oral Slope Factor	1.5	1.5	1.5	1/(mg/kg-day) or risk/pCi
Inhalation Unit Risk/Slope Factor	15.1	4.3		1/(mg/m <sup>3</sup> ) or risk/pCi
Dermal Slope Factor	3.66	3.66		1/(mg/kg-day)
External Slope Factor				risk/yr per pCi/g

Save Changes      Help      Exit

Select the contaminant of interest from the drop down menu at the top of the window to view the corresponding toxicity parameters. You may edit the entries by clicking in the corresponding cell boxes and pressing the **Save Changes** button. Equations using these parameters can be found in the Risk Equations chapter.

The Chemical Parameters Toolbar performs the following functions.



**Print** – Prints toxicological parameters.



**Copy to Floppy** – Copies toxicological parameters to comma delimited text file.



**Copy** – Copies current image to a clipboard. It can then be pasted into most Windows packages.



**Export to Excel** – Automatically dumps spreadsheet to an Excel file.

## Scenario Parameters

To view the scenario parameters, select **Configure Human Health** and then **Scenario Parameters** from the **Human Health** menu in the main window. The **Set Human Health Exposure Parameters** window appears for the selected media. The following images show the parameters for soil and surface water.

**Set Human Health Exposure Parameters**

Exposure Parameters - Soil

	Residential	Industrial	Recreational	Excavation	Agricultural	
Exposure frequency	350	250	40	20	350	days/yr
Adult exposure duration	24	25	24	1	24	years
Child exposure duration	6	0	6	0	6	years
Adult soil ingestion rate	100	100	100	480	100	mg/day
Child soil ingestion rate	200	0	200	0	200	mg/day
Fraction ingested	1	1	1	1	1	unitless
Inhalation rate	20	20	20	20	20	m <sup>3</sup> /day
Adult surface area	0.53	0.316	0.53	0.53	0.53	m <sup>2</sup> /day
Adherence factor	1	1	1	1	1	mg/cm <sup>2</sup>
Gamma exposure factor	1	0.3333	0.041667	0.3333	1	unitless
Gamma shielding factor	0.2	0.2	0.2	0.2	0.2	unitless

General

Body weight: Adult  kg, Child  kg

Lifetime:  years

Mass loading factors

Plant MLF: Residential  unitless, Agricultural  unitless

Pasture MLF: Residential  unitless, Agricultural  unitless

Milk food chain pathway (Dairy cattle)

	Residential	Agricultural	
Fraction on-site	<input type="text" value="1"/>	<input type="text" value="1"/>	unitless
Fraction feed from site	<input type="text" value="1"/>	<input type="text" value="1"/>	unitless
Quantity pasture ingested	<input type="text" value="16.1"/>	<input type="text" value="16.1"/>	kg/day
Quantity soil ingested	<input type="text" value="1"/>	<input type="text" value="1"/>	kg/day

Beef food chain pathway (Beef cattle)

	Residential	Agricultural	
Fraction on-site	<input type="text" value="1"/>	<input type="text" value="1"/>	unitless
Fraction feed from site	<input type="text" value="1"/>	<input type="text" value="1"/>	unitless
Quantity pasture ingested	<input type="text" value="7.2"/>	<input type="text" value="7.2"/>	kg/day
Quantity soil ingested	<input type="text" value="1"/>	<input type="text" value="1"/>	kg/day

Buttons: Save Changes, Help, Exit



**Set Human Health Exposure Parameters**

Exposure Parameters - Surface Water

	Residential	Industrial	Recreational	Excavation	Agricultural	
Exposure frequency	350	250	7	0	350	days/yr
Exposure duration	30	25	30	25	30	years
Adult surface area	1.94	0	1.94	1.94	1.94	m <sup>2</sup> /day
Inhalation rate	20	0	20	0	20	mg/day
Water ingestion rate	2	1	0.05	0	2	L/day
Fraction ingested	1	1	1	1	1	unitless
Exposure time (showering)	0.2	0	2.6	0	0.2	hours/day
Fish exposure frequency	350	0	350	0	350	days/yr
Fish ingestion rate	0.054	0	0.054	0	0.054	kg/day

Farming Parameters

	Residential	Agricultural	
Above ground exposure time	60	60	days
Area density for root zone	240	240	kg/m <sup>2</sup>
Interception fraction	0.42	0.42	unitless
Irrigation period	0.25	0.25	unitless
Irrigation rate	2.08	2.08	L/m <sup>2</sup> -day
Long-term deposition and buildup	10950	10950	day
Vegetable Mass Loading Factor	0.26	0.26	unitless
Plant yield wet	2	2	kg/m <sup>2</sup>
Quantity water ingested- Beef cattle	50	50	L/day
Quantity water ingested- Dairy cattle	75	75	L/day
Soil leaching rate	0.000027	0.000027	1/day
Translocation factor	1	1	unitless
Weathering half-life	14	14	days

General

Body weight	Adult	70	kg
Lifetime		70	years

Save Changes      Help      Exit

The display operates as a spreadsheet. To change a parameter, click into its cell and type a new value, then press the **Save Changes** button.

The Scenario Parameters toolbar functions are as follows.



**Print** – Prints toxicological parameters.



**Copy to Floppy** – Copies toxicological parameters to comma delimited text file.



**Copy** – Copies current image to a clipboard. It can then be pasted into most Windows packages.





**Export to Excel** – Automatically dumps spreadsheet to an Excel file.

## Physical Parameters

To view physical parameters, select **Configure Human Health** and then **Physical Parameters** from the **Human Health** menu in the main window. The **Set Human Health Contaminant Physical Parameters** window appears.

Physical Contaminant Parameters		
Soil-to-air Volatilization Factor (VF)	696000	m <sup>3</sup> /kg
Soil-to-air Particulate Emission Factor (PEF)	132000000	m <sup>3</sup> /kg
Dermal Absorption Factor (ABS)	0.01	unitless
Permeability Constant (KP)	0.225	cm/hr
Saturation Coefficient (CSAT)		mg/kg
Half-life		days
Inhalation Exposure Factor (Rad)		(L-hr)/(m <sup>3</sup> -day)

Food Chain Contaminant Parameters		
Soil-to-plant wet uptake (BV Wet)	0.0216	(mg/kg)/(mg/kg)
Soil-to-plant dry uptake (BV Dry)	0.107	(mg/kg)/(mg/kg)
Milk transfer coefficient (Milk BTF)	0.0002	day/kg
Beef transfer coefficient (Beef BTF)	0.00063	day/kg
Fish bioaccumulation factor (Fish BTF)	533	L/kg

Select the contaminant of interest from the drop down menu at the top of the window to view the corresponding physical parameters. You may edit the entries by clicking in the corresponding cell boxes and pressing the **Save Changes** button.

The Physical Parameters toolbar functions are as follows.



**Print** – Prints toxicological parameters.



**Copy to Floppy** – Copies toxicological parameters to comma delimited text file.



**Copy** – Copies current image to a clipboard. It can then be pasted into most Windows packages.

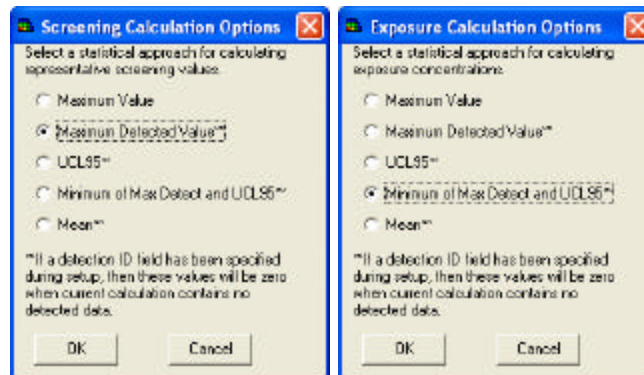


**Export to Excel** – Automatically dumps spreadsheet to an Excel file.

## Set Statistics

SADA allows the user to select the statistical approach for calculating screening values and exposure concentrations.

From the Analysis menu (**Human Health**, **Ecological**, or **Custom**), select **Configure (AnalysisType)** and then **Set Screening Statistics** or **Set Exposure Statistics**. SADA opens one of the following windows.



Select the desired statistical approach and press the **OK** button. The different approaches are defined as follows:

- Maximum Value – the maximum concentration, detected or nondetected, for normal or lognormal distribution
- Maximum Detected Value – the maximum detected concentration for normal or lognormal distribution
- UCL95 – the 95% upper confidence limit on the mean for normal or lognormal distribution
- Mean – the average concentration over all values for normal or lognormal distribution

*Note: For screening calculations, the maximum detected value is the default option while for exposure calculations, the lesser of the maximum detected value and the UCL95 is the default option.*

## Preliminary Remediation Goals (PRGs)

Chemical-specific preliminary remediation goals (PRGs) are concentration goals for individual chemicals in specific medium and land use combinations that are used by risk managers as targets during the analysis and selection of remedial alternatives. They:

- are developed during the project scoping phase to facilitate development of appropriate detection limits and remedial alternatives or to identify data needs or limitations
- can be used as screening tools to focus concern on a specific medium or COPC, support no further action recommendations, or support the need for additional study
- can be used as toxicity screens
- Can be used as a risk-based concentration goal and considered a final remediation level
- identify data needs and limitations (e.g., detection limits are greater than risk-based PRGs)
- focus future sampling and analysis on chemicals and exposure pathways of potential concern
- establish appropriate detection limits for subsequent environmental sample analysis
- support a No Further Investigation Determination
- quantitatively support the need for additional study

To view the preliminary remediation goals (PRGs) in SADA, select the contaminant of interest in the **Data Name Box** of the secondary toolbar. Then, select **PRG Table** from the **Human Health** Menu on the main window. SADA calculates the risk-based goals for this contaminant(s) in the following window. To calculate PRGs for all contaminants, select **Pooled Data** in the **Data Name Box**. The PRGs will always be calculated for the media you have currently selected in the **Data Type Box** of the secondary toolbar.

Name	CAS	Ingestion			Inhalation		Dermal		Vegetables	
		HQ (Adult)	HQ (Child)	R	HQ	R	HQ	R	HQ	R
Benzene	7440359	5.1E+4	5.5E+3		6.9E+5		6.7E+4		2.4E+2	
Arsenic, Inol	7440382	2.2E+2	2.3E+1	4.3E-1		7.9E+2	1.7E+3	8.8E+0	1.1E+0	
Anthracene	120127	2.2E+5	2.3E+4				3.1E+5		9.7E+2	

In the example above, **Pooled Data** was selected to demonstrate all of the toolbar buttons available. These toolbar buttons permit combination views of rads/nonrads/both and carcinogenic/noncarcinogenic/both for the five scenarios of residential, industrial, agricultural, recreational, and excavation.

The **Pathway** checkboxes allow you to control which pathways are shown. The **All** pathway reflects exposure to all the currently checked pathways.

Following are the units for each media.

- Soil and Sediment: mg/kg for nonradionuclides, pCi/g for radionuclides
- Surface/Groundwater: mg/L for nonradionuclides, pCi/L for radionuclides

The user should remember that chemical-specific PRGs are initial guidelines (protective of human health and the environment) that are based on readily available information and comply with applicable or relevant and appropriate requirements (ARARs). They are not cleanup goals. All chemical-specific PRGs are generally modified utilizing the site-specific data gathered during the RI/FS; however, design staff may be able to streamline the analysis of remedial alternatives by using chemical-specific PRGs early in the decision-making process (before the RI/FS and the baseline risk assessment are completed). A risk-based concentration is considered a final remediation level only after appropriate analysis in the RI/FS and Record of Decision (ROD).

The Preliminary Remediation Goals toolbar functions are as follows.



**Print** – Prints risk results (PRGs, Screenings, Risk).



**Copy to File** – Copies risk results (PRGs, Screenings, Risk) to file.



**Add to Report** – Copies results to a report.



**Anatype** – Displays, respectively, the results for radionuclides, nonradionuclides, or both.



**Carcinogenic Options** – Displays, respectively, the results for Carcinogens, Noncarcinogens, or both.



**Risk Scenarios** – Displays, respectively, risk results for residential, industrial, agricultural, recreational, or excavation scenarios.

## Setting Target Risk/Hazard Index

To change the target risk (for carcinogens) or target health index (for noncarcinogens), select **Configure Human Health** and then **Target Risk** from the **Human Health Menu**.



The default values are 0.000001 for target risk and 1 for target health index. To change the screening statistical approach, see the section **Set Statistics**.

## Screening Data Against Risk

For a given set of points, SADA takes the maximum detected value and compares it to the decision criteria when screening data against risk. For human health risk, the data is compared to a Preliminary Remediation Goals (PRGs), which is a function of a given target risk level and land use scenario.

To view the screening results, select the contaminant (select **Pooled Data** to screen all) and media of interest in the secondary toolbar. From the **Human Health** menu, select **PRG Screen Table**. This information is displayed in the **Screening Graphics Window**.

Screening Results: Target risk = 0.000001/Target Health Index = 1.

Pathways:

Ingestion    Dermal    Fish    Beef    All  
 Inhalation    External    Vegetables    Dairy

**Nonrads/Soil/Residential/Carcinogenic and Noncarcinogenic**

Name	CAS	Conc	Ingestion			Inhalation		Dermal		Vege
			HQ (Adult)	HQ (Child)	R	HQ	R	HQ	R	
Banun	7440388	104.8								
Arsenic, Inoi	7440382	53.6		Yes	Yes				Yes	Yes
Anthracene	120127	5.5								

In the example above, **Pooled Data** was selected to demonstrate all of the toolbar buttons available. These toolbar buttons permit combination views of rads/nonrads/both and carcinogenic/noncarcinogenic/both for the five scenarios of residential, industrial, agricultural, recreational, and excavation.

The **Pathway** checkboxes allow you to control which pathways are shown. The **All** pathway reflects exposure to **all** the currently checked pathways.

If a PRG is exceeded for a particular scenario, the cell value is "Yes". The cell is blank if the risk calculation was not available (due to lacking toxicological information) or was less than the PRG. This is useful for quickly identifying contaminants of concern in a risk assessment.

Following are the units for each media. SADA assumes that your sampled values are in the correct units.

- Soil and Sediment: mg/kg for nonradionuclides, pCi/g for radionuclides
- Surface/Groundwater: mg/L for nonradionuclides, pCi/L for radionuclides

The user should remember that chemical-specific PRGs are initial guidelines (protective of human health and the environment) that are based on readily available. They are not cleanup goals. All chemical-specific PRGs are generally modified utilizing the site-specific data gathered during the RI/FS; however, design staff may be able to streamline the analysis of remedial alternatives by using chemical-specific PRGs early in the decision-making process (before the RI/FS and the baseline risk assessment are completed). A risk-based concentration is considered a final remediation level only after appropriate analysis in the RI/FS and Record of Decision (ROD).

The Screening Results toolbar functions are as follows.



**Print** – Prints risk results (PRGs, Screenings, Risk).



**Copy to File** – Copies risk results (PRGs, Screenings, Risk) to file.



**Add to Report** – Copies results to a report.



**Copy** – Copies current image to a clipboard. It can then be pasted into most Windows packages.



**Export to Excel** – Automatically dumps spreadsheet to an Excel file.



**Anatype** – Displays respectively, the results for radionuclides, nonradionuclides, or both.



**Carcinogenic Options** – Displays respectively, the results for carcinogens, noncarcinogens, or both.



**Risk Scenarios** – Displays, respectively, risk results for residential, industrial, agricultural, recreational, or excavation scenarios.

## Calculating Risk

To calculate the risk or health hazard Index, select the contaminant (select **Pooled Data** to calculate all) and media of interest in the secondary toolbar. To change the exposure statistical approach, see the section **Set Statistics**. From the **Human Health** menu, select **Risk Table**. The following window is displayed.

Nonrads/Soil/Residential/Carcinogenic and Noncarcinogenic											
Name	CAS	Conc	Ingestion			Inhalation		Dermal		Vege	
			HQ (Adult)	HQ (Child)	R	HQ	R	HQ	R	HQ	
Barium	7440393	3352463942	1.0E-3	1.7E-2		1.3E-4		1.4E-3			
Arsenic, Inal	7440382	315389452	1.9E-1	1.0E+0	9.7E-5		5.9E-8	2.4E-2	4.7E-6		
Anthracene	120127	3528065391	1.7E-5	1.6E-4				1.2E-5			
Total			1.9E-1	1.8E+0	9.7E-5	1.3E-4	5.9E-8	2.6E-2	4.7E-6		

In the example above, **Pooled Data** was selected to demonstrate all of the toolbar buttons available. These toolbar buttons permit combination views of rads/nonrads/both and carcinogenic/noncarcinogenic/both for the five scenarios of residential, industrial, agricultural, recreational, and excavation.

The **Pathway** checkboxes allow you to control which pathways are shown. The **All** pathway reflects exposure to **all** the currently checked pathways.

For each scenario and analyte type, the risk or index associated with each pathway is calculated for the current media.

The Human Health Risk Results toolbar functions are as follows.



**Print** – Prints risk results (PRGs, Screenings, Risk).



**Copy to File** – Copies risk results (PRGs, Screenings, Risk) to file.



**Copy** – Copies current image to a clipboard. It can then be pasted into most Windows packages.



**Add to Report** – Adds risk results to a report.



**Export to Excel** – Automatically dumps spreadsheet to an Excel file.



**Anatype** – Displays, respectively, the results for radionuclides, nonradionuclides or both.



**Carcinogenic Options** – Displays respectively, the result for carcinogens, noncarcinogens, or both.



**Risk Scenarios** – Displays, respectively, risk results for residential, industrial, agricultural, recreational, or excavation scenarios.

## Spatial Risk Issues

SADA will convert any geospatial estimation map into a geospatial risk map. This conversion is performed by using each modeled block concentration value as the exposure concentration in the risk models.

From a risk standpoint, individual block risk may not provide useful information, especially for small block sizes. The scenario parameters often assume the receptor will be exposed to the contaminant over a number of years. This translates into an assumption that the individual will be exposed to a single block for a number of years and/or a large portion of the day. For small block sizes (e.g., 1ft x 1ft), this is not reasonable. However, for block sizes that are equivalent to the exposure area, block sizes can give an accurate perspective on the potential areas of concern at the site.

The spatial risk map does, however, provide useful information from a decision standpoint. With the risk map visible, areas of concern are more easily identified. These areas can then be captured within a reasonable exposure unit size by polygons. By pressing the **Statistics** button on the main toolbar, the average risk over these blocks in the polygon can be calculated by selecting "Mean". *Note: this corresponds to averaging the block concentration values for the polygonal area and applying the result to the risk models.*

Spatial risk maps play important roles in other decision frameworks, as well - area of concern maps, probability maps, area of concern boundary sample design, and minimizing/maximizing area of concern sample design.

SADA provides three spatial risk maps for human health: data screen map, point risk map, and contoured risk map.

## Scenario Parameters Window

When the human health risk module has been setup, the scenario parameters associated with risk assessment can be viewed and edited through the **Scenario Parameters** window. If Human Health is selected in the analysis combo box of the secondary toolbar, a **Human Health** menu will appear in SADA. From this menu, select **Configure Human Health** and then **Scenario Parameters**. The **Scenario Parameters** window will appear.





Select the appropriate pathway from the dropdown box. The scenario parameters for each media type in the current SADA file are displayed. These parameters are used during the risk calculations.

To edit a value, click on the corresponding cell value and type in the new value.

The Scenario Parameters window contains the following buttons.



Print – Prints scenario parameters.



Copy To File – Copies Scenario parameters to a comma delimited ASCII file.



Auto-Add – Copies scenario parameters to a report.



Copy to Clipboard – Copies the current image to the clipboard. It can then be pasted into most Windows packages.



Export to Excel – Automatically dumps the spreadsheet to an Excel file.

## Draw a Data Screen Map (human health) - Interview

With data screen maps, the user can screen the data against human health PRGs.

From the Interviews list, select **Draw a data screen map**. Follow the steps that are listed.

### Availability

This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

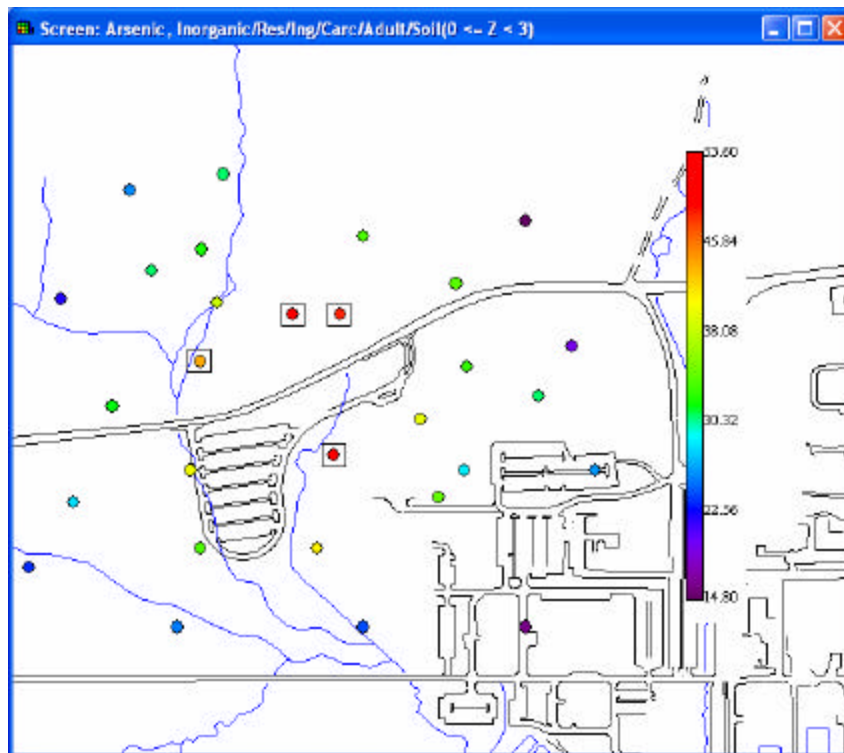
1. See the data



2. Set up the site
3. Set GIS Overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

For human health analyses, make sure that the analysis type is set to Human Health and the desired contaminant and media are selected in the secondary toolbar. When **Show the results** is selected, SADA will present the Risk Scenario selection window.

After selecting the applicable land use and pathway(s), select **OK**. SADA will present a box around each point that exceeds the PRG.



### Draw a Point Risk Map (human health) - Interview

To display concentration to risk at each point, make sure that your analysis type is set to Human Health and the desired contaminant and media are selected in the secondary toolbar.

From the Interviews list, select **Draw a point risk map**. Follow the steps that are listed.

#### Availability

This interview is available for human health analyses with pooled or unpooled data.

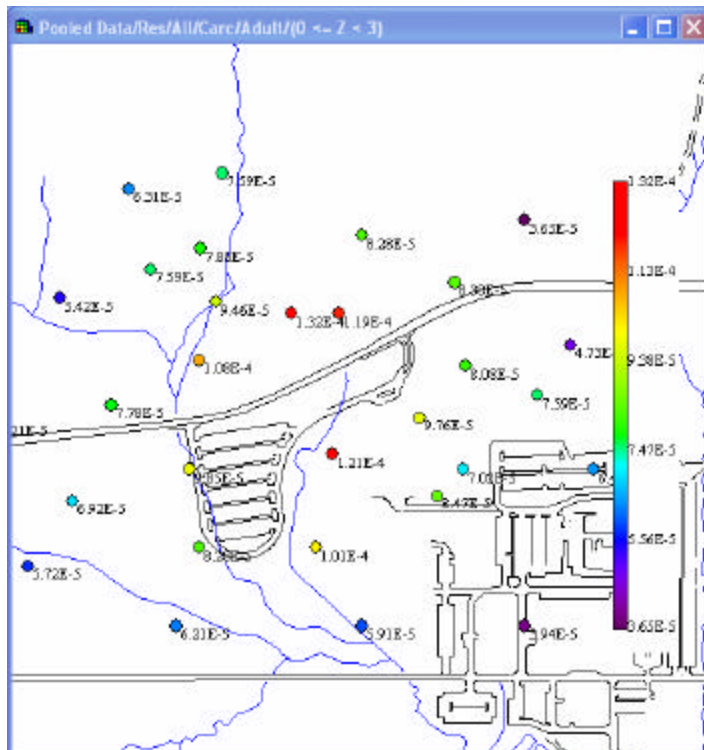
#### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site

3. Set GIS Overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

When **Show the results** is selected, SADA will present the Risk Scenario selection window. After selecting the applicable land use and pathway(s), select **OK**. In the Graphics Window, SADA now presents the plotted value (selected through the data labels box) as risk values.



### Draw a contoured risk map - human health

To display a modeled map of concentration to risk, make sure that your analysis type is set to Human Health and the desired contaminant and media are selected in the secondary toolbar.

#### Availability

This interview is available for human health analyses with pooled or unpooled data.

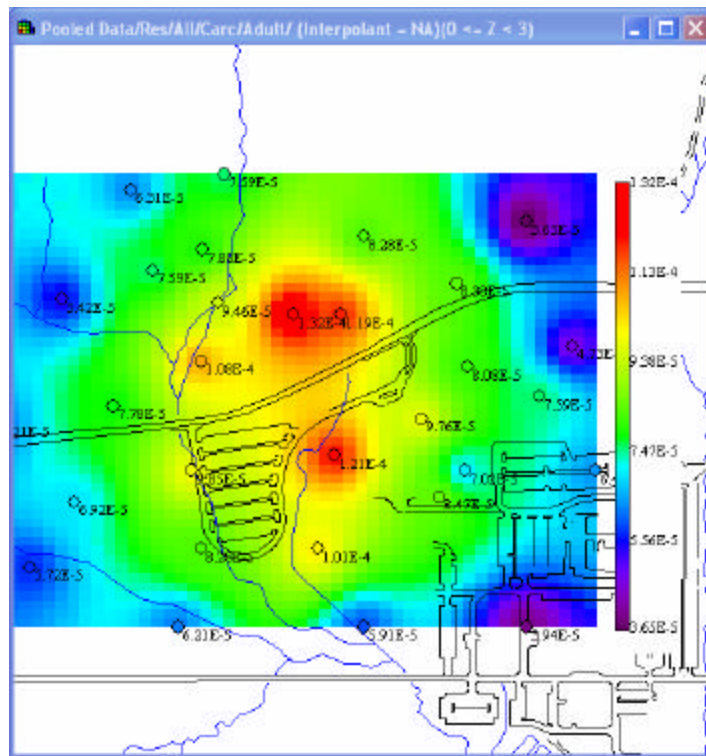
#### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS Overlays
4. Set grid specs
5. Interpolation Methods\_ (this step is not enabled for pooled data with human health)

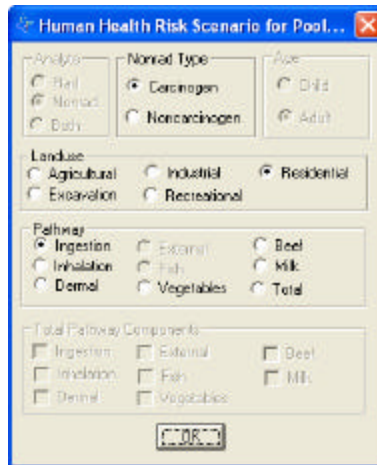
6. Correlation modeling\_(only available if OK or IK\_is selected under Interpolation method; not enabled for pooled data with human health)
7. Search neighborhood\_(only available if OK, IK, or Inverse Distance is selected under Interpolation method; not enabled for pooled data with human health)
8. Show the results
9. Cross validation\_(this step is not enabled for pooled data with human health)
10. Format picture
11. Auto-document
12. Add to results gallery

When **Show the results** is selected, SADA will present the Risk Scenario selection window. After selecting the applicable land use and pathway(s), select **OK**. In the Graphics Window, SADA now presents a map or modeled risk values for the selected contaminants.



### Risk Scenario Selection Window

Each time a geospatial risk function is requested by the user, the **Risk Scenario** selection window is enabled. This window allows the user to choose an available risk scenario for the geospatial model function or set a user-defined concentration value for the currently selected contaminant. If the choice is **Pooled Data**, then the options adjust themselves to include a combination of scenarios.



## Risk Equations

In SADA, five land use scenarios are considered: residential, recreational, industrial, excavation, and agricultural. The exposure pathways are grouped by soil-based exposure pathways (soil, and sediment) and by water-based exposure pathways (surface water and groundwater). The tables presented for each pathway list the default values that are in SADA. They can be changed by the user as necessary to reflect updated guidance or site-specific conditions. References are also provided for the risk equations.

## Land Use Scenarios

The five land use scenarios considered in SADA are: future unrestricted industrial, residential, recreational, excavation, and agricultural exposures. The purpose of evaluating future land use scenarios as part of the risk assessment is to establish whether remedial action is necessary for alternate land uses by determining if the cumulative risk or hazard index from the source areas could exceed levels of concern. The future land use scenarios are based on the assumption that unrestricted industrial workers, residents, farmers, or recreational users of the area could be exposed. Current contaminant concentrations are used for the on-site assessment of future exposure. This represents a maximum exposure to contaminants in the area and will serve to define the potential human health risks that would exist if residential, unrestricted industrial, or recreational occupation were to begin within a short time frame.

Under the industrial scenario, industrial workers are expected to be routinely exposed to contaminated media within a commercial area or industrial site. The future industrial scenario is evaluated using industrial default occupational values provided by EPA. Pathways are evaluated for exposures to surface soil, sediment, and surface water. The exposures are based on the potential for the use of heavy equipment and related traffic in and around the contaminated soil and sediment in an unrestricted industrial scenario. Soils and sediment could be disturbed, thereby producing particulate emissions which could then be inhaled by the industrial worker. It should be noted that the assumptions and default parameters for the industrial land use scenario do not reflect the use of protective clothing or other safety precautions. The drinking water pathway to surface water (based on 1 L/day ingestion) is also evaluated for future industrial land use, although it is unlikely.

Under the residential land use scenario, future residents are expected to be in frequent, repeated contact with contaminated media. The assumptions in this scenario account for daily exposure over the long term and generally result in the highest potential exposures and risk. Exposure is calculated for a lifetime, which includes exposures for the receptor as both child and adult. Pathways are evaluated for exposures to surface soil, sediment, and surface water. In an industrial area where redevelopment for homes is not feasible now or in the foreseeable future, future land use planning scenarios would be more accurately reflected as industrial rather than residential. However, to provide a conservative assessment of risk, a

residential land use scenario is assumed as one of the potential receptors. Consequently, appropriate default parameters and equations for residential land use are evaluated.

The recreational scenario addresses exposure to children and adults who spend a limited amount of time at or near the site while engaging in outdoor activities. The recreational land use scenario is also referred to as the trespasser or site visitor scenario. Pathways are evaluated for exposures to surface soil, sediment, and surface water.

For the excavation scenario, exposure to soil and sediment for a short period are considered to be appropriate. The exposure routes for soil and sediment for the excavation worker are: incidental ingestion, inhalation of emitted particulates and vapors, dermal contact, and external exposure to ionizing radiation.

The agricultural scenario assumes a resident is exposed to homegrown farm products. Exposure routes considered, in addition to the residential pathways, include the consumption of vegetables, the consumption of whole milk, and the consumption of beef.

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### **Soil/ Sediment Exposure Pathways**

Exposure pathways evaluated for soil and sediment include incidental ingestion, inhalation, dermal contact, external exposure, and agricultural pathways. Table 1 summarizes the pathways that can be evaluated for each scenario in SADA.

**Table 1. Soil/Sediment Exposure Pathways by Scenario**

<b>Land use/Pathway</b>	<b>Residential</b>	<b>Industrial</b>	<b>Recreational</b>	<b>Excavation</b>	<b>Agricultural</b>
Incidental Ingestion	Yes	Yes	Yes	Yes	Yes
Inhalation	Yes	Yes	Yes	Yes	Yes
Dermal Contact	Yes	Yes	Yes	Yes	Yes
External	Yes	Yes	Yes	Yes	Yes
Vegetable Ingestion	Yes	No	No	No	Yes
Beef Ingestion	Yes	No	No	No	Yes
Milk Ingestion	Yes	No	No	No	Yes

**Incidental Soil/Sediment Ingestion**

The incidental ingestion of soil is a potentially significant source of exposure. Equation 1 (non-radionuclides), Equation 2 (radionuclides), and Table 2 present the exposure variables for the soil/sediment ingestion pathway for the residential, industrial, recreational, and agricultural scenarios. The potential for exposure to children is greater due to behavioral patterns present during childhood. The higher value for children, under the non-industrial scenarios, are based on fecal tracer studies and account for the ingestion of both indoor and outdoor dust.

$$Nonrad\ Intake_{ing} = \frac{C_{soil} CF_1 EF FI ED IR_{ac}}{CF_2 BW_{ac} AT} \quad (1)$$

$$Rad\ Intake_{ing} = C_{soil} CF_3 EF FI ED IR \quad (2)$$

**Table 2. Soil/Sediment Ingestion Parameters**

Parameter	Units	Residential	Industrial	Recreational	Excavation	Agricultural
Non-radionuclide chemical concentration in soil = <b>C<sub>sn</sub></b>	mg/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in soil = <b>C<sub>sr</sub></b>	pCi/g	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Conversion factor = <b>CF1</b>	kg/mg	10 <sup>-6</sup>	10 <sup>-6</sup>	10 <sup>-6</sup>	10 <sup>-6</sup>	10 <sup>-6</sup>
Exposure frequency = <b>EF</b>	days/yr	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	20	350 (EPA 1989a)
Fraction ingested = <b>FI</b>	unitless	1 24 (adult)	1 25 (adult)	1 24 (adult)	1 1	1 24 (adult)
Exposure duration = <b>ED</b>	years	6 (child) (EPA 1989a)	(EPA 1991a)	6 (child) (EPA 1989a)		6 (child) (EPA 1989a)
Conversion factor = <b>CF8</b>	g/mg	10 <sup>-3</sup>	10 <sup>-3</sup>	10 <sup>-3</sup>	10 <sup>-3</sup>	10 <sup>-3</sup>
Ingestion rate of soil = <b>IR</b>	mg/d	100 (adult) 200 (child) (EPA 1989a)	200 (adult) (EPA 1989a)	100 (adult) 200 (child) (EPA 1989a)	480 (construction worker) (EPA 1991b)	100 (adult) 200 (child) (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (adult) 15 (child) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) 15 (child) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) 15 (child) (EPA 1991a)
Conversion Factor == <b>CF2</b>	days/yr	365	365	365	365	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)

### Soil/Sediment Inhalation

Equation 3 (non-radionuclides), equation 4 (radionuclides), and Table 3 present the exposure variables for the soil/sediment inhalation pathway for the residential, industrial, recreational, and agricultural scenarios. The particulate emission factor (PEF) is represented by the term that includes V, Um/Ut, F(x), Q/C, and CF3. The default PEF in SADA is 1.32E+9 (EPA 1996). The 1/VF term is only present if the contaminant is a volatile.



$$Nonrad\ Intake_{inh} = \frac{C_{sn} EF ED \left( \frac{1}{VF} + \frac{0.036 (1-V)(U_m/U_t)^3 F(x)}{(Q/C) CF_3} \right) IR_{air}}{CF_2 BW AT} \quad (3)$$

$$Rad\ Intake_{inh} = C_{sr} CF_3 EF ED \left( \frac{1}{VF} + \frac{0.036 (1-V)(U_m/U_t)^3 F(x)}{(Q/C) CF_3} \right) IR_{air} \quad (4)$$

**Table 3. Soil/Sediment Inhalation Parameters**

Parameter	Units	Residential	Industrial	Recreational	Excavation	Agricultural
Non-radionuclide chemical concentration in soil = <b>Csn</b>	mg/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in soil = <b>Csr</b>	pCi/g	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Exposure frequency = <b>EF</b>	day/year	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	20	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	1	30 (EPA 1989a)
Conversion factor = <b>CF5</b>	g/kg	1000	1000	1000	1000	1000
Volatilization factor = <b>VF</b>	m <sup>3</sup> /kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Fraction of vegetative cover = <b>V</b>	unitless	0.5 (EPA 1996)	0.5 (EPA 1996)	0.5 (EPA 1996)	0.5 (EPA 1996)	0.5 (EPA 1996)
Mean annual windspeed = <b>Um</b>	m/s	4.69 (EPA 1996)	4.69 (EPA 1996)	4.69 (EPA 1996)	4.69 (EPA 1996)	4.69 (EPA 1996)
Equivalent threshold value of windspeed at 7 m = <b>Ut</b>	m/s	11.32 (EPA 1996)	11.32 (EPA 1996)	11.32 (EPA 1996)	11.32 (EPA 1996)	11.32 (EPA 1996)
Function dependent on <b>Um/Ut= F(x)</b>	unitless	0.194 (Cowherd 1985)	0.194 (Cowherd 1985)	0.194 (Cowherd 1985)	0.194 (Cowherd 1985)	0.194 (Cowherd 1985)
Inverse of the mean concentration at the center of a 0.5 acre-square source = <b>Q/C</b>	(g m <sup>3</sup> )/ (m <sup>2</sup> s kg)	90.8 (EPA 1996)	90.8 (EPA 1996)	90.8 (EPA 1996)	90.8 (EPA 1996)	90.8 (EPA 1996)

Seconds in an hour = <b>CF3</b>	s/h	3600	3600	3600	3600	3600
Total inhalation rate = <b>IRair</b>	m <sup>3</sup> /day	20 (EPA 1989a)	20 (EPA 1989a)	6.7 (8 hours) (EPA 1992)	20 (EPA 1989a)	20 (EPA 1989a)
Conversion Factor = <b>CF2</b>	days/yr	365	365	365	365	365
Body weight = <b>BW</b>	kg	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)
Lifetime = <b>LT</b>	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)

### Soil/Sediment Dermal Contact

Equation 5 (non-radionuclides) and Table 4 present the exposure variables for the soil/sediment dermal contact pathway for the residential, industrial, and recreational scenarios.

$$Nonrad\ Intake_{der} = \frac{C_m CF_4 SA AF ABS EF ED}{CF_2 BW AT} \quad (5)$$

**Table 4. Soil/Sediment Dermal Contact Parameters**

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in soil = <b>C<sub>sn</sub></b>	mg/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Conversion factor = <b>CF<sub>4</sub></b>	(kg-cm <sup>2</sup> )/ (mg-m <sup>2</sup> )	0.01	0.01	0.01	0.01
Surface area = <b>SA</b>	m <sup>2</sup> /day	0.53 Hand, forearms, head lower legs (EPA 1992)	0.316 Hands, forearms, head (EPA 1992)	0.53 Hand, forearms, head lower legs (EPA 1992)	0.53 Hand, forearms, head lower legs (EPA 1992)
Adherence factor = <b>AF</b>	mg/cm <sup>2</sup>	1 (EPA 1992)	1 (EPA 1992)	1 (EPA 1992)	1 (EPA 1992)
Absorption factor = <b>ABS</b>	unitless	0.01 (organic) 0.001 (inorganic) (EPA 1995)	0.01 (organic) 0.001 (inorganic) (EPA 1995)	0.01 (organic) 0.001 (inorganic) (EPA 1995)	0.01 (organic) 0.001 (inorganic) (EPA 1995)
Exposure frequency = <b>EF</b>	day/yr	350 (EPA 1991)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1991)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)
Conversion Factor = <b>CF<sub>2</sub></b>	days/yr	365	365	365	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)

### External Exposure

Equation 6 (radionuclides) and Table 5 present the exposure variables for the external exposure pathway for the residential, industrial, recreational, excavation, and recreational scenarios.

$$Rad\ Dose_{ext} = C_{sr}(1 - S_e) T_e ED EF CF_5 \quad (6)$$

**Table 5. Soil/Sediment External Exposure Parameters**

Parameter	Units	Residential	Industrial	Recreational	Excavation	Agricultural
Radionuclide chemical concentration in soil = <b>C<sub>sr</sub></b>	pCi/g	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Gamma Shielding Factor = <b>Se</b>	unitless	0.2 (EPA 1991a)	0.2 (EPA 1991a)	0.2 (EPA 1991a)	0.2 (EPA 1991a)	0.2 (EPA 1991a)
Gamma exposure time factor = <b>Te</b>	unitless	1 (EPA 1991a)	8/24 (EPA 1991a)	1/24 (EPA 1991a)	8/24 (EPA 1991a)	1 (EPA 1991a)
Exposure frequency = <b>EF</b>	days/yr	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	20	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	24 (adult) 6 (child) (EPA 1989a)	25 (adult) (EPA 1991a)	24 (adult) 6 (child) (EPA 1989a)	1	24 (adult) 6 (child) (EPA 1989a)
Conversion factor = <b>CF<sub>9</sub></b>	yr/days	1/365	1/365	1/365	1/365	1/365

### Soil/Sediment Produce Ingestion

Equation 7 (non-radionuclides), equation 8 (radionuclides), and Table 6 present the exposure variables for the soil/sediment produce ingestion pathway. The produce ingestion pathway is conducted for the agricultural scenario only.

$$Nonrad\ Intake_{yr\ ing} = \frac{C_{sr} (BV_{wet} + MLF) FI_v IR_v EF ED}{CF_2 BW AT} \quad (7)$$

$$Rad\ Intake_{yr\ ing} = C_{sr} (BV_{wet} + MLF) CF_3 FI_v IR_v EF ED \quad (8)$$

**Table 6. Soil/Sediment Produce Ingestion Parameters**

<b>Parameter</b>	<b>Units</b>	<b>Agricultural</b>
Non-radionuclide chemical concentration in soil = <b>Csn</b>	mg/kg	Chemical-specific
Radionuclide chemical concentration in soil = <b>Csr</b>	pCi/g	Chemical-specific
Soil to plant uptake factor (wet) = <b>BVwet</b>	kg/kg	Chemical-specific
Mass loading factor = <b>MLF</b>	unitless	0.26 (Pinder and McLeod 1989)
Conversion factor = <b>CF5</b>	g/kg	1000
Diet fraction = <b>Fiv</b>	unitless	0.4 (EPA 1989b)
Ingestion rate = <b>IRv</b>	kg/d	0.2 (EPA 1989b)
Exposure frequency = <b>EF</b>	d/year	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)
Conversion Factor = <b>CF2</b>	days/yr	365
Body weight (adult) = <b>BW</b>	kg	70 (EPA 1989a)
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)

### **Soil/Sediment Beef Ingestion**

Equation 9 (non-radionuclides), equation 10 (radionuclides), and Table 7 present the exposure variables for the soil/sediment beef ingestion pathway. The beef ingestion pathway is conducted for the agricultural scenario only.

$$Nonrad\ Intake_{beef\ ing} = \frac{F_f C_{sn} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s) IR_f FI EF ED}{CF_2 BW AT} \quad (9)$$

$$Rad\ Intake_{beef\ ing} = F_f C_{sr} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s) CF_5 IR_f FI EF ED \quad (10)$$

**Table 7. Soil/Sediment Beef Ingestion Parameters**

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in soil = <b>Csn</b>	mg/kg	Chemical-specific
Radionuclide chemical concentration in soil = <b>Csr</b>	pCi/g	Chemical-specific
Beef transfer coefficient = <b>Ff</b>	day/kg	Chemical-specific
Fraction of year animal is on site = <b>fp</b>	unitless	1 (Site-specific)
Soil to plant uptake factor (dry) = <b>BVdry</b>	kg/kg	Chemical-specific
Mass loading factor = <b>MLF</b>	unitless	0.26 (Pinder and McLeod 1989)
Quantity of pasture ingested = <b>Qp</b>	kg/day	7.2 (IAEA 1994)
Quantity of soil ingested = <b>Qs</b>	kg/day	1 (Darwin 1990)
Fraction of animal feed from site = <b>fs</b>	unitless	1 (Site-specific)
Beef ingestion rate <sup>c</sup> = <b>IRf</b>	kg/day	0.075 (EPA 1989b)
Conversion factor = <b>CF5</b>	g/kg	1000
Diet fraction = <b>FI</b>	unitless	1 (Site-specific)
Exposure frequency = <b>EF</b>	day/yr	350 (EPA 1989a)

Exposure duration = <b>ED</b>	years	30 (EPA 1989a)
Conversion Factor = <b>CF2</b>	days/yr	365
Body weight = <b>BW</b>	kg	70 (EPA 1989a)
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)

### Soil/Sediment Milk Ingestion

Equation 11 (non-radionuclides), equation 12 (radionuclides), and Table 8 present the exposure variables for the soil/sediment milk ingestion pathway. The milk ingestion pathway is conducted for the agricultural pathway only.

$$Nonrad\ Intake_{milk} = \frac{F_m C_{sn} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s) IR_m FI EF ED}{CF_2 BW AT} \quad (11)$$

$$Rad\ Intake_{milk} = F_m C_{sr} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s) CF_3 IR_m FI EF ED \quad (12)$$

**Table 8. Soil/Sediment Milk Ingestion Parameters**

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in soil = <b>Csn</b>	mg/kg	Chemical-specific
Radionuclide chemical concentration in soil = <b>Csr</b>	pCi/g	Chemical-specific
Milk transfer coefficient = <b>Fm</b>	day/L	Chemical-specific
Fraction of year animal is on site = <b>fp</b>	unitless	1 (Site-specific)
Soil to plant uptake factor (dry) = <b>BVdry</b>	kg/kg	Chemical-specific
Mass loading factor = <b>MLF</b>	unitless	0.26 (Pinder and McLeod 1989)
Quantity of pasture ingested = <b>Qp</b>	kg/day	16.1

		(IAEA 1994)
Quantity of soil ingested = <b>Qs</b>	kg/day	1 (Darwin 1990)
Fraction of animal feed from site = <b>fs</b>	unitless	1 (Site-specific)
Conversion factor = <b>CF5</b>	g/kg	1000
Diet fraction = <b>FI</b>	unitless	1 (Site-specific)
Ingestion Rate = <b>IRm</b>	L/d	0.509 (adult) 0.305 (child) (EPA 1989b)
Exposure frequency = <b>EF</b>	d/year	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	24 (adult) 6 (child) (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (adult) 15 (child) (EPA 1991a)
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	yr H day/yr	70 H 365 (carcinogen) ED H 365 (noncarcinogen)

## Surface Water/ Groundwater Exposure Pathways

Exposure pathways evaluated for surface water and groundwater include ingestion, indoor inhalation, dermal contact, and agricultural pathways. Table 9 summarizes the pathways that can be evaluated for each scenario in SADA.



**Table 9. Soil/Sediment Exposure Pathways by Scenario**

Land use/Pathway	Residential	Industrial	Recreational	Excavation	Agricultural
Incidental Ingestion	Yes	Yes	Yes	No	Yes
Inhalation	Yes	Yes	Yes	No	Yes
Dermal Contact	Yes	Yes	Yes	No	Yes
Vegetable Ingestion	Yes	No	No	No	Yes
Beef Ingestion	Yes	No	No	No	Yes
Milk Ingestion	Yes	No	No	No	Yes
Fish ingestion	Yes	No	Yes	No	Yes

**Surface Water/Groundwater Ingestion**

Equation 13 (non-radionuclides), equation 14 (radionuclides), and Table 10 present the exposure variables for the surface water/groundwater ingestion pathway. This pathway is conducted for the residential, industrial, and inhalation pathways.

$$Nonrad\ Intake_{ing} = \frac{C_{w\&g} IR_w EF ED}{CF_2 BW AT} \quad (13)$$

$$Rad\ Intake_{ing} = C_w IR_w EF ED \quad (14)$$

**Table 10. Surface Water/Groundwater Ingestion Parameters**

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in water = <b>C<sub>w</sub></b>	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in water = <b>C<sub>wr</sub></b>	pCi/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Ingestion Rate = <b>IR<sub>w</sub></b>	L/d	2 (EPA 1989a)	1 (EPA 1991a)	.05 (EPA 1995)	2 (EPA 1989)
Exposure frequency = <b>EF</b>	d/year	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Conversion Factor = <b>CF<sub>2</sub></b>	days/yr	365	365	365	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)

### Surface Water/Groundwater Indoor Inhalation

Equation 15 (non-radionuclides), equation 16 (radionuclides), and Table 11 present the exposure variables for the surface water/groundwater inhalation pathway from showering and from indoor water use. This pathway is conducted for the residential and agricultural scenarios only. The industrial and recreational default intake rates are set to 0 m<sup>3</sup>/day.

$$Nonrad\ Intake_{ink} = \frac{C_{wn} VF IR_{air} EF ED}{CF_2 BW AT} \quad (15)$$

$$Rad\ Intake_{ink} = C_{wr} IR_{air} CF_9 IEF EF ED \quad (16)$$

**Table 11. Surface Water/Groundwater Inhalation while Showering Parameters**

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in water = <b>C<sub>wn</sub></b>	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in water = <b>C<sub>wr</sub></b>	pCi/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Volatilization Factor = <b>VF</b>	L/m <sup>3</sup>	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Inhalation rate = <b>IR<sub>air</sub></b>	m <sup>3</sup> /hour	20 (EPA 1989a)	0	0	20 (EPA 1989a)
Exposure frequency = <b>EF</b>	day/year	350 (EPA 1991)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1991)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Inhalation exposure factor = <b>IEF</b>	(L hr)/ (m <sup>3</sup> day)	0.2802 (Tritium) 7.603 (Radon) 0 (other radionuclides)	0.2802 (Tritium) 7.603 (Radon) 0 (other radionuclides)	0.2802 (Tritium) 7.603 (Radon) 0 (other radionuclides)	0.2802 (Tritium) 7.603 (Radon) 0 (other radionuclides)
Body weight = <b>BW</b>	kg	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Conversion Factor = <b>CF<sub>9</sub></b>	days/hr	1/24	1/24	1/24	1/24
Conversion Factor = <b>CF<sub>2</sub></b>	days/yr	365	365	365	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)

**Surface Water/Groundwater Dermal Contact**

Equation 17 (non-radionuclides) and Table 12 present the exposure variables for the surface water/groundwater dermal contact pathway. This pathway is conducted for the residential, recreational,

and agricultural scenarios only. The industrial scenario has the skin surface area exposed set to 0 m<sup>3</sup> and the exposure time is set to 0 hours.

$$Nonrad\ Intake_{der} = \frac{C_{wrs} SA P_c CF_6 ED EF ET}{CF_2 BW AT} \quad (17)$$

**Table 12. Surface Water/Groundwater Dermal Contact Parameters**

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in water = <b>C<sub>w</sub></b>	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in water = <b>C<sub>wr</sub></b>	pCi/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Skin surface area exposed <sup>c</sup> = <b>SA</b>	m <sup>2</sup>	1.94 (EPA 1989a)	0	1.94 (EPA 1989a)	1.94 (EPA 1989a)
Skin permeability constant = <b>P<sub>c</sub></b>	cm/hr	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Conversion Factor = <b>CF<sub>6</sub></b>	(L-m)/ (cm-m <sup>3</sup> )	10	10	10	10
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Exposure frequency = <b>EF</b>	events/yr	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1989a)
Exposure time = <b>ET</b>	hrs/event	0.2 (EPA 1992)	0	2.6 (EPA 1989a)	0.2 (EPA 1992)
Body weight = <b>BW</b>	kg	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Conversion Factor = <b>CF<sub>2</sub></b>	days/yr	365	365	365	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)	LT (carcinogen) ED (noncarcinogen)

## Surface Water/Groundwater Produce Ingestion

Equation 18 (non-radionuclides), equation 19 (radionuclides), and Table 13 present the exposure variables for the surface water/groundwater produce ingestion pathway. The produce ingestion pathway is conducted for the agricultural pathway only.

$$Nonrad\ Intake_{proing} = \frac{C_{wn} r_{irr} f_{irr} \left[ \frac{(BV_{wet} + MLF)(1 - \exp(-\lambda t_d))}{P \lambda} + \frac{I_f T (1 - \exp(-\lambda_B t_v))}{Y_v \lambda_B} \right] FI_v IR_v EF ED}{CF_2 BW AT} \quad (18)$$

$$Rad\ Intake_{proing} = C_{wr} r_{irr} f_{irr} \left[ \frac{(BV_{wet} + MLF)(1 - \exp(-\lambda t_d))}{P \lambda} + \frac{I_f T (1 - \exp(-\lambda_B t_v))}{Y_v \lambda_B} \right] FI_v IR_v EF ED \quad (19)$$

**Table 13. Surface Water/Groundwater Produce Ingestion Parameters**

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = <b>C<sub>wn</sub></b>	mg/L	Chemical-specific
Radionuclide chemical concentration in water = <b>C<sub>wr</sub></b>	pCi/L	Chemical-specific
Irrigation rate = <b>r<sub>irr</sub></b>	L/m <sup>2</sup> day	2.08 (Kennedy and Strenge 1992)
Irrigation period = <b>f<sub>irr</sub></b>	unitless	0.25 (3 months)
Soil to plant uptake factor (wet) = <b>BV<sub>wet</sub></b>	kg/kg	Chemical-specific
Mass loading factor = <b>MLF</b>	unitless	0.26 (Pinder and McLeod 1989)
Effective removal rate = <b>λ</b>	1/day	<b>λ + λ<sub>B</sub></b>
Soil leaching rate = <b>λ<sub>B</sub></b>	1/day	2.7E-5 (NCRP 1989)
Radionuclide half-life = <b>λ<sub>B</sub></b>	1/day	Chemical-specific
Long-term deposition and buildup = <b>tb</b>	day	10950 (NCRP 1985)
Areal density for root zone = <b>P</b>	kg/m <sup>2</sup>	240

		(Hoffman et al. 1982)
Interception fraction = <b>If</b>	unitless	0.42 (Miller 1980)
Translocation factor = <b>T</b>	unitless	1 (McKone 1994)
Decay for removal on produce = <b><math>\lambda</math></b>	1/day	$\lambda + 0.693/tw$ (NCRP 1989)
Weathering half-life = <b>tw</b>	1/day	14 (NCRP 1985)
Above ground exposure time = <b>tv</b>	days	60 (NCRP 1985)
Plant yield (wet) = <b>Yv</b>	kg/m <sup>2</sup>	2 (NCRP 1985)
Diet fraction = <b>Fiv</b>	unitless	0.4 (EPA 1989b)
Ingestion rate = <b>IRv</b>	kg/d	0.2 (EPA 1989b)
Exposure frequency = <b>EF</b>	d/year	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)
Body weight (adult) = <b>BW</b>	kg	70 (EPA 1989a)
Conversion Factor = <b>CF2</b>	days/yr	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)

### Surface Water/Groundwater Beef Ingestion

Equation 20 (non-radionuclides), equation 21 (radionuclides), and Table 14 present the exposure variables for the surface water/groundwater beef ingestion pathway. The beef ingestion pathway is conducted for the agricultural pathway only.

$$Nonrad\ Intake_{beef\ ing} = \frac{C_{wr} Q_w Bf\ IR\ FI\ EF\ ED}{CF_2 BW\ AT} \quad (20)$$

$$Rad\ Intake_{beef\ ing} = C_{wr} Q_w Bf\ IR\ FI\ EF\ ED \quad (21)$$

**Table 14. Surface Water/ Groundwater Beef Ingestion Parameters**

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = <b>C<sub>wn</sub></b>	mg/L	Chemical-specific
Radionuclide chemical concentration in water = <b>C<sub>wr</sub></b>	pCi/L	Chemical-specific
Quantity of water ingested (cattle) = <b>Q<sub>w</sub></b>	L/day	50 (IAEA 1994)
Beef transfer coefficient = <b>B<sub>f</sub></b>	day/kg	Chemical-specific
Ingestion rate <sup>c</sup> = <b>IR</b>	kg/day	0.075 (EPA 1989b)
Conversion factor = <b>CF</b>	g/kg	1000
Diet fraction = <b>FI</b>	unitless	1
Exposure frequency = <b>EF</b>	day/yr	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (EPA 1989a)
Conversion Factor = <b>CF2</b>	days/yr	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)

### Surface Water/Groundwater Milk Ingestion

Equation 22 (non-radionuclides), equation 23 (radionuclides), and Table 15 present the exposure variables for the surface water/groundwater milk ingestion pathway. The milk ingestion pathway is conducted for the agricultural pathway only.



$$Nonrad\ Intake_{milk} = \frac{C_{wn} Bm Q_w IR_m FI EF ED}{CF_2 BW AT} \quad (22)$$

$$Rad\ Intake_{milk} = C_{wr} Bm Q_w IR_m FI EF EL \quad (23)$$

**Table 15. Surface Water/Groundwater Milk Ingestion Parameters**

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = <b>Cwn</b>	mg/L	Chemical-specific
Radionuclide chemical concentration in water = <b>Cwr</b>	pCi/L	Chemical-specific
Quantity of water ingested (dairy) = <b>Qw</b>	L/day	75 (IAEA 1994)
Milk transfer coefficient = <b>Bm</b>	day/L	Chemical-specific
Ingestion Rate = <b>IRm</b>	L/d	0.305 (adult) (EPA 1989b) 0.509 (child) (Pao et al. 1982)
Exposure frequency = <b>EF</b>	d/year	350 (EPA 1989a)
Exposure duration = <b>ED</b>	years	24 (adult) 6 (child) (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (adult) 15 (child) (EPA 1991a)
Conversion Factor = <b>CF2</b>	days/yr	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)

## Surface Water Fish Ingestion

Equation 24 (non-radionuclides), equation 25 (radionuclides), and Table 16 present the exposure variables for the surface water fish ingestion pathway. The fish ingestion pathway is conducted for the recreational pathway only.

$$Nonrad\ Intake_{fishing} = \frac{C_{wn} B_{fish} IR_{fish} FI EF ED}{CF_2 BW AT} \quad (24)$$

$$Rad\ Intake_{fishing} = C_{wr} B_{fish} IR_{fish} FI EF ED \quad (25)$$

**Table 16. Surface Water Fish Ingestion Parameters**

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = <b>Cwn</b>	mg/L	Chemical-specific
Radionuclide chemical concentration in water = <b>Cwr</b>	pCi/L	Chemical-specific
Fish transfer coefficient = <b>Bfish</b>	day /L	Chemical-specific
Ingestion Rate = <b>IRm</b>	kg/fish meal	0.054 (adult) (EPA 1991a)
Exposure frequency = <b>EF</b>	fish meal /year	45 (EPA 1995)
Exposure duration = <b>ED</b>	years	30 (EPA 1989a)
Body weight = <b>BW</b>	kg	70 (adult) (EPA 1991a)
Conversion Factor = <b>CF2</b>	days/yr	365
Lifetime = <b>LT</b>	years	70 (EPA 1989a)
Averaging time = <b>AT</b>	years	LT (carcinogen) ED (noncarcinogen)

# Ecological Risk Assessment

This chapter provides the following subchapters:

- Ecological Risk Configuration
- Browse Ecological Benchmarks
- Ecological Benchmark Screening
- Spatial Ecological Maps
- Ecological Benchmarks
- Terrestrial Wildlife Exposure Modeling

## Overview of Ecological Risk Assessment

Ecological risk assessment explicitly attempts to estimate the probability and magnitude of the effects of exposure of an ecological endpoint to contamination. There are 4 steps to an ecological risk assessment: Hazard Identification, Dose Response Evaluation, Exposure Assessment, and Risk Characterization. This help file only provides an overview of the process and assumes that the user is familiar with ecological risk assessment.

### Step 1 - Hazard Identification

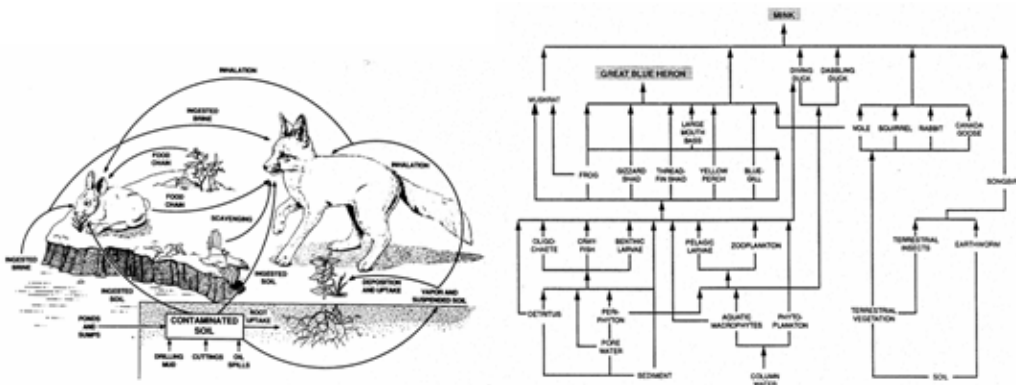
This step consists of comparing (or screening) environmental measurements to benchmarks. Benchmarks are environmental effects concentrations derived from toxicity testing.

### Step 2 – Dose Response Evaluation

This step consists of generating dose responses. Since there is no central database approved for use, these can be pulled out of the same data used to generate screening benchmarks.

### Step 3 – Exposure Assessment

This step consists of determining which ecological receptors and pathways to model by taking into account bioavailability, behavior, growth, and spatial distribution. A conceptual site model is used at this point.



Exposure can also be directly measured via measurements of body burdens or tissue residues.

### Step 4 – Risk Characterization

Risk Characterization incorporates the outcomes of the previous activities (Hazard Identification, Dose Response Evaluation, and Exposure Assessment) to estimate the likelihood that significant effects are occurring or will occur and describe the nature, magnitude, and extent of effects on the designated assessment endpoints.

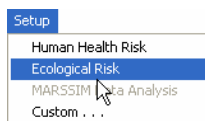
## Ecological Risk Configuration

A number of features are available to set up your SADA file in order to perform screening ecological risk assessments. These include:

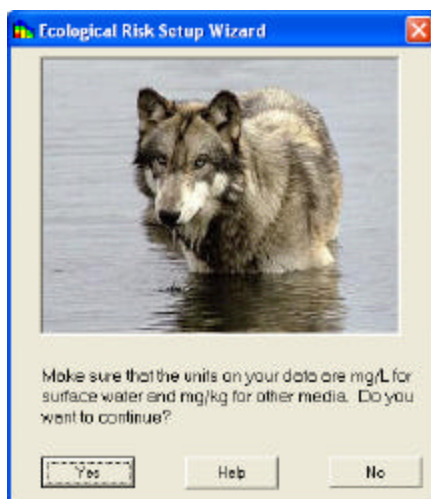
- Ecological Risk Setup
- Delete Ecological Risk
- Rematch Single Contaminant
- Set Physical Parameters
- Check Eco Version

## Ecological Risk Setup

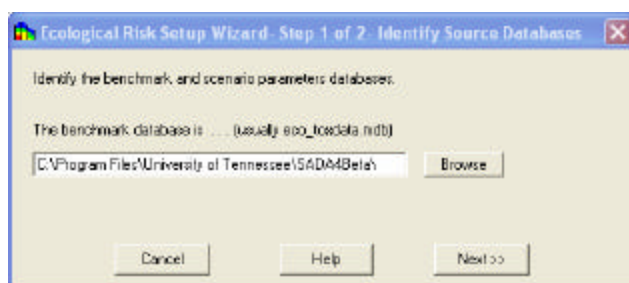
After you have successfully created a SADA file, you may setup ecological risk for the contaminants in this file by selecting **Ecological Risk** from the **Setup** menu.



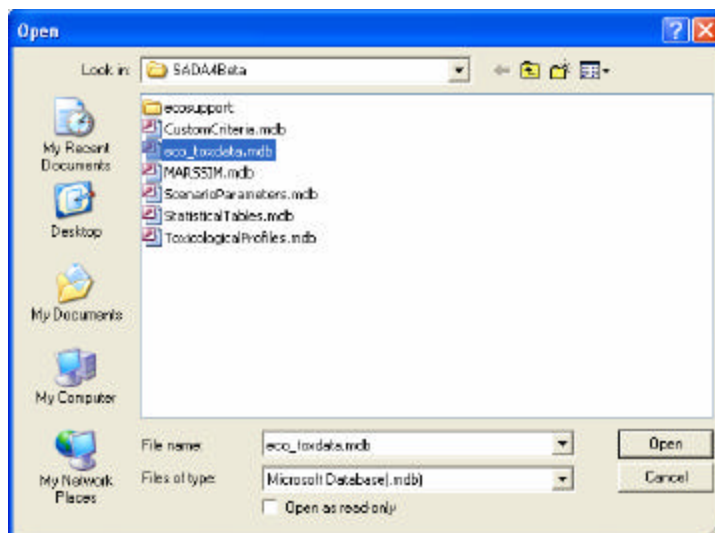
The following introductory form for the ecological risk setup will appear.



After selecting **Yes**, the ecological risk setup wizard will begin. The first step is to identify the source file for the ecological risk information. The SADA installation will create a file called `eco_toxdata.mdb`, which contains all the necessary information. This file should already be present in the root SADA directory (usually `C:\Program Files\SADA\`).



To locate a file, click on the **Browse** button. A typical browse folder will then appear that will default to the directory in which the SADA executable resides.



Select `eco_toxdata.mdb` and then select **Open**.

*Note: To get the most recent `eco_toxdata.mdb` file, visit the SADA web site at: <http://www.tiem.utk.edu/~sada/>. Here you can download the `eco_toxdata.mdb` file and copy it over the one that exists in the installation directory. You can perform a Check Eco Version and compare the dates and version numbers with the file at the web site to see if updating is necessary.*

Once `eco_toxdata.mdb` has been selected, click **Next>>** from the Step 1 form.

SADA now attempts to match each contaminant in your file with a contaminant found in the toxicological database. SADA matches by CAS number first (if available) and then by name. If the CAS number and name match exactly, SADA classifies it as Matched. If only the Name or the CAS number match, then the classification is Partial Match. Finally, if no match is found for either, the classification is No Match. These three classifications are presented in the next window.



On the left, your contaminants have been divided into the three categories. To view a resulting match for any contaminant, click on the down arrow and select your contaminant from the resulting drop down list. The corresponding selection on the right hand side will change to show SADA's match for your contaminant. If the match is acceptable, press the **Register** button. If all matches within a category are acceptable, press **Register All**. To unregister a matched pair(s), select the pair(s) in the registered

contaminants box and press **Unregister**. Your contaminants will return to their original classification with their original match.

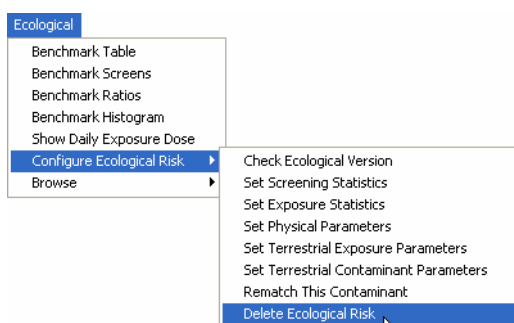
If no match is available for some of your contaminants, you may leave them as unregistered. Later, if the toxicological information becomes available, you may link these (or re-link registered) contaminants separately without setting up the entire risk module again.

Press **Next>>** to conclude setting up the risk module. Once the module is complete, you will have access to an ecological menu.

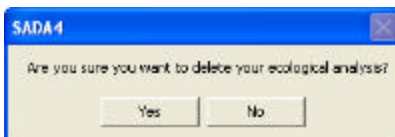
You may reset the Risk module at any time; simply select **Ecological** under the **Setup** menu of the main window. The process is the same as before; however, SADA will give you the opportunity to reset or skip the selection of the benchmark and scenario parameters database.

## Delete Ecological Risk

If you would like to delete the ecological risk setup that has been established within the SADA file, then from the **Ecological** menu select **Configure Ecological Risk**, **Delete Ecological Risk**.



You will be asked to confirm that you want to delete the analysis with the following form:

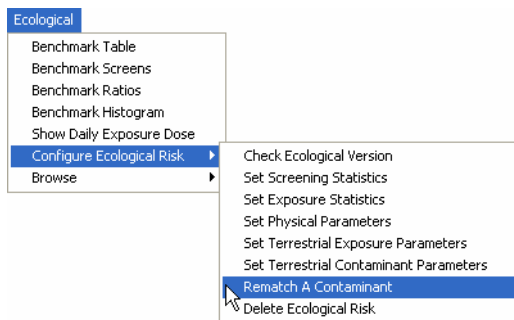


If **Yes** is selected, then the ecological references within your SADA file will be removed. You will then need to rerun the Ecological Risk Setup again in order to perform screening ecological risk assessments.

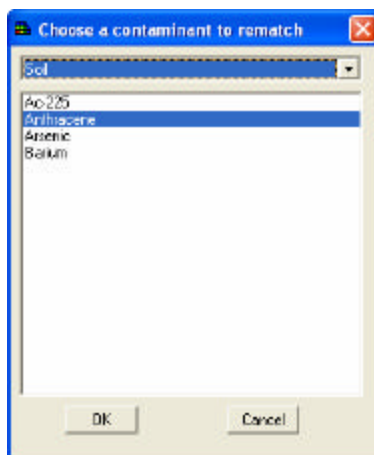
## Rematch Single Ecological Contaminant

If you would like to change a reference for a particular contaminant in the ecological risk setup, you may rematch a single contaminant. Make sure that your analysis type is set to Ecological.

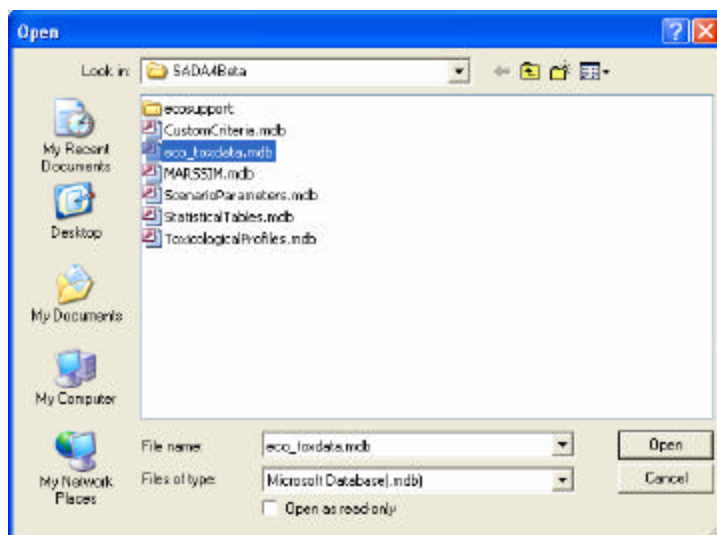
From the **Ecological** menu, select **Configure Ecological Risk** and then **Rematch A Contaminant**, as shown in the following image.



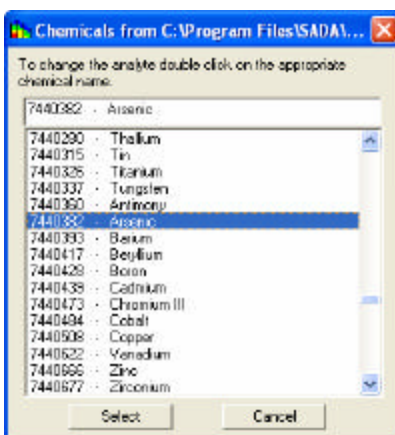
Select a media type and the contaminant choice from the following window. Press **OK**.



You will then be prompted to enter the most recent `eco_toxdata.mdb` file as a source for new contaminant information. When the correct file has been selected, press **Open**.



A form will then be shown of all the available choices for re-matching. It is displayed in CAS Number order, so you may either select the desired contaminant or type in the contaminant name to be matched on the entry line in order to quickly find the appropriate re-link.

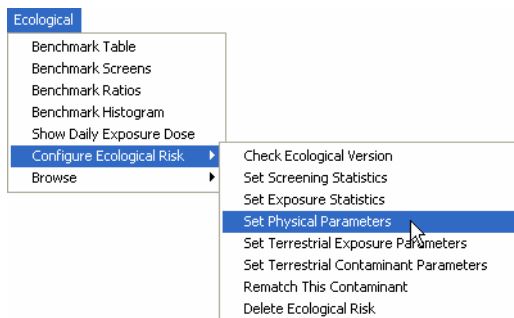


Pressing **Select** will then conclude the Rematch Single Contaminant task and the appropriate information will be updated in the SADA file. If the number of contaminants to re-link is high, it may be more efficient to rerun the Ecological Risk Setup.

## Set Physical Parameters

A number of benchmarks are a function of site-specific physical parameters. The ability to Set Physical Parameters allows one to store this information within the SADA file and automatically modify screening benchmarks to reflect site-specific conditions.

Site-specific variables that may be stored in the SADA file include: Water Analysis Type, hardness, and pH for surface water and organic carbon content for sediment. They may be modified by selecting **Configure Ecological Risk** and then **Set Physical Parameters** from the **Ecological** menu.



The next window will display the current defaults for these parameters within your SADA file. You may adjust the values, but are restricted to certain applicable ranges:

- Hardness: 25-400 mg CaCO<sub>3</sub>/L
- pH: 3-11
- Organic Carbon Content 0-1.



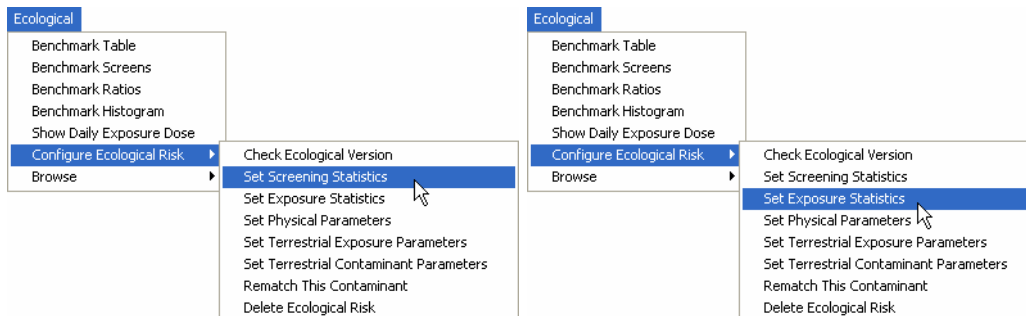
Once you have made your changes, select **OK**. If the selected value is outside the range, then it will be restored to the default value and you may adjust it again, if necessary.

## Set Ecological Statistics

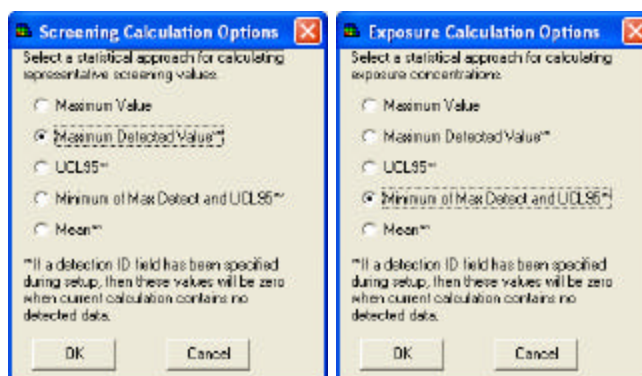
SADA allows the user to select the statistical approach for calculating screening values and exposure concentrations.



From the **Ecological** menu, select **Configure Ecological Risk** and then **Set Screening Statistics** or **Set Exposure Statistics**.



SADA opens one of the following windows.



Select the desired statistical approach and press the **OK** button. The different approaches are defined as follows:

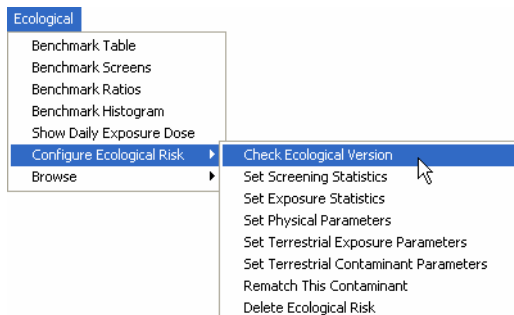
- Maximum Value – the maximum concentration, detected or nondetected, for normal or lognormal distribution
- Maximum Detected Value – the maximum detected concentration for normal or lognormal distribution
- UCL95 – the 95% upper confidence limit on the mean for normal or lognormal distribution
- Mean – the average concentration over all values for normal or lognormal distribution

*Note: For screening calculations, the maximum detected value is the default option while for exposure calculations, the lesser of the maximum detected value and the UCL95 is the default option.*

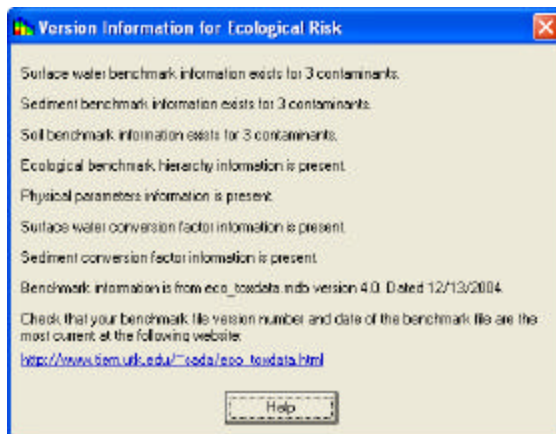
The option selected for Screening Calculations will be used when you choose to conduct Benchmark Screens. The option selected for Exposure Calculations will be used when you choose to conduct Benchmark Ratios or Show Daily Exposure Dose.

## Check Eco Version

A check eco version function is included to ensure that the ecological risk is properly setup for your SADA file. From the **Ecological** menu, select **Configure Ecological Risk** and then **Check Ecological Version**.



The resulting form contains information concerning the ecological risk setup of the current SADA file.



If all is well with the ecological risk setup, you will get a form display that is similar to that above. It will list the number of contaminants for which benchmark information is set up for each media and whether auxiliary information concerning benchmark hierarchy information, physical parameters, and benchmark conversion factors is present. It will give the date of the source file used for setting up the benchmark information as well as a web site that can be visited to see if the information used was the most current.

If necessary information is missing, then you will get text messages indicating the problems. You may have to conduct an Ecological Risk Setup again in order to repair the setup.

## Browse Ecological Benchmarks

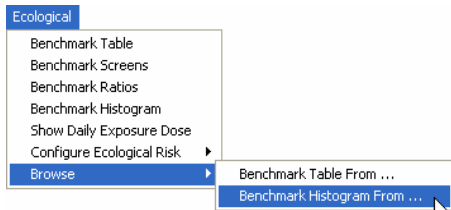
The Browse Ecological Benchmarks features allows one to view either a histogram or a table of **all** the available benchmarks within the Ecological Risk Setup file, rather than just the ones that you have previously setup within your SADA file.

- Browse Benchmark Histograms
- Browse Benchmark Tables

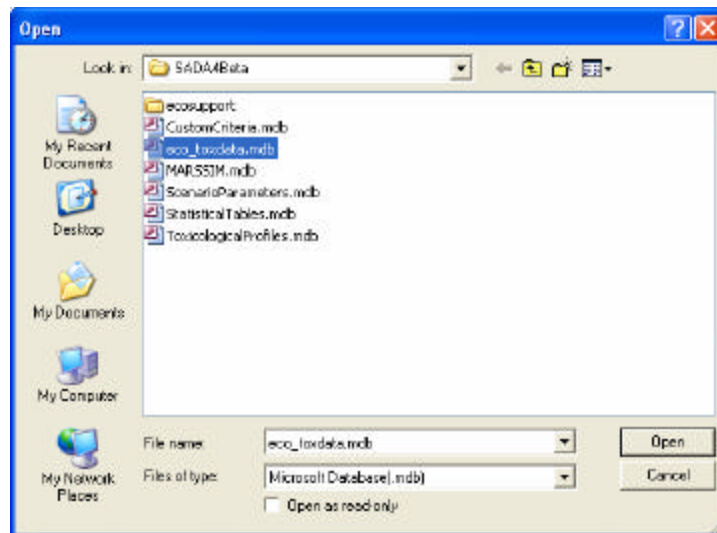
This capability is useful for determining which contaminants have benchmarks, for determining appropriate detection limits before sampling in the field, for assessing the variability of benchmarks for a particular contaminant, and as a means for ecological risk assessment reviewers to ensure that appropriate benchmarks are being used.

## Browse Benchmark Histograms

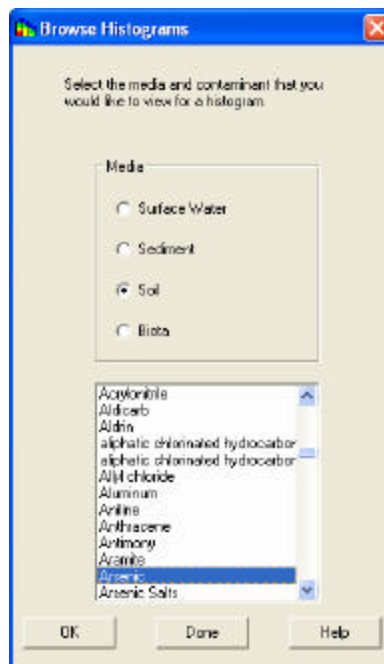
In order to browse a histogram for a particular contaminant, select **Browse** and then **Benchmark Histogram From ...** from the **Ecological** menu.



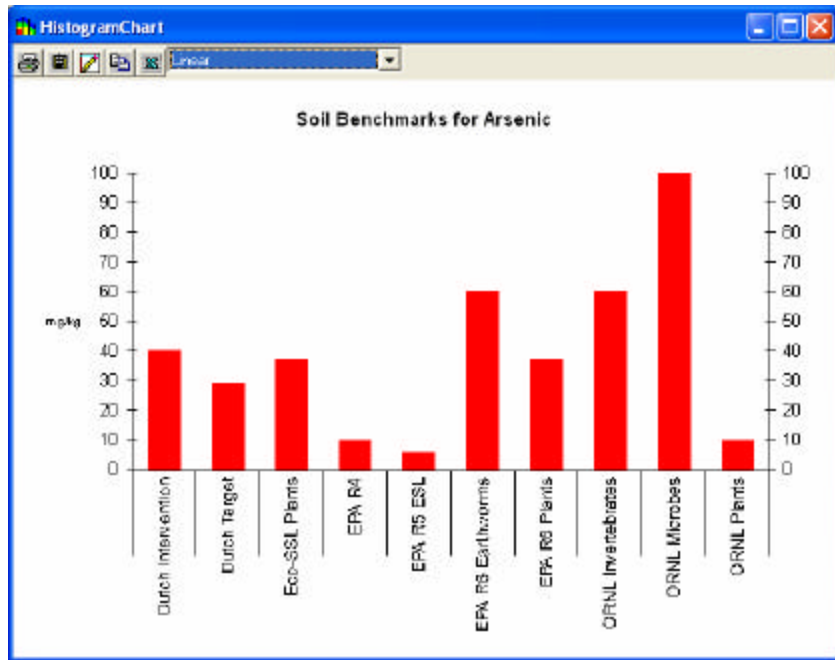
The resulting form prompts for the source data file. Select `eco_toxdata.mdb`, which should be in your root SADA file directory (typically `C:/Program Files/SADA/`).



Select **Open** and the Browse form will appear. Select a contaminant and media combination that you wish to view all benchmarks for. The following example shows Arsenic selected for Soil.



Selecting **OK** will produce a histogram of the available benchmarks (if there are benchmarks available). Select **Done** to close this window.

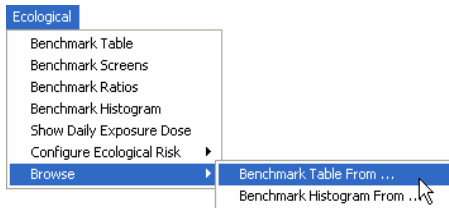


There are different scaling options available. If the display is unsatisfactory, select between linear, natural log, and base 10 log scales for viewing the benchmarks using the dropdown combo box at the top of the form. A benchmark that appears to be missing generally has a very small value relative to the highest value, so it may not show on the linear scale.

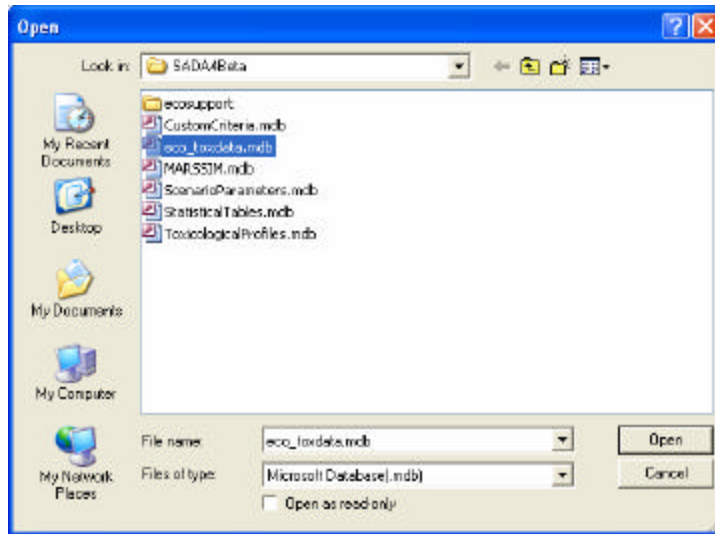


### Browse Benchmark Table

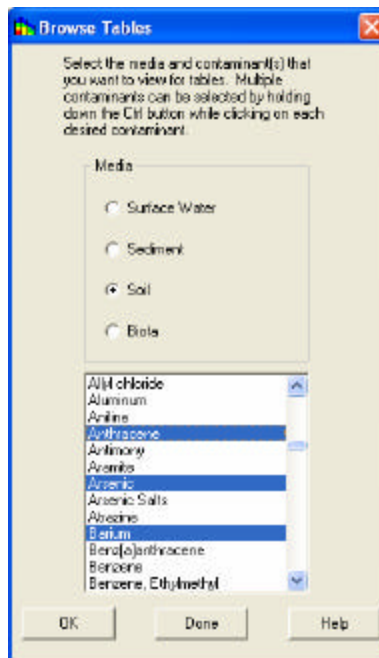
In order to browse a table for a particular contaminant, select **Browse** and then **Benchmark Table From ...** from the **Ecological** menu.



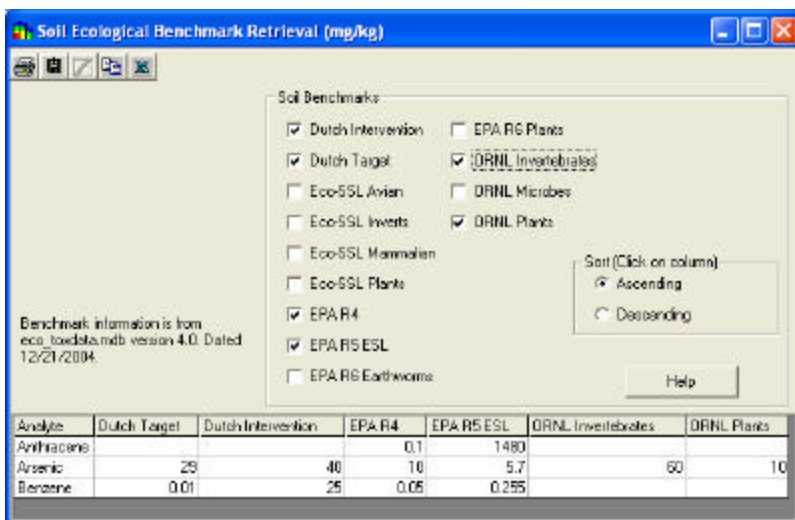
The resulting form prompts for the source data file. Select `eco_toxdata.mdb`, which should be in your root SADA file directory (typically `C:/Program Files/SADA/`).



Select **Open** and the Browse form will appear. Select a contaminant and media combination that you wish to view all benchmarks for. It is also possible to select multiple contaminants by holding down the **Control** key while selecting contaminants. The following example shows soil benchmarks for Arsenic, Anthracene, and Barium.



Press **OK** to bring up an empty table of benchmarks. Click **Done** to close this window.



A number of checkboxes are available in this window. Each box represents a different benchmark source. A more complete description of each source is available by holding the mouse over the benchmark name for a moment or by searching this help file. Check the boxes for the benchmarks that you wish to view, and they will be displayed in table format in the bottom of this window.

The buttons on the toolbar at the top allow a number of different operations to be performed with this data:



**Print** — Prints the data set.



**Copy to File** — Saves the data set in comma-delimited format.



**Add to Report** — Adds information to an auto-documentation report.



**Copy to Clipboard** — Copies information to the clipboard. It may then be pasted into most Windows applications.



**Export to Excel** — Open an instance of and export the information to Excel.

## Ecological Benchmark Screening

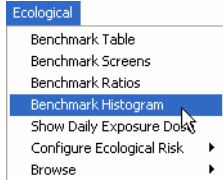
There are four methods available for viewing benchmarks or the results of screening data against benchmarks:

- Show Benchmark Histogram
- Show Benchmark Table
- Show Benchmark Ratios
- Show Benchmark Screens

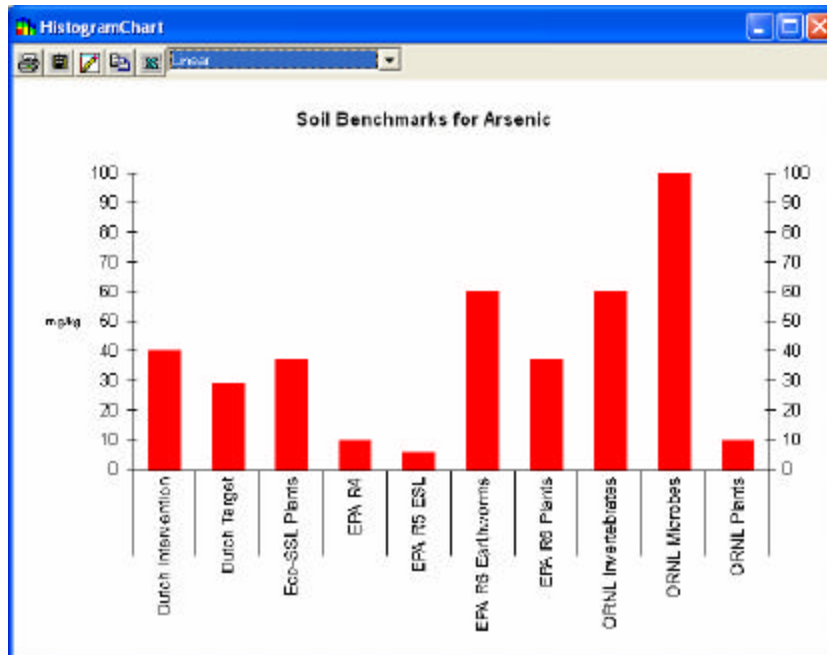
## Show Benchmark Histogram

In order to show a benchmark histogram for a given contaminant that is in your SADA file, make sure that your analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar.

From the **Ecological** menu, select **Benchmark Histogram**.



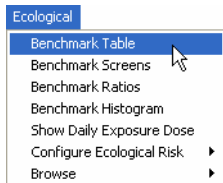
This will automatically display the available benchmarks in a histogram. If applicable, the benchmarks will be based on the physical property value currently stored in the SADA file (as opposed to the Browse Benchmark Histogram, which is always based on default properties).



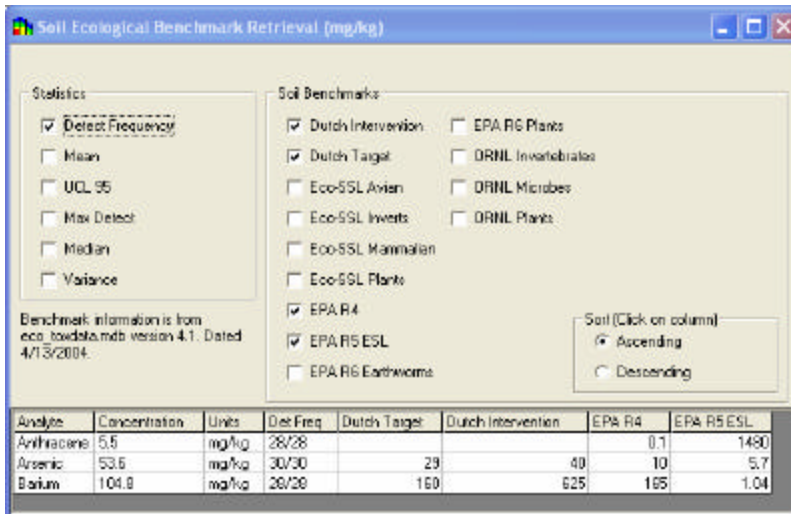
## Show Benchmark Table

To display a table of available benchmarks, make sure that your analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar.

From the **Ecological** menu, select **Benchmark Table**.



A media-dependent form will then be displayed that will allow you to check the desired benchmarks. The following example displays the form for soil.



Click in the checkboxes for each benchmark type to display the value in the bottom of the window.

The buttons on the toolbar at the top allow a number of different operations to be performed with this data:



**Print** — Prints the data set.



**Copy to File** — Saves the data set in comma-delimited format.



**Add to Report** — Adds information to an auto-documentation report.



**Copy to Clipboard** — Copies information to the clipboard. It may then be pasted into most Windows applications.

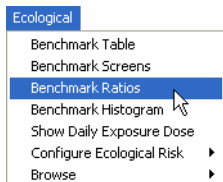


**Export to Excel** — Open an instance of and export the information to Excel.

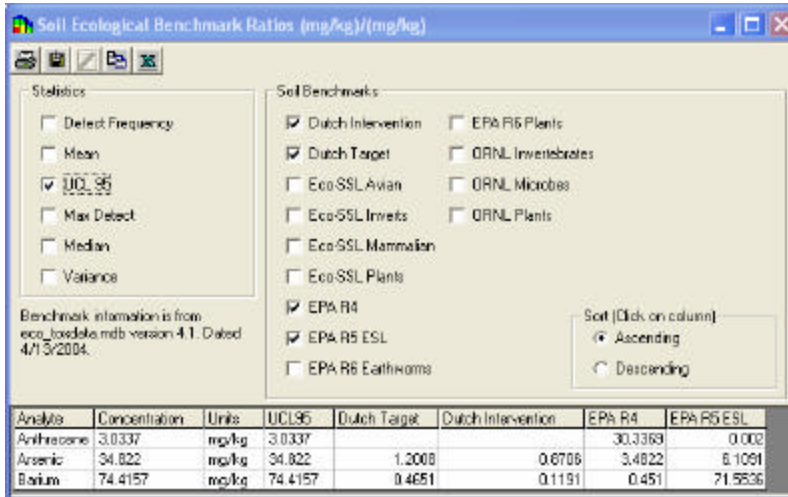
## Show Benchmark Ratios

In order to show the concentration to benchmark ratios for a given area, make sure that your analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar.

From the **Ecological** menu, select: **Benchmark Ratios**.







Click in the checkboxes for each benchmark type to display the value in the bottom of the window.

The buttons on the toolbar at the top allow a number of different operations to be performed with this data:



**Print** — Prints the data set.



**Copy to File** — Saves the data set in comma-delimited format.



**Add to Report** — Adds information to an auto-documentation report.



**Copy to Clipboard** — Copies information to the clipboard. It may then be pasted into most Windows applications.

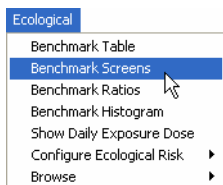


**Export to Excel** — Open an instance of and export the information to Excel.

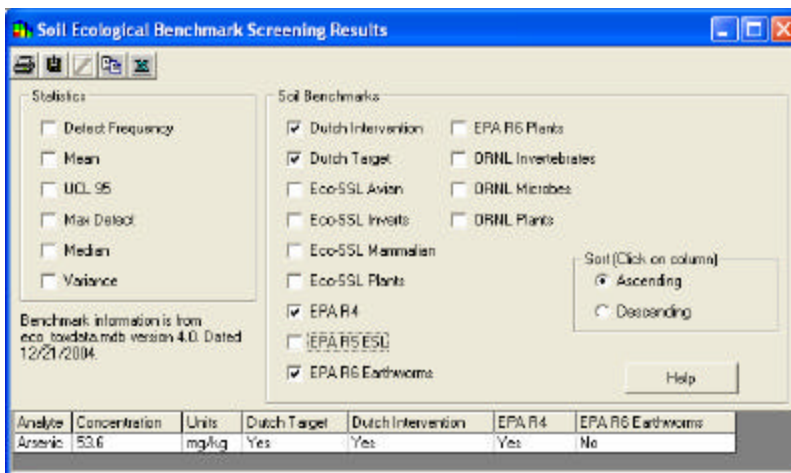
## Show Benchmark Screens

To view the benchmark screens, make sure that your analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar.

From the **Ecological** menu, select: **Benchmark Screens**



The following window of screening results will show "Yes" if the concentration exceeds the benchmark, "No" if the concentration is less than the benchmark, and a blank cell if there is no benchmark for that contaminant-benchmark combination.



Click in the checkboxes for each benchmark type to display the value in the cell.

The buttons on the toolbar at the top allow a number of different operations to be performed with this data:



**Print** — Prints the data set.



**Copy to File** — Saves the data set in comma-delimited format.



**Add to Report** — Adds information to an auto-documentation report.



**Copy to Clipboard** — Copies information to the clipboard. It may then be pasted into most Windows applications.



**Export to Excel** — Open an instance of and export the information to Excel.

## Spatial Ecological Maps

Spatial ecological maps play important roles in other decision frameworks. See the sections on Area of concern maps, probability maps, area of concern boundary sample design, and minimizing/maximizing area of concern sample design.

There are five types of spatial ecological maps in SADA: data screen map, point risk map, point dose map, contoured risk map, contoured dose map.

### Draw a Data Screen Map (Eco) - Interview

With data screen maps, the user can screen the data against ecological benchmarks.

From the Interviews list, select **Draw a data screen map**. Follow the steps that are listed.

### Availability

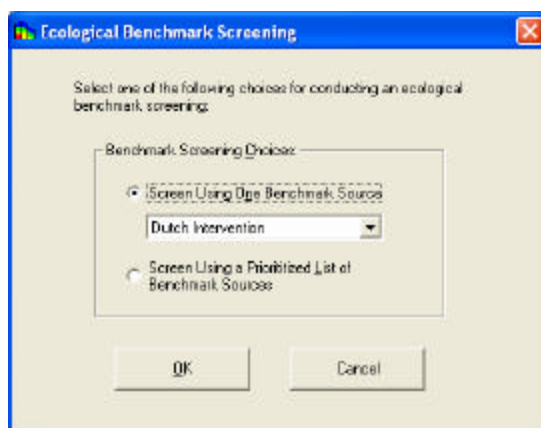
This interview is available for ecological analyses with all data types except Geobayesian.

### Steps

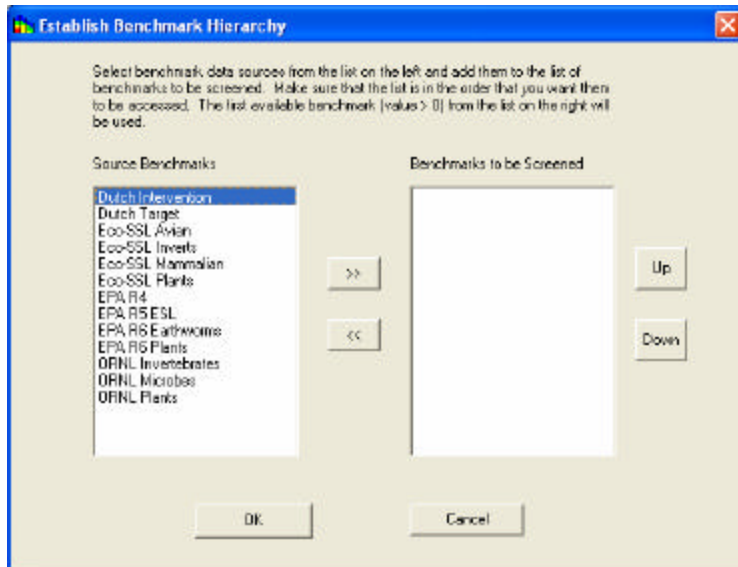
These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

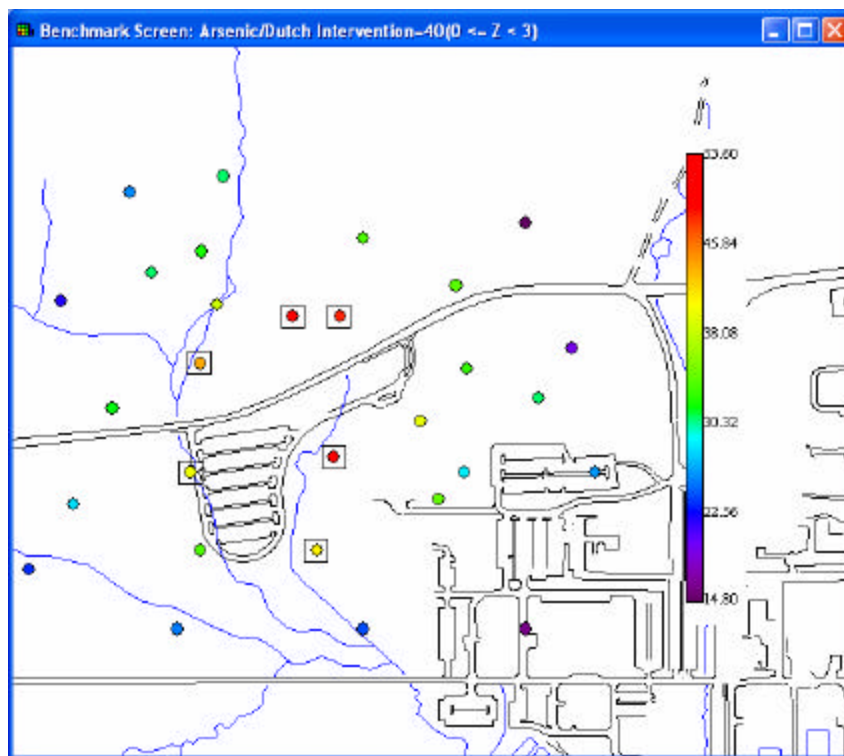
Make sure that the analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar. When **Show the results** is selected, SADA will prompt the user to select the ecological benchmarks to be screened against:



To select a single benchmark source, select **Screen Using One Benchmark Source**. To screen against a prioritized list, select **Screen Using a Prioritized List of Benchmark Sources** and the following form appears:



Here you can select which benchmarks are to be screened using the >> button and the order in which they will be accessed using the **Up** and **Down** buttons. Clicking **OK** will then display the map with a box around each point that exceeds the chosen benchmark.



### Draw a Point Risk Map (Eco) - Interview

To display concentration to benchmark ratios at each point, make sure that your analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar.

From the Interviews list, select **Draw a point risk map**. Follow the steps that are listed.

## Availability

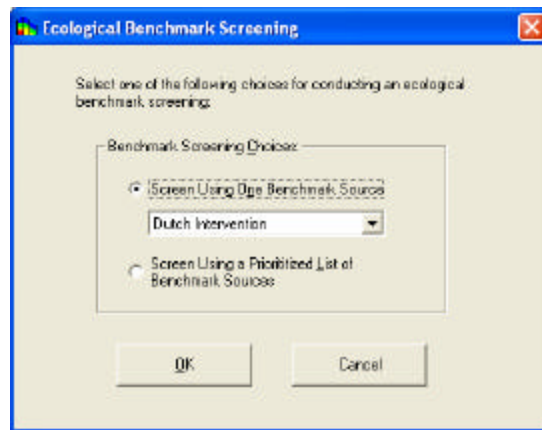
This interview is only available for ecological analyses with unpooled data.

## Steps

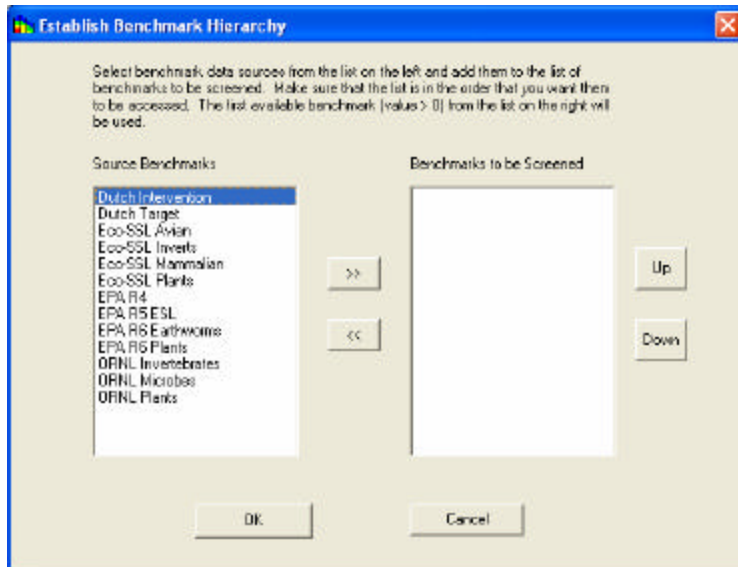
These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

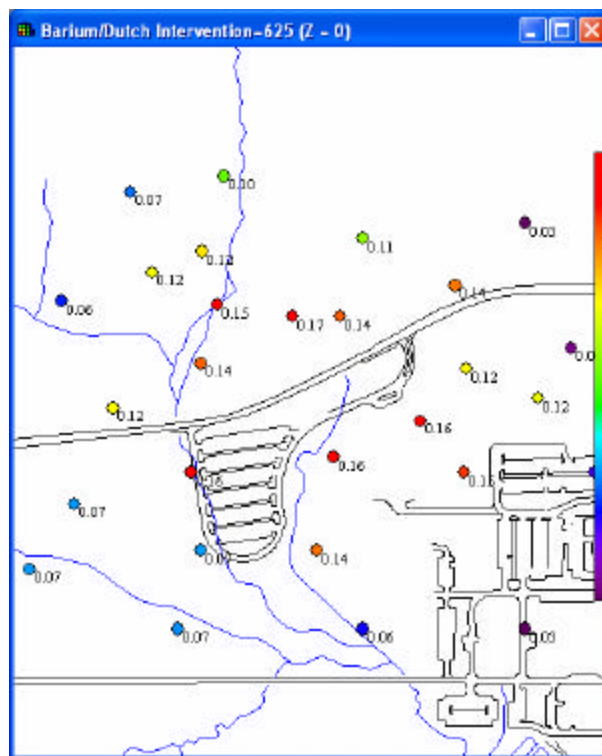
Make sure that the analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar. When **Show the results** is selected, SADA will prompt the user to select the ecological benchmarks to be screened against:



To select a single benchmark source, select **Screen Using One Benchmark Source**. To screen against a prioritized list, select **Screen Using a Prioritized List of Benchmark Sources** and the following form appears:



Here you can select which benchmarks are to be screened using the >> button and the order in which they will be accessed using the **Up** and **Down** buttons. Click **OK** to display concentration to benchmark ratios in the Graphics Window.



### Draw an Eco Point Dose Map - Interview

This function displays dose calculations at each point based on the species and exposure assumptions. First, make sure that the analysis type is set to Ecological, the media type is set to Soil, and the desired contaminant is selected in the secondary toolbar.

From the Interviews list, select **Draw an Eco point dose map**. Follow the steps that are listed.

## Availability

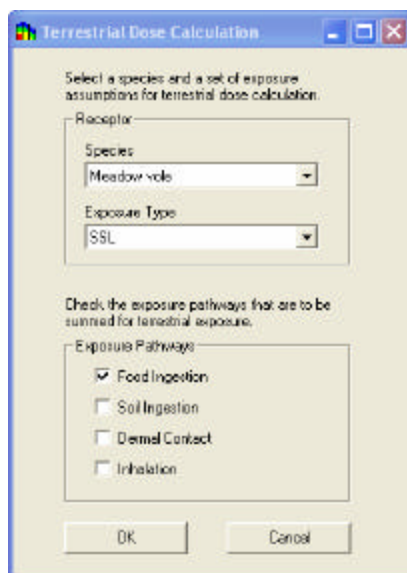
This interview is only available for ecological analyses with unpooled data.

## Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS overlays
4. Show the results
5. Format picture
6. Auto-document
7. Add to results gallery

When **Show the results** is selected, SADA will prompt the user to select the species and exposure assumptions:

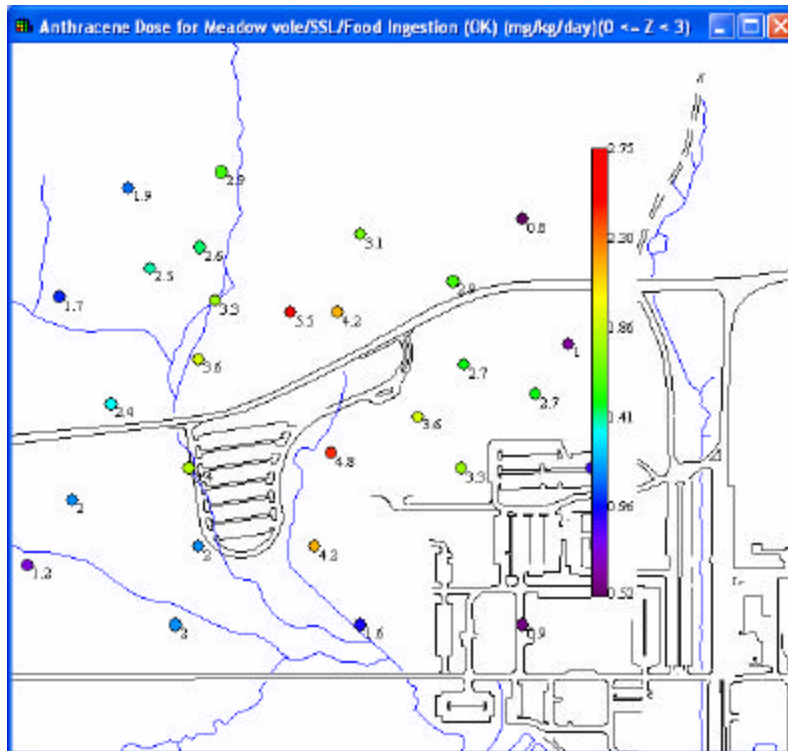


The screenshot shows a dialog box titled "Terrestrial Dose Calculation". It contains the following elements:

- A title bar with the text "Terrestrial Dose Calculation" and standard window controls.
- Instructional text: "Select a species and a set of exposure assumptions for terrestrial dose calculation."
- A section titled "Receptor" containing:
  - A "Species" dropdown menu with "Meadow vole" selected.
  - An "Exposure Type" dropdown menu with "SSL" selected.
- Instructional text: "Check the exposure pathways that are to be summed for terrestrial exposure."
- A section titled "Exposure Pathways" containing four checkboxes:
  - Food Ingestion
  - Soil Ingestion
  - Dermal Contact
  - Inhalation
- At the bottom, there are "OK" and "Cancel" buttons.

Select the species and exposure type using the drop down combo boxes. The exposure types are SSL, Female, Male, or Juvenile. Choosing SSL will use parameter values from EPA's draft Eco-SSL guidance (EPA 2000), which represents data from males and females combined. Choosing Female or Male will restrict the parameter values to those for that gender. SADA does not currently provide parameter values for juveniles, but custom values can be entered via **Set Terrestrial Exposure Parameters**.

Select the exposure pathway(s) and then press **OK**. SADA will now present the dose calculations.



If SADA was able to successfully calculate a pathway, then an (OK) will be after the pathway type in the title. If data is missing to calculate a pathway, then a (NA) will be shown. In the latter case, go to **Set Terrestrial Contaminant Parameters** or **Set Terrestrial Exposure Parameters** to fix any missing parameter values (i.e., if (NA) is shown).

## Draw a Contoured Risk Map (Eco) - Interview

### Availability

This interview is only available for ecological analyses with unpooled data.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

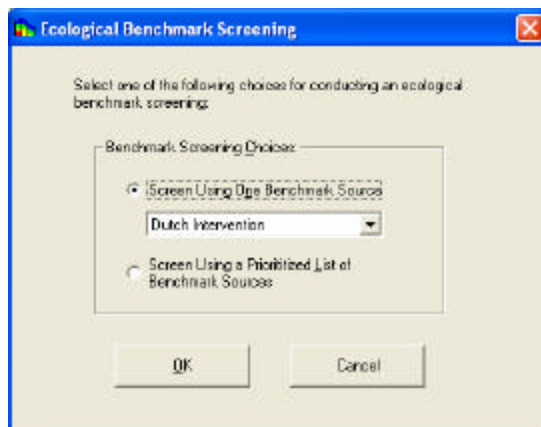
1. See the data
2. Set up the site
3. Set GIS overlays
4. Set grid specs
5. Interpolation Methods\_(this step is not enabled for pooled data with human health)
6. Correlation modeling\_(only available if OK or IK is selected under Interpolation method; not enabled for pooled data with human health)
7. Search neighborhood\_(only available if OK, IK, or Inverse Distance is selected under Interpolation method; not enabled for pooled data with human health)
8. Show the results
9. Cross validation\_(this step is not enabled for pooled data with human health)
10. Format picture



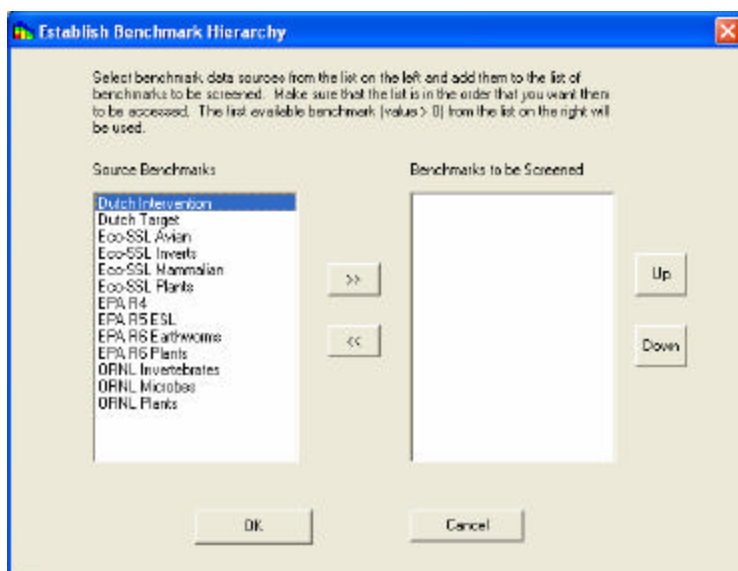
11. Auto-document

12. Add to results gallery

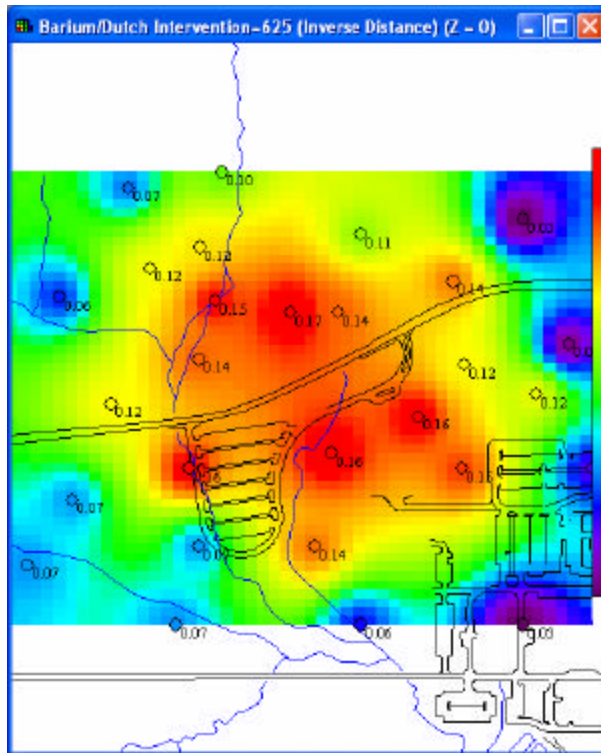
Make sure that the analysis type is set to Ecological and the desired contaminant and media are selected in the secondary toolbar. When **Show the results** is selected, SADA will prompt the user to select the ecological benchmarks to be screened against:



To select a single benchmark source, select **Screen Using One Benchmark Source**. To screen against a prioritized list, select **Screen Using a Prioritized List of Benchmark Sources** and the following form appears:



Here you can select which benchmarks are to be screened using the >> button and the order in which they will be accessed using the **Up** and **Down** buttons. Click **OK** to display a modeled map of concentration to risk in the Graphics Window.



## Draw a Contoured Eco Dose Map - Interview

### Availability

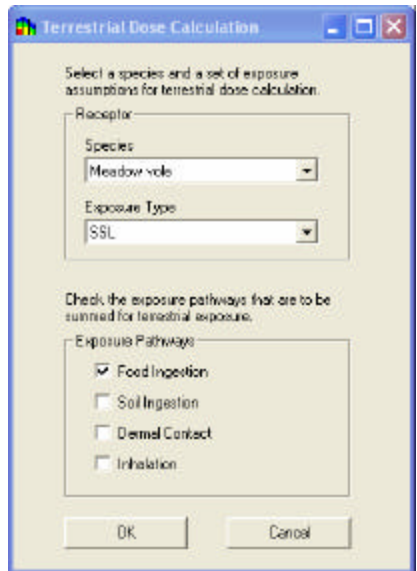
This interview is only available for ecological analyses with unpooled data.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

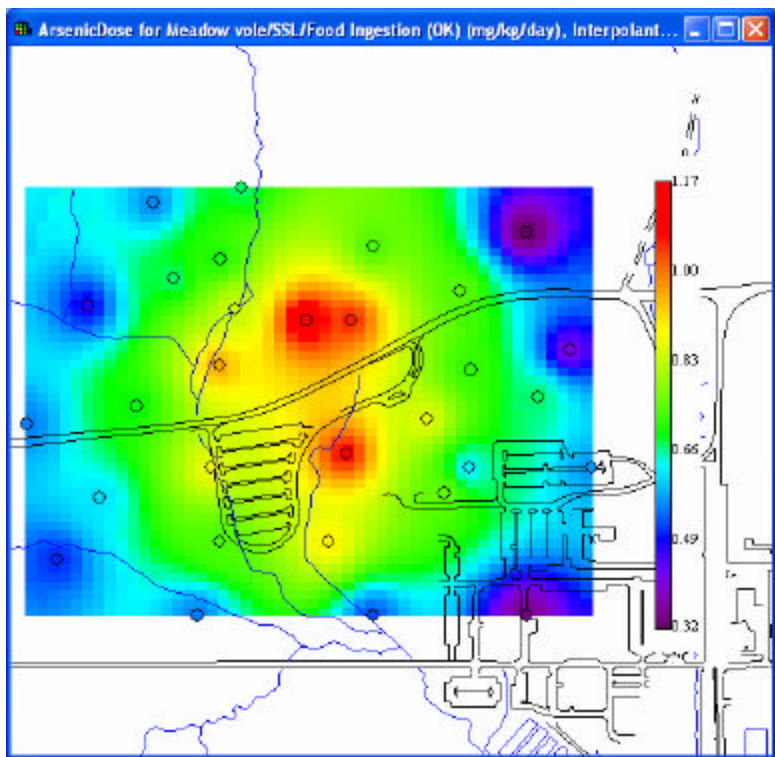
1. See the data
2. Set up the site
3. Set GIS overlays
4. Set grid specs
5. Interpolation methods
6. Correlation modeling\_(only available if OK or IK is selected under Interpolation method)
7. Search neighborhood\_(only available if OK, IK, or Inverse Distance is selected under Interpolation method)
8. Show the results
9. Cross validation
10. Format picture
11. Auto-document
12. Add to results gallery

When **Show the results** is selected, SADA will prompt the user to select the species and exposure assumptions:



Select the species and exposure type using the drop down combo boxes. The exposure types are SSL, Female, Male, or Juvenile. Choosing SSL will use parameter values from EPA's draft Eco-SSL guidance (EPA 2000), which represents data from males and females combined. Choosing Female or Male will restrict the parameter values to those for that gender. SADA does not currently provide parameter values for juveniles, but custom values can be entered via **Set Terrestrial Exposure Parameters**.

Select the exposure pathway(s) and then press **OK**. SADA will now present the contoured dose results.



## Ecological Benchmarks

SADA provides 4 types of ecological benchmarks:

- Surface Water
- Sediment
- Soil
- Biota

### Surface Water Ecological Benchmarks

A number of different benchmarks are available for surface water. These include:

- Canadian WQG
- EC20 Daphnids
- EC20 Fish
- EC25 Bass Population
- EC20 Sensitive Species
- EPA Region 4- Acute
- EPA Region 4- Chronic
- EPA Region 5 ESLs - SW
- LCV Aquatic Plants
- LCV Daphnids
- LCV Fish
- LCV Non-Daphnid Inverts
- NAWQC- Acute
- NAWQC- Chronic
- Tier II SAV
- Tier II SCV
- EPA Region 6 Freshwater
- EPA Region 6 Marine

### Canadian WQG

The National Guidelines and Standards Office of the Environmental Quality Branch of Environment Canada provides nationally approved, science-based guidelines for water quality. The Canadian Water Quality Guidelines (CWQG) are developed to provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values for Canadian species to protect specific water uses. In deriving Canadian water quality guidelines for aquatic life, all components of the aquatic ecosystem (e.g., algae, macrophytes, invertebrates, fish) are considered if the data are available. The goal is to protect all life stages during an indefinite exposure to water. The guidelines provide a numeric value or narrative statement outlining the recommended guideline for over 100 substances, which, if exceeded, may impair the health of Canadian ecosystems and their beneficial uses.

The CWQGs are derived from the available literature on the effects of the substance or physical property (e.g., temperature) on various species for the protection of the appropriate use (e.g., aquatic life).

Guidelines should not be regarded as a blanket value for national water quality; guidelines may need to be modified on a site-specific basis to account for local conditions. For most water quality variables, a single maximum value, which is not to be exceeded, is recommended as a Canadian water quality guideline. This maximum value is based on a long-term no effect concentration. Unless otherwise specified, a guideline value refers to the total concentration in an unfiltered sample. When available, the lowest\_observable\_effects level (LOEL) from a chronic exposure study on the most sensitive native Canadian species is multiplied by a safety factor of 0.1 to arrive at the final guideline concentration. Alternatively, the lowest LC50 or EC50 from an acute exposure study is multiplied by an acute/chronic ratio or the appropriate application factor (i.e., 0.05 for nonpersistent variables; 0.01 for persistent variables) to determine the final guideline concentration.

Aluminum is dependent on pH, Ca<sup>2+</sup>, and DOC:

0.005 mg/L if pH < 6.5, Ca < 4 mg/L, DOC < 2 mg/L, or

0.1 mg/L if pH ≥ 6.5, Ca ≥ 4 mg/L, DOC ≥ 2 mg/L

SADA v4 does not include a default CWQG for aluminum.

Ammonia is pH dependent:

1.37 mg/L at pH 8.0 and temp 10 C, or

2.2 mg/L at pH 6.5 and temp 10 C

SADA v4 does not include a default CWQG for ammonia.

Copper is hardness dependent:

0.002 mg/L at hardness 0-120 mg/L CaCO<sub>3</sub>

0.003 mg/L at hardness 120-180 mg/L

0.004 mg/L at hardness >180

entered 0.002 as default

Lead is hardness dependent:

0.001 mg/L at hardness from 0-60 mg/L CaCO<sub>3</sub>

0.002 from 60-120

0.004 from 120-180

0.007 at hardness >180

SADA v4 uses 0.002 as default

Nickel is hardness dependent:

0.025 mg/L at hardness from 0-60 mg/L CaCO<sub>3</sub>

0.065 from 60-120

0.11 from 120-180

0.15 at hardness >180

SADA v4 uses 0.065 as default

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at <http://www.ec.gc.ca/CEQG-RCQE/English/Cegg/Water/default.cfm> and [http://www.ccme.ca/assets/pdf/e1\\_06.pdf](http://www.ccme.ca/assets/pdf/e1_06.pdf). Updated 2002.

### **EC20 Daphnids**

This benchmark is the lowest test EC20 (20% effects concentration) values for daphnids. It represents the highest tested concentration not causing a reduction of as much as 20% in the reproductive output of female test organisms.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. *Environ. Toxic. Chem.* 15:1232-1241.

### **EC20 Fish**

This benchmark is the lowest test EC20 (20% effects concentration) values for fish. It represents the highest tested concentration not causing a reduction of as much as 20% in the reproductive output of female test organisms.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. *Environ. Toxic. Chem.* 15:1232-1241.

### **EC25 Bass Population**

This benchmark consists of estimates of the concentration causing a 25% reduction in the recruit abundance of a population of largemouth bass.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. *Environ. Toxic. Chem.* 15:1232-1241.

### **EC20 Sensitive Species**

These benchmarks were derived similar to chronic criteria, except that the lowest EC20 for the chemical was used in place of the lowest chronic value.

Suter, G.W. II. 1996. Toxicological benchmarks for screening contaminants of potential concern for effects on freshwater biota. *Environ. Toxic. Chem.* 15:1232-1241.

### **EPA Region 4- Acute**

These benchmarks, derived by the EPA's Southeastern region, are criteria or test endpoints divided by a factor of 10. The Region IV surface water screening values were obtained from Water Quality Criteria documents and represent the chronic ambient water quality criteria values for the protection of aquatic life. They are intended to protect 95% of the species, 95% of the time. If there was insufficient information available to derive a criterion, the lowest reported effect level was used with the application of a safety factor of ten to protect for a more sensitive species. A safety factor of ten was also used to derive a chronic value if only acute information was available. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Note that equations for hardness dependent metals do not match those in EPA (2002). See <http://www.epa.gov/region04/waste/ots/ecolbul.htm#tbl1>.

### **EPA Region 4- Chronic**

These benchmarks, derived by the EPA's Southeastern region, are criteria or test endpoints divided by a factor of 10. The Region IV surface water screening values were obtained from Water Quality Criteria documents and represent the chronic ambient water quality criteria values for the protection of aquatic life. They are intended to protect 95% of the species, 95% of the time. If there was insufficient information available to derive a criterion, the lowest reported effect level was used with the application of

a safety factor of ten to protect for a more sensitive species. A safety factor of ten was also used to derive a chronic value if only acute information was available. Since these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site. Note that equations for hardness dependent metals do not match those in EPA (2002). See <http://www.epa.gov/region04/waste/ots/ecolbul.htm#tbl1>.

### **EPA Region 5 ESLs - SW**

The ESL reference database consists of Region 5 media-specific (soil, water, sediment, and air) Ecological Screening Levels (ESLs) for RCRA Appendix IX hazardous constituents. The ESLs are initial screening levels with which the site contaminant concentrations can be compared. The ESLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. ESLs also impact the data requirements for the planning and implementation of field investigations. ESLs alone are not intended to serve as cleanup levels. See the August 2003 revision of the ESLs (formerly EDQLs) at <http://www.epa.gov/reg5rcra/ca/ESL.pdf>.

### **LCV Aquatic Plants**

The lowest acceptable chronic value for aquatic plants is based on the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration. Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, EPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. <http://www.hsrdo.ornl.gov/ecorisk/tm96r2.pdf>.

### **LCV Daphnids**

The lowest acceptable chronic value for daphnids is based on either the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration or an extrapolation from 48-hour LC50s using equations from Suter et al (1987) and Suter (1993).

The equations for a daphnid CV for a metallic contaminant is:

$$\text{Log CV} = 0.96 \log \text{LC50} - 1.08 \text{ (PI} = 1.56\text{)}$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.11 \log \text{LC50} - 1.30 \text{ (PI} = 1.35\text{)}$$

The LC50 is the lowest species mean 48-hour EC50 for Daphnids. The 95% prediction interval is log CV +/- the PI value (95% prediction intervals contain 95% of observations).

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (<http://www.hsrdo.ornl.gov/ecorisk/tm96r2.pdf>)

Suter, G.W. II, A.E. Rosen, E. Linder, and D.F. Parkhurst 1987. End points for responses of fish to chronic toxic exposures. Environmental Toxicology and Chemistry 6:793-809.

Suter, G.W. II. 1993. Ecological Risk Assessment. Lewis Publishers, Chelsea, MI.

### **LCV Fish**

The lowest acceptable chronic value for fish is based on either the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration or an extrapolation from 96-hour LC50s using equations from Suter et al (1987) and Suter (1993).

The equations for a fish CV for a metallic contaminant is:

$$\text{Log CV} = 0.73 \log \text{LC50} - 0.70 \text{ (PI} = 1.2\text{)}$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.07 \log \text{LC50} - 1.51 \text{ (PI} = 1.5\text{)}$$

The LC50 is the lowest species mean 96-hour EC50 for fish. The 95% prediction interval is log CV +/- the PI value (95% prediction intervals contain 95% of observations).

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (<http://www.hsrdo.ornl.gov/ecorisk/tm96r2.pdf>)

Suter, G.W. II, A.E. Rosen, E. Linder, and D.F. Parkhurst 1987. End points for responses of fish to chronic toxic exposures. Environmental Toxicology and Chemistry 6:793-809.

Suter, G.W. II. 1993. Ecological Risk Assessment. Lewis Publishers, Chelsea, MI.

### **LCV Non-Daphnid Inverts**

The lowest acceptable chronic value for aquatic plants is based on the geometric mean of the Lowest Observed Effect Concentration and the No Observed Effect Concentration. Chronic values are used to calculate the chronic NAWQC, but the lowest chronic value may be lower than the chronic NAWQC. Because of the short generation time of algae and the relative lack of standard chronic tests for aquatic plants, EPA guidelines are followed in using any algal test of at least 96-hour duration and any biologically meaningful response for the plant values.

Suter, G.W. II and C.L. Tsao 1996. Toxicological benchmarks for screening potential contaminants of concern for effects on aquatic biota: 1996 revision. ES/ER/TM-96/R2. Oak Ridge National Laboratory, Oak Ridge, TN. (<http://www.hsrdo.ornl.gov/ecorisk/tm96r2.pdf>)

### **NAWQC- Acute**

Acute National Ambient Water Quality Criteria. These criteria are applicable regulatory standards. The National Ambient Water Quality Criteria (NAWQC) are calculated by the EPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48- to 96-hour LC50 values or equivalent median effective concentration (EC50) values for each criterion chemical (Stephan et al. 1985). The acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQC are applied. The chronic NAWQC are the FAVs divided by the Final Acute-Chronic Ratio (FACR), which is the geometric mean of quotients of at least three LC50/CV ratios from tests of different families of aquatic organisms (Stephan et al. 1985). It is intended to prevent significant toxic effects in chronic exposures and is used as a lower screening benchmark. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg CaCO<sub>3</sub>/L, but equations are provided to obtain values based on site-specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column.

United States Environmental Protection Agency. 2002. National Recommended Water Quality Criteria :2002. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. November. EPA 822-R-02-047. (Available at <http://www.epa.gov/ost/pc/revcom.pdf>).

### **NAWQC- Chronic**

Chronic National Ambient Water Quality Criteria. These criteria are applicable regulatory standards. The National Ambient Water Quality Criteria (NAWQC) are calculated by the EPA as half the Final Acute Value (FAV), which is the fifth percentile of the distribution of 48\_ to 96-hour LC50 values or equivalent median effective concentration (EC50) values for each criterion chemical (Stephan et al. 1985). The



acute NAWQC are intended to correspond to concentrations that would cause less than 50% mortality in 5% of exposed populations in a brief exposure. They may be used as a reasonable upper screening benchmark because waste site assessments are concerned with sublethal effects and largely with continuous exposures, rather than the lethal effects and episodic exposures to which the acute NAWQC are applied. The chronic NAWQC are the FAVs divided by the Final Acute-Chronic Ratio (FAC), which is the geometric mean of quotients of at least three LC50/CV ratios from tests of different families of aquatic organisms (Stephan et al. 1985). It is intended to prevent significant toxic effects in chronic exposures and is used as a lower screening benchmark. NAWQC for several metals are functions of water hardness. Values for hardness-dependent metals default to 100 mg CaCO<sub>3</sub>/L, but equations are provided to obtain values based on site-specific hardness values. Recommended values for metals are expressed in terms of dissolved metal in the water column.

United States Environmental Protection Agency. 2002. National Recommended Water Quality Criteria :2002. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. November. EPA 822-R-02-047. (Available at <http://www.epa.gov/ost/pc/revcom.pdf>)

### **Tier II SAV**

Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for National Ambient Water Quality Criteria. The Tier II Secondary Acute Value (SAV) is derived by taking the lowest genus mean acute value from data meeting specified criteria and dividing it by a Final Acute Value Factor whose value depends on the number of acute data requirements that are met. Values provided here are from Suter and Tsao (1996).

Suter, G.W., II, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. ES/ER/TM-96/R2. <http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf>.

### **Tier II SCV**

Tier II values were developed so that aquatic benchmarks could be established with fewer data than are required for National Ambient Water Quality Criteria. The Tier II Secondary Chronic Value (SCV) is derived by dividing the Secondary Acute Value (see above) by the Secondary Acute-Chronic Ratio. Values provided here are from Suter and Tsao (1996).

Suter, G.W., II, and C.L. Tsao. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. 104pp. ES/ER/TM-96/R2. <http://www.esd.ornl.gov/programs/ecorisk/documents/tm96r2.pdf>.

### **EPA Region 6 Ecological Screening Benchmarks: Freshwater**

U.S. EPA Region 6 recommends use of surface water benchmarks developed for the Texas Natural Resource Conservation Commission. These benchmarks are conservative screening level values intended to be protective of aquatic biota. Values were compiled from a prioritized list of published values. The primary benchmarks are chronic criteria obtained from Texas surface water quality standards or the most current federal National Ambient Water Quality Criteria. Additional benchmarks were derived using the LC<sub>50</sub> approach. TNRCC Water Quality Division chronic values, ORNL secondary chronic values (Suter and Tsao 1996), or EPA Region 4 chronic screening values, in that order, were consulted to expand the number of chemicals with acceptable benchmarks. Values for hardness-dependent metals assume a hardness of 50 mg/L. Values for arsenic, cadmium, chromium, copper, lead, nickel, silver, uranium, and zinc apply to dissolved concentrations.

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

## **EPA Region 6 Ecological Screening Benchmarks: Saltwater (Marine)**

U.S. EPA Region 6 recommends use of saltwater benchmarks developed for the Texas Natural Resource Conservation Commission. These benchmarks are conservative screening level values intended to be protective of aquatic biota. Values were compiled from a prioritized list of published values. The primary benchmarks are chronic criteria obtained from Texas surface water quality standards or the most current federal National Ambient Water Quality Criteria. Additional benchmarks were derived using the LC<sub>50</sub> approach. TNRCC Water Quality Division chronic values or EPA Region 4 chronic screening values, in that order, were consulted to expand the number of chemicals with acceptable benchmarks.

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

## **Sediment Ecological Benchmarks**

A number of different benchmarks are available for sediment, these include:

- ARCS NEC
- ARCS TEC
- ARCS PEC
- Canadian ISQG
- Canadian PEL
- Consensus PEC
- Consensus TEC
- EPA Region 4
- EPA Region 5 ESLs - Sed
- FDEP TEL
- FDEP PEL
- NOAA ERL
- NOAA ERM
- Ontario Low
- Ontario Severe
- OSWER
- Washington NEL
- Washington MAEL
- EPA Region 6 Freshwater
- EPA Region 6 Marine

### **ARCS NEC**

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the high no-effect-concentrations for *Hyalella azteca* and *Chironomus riparius* are presented in EPA (1996). It is a concentration above which statistically significant adverse

biological effects always occur. Effects may occur below these levels. The majority of the data are for freshwater sediments.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyaella azteca* and the midge *Chironomus riparius*. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL.

(<http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html>)  
(<http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html> )

### **ARCS TEC**

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the ER-Ls and TELs for *Hyaella azteca* and *Chironomus riparius* are presented in EPA (1996). The TEC is the geometric mean of the 15th percentile in the effects data set and the 50th percentile in the no effects data set. It is a concentration that represents the upper limit of the range dominated by no effects data. Concentrations above the TEC may result in adverse effects to these organisms; concentrations below the TEC are unlikely to result in adverse effects. The majority of the data are for freshwater sediments. These are possible-effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyaella azteca* and the midge *Chironomus riparius*. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL.

(<http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html>)  
(<http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html> )

### **ARCS PEC**

U.S. EPA Assessment and Remediation of Contaminated Sediments Program. The representative effect concentration selected from among the ER-MS and PELs for *Hyaella azteca* and *Chironomus riparius* are presented in EPA (1996). The PEC is the geometric mean of the 50th percentile in the effects data set and the 85th percentile in the no effects data set. It represents the lower limit of the range of concentrations usually associated with adverse effects. A concentration greater than the PEC is likely to result in adverse effects to these organisms. The majority of the data are for freshwater sediments. These are probable-effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyaella azteca* and the midge *Chironomus riparius*. EPA 905/R96/008. Great Lakes National Program Office, Chicago, IL.

(<http://www.cerc.usgs.gov/clearinghouse/data/brdcerc0004.html>)  
(<http://www.cerc.usgs.gov/pubs/sedtox/sec-dev.html> )

### **Canadian ISQG**

The Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment (CCME) developed chemical concentrations recommended to support and maintain aquatic life associated with bed sediments. These values are derived from available scientific information on biological effects of sediment-associated chemicals and are intended to support the functioning of healthy ecosystems. The Sediment quality guidelines protocol relies on the National Status and Trends Program approach and the Spiked-Sediment Toxicity Test approach. The Interim Sediment Quality Guidelines (ISQG) correspond to threshold level effects below which adverse biological effects are not expected.

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at <http://www.ec.gc.ca/ceqg-rcqe/English/Ceqg/Sediment/default.cfm> and [http://www.ccme.ca/assets/pdf/e1\\_06.pdf](http://www.ccme.ca/assets/pdf/e1_06.pdf). Updated 2002.

## Canadian PEL

The Water Quality Guidelines Task Group of the Canadian Council of Ministers of the Environment (CCME) developed chemical concentrations recommended to support and maintain aquatic life associated with bed sediments. These values are derived from available scientific information on biological effects of sediment-associated chemicals and are intended to support the functioning of healthy ecosystems. The Sediment quality guidelines protocol relies on the National Status and Trends Program approach and the Spiked-Sediment Toxicity Test approach. The Probable Effects Levels (PEL) correspond to concentrations above which adverse biological effects are frequently found.

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at <http://www.ec.gc.ca/cegg-rcqe/English/Cegg/Sediment/default.cfm> and [http://www.ccme.ca/assets/pdf/e1\\_06.pdf](http://www.ccme.ca/assets/pdf/e1_06.pdf). Updated 2002.

## Consensus PEC

Consensus-based Sediment Quality Guidelines (SQG) represent the geometric mean of published SQGs from a variety of sources. Sources for Probable Effect Concentrations (PEC) include probable effect levels, effect range median values, severe effect levels, and toxic effect thresholds (see MacDonald et al. 2000 for references). PECs are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur more often than not.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39: 20-31.

## Consensus TEC

Consensus-based Sediment Quality Guidelines (SQG) represent the geometric mean of published SQGs from a variety of sources. Sources for Threshold Effect Concentrations (TEC) include threshold effect levels, effect range low values, lowest effect levels, minimal effect thresholds, and sediment quality advisory levels (see MacDonald et al. 2000 for references). TECs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol.* 39: 20-31.

## EPA Region 4

The higher of the EPA Contract Laboratory Program Practical Quantitation Limit and the Effects Value, which is the lower of the ER-L and the TEL. These are possible effects benchmarks.

EPA Region IV (U.S. Environmental Protection Agency Region IV) 1995. Ecological screening values, Ecological Risk Assessment Bulletin No. 2, Waste Management Division. Atlanta, Georgia. (superseded by <http://www.epa.gov/region04/waste/ots/ecolbul.htm#tbl3>).

## EPA Region 5 ESLs - Sed

The ESL reference database consists of Region 5 media-specific (soil, water, sediment, and air) Ecological Screening Levels (ESLs) for RCRA Appendix IX hazardous constituents. The ESLs are initial screening levels with which the site contaminant concentrations can be compared. The ESLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. ESLs also impact the data requirements for the planning and implementation of field investigations. ESLs alone are not intended to serve as cleanup levels. See the August 2003 revision of the ESLs (formerly EDQLs) at <http://www.epa.gov/reg5rcra/ca/ESL.pdf>.

## FDEP TEL

Sediment quality assessment guidelines developed for the State of Florida for 34 priority substances based on the approach recommended by Long and Morgan (1990). They are intended to assist sediment quality assessment applications, such as identifying priority areas for non-point source management actions, designing wetland restoration projects, and monitoring trends in environmental contamination. They are not intended to be used as sediment quality criteria.

Long, E.R. and L.G. Morgan 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. National Oceanic and Atmospheric Administration. Seattle, WA.

MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Office of Water Policy, Florida Department of Environmental Protection, Tallahassee, Florida. (<http://www.dep.state.fl.us/water/monitoring/docs/seds/vol1/volume1.pdf>)

## FDEP PEL

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MacDonald, D.D. 1994. Approach to the Assessment of Sediment Quality in Florida Coastal Waters. Office of Water Policy, Florida Department of Environmental Protection, Tallahassee, Florida. (<http://www.dep.state.fl.us/water/monitoring/docs/seds/vol1/volume1.pdf>)

## NOAA ERL

1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, DDE, PAHs, total DDT, total PCBs, and total PAH were obtained from this source.) <http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf>.
2. Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments," *Environ. Manage.* 19: 81-97. (Values for metals and organics not listed in 1 or 3 were obtained from this source.)
3. Long, E. R. and L. G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*, National Oceanographic and Atmospheric Administration, Tech. Memorandum NOS OMA 52, August 1991. Seattle, Washington. (Values for DDD, DDT, Antimony, Chlordane, Dieldrin, and Endrin were obtained from this source.)

## NOAA ERM

1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, DDE, PAHs, total DDT, total PCBs, and total PAH were obtained from this source.) <http://response.restoration.noaa.gov/cpr/sediment/SPQ.pdf>.
  2. Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. "Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments," *Environ. Manage.* 19: 81-97. (Values for metals and organics not listed in 1 or 3 were obtained from this source.)
- Long, E. R. and L. G. Morgan. 1991. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program*, National Oceanographic and

Atmospheric Administration, Tech. Memorandum NOS OMA 52, August 1991. Seattle, Washington. (Values for DDD, DDT, Antimony, Chlordane, Dieldrin, and Endrin were obtained from this source.)

NOAA SQUIRT (<http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html>).

### **Ontario Low**

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment and Energy. August. ISBN 0-7729-9248-7. (Available at <http://www.ene.gov.on.ca/envision/gp/B1-3.pdf>).

### **Ontario Severe**

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Ontario Ministry of the Environment and Energy. August. ISBN 0-7729-9248-7. (Available at <http://www.ene.gov.on.ca/envision/gp/B1-3.pdf>).

### **OSWER**

OSWER (Office of Solid Waste and Emergency Response). 1996. Ecotox thresholds. U.S. Environmental Protection Agency. ECO Update 3 (2):1-12. ([http://www.epa.gov/superfund/programs/risk/eco\\_updt.pdf](http://www.epa.gov/superfund/programs/risk/eco_updt.pdf))

### **WASHINGTON NEL**

Washington NEL Sediment Quality Standards (WAC 172-204-320) are used as a sediment quality goal for Washington state sediments. These are "no effects" level values. No effects means a concentration that does not result in acute or chronic adverse effects to biological resources relative to reference [WAC 173\_204\_200(3)] and does not result in significant human health risk. Washington lists criteria for organics other than phenol, 2-methyl phenol, 4-methyl phenol, 2,4-dimethyl phenol, benzyl alcohol, and benzoic acid on a total organic carbon basis. The values included in SADA have been converted to mg/kg sediment assuming 1% organic carbon (criteria from Washington table were multiplied by 0.01). The value for Low Molecular Weight PAHs (LPAH) applies to the sum of concentrations of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, and Anthracene. The value for High Molecular Weight PAH's (HPAH) applies to the sum of Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene. Total Benzofluoranthenes represents the sum of the b, j, and k isomers.

Washington Department of Ecology, Sediment Management Unit, Sediment Quality Chemical Criteria, updated 8/9/2001 – [http://www.ecy.wa.gov/programs/tcp/smu/sed\\_chem.htm](http://www.ecy.wa.gov/programs/tcp/smu/sed_chem.htm)

### **WASHINGTON MAEL**

Washington MAEL represent Sediment Impact Zone Maximum Level (WAC 173-204-420) and Sediment Cleanup Screening Level/Minimum Cleanup Level (WAC 173-204-520) values. These are used as an upper regulatory level for source control and cleanup decision making. They are "minor adverse effects" level values. Minor adverse effect levels are concentrations that result in an acute or chronic adverse effect to biological resources relative to reference in no more than one appropriate biological test [WAC 173\_204\_200(3)], result in a significant response relative to reference [WAC 173\_204\_200(3)], and do not result in significant human health risk. Washington lists criteria for organics other than phenol, 2-methyl phenol, 4-methyl phenol, 2,4-dimethyl phenol, benzyl alcohol, and benzoic acid on a total organic carbon basis. The values included in SADA have been converted to mg/kg sediment assuming 1% organic carbon (criteria from Washington table were multiplied by 0.01). The value for Low Molecular Weight PAHs (LPAH) applies to the sum of concentrations of Naphthalene, Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, and Anthracene. The value for High Molecular Weight PAH's (HPAH) applies to the sum of Fluoranthene, Pyrene, Benz(a)anthracene, Chrysene, total Benzofluoranthenes, Benzo(a)pyrene, Indeno(1,2,3-c,d)pyrene, Dibenzo(a,h)anthracene, and Benzo(g,h,i)perylene. Total Benzofluoranthenes represents the sum of the b, j, and k isomers.

Washington Department of Ecology, Sediment Management Unit, Sediment Quality Chemical Criteria, updated 8/9/2001 – [http://www.ecy.wa.gov/programs/tcp/smu/sed\\_chem.htm](http://www.ecy.wa.gov/programs/tcp/smu/sed_chem.htm)

### **EPA Region 6 Ecological Screening Benchmarks: Freshwater Sediment**

U.S. EPA Region 6 recommends use of benchmarks developed for the Texas Natural Resource Conservation Commission. These benchmarks are conservative screening level values intended to be protective of benthic biota. Values were compiled from a prioritized list of published values. The primary benchmarks are Threshold Effects Levels (TEs) from Smith et al. (1996), but values for antimony and silver are Effect Range-Low (ER-L) values from Long and Morgan (1990), values for iron, manganese, total PAHs, several pesticides, and PCBs are Lowest Effects Levels (LEs) from Persaud et al. (1993), anthracene, dibenz(a,h)anthracene, and naphthalene are Threshold Effect Concentrations (TECs) from MacDonald et al. (2000), and sum DDT, DDE, and DDD values are from Environment Canada (1997).

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

### **EPA Region 6 Ecological Screening Benchmarks: Marine Sediment**

U.S. EPA Region 6 recommends use of benchmarks developed for the Texas Natural Resource Conservation Commission. These benchmarks are conservative screening level values intended to be protective of benthic biota. Values were compiled from a prioritized list of published values. The primary benchmarks are Effect Range-Low (ER-L) values from Long et al. (1995), but values for Chlordane, lindane, dieldrin, and phthalates are Threshold Effects Levels (TEs) from Smith et al. (1996), and sum DDT, DDE, and DDD values are from Environment Canada (1997).

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

## **Soil Ecological Benchmarks**

There are a number of soil benchmarks included, these are:

- Dutch Intervention
- Dutch Target
- EPA Eco ESLs
- EPA Region IV
- EPA Region 5 ESLs - Soil
- EPA Region 6 Benchmarks – Plants
- EPA Region 6 Benchmarks – Soil Invertebrates
- ORNL Invertebrates
- ORNL Microbes
- ORNL Plants

### **Dutch Intervention**

Target Values for soil are related to negligible risk for ecosystems. This is assumed to be 1% of the Maximal Permissible Risk (MPR) level for ecosystems, where MPR is the concentration expected to be hazardous for 5% of the species in the ecosystem, or the 95% protection level. For metals, background concentrations are taken into account in arriving at a value. The relationship between soil concentration



and irreparable damage to terrestrial species composition and the relationship between soil concentration and adverse effects on microbial and enzymatic processes were derived to quantify the ecotoxicological effects on ecosystems. The ecological Intervention Value is the concentration expected to be hazardous to 50% of the species in the ecosystem. It cannot be assumed that sensitive species will be protected at the Intervention levels. Site concentrations less than Target Values indicate no restrictions necessary; concentrations between Target Values and Intervention Values suggests further investigation or restrictions may be warranted. Site concentrations exceeding the Intervention Value indicate remediation is necessary. Site-specific values based on percent clay and organic matter for metals and percent organic matter for organic compounds may be derived.

Swartjes, F.A. 1999. Risk-based Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency. *Risk Analysis* 19(6): 1235-1249

The Netherlands Ministry of Housing, Spatial Planning and Environment's Circular on target values and intervention values for soil remediation [http://www2.minvrom.nl/Docs/internationaal/S\\_I2000.pdf](http://www2.minvrom.nl/Docs/internationaal/S_I2000.pdf) and Annex A: Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination [http://www2.minvrom.nl/Docs/internationaal/annexS\\_I2000.pdf](http://www2.minvrom.nl/Docs/internationaal/annexS_I2000.pdf) were also consulted, but they combine the ecological and human health values.

### **Dutch Target**

Target Values for soil are related to negligible risk for ecosystems. This is assumed to be 1% of the Maximal Permissible Risk (MPR) level for ecosystems, where MPR is the concentration expected to be hazardous for 5% of the species in the ecosystem, or the 95% protection level. For metals, background concentrations are taken into account in arriving at a value. The relationship between soil concentration and irreparable damage to terrestrial species composition and the relationship between soil concentration and adverse effects on microbial and enzymatic processes were derived to quantify the ecotoxicological effects on ecosystems. The ecological Intervention Value is the concentration expected to be hazardous to 50% of the species in the ecosystem. It cannot be assumed that sensitive species will be protected at the Intervention levels. Site concentrations less than Target Values indicate no restrictions necessary; concentrations between Target Values and Intervention Values suggests further investigation or restrictions may be warranted. Site concentrations exceeding the Intervention Value indicate remediation is necessary. Site-specific values based on percent clay and organic matter for metals and percent organic matter for organic compounds may be derived.

Swartjes, F.A. 1999. Risk-based Assessment of Soil and Groundwater Quality in the Netherlands: Standards and Remediation Urgency. *Risk Analysis* 19(6): 1235-1249

The Netherlands Ministry of Housing, Spatial Planning and Environment's Circular on target values and intervention values for soil remediation [http://www2.minvrom.nl/Docs/internationaal/S\\_I2000.pdf](http://www2.minvrom.nl/Docs/internationaal/S_I2000.pdf) and Annex A: Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination [http://www2.minvrom.nl/Docs/internationaal/annexS\\_I2000.pdf](http://www2.minvrom.nl/Docs/internationaal/annexS_I2000.pdf) were also consulted, but they combine the ecological and human health values.]

### **EPA Eco ESLs**

EPA Ecological Soil Screening Level (Eco-ESL) Guidance. The Eco-ESL guidance provides a set of risk-based soil screening levels (Eco-ESLs) for several soil contaminants that are frequently of ecological concern for terrestrial plants and animals at hazardous waste sites. It also describes the process used to derive these levels and provides guidance for their use. SADA version 4 does not include values from the draft guidance released in 2000; these values were included in SADA version 3. SADA version 4 only includes Eco-ESLs for chemicals addressed in the 2003 guidance.

### **Eco-ESL Avian**

As of December 2003 avian Eco-ESLs were available for cadmium, cobalt, lead, and dieldrin. **Eco-ESL Inverts.** As of December 2003 soil invertebrate Eco-ESLs were available for antimony, barium, beryllium, cadmium, and lead.



### **Eco-ESL Mammalian**

As of December 2003 mammalian Eco-ESLs were available for antimony, barium, beryllium, cadmium, cobalt, lead, and dieldrin.

### **Eco-ESL Plants**

As of December 2003 terrestrial plant Eco-ESLs were available for cadmium, cobalt, and lead

Narrative statements are available for aluminum and iron, but no soil screening levels were developed.

EPA 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-55. November 2003. (<http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm>).

EPA. 2003. Ecological Soil Screening Levels for Antimony: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-61

EPA. 2003. Ecological Soil Screening Levels for Barium: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-63

EPA. 2003. Ecological Soil Screening Levels for Beryllium: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-64

EPA. 2003. Ecological Soil Screening Levels for Cadmium: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-65

EPA. 2003. Ecological Soil Screening Levels for Cobalt: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-67

EPA. 2003. Ecological Soil Screening Levels for Lead: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-70

EPA. 2003. Ecological Soil Screening Levels for Dieldrin: Interim Final. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, DC. OSWER Directive 9285.7-56

### **EPA Region IV**

EPA. 2001. Supplemental Guidance to RAGS: Region 4 Bulletins, Ecological Risk Assessment. Originally published: EPA Region IV. 1995. *Ecological Risk Assessment Bulletin No. 2: Ecological Screening Values*. U.S. Environmental Protection Agency Region 4, Waste Management Division, Atlanta, GA. Website version last updated 30 November 2001: <http://www.epa.gov/region4/waste/ots/epatab4.pdf>.

### **EPA Region 5 ESLs - Soil**

The ESL reference database consists of Region 5 media-specific (soil, water, sediment, and air) Ecological Screening Levels (ESLs) for RCRA Appendix IX hazardous constituents. The ESLs are initial screening levels with which the site contaminant concentrations can be compared. The ESLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. ESLs also impact the data requirements for the planning and implementation of field investigations. ESLs alone are not intended to serve as cleanup levels. See the August 2003 revision of the ESLs (formerly EDQLs) at <http://www.epa.gov/reg5rcra/ca/ESL.pdf>.

## **EPA Region 6 Ecological Screening Benchmarks: Surface Soil – Plants**

U.S. EPA Region 6 recommends use of benchmarks adopted by the Texas Natural Resource Conservation Commission. For the most part, these are benchmark values for terrestrial plants developed by Efroymson et al. (1997), but values for arsenic, cadmium, chromium, and zinc are from EPA's Ecological Soil Screening Level Guidance effort.

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

## **EPA Region 6 Ecological Screening Benchmarks: Surface Soil – Soil Invertebrates**

U.S. EPA Region 6 recommends use of benchmarks adopted by the Texas Natural Resource Conservation Commission. For the most part, these are benchmark values for earthworms developed by Efroymson et al. (1997), but values for cadmium, copper, and zinc are from EPA's Ecological Soil Screening Level Guidance effort.

Texas Natural Resource Conservation Commission. 2001. Guidance for Conducting Ecological Risk Assessments at Remediation Sites in Texas. Toxicology and Risk Assessment Section, Texas Natural Resource Conservation Commission, Austin, TX. RG-263 (revised).

### **ORNL Invertebrates**

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at <http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf>)

### **ORNL Microbes**

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-126/R2. (Available at <http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf>)

### **ORNL Plants**

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3. (Available at <http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf>)

## **Biota Ecological Benchmarks (Tissue Concentration Benchmarks)**

There are a number of tissue concentration benchmarks included. Many of these are specific to a taxonomic group (avian, mammalian) or to a particular tissue. Sources included provide summary values potentially of use in screening. Measured or modeled site tissue concentrations are compared to these benchmarks to determine whether further investigations into potential risks to aquatic organisms or piscivorous wildlife are warranted. Two other good sources of tissue residue effects were not included because they do not condense reported studies into a recommended value for each chemical: Jarvinen, A.W., and G.T. Ankley. 1999. Linkage of effects to tissue residues: development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals, Pensacola FL: Society of Environmental Toxicology and Chemistry (SETAC). 364 pp. and U.S. Army Corps of Engineers/ U.S. Environmental Protection Agency Environmental Residue-Effects Database (ERED). <http://www.wes.army.mil/el/ered/index.html>

- ECW avian and mammalian tissue concentrations
- BCMOELP 1998 pw
- CEC 1988 fish
- CCME 1999 pw
- Environment Ontario 1984 pw
- Newell et al. 1987 pw
- Swain and Holmes 1985 fish

### **ECW avian and mammalian tissue concentrations**

Tissue residue benchmarks were derived from the SETAC special publication "Environmental Contaminants in Wildlife Interpreting Tissue Concentrations" edited by W.N. Beyer, G.H. Heinz, and A.W. Redmon-Norwood. The ECW (Environmental Contaminants in Wildlife) in the benchmark name indicates the value came from this source, which is a series of chapters by individual authors discussing tissue residue – effects data for a variety of contaminants and taxonomic groups. Recommended threshold values for protection of fish or wildlife were included in the biota benchmark table. Because chemicals may have a greater effect on or accumulate to a greater degree in specific tissues within an animal, recommended values are generally tissue-specific, including avian blood, bone (dry weight), brain, carcass, egg, kidney, or liver; fish brain, egg, muscle, or whole body; and mammal blood, fat, kidney, or liver. Site tissue concentrations lower than these threshold values are not expected to cause significant adverse effects.

Beyer, W.N., G.H. Heinz and A.W. Redmon-Norwood (eds.). 1996. Environmental Contaminants in Wildlife - Interpreting Tissue Concentrations, Special Publication of SETAC, CRC Press, Inc. 494 p.

### **BCMOELP 1998 pw**

Provides a maximum allowable fish tissue concentration for total PCBs protective of piscivorous wildlife.

BCMOELP (British Columbia Ministry of Environment, Land, and Parks). 1988. British Columbia approved water quality guidelines (Criteria): 1998 Edition. British Columbia Ministry of Environment, Land, and Parks. Environmental Protection Department. Water Management Branch. Victoria, British Columbia.

### **CEC 1988 fish**

Provides a maximum allowable value for total Mercury in fish flesh.

CEC (Commission of European Communities). 1988. European community environmental legislation: 1967-1987. Document number XI/989/87. Directorate- General for Environment, Consumer Protection and Nuclear Safety. Brussels, Belgium.

### **CCME 1999 pw**

Provides maximum fish or aquatic organisms tissue residue guidelines for the protection of wildlife consumers of aquatic biota. Values are included for total DDT, Methylmercury, and Toxaphene. Values for PCBs and Polychlorinated Dibenzo-*p*-dioxins and dibenzofurans reported on a toxic equivalents basis are not currently in SADA's ecotox database.

Environment Canada, National Guidelines and Standards Office website <http://www.ec.gc.ca/ceqg-rcqe/English/Ceeg/Tissue/default.cfm> and [http://www.ccme.ca/assets/pdf/e1\\_06.pdf](http://www.ccme.ca/assets/pdf/e1_06.pdf). Updated 2002.

### **Environment Ontario 1984 pw**

Provides a tissue residue guideline for total DDT meant to be protective of fish-consuming birds. The value applies to whole body fish tissue concentrations.

Environment Ontario 1984. Water management: Goals, policies, objectives, and implementation procedures of the Ministry of the Environment. Water Resources Branch, Toronto, Ontario. 70 p.

**Newell et al. 1987 pw**

Provides noncarcinogenic and 1 in 100 cancer risk fish flesh criteria for the protection of piscivorous wildlife. Criteria were developed as part of the Niagara River Biota Contamination Project for New York State.

Newell, A.J., D.W. Johnson, and L.K. Allen. 1987. Niagara River biota contamination project: Fish flesh criteria for piscivorous wildlife. Technical Report 87-3. Division of Fish and Wildlife. Bureau of Environmental Protection. New York State Department for Environmental Conservation. New York, NY.

**Swain and Holmes 1985 fish**

Provides fish tissue concentrations protective of fish and aquatic life for PCBs and Chlorophenols.

Swain, L.G. and G.B. Holms. 1985. Fraser- Delta Area: Fraser River Sub-basin from Kanaka Creek to the mouth water quality assessment and objectives. Water Management Branch. British Columbia Ministry of Environment. Victoria, British Columbia.

**Terrestrial Wildlife Exposure Modeling**

This section covers bioaccumulation, terrestrial daily exposure dose, and setting terrestrial exposure parameters and terrestrial contaminant parameters.

**Bioaccumulation**

**Overall model for estimation of soil-to-earthworm BAFs for non-ionic organic analytes (EPA 2003):**

$$BAF_{worm} = \frac{10^{\log K_{ow} - 0.6}}{f_{oc} \times 10^{0.923 \log K_{ow} - 0.00022}}$$

$$\frac{mg / kg \text{ dry worm}}{mg / kg \text{ dry soil}}$$

where BAF<sub>worm</sub> = soil to earthworm bioaccumulation factor (  $\frac{mg / kg \text{ dry worm}}{mg / kg \text{ dry soil}}$  )

foc = fraction organic carbon in soil. Default is set to 1%.

Kow = octanol-water partitioning coefficient.

**Model for estimation of soil-to-plant foliage BAFs for non-ionic organic analytes (EPA 2003):**

$$BAF_{plant} = 10^{-0.4965 \log K_{ow} + 2.563}$$

$$\frac{mg / kg \text{ dry plant}}{mg / kg \text{ dry soil}}$$

where BAF<sub>plant</sub> = soil to plant foliage bioaccumulation factor (  $\frac{mg / kg \text{ dry plant}}{mg / kg \text{ dry soil}}$  )

Kow = octanol-water partitioning coefficient.

## Sources for soil-to-plant bioaccumulation factors

Bioaccumulation factors were obtained from a variety of sources. Preference was given to regression models from EPA's soil screening level guidance (EPA 2003) and Bechtel-Jacobs (1998). Other sources included IAEA (1994), NCRP (1989), and Baes et al. (1984). Values for non-ionic organic compounds not included in the list below were calculated based on  $K_{ow}$  using the relationship developed for EPA's soil screening levels (EPA 2003):  $BAF_{plant} = 10^{-0.4965 \log K_{ow} + 2.563}$ . Values are presented on a dry weight basis.

Analyte	BAF type	Source
2,4,6-Trinitrotoluene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance.
4,4-DDD	soil-to-plant	Assumed value same as for DDE.
4,4-DDE	soil-to-plant	Median from EPA (2003) ECO-SSL
4,4-DDT	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Aluminum	soil-to-plant	Baes et al. (1984)
Anthracene	soil-to-plant	Regression model from EPA (2003) ECO-SSL guidance
Antimony	soil-to-plant	Regression model from EPA (2003) ECO-SSL guidance
Arsenic	soil-to-plant	Median value from Bechtel-Jacobs (1998)
Barium	soil-to-plant	Median value from Bechtel-Jacobs (1998)
Benz[a]anthracene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Benzo(ghi)perylene	soil-to-plant	Regression model from EPA (2003) ECO-SSL guidance
Benzo[a]pyrene	soil-to-plant	Regression model from EPA (2003) ECO-SSL guidance
Benzo[b]fluoranthene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Benzo[k]fluoranthene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Beryllium	soil-to-plant	Baes et al. 1984
Cadmium	soil-to-plant	Regression model from Bechtel-Jacobs (1998).
Calcium	soil-to-plant	Baes et al. 1984
Chromium III	soil-to-plant	Median value from Bechtel-Jacobs (1998)
Chrysene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Cobalt	soil-to-plant	Median value from Bechtel-Jacobs (1998)
Copper	soil-to-plant	Regression model from Bechtel-Jacobs (1998).
Dibenz[ah]anthracene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Dieldrin	soil-to-plant	Regression model from EPA (2003) ECO-SSL guidance
Fluoranthene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Fluorene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Indeno[1,2,3-cd]pyrene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Iodine	soil-to-plant	Expected value from IAEA (1994).
Iron	soil-to-plant	Expected value from IAEA (1994).
Lanthanum	soil-to-plant	Foliage: expected value for mixed green vegetables from IAEA (1994); Seeds: expected value for beans from IAEA (1994).
Lead	soil-to-plant	Regression model from Bechtel-Jacobs (1998).

Lithium	soil-to-plant	Baes et al. (1984)
Magnesium	soil-to-plant	Baes et al. (1984)
Manganese	soil-to-plant	Median value from Bechtel-Jacobs (1998)
Mercury	soil-to-plant	Dry forage value from NCRP (1989)
Molybdenum	soil-to-plant	Expected value from IAEA (1994).
Naphthalene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Nickel	soil-to-plant	Regression model from Bechtel-Jacobs (1998).
Niobium	soil-to-plant	Expected value for rape from IAEA (1994).
Pentachlorophenol	soil-to-plant	Estimated from Kow: EPA (2003) ECO-SSL guidance. Note: EPA guidance is unclear whether median should be 9.615 from Table 8 or 0.24 from Table 11. SADA currently references Table 8.
Phenanthrene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
Phosphorus (total)	soil-to-plant	Dry forage value from NCRP (1989)
Potassium	soil-to-plant	Dry forage value from NCRP (1989)
Pyrene	soil-to-plant	Median from EPA (2003) ECO-SSL guidance
RDX (Cyclonite)	soil-to-plant	Median from EPA (2003) ECO-SSL guidance.
Selenium	soil-to-plant	Regression model from Bechtel-Jacobs (1998).
Silver	soil-to-plant	Median value from Bechtel-Jacobs (1998)
Sodium	soil-to-plant	Expected value from IAEA (1994).
Strontium	soil-to-plant	Foliage: expected value for grass from IAEA (1994). Seeds: expected value for peas from IAEA (1994).
Sulfur	soil-to-plant	Dry forage value from NCRP (1989)
Technetium	soil-to-plant	Foliage: expected value for spinach from IAEA (1994). Seeds: expected value for peas from IAEA (1994).
Thallium	soil-to-plant	Baes et al. (1984)
Tin	soil-to-plant	Dry forage value from NCRP (1989)
Titanium	soil-to-plant	Baes et al. (1984)
Tungsten	soil-to-plant	Baes et al. (1984)
Uranium	soil-to-plant	Foliage: expected value for grass from IAEA (1994). Seeds: expected value for cereal from IAEA (1994).
Vanadium	soil-to-plant	Baes et al. (1984)
Zinc	soil-to-plant	Regression model from Bechtel-Jacobs (1998).
Zirconium	soil-to-plant	Expected value from IAEA (1994).

#### References:

Baes, C.F., III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, TN. 150pp.

Bechtel-Jacobs. 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel Jacobs Company LLC, Oak Ridge, TN. BJC/OR-133

EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Table 8 in Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

IAEA (International Atomic Energy Agency). 1994. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Technical Report Series No. 364.

NCRP. 1989. Screening techniques for determining compliance with environmental standards. Releases of radionuclides to the atmosphere. NCRP Commentary No. 3. Jan. 1989. National Council on Radiation Protection and Measurements, Bethesda, MD.

### Sources for soil-to-invertebrate bioaccumulation factors

Bioaccumulation factors were obtained from a variety of sources. Preference was given to regression models from EPA's soil screening level guidance (EPA 2003) and Sample et al. (1999). Median values from Sample et al. (1998) were included for several analytes. Values for non-ionic organic compounds not included in the list below were calculated based on Kow using the relationship developed for EPA's soil screening levels (EPA 2003):

$$BAF_{worm} = \frac{10^{foc \cdot Kow - 0.6}}{f_{oc} \cdot 10^{0.25 \cdot Kow - 0.00025}}$$

where  $BAF_{worm}$  = soil to earthworm bioaccumulation factor (  $\frac{mg/kg\ dry\ worm}{mg/kg\ dry\ soil}$  )

foc = fraction organic carbon in soil. Default is set to 1%.

Kow = octanol-water partitioning coefficient.

Analyte	BAF type	Source
2,4,6-Trinitrotoluene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
4,4-DDD	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
4,4-DDE	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
4,4-DDT	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Acenaphthene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Anthracene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Arsenic	soil-to-earthworm	Regression from Sample et al. 1999
Barium	soil-to-earthworm	Median value from Sample et al. 1998:earthworms
Benz[a]anthracene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Benzo(ghi)perylene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Benzo[a]pyrene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Benzo[b]fluoranthene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Benzo[k]fluoranthene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Beryllium	soil-to-earthworm	Median value from Sample et al. 1998:earthworms
Cadmium	soil-to-earthworm	Regression from Sample et al. 1999

Chromium III	soil-to-earthworm	Median value from Sample et al. 1999
Chrysene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Cobalt	soil-to-earthworm	Median value from Sample et al. 1998:earthworms
Copper	soil-to-earthworm	Median value from Sample et al. 1999
Dibenz[ah]anthracene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Dieldrin	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Lead	soil-to-earthworm	Regression from Sample et al. 1999
Manganese	soil-to-earthworm	Regression from Sample et al. 1999
Naphthalene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Nickel	soil-to-earthworm	Median value from Sample et al. 1999
PAHs, Total	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Pentachlorophenol	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Phenanthrene	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
RDX (Cyclonite)	soil-to-earthworm	Median from EPA (2003) Eco-SSL guidance.
Selenium	soil-to-earthworm	Regression from Sample et al. 1999
Silver	soil-to-earthworm	Median value from Sample et al. 1998:earthworms
Zinc	soil-to-earthworm	Regression from Sample et al. 1999

**References:**

EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Table 8 in Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter,II, and T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory, Oak Ridge TN. 93 pp, ES/ER/TM-220

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter,II. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Environ. Toxicol. Chem. 18:2110-2120.

**Sources for soil-to-mammal and diet-to-mammal bioaccumulation factors**

Bioaccumulation factors were obtained from a variety of sources. Preference was given to soil-to-tissue regression models from EPA’s soil screening level guidance (EPA 2003) and Sample et al. (1998) followed by point estimates of soil-to-tissue biotransfer. Where soil-to-tissue values were lacking, diet-to-tissue values from IAEA (1994), NCRP (1989), and Baes et al. (1984) were included.

Analyte	BAF type	Source
4,4-DDD	diet-to-mammal	Assumed same as value for DDT from EPA (2003) ECO-SSL guidance
4,4-DDE	diet-to-mammal	Median from EPA (2003) ECO-SSL guidance
4,4-DDT	diet-to-mammal	Median from EPA (2003) ECO-SSL guidance
Aluminum	diet-to-mammal	Baes et al. 1984



Antimony	diet-to-mammal	Baes et al. 1984
Arsenic	soil-to-mammal	Regression for mammals from Sample et al. 1998
Barium	diet-to-mammal	Baes et al. 1984
Beryllium	diet-to-mammal	Baes et al. 1984
Boron	diet-to-mammal	Baes et al. 1984
Cadmium	soil-to-mammal	Regression for herbivorous mammals from Sample et al. 1998
Calcium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Chlorine	diet-to-mammal	From IAEA (1994) beef transfer factor.
Chromium III	soil-to-mammal	Regression for mammals from Sample et al. 1998
Cobalt	soil-to-mammal	Regression for mammals from Sample et al. 1998
Copper	soil-to-mammal	Regression for mammals from Sample et al. 1998
Dieldrin	diet-to-mammal	Median from EPA (2003) ECO-SSL guidance
Iodine	diet-to-mammal	From IAEA (1994) beef transfer factor.
Iron	diet-to-mammal	From IAEA (1994) beef transfer factor.
Lead	soil-to-mammal	Regression for mammals from Sample et al. 1998
Lithium	diet-to-mammal	Baes et al. (1984).
Magnesium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Manganese	soil-to-mammal	Median value for mammals from Sample et al. 1998
Mercury	diet-to-mammal	From NCRP (1989) beef transfer factor.
Molybdenum	diet-to-mammal	From IAEA (1994) beef transfer factor.
Nickel	soil-to-mammal	Regression for mammals from Sample et al. 1998
Niobium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Pentachlorophenol	diet-to-bird	Regression from Stedman et al. (1980) as reported in EPA (2003) ECO-SSL guidance: tissue (dry wgt.) = 0.00452 x Cdiet + 0.198
Phosphorus (total)	diet-to-mammal	From IAEA (1994) beef transfer factor.
Potassium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Selenium	soil-to-mammal	Regression for mammals from Sample et al. 1998
Silver	soil-to-mammal	Median value for mammals from Sample et al. 1998
Sodium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Strontium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Technetium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Thallium	diet-to-mammal	Baes et al. (1984).
Tin	diet-to-mammal	From NCRP (1989) beef transfer factor.
Titanium	diet-to-mammal	Baes et al. (1984).
Tungsten	diet-to-mammal	Baes et al. (1984).
Uranium	diet-to-mammal	From IAEA (1994) beef transfer factor.
Vanadium	diet-to-mammal	Baes et al. (1984).

Zinc	soil-to-mammal	Regression for herbivorous mammals from Sample et al. 1998
Zirconium	diet-to-mammal	From IAEA (1994) beef transfer factor.

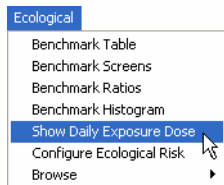
### References:

- Baes, C.F., III, R.D. Sharp, A.L. Sjoreen, and R.W. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture, ORNL-5786, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, TN. 150pp.
- EPA. 2003. Wildlife Exposure Factors Handbook. Vol. 1. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. December 1993.
- EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Table 8 in Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)
- IAEA (International Atomic Energy Agency). 1994. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. Technical Report Series No. 364.
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- Sample, B.E., J.J. Beauchamp, R.A. Efroymsen, G W. Suter II, and T.L. Ashwood. 1998. Development and Validation of Bioaccumulation Models for Small Mammals, ES/ER/TM-219, Oak Ridge National Laboratory, Oak Ridge, TN.

### Terrestrial Daily Exposure Dose

SADA calculates dose (mg/kg BW d) from food ingestion, soil ingestion, dermal contact, and inhalation for terrestrial exposures as well as total dose summed over all pathways selected.

To select a pathway for dose estimation, select a soil contaminant and from the **Ecological** menu select **Show Daily Exposure Dose**.



From the following menu, select a receptor and set of parameters from the drop down list. Then, select the pathway(s) for which you want to calculate dose. The parameter sets are SSL, Female, Male, or Juvenile. Choosing SSL will use parameter values from EPA's Eco-SSL guidance (EPA 2003), which represents data from males and females combined. Choosing Female or Male will restrict the parameter values to those for that gender. SADA does not currently provide parameter values for juveniles, but custom values can be entered via Set Terrestrial Exposure Parameters. Note that SSL parameter values are not available for species not included in the Eco-SSL guidance.

Analyte	Concentration	Food Ingestion	Soil Ingestion	Dermal Contact	Inhalation	Total Dose
Barium	74.4157	6.7331	1.2948	0.0003	0.000001757	8.0282

Modeling dose to wildlife receptors requires a number of chemical-specific and species-specific exposure parameters. To view (and/or change) the contaminant-specific or species-specific parameter values used in estimation of dose, close the Daily Exposure Dose window, and from the **Ecological** menu, click **Configure Ecological Risk**, and either **Set Terrestrial Contaminant Parameters** or **Set Terrestrial Exposure Parameters**.

**Model for dose to wildlife receptor from ingestion of contaminated food:**

$$Dose_{food} = FIR_{BW} \times [(C_{plant} \times P_{plant}) + (C_{invert} \times P_{invert}) + (C_{mamm\ prey} \times P_{mamm\ prey})] \times AF \times AUF$$

*mg/kg dry soil*

where

- FIR<sub>BW</sub> = Dry food ingestion rate as a function of body weight (kg dry food/kg BW/d)
- C<sub>plant</sub> = Chemical concentration in plant (mg/kg dry weight). Estimated from regression equation, or estimated as C<sub>plant</sub> = C<sub>soil</sub> x BAF<sub>plant</sub>
- BAF<sub>plant</sub> = soil to plant bioaccumulation factor (mg/kg dry plant per mg/kg dry soil)
- P<sub>plant</sub> = Plant ingestion as a percentage of diet (unitless)
- C<sub>invert</sub> = Chemical concentration in invertebrate (mg/kg dry weight). Estimated from regression equation, or estimated as C<sub>invert</sub> = C<sub>soil</sub> x BAF<sub>invert</sub>
- BAF<sub>invert</sub> = soil to invertebrate bioaccumulation factor (mg/kg dry invertebrate per mg/kg dry soil)
- P<sub>invert</sub> = Soil invertebrate ingestion as a percentage of diet (unitless)
- C<sub>mamm prey</sub> = Chemical concentration in vertebrate, primarily small mammalian, prey (mg/kg dry weight). Estimated from regression equation, estimated as C<sub>mamm prey</sub> = C<sub>soil</sub> x BAF<sub>soil-to-mamm</sub>, or, if transfer factor is diet-to-tissue, as C<sub>mamm prey</sub> = C<sub>diet</sub> x BAF<sub>diet-to-mamm</sub>.
- BAF<sub>soil-to-mamm</sub> = soil to mammal bioaccumulation factor (mg/kg dry plant per mg/kg dry soil)
- C<sub>diet</sub> = Chemical concentration in diet of mammalian prey (mg/kg dry weight), measured or estimated as C<sub>diet</sub> = (C<sub>plant</sub> x P<sub>plant</sub>) + (C<sub>invert</sub> x P<sub>invert</sub>) + (C<sub>soil</sub> x P<sub>soil</sub>) with C<sub>plant</sub>, C<sub>invert</sub>, P<sub>plant</sub>, P<sub>invert</sub>, and P<sub>soil</sub> referring to mammalian prey parameters rather than the focal receptor.
- BAF<sub>diet-to-mamm</sub> = food to mammal bioaccumulation factor (mg/kg dry mammal per mg/kg dry food)
- P<sub>mamm</sub> = Proportion of vertebrate prey in the diet (unitless)
- AF = Absorbed fraction of chemical from ingested food. Assumed = 1. (unitless)
- AUF = Area use factor = ratio of animal's home range to area of site. Maximum is 1, which assumes animal is on-site 100% of the time. Default is 1. (unitless)

**Model for dose to wildlife receptor from ingestion of contaminated soil:**

$$Dose_{soil} = FIR_{BW} \times C_{soil} \times P_{soil} \times AF_{soil} \times AUF$$

where

- FIR BW = Dry food ingestion rate as a function of body weight (kg dry food/kg BW/d)  
 C soil = Chemical concentration in dry soil (mg/kg)  
 P soil = Soil ingestion as a percentage of diet (unitless)  
 AF soil = Absorbed fraction of chemical from soil. Assumed = 1. (unitless)  
 AUF = Area use factor = ratio of animal's home range to area of site. Maximum is 1, which assumes animal is on-site 100% of the time. Default is 1. (unitless)

**Model for estimation of dose to terrestrial receptors from dermal contact:**

$$D_{dermal} = \frac{C_{soil} \times SA \times AdF \times AbF}{BW}$$

where

- C soil = Chemical concentration in dry soil (mg/kg)  
 SA = Receptor's surface area (cm<sup>2</sup>/d)  
 AdF = Adherence Factor, a measure of tendency of soil to adhere to skin. Default set to 1 x 10<sup>-6</sup> kg/cm<sup>2</sup> (EPA Region IV. 1992. New Interim Region IV Guidance Memorandum from Region IV, Atlanta, Georgia. February 11, 1992) (kg/cm<sup>2</sup>)  
 AbF = Absorption Fraction, a measure of the fraction of chemical in contact with skin that is actually absorbed into the body. Default 0.001 for metals and 0.01 for organics (EPA. 1995. Supplemental Guidance to RAGS: Region 4 Bulletins, Human Health Risk Assessment (Interim Guidance). Waste Management Division, Office of Health Assessment, U.S. Environmental Protection Agency, Washington, D.C.). (unitless)  
 BW = Receptor's body weight (kg)

**Model for estimation of dose to terrestrial receptors from inhalation:**

$$D_{inhalation} = \frac{IR_{air} \times C_{air}}{BW}$$

where

- IRair = Receptor's inhalation rate (m<sup>3</sup>/d)  
 Cair = Concentration of chemical in air, calculated as Csoil x PEF for nonvolatile chemicals or as Csoil x 1/VF for volatile chemicals (mg/m<sup>3</sup>)  
 C soil = Chemical concentration in dry soil (mg/kg)  
 PEF = Particulate Emissions Factor, estimate of concentration of dust particles in the air (kg/m<sup>3</sup>)  
 VF = Volatilization Factor, a chemical-specific soil-to-air volatilization factor (m<sup>3</sup>/kg)  
 BW = Receptor's body weight (kg)

**Model for total dose to wildlife receptor from terrestrial exposures:**

This model assumes all pathways are checked.

$$Dose_{receptor} = Dose_{food} + Dose_{soil} + Dose_{dermatocutaneous} + Dose_{inhalation}$$

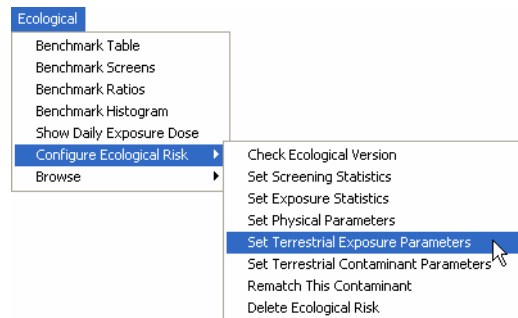
where

- Dosereceptor = Dose to wildlife receptor from terrestrial exposures (mg/kg BW/d)
- Dosefood = Dose from ingestion contaminated food items (mg/kg BW/d)
- Dosesoil = Dose from ingestion of contaminated soil (mg/kg BW/d)
- Dosedermal contact = Dose from dermal exposure to chemicals in soil (mg/kg BW/d)
- Doseinhalation = Dose from inhalation of airborne chemicals (mg/kg BW/d)

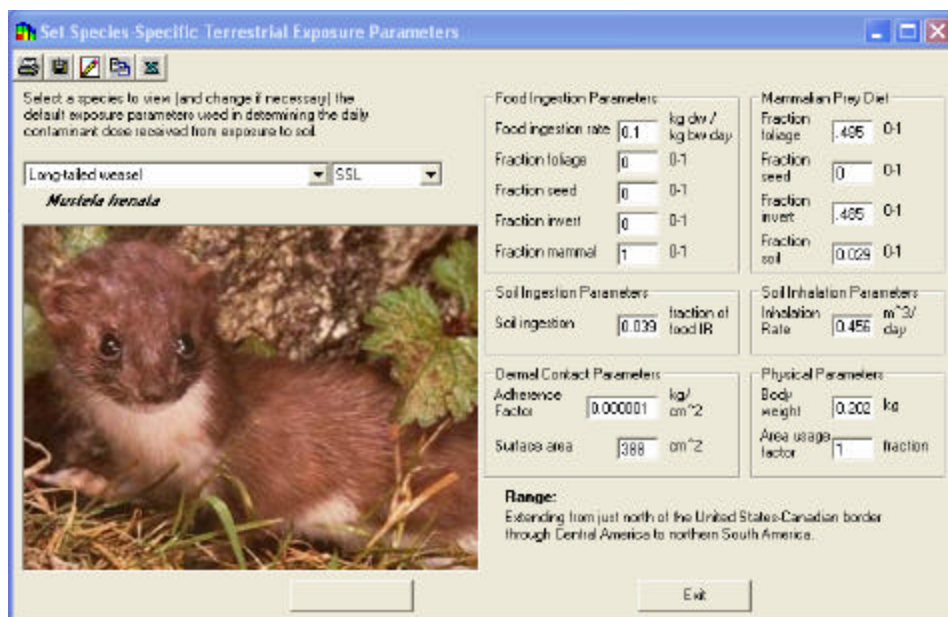
## Set Terrestrial Exposure Parameters

SADA comes preloaded with default exposure parameters for a variety of wildlife receptors, including representative herbivores, insectivores, and carnivores. Defaults are provided for each parameter, but custom values can be entered in the **Set Species-specific Terrestrial Exposure Parameters Window**. These parameters are used in modeling dose to each receptor from selected pathways.

To view (and change if desired) current exposure parameters, from the **Ecological** menu, select **Configure Ecological Risk**, and **Set Terrestrial Exposure Parameters**.



From the resulting window, select a species and whether you want values for adult females, adult males, juveniles, or SSL. SSL follows EPA (2003) guidance for deriving ecological soil screening levels and combines data from adult males and adult females. While custom values can be entered for juveniles, SADA Version 3 does not include default values for juveniles. Note that SSL parameter values are not available for species not included in the Eco-SSL guidance.



To change a parameter value, click on the box corresponding to that parameter, and enter the value. It is very important to use the appropriate units for all parameters.

### **Food ingestion rate**

Food ingestion rate is expressed in terms of kg dry food/kg body weight/day. Entering an ingestion rate in kg/d that has not been adjusted for body weight will result in faulty dose estimates.

### **Diet**

A receptor's diet is described by the proportion of each food type that makes up its total diet. Food types currently allowed in SADA include plants (foliage and/or seeds), invertebrates, and vertebrates. All types of invertebrates are lumped into Fraction Insect, and all types of vertebrates are lumped into Fraction Mamm. The fraction of plants, invertebrates, and vertebrates in the diet should sum to 1.

#### *Mammalian Prey Diet*

Mammalian prey diet is only used when Fraction Mammal is >0 and no soil-to-small mammal bioaccumulation factor is available. Modeling the dose to wildlife receptors requires information on the chemical concentration in the foods they eat. This is fairly straight-forward when soil-to-plant tissue, soil-to-invertebrate tissue, or soil-to-small mammal tissue bioaccumulation factors or regressions are available, since these can be used to estimate food type concentrations directly from the chemical concentration in soil. However, for some chemicals, soil-to-small mammal tissue factors are unavailable, and only diet-to-small mammal tissue biotransfer factors are available. In order to estimate the chemical concentration in vertebrate prey of carnivorous wildlife in these cases, it is necessary to specify the diet of the vertebrate prey. The default in SADA is a small omnivorous mammal consuming 50% plants and 50% invertebrates with soil ingestion equal to 3% of its total food ingestion. The concentration in the diet of the vertebrate prey is then multiplied by the diet-to-tissue transfer factor to estimate the chemical concentration in vertebrate prey.

### **Soil ingestion**

Wildlife receptor soil ingestion is expressed as a fraction of overall ingestion rate.

### **Dermal Contact**

#### *Adherence factor*

The adherence factor is a measure of the tendency for soil to adhere to skin. The data necessary to estimate the dermal adherence factor for wildlife are generally limited or not available. Therefore, a conservative human health value of 1 mg/cm<sup>2</sup> (0.000001 kg/cm<sup>2</sup>) is set as the default for the species provided in SADA (EPA 1992). This value is based on results for laboratory rodents and was developed by shaving the fur and applying the contaminant directly to the exposed skin. However, feathers of birds, fur on mammals, and scales on reptiles are believed to reduce dermal exposure by limiting the contact of the skin surface with the contaminated media (EPA 2000). The user can customize these values if guidance or data is available.

#### *Surface area*

Defaults for wildlife receptor surface area (cm<sup>2</sup>) are based on published studies or modeled based on default body weight using allometric equations for birds or mammals in EPA (1993) Wildlife Exposure Factors Handbook.

### **Inhalation rate**

Inhalation rate is expressed in m<sup>3</sup>/d. Default wildlife receptor inhalation rates are based on published studies or modeled based on default body weight using allometric equations for birds or mammals in EPA (1993) Wildlife Exposure Factors Handbook.

### **Body weight**

Wildlife receptor body weights are expressed in kg. Note that entering a custom body weight will not automatically change the values for surface area and inhalation rate.

## Area Use Factor

The Area Use Factor, or AUF, accounts for the size of the site relative to the size of the receptor's home range. The default assumes the animal spends 100% of its time on the site, so the AUF = 1. This value can be adjusted to any value between 0 and 1 if the receptor uses the site less than 100% of the time.

## Wildlife Exposure Parameters: References

### Food Ingestion Rate (kg dw/kg BW d)

#### *Meadow Vole:*

SSL (Male & Female) -- 90th %ile of distribution for male and female calculated using allometric relationship of Nagy et al. (1999) and full distribution of body weights from EPA (2003). Table 5 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Ann. Rev. Nutr.* 19: 247-277.

Male – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for an herbivorous mammal.

Female – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for an herbivorous mammal.

#### *Mourning Dove:*

SSL (Male & Female) -- 90th %ile of distribution for male and female calculated using allometric relationship of Nagy et al. (1999) and full distribution of body weights from EPA (2003). Table 5 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Ann. Rev. Nutr.* 19: 247-277.

Male – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for a granivorous bird.

Female – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for a granivorous bird.

#### *Short-tailed Shrew:*

SSL (Male & Female) -- 90th %ile of distribution for male and female calculated using allometric relationship of Nagy et al. (1999) and full distribution of body weights from EPA (2003). Table 5 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Ann. Rev. Nutr.* 19: 247-277.

Male – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for an insectivorous mammal.

Female – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for an insectivorous mammal.

*Long-tailed Weasel:*

SSL (Male & Female) -- 90th %ile of distribution for male and female calculated using allometric relationship of Nagy et al. (1999) and full distribution of body weights from EPA (2003). Table 5 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Ann. Rev. Nutr.* 19: 247-277.

Male – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for a carnivorous mammal.

Female – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for a carnivorous mammal.

*American Woodcock:*

SSL (Male & Female) -- 90th %ile of distribution for male and female calculated using allometric relationship of Nagy et al. (1999) and full distribution of body weights from EPA (2003). Table 5 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Ann. Rev. Nutr.* 19: 247-277.

Male – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for an insectivorous bird.

Female – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for an insectivorous bird.

*Red-tailed Hawk:*

SSL (Male & Female) -- 90th %ile of distribution for male and female calculated using allometric relationship of Nagy et al. (1999) and full distribution of body weights from EPA (2003). Table 5 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Nagy, K.A., I.A. Girard, and T.K. Brown. 1999. Energetics of free-ranging mammals, reptiles, and birds. *Ann. Rev. Nutr.* 19: 247-277.

Male – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for a carnivorous bird.

Female – Calculated based on selected male body weight and FMR and FIR data from Nagy et al. (1999) and EPA Eco-SSL Guidance (EPA 2003) for a carnivorous bird.

**Diet**

*Meadow Vole:*

SSL (Male & Female) – Diet for herbivorous mammal was assumed to be 100% plant material.

Male – Diet for herbivorous mammal was assumed to be 100% plant material.



Female – Diet for herbivorous mammal was assumed to be 100% plant material.

*Mourning Dove:*

SSL (Male & Female) -- Diet for granivorous bird was assumed to be 100% plant material.

Male – Diet for granivorous bird was assumed to be 100% plant material.

Female – Diet for granivorous bird was assumed to be 100% plant material.

*Short-tailed Shrew:*

SSL (Male & Female) -- Diet for insectivorous mammal was assumed to be 100% soil invertebrates.

Male – Diet for insectivorous mammal was assumed to be 100% soil invertebrates.

Female – Diet for insectivorous mammal was assumed to be 100% soil invertebrates.

*Long-tailed Weasel:*

SSL (Male & Female) -- Diet for carnivorous mammal was assumed to be 100% small mammals.

Male – Diet for carnivorous mammal was assumed to be 100% small mammals.

Female – Diet for carnivorous mammal was assumed to be 100% small mammals.

*American Woodcock:*

SSL (Male & Female) -- Diet for insectivorous bird was assumed to be 100% soil invertebrates.

Male – Diet for insectivorous bird was assumed to be 100% soil invertebrates.

Female – Diet for insectivorous bird was assumed to be 100% soil invertebrates.

*Red-tailed Hawk:*

SSL (Male & Female) -- Diet for carnivorous bird was assumed to be 100% small mammals.

Male – Diet for carnivorous bird was assumed to be 100% small mammals.

Female – Diet for carnivorous bird was assumed to be 100% small mammals.

**Soil Ingestion (as a fraction of total diet)**

*Meadow Vole:*

SSL (Male & Female) -- 90th %ile of Monte Carlo analyses distribution from EPA ECO-SSL Guidance based on Beyer et al. (1994) model. Table 7 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J. Wildl. Manage. 58: 375-382.

Male – Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J. Wildl. Manage. 58: 375-382.

Female – Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. J. Wildl. Manage. 58: 375-382.

*Mourning Dove:*

SSL (Male & Female) -- 90th %ile of Monte Carlo analyses distribution from EPA ECO-SSL Guidance based on Beyer et al. (1994) model. Table 7 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1

Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.

[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Male – % Soil ingestion was assumed to be the same as for Wild Turkey in Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Female – % Soil ingestion was assumed to be the same as for Wild Turkey in Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

*Short-tailed Shrew:*

SSL (Male & Female) -- 90th %ile of Monte Carlo analyses distribution from EPA ECO-SSL Guidance based on Beyer et al. (1994) model. Table 7 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.

[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Male – Based on unpublished data of C. Garten as reported in Talmage, S.S., and B.T. Walton. 1993. Food chain transfer and potential renal toxicity to small mammals at a contaminated terrestrial field site. *Ecotoxicol.* 2: 243-256. (Sylvia Talmage, Pers. Comm.)

Female – Based on unpublished data of C. Garten as reported in Talmage, S.S., and B.T. Walton. 1993. Food chain transfer and potential renal toxicity to small mammals at a contaminated terrestrial field site. *Ecotoxicol.* 2: 243-256. (Sylvia Talmage, Pers. Comm.)

*Long-tailed Weasel:*

SSL (Male & Female) -- 90th %ile of Monte Carlo analyses distribution from EPA ECO-SSL Guidance based on Beyer et al. (1994) model. Table 7 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.

[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Male – % Soil ingestion was assumed to be the same as for Red Fox in Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Female – % Soil ingestion was assumed to be the same as for Red Fox in Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

*American Woodcock:*

SSL (Male & Female) -- 90th %ile of Monte Carlo analyses distribution from EPA ECO-SSL Guidance based on Beyer et al. (1994) model. Table 7 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.

[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Male – Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Female – Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

*Red-tailed Hawk:*

SSL (Male & Female) -- 90th %ile of Monte Carlo analyses distribution from EPA ECO-SSL Guidance based on Beyer et al. (1994) model. Table 7 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL. [http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Male – % Soil ingestion was assumed to be the same as for Red Fox in Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

Female – % Soil ingestion was assumed to be the same as for Red Fox in Beyer, W.N., E. Conner, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *J. Wildl. Manage.* 58: 375-382.

**Adherence Factor**

A conservative human health value of 1 mg/cm<sup>2</sup> (0.000001 kg/cm<sup>2</sup>) is set as the default for the species provided in SADA.

United States Environmental Protection Agency Region IV. February 11, 1992. New Interim Region IV Guidance Memorandum from Region IV, Atlanta, Georgia.

**Surface Area (cm<sup>2</sup>)**

*Meadow Vole:*

Male & Female -- Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 12.3 BW<sup>0.65</sup> of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Male – Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 12.3 BW<sup>0.65</sup> of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Female – Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 12.3 BW<sup>0.65</sup> of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

*Mourning Dove:*

Male & Female -- Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 10 BW<sup>0.667</sup> of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Male – Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 10 BW<sup>0.667</sup> of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Female – Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 10 BW<sup>0.667</sup> of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

*Short-tailed Shrew:*

Male & Female -- Based on body weight (g) to surface area relationship of SA (cm<sup>2</sup>) = 12.3 BW<sup>0.65</sup> of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Male – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 12.3 BW^{0.65}$  of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Female – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 12.3 BW^{0.65}$  of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

*Long-tailed Weasel:*

Male & Female -- Based on body weight (g) to surface area relationship of  $SA (cm^2) = 12.3 BW^{0.65}$  of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Male – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 12.3 BW^{0.65}$  of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Female – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 12.3 BW^{0.65}$  of Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

*American Woodcock:*

Male & Female -- Based on body weight (g) to surface area relationship of  $SA (cm^2) = 10 BW^{0.667}$  of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Male – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 10 BW^{0.667}$  of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Female – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 10 BW^{0.667}$  of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

*Red-tailed Hawk:*

Male & Female -- Based on body weight (g) to surface area relationship of  $SA (cm^2) = 10 BW^{0.667}$  of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Male – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 10 BW^{0.667}$  of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

Female – Based on body weight (g) to surface area relationship of  $SA (cm^2) = 10 BW^{0.667}$  of Walsberg and King 1978 as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a.

**Inhalation Rate ( $m^3/d$ )**

*Meadow Vole:*

Male & Female -- Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Male – Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of

Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Female – Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

*Mourning Dove:*

Male & Female -- Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Male – Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Female – Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

*Short-tailed Shrew:*

Male & Female -- Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Male – Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Female – Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

*Long-tailed Weasel:*

Male & Female -- Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Male – Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-

93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Female – Estimated using allometric relationship between body weight and inhalation rate for mammals developed by Stahl (1967) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

*American Woodcock:*

Male & Female -- Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Male – Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Female – Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

*Red-tailed Hawk:*

Male & Female -- Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Male – Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

Female – Estimated using allometric relationship between body weight and inhalation rate for nonpasserine birds developed by Lasiewski and Calder (1971) as reported in EPA. 1993. Wildlife Exposure Factors Handbook. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-93/187a. Result was multiplied by a 3x correction factor applied to account for differences between field and standard metabolic rates.

**Body Weight (kg)**

*Meadow Vole:*

SSL (Male & Female) -- Mean for males and females based on Monte Carlo analyses of literature data. Appendix 4-1 Table 2 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.

[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Male – Reich, L.M. 1981. *Microtus pennsylvanicus*. Mammalian Species Account. Amer. Soc.Mammal. Species No. 159. 8 pp.



Female – Reich, L.M. 1981. *Microtus pennsylvanicus*. Mammalian Species Account. Amer. Soc.Mammal. Species No. 159. 8 pp.

*Mourning Dove:*

SSL (Male & Female) -- Mean for males and females based on Monte Carlo analyses of literature data. Appendix 4-1 Table 2 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.  
[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Male – Dunning, J.B. 1993. CRC Handbook of Avian Body Masses. CRC Press, Boca Raton, FL.

Female – Dunning, J.B. 1993. CRC Handbook of Avian Body Masses. CRC Press, Boca Raton, FL.

*Short-tailed Shrew:*

SSL (Male & Female) -- Mean for males and females based on Monte Carlo analyses of literature data. Appendix 4-1 Table 2 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.  
[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Male – Silva, M., and J.A. Downing. 1995. CRC Handbook of Mammalian Body Masses. CRC Press, Boca Raton, FL.

Female – Silva, M., and J.A. Downing. 1995. CRC Handbook of Mammalian Body Masses. CRC Press, Boca Raton, FL.

*Long-tailed Weasel:*

SSL (Male & Female) -- Mean for males and females based on Monte Carlo analyses of literature data. Appendix 4-1 Table 2 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.  
[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Male – Mumford, R.E., and J.O. Whitaker, Jr. 1982. Mammals of Indiana. Indiana Univ. Press, Bloomington.

Female – Mumford, R.E., and J.O. Whitaker, Jr. 1982. Mammals of Indiana. Indiana Univ. Press, Bloomington.

*American Woodcock:*

SSL (Male & Female) -- Mean for males and females based on Monte Carlo analyses of literature data. Appendix 4-1 Table 2 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.  
[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

Male – Keppie, D.M., and R.M. Whiting, Jr. 1994. American Woodcock (*Scolopax minor*). In The Birds of North America, No. 100. The Birds of North America, Inc., Philadelphia, PA.

Female – Keppie, D.M., and R.M. Whiting, Jr. 1994. American Woodcock (*Scolopax minor*). In The Birds of North America, No. 100. The Birds of North America, Inc., Philadelphia, PA.

*Red-tailed Hawk:*

SSL (Male & Female) -- Mean for males and females based on Monte Carlo analyses of literature data. Appendix 4-1 Table 2 in EPA ECO-SSL guidance (EPA. 2003. Guidance for Developing Ecological Soil Screening Levels. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 92857-55. Attachment 4-1 Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSL.

[http://www.epa.gov/ecotox/ecossl/pdf/ecossl\\_attachment\\_4-1.pdf](http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf)

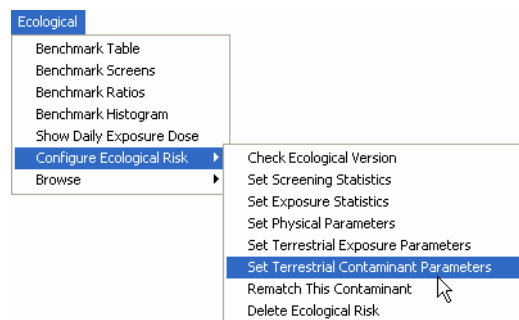
Male – Preston, C.R., and R.D. Beane. 1993. Red-tailed Hawk (*Buteo jamaicensis*). In The Birds of North America, No. 52. The Birds of North America, Inc., Philadelphia, PA.

Female – Preston, C.R., and R.D. Beane. 1993. Red-tailed Hawk (*Buteo jamaicensis*). In The Birds of North America, No. 52. The Birds of North America, Inc., Philadelphia, PA.

## Set Terrestrial Contaminant Parameters

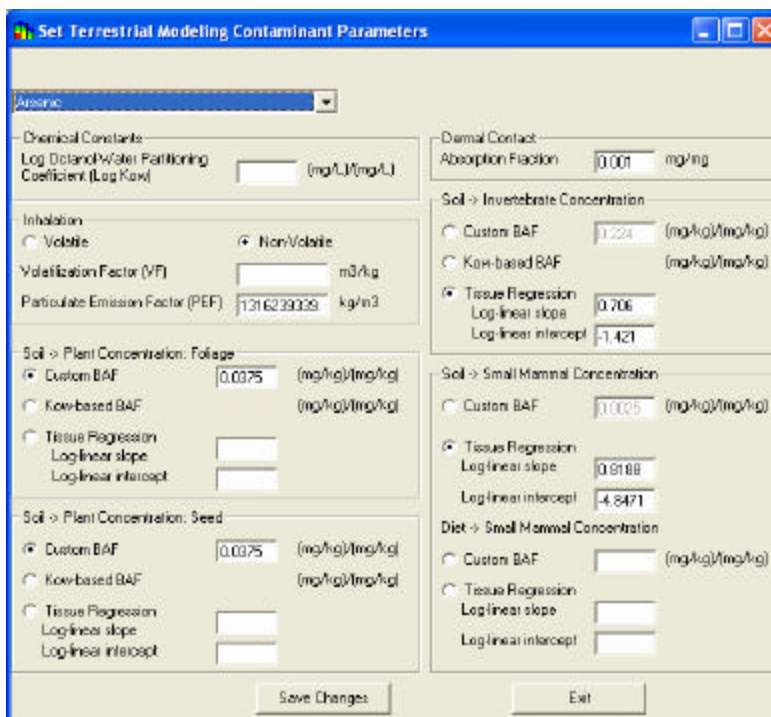
Many of the parameters used in modeling dose to wildlife receptors are chemical-specific rather than species-specific. For species-specific parameters, see the section **Set Terrestrial Exposure Parameters**. Custom values for contaminant-specific parameters can be entered in the **Set Terrestrial Modeling Contaminant Parameters Window**. These parameters are used in modeling dose to each receptor from selected pathways.

To view (and change if desired) current contaminant-specific exposure parameters, from the **Ecological** menu, select **Configure Ecological Risk**, and **Set Terrestrial Modeling Contaminant Parameters**.



In the resulting window, select an analyte from the drop down list.





To change a parameter value, click on the box corresponding to that parameter, and enter the value. When you've finished modifying the parameters for the species, click the **Save Changes** button, and the changes will be saved to your SADA file. Otherwise, changes will not be saved.

It is very important to use the appropriate units for all parameters.

### Log Octanol-Water Partitioning Coefficient (log Kow)

The octanol-water partition coefficient (Kow) is a measure of the equilibrium concentration of a compound between octanol and water that indicates the potential for partitioning into soil organic matter (i.e., a high Kow indicates a compound which will preferentially partition into soil organic matter rather than water). Kow is inversely related to the solubility of a compound in water. Log Kow is used in models to estimate plant and soil invertebrate bioaccumulation factors.

### Inhalation Parameters

Inhalation exposures occur when a chemical volatilized from soil is inhaled as a vapor or when soil particles containing the chemical are respired. Two parameters are needed to estimate chemical concentrations in air to determine dose from inhalation exposures: the Volatilization Factor (VF) and the Particulate Emission Factor (PEF).

#### *Volatilization Factor*

The Volatilization Factor (VF), in  $\text{m}^3/\text{kg}$ , is a measure of the tendency of a chemical to volatilize from soil to vapor. Volatile Organic Compounds (VOC) are defined by USEPA (1998) as chemicals with Henry's Law constants greater than  $10^{-5} \text{ atm}\cdot\text{m}^3/\text{mol}$  and molecular weights less than 200 grams/mol.

#### *Particulate Emission Factor*

The Particulate Emission Factor (PEF), expressed in  $\text{kg soil}/\text{m}^3 \text{ air}$ , is a measure of the amount of respirable soil particles in a volume of air. It is used to estimate chemical concentrations in air from concentrations in soil.

### Soil-to-Plant Concentration

Modeling ingestion exposures for herbivorous wildlife receptors requires information on chemical concentrations in plant tissues. Chemical concentrations in plant tissues are calculated from soil

concentrations using point estimates of soil-to-plant bioaccumulation factors (BAF), estimated bioaccumulation factors based on octanol-water partitioning coefficients (for nonionic organic analytes), or soil-to-plant tissue regression relationships. Regression relationships are the preferred means of calculating plant concentrations. SADA Version 3 separates plant tissues into two types: foliage and seeds. In many cases, current default settings assume seed and foliage uptake are similar since soil-to-foliage values are more generally available.

Default point estimates appear as **Custom BAFs**. Users can modify these values if they have site-specific values or prefer values from a source other than that used to derive default values for SADA.

**Kow-based soil-to-plant BAFs** were generated using the following equation from EPA (2000):

$$BAF_{plant} = 10^{2.563 - 0.4965 \log K_{ow}}$$

where

BAF<sub>plant</sub> = soil to plant foliage bioaccumulation factor (  $\frac{mg / kg \text{ dry plant}}{mg / kg \text{ dry soil}}$  )  
 Kow = octanol-water partitioning coefficient.

**Soil-to-plant tissue regression** relationships are of the form:

$$C_{tissue} = e^{\text{slope} \times \ln(C_{soil}) + \text{intercept}}$$

where

C<sub>tissue</sub> = Chemical concentration in plant tissue (mg/kg, dry weight)  
 C<sub>soil</sub> = Chemical concentration in dry soil (mg/kg)  
 Slope = coefficient for slope of the regression model  
 Intercept = value for the y-intercept of the regression model.

### Dermal Contact Parameters

Absorption factor

The absorption factor for dermal contact is a ratio of the amount of chemical in contact with the skin that is actually absorbed into the body.

### Soil-to-Invertebrate Concentration

Modeling ingestion exposures for insectivorous wildlife receptors requires information on chemical concentrations in invertebrate tissues. Chemical concentrations in invertebrate tissues are calculated from soil concentrations using point estimates of soil-to-invertebrate bioaccumulation factors (BAF), estimated bioaccumulation factors based on octanol-water partitioning coefficients (for nonionic organic analytes), or soil-to-invertebrate tissue regression relationships. Regression relationships are the preferred means of calculating invertebrate concentrations.

Default point estimates appear as **Custom BAFs**. Defaults are largely based on data for earthworms. Earthworms live in direct contact with soil, process large amounts of soil through their bodies, and are assumed to be on the high end of bioaccumulation by invertebrates. Users can modify these values if they have site-specific values or prefer values from a source other than that used to derive default values for SADA.

**Kow-based soil-to-invertebrate BAFs** were generated using the following equation from EPA (2000):

$$BAF_{worm} = \frac{10^{foc \cdot Kow - 0.6}}{f_{oc} \times 10^{foc \cdot Kow - 0.6}}$$

where

- BAF<sub>worm</sub> = soil to earthworm bioaccumulation factor (  $\frac{mg/kg\ dry\ worm}{mg/kg\ dry\ soil}$  )
- foc = fraction organic carbon in soil. Default is set to 1%.
- Kow = octanol-water partitioning coefficient.

**Soil-to-invertebrate tissue regression** relationships are of the form:

$$C_{tissue} = e^{slope \times \ln(C_{soil}) + intercept}$$

where

- C<sub>tissue</sub> = Chemical concentration in invertebrate tissue (mg/kg, dry weight)
- C<sub>soil</sub> = Chemical concentration in dry soil (mg/kg)
- Slope = coefficient for slope of the regression model
- Intercept = value for the y-intercept of the regression model.

#### Soil-to-Small Mammal Concentration

Modeling ingestion exposures for carnivorous wildlife receptors requires information on chemical concentrations in vertebrate prey. Chemical concentrations in vertebrate prey are calculated from soil concentrations using point estimates of soil-to-vertebrate bioaccumulation factors (BAF) or soil-to-vertebrate tissue regression relationships. Regression relationships are the preferred means of calculating mammalian prey concentrations. When soil-to-tissue relationships are unavailable, it may be necessary to use diet-to-tissue bioaccumulation factors. In SADA, the simplifying assumption that carnivores eat small mammals has been made. This is because bioaccumulation factors for mammals are available for a wide range of chemicals whereas they are often lacking for birds and other vertebrates. Therefore, SADA refers to Fraction Mammal in the diet and Soil-to-Small Mammal BAFs.

Default Soil-to-Small Mammal point estimates appear as **Custom BAFs**. Defaults are largely based on data compiled by Sample et al. (1998) or EPA (2003). Users can modify these values if they have site-specific values or prefer values from a source other than that used to derive default values for SADA.

**Kow-based soil-to-vertebrate or diet-to-vertebrate BAFs** are not provided in SADA Version 3 based upon recommendations in EPA (2003).

**Soil-to-vertebrate tissue regression** relationships are of the form:

$$C_{tissue} = e^{slope \times \ln(C_{soil}) + intercept}$$

where

- C<sub>tissue</sub> = Chemical concentration in vertebrate tissue (mg/kg, dry weight)
- C<sub>soil</sub> = Chemical concentration in dry soil (mg/kg)
- Slope = coefficient for slope of the regression model
- Intercept = value for the y-intercept of the regression model.

#### Diet-to-Small Mammal Concentration

When Soil-to-Small Mammal relationships are unavailable, chemical concentrations in vertebrate prey of carnivorous wildlife may be estimated from Diet-to-Small Mammal BAFs. Unlike soil-to-tissue BAFs where the BAF is multiplied by the soil concentration to arrive at the tissue concentration, diet-to-tissue BAFs are multiplied by the chemical concentration in the prey animal's diet to determine the tissue concentration. Thus, it's necessary to estimate the chemical concentration in the prey animal's diet. SADA does this using dietary information specified for **Mammalian Prey Diet** at the **Set Terrestrial Exposure Parameters** screen.

Default Diet-to-Small Mammal point estimates appear as **Custom BAFs**. Defaults are largely based on studies of uptake into beef. When necessary, they were converted from transfer factors in d/kg to BAFs in mg/kg tissue per mg/kg dry food by multiplying the transfer factor by the dry food ingestion rate for beef cows. Users can modify these values if they have site-specific values or prefer values from a source other than that used to derive default values for SADA.

No Diet-to-Tissue regression relationships have been included in SADA, but users who have developed their own relationships may enter the slope and intercept values under Diet-to-Small Mammal Concentration, Tissue Regression if the **Diet-to-vertebrate tissue regression** relationship is of the form:

$$C_{\text{tissue}} = e^{\text{slope} \times \ln(C_{\text{diet}}) + \text{intercept}}$$

where

C<sub>tissue</sub> = Chemical concentration in vertebrate tissue (mg/kg, dry weight)

C<sub>diet</sub> = Chemical concentration in diet (mg/kg, dry weight)

Slope = coefficient for slope of the regression model

Intercept = value for the y-intercept of the regression model.

# MARSSIM

## MARSSIM Overview

SADA version 4 includes a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) module. MARSSIM implements a nonparametric statistical methodology for the design and analysis of final status decommissioning surveys for the Nuclear Regulatory Commission. Nonparametric statistical methods for testing compliance with decommissioning criteria are provided for the case where radionuclides of concern are in background and also for when they are not in background. The tests implemented are the Sign Test and the Wilcoxon Rank Sum Test. The tests are performed in conjunction with an Elevated Measurement Comparison to provide confidence that the radiological criteria specified for license termination are met. Principles and methods from the Data Quality Objectives process are used for the planning of final site surveys. Methods for determining the number of samples for obtaining statistically valid comparisons with the cleanup criteria and the methods for conducting the statistical tests with the collected data are included.

A fairly focused approach is used in SADA for MARSSIM. This module was created under the close guidance of the NRC. The steps for performing MARSSIM analysis are as follows.

1. Create an empty SADA file.
2. Establish site boundaries and survey units.
3. Parameterize and create one or more MARSSIM sample designs.
4. Name/lock the created designs.
5. Import data into the empty SADA file
6. Associate newly imported contaminants with named designs.
7. Perform MARSSIM analysis.

## Develop MARSSIM Sample Design - Interview

This interview produces a sample design strategy for empty SADA files based on MARSSIM principles.

### Availability

This interview is only available for empty SADA files.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. Display empty plot
2. Set up the site
3. Set GIS Overlays
4. MARSSIM Parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document

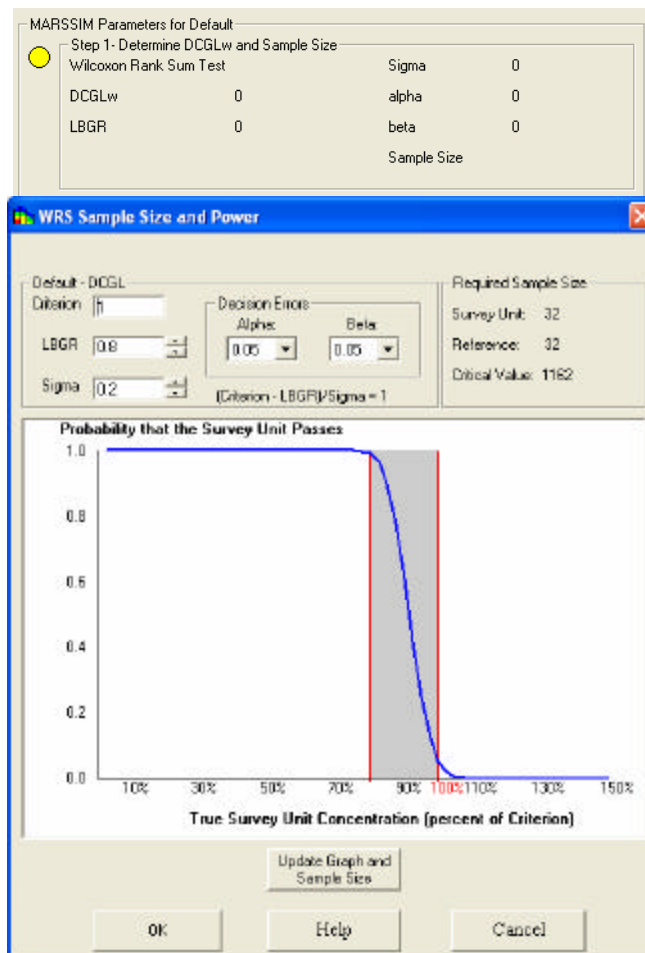
The user must establish site boundaries using Step 2 Set up the site. If desired, the polygon tool may be used to establish one or more survey units within the site. When developing a MARSSIM design, only a surface layer design is permitted. A surface layer design is defined as a single layer design with Z min =0

and  $Z_{max} = 0$ . SADA automatically creates a default and uneditable layer called "Surface Layer" that satisfies these requirements or the user may choose to create and use one of their own.

Once the site parameters are established, the user must specify the MARSSIM sample design parameters. Click on MARSSIM parameters to choose the MARSSIM class, choose the statistical test, and select whether the grid sampling will be triangular or square. The MARSSIM class choices are I, II, or III.

Once the MARSSIM parameters are setup as needed, the user must select Step 5. Show The Results to go through the process of determining the number of samples needed.

Given a test method, the user then inputs the Derived Concentration Guideline (DCGL), the Lower Bound of the Gray Region (LBGR), the expected standard deviation (Sigma), and the acceptable rates for alpha (false positive) and beta (false negative) decision errors. With these inputs, SADA will show a power curve and the number of samples necessary to characterize the decision.



For Class I and II sites, based upon the area of the site and the number of samples to be collected, a grid area can be derived which is the maximum area of a hot spot that can be missed by systematic sampling. Associated with this is an area factor which is a factor used to adjust the DCGLw in order to estimate DCGL<sub>emc</sub> and the minimum detectable concentration for scanning surveys.

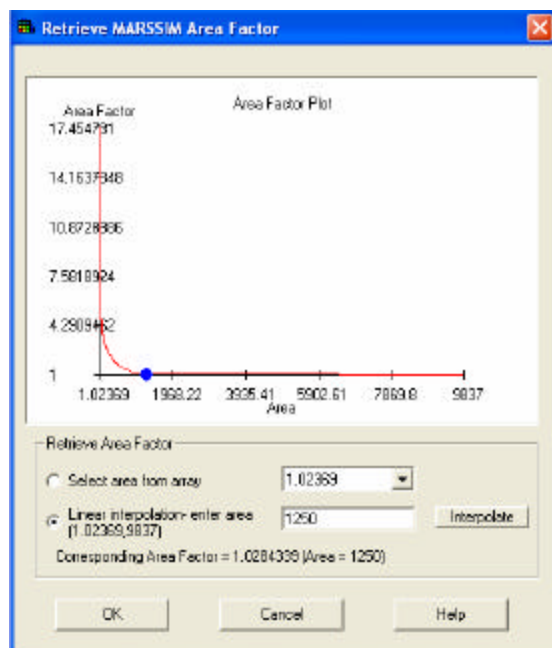
Step 2- Enter Area Factor

Grid Area (Survey area/ Sample Size) 1250 (40000/32)

Area Factor (AF) for Grid Area 0 >=1

Retrieve AF from RESRAD-MARSSIM

If necessary, the area factor can be retrieved from an excel file that contains adjoining columns for area and area factor. The range of interest must be a range named in Excel as "Marssim". Once the file is successfully imported the Area-Area Factor plot will be displayed.



SADA will interpolate the area factor for the area of your site based upon the area-area factor curve for your contaminant.

Once the area factor is entered, the DCGLemc can be calculated and the user must enter the Minimum Detectable Concentration (MDC) of the scanning instrument to ensure that the scanning instrument can detect radionuclide concentrations at the DCGLemc. If the MDC is less than or equal to the DCGLemc:

Step 3- Enter Minimum Detectable Concentration (MDC)

DCGLemc 1.0284339

MDC for Instrument 1

Then the user will get a message that the instrument check has passed and the number of samples that were calculated earlier is sufficient:

Step 4- Instrumentation Check

**Current check of instrumentation has passed. The Minimum Detectable Concentration of 1 is less than or equal to the DCGLemc of 1.0284339.**

However, if the MDC is greater than the DCGLemc:

Step 3- Enter Minimum Detectable Concentration (MDC)

DCGLemc 1.0284339

MDC for Instrument 2

The user will get a message stating that the instrument check has failed and that a revised grid area is needed in order to support the scanning capabilities.

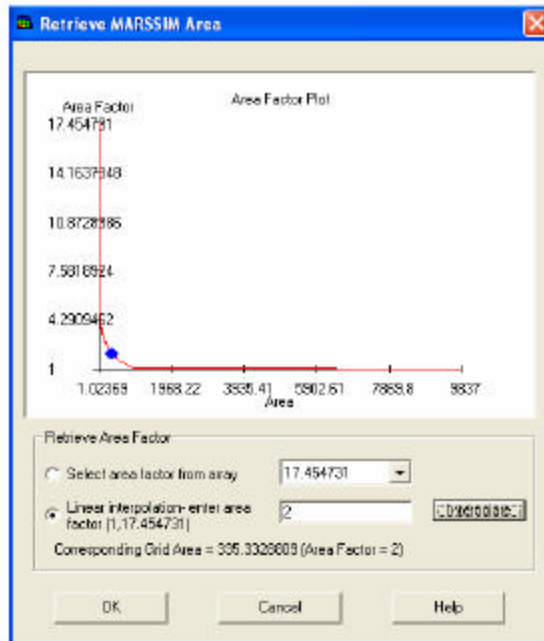
Step 4- Instrumentation Check

**Current check of instrumentation has failed. The Minimum Detectable Concentration of 2 is greater than the DCGLemc of 1.0284339. Please enter a revised grid area.**

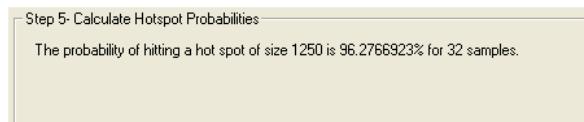
Grid Area for needed Area Factor (AF=2) 335.3328809 0 < New Grid Area < 1250

Sample N for New Grid Area Retrieve Grid Area from RESRAD-MARSSIM

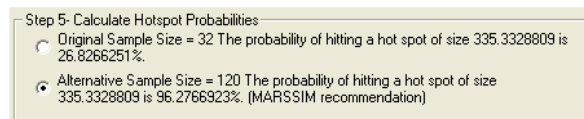
The user can either enter the revised grid area for a DCGL<sub>mc</sub> that is equal to the MDC, or it can once again be retrieved from the excel file with the Area-Area Factor curve by selecting "Retrieve Grid Area from RESRAD-MARSSIM":



If the user passed the instrument test, then SADA will perform a hot spot probability check to estimate the chances of hitting a hot spot equivalent to the size of the grid area.



If the user failed the instrument test, then SADA will perform a hot spot probability estimate for both the original sample size and the alternative sample size based upon the new (smaller) grid area.



The user can select either the original sample size, or the alternative sample size, but MARSSIM recommends use of the alternative sample size.

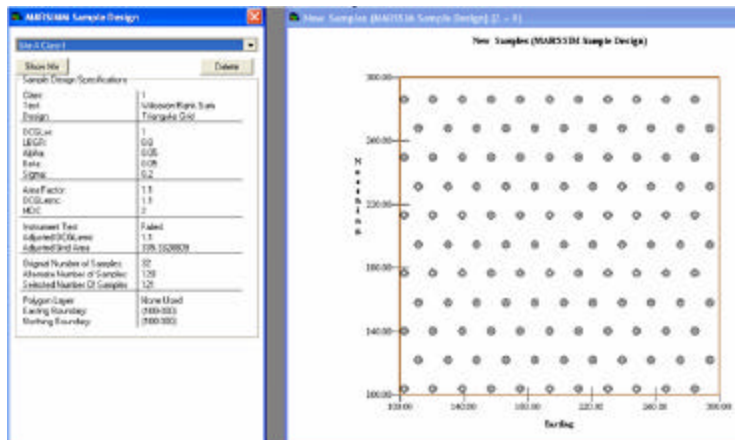
Once these parameters are complete and a sample size has been determined, SADA will then generate a grid design for Class I and II sites. When generating a grid design, SADA uses its simple grid mechanism. This approach chooses a random starting point in the survey unit. This starting point serves as an anchor for the design. Samples are then distributed according to the recommended separation distance  $D = (\text{Survey Area})/(\text{Number Of Samples})$ .

Often this recommended separation is unsuitable to adequately fill the survey area. SADA then iteratively contracts or expands the distance between sample points until a grid design is arrived at that 1) completely fills the survey unit and 2) comes as close as possible to the number of samples required. The number of samples will always be at least as large as the number required. However due to grid specifications and survey unit geometries more samples may be required to fill the area.

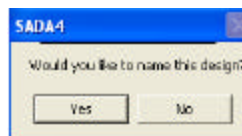




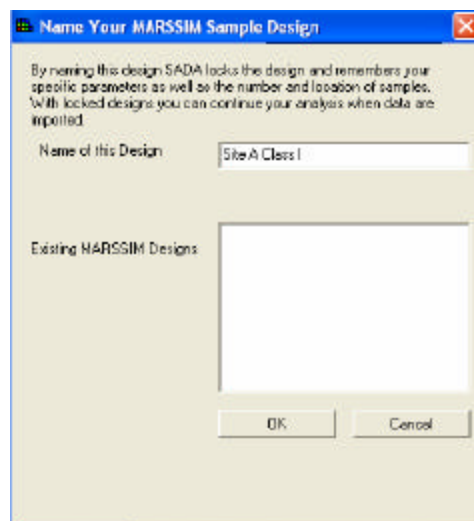
The user can then view the sample design.



If the generated design is acceptable, name the design and SADA will lock it permanently. When SADA locks a design it freezes all parameters including MARSSIM parameters, site boundaries, survey units, and generated sample designs.



The user should enter a name for the locked design to save it.



The user can see these locked values by selecting the MARSSIM name from the MARSSIM parameters step.

## MARSSIM Parameters Step

This step is used to set the parameters for a MARSSIM sample design. This step is only available when the Develop a sample design interview is selected.

Select **MARSSIM Parameters** from the Steps Window. The Parameters Window will display the following.



### Step 1: Choose the class

*Class I Areas:* Areas containing locations where, prior to remediation, the concentrations of residual radioactivity may have exceeded the DCGLW.

*Class II Areas:* Areas containing no locations where, prior to remediation, the concentrations of residual radioactivity may have exceeded the DCGLW.

*Class III Areas:* Areas with a low probability of containing any locations with residual radioactivity.

Class I areas have the highest potential for containing small areas of elevated activity exceeding the release criterion. Therefore, both the number of sampling locations and the extent of scanning effort is greatest. The sampling effort is driven by the goal of finding areas with concentrations in exceedance of the DCGLEMC. Sampling is done on a systematic grid and the distance between sampling locations is made small enough so that any elevated area that might be missed by sampling would be found by scanning.

Class II areas may contain residual radioactivity, but the potential for elevated areas is very small. Sampling is done on a systematic grid and the distance between samples is limited by limiting the maximum size of the survey unit. Scanning coverage ranges from 10-100% depending on the potential for elevated areas.

Class III areas should contain little, if any, residual radioactivity. There should be virtually no potential for elevated areas. Sampling is random across the unit and the sampling density can be very low. Scanning is performed on a judgmental basis.

### Step 2: Choose the statistical test

The type of test that is performed depends on whether the radionuclide is naturally present in background or not. If the contaminant is present in background, then data for the contaminant is collected from a reference area and the Wilcoxon Rank Sun test is performed. If the contaminant is not expected to be present in reference samples, then the Sign Test is performed.

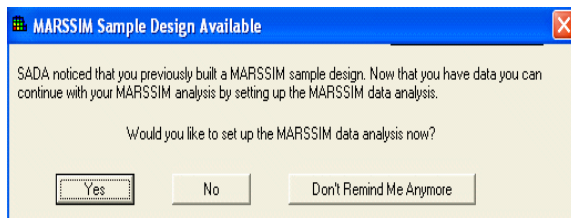
### Step 3: Set the sampling grid style

For Class I and II areas where systematic sampling is performed, the grid designs can be either triangular or square. Generally, triangular grids are preferred to square grids for systematic sample designs due to its ability to minimize the area of a missed hot spot with the same number of samples.

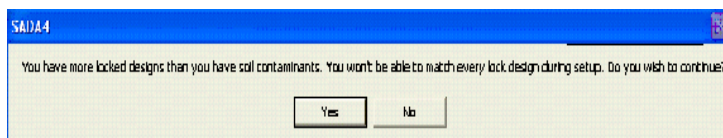
## Perform MARSSIM Analysis

Once one or more MARSSIM sample designs have been locked, users can import sampled data. Once data is imported into SADA, they user can no longer create new MARSSIM sample designs. If unsure about the need for more additional designs, a backup of the file should be made prior to importing new data.

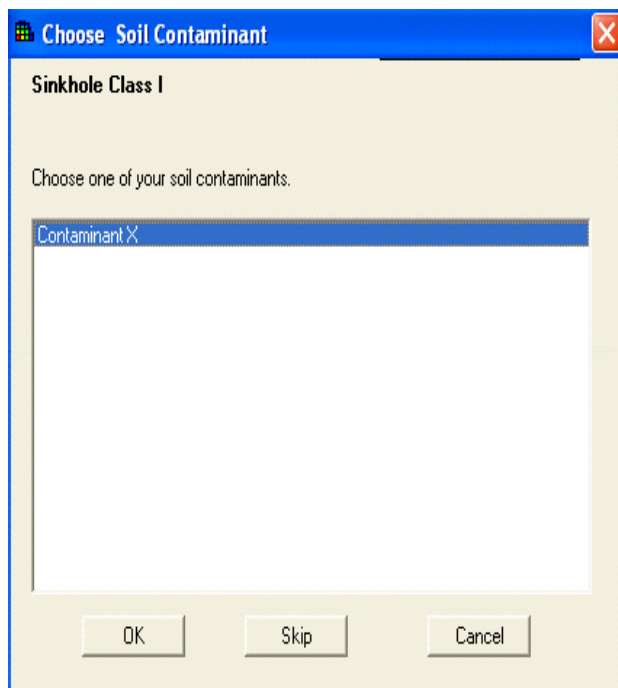
Click on "Import Sampled Data to begin". SADA will present the locked designs and confirm that these are all the designs needed. SADA proceeds through the normal import data process. Once complete, SADA presents the user with the opportunity to now set up the SADA file for MARSSIM. Users can only set up a SADA file for MARSSIM analysis if there are locked MARSSIM designs available. You can choose to set the MARSSIM analysis up now or later select **Setup MARSSIM** from the **Setup** menu.



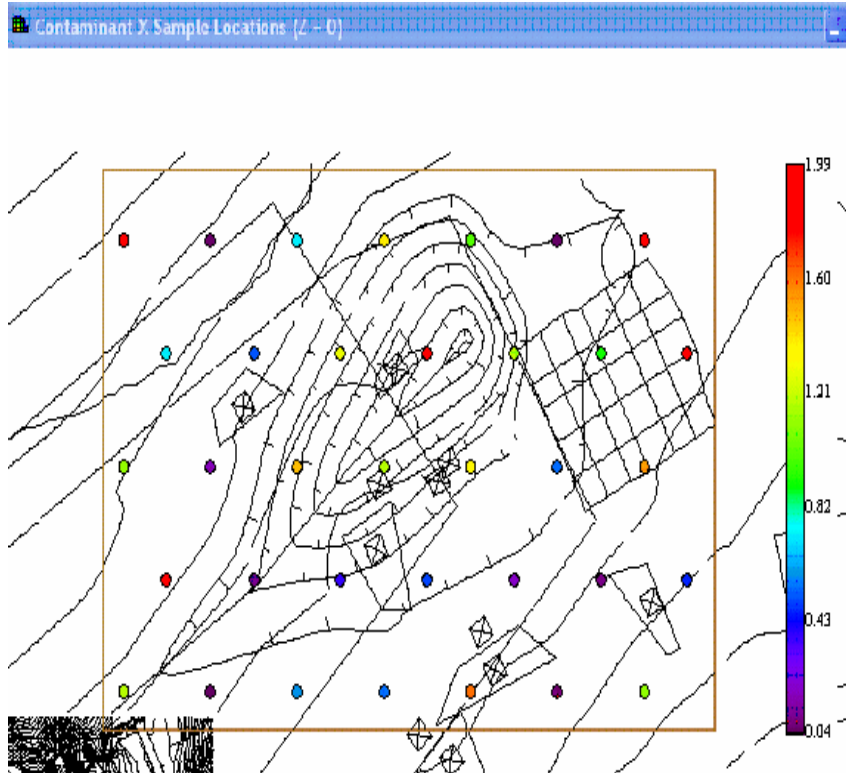
For each MARSSIM design, you may choose only one contaminant to perform a detection test at a time. When setting up the MARSSIM analysis, SADA presents the following form.



For each MARSSIM design choose a contaminant. The MARSSIM design is bolded at the top. If the user does not wish to associate the selected MARSSIM design with a contaminant press **Skip**.



Once all the associations have been made and the MARSSIM analysis has been completed the user will have access to the MARSSIM analysis functions and the data.



Once the setup is complete, switch to MARSSIM data analysis in the interview box. SADA permits only one action under MARSSIM: Perform MARSSIM Analysis (Scenario A).

Like all analysis types, only those contaminants involved in the setup are available in the drop down list. Choose the contaminant of interest and the associated MARSSIM locked design will present itself in a design/data combo plot. This plot shows where samples were planned versus where they were taken. Press **Show the Results** to run the test for detecting elevated areas.

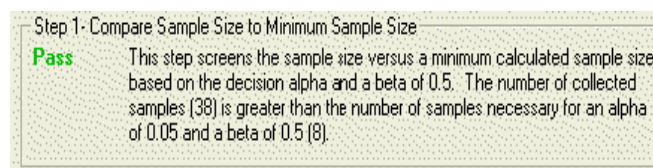
There are 5 primary steps to the MARSSIM analysis

1. Compare sample size to minimum sample size
2. Compare all measurements to a DCGL value
3. Compare survey area mean to a DCGL value
4. Conduct statistical test versus DCGL value
5. Compare all measurements to a DCGL value

The exact values used vary for the Class type and there are differences in the statistical test based upon whether background data is available (WRS Test) or not (Sign Test).

### Step 1: Compare sample size to minimum sample size

An alternative sample size is calculated based on the alpha decision error and a beta error of 0.5. This sample size is compared to the number of actual samples for that analysis. If there are sufficient samples then the user will get a message:



If there are not enough samples then the message will indicate that the user failed step 1:

Step 1- Compare Sample Size to Minimum Sample Size  
**Fail** This step screens the sample size versus a minimum calculated sample size based on the decision alpha and a beta of 0.5. The number of collected samples (5) is less than the number of samples necessary for an alpha of 0.05 and a beta of 0.5 (8).

### Step 2: Compare all measurements to DCGL value

In this step, for the Sign Test, all the measurements are individually compared to the DCGL value. The step will indicate the number of samples that exceed the DCGL. If all the measurements are below the DCGL then the message will indicate that the user has passed and that steps 3 and 4 are not necessary. For the WRS test, the maximum of the sample data is compared to the minimum of the background data. If this maximum value minus the minimum of the background data is greater than the DCGL then steps 3 and 4 are not necessary.

For the Sign Test:

Step 2- Compare all measurements to DCGLw  
**Pass** All values are less than the DCGLw (1).

Step 3- Compare survey area mean to DCGLw  
Comparison of area mean to DCGLw is not necessary.

Step 4- Conduct statistical test versus DCGLw  
Sign test not necessary.

For the WRS Test:

Step 2- Compare site measurements versus DCGLw  
**Pass** The maximum of the survey data (0.4107868) minus the minimum of the background data (0.0224778) is less than the DCGLw (1).

Step 3- Compare mean difference between survey and background to DCGLw  
Comparison of mean difference between background and the survey data to DCGLw is not necessary.

Step 4- Conduct statistical test versus DCGLw  
WRS test not necessary.

If some of the values are greater than the DCGL for the Sign Test then steps 3 and 4 are necessary and the user will get a message indicating the number of samples in exceedance.

Step 2- Compare all measurements to DCGLw  
**Fail** 20 of 26 values (max = 4.7222757) exceed the DCGLw (1).

Likewise, if the maximum of the survey data is greater than the minimum of the background data by the magnitude of the DCGL then the user will get a failure message.

Step 2- Compare site measurements versus DCGLw  
**Fail** The maximum of the survey data (4.9239346) minus the minimum of the background data (0.0224778) exceeds the DCGLw (1).

### Step 3: Compare survey area mean to a DCGL value

If step 2 fails, then a comparison is made. For the Sign Test, the comparison is between the mean of the data and the DCGL. For the WRS test, the comparison is between the mean of the survey data and the mean of the background data. If the comparison fails then step 4 is not necessary.

Step 3- Compare mean difference between survey and background to DCGLw  
**Fail** Mean difference between survey (2.693962) and background (0.2741247) exceeds the DCGLw (1).

Step 4- Conduct statistical test versus DCGLw  
WRS test not necessary.

### Step 4: Perform statistical test

Performing the actual statistical test is necessary when step 3 fails and step 4 passes. The result of the test will be given along with the significance statistics.

Step 4- Conduct statistical test versus DCGLw  
**Pass** WRS Test comparison between the survey data and the DCGLw passed.  
Critical value = 1111. Sum of ranks for contaminant one is 1346.

Step 4- Conduct statistical test versus DCGLw  
**Fail** WRS Test comparison between the survey data and the DCGLw failed.  
Critical value = 1129. Sum of ranks for contaminant one is 697.

### Step 5: Compare all measurements to DCGLemc

Individual measurements are compared to the DCGLemc, if any locations exceed this value, then the site fails this step.

Step 5- Class I: Compare all measurements to DCGLemc  
**Pass** 0 of 38 values exceed the DCGLemc (1).

Step 5- Class I: Compare all measurements to DCGLemc  
**Fail** 15 of 31 values exceed the DCGLemc (1).

An overall summary is given at the bottom of the form, this text indicates whether the site passed overall or not based upon the results of the 5 steps.

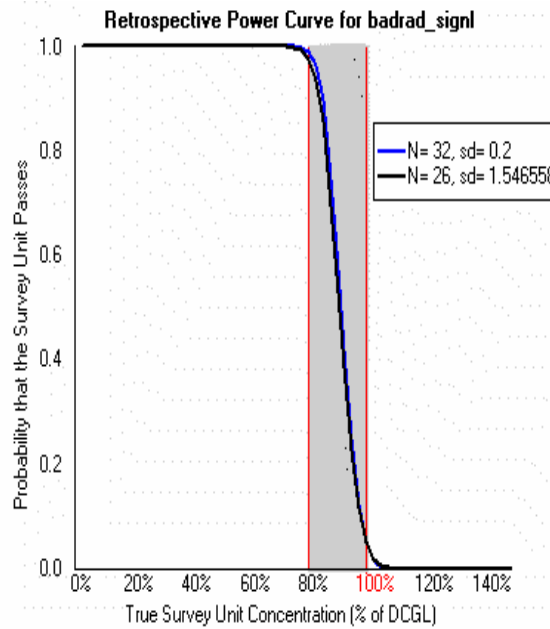
**No elevated areas were detected in the survey area data.**

**Elevated areas were detected in the survey area data.**

### Retrospective power curves

Retrospective power curves are generated based on the original power curve from the locked design and an updated curve that is a function of the actual number of samples collected and the standard deviation

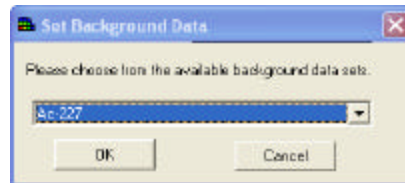
of the collected data. Depending on how similar these values are from the survey data compared to the original locked design, the power curves will either closely track each other:



### Set Background Data - Step

This step is available for the Perform MARSSIM Analysis (Scenario A) interview only.

Select **Set background data** from the Steps Window. The following information is displayed in the Parameters Window.



Select the applicable background data set with the drop down list and press **OK**.



## Custom Analysis

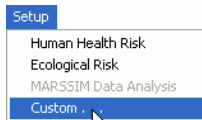
SADA provides a custom analysis module for importing external screening data. This module provides the following functions:

- Setup Custom Analysis
- Delete Custom Analysis
- Rematching Custom Contaminants
- Set Custom Screening Statistics
- Custom Values
- Screening Data Against Custom Values
- Using Custom Analysis Results

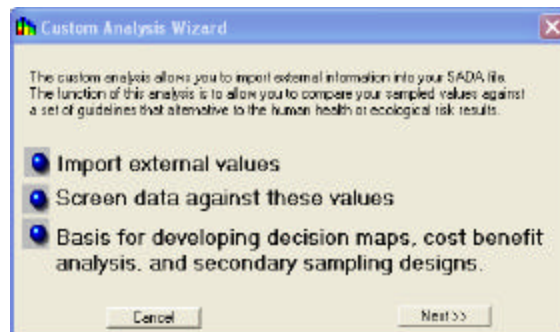
### Setup Custom Analysis

The custom criteria analysis allows users to import external data into SADA to use for screening purposes. For example, a user may wish to screen data against state soil screening values. The results may then be integrated into the other modules, such as decision maps, cost benefit analysis, or sampling schemes. First, the user must import the data into the SADA file via the Custom Analysis Wizard.

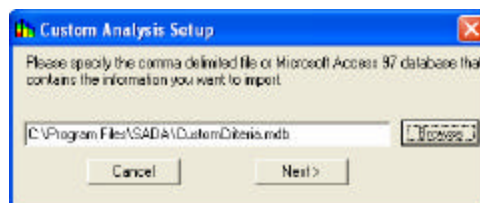
From the **Setup** menu, press **Custom...**



The Custom Analysis Wizard opens. Press **Next>>**.

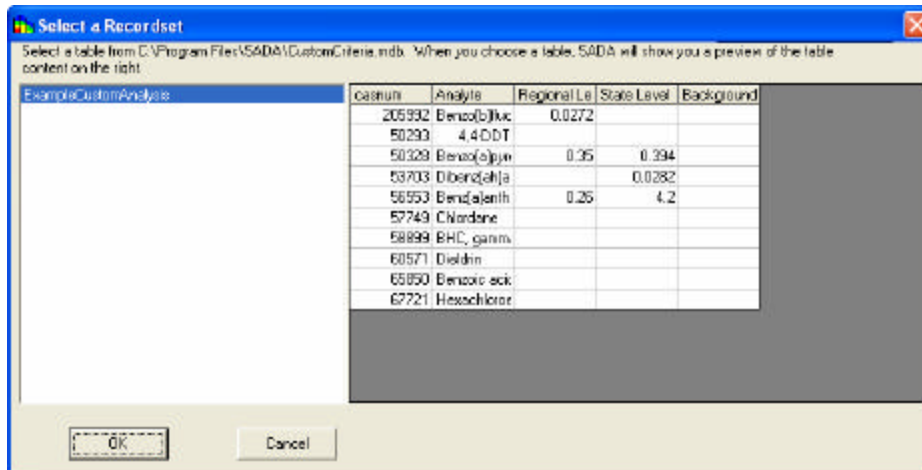


Enter the external file name that is to be imported in the text box or use the **Browse** button to select the file. Then press **Next>>**.

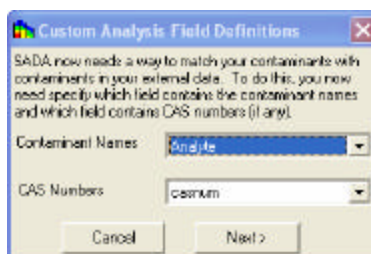


If the file is an Access database file, The **Select a Recordset** window will appear next. The left pane lists all the tables included in the database. Click on a table to see a preview of the table content in the right side of the window. Select the desired table and press **OK**.

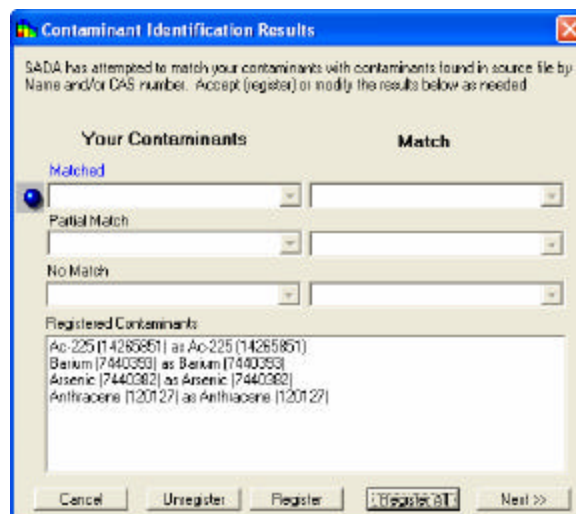




In the next window, SADA will attempt to match the contaminant and CAS Number information in the current SADA file with the appropriate columns in the external file. Select the appropriate column headings in the drop down boxes if they are not already selected. Then press **Next>>**.



SADA now attempts to match each contaminant in the current SADA file with a contaminant found in the external file. SADA searches by CAS number first (if available) and then by name. If the CAS number and name match exactly, SADA classifies it as **Matched**. If only the Name or the CAS number match, then the classification is **Partial Match**. Finally, if no match is found for either, the classification is **No Match**. These three classifications are presented in the next window.



On the left, your contaminants have been divided into each of these three categories. To view a resulting match for any contaminant click on the down arrow and select your contaminant from the resulting drop down list. The corresponding selection on the right hand side will change to show SADA's match for your contaminant. If the match is acceptable, press the **Register** button. If all matches within a category are acceptable, press **All**. To unregister a matched pair(s), select the pair(s) in the registered contaminants

box and press **Unregister**. Your contaminants will return to their original classification with their original match.

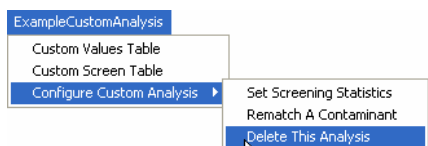
If no match is available for some of your contaminants, you may leave them as unregistered. If appropriate later, you may link these (or re-link registered) contaminants separately without setting up the entire custom analysis module again.

Press **Next>>** to conclude setting up the custom analysis module. Once the module is complete, a new analysis type will appear in the drop down box on the second toolbar with its name based on the name of the external file. When this analysis is selected on the toolbar, a new menu will appear with the same name and the menu options will be enabled.

**Note:** SADA allows more than one custom analysis to be setup within a SADA file. Each analysis will be identified in the analysis combo box with a unique name based on the name of the external data file.

## Delete Custom Analysis

For various reasons, a user may decide to delete a custom analysis. To delete a custom analysis, select the analysis in the combo box of the secondary toolbar. From the **Custom** menu, select **Configure Custom Analysis** and then **Delete This Analysis**



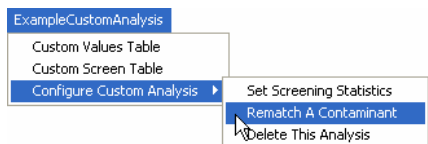
### WARNING

The user must be careful when using the delete analysis feature. Once an analysis has been removed, it cannot be re-established in SADA without having to setup custom analysis again.

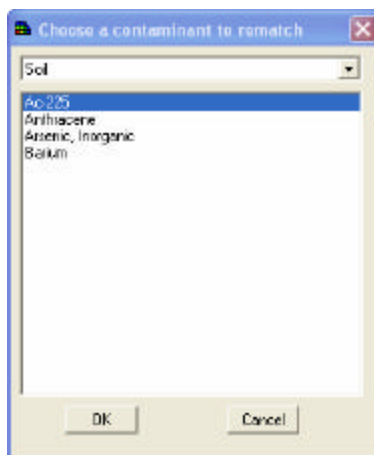
## Rematching Custom Contaminants

After the custom analysis module has been setup, you may revisit the external database (e.g. CustomAnalysis.mdb) in search of individual contaminant links. This utility is useful for correcting associations with the previously identified database. If the number of contaminants to relink is high, it may be more efficient to rerun the **Setup Custom Analysis** again.

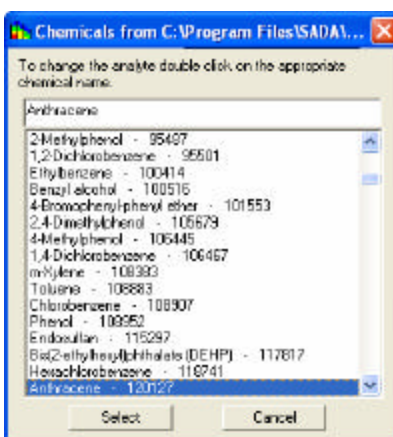
To link or relink a single contaminant, select **Configure Custom Analysis** and then **Rematch This Contaminant** from the **Custom** menu.



The following window appears.



Select the media and contaminant and press **OK**. SADA will then present the following window.

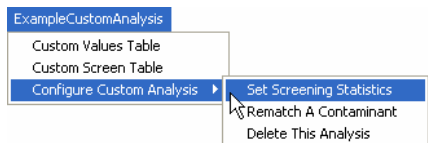


The user's contaminant name appears in the top box. Contaminants available from the database appear in the list box. To associate the contaminant in the top box, select a contaminant in the list box and press the **Select** button. Information from the associated selection is then transferred to the internal database and all relevant options in SADA are updated for this particular contaminant. This update occurs for the selected contaminant across all media types (soil, surface water, etc.) automatically.

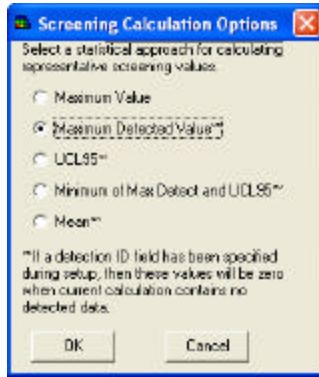
## Set Custom Screening Statistics

SADA Version 3 allows the user to select the statistical approach for calculating screening values.

From the **Custom Analysis** menu, select **Configure Custom Analysis** and then **Set Screening Statistics**.



SADA opens the following window.



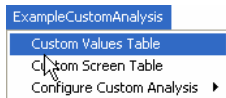
Select the desired statistical approach and press the **OK** button. The different approaches are defined as follows:

- Maximum Value – the maximum concentration, detected or nondetected, for normal or lognormal distribution
- Maximum Detected Value – the maximum detected concentration for normal or lognormal distribution
- UCL95 – the 95% upper confidence limit on the mean for normal or lognormal distribution
- Mean – the average concentration over all values for normal or lognormal distribution

*Note: For screening calculations, the maximum detected value is the default option.*

## Custom Values

To view the custom values imported into SADA, select the contaminant of interest in the **Contaminant** box of the secondary toolbar. Then select **Custom Values Table** from the Custom Analysis menu. *Note: this menu may have a different name, depending on the name of the external file brought into SADA during the custom analysis setup.*



The following window will display the custom values for **Pooled Data**.

Analyte	casnum	Regional Le	State Level	Background
Anthracene	120127	0.0316	0.548	
Ac-225	14265851	3	3.5	2.4
Arsenic	7440362	12.1	57	12
Barium	7440353	80	90	25

The Viewing Custom Values toolbar functions are as follows.



**Print** – Prints risk results (PRGs, Screenings, Risk).



**Copy to Clipboard** – Copies current image to the clipboard. It can then be pasted into most Windows packages.



**Copy to File** – Copies risk results (PRGs, Screenings, Risk) to file.



**Add to Report** – Copies results to a report.

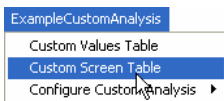


**Export to Excel** – Automatically dumps spreadsheet to an Excel file.

## Screening Data Against Custom Values

With custom analysis, users may import external data into SADA to use for screening purposes. For example, a user may wish to screen data against state soil screening values. To change the screening statistical approach, see the section **Set Custom Screening Statistics**. The results may then be integrated into the other modules, such as decision maps, cost benefit analysis, or sampling schemes. First the external data must be imported into SADA through the Setup Custom Analysis process.

Once setup is complete, SADA will determine which data points in the current SADA file exceed the Custom Values. To view this information, select the data name (select **Pooled Data** to screen all) and data type of interest from the secondary toolbar. Then, from the **Custom** menu, select **Custom Screen Table**.



SADA will screen the data against these custom values. If data exceeds the custom value, the cell value is Yes. The cell is blank if the calculation was not available (due to lacking toxicological information) or was less than the custom value.

caenum	Analyte	Regional Le	State Level	Background	Conc
7440353	Benium	Yes	Yes	Yes	104.8
7440352	Arsenic	Yes		Yes	53.6
120127	Anthracene	Yes	Yes		6.5

The Custom Screen Table toolbar functions are as follows.



**Print** – Prints risk results (PRGs, Screenings, Risk).



**Copy to Clipboard** – Copies current image to the clipboard. It can then be pasted into most Windows packages.



**Copy to File** – Copies risk results (PRGs, Screenings, Risk) to file.



**Add to Report** – Copies results to a report.



**Export to Excel** – Automatically dumps spreadsheet to an Excel file.

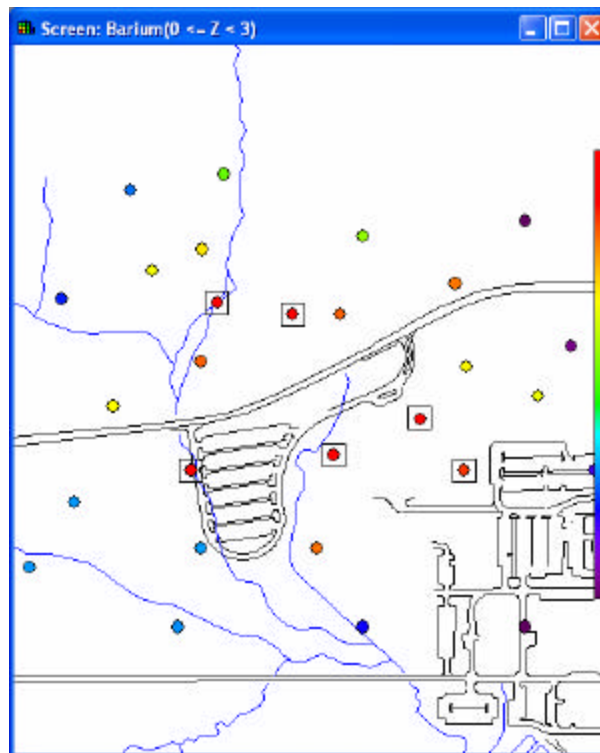
## Using Custom Analysis Results

Custom analysis results may be used in Spatial Screens, Probability Maps, Area of Concern Maps, or Cost Benefit Analysis Maps. Select the custom analysis in the analysis type box of the secondary toolbar.

When one of the following interviews is selected, the following window will appear.

- Draw a data screen map
- Draw a probability map
- Draw an area of concern map
- Calculate cost versus cleanup

Select the analysis choice (the list will include all column headings from the external database except Contaminant Name and CAS Number) and press the **OK** button. In the following example, State Level has been used to draw a data screen map. Boxes surround the data points that exceed the screening value for the selected contaminant.



**Spatial Screen Against State Levels for Barium in Soil**

## Decision Frameworks

This chapter includes an overview of decision frameworks and the following interviews and steps:

- Specify decision criteria - step
- Draw a probability map - interview
- Draw and area of concern map - interview
- Set eco framework - step
- Calculate cost versus cleanup - interview
- Set cost information - step

### Overview of Decision Frameworks

The SADA approach to decision making is to provide information in a concise and relevant format that allows the decision maker to make a more informed decision. SADA does not attempt to make decisions for stakeholders nor remove their expertise from the process. The decision framework depends on the decision basis and the decision scale.

Decision framework parameters are used by Probability Maps, Area of Concern Maps, Cost Benefit Analysis, Sample Designs, and Spatial Screens.

### Decision Basis

The decision basis allows the user to make decisions, screen data, and produce probability maps against a specific concentration value or a risk-based criteria. When General is the analysis type, SADA uses a user-defined decision goal, a concentration option, as the decision basis. For all other analyses, SADA uses an analysis-based decision framework.

- **Analysis-Based Option**

If the current analysis is . . .

1. Human Health – SADA will identify data points and/or areas of the site that exceed or are predicted to exceed the target risk level for a specific risk scenario. When the Draw a data screen map, Draw a probability map, Draw an area of concern map, Calculate cost versus cleanup, or Develop a sample design (with area of concern boundary chosen as the design) interviews are selected for human health, the user will be prompted to specify the correct pathway in the Risk Scenario Selection Window.

2. Ecological – When the Draw a probability map, Draw an area of concern map, or Develop a sample design (with area of concern boundary chosen as the design) interviews are selected for ecological, the Steps Window displays an additional step called **Set eco framework**. This step affects the ecological decision framework. When **Based on Benchmarks** is selected, the user will be prompted to select the ecological benchmark for the decision framework. When **Based on Dose** is selected, enter a relevant toxicity reference value for the contaminant and species that is being modeled for the purposes of comparing to the dose modeling results.

3. Custom Criteria – SADA will identify data points and/or areas of the site that exceed or are predicted to exceed imported custom values. When the Draw a data screen map, Draw a probability map, Draw an area of concern map, Calculate cost versus cleanup, or Develop a sample design (with area of concern boundary chosen as the design) interviews are selected for custom analysis, the user will be prompted to specify a particular custom criteria.

- **Concentration Option**

This option, available only for General Analysis, will identify data points and/or areas of the site that exceed or are predicted to exceed the concentration value entered by the user.

## Decision Scale

There are two types of decision scale, block scale and site scale. These parameters only apply to remedial design and to cost benefit analysis.

- **Block Scale**

With block scale, each block within the contour map will be remediated if it fails to pass the "criteria". For ordinary and indicator kriging, note that the method of interpolation applies here. If the user requests a percentile map, then the criteria is applied to this percentile map. For example, if the user requests a 10<sup>th</sup> percentile map, then any block whose 10<sup>th</sup> percentile is greater than the criteria must be included in the area of concern. In the case of the 10<sup>th</sup> percentile map this would equate to a 90% confidence map used in Version 4.0 and earlier.

- **Site Scale**

With this choice, the decision basis is applied to the entire site. If polygons are present, then the "criteria" applies to the interior of the polygon. Under site scale, the blocks are remediated by replacing the contoured value with the post remediation concentration. This process is implemented from most contaminated blocks to least contaminated blocks until the site average falls below the decision criteria. For certain choices of clean-up goal and post remediation values, a remedial design may not be possible. It is not necessary, however, that the **post remedial concentration** be less than the decision goal. For pooled data, the individual post remediation concentrations for each contaminant are used, and a resulting risk value from these pooled post remedial values is generated. For ordinary and indicator kriging, note that the method of interpolation applies here. If the user requests a percentile map, then the criteria is applied the average of this percentile map. For example, if the user requests a 10<sup>th</sup> percentile map, then site scale is based on the average of the 10<sup>th</sup> percentiles.

### Backfill Concentration

This value is always used when **site scale** is chosen. Site scale calculates the average remaining concentrations over the site. Under this circumstance, one must consider the amount of contamination left in each block or artificially placed there by a back fill process. Given certain values for the decision goal, certain choices for post remedial concentration may lead to impossible remedial designs (e.g., a site decision goal of 1 and a post remedial concentration of 10,000). It is not necessary, however, that the post remedial value be less than the site decision goal. For example, one may begin with a site average of 5 and a maximum block value of 10. Depending on how the rest of the block values are distributed, a post remediation value of 6 may successfully bring the site average down to 5. Clearly though, the post remediation value must be less than the maximum block value.

This parameter is not used in the block scale method since the goal is to remediate each block below the decision criteria. Clearly, if the post remediation value is greater than the goal, then the block goal will never be achieved. On the other hand, if the post remedial value is less than the decision goal, then the remedial design can succeed. There are no other options.

### Density Parameter

The density parameter is used to estimate the mass associated with a given remedial area as determined by the Area of Concern tool. The mass is calculated by the product of the volume to be remediated and the entered density value for the media. This calculated mass value can be used to better estimate costs of remediation when mass is a cost driver.

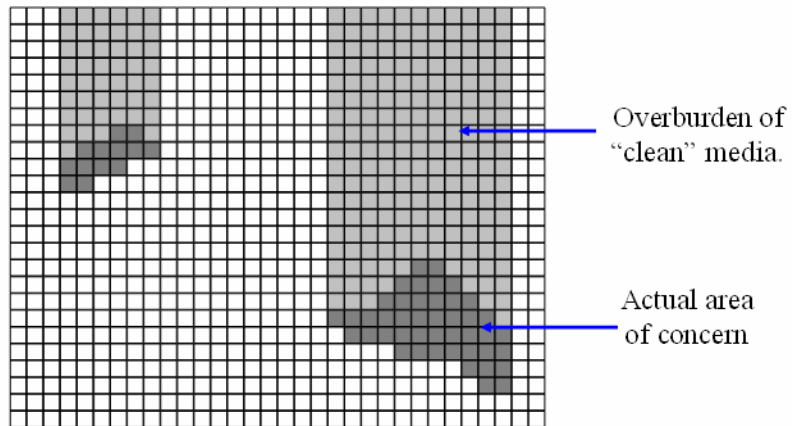
### Calculate Overburden

After the area of concern has been identified using either block or site scale, SADA can evaluate the "overburden" associated with this area. The overburden is any part of the site not included in the area of concern but lying vertically above the area of concern. The idea is to determine in an excavation type scenario how much media would have to be excavated, including both clean and unclean zones. However, in order to be included in the overburden, a region must be found directly over the area of concern. More detailed implementation of the overburden model, which include "benching angles" or gradients in general, are not currently available. Whether the overburden is used or not depends on the



characterization need. For example, if the purpose of the effort is to delineate the plume or to estimate a source term for calibrating a groundwater model, then the overburden should not be included. However, if the media is soil or sediment and an excavation scenario is required, SADA can provide two solutions. First, turn the overburden off to determine the volume of contaminated media that may be shipped or remediated. This will help ascertain the cost of dealing with the affected zone once it has been excavated. Secondly, turn the overburden on to determine the total volume that would be involved in vertically reaching and removing the affected area.

Area of Concern Cross Section

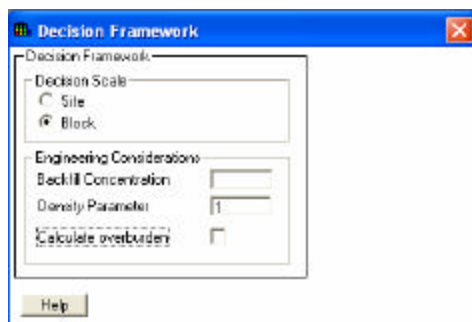


### Specify Decision Criteria - Step

This step allows the user to select the decision scale.

This step is available when one of the following interviews is selected: Draw an area of concern map or Calculate cost versus cleanup.

Select **Specify decision criteria** from the Steps Window. The following information is displayed in the Parameters Window.



Select site or block scale and enter the applicable engineering considerations.

### Set Eco framework - Step

This step is available for ecological analyses when one of the following interviews is selected: Draw an area of concern map or Draw a Probability Map.

Select **Set Eco framework** from the Steps Window. The following information is displayed in the Parameters Window.



Select one of the eco decision options:

- Based on Benchmark – bases the decision framework on a benchmark or prioritized list of benchmarks.
- Based on Dose – bases the decision framework on a specific species and exposure assumption for the terrestrial dose calculator.

## Draw a Probability Map - Interview

This interview produces a map that graphically shows the probability of each block exceeding a specified value when using either ordinary kriging or indicator kriging. This value is either analysis-based or concentration-based, depending on the type of analysis.

### Availability

This interview is available for all analyses that have sampled data (unpooled only), with all data types except Geobayesian. It is only available if ordinary kriging or indicator kriging is selected as the interpolant.

### Steps

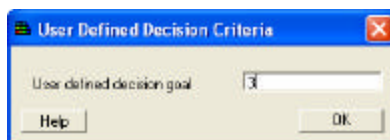
These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data
2. Set up the site
3. Set GIS Overlays
4. Set grid specs
5. Interpolation Methods
6. Correlation modeling
7. Search neighborhood
8. Set eco framework (only available for ecological analyses)
9. Show the results
10. Format picture
11. Auto-document
12. Add to results gallery

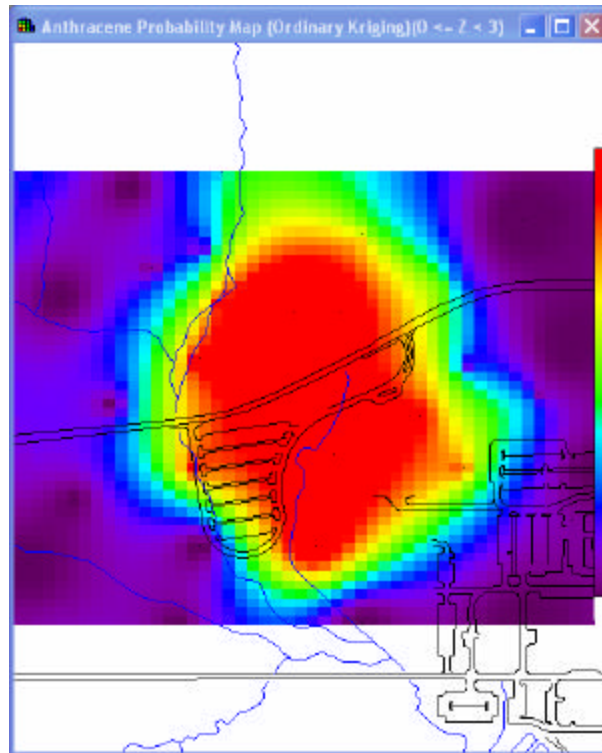
When **Show the results** is selected from the Steps Window, SADA will ask for the decision criteria. This criteria will depend on the type of analysis.

- *General Analyses*

After selecting **Show the Results**, SADA asks the user for the decision criteria.



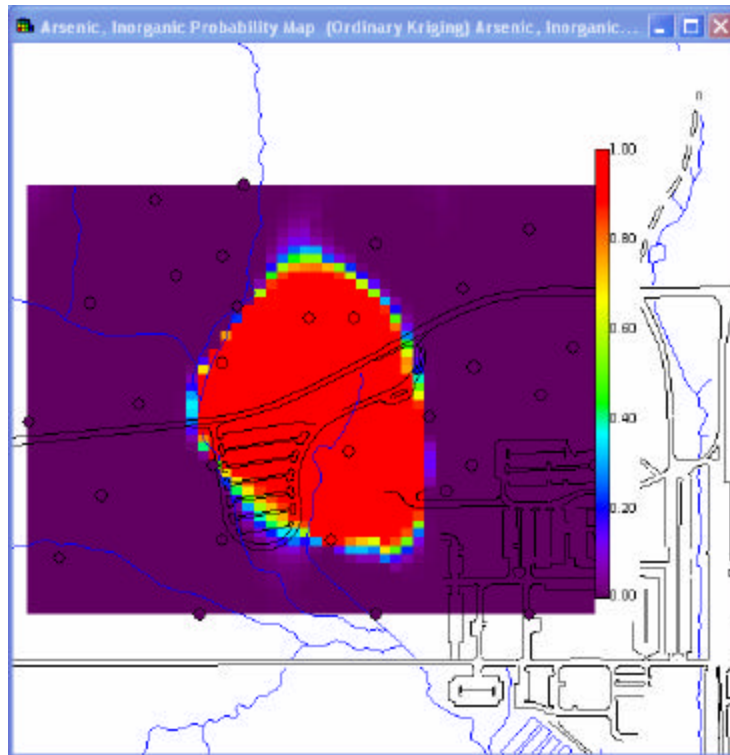
In the text box, enter a concentration value. Then, press **OK**. SADA displays the probability of each block exceeding the specified value.



- *Human Health*

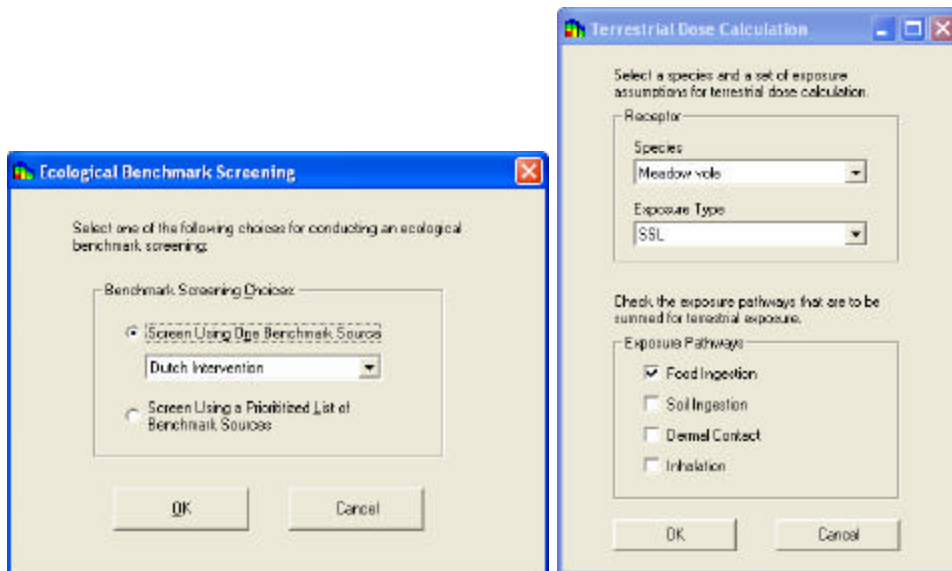
After selecting **Show the Results**, SADA presents the risk scenario selection window.

Select the risk scenario of interest and press **OK**. SADA displays the probability of each block exceeding the selected PRG.

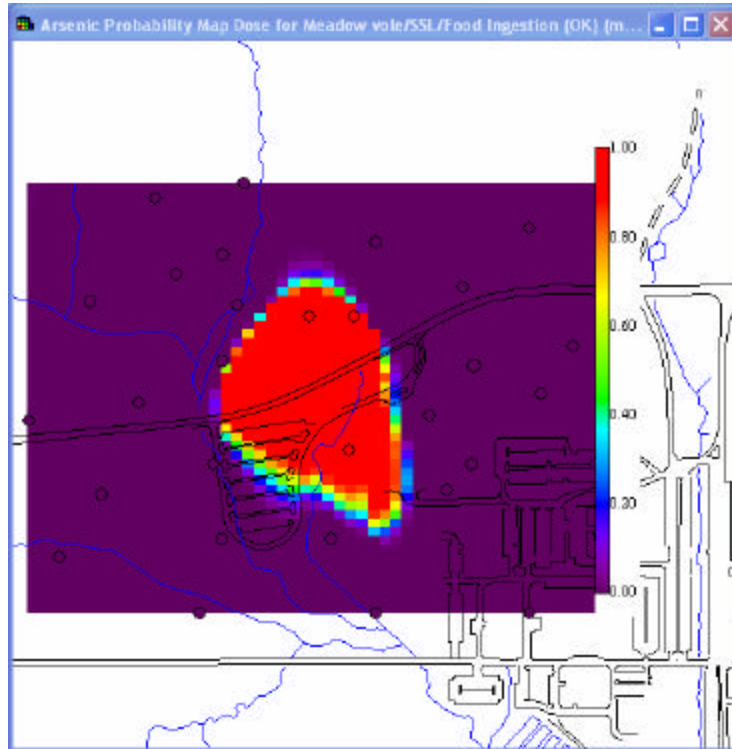


- *Ecological*

After selecting **Show the Results**, SADA presents the ecological benchmark screening window or the terrestrial dose calculation window, depending on what was selected in the step **Set eco framework**.

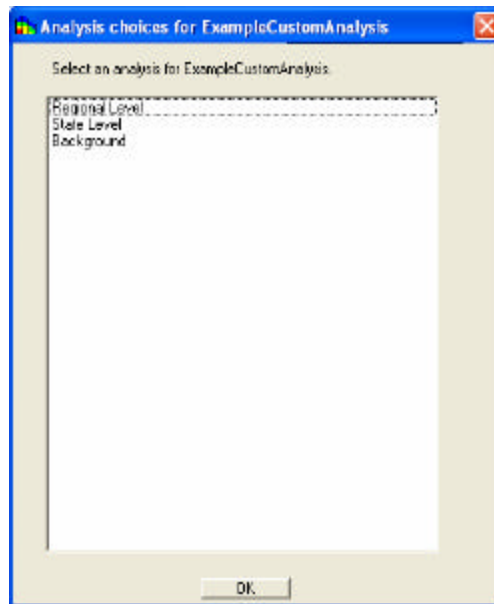


Select the screening option and press **OK**. SADA displays the probability of each block exceeding the selected benchmark(s) or dose.

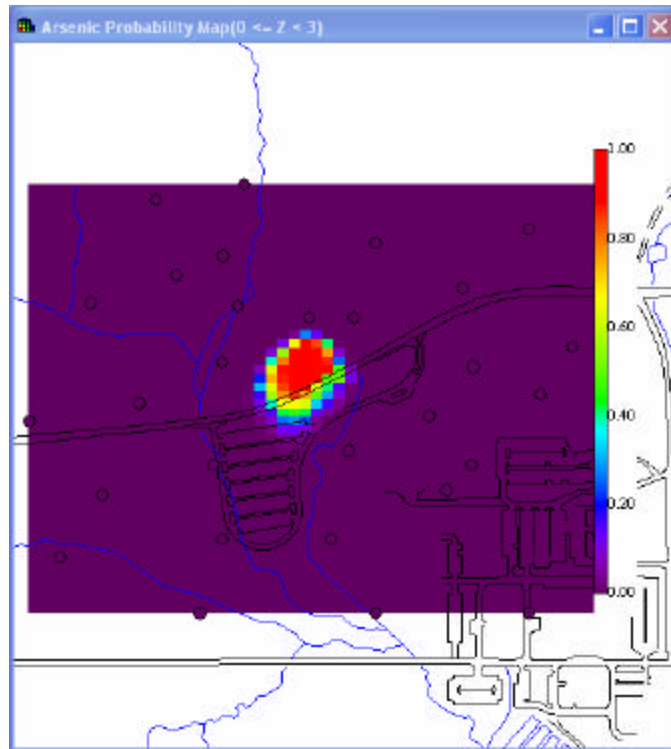


- *Custom*

After selecting **Show the Results**, SADA asks the user for the decision criteria.



Select the screening criteria of interest and press **OK**. SADA displays the probability of each block exceeding the selected criteria.



## Draw an Area of Concern Map - Interview

This interview will estimate the area of concern based on the current contaminant, interpolation method, and decision criteria. Recall that with geostatistical interpolants, this tool will strictly use the results of the interpolation routine. That is, if one plots a 10<sup>th</sup> percentile map, then the decision criteria is applied to the 10<sup>th</sup> percentile map. If a mean map is produced, then the decision criteria is applied to the mean map.

### Availability

This interview is available for all analyses that have sampled data (unpooled only) with all data types, including Geobayesian. In addition, it is available for human health analyses with pooled data.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data, Draw/Edit Prior
2. Set up the site (not available for Geobayesian data)
3. Set GIS Overlays
4. Set update data (only available for Geobayesian data)
5. Set grid specs (not available for Geobayesian data)
6. Interpolation Methods (this step is not enabled for pooled data with human health or Geobayesian data)
7. Correlation modeling (only available if OK or IK<sub>i</sub> is selected under Interpolation method; not enabled for pooled data with human health)

8. Search neighborhood (only available if OK, IK, or Inverse Distance is selected under Interpolation method; not enabled for pooled data with human health)
9. Specify decision criteria (not available for Geobayesian data)
10. Set eco framework (only available for ecological analyses)
11. Show the results
12. Cross validation (this step is not enabled for pooled data with human health or Geobayesian data)
13. Format picture
14. Auto-document
15. Add to results gallery

When **Show the results** is selected from the Steps Window, SADA will ask for the decision criteria. This criteria will depend on the type of analysis.

- *General Analyses*

After selecting **Show the Results**, SADA asks the user for the decision criteria.



In the text box, enter a concentration value. Then, press **OK**.

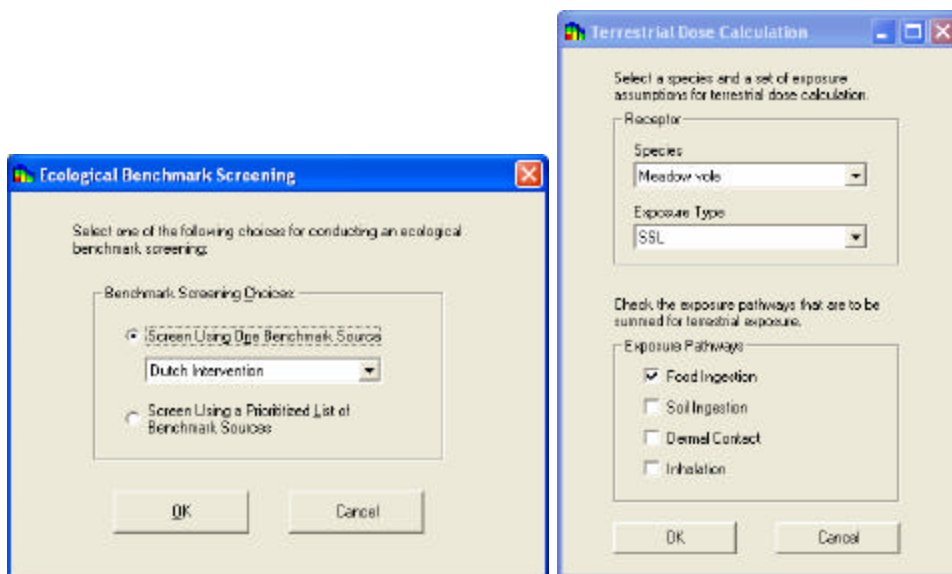
- *Human Health*

After selecting **Show the Results**, SADA presents the risk scenario selection window.

Select the risk scenario of interest and press **OK**.

- *Ecological*

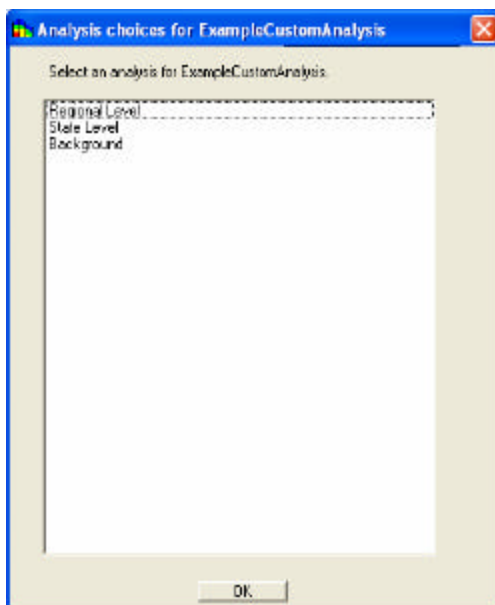
After selecting **Show the Results**, SADA presents the ecological benchmark screening window or the terrestrial dose calculation window, depending on what was selected in the step **Set eco framework**.



Select the screening option and press **OK**.

- *Custom*

After selecting **Show the Results**, SADA asks the user for the decision criteria.



Select the screening criteria of interest and press **OK**.

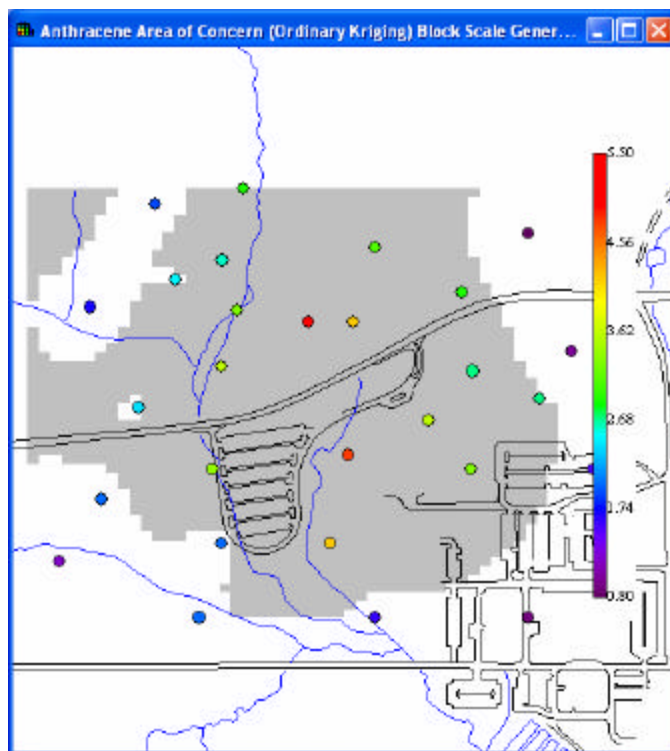
- *Geobayesian*

After selecting **Show the Results**, SADA asks the user for a probability cleanup value.



The following image displays a sample Block Scale Area of Concern Map for General Analysis, Anthracene with Cleanup Goal of 3 at 90% confidence.





## Calculate Cost versus Cleanup - Interview

An important component to decision analysis software is cost/benefit analysis. This may be translated as payoff per level of effort. In a cost/benefit analysis, the level of effort or cost required to achieve a desired goal is modeled or estimated. Often, if the goal is numerically definable and ranges over a set of values, cost benefit curves incrementally show how cost increases, decreases, or fluctuates across an increasing range of goal values through an XY graph. SADA provides cost/benefit curves for a range of remedial action goals. These goals may range over the minimum and maximum sample values or may range over the corresponding human health risk values, Ecological Benchmark ratios, or Custom Values.

Recall that with geostatistical interpolants, this tool will strictly use the results of the interpolation routine. That is, if one plots a 10<sup>th</sup> percentile map, then the decision criteria is applied to the 10<sup>th</sup> percentile map. If a mean map is produced, then the decision criteria is applied to the mean map.

To utilize the cost benefit tool in SADA, you must specify parameters for Decision Scale.

### Availability

This interview is available for all analyses that have sampled data (unpooled only) with all data types, including Geobayesian. In addition, it is available for human health analyses with pooled data.

### Steps

These are the steps that display in the Steps Window when this interview is selected. Click on the links below for more details about the following steps.

1. See the data, Draw/Edit Prior
2. Set up the site (not available for Geobayesian data)
3. Set GIS Overlays
4. Set update data (only available for Geobayesian data)

5. Set grid specs (not available for Geobayesian data)
6. Interpolation Methods (this step is not enabled for pooled data with human health or Geobayesian data)
7. Correlation modeling (only available if OK or IK<sub>is</sub> is selected under Interpolation method; not enabled for pooled data with human health)
8. Search neighborhood (only available if OK, IK, or Inverse Distance is selected under Interpolation method; not enabled for pooled data with human health)
9. Specify decision criteria (not available for Geobayesian data)
10. Set cost information
11. Show the results
12. Format picture
13. Auto-document
14. Add to results gallery

When **Show the results** is selected from the Steps Window for human health, ecological, or custom analyses, SADA will ask for the decision criteria. This criteria will depend on the type of analysis. For Geobayesian data, no decision criteria is required.

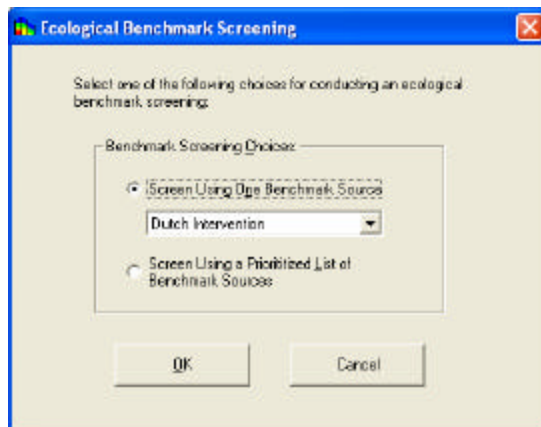
- *Human Health*

After selecting **Show the Results**, SADA presents the risk scenario selection window.

Select the risk scenario of interest and press **OK**.

- *Ecological*

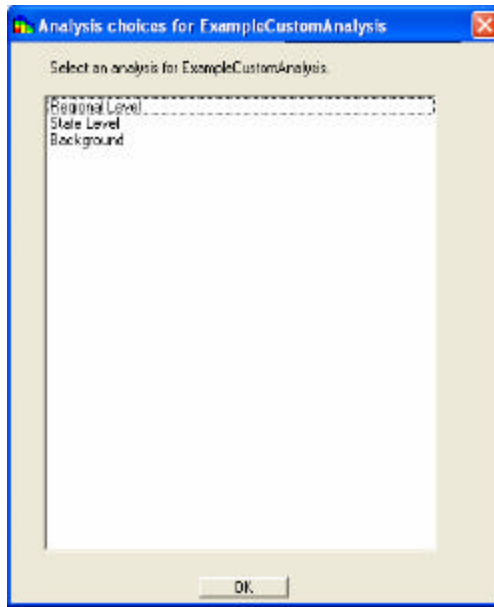
After selecting **Show the Results**, SADA presents the ecological benchmark screening window.



Select the screening option and press **OK**.

- *Custom*

After selecting **Show the Results**, SADA asks the user for the decision criteria.



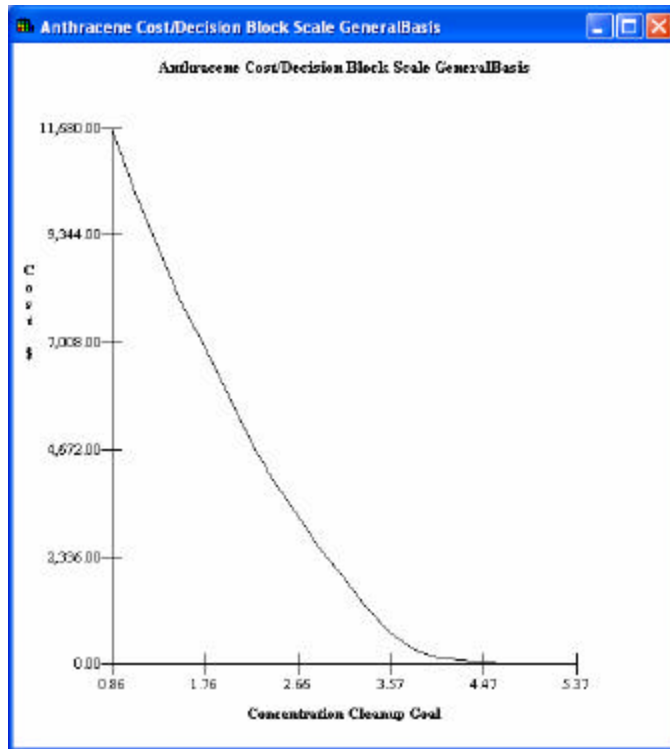
Select the screening criteria of interest and press **OK**.

- *Geobayesian*

After selecting **Show the Results**, SADA asks the user for a probability cleanup value.



The following image displays a sample block scale Cost versus cleanup map for Anthracene, with general analysis, a confidence of 90%, and a cost per block of 2.



### Set Cost Information - Step

This step is available when one of the following interviews is selected: Calculate cost versus cleanup or Calculate cost versus cleanup Based on soft Data Only.

Select **Set cost information** from the Steps Window. The following information is displayed in the Parameters Window.

Enter the cost to remediate per unit volume in the text box.

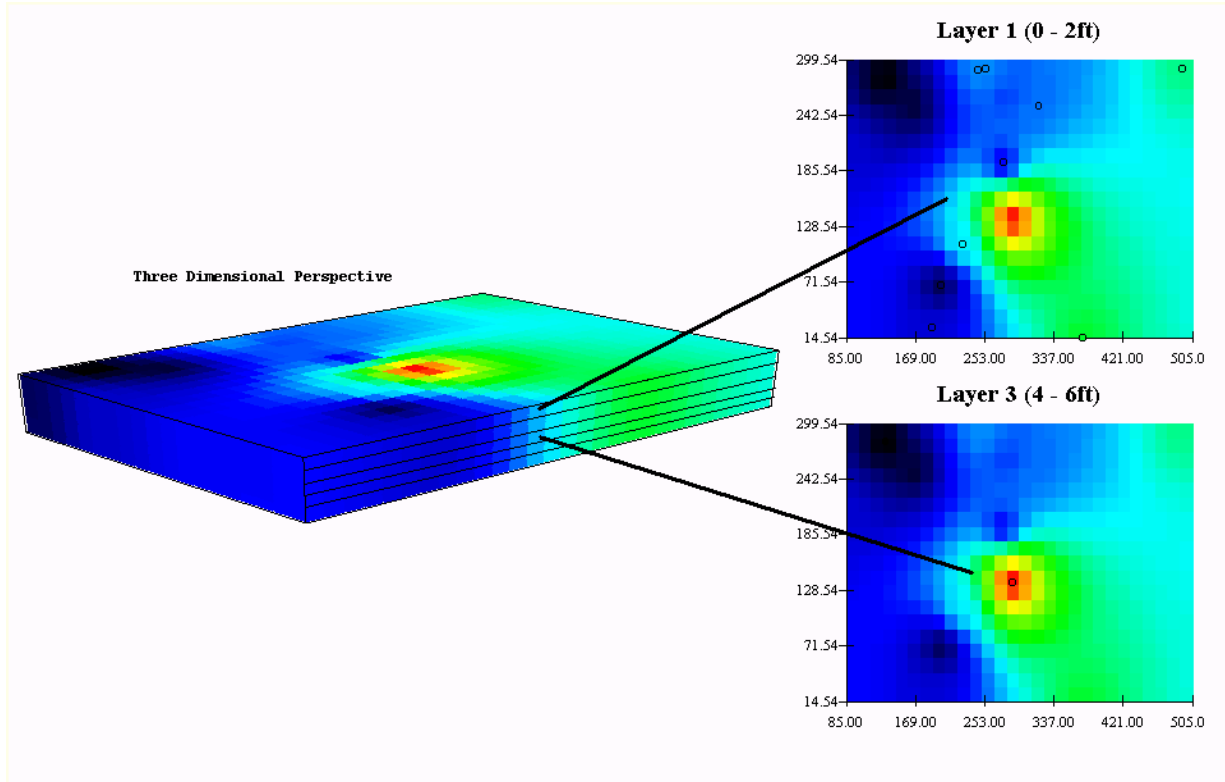
## Three Dimensional Visualization

SADA uses two approaches for visualizing three-dimensional information: 1) a layering approach with layers shown only and 2) a true three dimensional volume rendering.

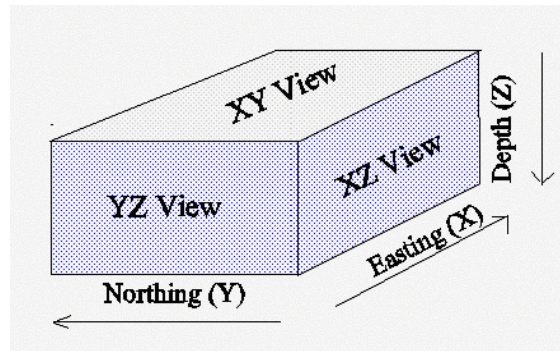
### Layering Approach

In this approach, the 3D is split into slices which may be viewed one at a time. The depth of these layers is defined either by the Vertical Layers step for data layers or by defining the grid for model layers.

In the following image, the 3D volume is divided into layers and shown one at a time.



Note that polygons, which are only available in an easting-northing view, may be applied to all layers or to select layers through the set vertical layers step.



### True Three Dimensional Rendering

To view the true three dimensional rendering, select **Show 3d View** from the **Graphics** menu. SADA will add the three-dimensional rendering results view to the regular layering view in the Graphics Window.

You can make changes to the layering view, and the three-dimensional view will be updated (e.g. polygons, formatting, etc.).

SADA presents the three-dimensional results in three different ways: points blocks, and isosurfaces.

At the top of the 3d viewer are six toolbar buttons.



**Print** – prints a copy of the current view.



**Copy** – copies the current view to clipboard.



**Save** – saves the current view to file (jpg format).



**Def. View** – resets the view to the default.

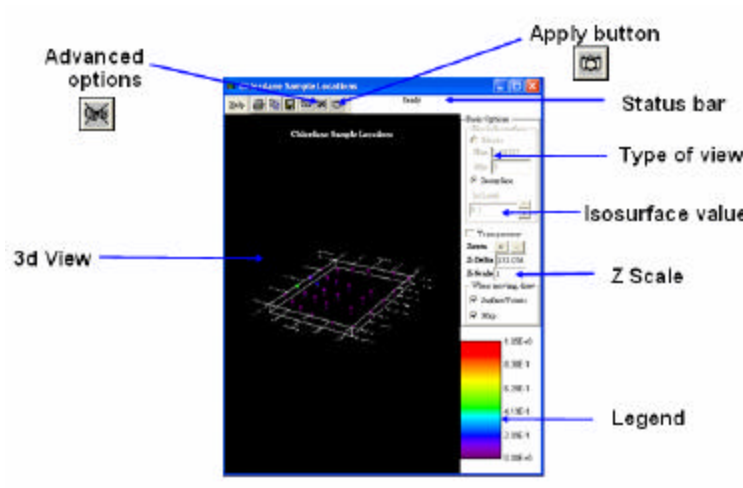


**Opts** – presents the Options Form for the 3d viewer.



**Redraw Image** – redraws all for current view (do this after changing the view). This will take longer to render than when the object is being moved.

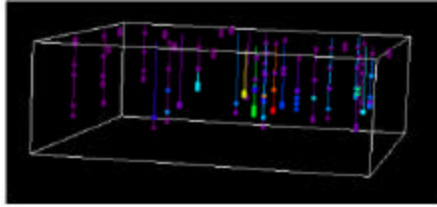
The following image shows the commonly used features.



## Points View

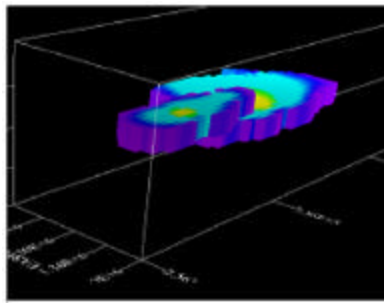
The 3d viewer allows users to plot sampled points in 3d space and to apply a number of visualization tools, such as borehole lines.

The following image shows the true 3d rendering for data points.



## Blocks View

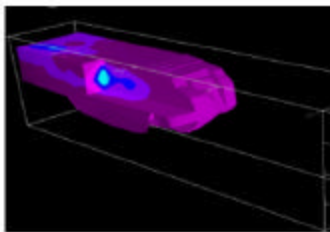
Users can plot the blocks as you would see them in the 2d viewer (with depth added). This provides users with an accurate view of the raw model results.



## Isosurface View

Users can plot isosurface ranges as well. Most major visualization packages provide this as a default view for users as it can take less time to plot.

The isosurface view allows users to see through the mass with the use of the chair cut. The chair cut essentially removes a block section out of the view to reveal the interior.



## How to Move the 3D Object

The object can be moved with either the mouse or with specific keystrokes.

### *Moving the Object with the Mouse*

Left-clicking and dragging the mouse will move the object as if the screen is the front of a "trackball". Moving the mouse up will rotate the object up about its center, and vice versa. Moving the mouse to the left or right will rotate the object left or right about its center.

Right-clicking and dragging the mouse will translate the object in the direction the mouse is moving.

### *Moving the Object with Keystrokes*

Zoom In/Out: Shift+Up/Down Arrow

Translate Left/Right: Ctrl+Left/Right Arrow

Translate Up/Down: Ctrl+Up/Down Arrow

Rotate Left/Right about vertical line through midpoint: Left/Right Arrow

Rotate about horizontal line parallel to Northing through midpoint : Up/Down Arrow

Rotate about horizontal line parallel to Easting through midpoint : Shift+Left/Right Arrow

## Basic Options

The following commands may be viewed on the right side of the **3D View** window: blocks/isosurface, transparency, zoom in/out, z delta, z scale, and when moving, draw.

### Blocks/Isosurface

When "Blocks" is selected, only blocks with a value in the specified range will be displayed. The upper and lower bounds for this range are determined from the data points.

If "Isosurface" is selected (the default), then an isosurface will be drawn. The value being viewed can be increased or decreased by clicking the **Up** and **Down** buttons. This will increase/decrease the current level by a hundredth of the entire range. This can also be accomplished by typing "u" or "d", respectively. To set the isolevel being viewed to a specific value, click on the **Set** button and enter the desired value when prompted. If there is only one z-level, then the isosurface options will not be available.

***Note:** the blocks/isosurface option will only display these changes for modeled values not data points .*

### Transparency

If this option is selected (the default), then the color will be transparent. The exact degree of transparency depends on how large the value is. Lower values will be more transparent. This allows the user to "see through" low concentration volumes into higher values.

### Zoom In/Out

These buttons are provided for convenience when moving the object with the mouse to zoom in or out.

### Z Delta

This value impacts how much you zoom in and out.

### Z-Scale

This option changes the scaling in the z direction. **Note:** this can also be done on the Scaling tab of the Options Form.

### When Moving, Draw

Use these buttons to enable or disable the redrawing of surface/points and the map when moving the image, either with the mouse or with keystrokes. When redrawing is enabled, it may take longer for SADA to render a new picture each time. In these cases, one may want to disable how often the surface/points and/or map are rendered. One can always have the entire image redrawn by clicking on the **Redraw Image** toolbar button at the top of the 3D form. Note that if isosurfaces are not being shown and moving with the mouse, the cubes are never redrawn each time the image is drawn.

## Advanced Options

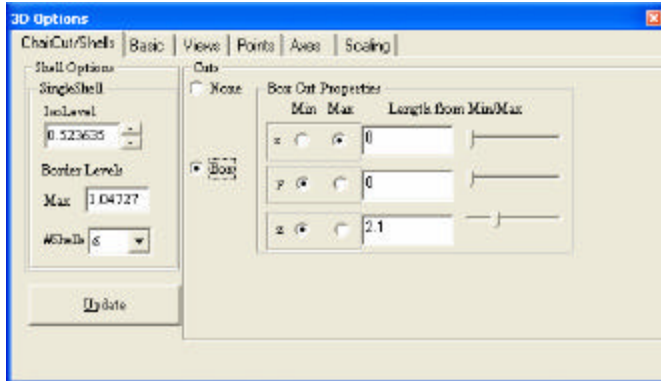
These options are available by selecting the **Advanced Options** button:

- Chair cut/shells tab



- Basic tab
- Views tab
- Points tab
- Axes tab
- Scaling tab

### ChairCut/Shells Tab

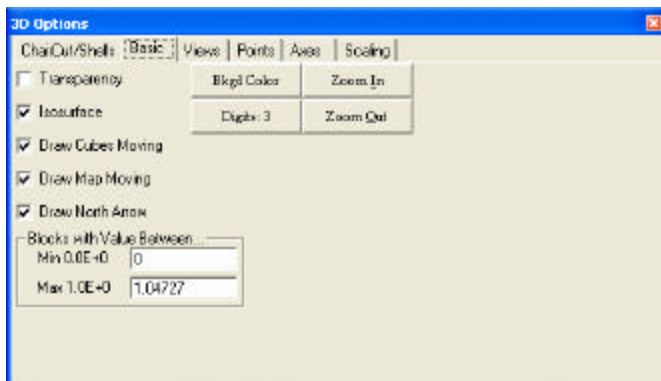


The options on this Tab control the isosurface levels and box cuts. In all cases, the **Update** button must be clicked in order for the 3D view to be re-rendered.

The controls in the **Shell Options** part of this tab determine the isosurface levels used in showing the isosurface shells, whether or not a "cut" is being made. The value in the **IsoLevel** box is the minimum isosurface level, and the value in the **Max** box is the maximum isosurface level. The **#Shells** option controls how many shells are shown between **IsoLevel** and **Max**. If there is only one shell selected, then there will be a single shell at **IsoLevel**.

The controls in the **Cuts** part of this tab determine if a "chair cut" is made into the isosurface and the properties of the cut itself. A "chair cut" is made if the **Box** option is selected. In all cases, the "cut" is made starting from one of the corners of the cube bounding the plot. The **Min/Max** options for each dimension determine the corner from which the cut is made. The length of the cut into the surface in each dimension is controlled with the sliders, or by entering values directly in the text boxes.

### Basic Tab



This tab has the same options that are shown in the right side of the 3d viewer plus a few extra options.

*Background Color*

The background of the image can be changed by clicking on the button labeled **Bkgd Color**. The user will be prompted with a form that allows them to choose a color to use for the background. Note that the color of the axes and title will always be set to the opposite color of the background, to provide the most contrast.

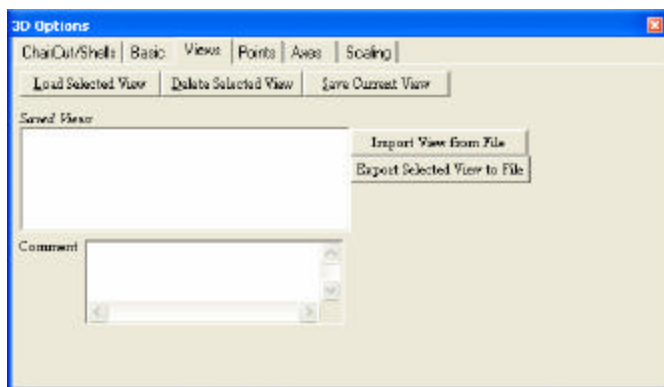
### *Digits*

Click this button to select how many total digits to show for the axes. Currently, the numbers will always be displayed using scientific notation.

### *Draw North Arrow*

Check this box to display a North arrow on the map.

## **Views Tab**



The Views tab is used to access and save custom 3D views. The saved views are stored in the associated SADA file. Note that the point/interpolation data are not stored as part of the view.

### *Save Current View*

Clicking this button will allow you to save the current settings with respect to view orientation, point options, scaling options, etc. You will be prompted to enter a name for the view, and you can add a comment that will be stored along with the view. Once a view has been saved, it will show up in the list under **Saved Views**.

### *Load Selected View*

This button will load the currently selected view and apply it to the 3D rendering.

### *Delete Selected View*

This button will delete the currently selected view from the SADA file. It will not affect the figure currently being rendered.

### *Saved Views*

This box will contain a list of all of the views stored in the current SADA file.

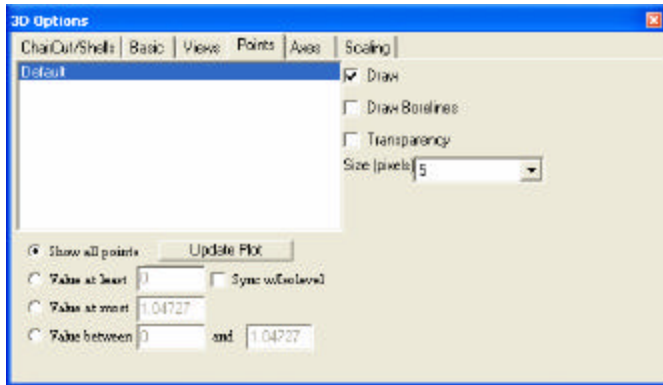
### *Import View from File*

Click this button to pick a file from which to load a view. Only files created with the 3D viewer can be loaded.

### *Export Selected View to File*

Click this button to export the current selected view (in the **Saved Views** list) into a file. This file can be then imported with the 3D viewer.

## Points Tab



This tab can be used to set options related to how the points are displayed. On the left will be a list of the different point groups defined (in SADA Version 3, there is only a single point group, named "Default").

### *Draw*

This box indicates whether or not to draw the points in the current view.

### *Draw Borelines*

If this box is checked, a line will be drawn from each point in the group to the surface ( $z=0$ ).

### *Transparency*

If this box is checked, then the point will be transparent. The degree of transparency depends on the value at the point.

### *Size (pixels)*

This box determines how large the displayed points are, in units of screen pixels.

The options at the bottom of the tab may be used to limit the points to those that satisfy certain conditions. In all cases, click the "Update Plot" button to update the image based on the settings.

### *Show All Points*

When this box is checked, all data points will be shown.

### *Value at Least*

When this box is checked, only those points with a value above the specified level will be shown.

### *Sync w/Isoslevel*

When this box is checked, only those points with a value that is at least equal to the current isoslevel surface will be shown.

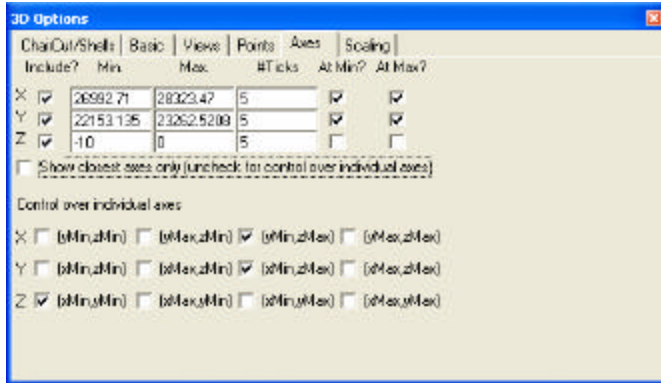
### *Value at Most*

When this box is checked, only those points with a value below the specified level will be shown.

### *Value Between*

When this box is checked, only those points with a value between the specified levels will be shown.

## Axes Tab

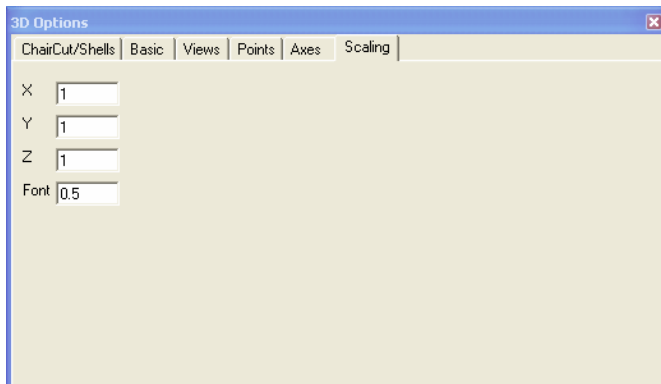


This tab allows detailed control over which axes are shown. The default is that the closest axis to the viewpoint is shown, with 5 tick marks per axis. The default upper and lower bounds for the axes are determined from the project data. For the Z-axis (depth), the labels at the minimum and maximum value are not displayed by default, as this results in the labels intersecting each other and obscuring the numbers.

The checkboxes under **At Min?** and **At Max?** control whether or not numbers are shown at the respective minimum/maximum for a particular axis.

If you want to have control over which axes have numbers shown, uncheck the **Show closest axes only...** checkbox and then pick the desired axes from the area below.

## Scaling Tab



Use this option to stretch/shrink the graph in specified directions, or to change the size of the font relative to the default (a value of 1 is the default, a value of 2 will result in a font twice as large as the default, a value of 0.5 will result in a font that is half the size of the default font).

## Sample Designs

SADA Version 4 has 21 sample design strategies. The two major categories for sample designs are initial and secondary sampling. Initial sample designs are used in empty SADA files; they are independent of previous samples and therefore may be used with prior information about the site to determine where to take the first round of samples. Secondary sample designs are used when sampled data and/or modeled results already exists in a SADA file to determine future sampling locations; they are dependent on the previous samples.

Most sample designs in SADA are available for 2d and 3d data.

To create sample designs, select the Develop a sample design interview.

### Develop a Sample Design - Interview

#### Availability

This interview is available for all data types in SADA; however, the availability of specific sample designs depends on whether there is sampled data and the data type. The following table lists all the sample designs and when they are available.

#### Steps

The steps for this interview are dependent on the type of sample design selected. Refer to the section on one of the sample designs for a description of the design and the applicable steps.

Sample Design	Empty SADA files	Sampled data with all data types except Geobayesian	Sampled data with Geobayesian data type
Judgmental	Yes	Yes	Yes
Simple Random	Yes	Yes	Yes
Simple Grid	Yes	Yes	Yes
Simple unaligned Grid	Yes	Yes	Yes
Standard Grid	Yes	Yes	Yes
Standard unaligned Grid	Yes	Yes	Yes
Hot Spot: Minimize Sample Size By Cost	Yes	Yes	Yes
Hot Spot: Minimize Sample Size By Hot Spot Definition	Yes	Yes	Yes
Hot Spot: Unknown Hot Spot	Yes	Yes	Yes
Hot Spot: Calculate Probability	Yes	Yes	Yes
3d Hot Spot Search	Yes	Yes	Yes
Threshold Radial		Yes	
Adaptive Fill		Yes	
Ripley's K		Yes	
Moran's I		Yes	
Geary's C		Yes	
High Value		Yes	Yes
Area of Concern Boundary		Yes	Yes

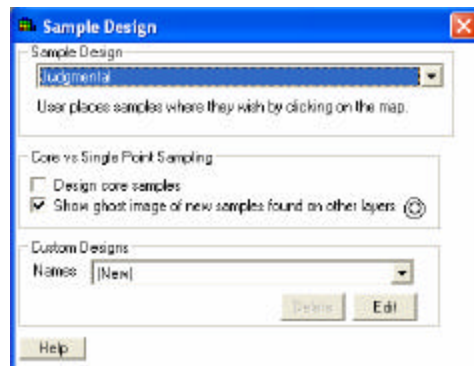
Minimizing/Maximizing Area of Concern	Yes	Yes
Highest Prior Values		Yes
AOC Prior Boundary		Yes

## Set Sampling Parameters - Step

This step is important for selecting the type of sample design. This step is only available when the Develop a sample design interview is selected.

Select **Set sampling parameters** from the Steps Window. The Parameters Window will display a drop down list of available sample designs.

**Note:** *Judgmental will always display when this step is selected since it is the first sample design in the list.*



Select a sample design. The information in the Parameters Window will change to present the parameters for the selected sample design. The other steps in the Steps Window may change as well.

See the table above to determine when a specific sample designs is available.

## Initial Sample Designs

Initial sample designs are used in empty SADA files; they are independent of previous samples and therefore may be used with prior information about the site to determine where to take the first round of samples.

- Judgmental
- Simple Random
- Simple Grid
- Simple Unaligned Grid
- Standard Grid
- Standard Unaligned Grid
- Hotspot: Minimize Sample Size By Cost
- Hotspot: Minimize Sample Size By Hot Spot Definition
- Hotspot: Unknown Hotspot
- Hotspot: Calculate Probability
- 3D Hot Spot Search

## Judgmental Sample Design

Under this initial sample design, the creation of new samples is completely up to the user. Using expert knowledge or professional judgment, the user must define the location and number of new samples by creating a Custom Design. This design can be saved and edited multiple times. This approach is easy to implement and can be more efficient; however, it introduces bias and cannot reliably estimate precision of estimates nor use statistical analyses to draw conclusions.

### Availability

This sample design is available for all SADA files.

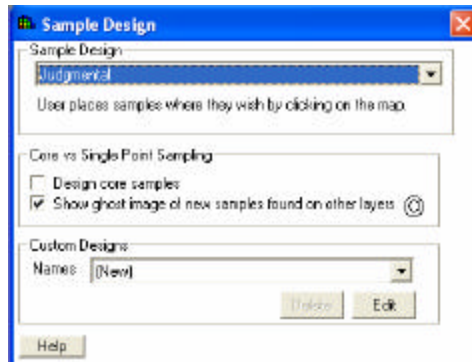
### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data , Draw/Edit Prior , Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

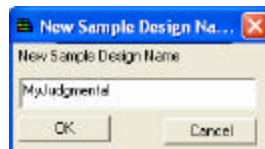
### Design-specific Parameters

When **Judgmental** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



Select **Design Core samples** or **Show Ghost Image** if desired.

Press **Show the Results** on the Steps Window or press the **Edit** button on the Parameters window to create a new judgmental design. SADA will prompt the user for a name.

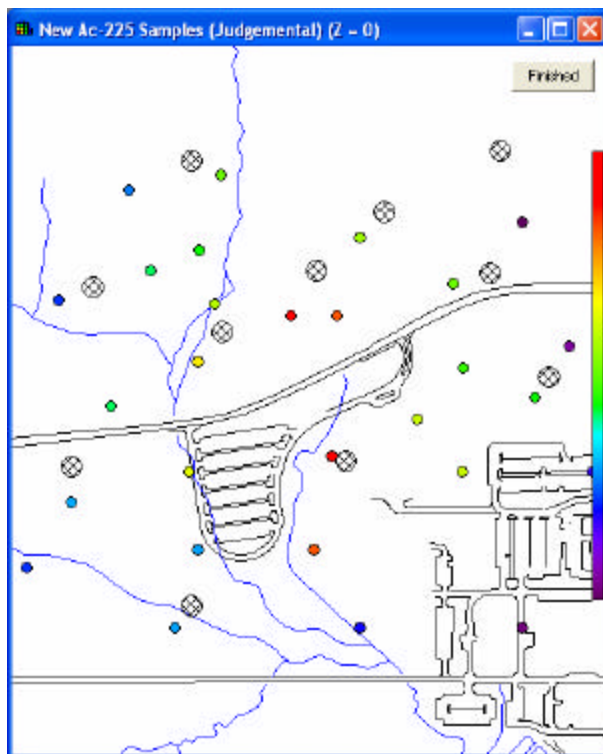


SADA will then go into edit mode, disabling everything else in SADA. Note that the **Edit** button on the **Parameters Window** has now changed to **Done**.

Use the mouse to select sample locations in the Graphics Window. Left click on the graphics window to add a new sample at the location of the click. This new sample is shown as a crosshatched gray circle. Move new samples by clicking & dragging on the circle. To delete new samples, left click on the desired circle (this changes its color to blue) and press the delete button. To add samples to multiple layers, change the active layer using the Layers Box.

Press **Done** when finished creating new samples. The design will now appear in the drop down box under Custom Designs on the Parameters Window.

Outside of edit mode, the created samples are shown as cross-hatched gray circles. Only samples that exist in the active layer are shown in the Graphics Window. To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.



## Simple Random Sample Design

Simple random is a 3d initial sample design that relies on the generation of coordinate values to create the new samples. Samples are distributed randomly across the site and across all included vertical layers. Random sample designs are an underlying assumption in most statistical tests; however, samples may miss areas of interest and can occasionally be clustered. This sample design is useful for class III MARSSIM data.

### Availability

This sample design is available for all SADA files.

### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

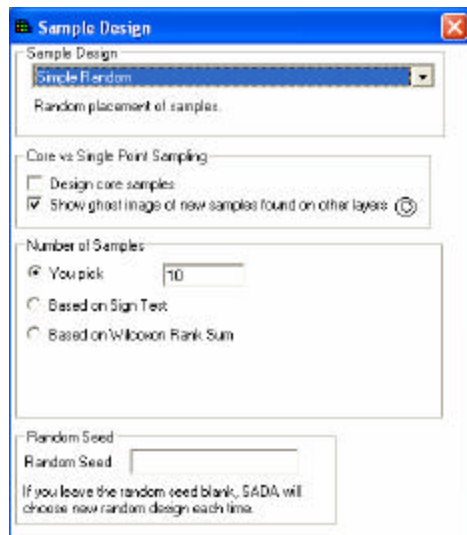
1. See the data, Draw/Edit Prior, Display empty plot



2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

### Design-specific Parameters

When **Simple Random** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



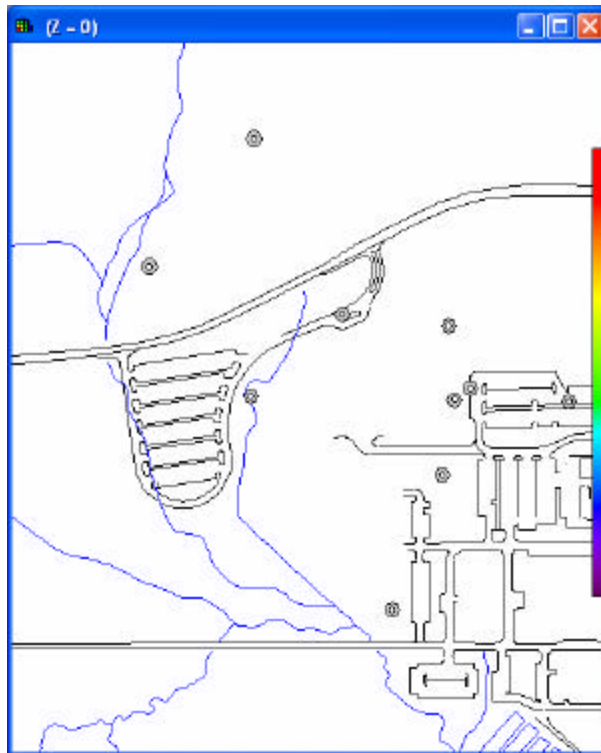
If there are polygons, new samples will only be placed inside the active polygons.

Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Number of Samples**, select the appropriate method.

Under **Random Seed**, enter a number to generate the same random design. If the random seed is blank, SADA will generate a distinct random design each time.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Simple Grid Sample Design

Simple grid is a 2d initial, systematic aligned grid design. SADA specifies a distance between sample points and uses a random starting point to generate either a square or triangular grid pattern. Triangular grids provide more information spatially than rectangular grids.

This design provides better spatial representation than a random placement and supports a geospatial analysis. The regularized pattern, however, may miss some features such as piping or ditches and the lack of truly random design may have an unknown impact on determining precision of simple statistical values or tests.

#### Availability

This sample design is available for all SADA files.

#### Steps

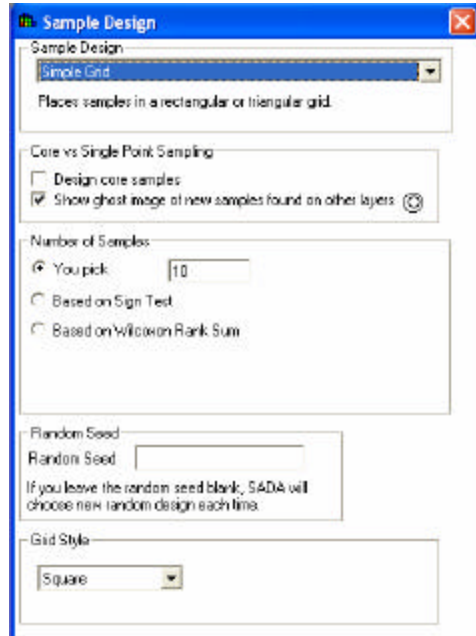
These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture

8. Auto-document
9. Add to results gallery (not available for empty SADA files)

### Design-specific Parameters

When **Simple Grid** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



Select **Design Core samples** or **Show Ghost Image** if desired.

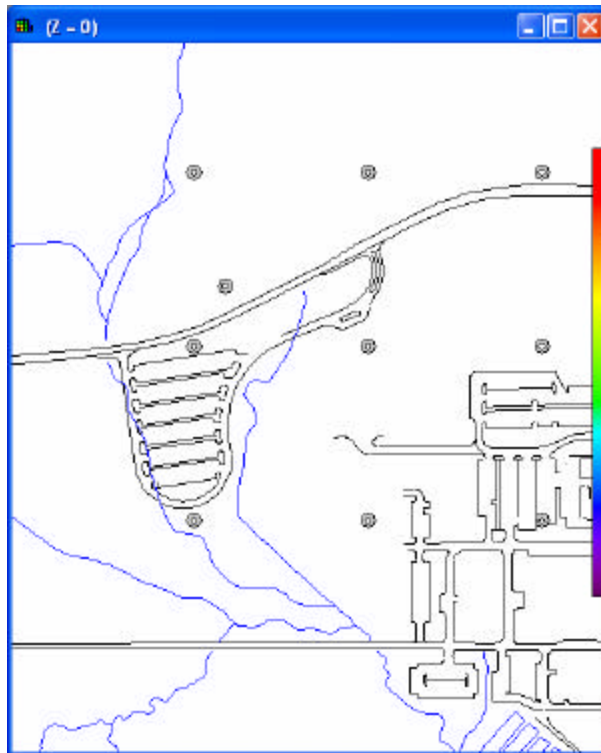
If there are polygons, new samples will only be placed inside the active polygons.

Under **Number of Samples**, select the appropriate method.

Under **Random Seed**, enter a number to generate the same random design. If the random seed is blank, SADA will generate a distinct random design each time.

Under **Grid Style**, select square or triangular.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window.



**Note:** Often this sample design will not return the exact number of desired samples due to constraints from the square grid type, the layering scheme, and the extents of the area.

To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Simple Unaligned Grid Sample Design

Simple Unaligned grid is a 2d initial, systematic unaligned sample design. SADA uses a random starting point to generate a square grid system, but rather than sampling the center of each cell, a random location in the cell is chosen.

This design can help overcome the problem of missing features by randomizing within the cell. It increases the random element of the design while enforcing a regular distribution across the site. The lack of truly random design, however, may have an unknown impact on determining precision of simple statistical values or tests.

#### Availability

This sample design is available for all SADA files.

#### Steps

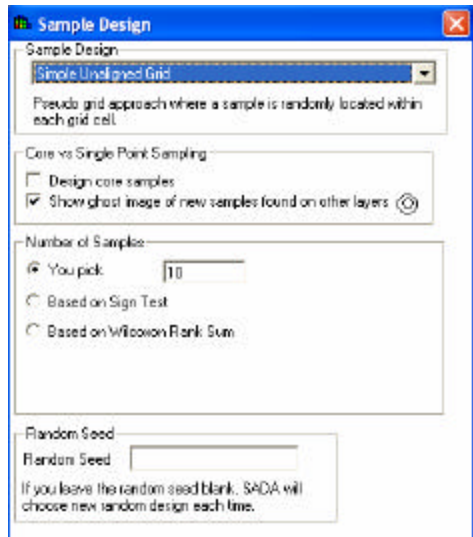
These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data

7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

### Design-specific Parameters

When **Simple Unaligned Grid** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



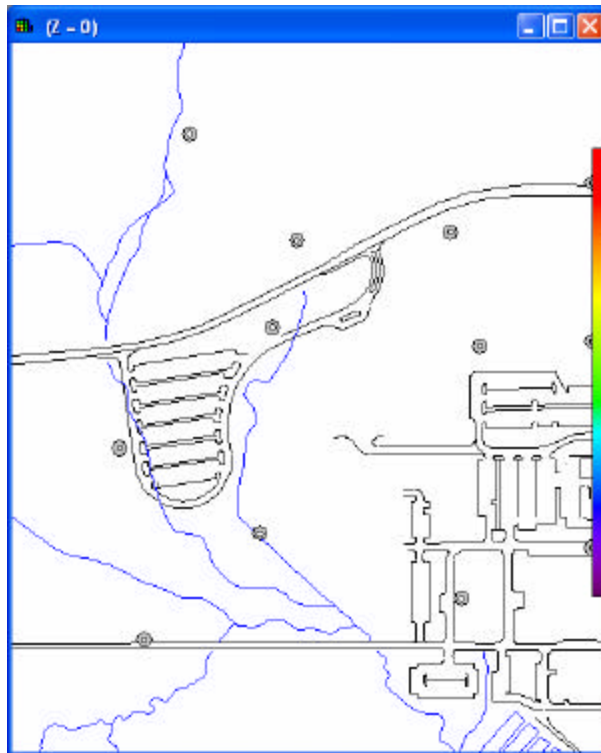
Select **Design Core samples** or **Show Ghost Image** if desired.

If there are polygons, new samples will only be placed inside the active polygons.

Under **Number of Samples**, select the appropriate method. See the section **Determining the Number of Samples** for more information.

Under **Random Seed**, enter a number to generate the same random design. If the random seed is blank, SADA will generate a distinct random design each time.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window.



**Note:** Often this sample design will not return the exact number of desired samples due to constraints from the square grid type, the layering scheme, and the extents of the area.

To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Standard Grid Sample Design

Standard grid is a 2d initial, systematic aligned grid design that relies on a user-defined grid definition and depth classification. Sample points are created in the center of each grid block.

This design provides better spatial representation than a random placement and supports a geospatial analysis. The regularized pattern, however, may miss some features such as piping or ditches and the lack of truly random design may have an unknown impact on determining precision of simple statistical values or tests.

#### Availability

This sample design is available for all SADA files.

#### Steps

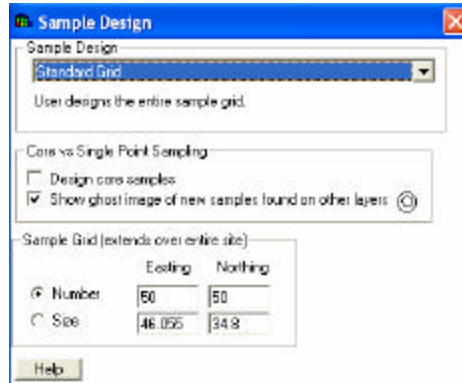
These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data

7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

### Design-specific Parameters

When **Standard Grid** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:

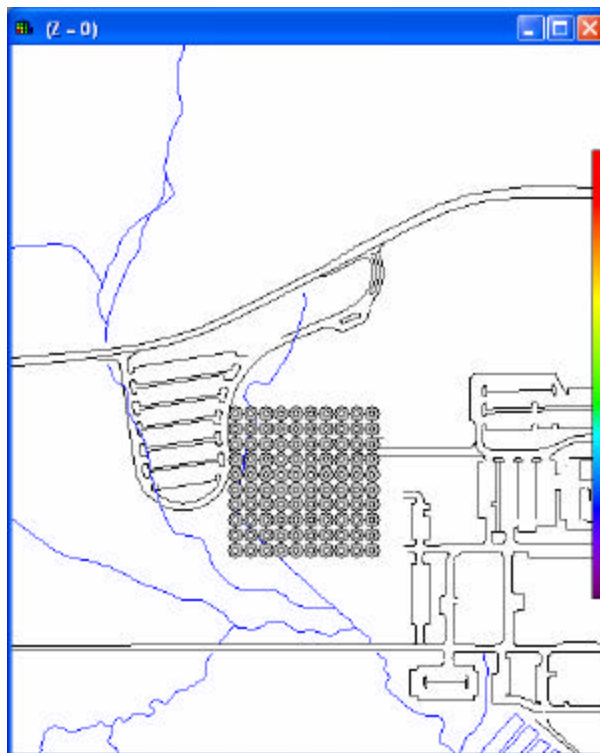


Select **Design Core samples** or **Show Ghost Image** if desired.

If there are polygons, new samples will only be placed inside the active polygons.

Under **Sample Grid**, select whether the design the grid based on number of blocks or size of blocks. Then, enter the applicable values in the Easting and Northing columns. (**Note:** SADA enters default values for these columns automatically.)

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

## Standard Unaligned Grid Sample Design

Standard Unaligned grid is a 2d initial, systematic unaligned sample design that relies on a user-defined grid definition and depth classification. Instead of being in the center, sample points are created in random locations within each grid block.

This design can help overcome the problem of missing features by randomizing within the cell. It increases the random element of the design while enforcing a regular distribution across the site. The lack of truly random design, however, may have an unknown impact on determining precision of simple statistical values or tests.

### Availability

This sample design is available for all SADA files.

### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

### Design-specific Parameters

When **Standard Unaligned Grid** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



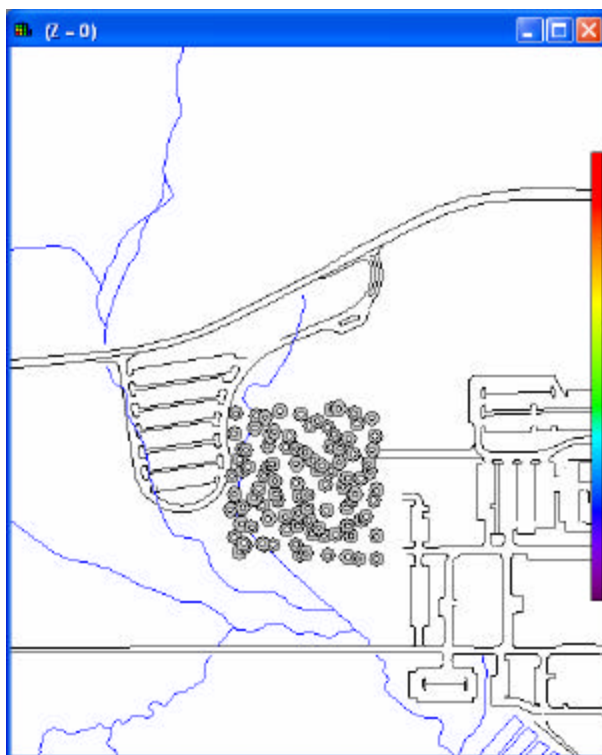
Select **Design Core samples** or **Show Ghost Image** if desired.



If there are polygons, new samples will only be placed inside the active polygons.

Under **Sample Grid**, select whether the design the grid based on number of blocks or size of blocks. Then, enter the applicable values in the Easting and Northing columns. (**Note:** SADA enters default values for these columns automatically.)

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window.



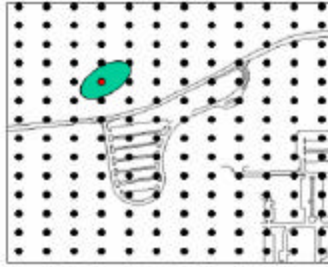
To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Hot Spot Sample Designs

Hot spot sampling is a 2d initial Ellipgrid model by Reference Search Strategy that was originally encoded as Ellipgrid PC by Oak Ridge National Laboratory. The goals of 2d hot spot sampling are to calculate:

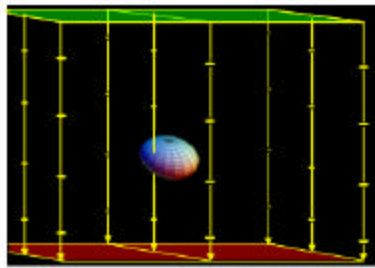
- the probability of hitting or, conversely, missing an elliptical hot spot of a defined size;
- the maximum size of a hot spot that would, with a defined probability, be hit by a sample grid definition;
- a grid of samples based on finding a hot spot of a defined size with a distinct probability; and
- a grid of samples based on the cost to sample, the sample area definition, and a limited budget.

2D Ellipgrid calculates the relationship between hotspot size, grid density, cost, and probability for a variety of circumstances. These designs are useful in determining tradeoffs between cost, size of hot spot, and cost to implement; however, most sample designs are fairly dense grids and too expensive for many sampling budgets.



There are four 2d hot spot sample designs in SADA: Hot Spot: Minimize Sample Size By Cost, Hot Spot: Minimize Sample Size By Hot Spot Definition, Hot Spot: Unknown Hot Spot, Hot Spot: Calculate Probability.

The concept of hot spot searches in two dimensions can easily be extended into the third dimension through the use of simulation. A grid is specified in three dimensions, and the locations of ellipsoids are simulated across the site. The likelihood of hitting such a hot spot is simply the ratio of simulated hits to total simulations. This provides an estimate of how effective a sampling grid will be at finding hot spots in subsurface. As with two dimensional hot spot searches, however, the grids can be too dense for practical sampling budgets.



The only 3d hot spot sample design in SADA is 3d Hot Spot Search.

### **Hot Spot: Minimize Sample Size By Cost**

With Hot Spot: Minimize Sample Size by Cost, the user defines the grid style and cost parameters. This combination yields a possible sample number. This sample number, grid style, and the limitations of the boundaries and layering scheme then define a grid block and grid block length.

### **Availability**

This sample design is available for all SADA files.

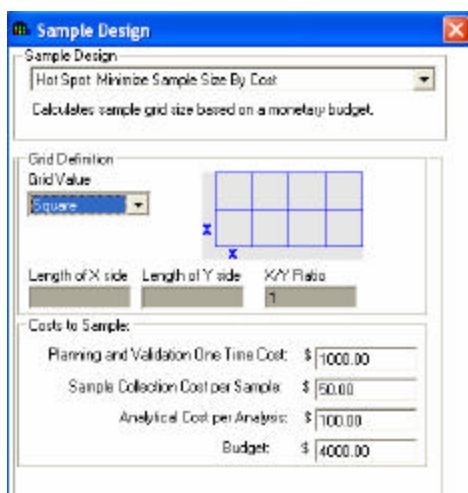
### **Steps**

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

## Design-specific Parameters

When **Hot Spot: Minimize Sample Size by Cost** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



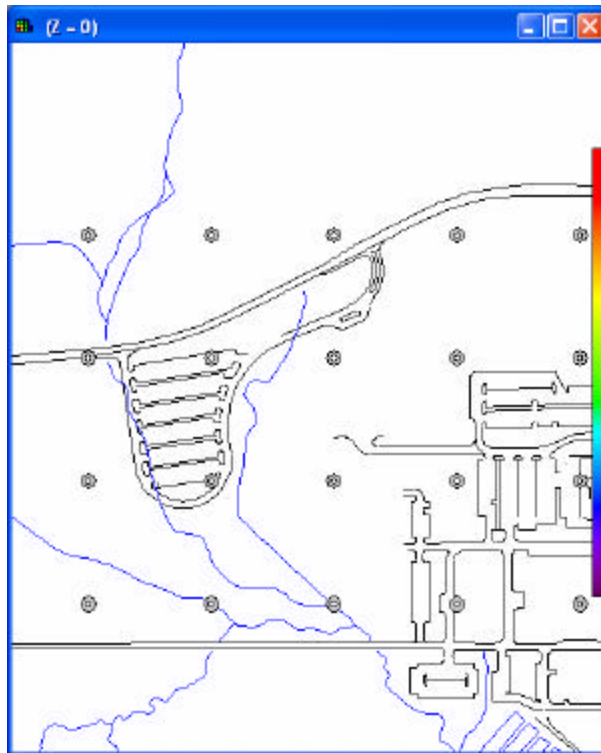
Under **Grid Definition**, select a square, triangle, or rectangle grid style and enter the cost parameters under **Costs to Sample** using positive US currency values with 2 decimal places. The planning cost is a one-time cost while the collection and analysis costs apply to each sample created. Enter a positive value large enough to create at least one sample in the Budget field.

Where N is the number of samples,

$[Total\ Budget] - [Planning\ Cost] = N * [(Collection\ Cost) + (Analysis\ Cost)]$  or

$N = [(total\ Budget) - (Planning\ Cost)] / [(Collection\ Cost) + (Analysis\ Cost)]$

Press **Show the Results** and SADA will determine the number of new samples and select their locations based on the grid style. SADA will also enter the resulting grid size information on the Parameters Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### **Hot Spot: Minimize Sample Size By Hot Spot Definition**

With Hot Spot: Minimize Sample Size by Hot Spot Definition, the user defines the grid style and the probability of hitting a hot spot of a given size, shape, and orientation. This combination yields a possible sample number, and grid definition.

### **Availability**

This sample design is available for all SADA files.

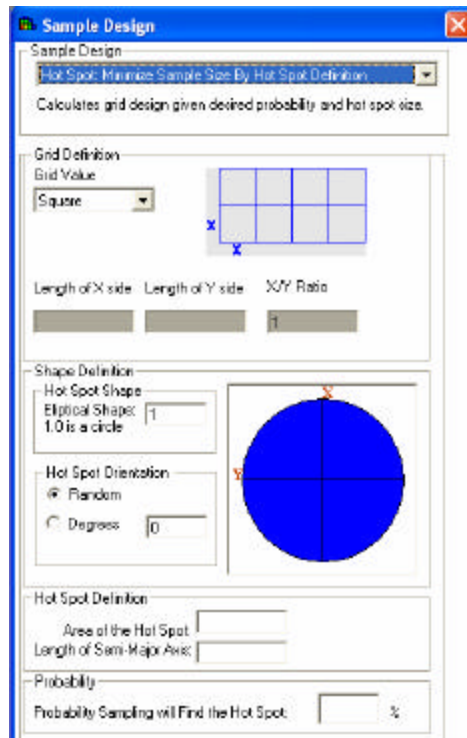
### **Steps**

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

## Design-specific Parameters

When **Hot Spot: Minimize Sample Size by Hot Spot Definition** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:

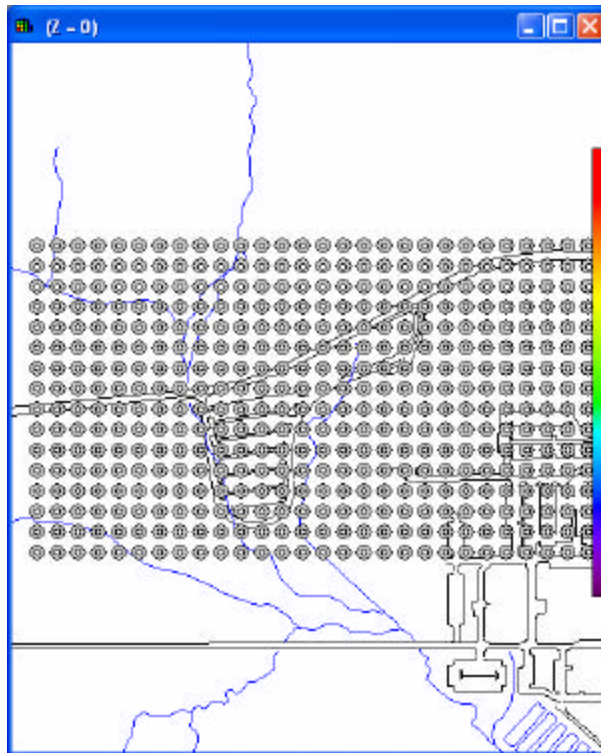


Under **Grid Definition**, select a square, triangle, or rectangle grid style.

Enter the parameters for **Shape Definition**. For **Hot Spot Shape**, enter a value that is greater than or equal to .2 and less than or equal to 1. This is the ratio between the major and minor axes of the elliptical hot spot. (Note that 1 is a circle.) For **Hot Spot Orientation**, select **Random** to use omni directional ellipses, or select **Degrees** and enter a value between 0 and 90.

Define the **Hot Spot Definition** by setting either the area or the length of the semi-major axis (note that the other value will change accordingly), and enter a value between 1 and 100 for the **Probability**.

Press **Show the Results** and SADA will determine the number of new samples and the grid design and display the sample locations in the Graphics Window. SADA will also enter the resulting grid size information on the Parameters Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### **Hot Spot: Unknown Hot Spot**

With Hot Spot: Unknown Hot Spot, the user defines the grid style and size, the hot spot shape and orientation, and the probability of detecting a hot spot of unknown size.

### **Availability**

This sample design is available for all SADA files.

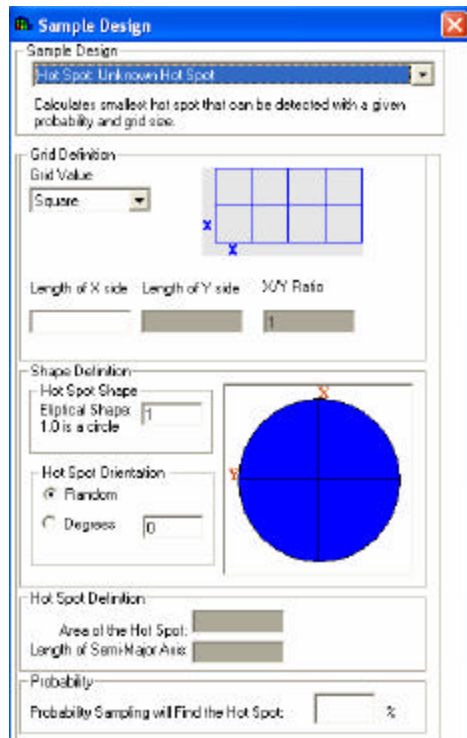
### **Steps**

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

## Design-specific Parameters

When **Hot Spot: Unknown Hot Spot** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:

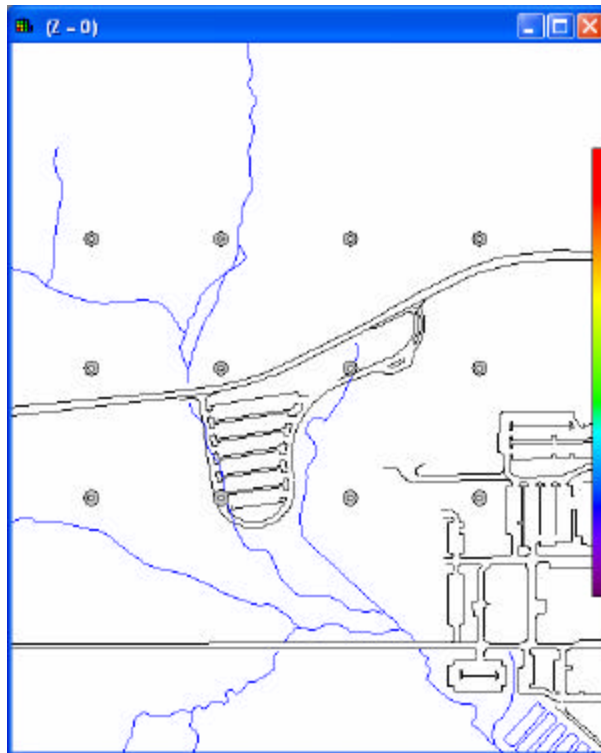


Under **Grid Definition**, select a square, triangle, or rectangle grid style.

Enter the parameters for **Shape Definition**. For **Hot Spot Shape**, enter a value that is greater than or equal to .2 and less than or equal to 1. This is the ratio between the major and minor axes of the elliptical hot spot. (Note that 1 is a circle.) For **Hot Spot Orientation**, select **Random** to use omni directional ellipses, or select **Degrees** and enter a value between 0 and 90.

Enter a value between 1 and 100 for the **Probability**.

Press **Show the Results** and SADA will determine the number of new samples and display their locations on the Graphics Window. SADA will also enter the resulting **Hot Spot Definition** on the Parameters Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### **Hot Spot: Calculate Probability**

With Hot Spot: Calculate Probability, the user defines the grid and the hot spot size, shape and orientation.

### **Availability**

This sample design is available for all SADA files.

### **Steps**

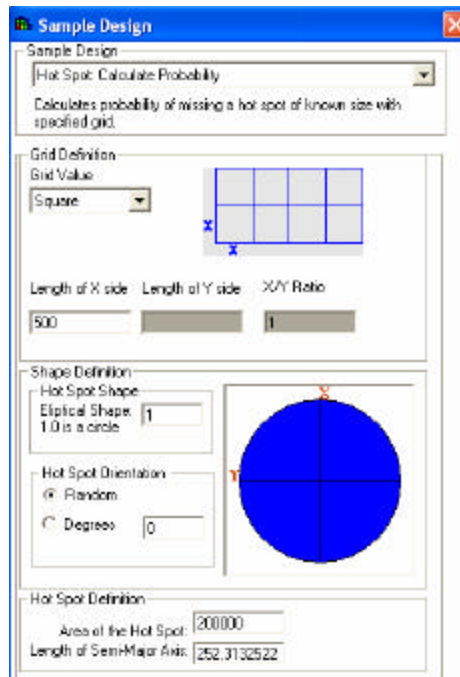
These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)



## Design-specific Parameters

When **Hot Spot: Calculate Probability** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:

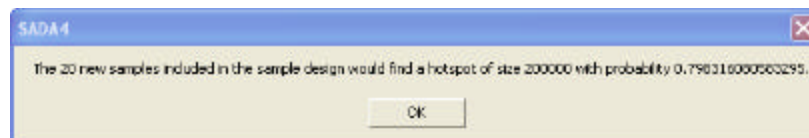


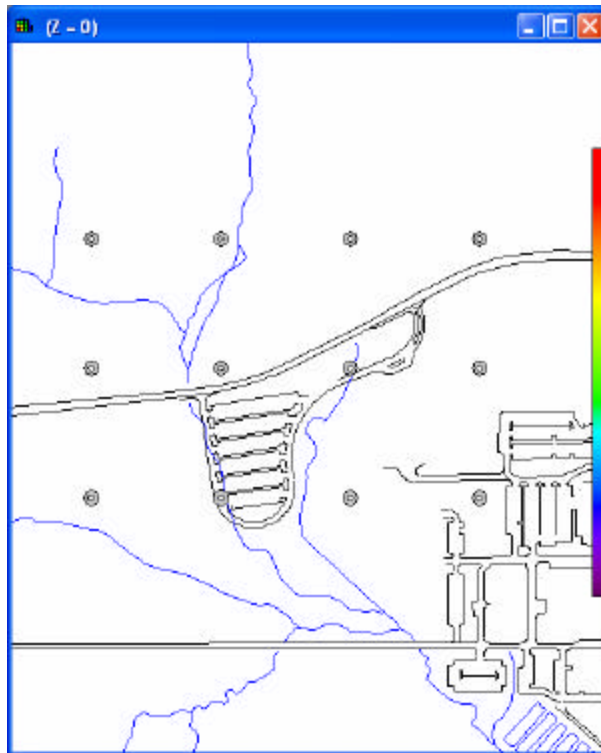
Under **Grid Definition**, select a square, triangle, or rectangle grid style and enter the Length of X side.

Enter the parameters for **Shape Definition**. For **Hot Spot Shape**, enter a value that is greater than or equal to .2 and less than or equal to 1. This is the ratio between the major and minor axes of the elliptical hot spot. (Note that 1 is a circle.) For **Hot Spot Orientation**, select **Random** to use omni directional ellipses, or select **Degrees** and enter a value between 0 and 90.

Define the **Hot Spot Definition** by setting either the area or the length of the semi-major axis (note that the other value will change accordingly).

Press **Show the Results**. SADA will present a message re the number of new samples and their probability of hitting a hot spot before displaying the new sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.





To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### 3d Hot Spot Search

3D Hot Spot Search is a 3d initial sample design that calculates the probability of hitting or missing an elliptical area of interest.

#### Availability

This sample design is available for all SADA files.

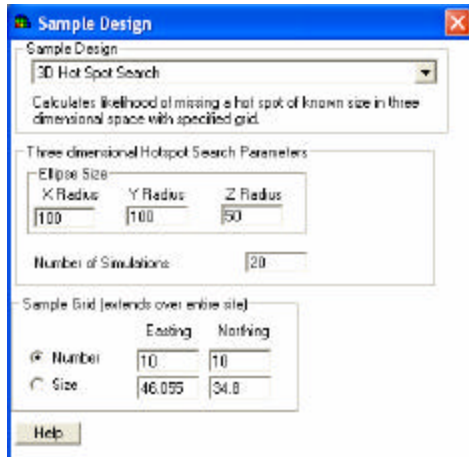
#### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data, Draw/Edit Prior, Display empty plot
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery (not available for empty SADA files)

## Design-specific Parameters

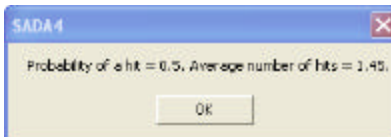
When **3D Hot Spot Search** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:

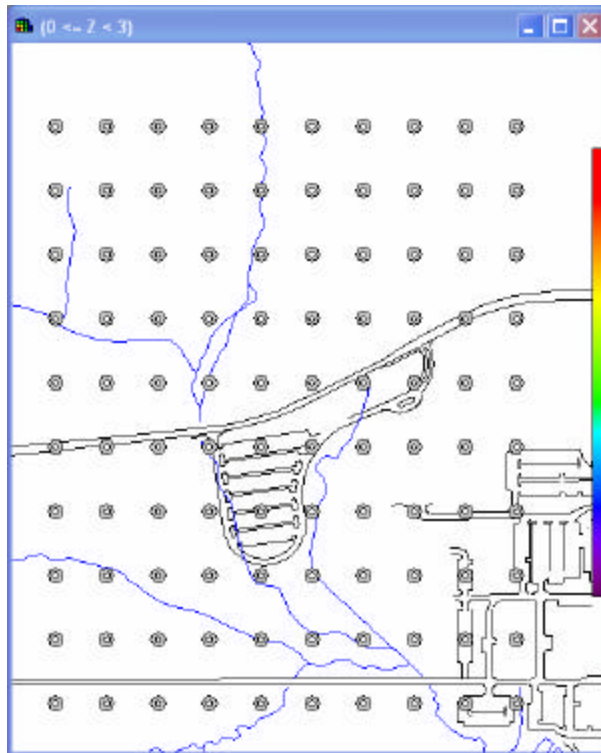


Enter the hot spot search parameters, number of simulations, and grid design.

Press **Show the Results**. For each simulation, the defined ellipse is randomly placed within the grid design and SADA calculates the number of nodes that would intersect this ellipse. Over a large number of simulations, SADA can calculate the probability of hitting (or missing) an ellipse of the given size for the specified grid.

SADA will first present a message of the probability of hitting the ellipsoid and the average number of hits. Then SADA displays the new sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.





To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

## Secondary Sample Designs

Unlike initial sample designs, secondary sampling designs are dependent on previously existing samples. SADA contains 11 secondary sample designs:

- Threshold Radial
- Adaptive Fill
- High Value
- Highest Prior Values
- Area of Concern Boundary
- AOC Prior Boundary
- Minimizing/Maximizing Area of Concern
- Ripley's K
- Moran's I
- Geary's C

### Threshold Radial Sample Design (Adaptive Cluster Sampling)

Threshold Radial (also known as Adaptive Cluster Sampling) is a straightforward secondary sample design that places samples in a radial pattern around existing data points that exceed a decision threshold. The user has control over the pattern of the surrounding new sample points. They can be circular or rectangular.

## Availability

This sample design is only available for SADA files with sampled data.

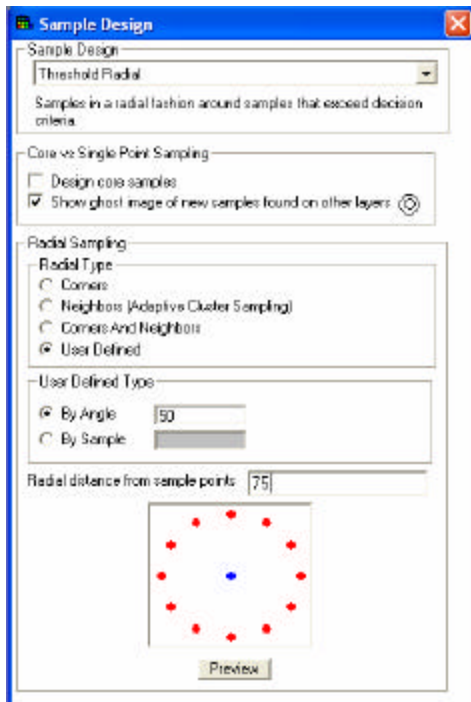
## Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery

## Design-specific Parameters

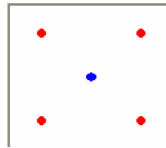
When **Threshold Radial** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



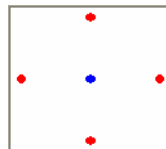
Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Radial Sampling**, select the radial type:

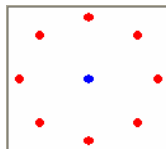
- **Corners** – SADA defines four new samples around every original point. The first sample is 45 degrees from the horizontal of the original point. A preview of this radial type is displayed in the preview box on the **Parameters Window**.



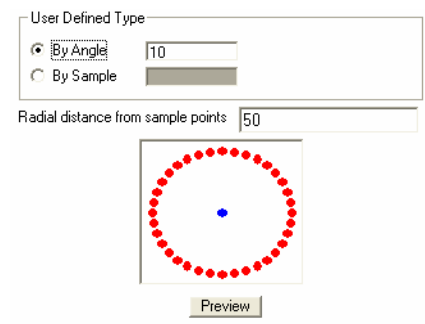
- **Neighbors** – SADA defines four new samples around every original point. This type of design is the traditional implementation of Adaptive Cluster Sampling. The first sample is horizontally in line with the original point. A preview of this radial type is displayed in the preview box on the **Parameters Window**.



- **Corners and Neighbors** – SADA defines eight new samples around every original point. This is a combination of the corners and neighbors radial types. A preview of this radial type is displayed in the preview box on the **Parameters Window**.

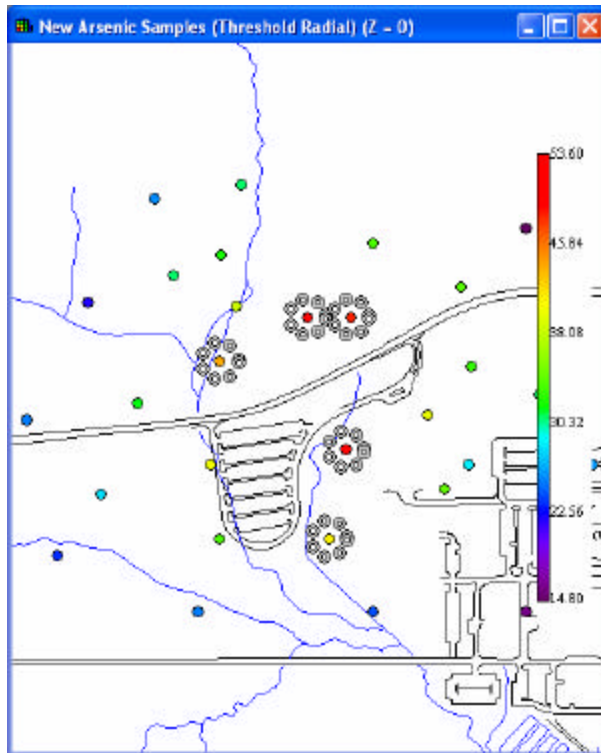


- **User Defined** – The user defines either the angle between samples or the number of new samples per every original point under **User Defined Type**. To preview the user definition, select **Preview**. A preview of this radial type is displayed in the preview box on the **Parameters Window**.



Enter a value for **Radial Distance Between Sampling Points**. This value defines the distance from the original point to each new sample.

Press **Show the Results**. Depending on the analysis type, SADA will request a general decision goal, human health risk scenario, ecological benchmark, custom decision criteria, or DCGL value. After selecting the appropriate decision criteria, SADA will display the new sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Adaptive Fill Sample Design

Adaptive Fill is a secondary sample design that spatially fills data gaps, independent of geospatial interpolation. New sample values are formed using coordinate values that are farthest away from any other original data point.

#### Availability

This sample design is available for SADA files with sampled data or Geobayesian data.

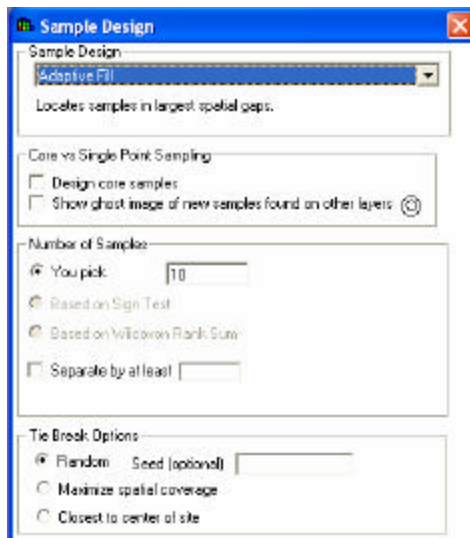
#### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Set grid specs
6. Show the results
7. Import sampled data
8. Format picture
9. Auto-document
10. Add to results gallery

## Design-specific Parameters

When **Adaptive Fill** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



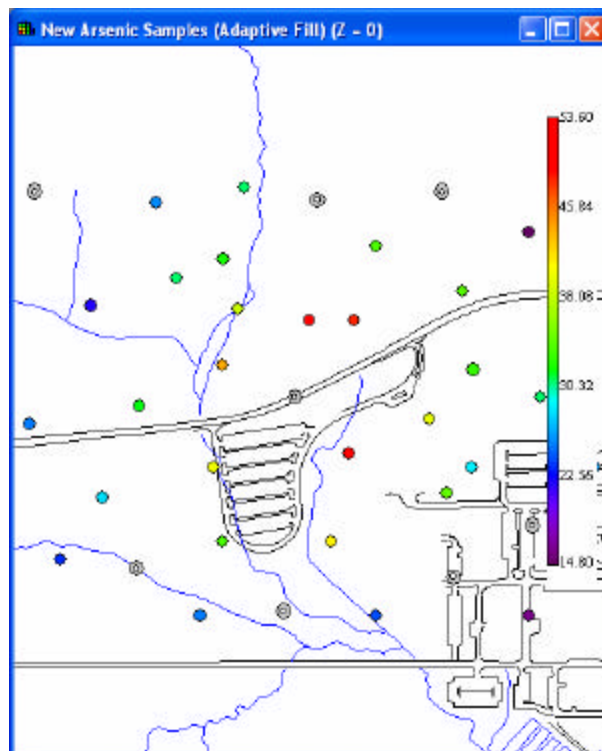
Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Number of Samples**, only you pick is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Under **Tie Break Options**, select the appropriate tie break method.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.





To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

## High Value Sample Design

High Value is a secondary sample design that generates new samples in locations where modeled values are the highest. This design may be useful for verifying the extent of hot spot regions.

### Availability

This sample design is available for SADA files with sampled data or Geobayesian data.

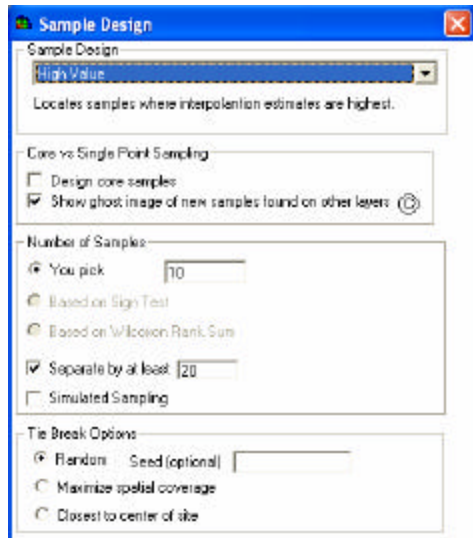
### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters. **Note:** *With Geobayesian data, SADA will automatically change the interpolant to kriging and not allow the user to alter this.*

1. See the data, Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Set update data (for Geobayesian files only)
6. Set grid specs (not available for Geobayesian)
7. Interpolation methods (not available for Geobayesian)
8. Correlation modeling (If indicator kriging or ordinary kriging )
9. Search neighborhood
10. Show the results
11. Import sampled data
12. Format picture
13. Auto-document
14. Add to results gallery

### Design-specific Parameters

When **High Value** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



Select **Design Core samples** or **Show Ghost Image** if desired.

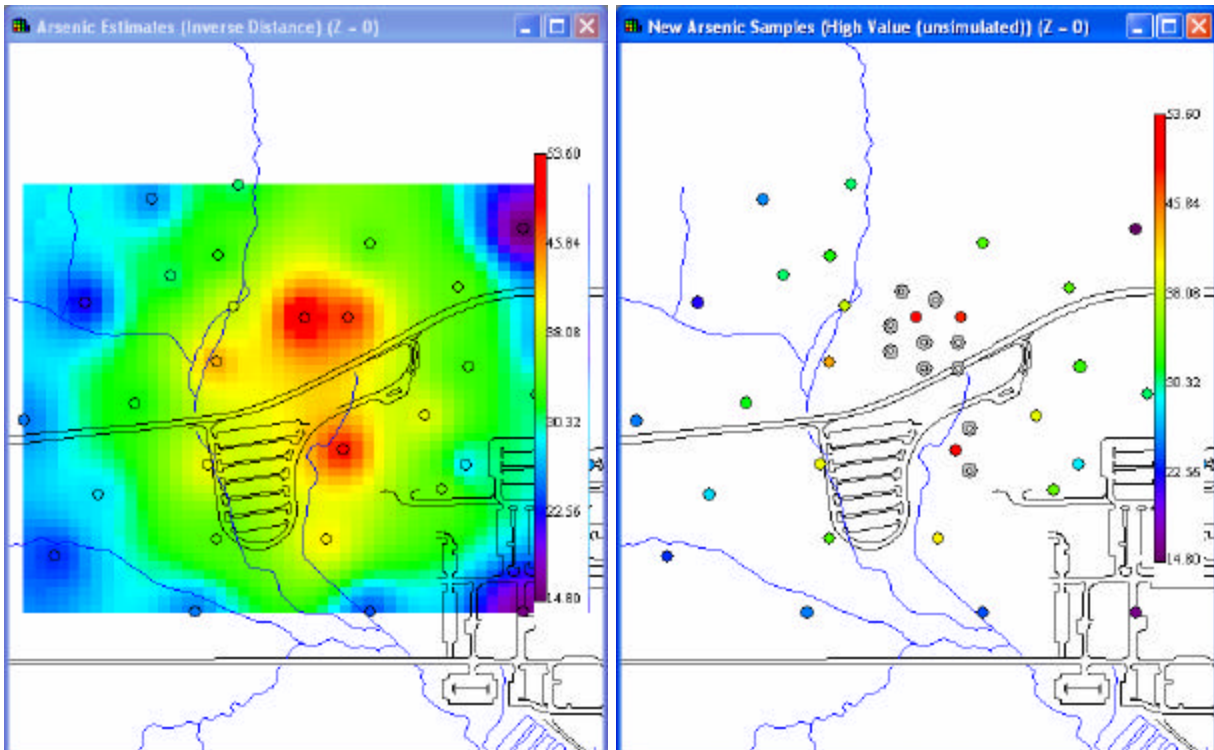
Under **Number of Samples**, only you pick is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Click on the box next to **Simulated Sampling** for simulated sampling.

Under **Tie Break Options**, select the appropriate tie break method.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

## Highest Prior Values Sample Design

Highest Prior Value is a secondary sample design for Geobayesian data that generates new samples in locations prior values are modeled to have high concentration levels.

### Availability

This sample design is only available for SADA files with Geobayesian data.

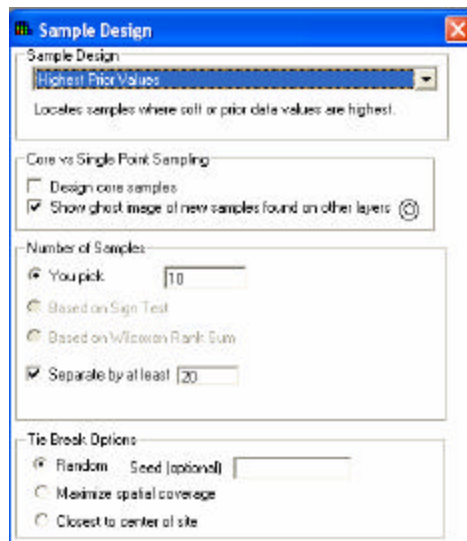
### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery

### Design-specific Parameters

When **Highest Prior Values** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



The screenshot shows a window titled "Sample Design" with a dropdown menu set to "Highest Prior Values". Below the dropdown, a description reads: "Locates samples where soil or prior data values are highest." The "Core vs Single Point Sampling" section has two checkboxes: "Design core samples" (unchecked) and "Show ghost image of new samples found on other layers" (checked). The "Number of Samples" section has three radio buttons: "You pick" (selected), "Based on Sign Test", and "Based on Wilcoxon Rank Sum". A "Separate by at least" checkbox is checked with a value of 20. The "Tie Break Options" section has three radio buttons: "Random" (selected), "Maximize spatial coverage", and "Closest to center of site".

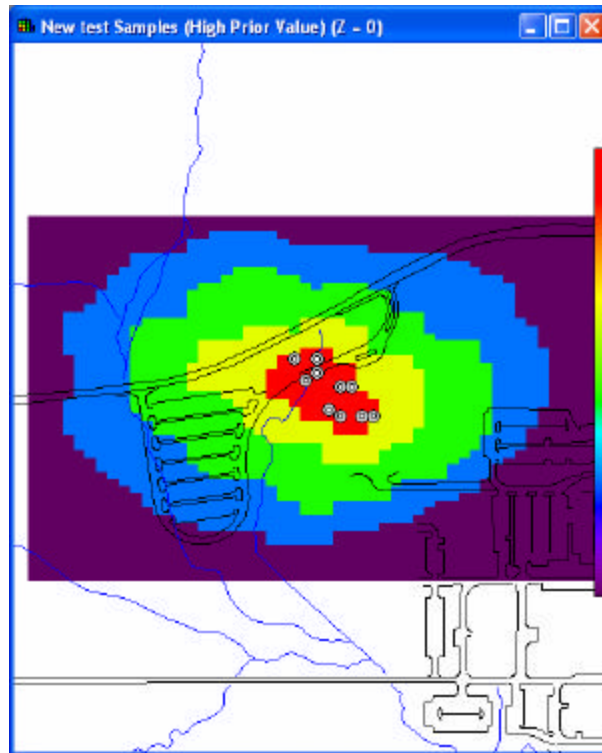
Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Number of Samples**, only you pick is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Under **Tie Break Options**, select the appropriate tie break method.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Area of Concern Boundary Sample Design

Area of Concern Boundary is a secondary sample design that places new samples in locations along the decision boundary.

Note that like AOC maps for geostatistical models, this routine will strictly use the results of the geospatial interpolation. That is, if the interpolation produces a mean map, then the AOC sample design is based on the mean map. If the interpolation produces a 10<sup>th</sup> percentile map, then the AOC sample design is based on the 10<sup>th</sup> percentile map. Note that because these percentile maps are now available to the user, the block confidence parameter is no longer required. In particular, if one wants to produce a 90% confidence map as defined in V4.0 and earlier, then the design should now be based on a 10<sup>th</sup> percentile map. By basing it on a 10<sup>th</sup> percentile map, the user requests that any block with greater than a 10% chance (90% confidence) of exceeding the criteria will be included.

### Availability

This sample design is available for SADA files with sampled data or with Geobayesian data.

### Steps

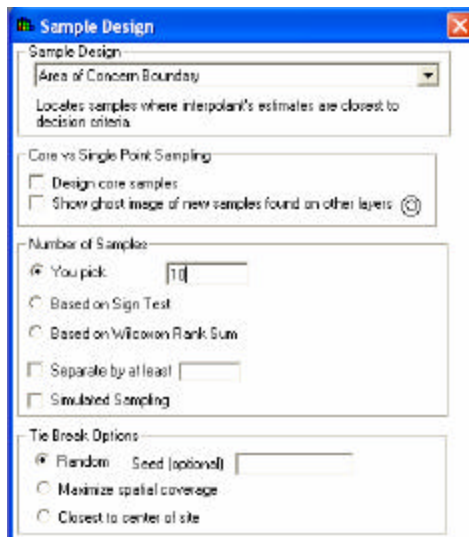
These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters. **Note:** *With Geobayesian data, SADA will automatically change the interpolant to kriging and not allow the user to alter this.*

1. See the data, Draw/Edit Prior
2. Set up the site
3. Set GIS overlays

4. Set sampling parameters
5. Set update data (for Geobayesian files only)
6. Set grid specs (not available for Geobayesian)
7. Interpolation methods (not available for Geobayesian)
8. Correlation modeling (If indicator kriging or ordinary kriging )
9. Search neighborhood
10. Show the results
11. Import sampled data
12. Format picture
13. Auto-document
14. Add to results gallery

### Design-specific Parameters

When **Area of Concern Boundary** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



Select **Design Core samples** or **Show Ghost Image** if desired.

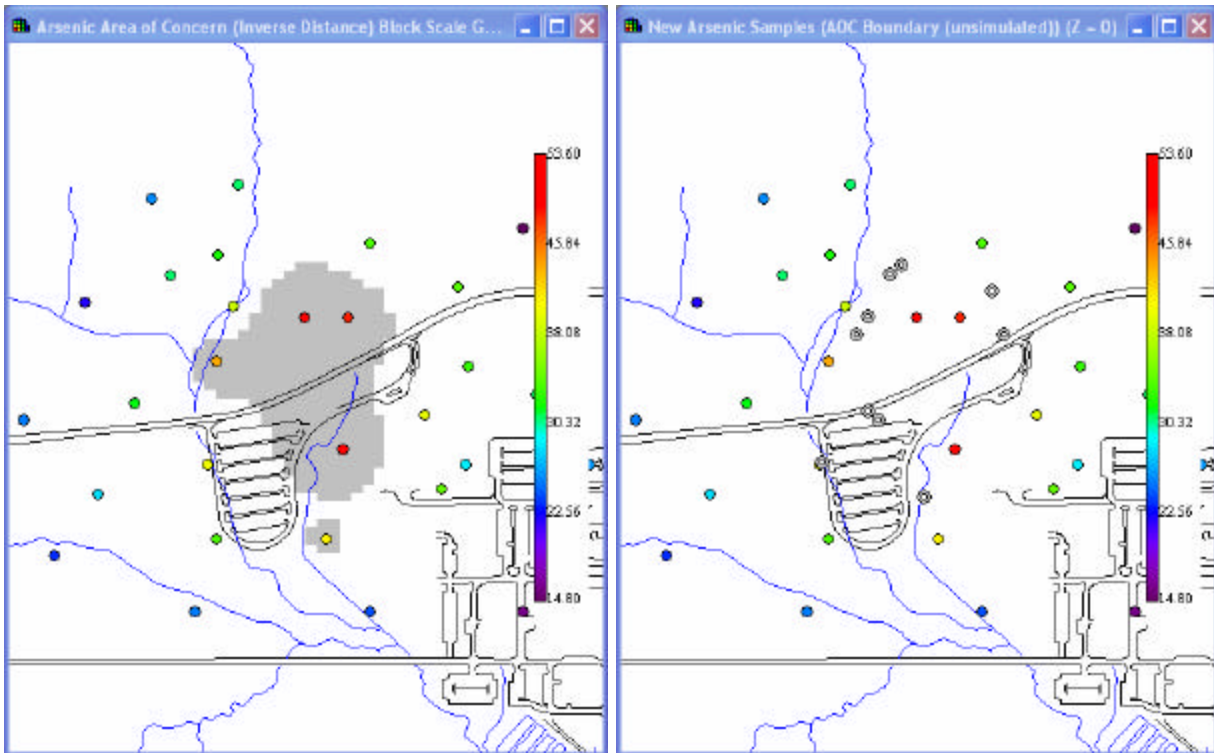
Under **Number of Samples**, only you pick is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Click on the box next to **Simulated Sampling** for simulated sampling.

Under **Tie Break Options**, select the appropriate tie break method.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### **AOC Prior Boundary Sample Design**

AOC Prior Boundary is a secondary sample design for Geobayesian data that generates new samples in locations with the highest uncertainty about exceeding the cleanup goal. This approach is useful for delineating the boundaries on an area of concern.

#### **Availability**

This sample design is only available for SADA files with Geobayesian data.

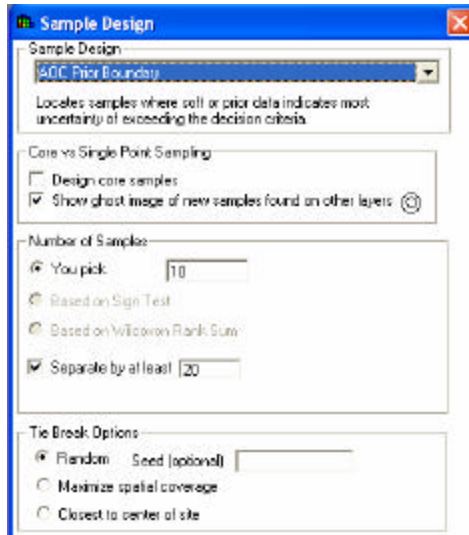
#### **Steps**

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Show the results
6. Import sampled data
7. Format picture
8. Auto-document
9. Add to results gallery

## Design-specific Parameters

When **AOC Prior Boundary** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



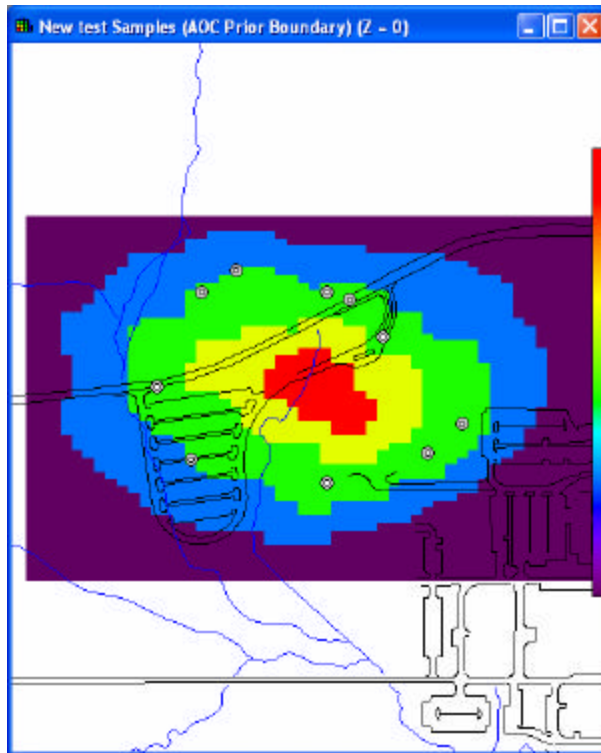
Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Number of Samples**, only you pick is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Under **Tie Break Options**, select the appropriate tie break method.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Minimizing/Maximizing Area of Concern Sample Design

Minimizing/Maximizing Area of Concern is a secondary sample design that generates new samples in locations that might minimize or maximize the area of concern. In the case of minimizing the area of concern, this method (based on the approach used by Dr. Bob Johnson at Argonne National Laboratory) tends to "march sample points" inward toward the area of concern. See the section

**Minimizing/Maximizing Area of Concern Discussion** for more information on this sample design.

#### Availability

This sample design is available for SADA files with sampled data or with Geobayesian data.

#### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters. **Note:** *With Geobayesian data, SADA will automatically change the interpolant to kriging and not allow the user to alter this.*

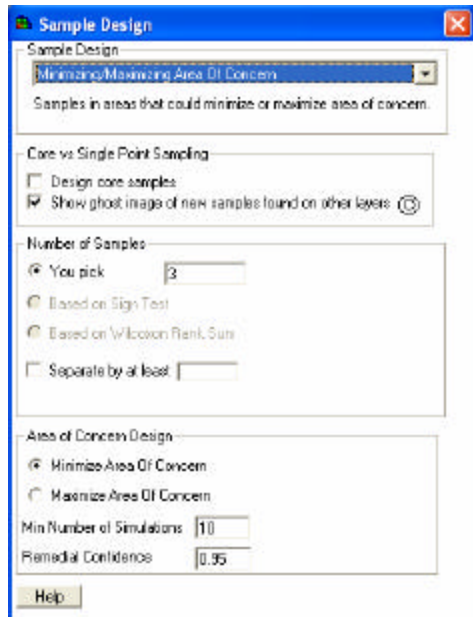
1. See the data, Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Set update data (for Geobayesian files only)
6. Set grid specs (not available for Geobayesian)
7. Interpolation methods (not available for Geobayesian)
8. Correlation modeling\_(If indicator kriging or ordinary kriging )



9. Search neighborhood
10. Show the results
11. Import sampled data
12. Format picture
13. Auto-document
14. Add to results gallery

### Design-specific Parameters

When **Minimizing/Maximizing Area of Concern** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



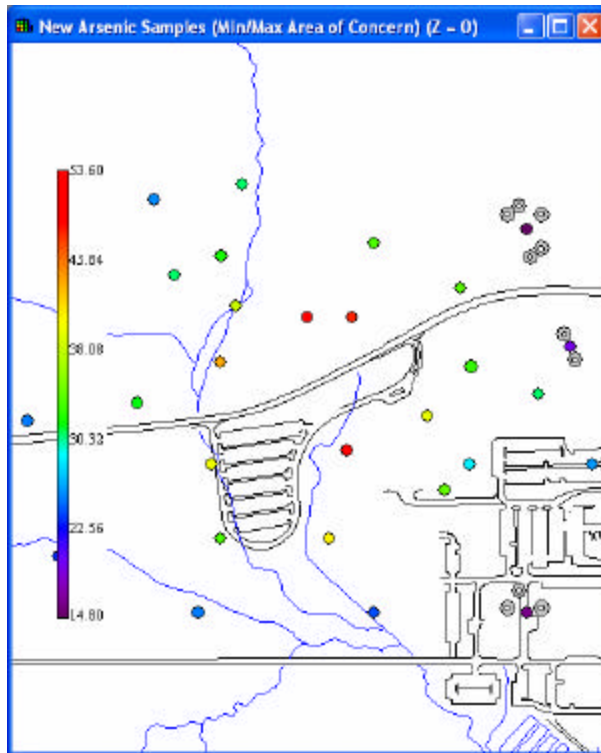
Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Number of Samples**, only "You pick" is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Select the type of **Area of Concern Design** and enter the minimum number of simulations and the remedial confidence.

Press **Show the Results** on the Steps Window. After asking for the decision criteria, SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

### Minimizing/Maximizing Area of Concern Discussion

This sampling routine identifies new sample locations where concentration levels predicted by the geospatial model would result in an area of concern that is less than (minimize) or greater than (maximize) the current area of concern. The idea is simple in concept but can be computationally very intensive.

Consider SADA's approach to other geospatially-based secondary sample designs, such as the high value design. If K new samples are requested and the user chooses to perform a simulated sample design, then SADA will initially contour the area and explore all nodes to identify the node with the highest modeled value. The location of this node then becomes a new sample location. The site is then re-contoured using the predicted value at the node as if it were a real sample point. The site is then re-explored to find the next highest predicted value. So for K new samples, the site is re-contoured K times. The total number of block estimations, N, would be estimated as

$$N = K \times (B-1) - 1$$

Where B is the number of blocks to be estimated in the volume. So, for a trivial three-dimensional application of 4x4 blocks and 2 layers (32 blocks), a site would be contoured 10 times to get 10 new samples or 309 blocks. Typically, applications of 100x100 with 5 layers take a few seconds to a couple of minutes to complete on most computers.

Note that this is an estimation, since some actual samples could inadvertently exist at a node value, reducing the number of blocks to estimate. This rarely occurs in practice. N can be a large number and require some time for large values of B.

This approach is not feasible for determining which sample node would reduce or increase the area of concern. A simple exploration of node values will not identify which node produces a reduction/increase in the area of concern. Rather for each new sample, the site would have to be re-contoured for each node using that node's value as a simulated sample value. SADA would then choose the node that result in the

smallest or greatest area of concern as a sample. This results in unacceptably high computational time. In particular, the number of calculations would be estimated as

$$N = B! - (B-K)!$$

Consider a trivial three-dimensional scheme with 4x4 blocks and 2 layers (32 blocks). To identify 2 new samples, minimizing or maximizing the area of concern would require the site to be re-contoured  $N = 32! - (32-2)! = 32! - 30! = 2.62E+35$ . It is fairly common to see 100x100 blocks with 5 or more layers ( $B=50,000$ ).

The location of a new sample will have a certain impact on the area of concern. In general, because of the nature of most spatial models, particularly those found in SADA, small changes in the location of that sample will have little or no practical impact on the area of concern. Therefore, from a practical standpoint, there is little need in investigating every single node, particularly for dense grids. It would be more computationally practical to select a subset of nodes to investigate. As illustrated above, however, even investigating a subset of 32 nodes is impractical.

Simulation of sampling designs is a useful approach for this overwhelming situation. Rather than visiting a subset of nodes one at a time, SADA randomly selects K nodes at a time from the full grid and calculates their impact on the area of concern. This represents one simulation of the design. If this process is repeated P times, the number of blocks estimated will be

$$N = P(B-K)$$

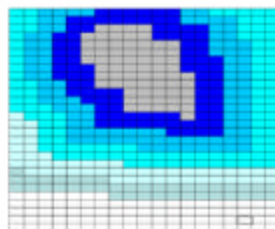
So, choosing 10 new samples from a 100x100 by 5 layer design by simulating the design 100 times will result in 100 site contours or  $N = 100(50000-10) = 4999000$  blocks. This takes only 2-3 minutes on a typical P4 machine with 490 sampled data points.

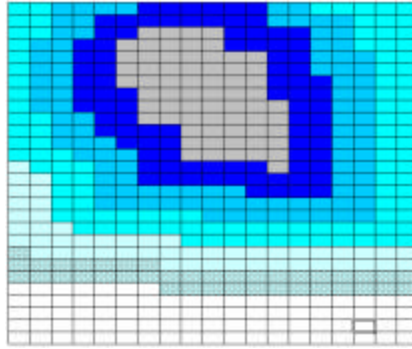
However, random selection across the entire site is an ineffective method for locating new samples. The presence of spatial correlation is an important theme in spatial mapping and in most cases, the closer sample points to a region of interest the more impact they have on the final result. It stands to reason that under most practical scenarios, those sample points that are in close proximity to the area of concern (but not contained within) are more highly correlated with and have a larger impact on regions found in the nearby area of concern than those located much further away.

Defining "nearby the area of concern" in any generalized way is difficult at best, given spatial correlation structures and the spatial arrangement of sampled points. This could be achieved through observed correlation lengths or search neighborhood parameters, but such guidelines are not universal (e.g. natural neighbor) to all contouring tools.

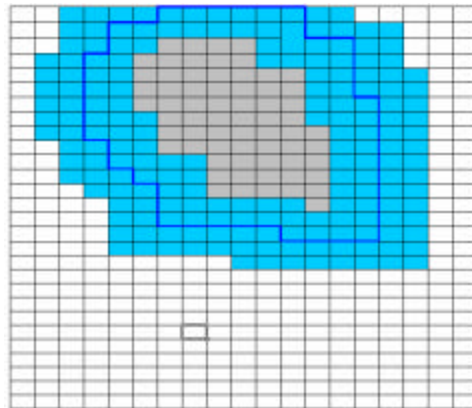
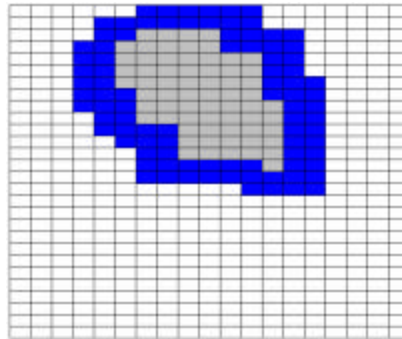
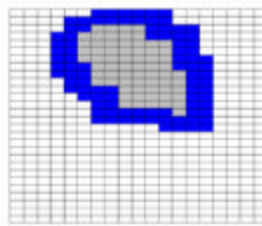
Still, it is important to recognize this spatial relationship and make use of it during simulation. As a result, SADA adheres to the following numerical approach for finding the greatest reduction or increase in the area of concern. For simplicity, we concentrate on minimization of the area of concern.

Given an area of concern map, SADA identifies 5 spatial bands around the area of concern called near field neighborhoods. In the figure below, the gray area is the area of concern and the blue areas are the neighborhood bands.

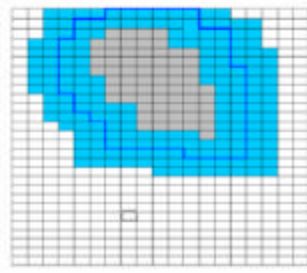




The requested number of simulations is divided evenly by 5. SADA then simulates the sample designs in increasing neighborhoods. For example, if the user requests 500 simulations, the first 100 simulations are constrained to the first neighborhood.



The second 100 simulations are constrained to the first and second neighborhood.



The same is true for the other simulations. This approach forces a preferential simulation in those areas near the area of concern. This is repeated for all five neighborhoods. The winning sample design from each neighborhood is compared, and the sample design with the greatest impact on the area of concern is selected as the winning sample design.

Of course when nodes are evaluated as potential sample point candidates, the normal constraints (such as separate by minimum distance) apply if the users requests.

During testing, this approach has proven to yield greater impact designs than when the entire site is permitted for all simulations. Typically, the first or second neighborhood will contain the winning design with the 4<sup>th</sup> through 5<sup>th</sup> rarely yielding the better result.

The bandwidths are estimated to be 1/10 the distance across the farthest horizontal extent of the site. So, a site that is 50 nodes by 100 nodes will have a neighborhood bandwidth of 10 nodes. Utilizing 5 neighborhoods will cover at least half the distance across the site and should be more than sufficient to identify optimal designs. Under rare conditions, it may be that SADA cannot identify any valid sample point nodes within these neighborhoods due to the minimum distance constraint. Under these situations, the neighborhoods are expanded to include the entire width of the site.

SADA reports the winning design as well as the expected increase or decrease in size of the area of concern. It is recommended that the user use at least 500 simulations. This would produce 100 simulations per neighborhood. More than 500 is preferred when possible. The greater the number of simulations, the more optimal the search design will be.

The principles of maximization work conversely. Neighborhood bands are found inside the area of concern and the winning design creates the greatest increase in the area of concern.

### **Coring issues**

When SADA is identifying a set of K samples under the "minimize the area of concern" framework, it only searches through nodes that are currently considered "clean". Therefore, SADA will never choose a point inside the area of concern to attempt to minimize the area of concern. This would result in the placement of a sample in the design greater than the design criteria and could expand the area of concern.

However, during coring in a 3d application, a winning design may include a new sample point located underneath an area of concern. In fact, SADA is trying to bound or minimize the AOC from underneath. When this occurs with the coring option selected, SADA will also include all samples in the core (some of which may be included in the area of concern). This can reduce the impact of the non-AOC sample point located beneath the AOC but attempts to reflect the true impact of analyzing cores rather than single points. For this reason, using the core option in 3d can sometimes yield smaller impacts to the area of concern because of this very situation. Turning off coring can greatly increase the impact to the area of concern because no simulated sample points will ever be greater than the decision criteria. While this may have a desirable affect on the area of concern, it may not reflect the reality of true soil coring activities. Furthermore, it assumes that other information found elsewhere in the core will be ignored, particularly if it is suspected of being too high. It is recommended to adhere to the coring principle particularly in this sample design.

## LISA Sample Designs

Ripley's K, Moran's I, and Geary's C are secondary sample designs that rely on number of samples and the local index of spatial association (LISA) map to generate new samples. See the section **LISA maps** for more information.

- Ripley's K – locations of new samples are based on areas with low sample density
- Moran's I – locations of new samples are based on areas with high sample variance
- Geary's C – locations of new samples are based on areas with high negative correlation

### Availability

This sample design is only available for SADA files with sampled data.

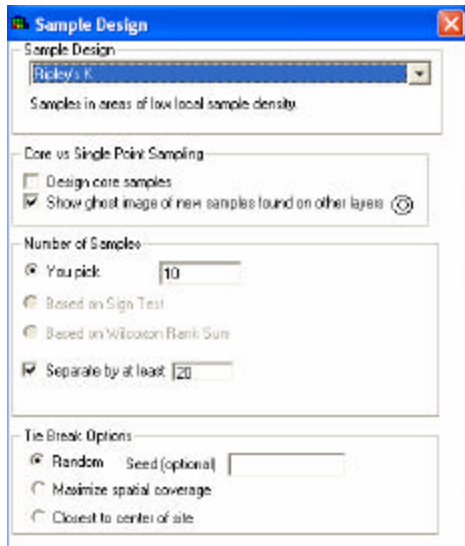
### Steps

These are the steps that display in the Steps Window when this sample design is selected during the step Set sampling parameters.

1. See the data
2. Set up the site
3. Set GIS overlays
4. Set sampling parameters
5. Set grid specs
6. Interpolation Methods (not available for Ripley's K)
7. Correlation Modeling (not available for Ripley's K)
8. Search Neighborhood (not available for Ripley's K)
9. Set LISA parameters
10. Show the results
11. Format picture
12. Auto-document
13. Add to results gallery

### Design-specific Parameters

When **Ripley's K**, **Moran's I**, or **Geary's C** is selected during the Set sampling parameters step, the Parameters Window changes to look like the following:



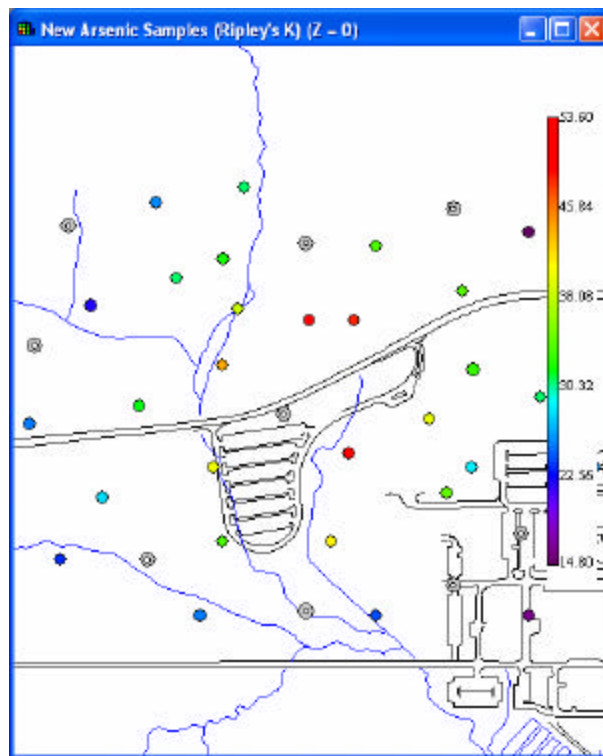
Select **Design Core samples** or **Show Ghost Image** if desired.

Under **Number of Samples**, only you pick is available. Enter the number of samples in the space provided.

To use the secondary minimum distance constraint, enter a value next to **Separate by at least**.

Under **Tie Break Options**, select the appropriate tie break method.

Press **Show the Results** on the Steps Window and SADA will display the sample locations in the Graphics Window. If there are polygons, new samples will only be placed inside the active polygons.



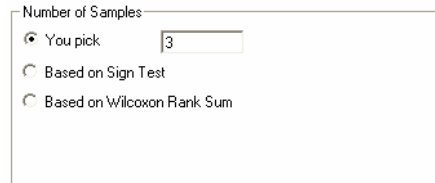
To view the actual coordinates of the new sample points export the information to a comma delimited excel file by using the Output to File toolbar button in main form of SADA.

## Determining the Number of Samples

There are three ways to define the number of new samples: user definition, sign test, and Wilcoxon rank sum test.

Select **Develop sample design** from the interview list, **Set sampling parameters** from the Steps Window, and the applicable sample design in the Parameters Window. Select the appropriate method for determining number of samples in the Parameters Window (for most sample designs).

For user definition, select the **You pick** radio button. Then enter the number of desired samples in the text box. SADA will determine that number of new samples for the selected sample design and show their locations in the Graphics Window.



Number of Samples

You pick

Based on Sign Test

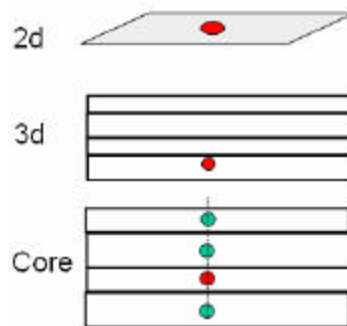
Based on Wilcoxon Rank Sum

**Based on Sign Test** uses the non-parametric Sign test to determine sample size with the following user inputs: DCGL, LBGR, and acceptable Type I and II error rates. This method is appropriate for grid designs, simple random sampling, and when no background is available.


**Based on Wilcoxon Rank Sum** uses the non-parametric Wilcoxon Rank Sum test to determine sample size with the following user inputs: DCGL, LBGR, and acceptable Type I and II error rates. This method is appropriate for grid designs, simple random sampling, and when no background is available.

## Design Core Samples

Selecting this option creates samples that go all the way through all vertical layers. In a core application, the sample is placed on a single layer at the depth required. Then all layers above and below the new sample are also sampled, subject to the polygon definitions.



## Show ghost image

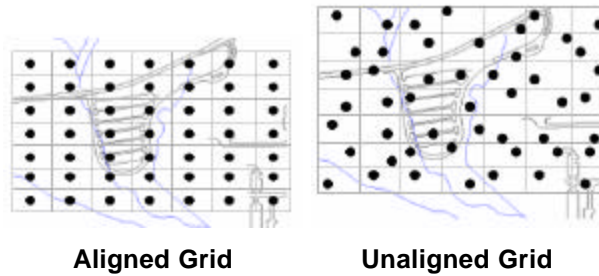
This option allows the user to view samples that exist in other layers of the sampling scheme. The ghost images are shown as doughnut-shaped clear/white objects inside the graphics window. To view the actual coordinates of these samples, click on the Output to File button  on the main toolbar.

## Square Grid Pattern

A square grid pattern places points perpendicular from one another (for aligned grids) or randomly (for unaligned grids) such that each point falls in an invisible square. The length of each grid side is dependent on the area of the sampling space. The area is then divided into N number of blocks, where N

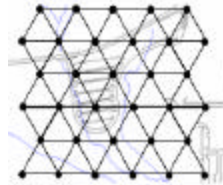


is the number of desired samples. Each block is then treated as a square and the square root of the area of a single block gives the estimated side length of the invisible grid definition.



## Triangular Grid Pattern

The triangular grid places points at the vertices of equilateral triangles. The length of each grid side is dependent on the area of the sampling space. The area is then divided into  $N$  number of blocks, where  $N$  is the number of desired samples. Each block is then treated as an equilateral triangle and the side length of a single triangle is a derivative of the area of that triangle.



## Simulated Sampling

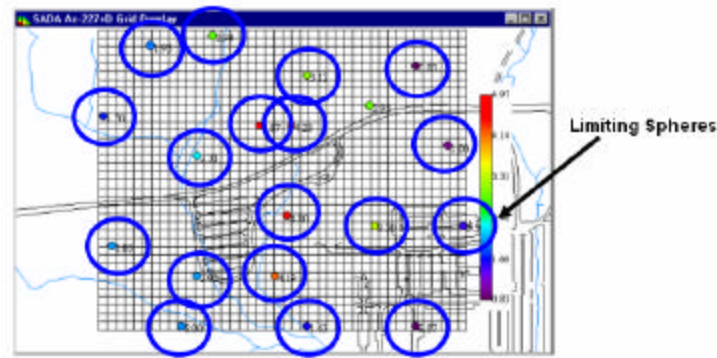
Simulated sampling finds each successive new sample. That sample is placed and the estimated value is added to the conditioning data as if they were real values. Since real values are not used, error rates are incurred in the process, which increase with each new additional sample location.

## Unsimulated Sampling

Unsimulated sampling simply locates all new samples off the same geospatial map without attempting to update the map after each point is found. The method is quick but does not always reflect the type of behavior the model will exhibit after each new sample is found, particularly for those methods that depend on measures of geospatial uncertainty.

## Secondary Minimum Distance Constraint

This constraint prevents clustering by setting the minimum distance a new sample point can exist from an existing new or actual sample point through a limiting sphere. All nodes within the sphere are eliminated from consideration as a new sample candidate.



## Tie Break Methods

There are times when multiple new sample locations fulfill the goal of the sample design. In this case, a decision must be made so that only one of the new sample locations is chosen. SADA has three types of tie break methods.

Tie Break Options


Random Seed (optional)

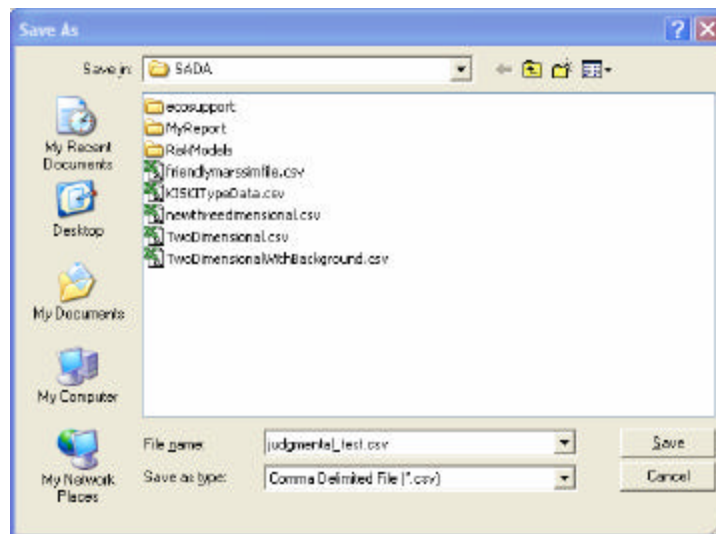
Maximize spatial coverage

Closest to center of site

- Random – A random number generator is used to select one of the sample locations. The seed is used to feed the random number generator. Using a seed allows the user to recreate a resulting sample design by entering the same value.
- Maximize spatial coverage – The value that will maximize the spatial coverage of the site is chosen as the new sample.
- Closest to center of site – The value that is closest to the center of the site is chosen as the new sample.

## Output to File

Use the Output to file button  to export the coordinates to a .comma delimited file (.csv file). SADA will prompt the user for a name for the file.



This file may now be opened in Excel or another spreadsheet program. The easting, northing, and depth coordinates are provided for the new sample locations.

	A	B	C	D	E	F	G
1	Easting	Northing	Depth				
2	28141.41	29271.95	0				
3	27777.68	23095.42	0				
4	29259.38	22534.07	0				
5	29035.98	22658.47	0				
6	28814.8	23256.61	0				
7	28401.92	23497.46	0				
8	27659.72	23689.15	0				
9	27281.24	23207.46	0				
10	27197.68	22519.32	0				
11	27659.72	21983.56	0				
12	28849.21	23733.38	0				
13							

## The Geobayesian Model

The Geobayesian model in SADA integrates bayesian update methods with standard geostatistical approaches in an effort to better characterize site conditions and to reduce the number of samples required. Bayesian methods are often used in statistics to make use of information available from prior knowledge, while geostatistics can be used to make more efficient use of spatial data. This approach first presented by Johnson (1996) incorporates prior knowledge or "soft information" explicitly in the process, integrating it with hard sample data to produce a combined or collective characterization result. "Soft information" is data other than the results of specific measurements.

The following interviews are available for Geobayesian data in SADA:

- View My Initial Probability Map
- View My Initial Variance Map
- Draw an Area of Concern Map Based on Soft Data Only
- Calculate Cost versus Cleanup Based on Soft Data Only
- Develop a Sample Design

More interviews become available after importing sampled data:

- Update My Prior Probability Map
- Update My Prior Variance Map
- Draw an Area of Concern Map
- Calculate Cost versus Cleanup

## Overview of Bayesian Approach

Johnson (1993, 1996, 1997) has shown that a combination of bayesian and geostatistical techniques can be effectively used in an adaptive sampling or iterative sampling approach that guides characterization of a site. Johnson (1996) contains the best available description of the technical aspects of the methodology.

The first step in the process is to create a grid over the area of interest. In each grid cell block, professional judgment and prior information is used to estimate the probability that *if a sample were taken at that point*, the result would exceed a specified threshold. At the same time, some idea of how confident one is in this prediction is also given. After this probabilistic soft data (referred to here as *professional judgment*) is available, hard or sampled data may be used to update the probability in each grid cell that a sample taken there would exceed a threshold value. *Note: this grid will later be the same grid on which the geostatistical methods are applied.*

In particular, one is estimating

$$\mu = \frac{\alpha}{\alpha + \beta}, \quad \sigma^2 = \frac{\alpha\beta}{(\alpha + \beta)^2(\alpha + \beta + 1)},$$

where  $\alpha > 0$  and  $\beta > 0$  are the parameters of a Beta Distribution. Here,  $\mu$  is the probability value and  $F$  is the measure of uncertainty about that probability value. The estimates of  $\mu$  and  $F$  may or may not be based on previously collected "hard data" taken during remediation control, characterization, or scoping data. They might be based only on general knowledge, such as the knowledge of a spill or the particular geology of the site.

The values of  $\mu$  and  $F$  that are entered are converted to  $\alpha$  and  $\beta$  values by solving the following equations:

$$\alpha = \mu(\mu - \mu^2 - \sigma^2) / \sigma^2 \quad \text{and} \quad \beta = (1 - \mu)(\mu - \mu^2 - \sigma^2) / \sigma^2.$$

In the current implementation, values of  $\mu$  and  $F$  can result in negative values of  $\alpha$  and  $\beta$ . For these instances, SADA sets  $\alpha$  and  $\beta$  equal to a small numerical value. Issues about controlling non-negative values have come out of developing this prototype module and will be addressed in the next version.

## Rational for using Beta Distribution

At each location,  $z$ , we have specified a prior probability,  $p(z)$ , that a sample taken there will exceed the release criterion. Suppose now that a sample is taken at location  $z$ . This is called a Bernoulli trial. Let  $y(z) = 1$  if a measurement at location  $z$  exceeds the release criterion, and let  $y(z) = 0$  if it does not. Such a function is called an indicator function, and we have that  $\Pr(y(z) = x | p(z)) = p^x(1-p)^{1-x}$ , for  $x = 0$  or  $x = 1$ . This is simply a binomial probability distribution with  $n = 1$ . For  $n$  trials (samples), we

$$\Pr(y(z) = x | p(z)) = \binom{n}{x} p^x (1-p)^{n-x}, \quad \text{for } x = 0, \dots, n.$$

Now suppose that we consider  $p(z)$  not as a fixed constant, but as a random variable itself. There will be a probability distribution describing how likely it is that  $p(z)$  takes on each value between zero and one, say  $f(p)$ . One possible candidate for  $f(p)$  is the Beta distribution,

$$B(p) = \frac{\Gamma(\alpha + \beta)}{\Gamma(\alpha)\Gamma(\beta)} p^{\alpha-1}(1-p)^{\beta-1}, \quad 0 < p < 1, \alpha > 0, \beta > 0$$

For various values of  $\alpha$  and  $\beta$ , the Beta distribution can produce a wide variety of shapes (i.e., it is a rich family of distributions to choose from). Notice that this distribution has a form very similar to that of the binomial probability distribution. In fact, the information implied by the specification of a particular Beta distribution with parameters  $\alpha$  and  $\beta$  is the same as that which would be obtained from a series of Bernoulli trials with  $\alpha - 1$  samples above the release criterion and  $\beta - 1$  samples below the release criterion.  $\alpha = \beta = 1$  corresponds to no information, and it also corresponds to a prior distribution which is uniform for  $p$  between zero and one.

The most important reason for using the Beta distribution is apparent when we apply Bayes theorem to update the prior distribution using the hard data we obtain.

Bayes theorem states that the updated probability distribution for  $p$ , given the result of the sample,

$f(p|y=x) = \Pr(y=x|p)f(p)/\Pr(y)$ , substituting in for

$$\Pr(y(z) = x | p(z)) = \binom{n}{x} p^x (1-p)^{n-x} \quad \text{and}$$

$$f(p) = B_{\alpha,\beta}(p) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} p^{\alpha-1} (1-p)^{\beta-1}, \quad \text{we find that}$$

$$f(p|y=x) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} p^{\alpha-1} (1-p)^{\beta-1} \binom{n}{x} p^x (1-p)^{n-x} / \Pr(y) = B_{\alpha+x,\beta+(n-x)}(p)$$

That is, the updated posterior probability distribution for  $p$  is also a Beta distribution. The Beta distribution is called a conjugate prior for the binomial likelihood.

In the case of  $n$  independent samples, the outcome that  $x$  of these exceed the release criterion results in the prior distribution  $B_{\alpha,\beta}(p)$  being updated to the posterior distribution  $B_{\alpha+x,\beta+(n-x)}(p)$ . Unfortunately, this analysis assumes that the result at each point  $z$  is independent of the result at any other point, and that the probability of exceeding the release criterion is the same at all possible sampling points.

## Geostatistics

The question now is how to update those probability distributions using information from actual samples taken nearby. Classical statistical methods applied to data using random sampling do not account for spatial correlations in the data. In fact, as indicated above, most of those methods assume that the data are independent. The correlation between concentration values at nearby locations can be considered an additional source of information. This information is ignored by the classical model of independent measurements, but it is central to geostatistical models used in kriging.

Given a set of sample results at locations,  $z_i$ ,  $i = 1, \dots, n$ , the kriging estimator of the result that would be expected at a nearby unsampled location is a weighted moving average of the sample results. The weights depend on the strength of the correlation of the concentrations at two locations as a function of the distance between them. A structural correlation model explicitly defines this correlation strength. Deriving this correlation model is an interim step in the kriging process. The parameters of this correlation model, along with the kriging results themselves, are also components in the eventual update of the prior distribution described in **Updating the Soft Information using Hard Information**. Currently, only an exponential correlation model may be used.

In the present case, we are interested in the probability distribution for  $p(z_0)$ , the probability that a measurement at a specific location,  $z_0$ , in the survey unit will exceed the release criterion. Given the sample result at location  $z_i$ , this probability is either zero or one, depending on the result of the

measurement. That is,  $p(z_i) = 0$  if the measurement at  $z_i$  is less than the release criterion, and

$p(z_i) = 1$  if the measurement at  $z_i$  is greater than the release criterion. The measurement has been transformed into an indicator value. This transformation occurs for each sampled point ( $i = 1$  to  $n$ ). A correlation model based on these transformed values is created and used with the ordinary kriging model to predict the probability distribution  $p(z_0)$ .

Typically, we are not just interested in a single specific location  $z_0$  but rather numerous unsampled locations usually on a regular grid. In particular, each unsampled location on the previous grid of prior probability and confidence values ( $\mu$ ,  $F$ ) described in the Bayesian Approach are important. Once the probability distribution  $p(z_0)$  is estimated by kriging for each node on the grid, we are ready to update the corresponding  $\mu$  and  $F$  at each node.

## Updating the Soft Information using Hard Information

Once the ordinary kriging model has been applied, these estimates can be used to update the initial estimate of the prior distribution  $B_{\alpha, \beta}(p)$  to the posterior distribution  $B_{\alpha+x, \beta+(n-x)}(p)$  at each node on the grid. Johnson (1996) used a heuristic approach to estimate the amount of information from the *correlated* sample results to insert into the Bayesian update equations based on *independent* results. His proposal is that the parameters of the Beta distribution be updated using  $x^* = n^* p(z_0)$  with  $n^* = \frac{2(c_0 + c)}{\sigma_{\text{krig}}^2(z_0)} - 1$ .

$c_0$  is the nugget and  $c$  is the sill of an assumed exponential semivariogram model (see the section **Spatial Correlation**),  $F^2(z_0)$  is the ordinary kriging variance at  $Z_0$ , and  $p(z_0)$  is the standard ordinary kriging estimation of the probability of exceeding the threshold at  $Z_0$ . Here,  $n^*$  is the number of pseudo samples. Using the values for  $X^*$  and  $n^*$ , you can update the values of  $\alpha$  and  $\beta$  with the following formulas.

$$\mu_{\text{posterior}} = \frac{\alpha + x}{\alpha + x + \beta + n - x} = \frac{\alpha + x}{\alpha + \beta + n} \quad \text{and} \quad \sigma_{\text{posterior}}^2 = \frac{(\alpha + x)(\beta + n - x)}{(\alpha + \beta + n)^2 (\alpha + \beta + n + 1)}$$

## Summary of the Procedure

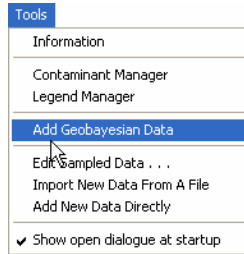
To summarize the steps of the process:

1. Create a grid across the area of interest.
2. In the center of each grid cell ( $z_0$ ), roughly estimate, using whatever information is at hand, the probability that a sample taken at that location would result in a measurement exceeding the release criterion.
3. In the center of each grid cell ( $z_0$ ), roughly estimate the uncertainty of the estimate made in step 2.
4. These estimates of  $p$  and  $F$  for the prior distribution of  $p(z_0)$  are converted into the parameters  $\alpha$  and  $\beta$  of a Beta distribution for each grid cell  $z_0$ .
5. Take hard data samples and convert the results to an indicator variable that is equal to 1 if the measurement exceeds the release criterion and 0 otherwise.
6. Develop a reasonable exponential correlation model for the transformed values.
7. Perform ordinary kriging at the center of each grid cell using transformed data and the correlation model developed in step 6. This gives you a kriging estimate of  $p(z_0)$  at the center of each cell.
8. Update the parameters  $\alpha$  and  $\beta$  of the Beta distribution.
9. Calculate updated estimates of  $\mu$  and  $F$ .

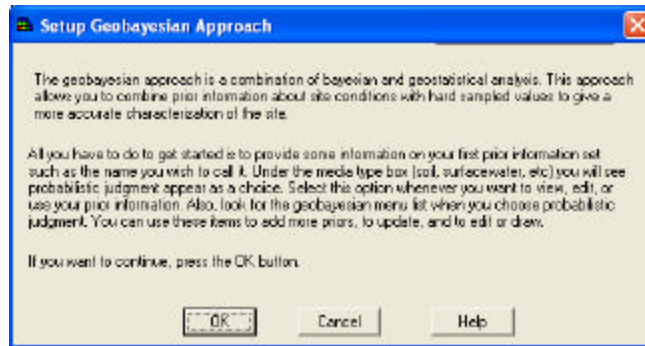
## Setup Geobayesian Model

A Geobayesian model may be setup with an empty SADA file or a file with sampled data.

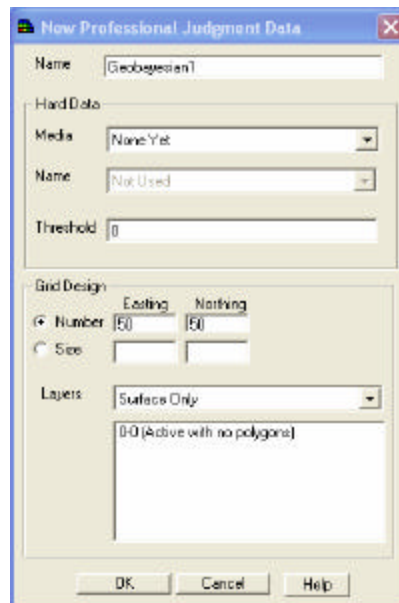
From the **Tools** menu, select **Add Geobayesian data**.



SADA will present the Setup Geobayesian Approach Window.



Select **OK**. SADA presents the **New Professional Judgment Data Window**.



Type an analysis name in the first entry box.

If the Geobayesian model is being setup in a file with sampled data, select the media type and the contaminant of interest for any available hard data in the **Hard Data** section. (*Note: None Yet is the default and the only available choice for an empty SADA file with no hard data.*)

Enter the cleanup criteria in the **Threshold** box.

SADA will enter default values for grid design, number of boxes as 50. Change these values if necessary or switch the grid design to box size and enter appropriate values. Change the layer design, if applicable.

Then press **OK**.

A new media type called Geobayesian data is available in the **media** box. Select this media type and notice that the **data name** box changes to the new Geobayesian data name and the blank prior probability information is displayed in the Graphics window.

A Geobayesian menu appears with one option, Create a New Prior.

The following interviews are available in the Interview Box: View My Initial Probability Map, View My Initial Variance Map, Draw an Area of Concern Map Based on Soft Data Only, Calculate Cost versus Cleanup Based on Soft Data Only, and Develop a Sample Design. After importing sampled data or if the file already has hard data, more interviews become available: Update My Prior Probability Map, Update My Prior Variance Map, Draw an Area of Concern Map, and Calculate Cost versus Cleanup.

## View My Initial Probability Map - Interview

This interview allows the user to "paint" and view prior probability information. This map displays the probability map with soft data only, before sampled data has been imported.

### Availability

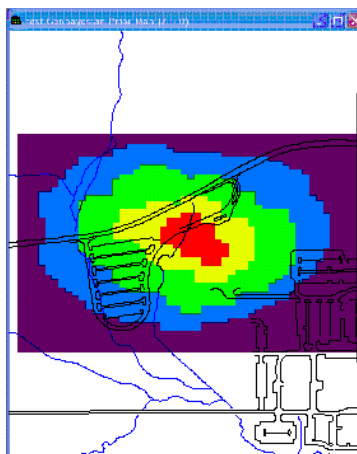
This interview is available for all analyses with Geobayesian data type.

### Steps

These are the steps that display in the Steps Window when this interview is selected.

1. Draw/Edit Prior
2. Set up the site
3. Set GIS Overlays
4. Show the results
5. Import Sampled Data
6. Format picture
7. Auto Document
8. Add to results gallery

Select the first step **Draw/Edit Prior** to develop the prior probability map for the Geobayesian data type. This map will then be displayed in the Graphics Window.



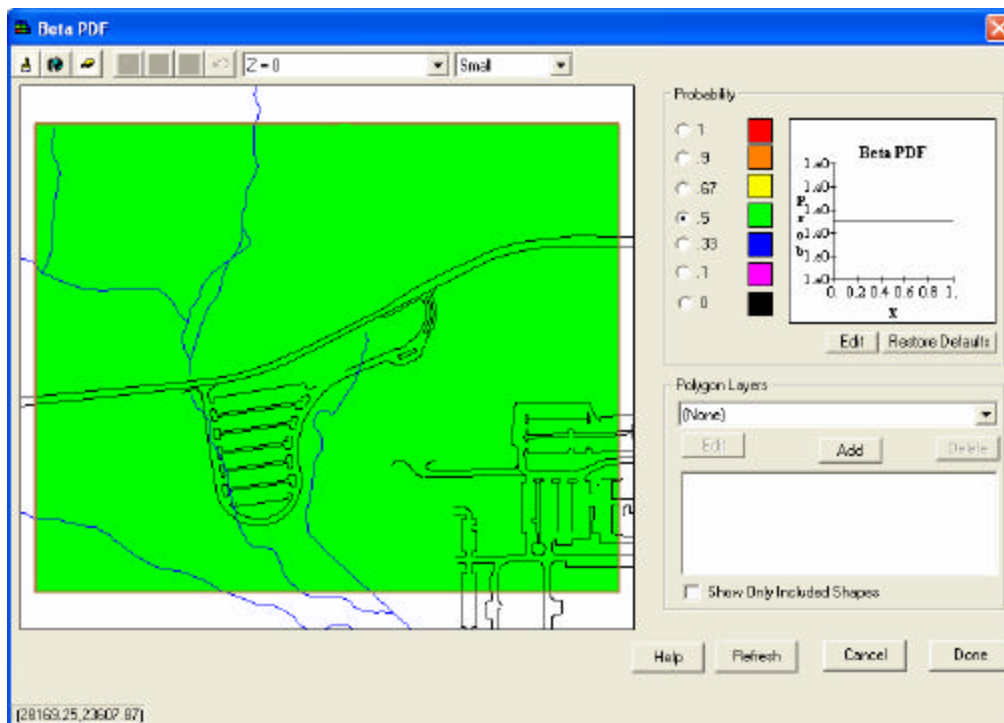
After creating an initial probability map and initial variance map, it is useful to develop a sample design. The purpose of this initial sample design is to reduce the number of samples required by optimizing sample locations and incorporating professional knowledge of the site.



## Draw/Edit Prior - Step

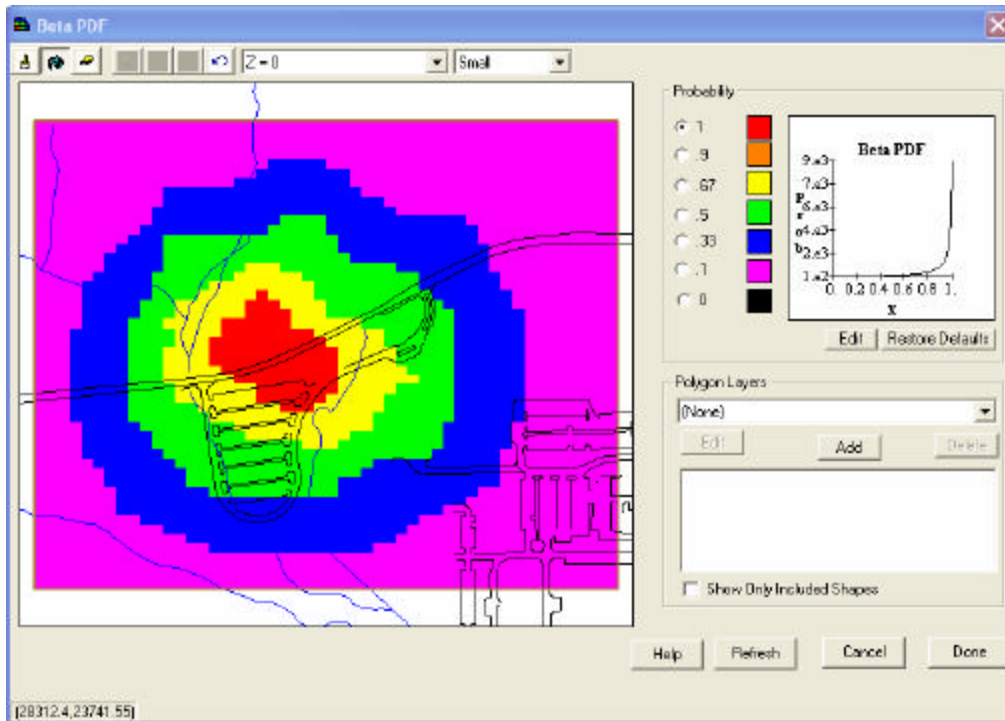
This step is available for the following interviews: View My Initial Probability Map, View My Initial Variance Map, Draw an Area of Concern Map Based on Soft Data Only, Calculate Cost versus Cleanup Based on Soft Data Only, Develop a Sample Design

Select **Draw/Edit Prior** from the Steps Window and then **Click Here to Change Your Prior** from the Parameters Window to adjust the prior information. The following window appears.

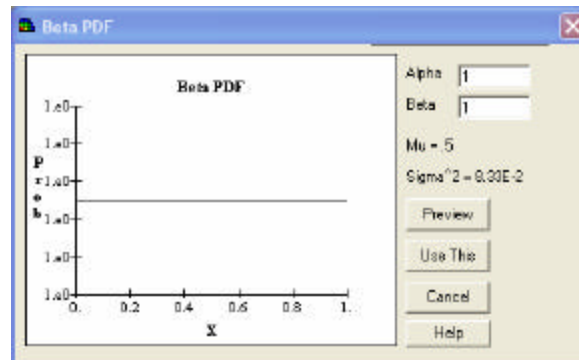


Select the probability on the right side of the window and use the paint buttons on the toolbar to “paint” professional judgment information onto the site. The graph next to the probabilities displays the beta distribution associated with the selected probability.

**Note:** for 3d data, use the layer box on the top of the window to select each layer and paint each separately.



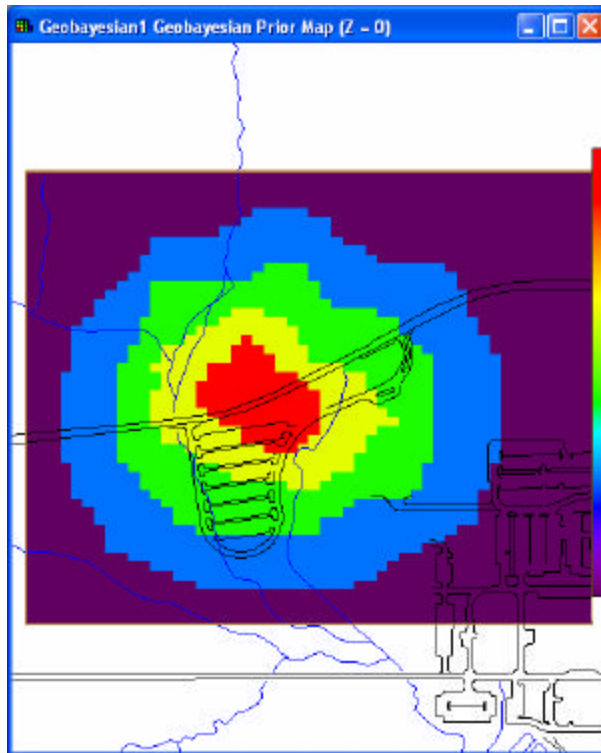
To edit a probability value, click in the button next to that probability value and then press the **Edit** button under the beta distribution plot. SADA displays the **Beta PDF Editor**. This editor allows user to modify the alpha and beta parameters of the beta distribution. The beta distribution is plotted in the graphics window and the corresponding mu and sigma are provided as well. Note that when the alpha and beta are changed, the mu (probability) and sigma change accordingly. Use the preview button to observe the effect of changes to alpha and beta before adopting them. Press the **Use This** button to finalize the change and return to the main editing window. **Cancel** terminates any changes to these values and returns the user to the editing window.



The **Restore Defaults** button resets all probabilities (and sigmas) to their original values.

**Note:** Polygons may be used to further define the site, if applicable.

Press **Done** when finished. SADA now displays the prior probability map in the Graphics Window.



## View My Initial Variance Map - Interview

This interview allows the user to view the uncertainties associated with the probabilities created during the View My Initial Probability Map interview. This map displays the probability map with soft data only, before sampled data has been imported.

### Availability

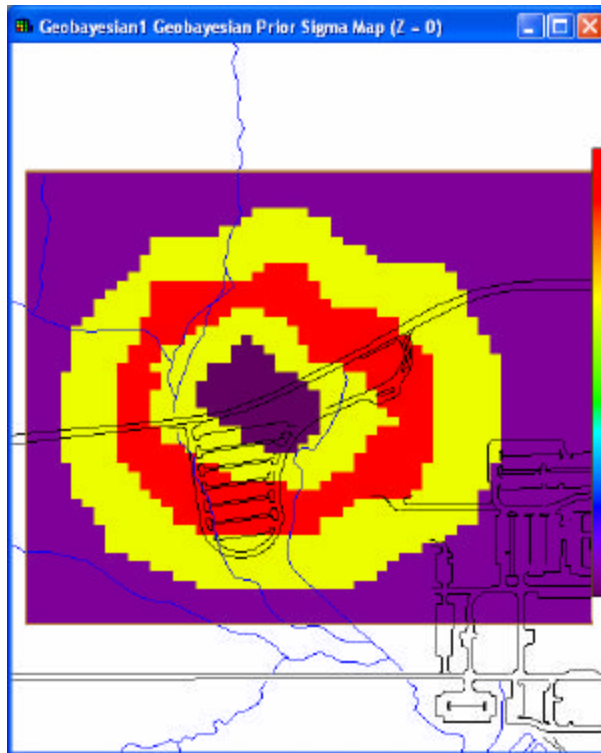
This interview is available for all analyses with Geobayesian data type.

### Steps

These are the steps that display in the Steps Window when this interview is selected.

1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Show the results
5. Import Sampled Data
6. Format picture
7. Auto Document
8. Add to results gallery

After selecting this interview, the Graphics Window will display the initial variance map for the Geobayesian data type.



After creating a prior probability map and prior variance map, it is useful to develop a sample design. The purpose of this initial sample design is to reduce the number of samples required by optimizing sample locations and incorporating professional knowledge of the site.

### **Update My Prior Probability Map - Interview**

This interview allows the user to adjust the prior probability information with hard data. This map displays the probability map after sampled data has been imported.

#### **Availability**

This interview is available for all analyses with Geobayesian data type.

#### **Steps**

These are the steps that display in the Steps Window when this interview is selected.

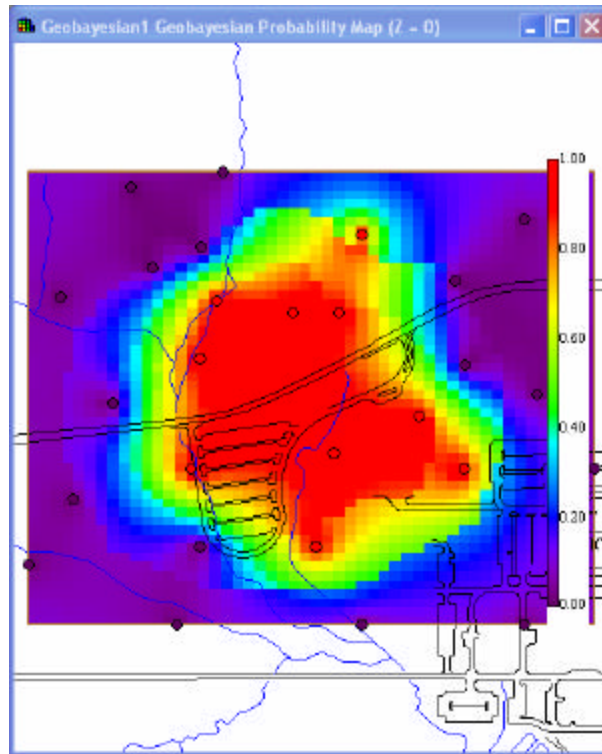
1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set update data
5. Correlation modeling
6. Search neighborhood
7. Show the results
8. Import Sampled Data
9. Format picture
10. Auto Document
11. Add to results gallery

The user must set the update data and define a correlation model and search neighborhood.

**Note:** Although the Geobayesian is selected as the data type, the correlation models and search neighborhood are applied to the hard data selected during set update data.

SADA performs the indicator transformation behind the scenes after the user has determined the appropriate parameters for a feasible correlation model required by the geostatistical routine. The end goal is to parameterize the correlation mode. When Geobayesian is selected as the data type, only two modeling options exist: *not used* or *exponential*.

Press **Show the Results** to display the updated probability map in the Graphics Window.

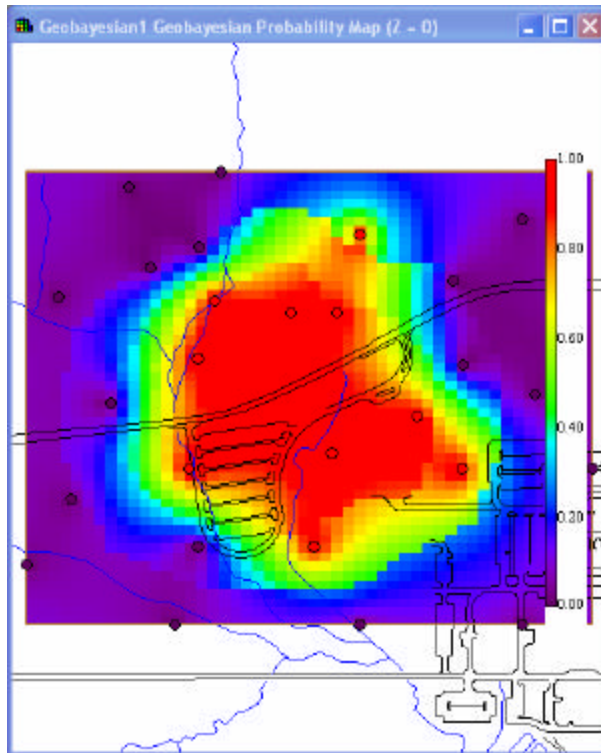


### Set Update Data - Step

This step is available for the following interviews: Update My Prior Probability Map, Update My Prior Variance Map, Draw an Area of Concern Map, and Calculate Cost versus Cleanup.

Select **Set Update Data** from the Steps Window. The following **Hard Data Support Window** appears.

Select the media and analyte to update the prior information with using the drop down boxes. Then enter the threshold value and press **OK**. SADA adds the sampled data points to the Graphics Window.



## Update My Prior Variance Map - Interview

This interview allows the user to adjust the prior variance information with hard data. This map displays the variance map after sampled data has been imported.

### Availability

This interview is available for all analyses with Geobayesian data type.

### Steps

These are the steps that display in the Steps Window when this interview is selected.

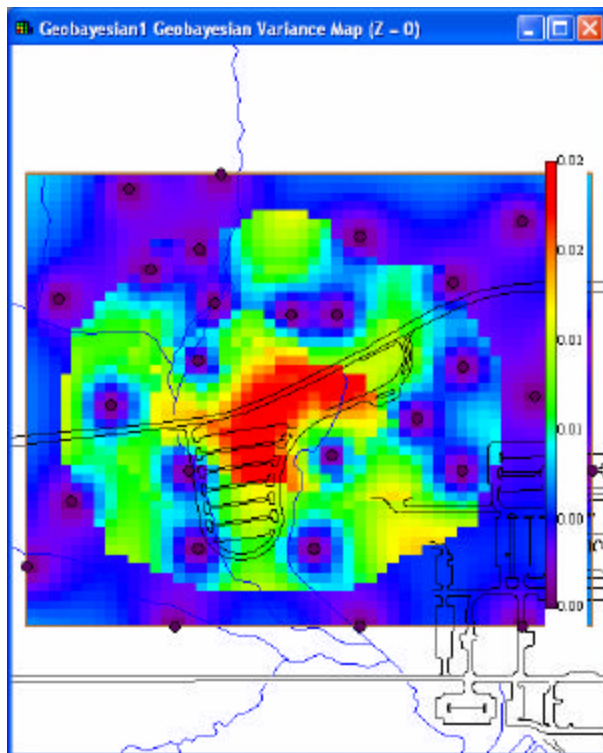
1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set update data
5. Correlation modeling
6. Search neighborhood
7. Show the results
8. Import Sampled Data
9. Format picture
10. Auto Document
11. Add to results gallery

The user must set the update data and define a correlation model and search neighborhood.

**Note:** Although the Geobayesian is selected as the data type, the correlation models and search neighborhood are applied to the hard data selected during set update data.

SADA performs the indicator transformation behind the scenes after the user has determined the appropriate parameters for a feasible correlation model required by the geostatistical routine. The end goal is to parameterize the correlation mode. When Geobayesian is selected as the data type, only two modeling options exist: *not used* or *exponential*.

Press **Show the Results** to display the updated variance map in the Graphics Window.



### **Draw an Area of Concern Map Based on Soft Data Only - Interview**

This interview allows the user to develop an area of concern map based on the probabilities created during the View My Initial Probability Map interview. This map is based on soft data only, before sampled data has been imported.

#### **Availability**

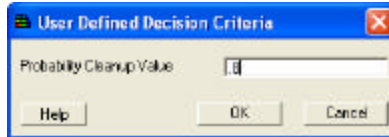
This interview is available for all analyses with Geobayesian data type.

#### **Steps**

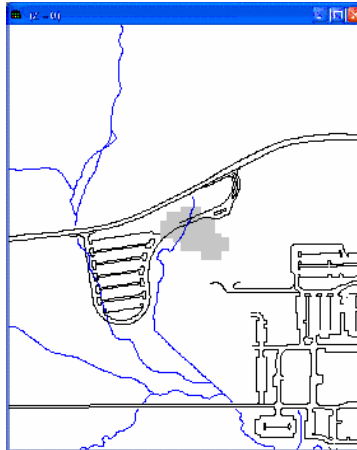
These are the steps that display in the Steps Window when this interview is selected.

1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Show the results
5. Format picture
6. Auto Document
7. Add to results gallery

Press **Show the Results**. SADA will request a decision criterion for cleanup. Enter a decimal between 0 and 1 and press **OK**.



SADA displays the area of concern map for the Geobayesian data type in the Graphics Window.



### **Calculate Cost versus Cleanup Based on Soft Data Only - Interview**

This interview allows the user to perform a cost benefit analysis based on the probabilities created during the View My Initial Probability Map interview. This map is based on soft data only, before sampled data has been imported.

#### **Availability**

This interview is available for all analyses with Geobayesian data type.

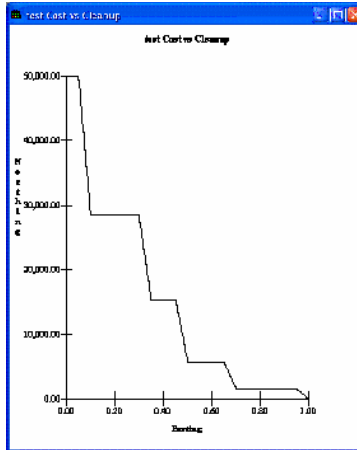
#### **Steps**

These are the steps that display in the Steps Window when this interview is selected.

1. Draw/Edit Prior
2. Set up the site
3. Set GIS overlays
4. Set cost information
5. Show the results
6. Format picture
7. Auto Document
8. Add to results gallery

After entering the cost to cleanup a block on the step Set cost information, press **Show the Results**. SADA displays the cost versus cleanup map for the Geobayesian data type in the Graphics Window.





## Create a New Prior

Select this item from the Geobayesian menu to create a new Geobayesian model. Same as the initial Geobayesian model setup, an empty SADA file or a file with sampled data may be used.

SADA presents the **New Professional Judgment Data Window**.

Type an analysis name in the first entry box.

If the Geobayesian model is being setup in a file with sampled data, select the media type and the contaminant of interest for any available hard data in the **Hard Data** section. (*Note: None Yet is the default and the only available choice for an empty SADA file with no hard data.*)

SADA will enter default values for grid design, number of boxes as 50. Change these values if necessary or switch the grid design to box size and enter appropriate values. Change the layer design, if applicable.

Then press **OK**.

The **data name** box now displays a list of created Geobayesian models. Select the new prior and the Graphics Window displays the blank prior probability information.

The following interviews are available in the Interview Box: View My Initial Probability Map, View My Initial Variance Map, Draw an Area of Concern Map Based on Soft Data Only, Calculate Cost versus Cleanup Based on Soft Data Only, and Develop a Sample Design. After importing sampled data, more interviews become available: Update My Prior Probability Map, Update My Prior Variance Map, Draw an Area of Concern Map, and Calculate Cost versus Cleanup.

## Miscellaneous Information

### Duplicate Values

Two samples are considered duplicate values if they are data measurements for a particular analyte that occur at the exact same location and at the same depth.

### Setting Normality/Lognormality Assumption

Normality/Lognormality can be set by checking/unchecking **Assume Lognormal** on the **Parameters Window** when **See the Data** is selected on the **Steps Window**. If the data are lognormal, check **Assume Lognormal** and SADA will perform a log transform (now normal) before applying the OK kriging model.

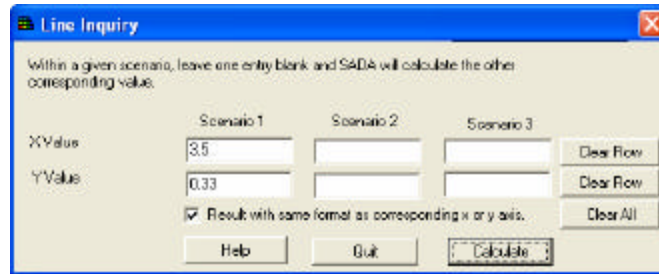
### Line Pointer

A pointer that provides an indication of the cost versus cleanup goal when the mouse is moved over the cost graph. The cost is indicated in the status bar at the bottom of the screen.

### Line Query

A comparison tool that allows the user to type in a value from the x or y axis and SADA will calculate the other value. This function is useful for calculating exact cleanup concentration value or cost or for obtaining information from the CDF.

Enter a x or y value and press the **calculate** button.



### Spatial Units

SADA has no spatial unit requirement; therefore, the user may input coordinate data that is in meters, feet, etc. If DXF layers will be used, however, the user needs to ensure that coordinates for data units are consistent with the DXF layers.

### Circumcircles

A circumcircle of a given two-dimensional geometric shape is the smallest circle which contains the shape completely within it

### Voronoi Polygons

For a member  $s$  of a set  $S$  of points in the Euclidean plane, the locus of points in the plane that are closer to  $s$  than to any other member of  $S$ .

### I Button



Press this button to retrieve information or results about the picture or subset of the picture currently visible.

### **Semi-variogram**

A geostatistical function describing in numerical terms (and represented graphically for ease of quantification) the predictability relationship between points of data at some distance from each other. This predictability constrains the confidence within which the estimation of a value is made, and therefore an estimate of the risk is quantified.