Spatial Analysis and Decision Assistance (SADA)

Version 2.3

User Guide

January 2002

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

SADA™

CONTENTS

FIGURES

INTRODUCTION

OVERVIEW

Spatial Analysis and Decision Assistance (SADA) is free software that incorporates tools from environmental assessment fields into an effective problem solving environment. These tools include integrated modules for visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment cost/benefit analysis, sampling design, and decision analysis. The capabilities of SADA can be used independently or collectively to address site specific concerns when characterizing a contaminated site, assessing risk, determining the location of future samples, and when designing remedial action.

The primary objective of SADA is to create a user-friendly, comprehensive software that links practical characterization tools to decision-making capabilities (particularly human health and ecological risk assessment). The software processes and produces information in a clear, transparent manner, directly supporting decision processes, and can serve as a communication tool between technical and non-technical audiences. The end result is that SADA can be used to facilitate decisions about a given site in a quick and cost effective manner. SADA has a strong emphasis on the spatial distribution of contaminant data and is therefore best suited for anyone who needs to look at data within a spatial context, such as statisticians, risk assessors, GIS users, project managers, and stakeholders.

SADA is a free stand-alone package for Windows 95, 98, 98SE, NTSP4 or higher, 2000, and ME that works with Data eXchange Format (DXF) GIS layers. Contact information, updates, documentation, and downloads are available on-line at http://www.tiem.utk.edu/~sada/.

WHAT'S NEW IN VERSION 2.3

The following features are new in version 2.3:

- Ecological Risk Assessment
- Custom Analysis
- Natural Neighbor Interpolation
- Judgmental Sample Design
- Improved 3D viewer: Better Speed and Isoclines
- Data Editing, Adding Contaminants
- Export To Excel

GOALS OF MANUAL

The goals of this manual are to:

- Know how to “get around” in SADA.
  - How is the interface organized?
  - What are all those buttons for?
  - How do I switch between contaminants?
  - How do I use the auto-documentation feature?
  - Why are some things disabled at times and available at other times?
  - How do I get information out of SADA?
- Be able to import data into a SADA file.

- Be able to perform a geospatial analysis.
- Use the decision analysis and cost benefit frameworks.
- Understand and use the sample design strategies.
- Setup human health, ecological, and custom analyses.
- Integrate human health, ecological, and custom analyses with geospatial analysis, decision frameworks, and sample design.

IMPORTING DATA INTO SADA

The creation sequence accepts a valid comma delimited ASCII text file or a Microsoft Access Office 97 file containing appropriate sampling information and subsequently establishes a SADA file.

Step 1. To begin the creation sequence, open SADA, select **File**, and from the menu bar choose **New**. See Figure 1.

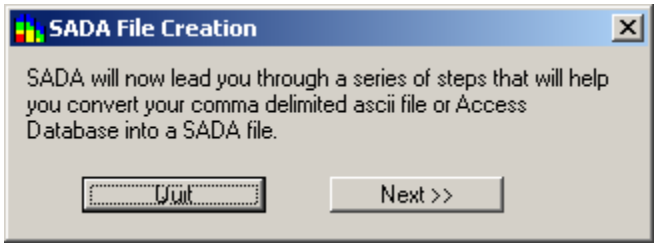


Figure 1. SADA File Creation

Step 2. Press **Next >>** to continue. At this point, enter the name of the comma-delimited ascii file or Access database that contains your data into the first textbox or press the Browse button. Then enter the name of your new SADA file. Press **Next >>** and SADA will convert your data file into this new SADA file. *Note: the external file itself is not affected by the conversion process.*

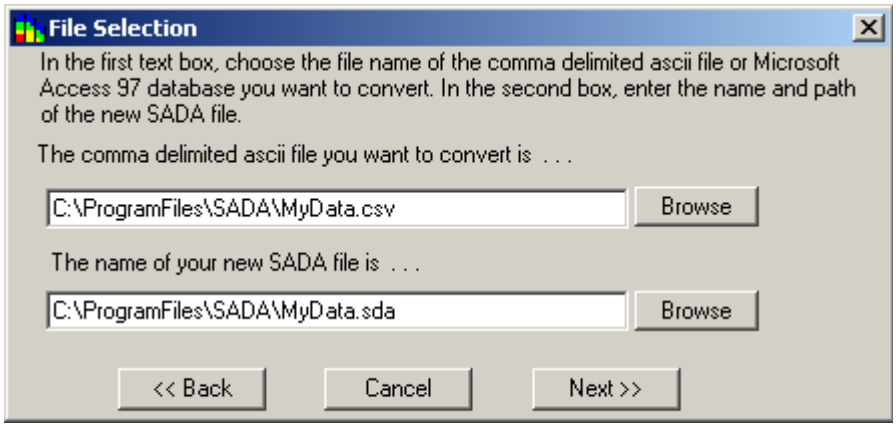


Figure 2. File Selection

Step 3. If your input file is an Access database, a window will appear like Figure 3.

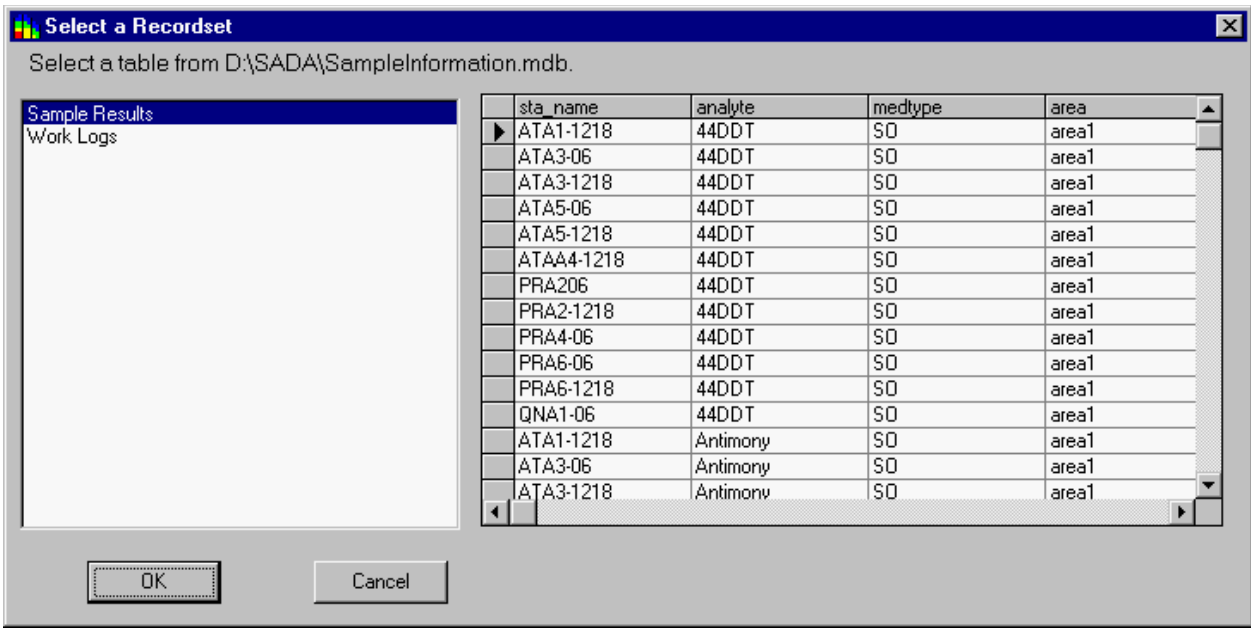


Figure 3. Select a Record Set

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

Step 4. The next step in the process 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. (See Figure 4.) 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.

Note: 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. (See Figure 5.)

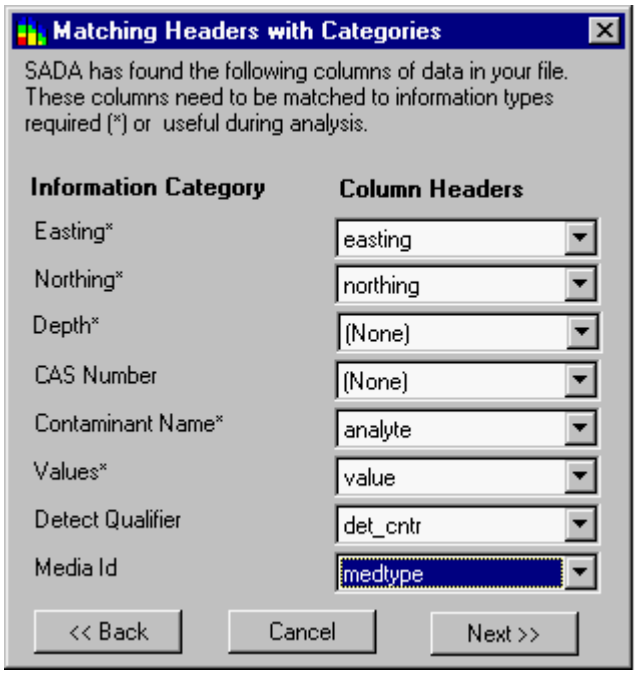


Figure 4. Matching Headers with Categories

Step 5. The Data Editor (figure 5) is a simple spreadsheet that shows how SADA views the data as it's being imported. It provides the user a chance to identify errors in the data set and correct them during the import process. 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 following example, the easting column contains a value of NA. Since SADA requires numerical values for every easting 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. Refer to Table 1 for allowable data types for each field.

Table 1. Allowable Data Types

Field	Data Type
Easting	Number
Northing	Number
Depth	Number
CAS #	Number
Name	Text
Values	Number
Detect Qualifier	0 (nondetects) or 1 (detects)
Media ID	SO, SD, SW, or GW

General Limitations for Constructing the Data Set

- Columns containing CAS Numbers, Detect Qualifiers, and Media Identification are optional. Additional columns are accepted (e.g., to be used as labels in the GIS); however, the total number of columns may not exceed 250. CAS Numbers are accepted 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 for sediment is SD.

- All columns must have a title row. Punctuation is not allowed in the title names.

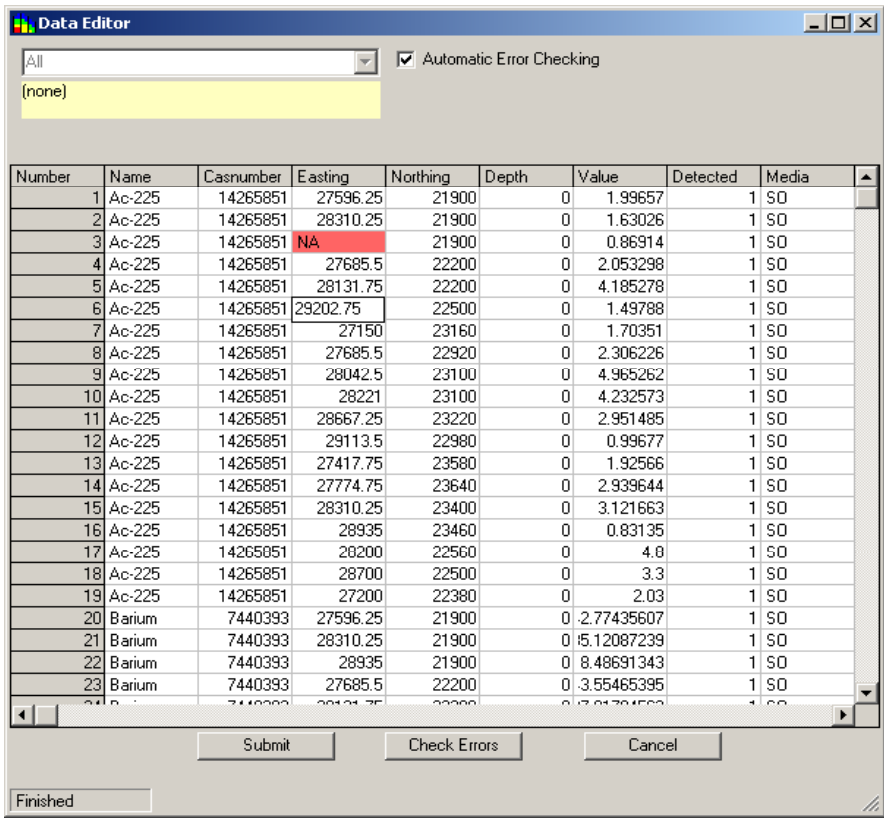
- If risk assessments are to be part of the analysis, then the concentration values are expected to be:

  — sediment: mg/kg for nonradionuclides, pCi/g for radionuclides
  — soil: mg/kg for nonradionuclides, pCi/g for radionuclides
  — surface water: mg/L for nonradionuclides, pCi/L for radionuclides

  In addition, a Media Identification column is required for setting up the human health and future ecological risk module.

- Quotation marks are located 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 interpreted as three column values: Sample located on, C, and Street. Conversely, Arsenic, Inorganic must be enclosed in quotes or SADA will read it as two field values: Arsenic and Inorganic.

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.



Number	Name	Casnumber	Easting	Northing	Depth	Value	Detected	Media
1	Ac-225	14265851	27596.25	21900	0	1.99657	1	SO
2	Ac-225	14265851	28310.25	21900	0	1.63026	1	SO
3	Ac-225	14265851	NA	21900	0	0.86914	1	SO
4	Ac-225	14265851	27685.5	22200	0	2.053298	1	SO
5	Ac-225	14265851	28131.75	22200	0	4.185278	1	SO
6	Ac-225	14265851	29202.75	22500	0	1.49788	1	SO
7	Ac-225	14265851	27150	23160	0	1.70351	1	SO
8	Ac-225	14265851	27685.5	22920	0	2.306226	1	SO
9	Ac-225	14265851	28042.5	23100	0	4.965262	1	SO
10	Ac-225	14265851	28221	23100	0	4.232573	1	SO
11	Ac-225	14265851	28667.25	23220	0	2.951485	1	SO
12	Ac-225	14265851	29113.5	22980	0	0.99677	1	SO
13	Ac-225	14265851	27417.75	23580	0	1.92566	1	SO
14	Ac-225	14265851	27774.75	23640	0	2.939644	1	SO
15	Ac-225	14265851	28310.25	23400	0	3.121663	1	SO
16	Ac-225	14265851	28935	23460	0	0.83135	1	SO
17	Ac-225	14265851	28200	22560	0	4.8	1	SO
18	Ac-225	14265851	28700	22500	0	3.3	1	SO
19	Ac-225	14265851	27200	22380	0	2.03	1	SO
20	Barium	7440393	27596.25	21900	0	-2.77435607	1	SO
21	Barium	7440393	28310.25	21900	0	5.12087239	1	SO
22	Barium	7440393	28935	21900	0	8.48691343	1	SO
23	Barium	7440393	27685.5	22200	0	-3.55465395	1	SO

Figure 5. Data Editor

Step 6. After contaminants have been selected, press Next>> and SADA checks for duplicate values. If duplicate values are found, the user is warned that the maximum value (detected if possible) will be used. You can accept this option or cancel the setup.

The SADA file is now successfully created and is automatically opened.

SWITCHING ANALYSES, MEDIA, AND CONTAMINANT TYPES

To switch between analysis, media, and contaminant types, use the drop down arrows on the toolbar (see figure 7.)

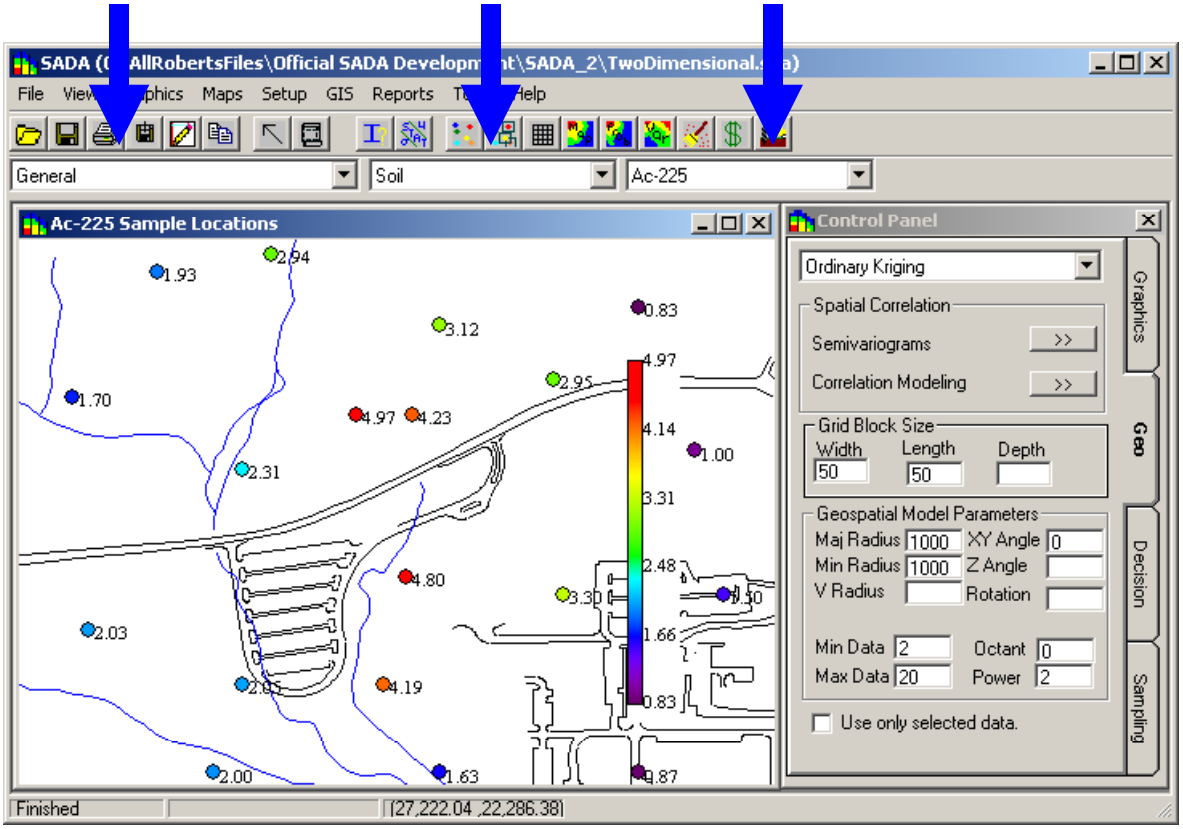


Figure 7. Analysis, Media, and Contaminant Combo Boxes

IMPORTING GIS LAYERS

SADA can read and overlay pictures with a layer that has been produced by a Geographic Information System (GIS) and saved in a Data eXchange Format (DXF).

Step 1. To add a layer to your data or modeling results, choose **GIS** from the main menu and select **Layer Control**. The window in Figure 8 appears.

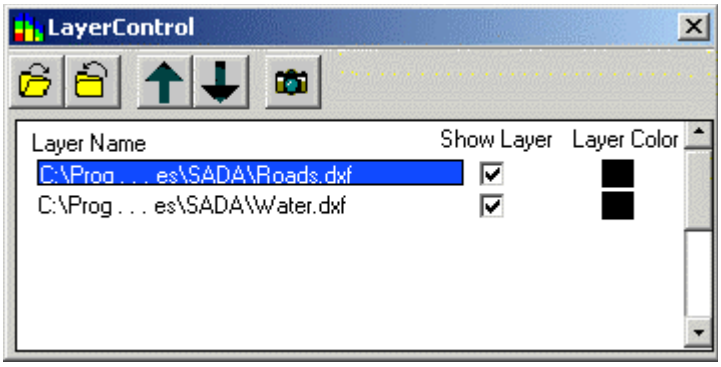


Figure 8. Layer Control

Step 2. Set layer option. To open another layer, press the **Open a New Layer** button. To close a layer, select the layer and press the **Close Layer** button. To change the position of a layer in the layering scheme, press the **Move Layer Up** and **Move Layer Down** buttons. To make a layer visible, check the box next to the name under the Show Layer column. To change the Layer Color, click the corresponding Layer Color box and choose a color from the Palette window. To view your changes, press the **Apply** button.

ZOOMING, SHIFTING, AND RESTORING

Once a GIS layer has been added, it is possible to zoom in and out of the site view.

Zooming In

Step 1. Right mouse click over any map plot and select **Zoom In**.

Step 2. Using the left mouse button, select the region to zoom in on. Releasing the mouse button produces the zoom.

Zooming Out

Step 1. Right mouse click over any map plot and select **Zoom Out**.

Step 2. Select the zoom area with the mouse, and the portion of the image that is visible is placed in the zoom box (see figure 9) to cause the zoom out effect.

Shifting

Step 1. Right mouse click over any map plot and select **Shift Picture**.

Step 2. 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.

Restoring

Step 1. Select **Restore** from the popup menu (see figure 9) to return the picture to its original scaling and position.

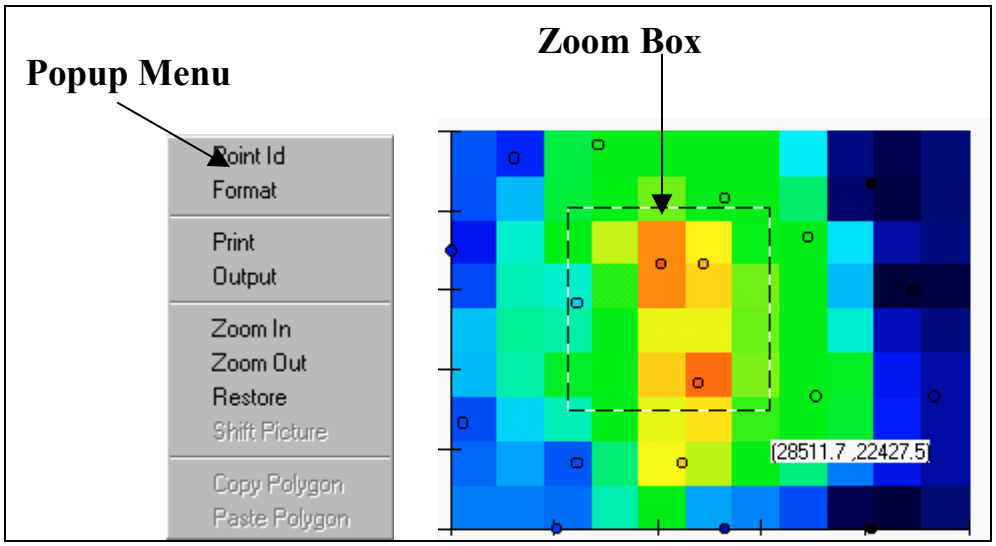


Figure 9. Zooming, Shifting, and Restoring

FORMATTING

SADA allows users to customize the format title, axis, and legend elements with or without GIS layers.

Step 1. The **Format** option becomes available in a popup menu when the right mouse button is pressed over a graphical image.

Step 2. Select the portion of the picture you wish to format on the left side of the window under **Object**. The current formatting scheme will appear on the right hand side.

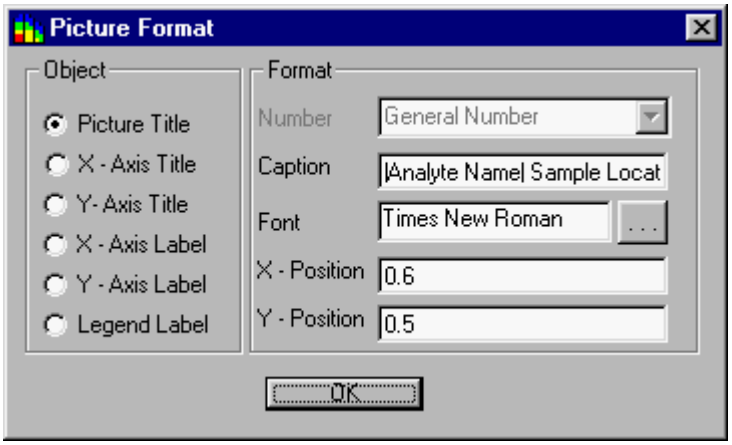


Figure 10. Picture Format

POLYGONS AND SPACE DEFINITION

SADA allows users to subset an area or define a specific space in a site by enclosing it in a polygon, but only one polygon at a time is allowed in Version 2.1. In 3d Space, however, polygons may be drawn in each layer (See Working in Three Dimensions).

There are two methods for using polygons: Select tool and Space Definition Manager

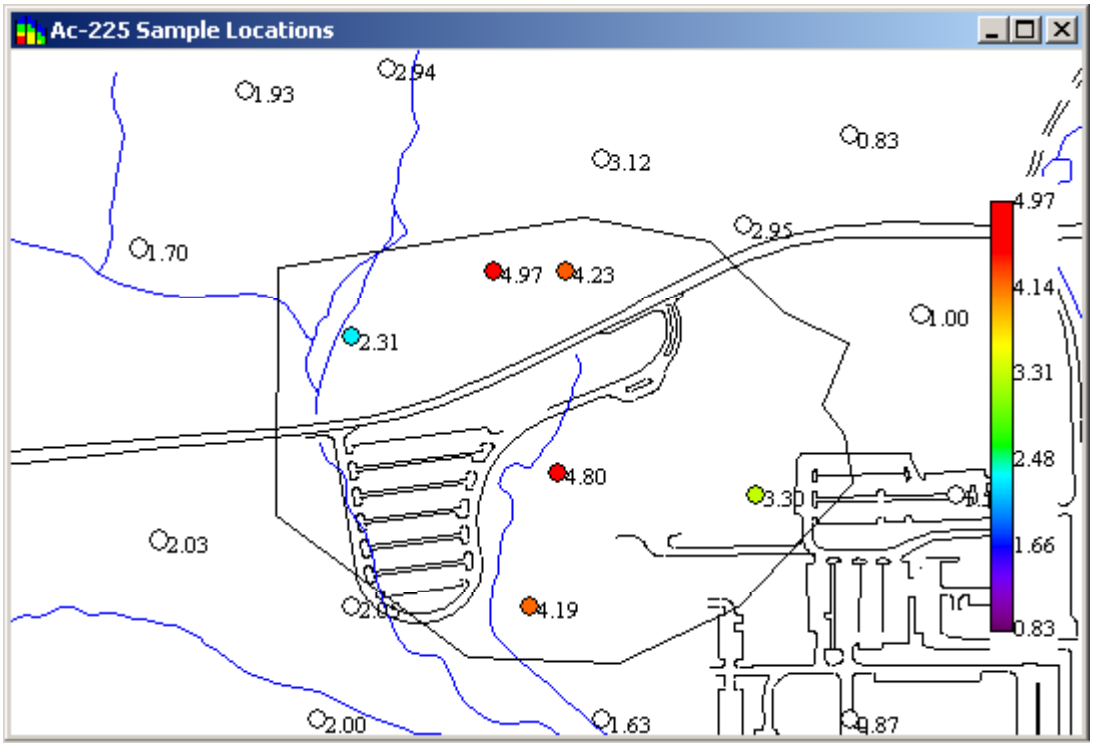


Figure 11. Polygon Example

Select Tool 

The objective of the select tool is to allow users to draw quick and temporary polygons to retrieve information about the data or model results within the boundaries. Items outside the boundary are deselected and appear empty. Polygons created with the select tool cannot be retrieved after they are removed. You may use the select tool whenever a graphical display is available, with the exception of sample designs.

Step 1. To create the polygon, press the **Select** button on the main menu.

Step 2. Click anywhere in the graphics window to start your polygon. Each click produces a new vertex. (Figure 12)

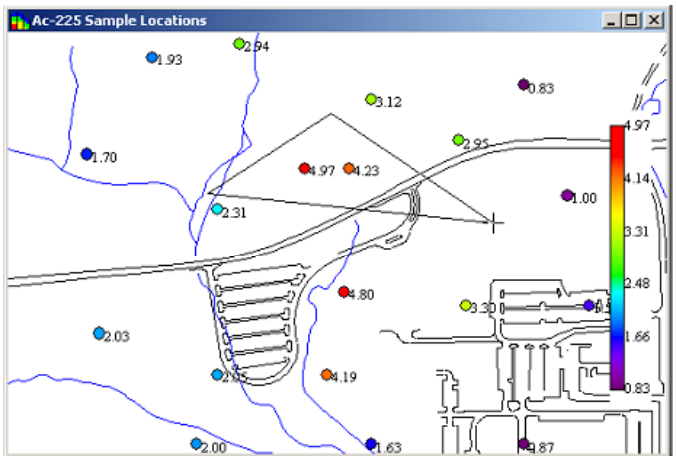


Figure 12. Creating a Polygon

Step 3. Double click when you are finished drawing the polygon.

Step 4. To edit the polygon, double click over the polygon and blue vertices will appear. (See figure 13.) Left click into one of the vertices and drag it to move this section of the polygon. Right click into any polygon and drag to move the entire polygon.

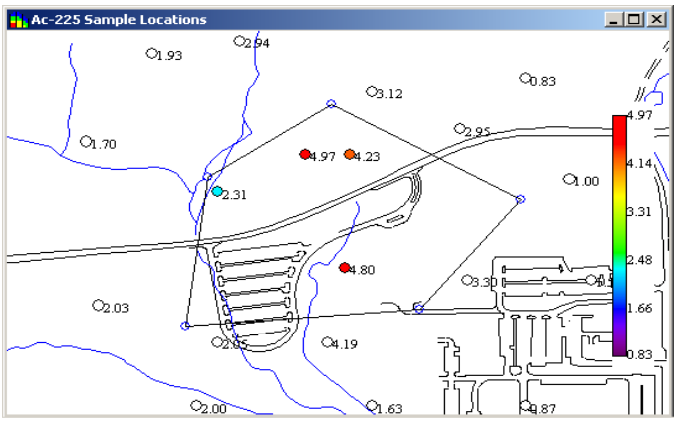


Figure 13. Editing a Polygon

Step 5. Double click the left mouse button again to turn off the blue vertices.

Step 6. Press the **Select** button again to remove the polygon.

Space Definition Manager 

The space definition manager draws and modifies polygons in the same way as the select tool; however, the manager allows you to store the polygon by name and recall it later. The polygon drawing methods are the same. You may use a space definition manager whenever a graphical display is available, with the exception of sample designs.

Step 1. To create a space definition, press the **Space Manager** button on the main menu.

Step 2. The left-handed side contains previously saved space definitions (there are none in figure 14). Choose one of these or press **New** to create a new one.

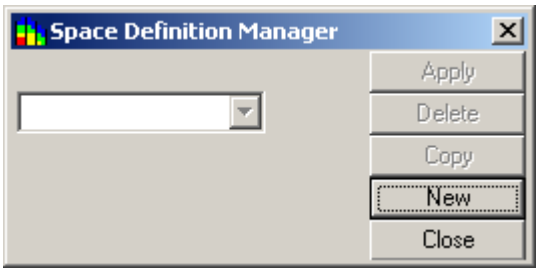


Figure 14. Define Space Definition Manager

Step 3. After pressing **New**, begin drawing the polygon. When you are finished, press the **Finish** button (see figure 15)

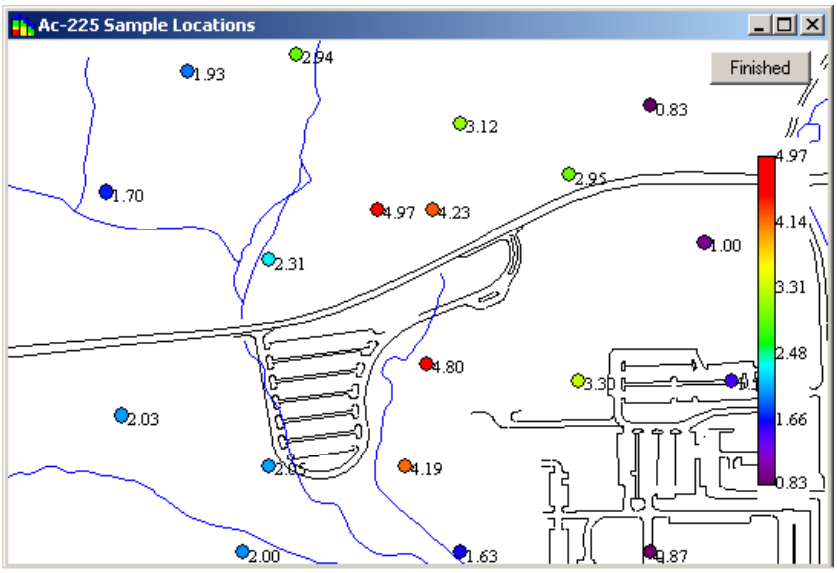


Figure 15. Develop Space Definition

Step 4. Pressing the **Space Manager** button again will remove the polygon.

Step 5. If you edit the polygon, SADA will give you a chance to rename before saving.

MANAGING LEGENDS

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

Continuous

Continuous legends are an unbroken color band that ranges from dark purple through a spectrum to bright red (see figure 16). They can be customized by manually stretching or compressing a subset of the color band.

Categorical

Categorical legends permit the user to break the legend into a series of ranges or categories with set names and colors. See figure 16.

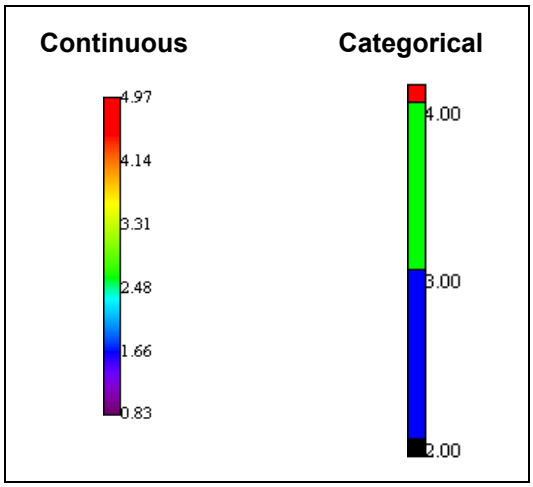


Figure 16. Legend Types

Step 1. To modify a legend or create a new legend, simply right mouse click over the legend itself or choose **Legend Manager** from the main **View** menu.

Step 2. You can choose from the list of available legend types or build a new one of your own (see figure 17). See the Help File for specifics.

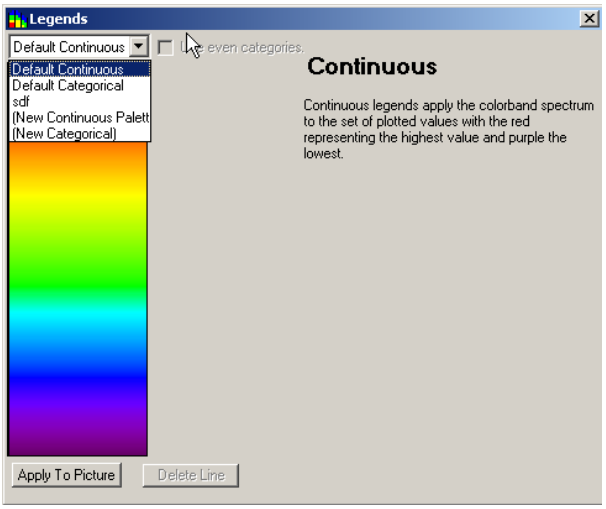


Figure 17. Legend Manager

CONTAMINANT MANAGER

At any time, you may remove a contaminant from the current analysis with the contaminant manager. After removing a contaminant, it will no longer appear in the contaminant combo box on the main toolbar and will no longer be included in any pooled data operations. A common use of this tool is to remove contaminants that are not considered Contaminants of Concern for quantitative risk calculations.

Step 1. To see the manager, click on **Tools** then **Contaminant Manager** in the main menu. (Figure 18)

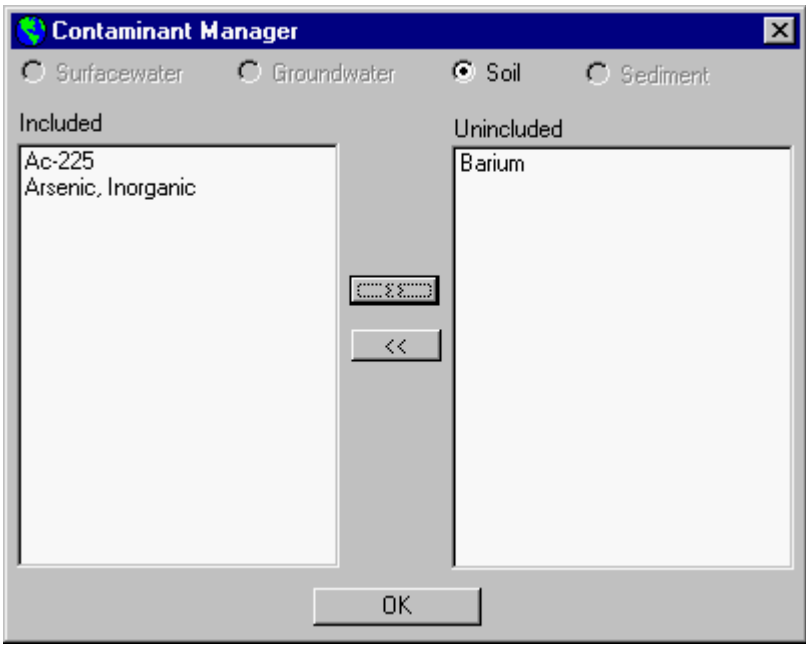


Figure 18. Contaminant Manager

Step 2. Select those contaminants you wish to remove from the analysis and press the **>>** button. Similarly, choose those contaminants in the box on the right you wish to return and press the **<<** button.

The media buttons allow you to toggle between media types. You may remove a particular contaminant from one media without removing it from the others.

GETTING INFORMATION

There are several ways to query the database using SADA.

Point ID

This feature allows you to click on a data point and retrieve all available information about that data point from the SADA file.

Step 1. To use point ID, have a data plot map open, right mouse click and choose **Point ID** from the pop-up menu. (Figure 19)

Step 2. Next, left click on any data point and a yellow box will appear with all available information. (Figure 19)

Step 3. Right mouse click and deselect **Point ID** to turn this feature off.

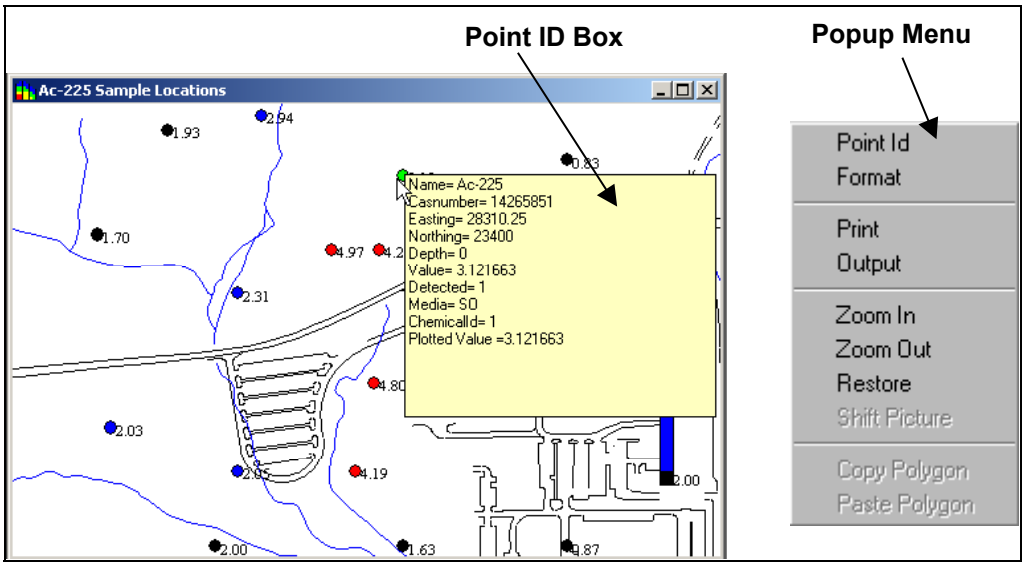
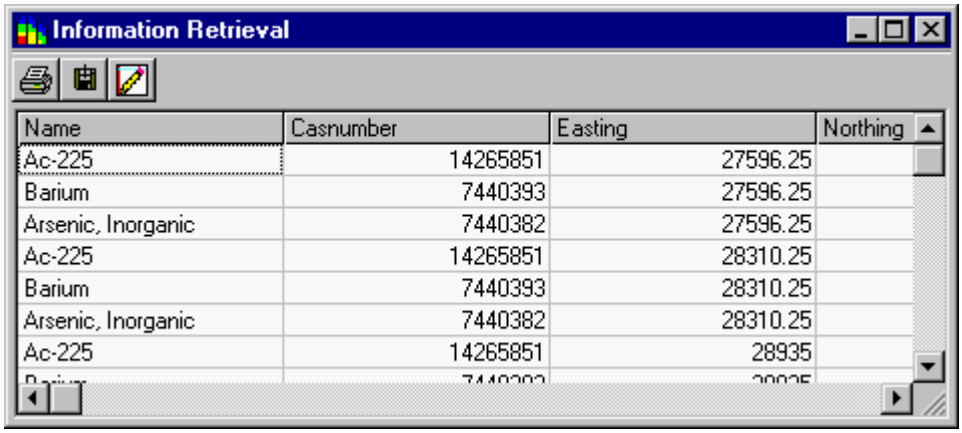


Figure 19. Point ID

Basic Information

Use this option to retrieve all available information on every data point (or modeled value).

Step 1. Click the **Information** button on the main toolbar while the applicable image is in view. When a polygon tool is on, this will return only those points found in the polygon.



Name	Casnumber	Easting	Northing
Ac-225	14265851	27596.25	
Barium	7440393	27596.25	
Arsenic, Inorganic	7440382	27596.25	
Ac-225	14265851	28310.25	
Barium	7440393	28310.25	
Arsenic, Inorganic	7440382	28310.25	
Ac-225	14265851	28935	

Figure 20. Information Button Results

Statistics

Use this option to calculate a number of statistical values on every data point (or modeled values). When a polygon tool is on, this feature will return only those points found in the polygon.

Step 1. To view the statistical results of a selected region, press the **Statistics** button on the main toolbar. (Figure 21)

Step 2. Format the results. All the available statistical choices are under the **Options** menu. To format a particular statistical value, click any cell in that column and choose **Format** from the statistics menu. Type in the number format you wish and continue.

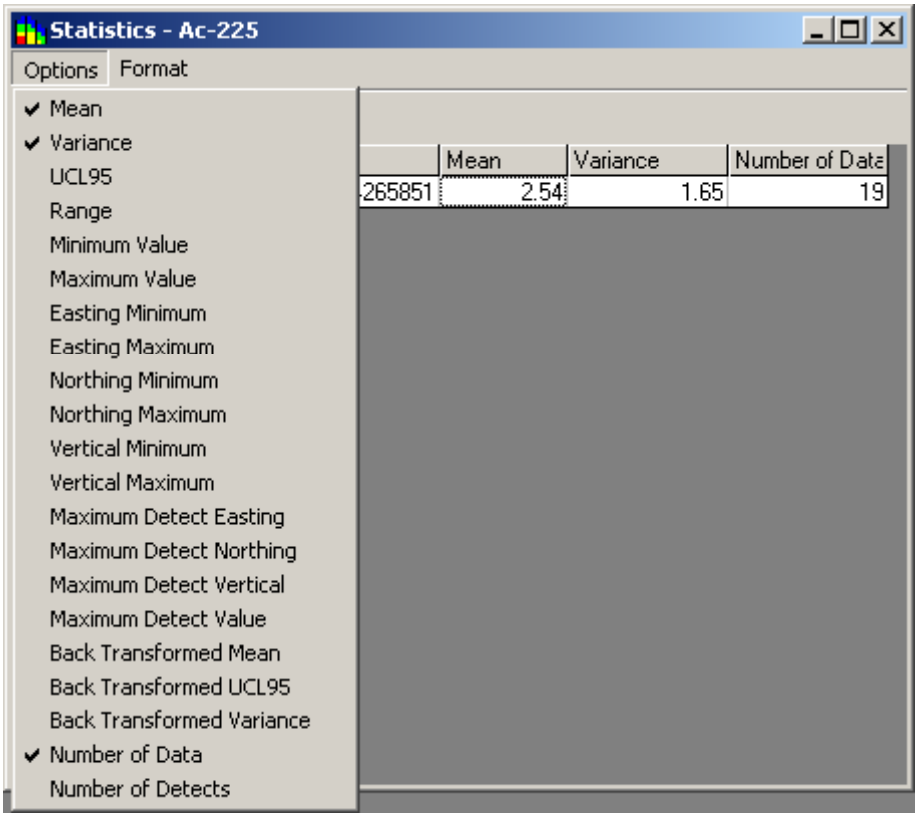


Figure 21. Statistics

AUTO DOCUMENTATION

When the user presses the **Add to Report** button, SADA will analyze any given result and produce a list of every type of model, parameter, assumption, result, etc. used in creating that result as well as the graphics. The user may then select those items of interest and SADA will automatically write everything to the HTML report. You can begin using auto-documentation immediately. If you do not have a report started, SADA will prompt you to start one.

Step 1. Begin by choosing human health as the analysis, selecting human health as the decision basis on the **Control Panel**'s **Decision** tab, choosing Ac-225 and Soil, and pressing the **Data Screen** button.

Step 2. When the **Risk Scenario** screen appears, select Residential, Ingestion, and press **OK.** What is created is a risk based data screening. (Figure 22)

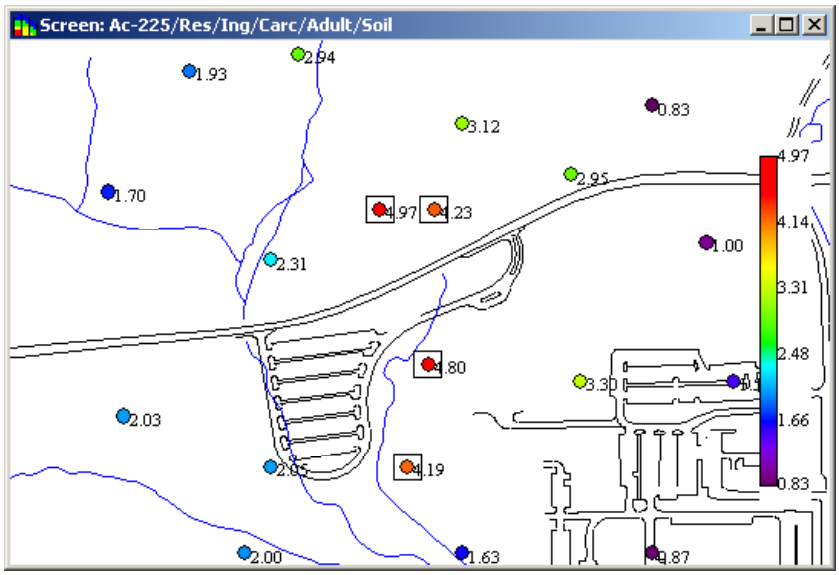


Figure 22. Risk Based Data Screening

Step 3. Now press the **Add to Report** button. Since a report is not open, SADA will ask you to create a new one. Type the name of the report without adding any suffixes to the end (e.g., .html, .wpd).

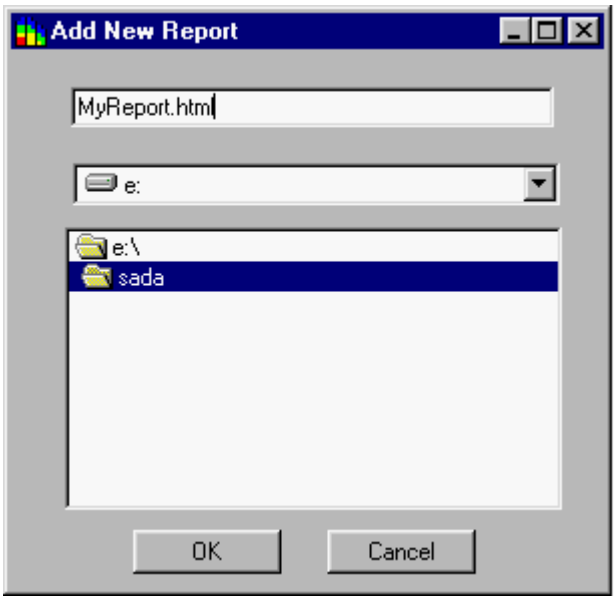


Figure 23. Add New Report

SADA will create a subdirectory and an HTML file with this name in that report. This directory is like a web site that contains all the files your report will need.

Step 4. SADA now presents a list of every "ingredient" used in creating this risk-based screening. Check each item you want to include. Select the report you want to add it to at the top and press **Add To Report**. (Figure 24)

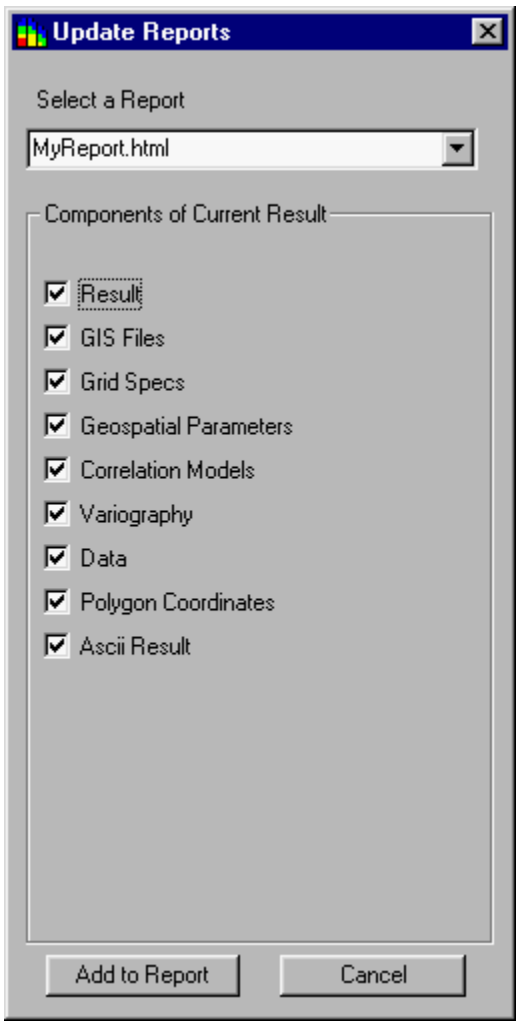


Figure 24. Update Reports

SADA now shows the result in your report (see Figure 25).

Step 5. You can also add notes to your report. Press the **HTML** button on the tool bar and an HTML editor window will appear at the bottom. If you know a little HTML, you can type your own codes here. Otherwise, you can import this file into Word Perfect or Word later and add notes then.

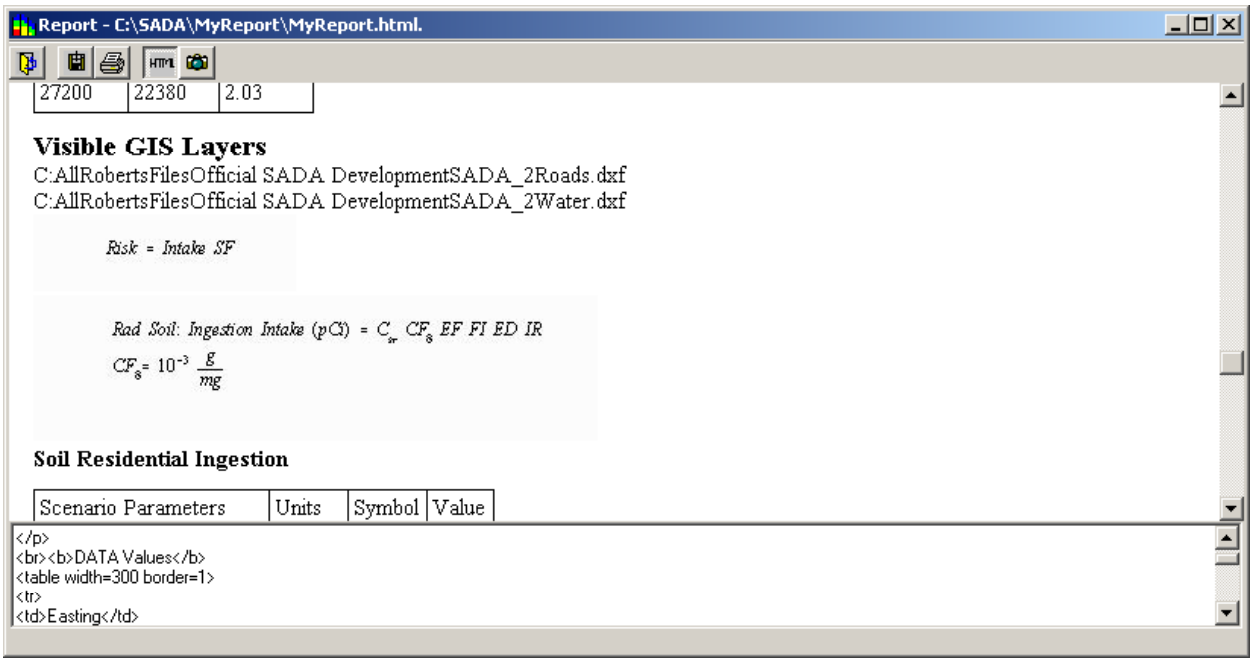


Figure 25. Example Report

All remaining report functions can be found on the main menu bar. See the help file for more details.

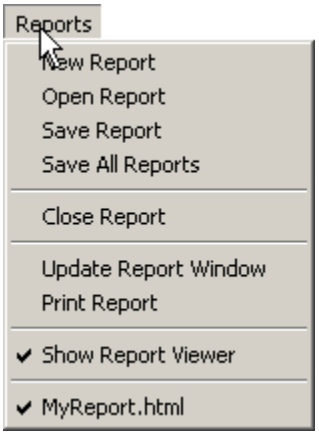


Figure 26. Reports Menu

SETUP HUMAN HEALTH

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. It also calculates risk-based screening values to quickly identify contaminants of concern.

This module may only be set up after a SADA file has been created. Additionally, 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.

Step 1. To initiate the **Risk Setup Wizard**, select **Human Health Risk** from the **Setup** menu of the main window. Then click **Yes**.

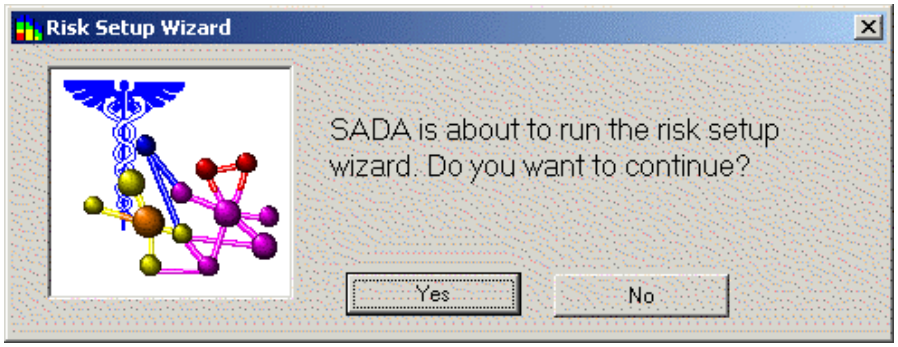


Figure 27. Risk Setup Wizard

Step 2. Type the name of the corresponding databases or press **Browse** to select. Once these have been selected, press **Next >>** to continue.

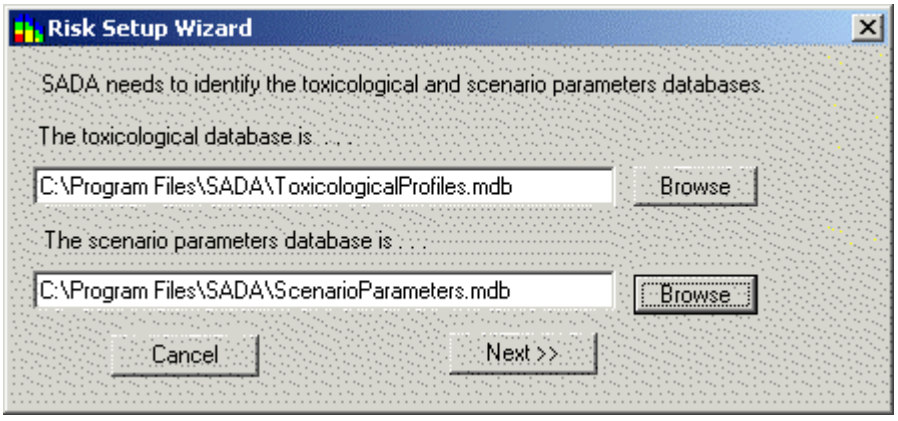


Figure 28. Select Human Health Databases

SADA now attempts to match each contaminant in your file with a contaminant found in the toxicological database. If available, SADA searches by CAS number first 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 (figure 29).

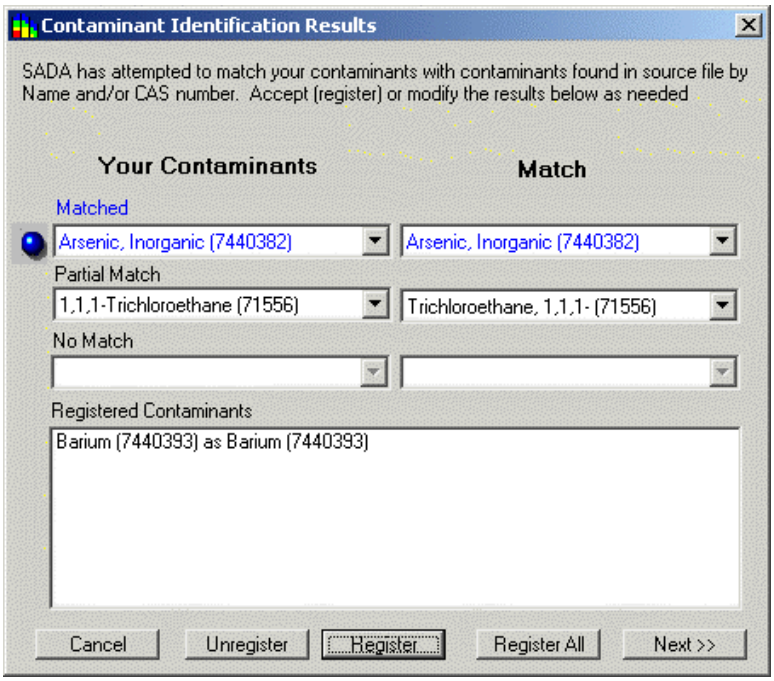


Figure 29. Contaminant Identification Results

Step 3. On the left side of the window, 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.

Step 4. Press **Next>>** to conclude setting up the risk module.

*Note: 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.*

PARAMETERS

Viewing Scenario Parameters

Scenario parameters may be viewed and customized for each media, exposure scenario, and exposure pathway.

Step 1. To view the scenario parameters, select **Human Health** on the Analysis drop down list of the main toolbar.

Step 2. Select **Configure Human Health** and then **Scenario Parameters** from the **Human Health** menu in the main window. The **Scenario Parameters** window appears.

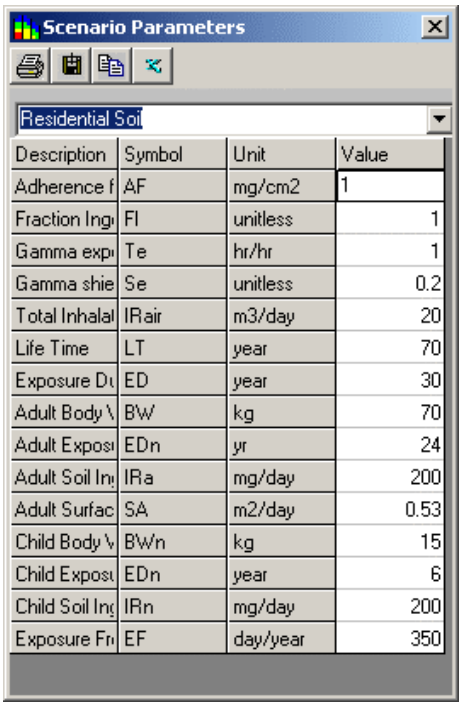


Figure 30. Scenario Parameters

Step 3. The display operates as a spreadsheet. To change a parameter, click into its cell and type a new value. The drop down box below the toolbar enables the user to select a risk scenario. When a new scenario is selected, the list of parameters and their applicable values will change to reflect the selected scenario. In the figure above, Residential Soil has been selected.

Viewing Toxicological Parameters

The toxicological parameters file that is included with SADA contains information taken from the United States Environmental Protection Agency's (EPA's) Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST), and other information sources. The file also includes the following physical parameters:

- Bioaccumulation factors,
- Volatilization Factors,
- Particulate Emission Factors,
- Permeability Constants,
- Absorption Factors,
- Saturation Coefficients, and
- Radionuclide Half-Lives

Step 1. To view toxicological parameters, select **Human Health** on the Analysis drop down list of the main toolbar.

Step 2. Select **Configure Human Health** and then **Toxicological Parameters** from the **Human Health** menu in the main window. The **Chemical Parameters** window appears. (Figure 31)

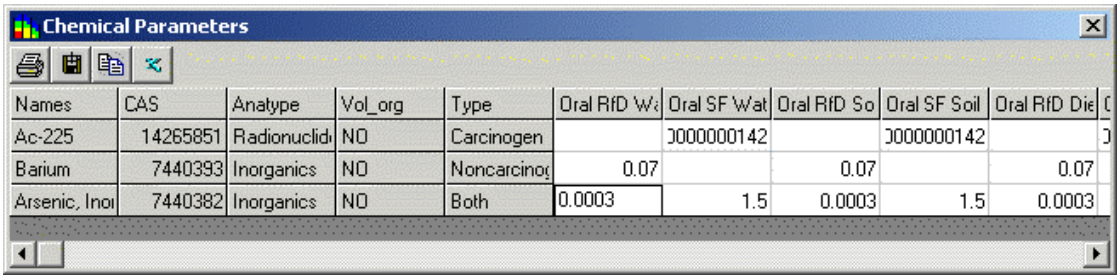


Figure 31. Toxicological Parameters

Step 3. The display operates as a spreadsheet. You may edit entries by clicking in the corresponding cell boxes. You may not edit the **Names**, **ANATYPE**, **VOL_ORG**, and **Type** columns.

SETTING TARGET RISK/HAZARD INDEX

Decision criteria used for screening in SADA is a function of a given target risk level and landuse scenario. In SADA, the default values are 0.000001 for target risk and 1 for target health index. These values may be adjusted as necessary.

Step 1. 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**.

Step 2. Enter the new value in the text box and press **OK**.

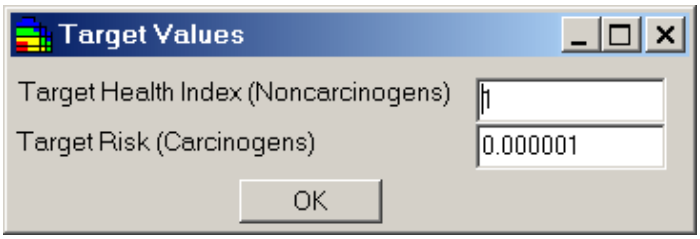


Figure 32. Target Values

PRG TABLES

SADA allows the user to view site-specific Preliminary Remediation Goals (PRGs) for different media and pathway combinations for both carcinogenic risk and noncarcinogenic hazard basis.

Step 1. To view the preliminary remediation goals (PRGs), select the contaminant of interest in the **Contaminant Box** of the secondary toolbar.

Step 2. 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 **Contaminant Box**. The PRGs will always be calculated for the media you have currently selected in the media combo box of the secondary toolbar.

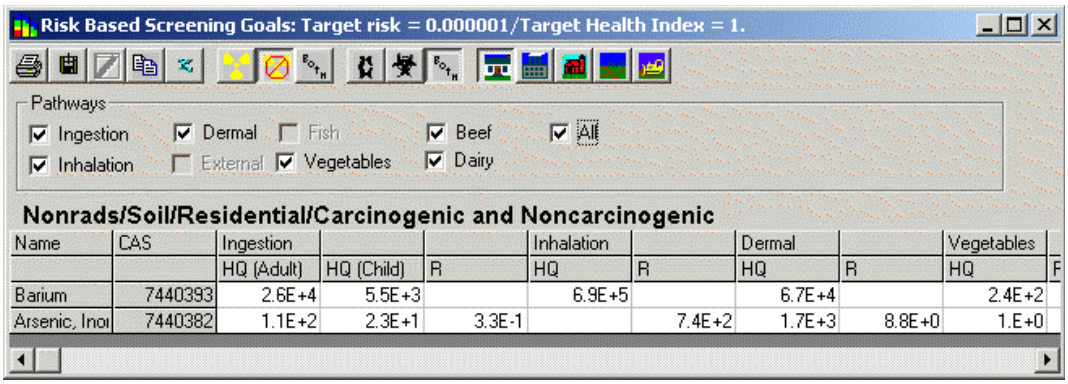


Figure 33. PRG Table

PRG SCREEN TABLES

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.

Step 1. To view the screening results, select the contaminant (select **Pooled Data** to screen all) and media of interest in the main toolbar.

Step 2. From the **Human Health** menu, select **PRG Screen Table**. This information is displayed in the **Screening Results** window.

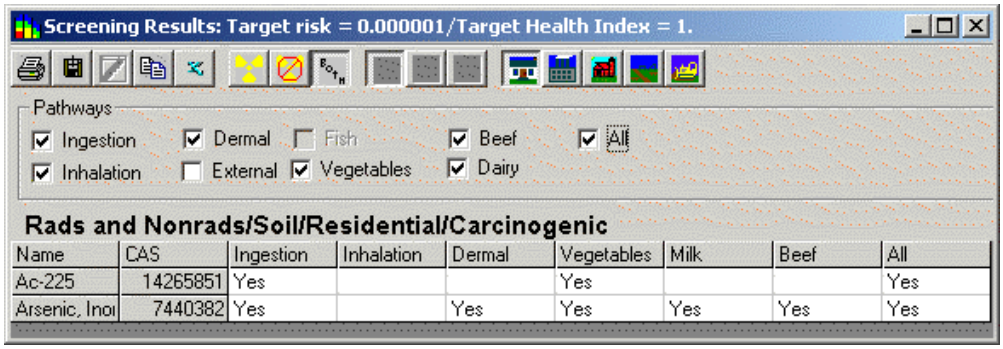


Figure 34. PRG Screen Table

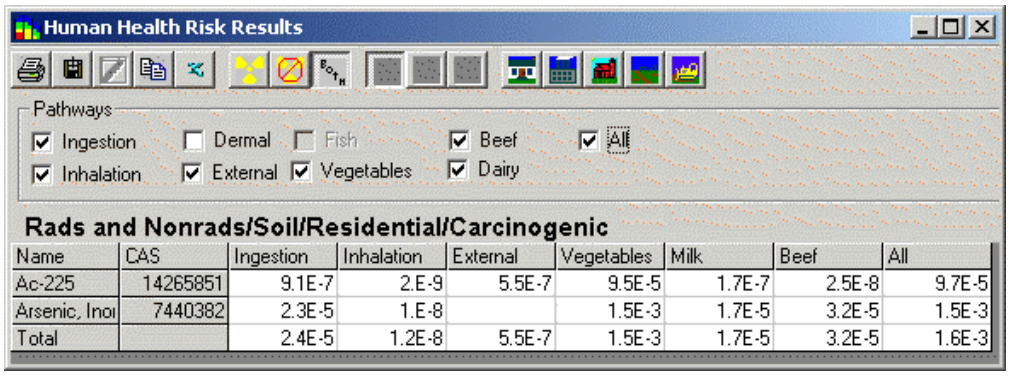
If a PRG is exceeded for a particular scenario, the cell value is Yes. The cell is blank if the risk calculation was not available (due to lacking toxicological information) or was less than the PRG. This is useful for quickly identifying contaminants of concern in a risk assessment.

RISK TABLES

For a given set of values, SADA finds the minimum of the UCL95 and the maximum detected value. Using this exposure concentration, SADA then calculated risk based on the contaminant and the exposure scenario.

Step 1. To calculate the risk or health hazard Index, select the contaminant (select **Pooled Data** to calculate all) and media of interest in the drop down boxes of the main toolbar.

Step 2. From the **Human Health** menu, select **Risk Table**. The following window is displayed.



Rads and Nonrads/Soil/Residential/Carcinogenic

Name	CAS	Ingestion	Inhalation	External	Vegetables	Milk	Beef	All
Ac-225	14265851	9.1E-7	2.E-9	5.5E-7	9.5E-5	1.7E-7	2.5E-8	9.7E-5
Arsenic, Inor	7440382	2.3E-5	1.E-8		1.5E-3	1.7E-5	3.2E-5	1.5E-3
Total		2.4E-5	1.2E-8	5.5E-7	1.5E-3	1.7E-5	3.2E-5	1.6E-3

Figure 35. Risk Table

SPATIAL PRG SCREENS

In a spatial screen, SADA compares a PRG or a specified concentration level to each sample location. Those sample points that are in exceedance of the specified PRG or concentration value are boxed. (Figure 36)

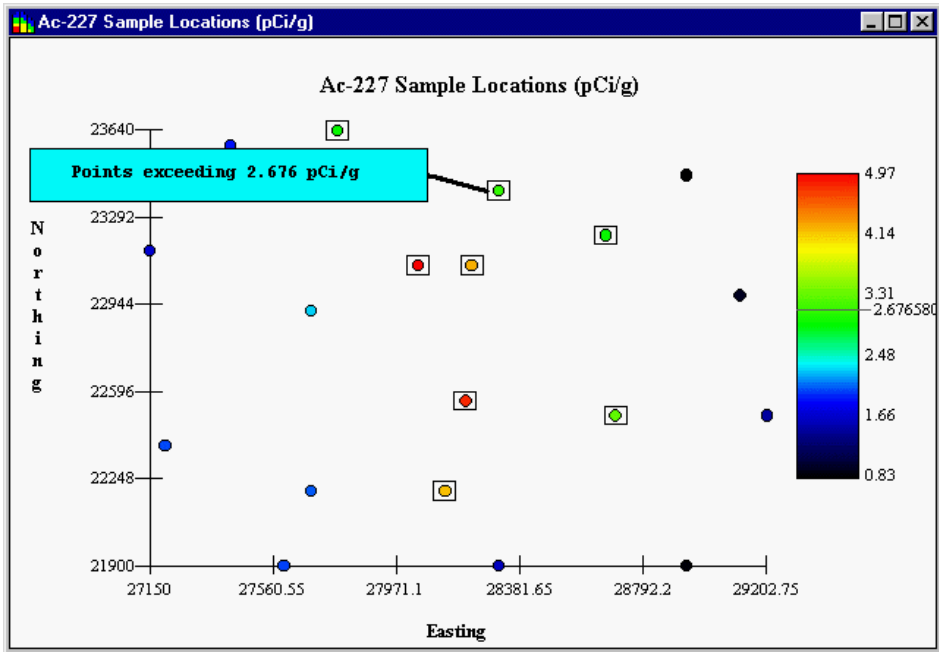


Figure 36. Spatial Screen

Step 1. Click on the **Decision** tab of the Control Panel. Under **Decision Basis,** click on the appropriate option. If the **Concentration** option is selected, enter a concentration value in the adjacent box. (See Figure 37.)

If human health risk, ecological risk, or custom analysis has been set up, this will be an additional option on the **Decision** tab (replaces General where the arrow is pointing in Figure 37).

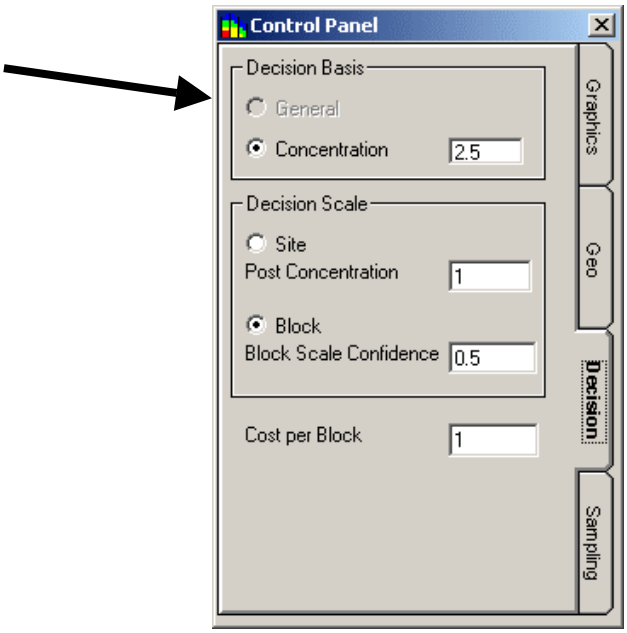


Figure 37. Decision Basis

Step 2. Now press the **Data Screen** button on the main toolbar.

If **Human Health**, **Ecological**, or **Custom** was selected as the decision basis (step 1), a screening selection window will appear.

Step 3. (If applicable) Select the appropriate screening scenario and press **OK**. (See Figure 38 for an example when human health was selected as the decision basis.)

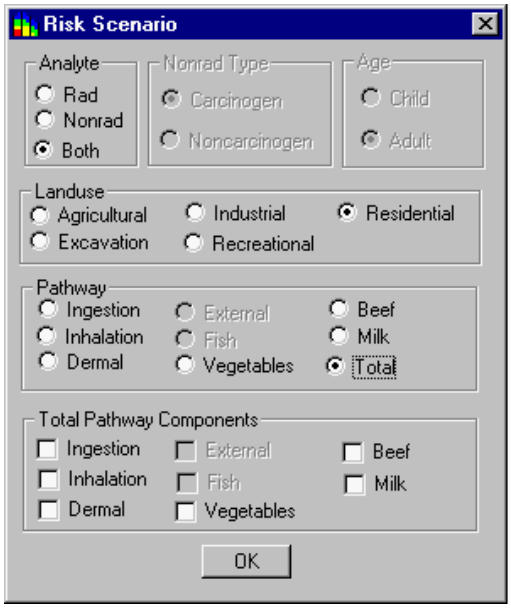


Figure 38. Risk Scenario Selection Window

POINT RISK MAPS

For point risk, SADA calculates risk for each sampling location based on the contaminant and exposure scenario. The legend scale changes to a risk scale.

Step 1. Select **Human Health** on the analysis drop down list of the main toolbar.

Step 2. Select **Point Risk** from the **Maps** menu or press the **Point Risk** button.

Step 3. Select the appropriate exposure scenario and pathways from the Risk Scenario Selection window (see Figure 38).

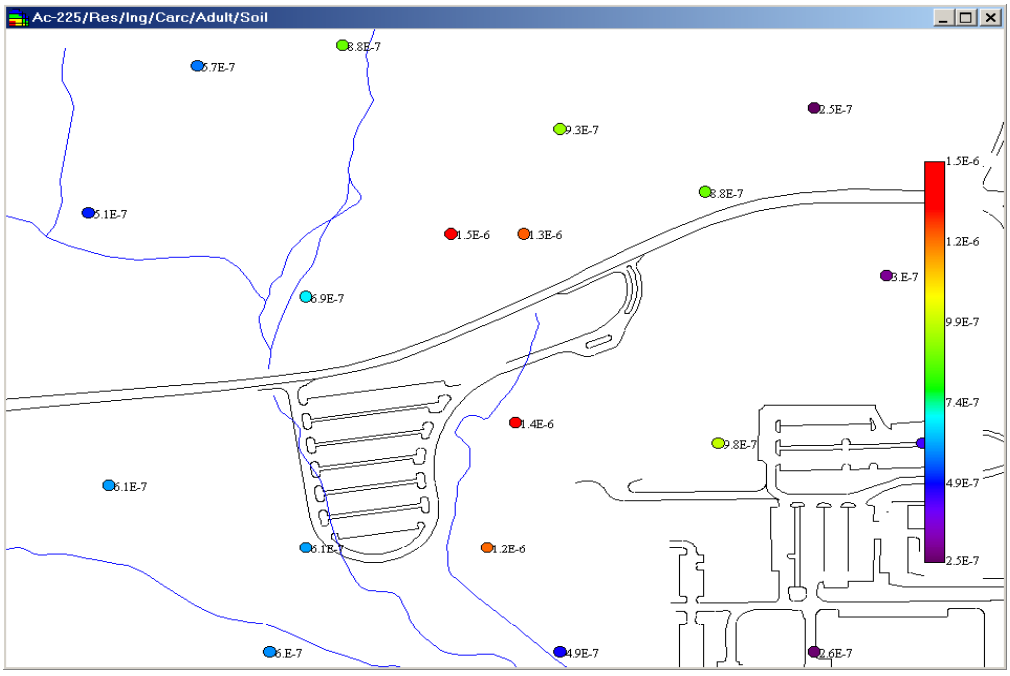


Figure 39. Point Risk Map

REMATCHING A SINGLE CONTAMINANT

This feature enables the user to change the toxicity information linked to a particular contaminant after the risk module has been setup. It is preferable to rerunning the Setup Risk Assessment again; however, if the number of contaminants to relink is high, it may be more efficient to rerun the Setup Risk Assessment.

Step 1. To link or relink a single contaminant, select the contaminant of interest from the combo box in the secondary toolbar.

Step 2. From the **Human Health** menu, select **Configure Human Health** and then **Rematch This Contaminant**.

Step 3. Select the appropriate database and press **OK**.

Step 4. Rematch the contaminant. The contaminant name being linked 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.

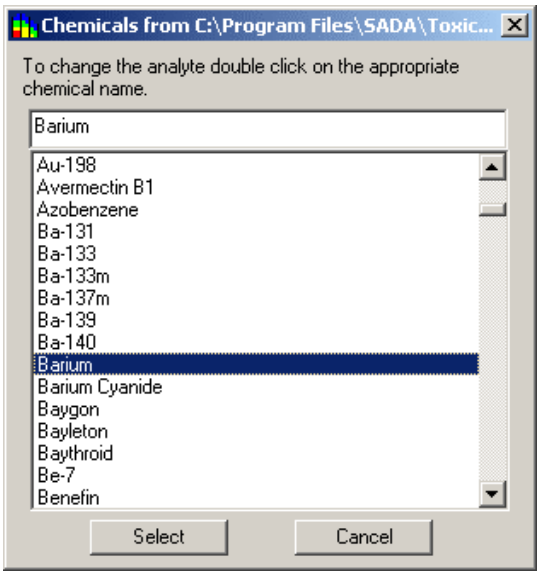


Figure 40. Rematch Single Contaminant

This update occurs for the selected contaminant across all media types (soil, surface water, etc.) automatically.

RISK EQUATIONS OVERVIEW

In SADA, five land use scenarios are considered: residential, recreational, industrial, excavation, and agricultural. The exposure pathways are grouped by soil-based exposure (soil and sediment) and by water-based exposure (surface water and groundwater). The tables presented for each pathway in Appendix A 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. (See Viewing Scenario Parameters.)

SETUP ECOLOGICAL RISK

Step 1. After you have successfully created a SADA file, you may setup ecological risk by selecting **Ecological Risk** from the **Setup** menu.

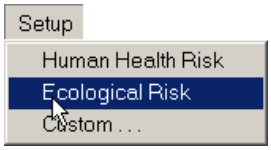


Figure 41. Select Ecological Risk Setup

Step 2. Press **Yes** to proceed with the setup wizard.

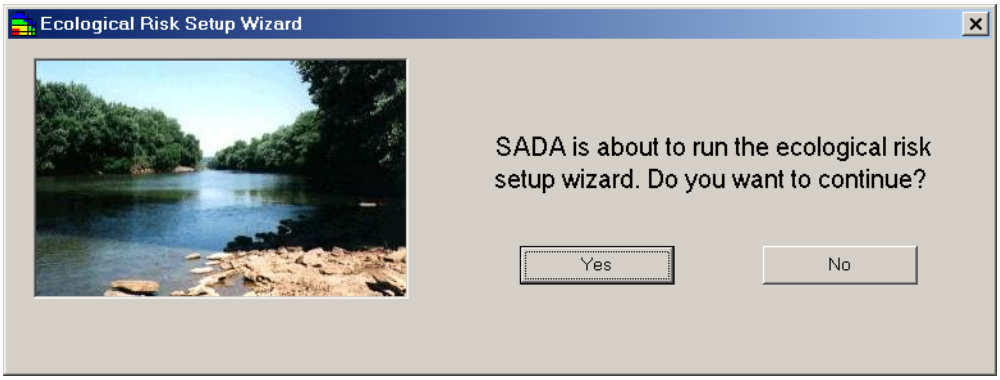


Figure 42. Ecological Risk Setup Wizard

Step 3. Identify the source file for the ecological risk information. To locate a file, click on the **Browse** button. Select eco_toxdata.mdb and then select **Open.** Once the file has been selected, press **Next>>**.

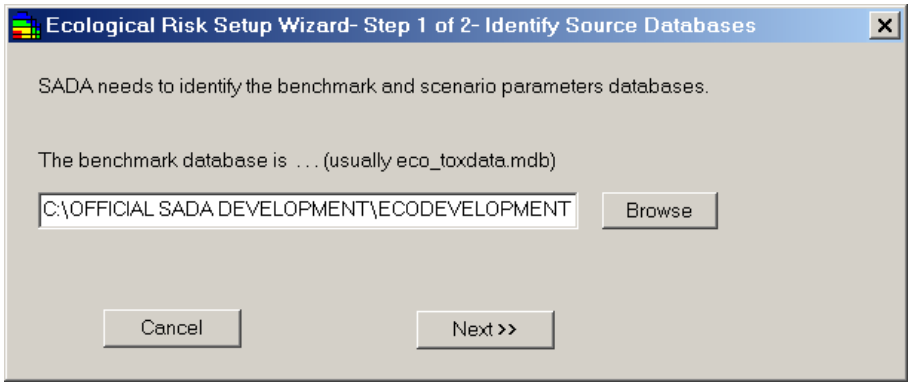


Figure 43. Identify Source Database

SADA now attempts to match each contaminant in your file with a contaminant found in the toxicological database by CAS number first 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.

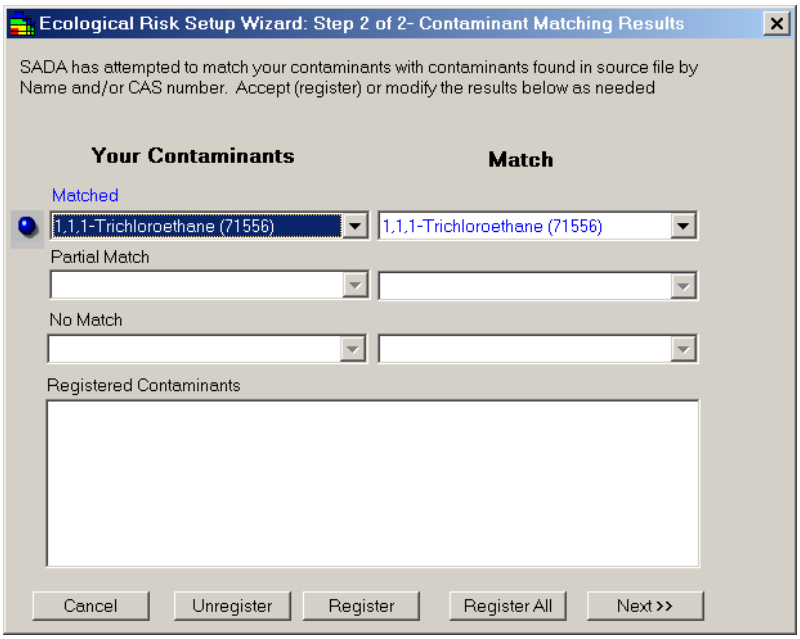


Figure 44. Contaminant Matching

Step 4. 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 **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 and relink these later.

Step 5. Press **Next>>** to conclude setting up the risk module. You may reset the Risk module at any time. 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.

ECOLOGICAL BENCHMARK DATABASES

The following benchmark databases are available in SADA. Descriptions of each database as well as web site addresses, if applicable, are presented in Appendix B.

Surface Water Benchmarks

- Canadian WQG
- EC20 Daphnids
- EC20 Fish
- EC25 Bass Population
- EC20 Sensitive Species
- EPA Region 4- Acute
- EPA Region 4- Chronic

- EPA Region 5 EDQLs
- LCV Aquatic Plants
- LCV Daphnids
- LCV Fish
- LCV Non-Daphnid Inverts
- NAWQC- Acute
- NAWQC- Chronic
- Tier II SAV
- Tier II SCV

Sediment Benchmarks

- ARCS NEC
- ARCS TEC
- ARCS PEC
- Canadian ISQG
- Canadian PEL
- EPA Region 4
- EPA Region 5 EDQLs
- FDEP TEL
- FDEP PEL
- NOAA ERL
- NOAA ERM
- Ontario Low
- Ontario Severe
- OSWER
- Washington AET

Soil Benchmarks

- Dutch Intervention
- Dutch Target
- Eco-SSL Avian
- Eco-SSL Inverts
- Eco-SSL Mammalian
- Eco-SSL Plants
- EPA Region IV
- EPA Region 5 EDQLs
- ORNL Invertebrates
- ORNL Microbes
- ORNL Plants

BROWSE FEATURES

Browse Benchmark Histogram

This feature is used to browse benchmarks from the master benchmark file or any SADA file in histogram form. All available benchmarks are displayed. The benchmarks are based on the physical properties saved in the file (e.g., hardness, pH, etc.).

Step 1. Select **Browse** and then **Benchmark Histogram From …** from the **Ecological** menu.

Step 2. Select the source data file and press **Open**. (Figure 45)

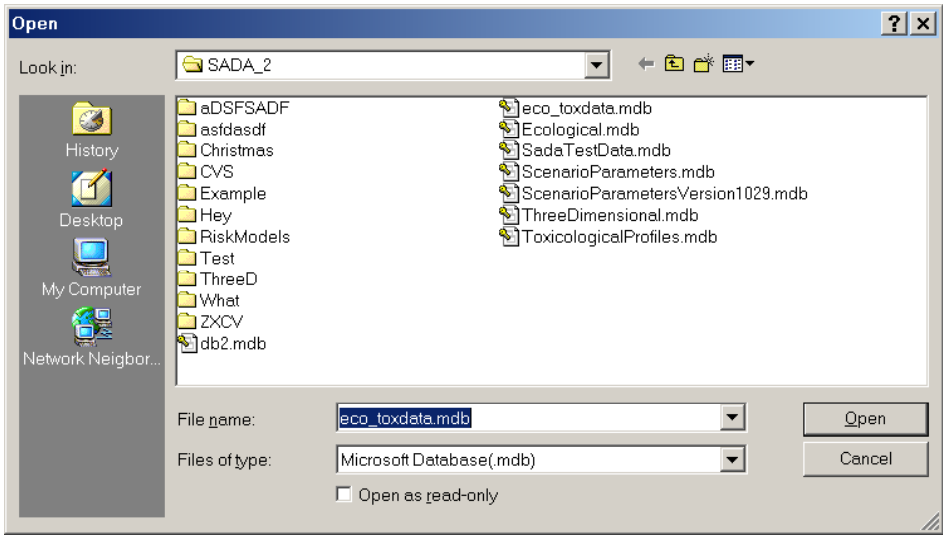


Figure 45. Select Source Data File

Step 3. Select a contaminant and media combination that you wish to view all benchmarks for and press **OK**. See Figure 46.

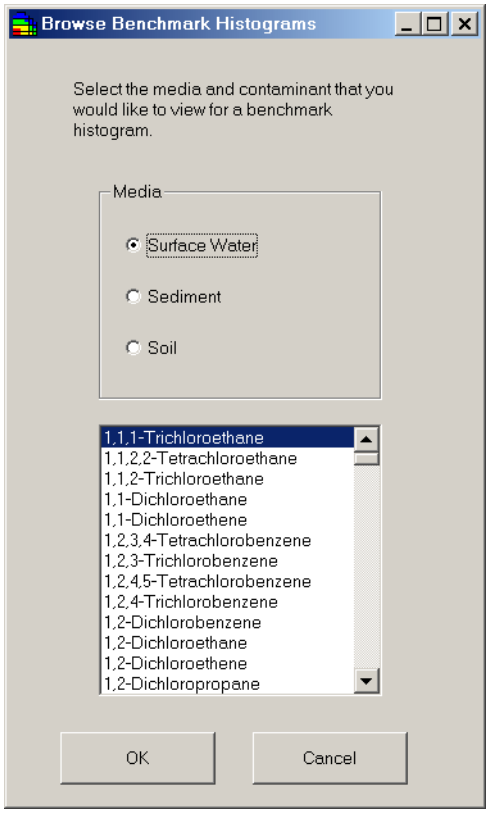


Figure 46. Browse Benchmark Histograms

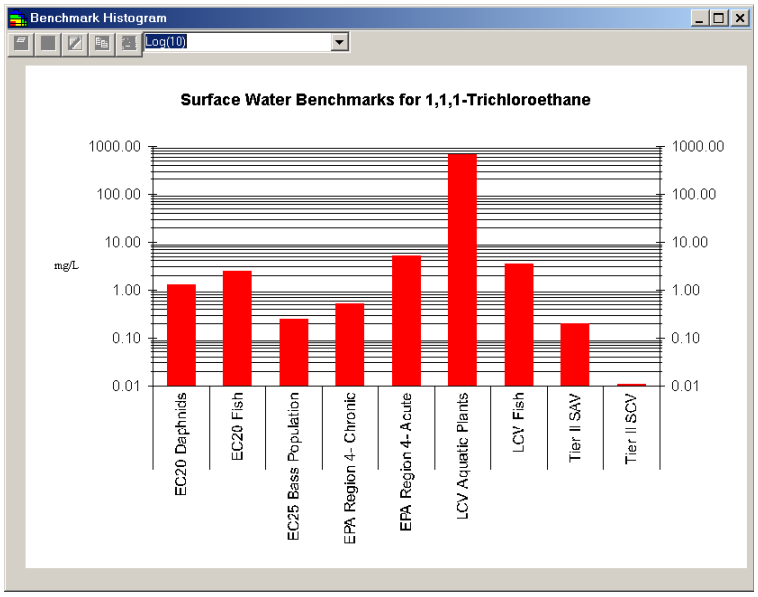


Figure 47. Benchmark Histogram Example

Browse Benchmark Tables

This feature is used to browse benchmarks from the master benchmark file or any SADA file in tabular form. Only selected benchmarks are displayed. The benchmarks are updated based on the defined physical properties (e.g., hardness, pH, etc.). Results may then be exported.

Step 1. Select **Browse** and then **Benchmark Table From …** from the **Ecological** menu.

Step 2. Select the source data file and press **Open**. (Figure 45)

Step 3. Select a contaminant and media combination that you wish to view all benchmarks for and press **OK**. It is also possible to select multiple contaminants by holding down the **Control** key while selecting contaminants. See Figure 48.

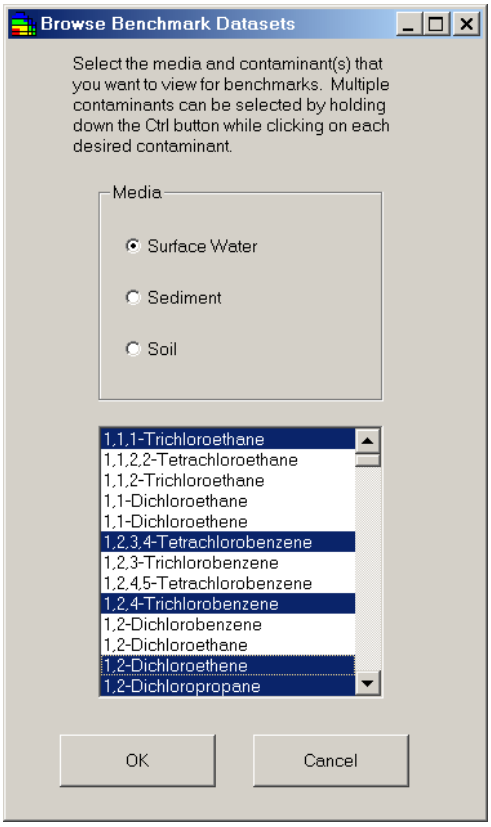


Figure 48. Browse Benchmark Datasets

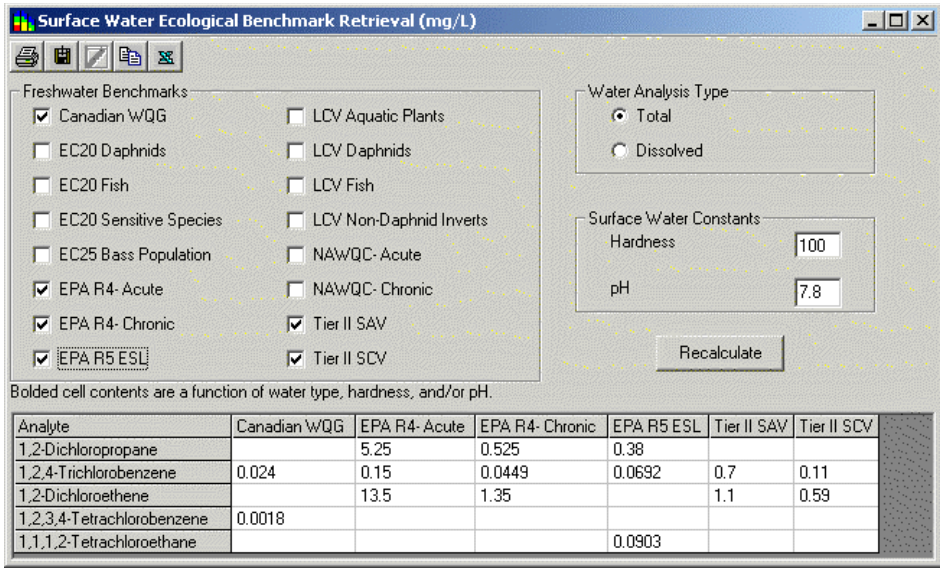


Figure 49. Benchmark Table Example

SETTING PHYSICAL PARAMETERS

A number of benchmarks are a function of site-specific physical parameters. The ability to Set Physical Parameters allows users to store this information within the SADA file and automatically modify screening benchmarks to reflect site-specific conditions.

Step 1. Select **Configure Ecological Risk** and then **Set Physical Parameters** from the **Ecological** menu.

Step 2. The next window (Figure 50) will display the current defaults for these parameters within your SADA file. Adjust the values as appropriate and press **OK**. If the adjusted value is outside an applicable range, then it will be restored to the default value and you may adjust it again, if necessary.

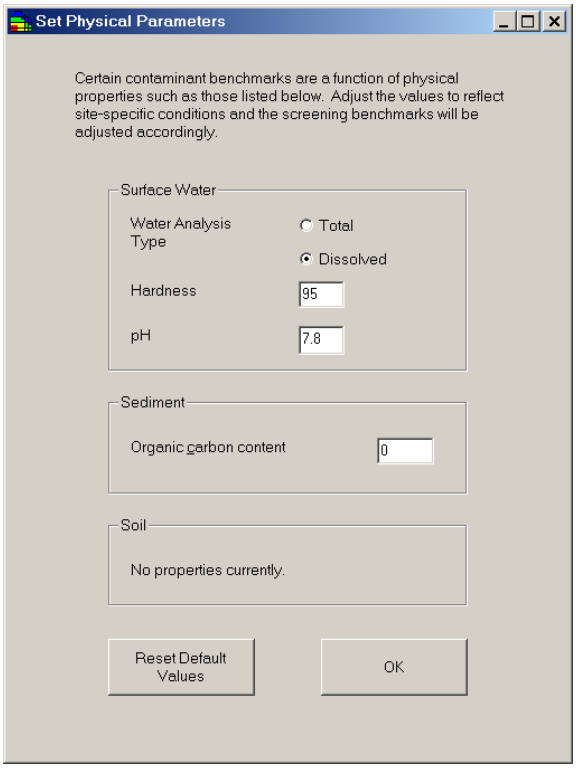


Figure 50. Set Physical Parameters

EXPOSURE AREA RESULTS

Exposure Area Result Screens

This feature provides a result for whether the maximum value exceeds the selected benchmark(s) for a particular area. A “Yes” indicates that the concentration exceeds the benchmark, “No” indicates that the concentration is less than the benchmark, and a blank cell indicates that there is no benchmark for that contaminant-benchmark combination.

Step 1. Set the analysis type **Ecological** and select the desired contaminant and media in the drop down boxes of the main toolbar.

Step 2. From the **Ecological** menu, select **Benchmark Screens**.

Step 3. Click in the checkboxes for each benchmark type to display the value in the cell. If the benchmark is a function of a given property (organic carbon, pH, hardness, or water type), then its display will be bolded. If you change one of these properties, then you must click the **Recalculate** button to update the results.

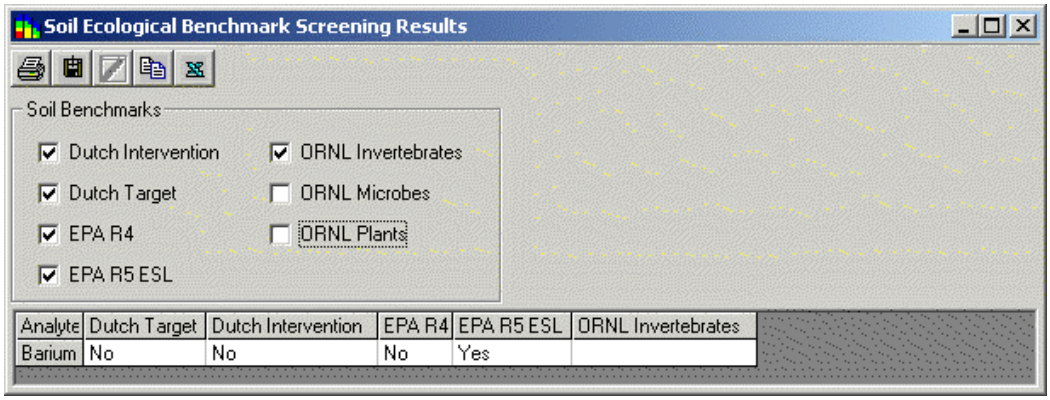


Figure 51. Benchmark Screen

Exposure Area Result Ratios

This feature provides a concentration to benchmark ratio based on the minimum value (UCL95, maximum detect) for the selected area. The user selects the values to be screened.

Step 1. Set the analysis type **Ecological** and select the desired contaminant and media in the drop down boxes of the main toolbar.

Step 2. From the **Ecological** menu, select **Benchmark Ratios**.

Step 3. Click in the checkboxes for each benchmark type to display the value in the bottom of the window. If the benchmark is a function of a given property (organic carbon, pH, hardness, or water type), then its display will be bolded. If you change one of these properties, then you must click the **Recalculate** button to update the results.

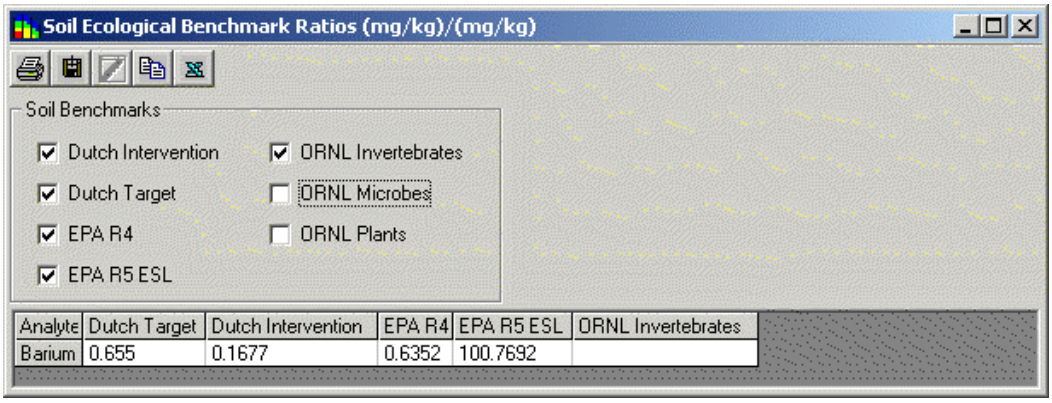


Figure 52. Benchmark Ratio

MAP RESULTS

Map Result Screens

This tool screens the concentration against benchmarks at each sample location and places a box around those points that exceed the benchmark. The user may choose to screen concentrations against one benchmark source or establish a site-specific hierarchy.

Step 1. Set the analysis type **Ecological** and select the desired contaminant and media in the drop down boxes of the main toolbar.

Step 2. From the **Maps** menu, select **Data Screen**. (Alternatively, you can select the **Data Screen** button from the main toolbar.)

Step 3. Select the ecological benchmarks to screen against.

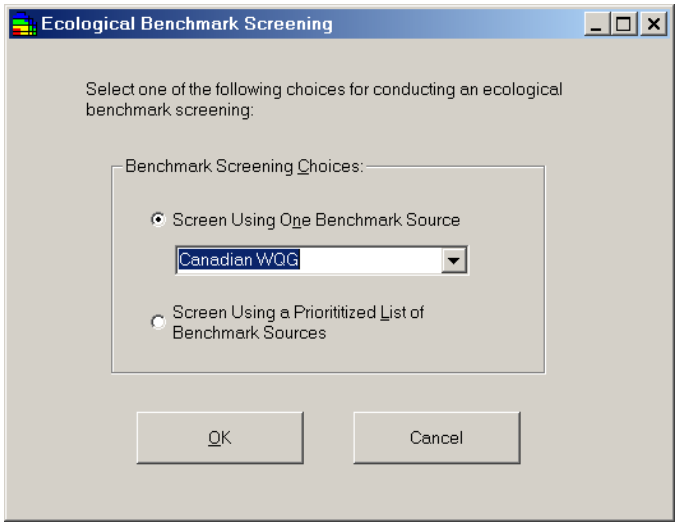


Figure 53. Benchmark Screening Selection

Step 4. To **Screen Using a Prioritized List of Benchmark Sources**, 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 (see figure 54). Clicking **OK** will then display the map with a box around each point that exceeds the chosen benchmark (see figure 55).

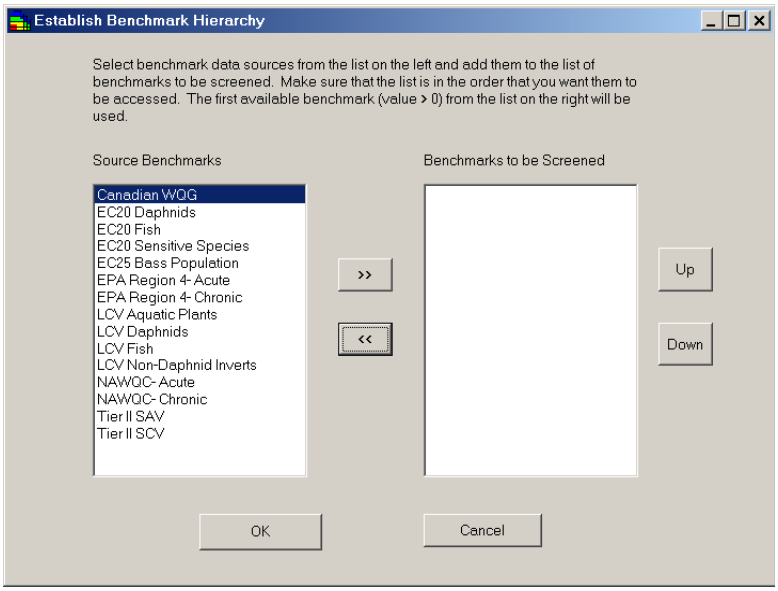


Figure 54. Establish Benchmark Hierarchy

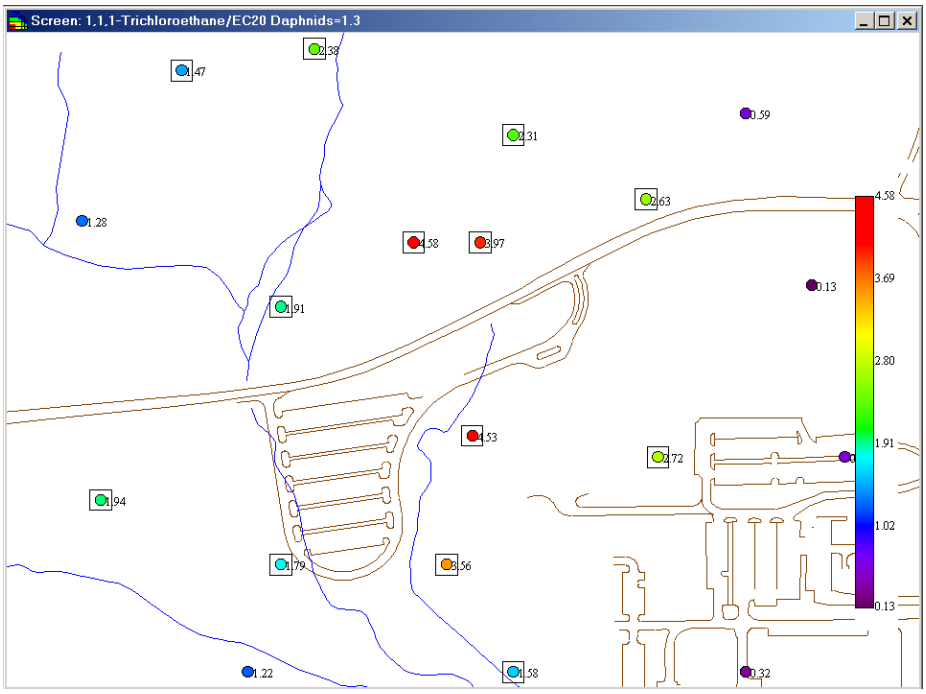


Figure 55. Data Screen Example

Map Result Ratios

This tool provides a concentration to benchmark ratio at each sample location for one benchmark source or a site-specific hierarchy of benchmarks. The legend on the map will change accordingly.

Step 1. Set the analysis type **Ecological** and select the desired contaminant and media in the drop down boxes of the main toolbar.

Step 2. From the **Maps** menu, select **Point Risk**. (Alternatively, you can select the **Point Risk** button from the main toolbar.)

Step 3. Select the ecological benchmarks to screen against. (See Figure 53.)

Step 4. To **Screen Using a Prioritized List of Benchmark Sources**, 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 (see figure 54).

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 results. (See Figure 56.)

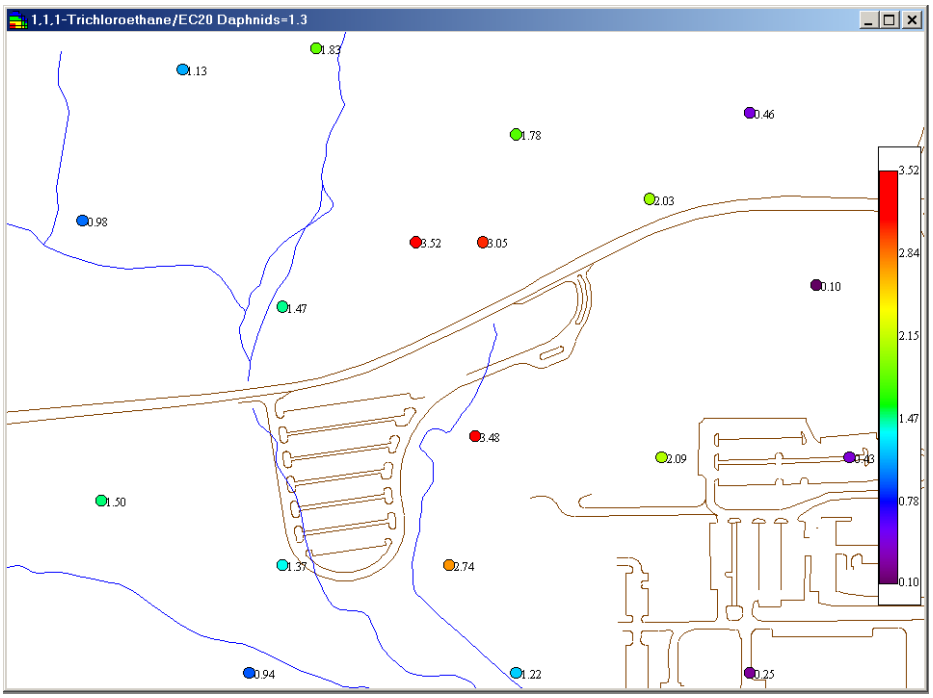


Figure 56. Point Risk Example

REMATCH A CONTAMINANT

This feature enables the user to change the benchmark information linked to a particular contaminant after the risk module has been setup. It is preferable to rerunning the Setup Risk Assessment again; however, if the number of contaminants to relink is high, it may be more efficient to rerun the Setup Risk Assessment.

Step 1. To link or relink a single contaminant, make sure that your analysis type is set to **Ecological** and the contaminant that you want to relink is selected in the main toolbar

Step 2. From the **Ecological** menu, select **Configure Ecological Risk** and then **Rematch This Contaminant**.

Step 3. Select the appropriate database and press **OK**.

Step 4. Select the desired contaminant or type in the contaminant name to be matched on the entry line in order to quickly find the appropriate relink (the contaminants are displayed in CAS number order). Pressing **Select** will then conclude the Rematch Single Contaminant task and the appropriate information will be updated in the SADA file.

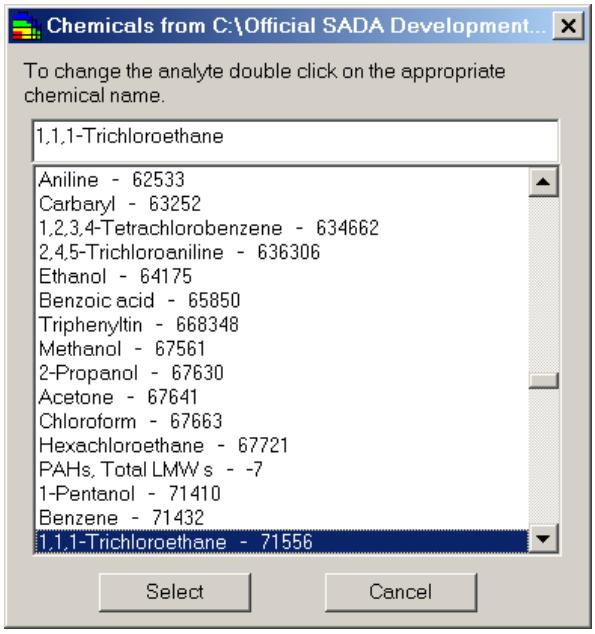


Figure 57. Relink Ecological Contaminant

CHECK ECOLOGICAL VERSION

This feature provides three main benefits.

- Enables the user to determine if ecological benchmark information was updated since the file was created;
- Provides a version number and date stamp for the benchmarks; and
- Provides a link to the SADA web site to download the latest benchmark version.

Step 1. From the **Ecological** menu, select **Configure Ecological Risk** and then **Check Ecological Version**.

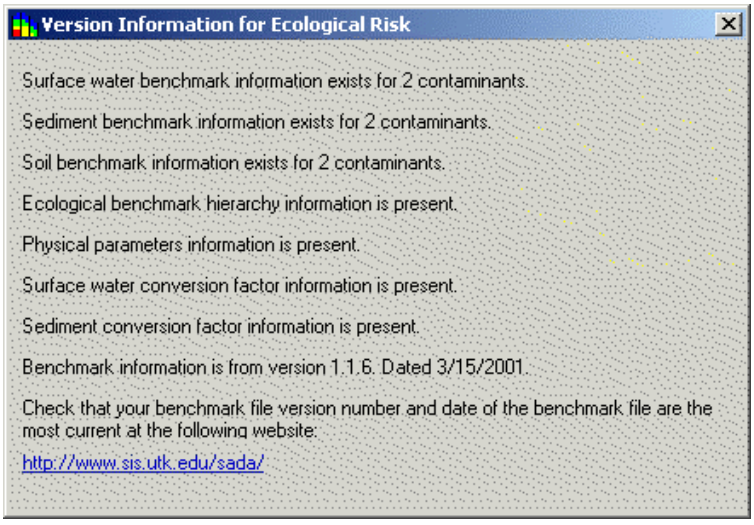


Figure 58. Check Ecological Version

Step 2. 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.

FUTURE DIRECTIONS

The following list includes future goals for the ecological module of SADA.

- Obtain prioritization by EPA Ecological Risk Assessment Forum.
- Implement exposure assessment methods for variety of receptors (e.g., ECO SSL).
- Add tissue residue benchmarks.
- Allow users to import tissue concentration data.
- Provide standard ecological tables for auto-documentation output.
- Allow users to import toxicity testing results.

CUSTOM ANALYSIS

ROLE OF CUSTOM ANALYSIS

Custom analysis refers to any outside values that can be imported into SADA. These values can be used to screen data, determine the area of concern, and support sample design. Custom analyses are imported into SADA in the same fashion as ecological and human health; however, there can be an unlimited number of custom analyses.

SETTING UP A CUSTOM ANALYSIS

Step 1. From the **Setup** menu, press **Custom…**

Step 2. The Custom Analysis Wizard opens. Press **Next>>**.

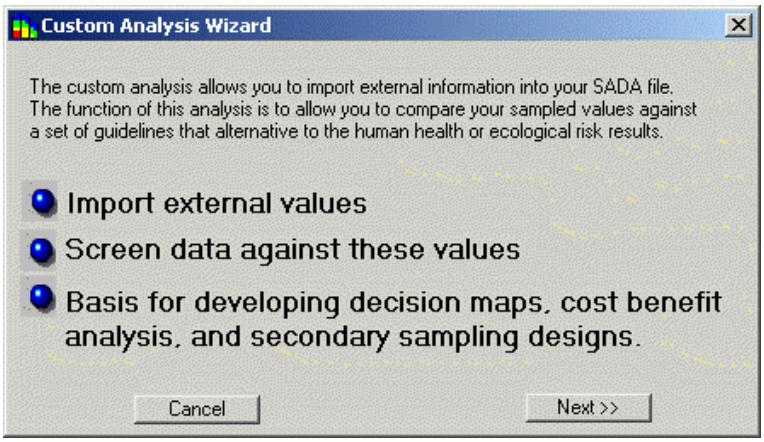


Figure 59. Custom Analysis Wizard

Step 3. 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>>**.

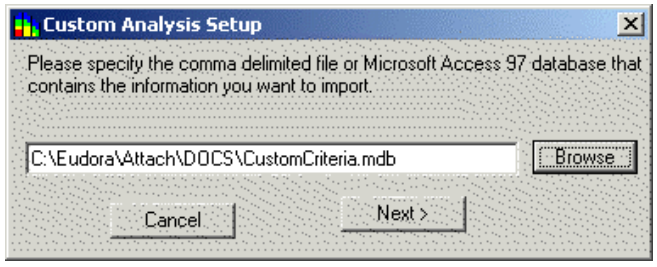


Figure 60. Select Custom File

Step 4. 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**.

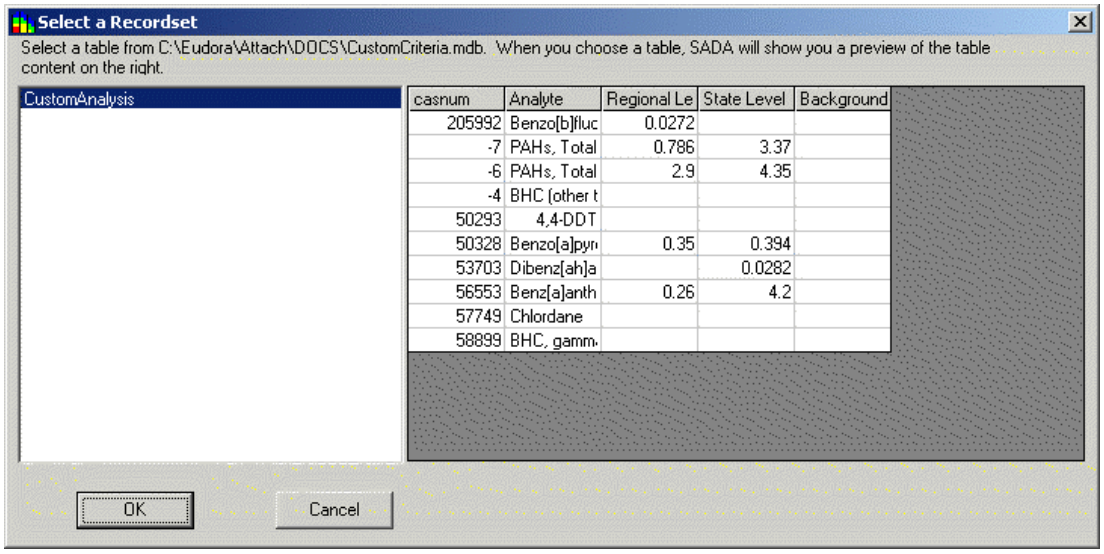


Figure 61. Select a Recordset

Step 5. Select the appropriate column headings in the drop down boxes to match with those in the current SADA file. Then press **Next>>**.

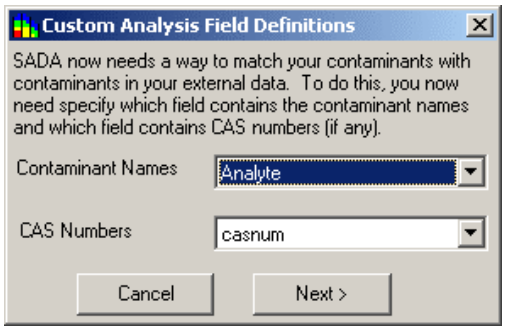


Figure 62. Custom Analysis Field Definitions

Step 6. If a 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 and relink them later. Press **Next>>** to conclude setting up the custom analysis module.

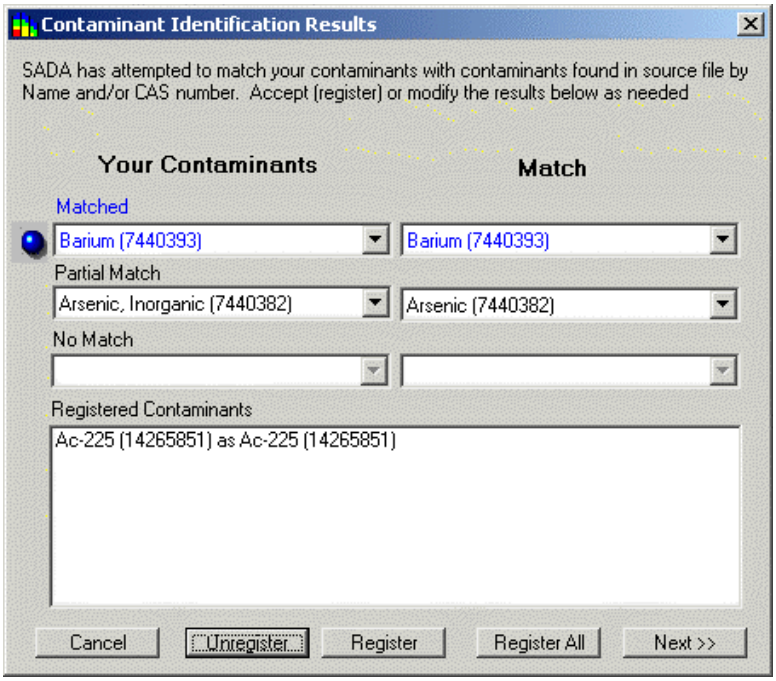


Figure 63. Match Custom Contaminants

VIEWING CUSTOM VALUES

Step 1. To view the custom values imported into SADA, select the contaminant of interest in the **Contaminant** box of the main toolbar.

Step 2. 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*.

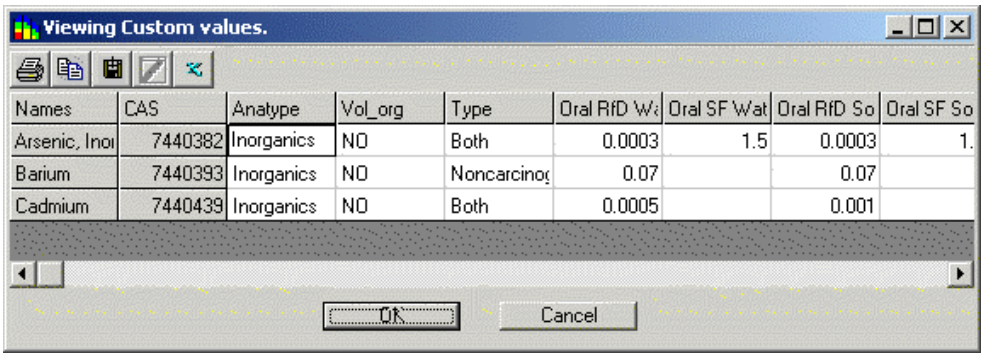


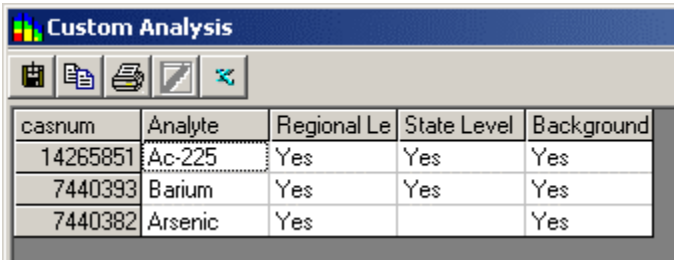
Figure 64. Viewing Custom Values

SCREENING CUSTOM VALUES

Tabular

Step 1. Select Custom Analysis, the contaminant, and media of interest from the main toolbar.

Step 2. Then, from the **Custom** menu, select **Custom Screen Table**. (Alternatively, press the **Risk Screen Table** button.) A "Yes" values indicate that a data point exceeds the custom value while a "No" indicates that the value was not exceeded or there is a lack of information.



casnum	Analyte	Regional Le	State Level	Background
14265851	Ac-225	Yes	Yes	Yes
7440393	Barium	Yes	Yes	Yes
7440382	Arsenic	Yes		Yes

Figure 65. Custom Screen Table

Spatial

Step 1. Select Custom Analysis, the contaminant (select **Pooled Data** to screen all) and media of interest from the main toolbar.

Step 2. On the **Decision** tab of the **Control Panel**, select **Custom Analysis** for the Decision Basis.

Step 3. Press the **Data Screen** button.

Step 4. Choose the appropriate screening criteria (see figure 66) and press **OK**. The results will be displayed on a map (figure 67).

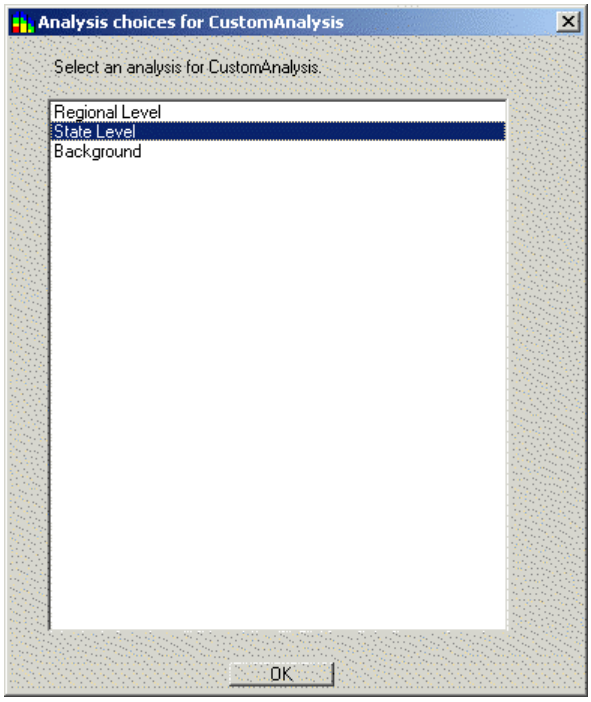


Figure 66. Choose Custom Analysis Criteria

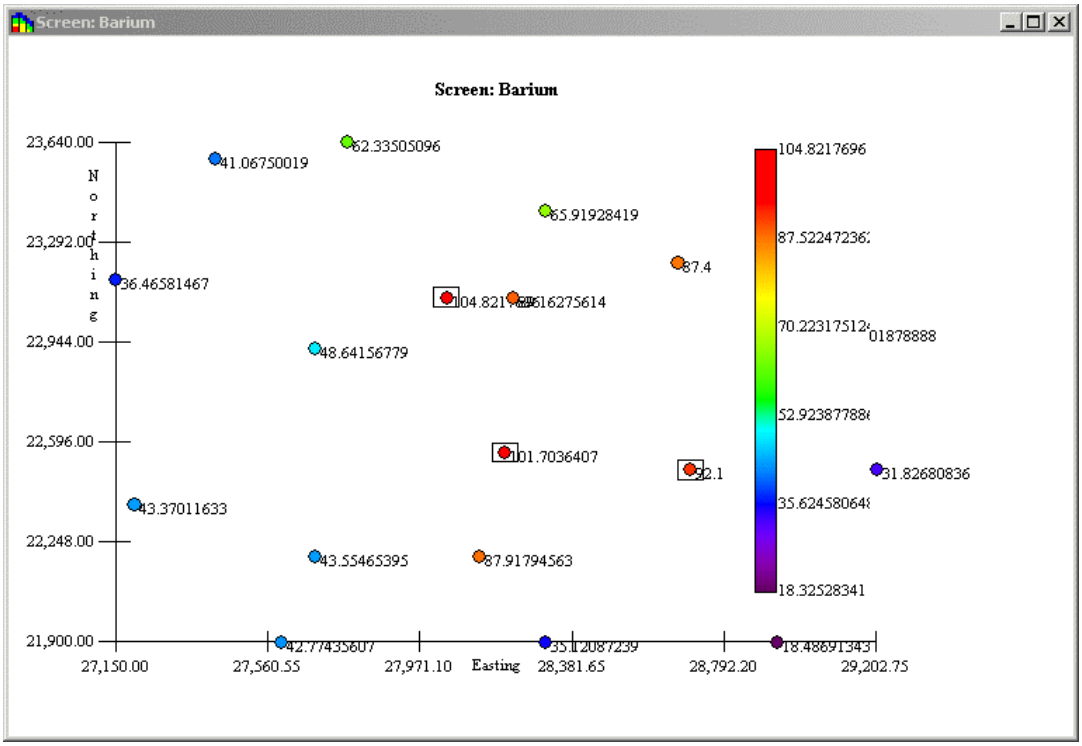


Figure 67. Spatial Custom Screen Example

REMATCHING CUSTOM CONTAMINANTS

This feature enables the user to change the benchmark information linked to a particular contaminant after the custom module has been setup. if the number of contaminants to relink is high, it may be more efficient to rerun the **Setup Custom...** again.

Step 1. To link or relink a single contaminant, make sure that your analysis type is set to **CustomAnalysis** and the contaminant that you want to relink is selected in the main toolbar

Step 2. From the **Custom** menu, select **Configure Custom Analysis** and then **Rematch This Contaminant**.

Step 3. Select the appropriate database and press **OK**.

Step 4. Select the desired contaminant or type in the contaminant name to be matched on the entry line. Pressing **Select** will then conclude the Rematch Single Contaminant task and the appropriate information will be updated in the SADA file.

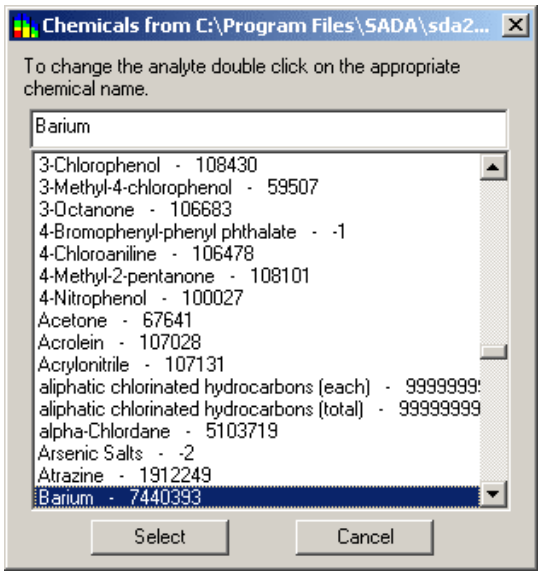


Figure 68. Rematch Custom Contaminant

OVERVIEW OF GEOSPATIAL APPROACHES

Geospatial approaches are used to model contaminant behavior between sampled data points. These approaches can estimate attribute values, and some 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.

GEOSTATISTICAL APPROACHES

Review of Spatial Interpolation

Spatial interpolation is used to predict values between sampled locations.

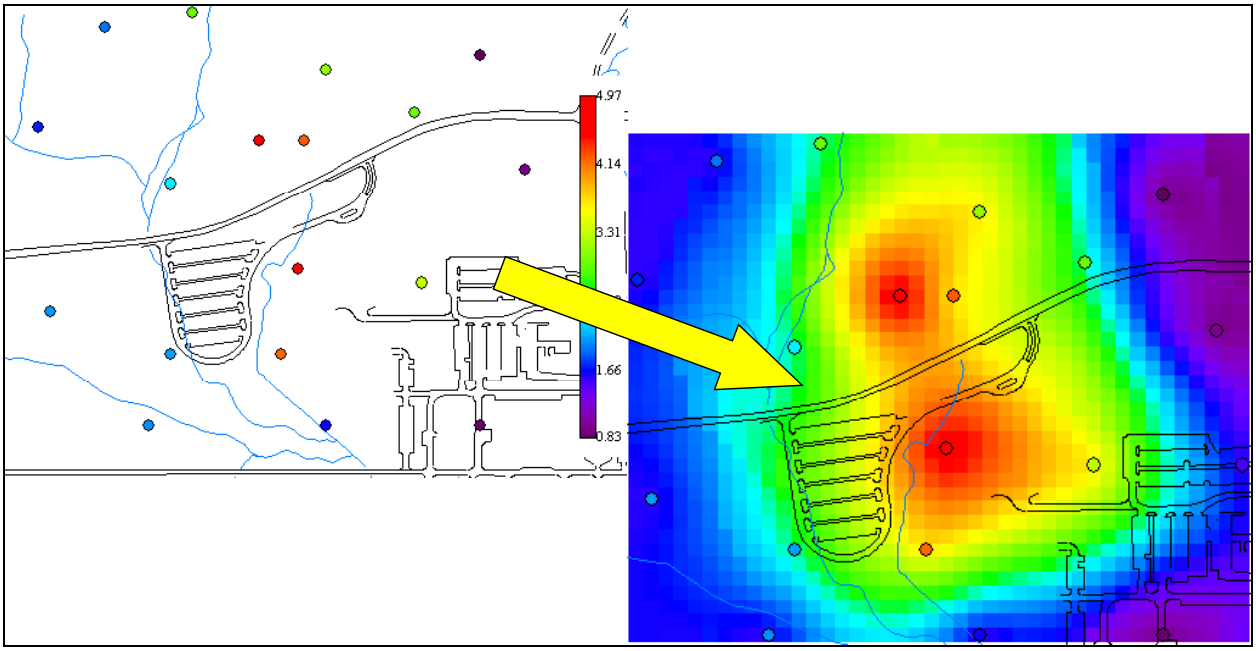


Figure 69. Spatial Interpolation

All spatial interpolators in SADA depend on a grid definition to function. A grid definition simply describes the number, size, and location of a uniform set of blocks.

Step 1. Define the grid block size in the **Geo** tab of the **Control Panel**.

Step 2. Press the **Grid** button on the main toolbar.

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.

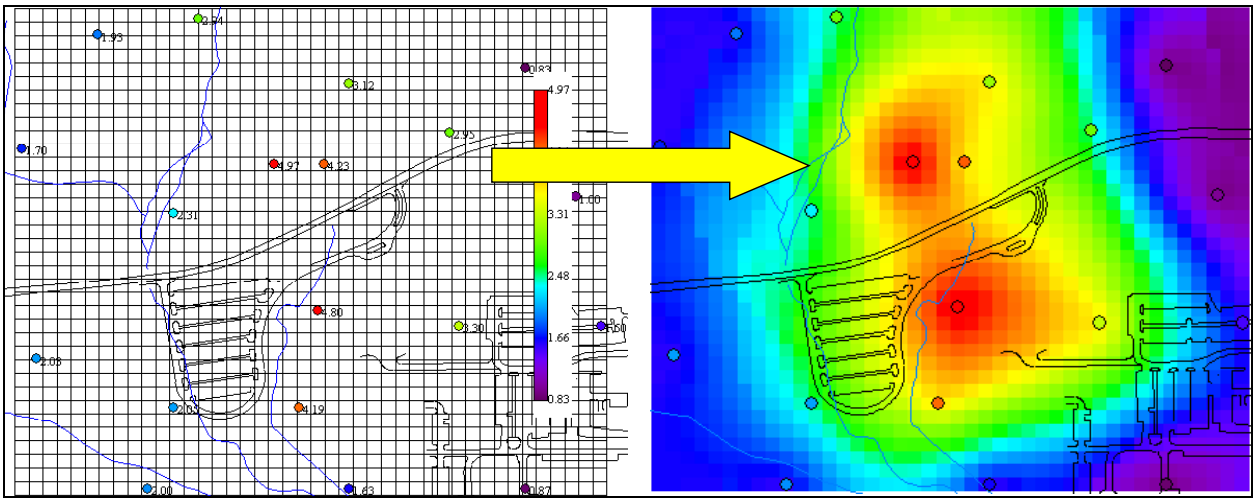


Figure 70. Grid Definition

Search Neighborhoods

Inverse distance, ordinary kriging, and indicator kriging 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 and size to include or exclude various data.

Step 1. Define the search ellipse parameters, which control the shape and size of the search ellipse, in the **Geo** tab of the **Control Panel**.

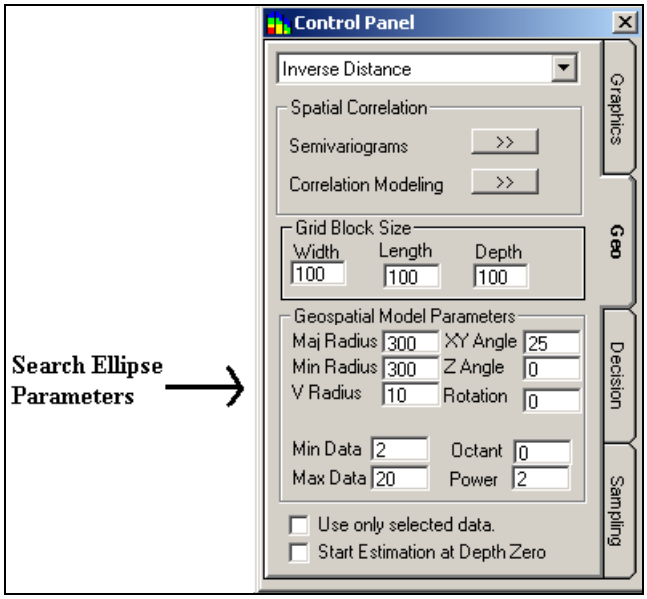


Figure 71. Search Ellipse Parameters

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

Major Radius
The long radius of the ellipse.

Minor Radius
The short radius of the ellipse.

XY Angle
The angle or direction the long radius points. This angle is measured clockwise from the positive Y axis (0 deg is North). The minor elliptical axis is perpendicular to the major axis.

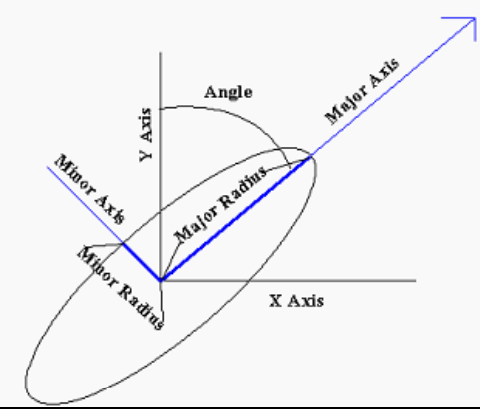


Figure 72. Search Ellipse

Step 2. For three-dimensional data, the ellipse becomes an ellipsoid. The parameters in figure 73, in addition to those listed in figure 72, 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

Also referred to as Z minor radius, it is the radius of the ellipse in the vertical 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.

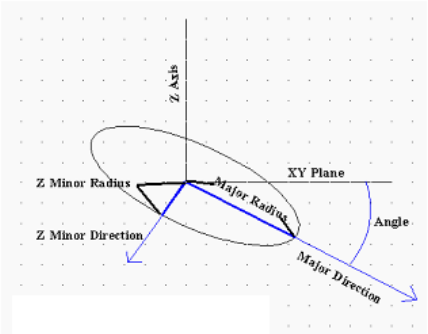


Figure 73. Search Ellipsoid

The following figure 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 unestimated value. You will be notified of the number of unestimated 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.

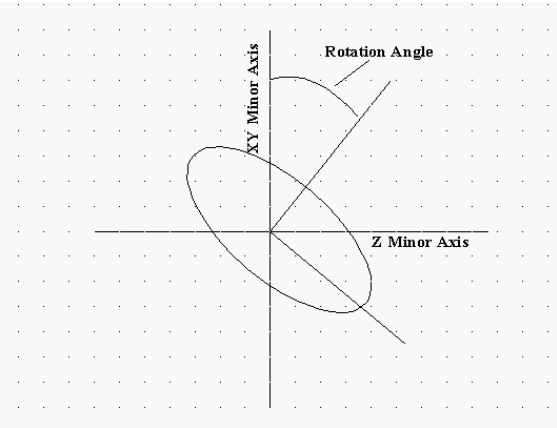


Figure 74. Search Criteria

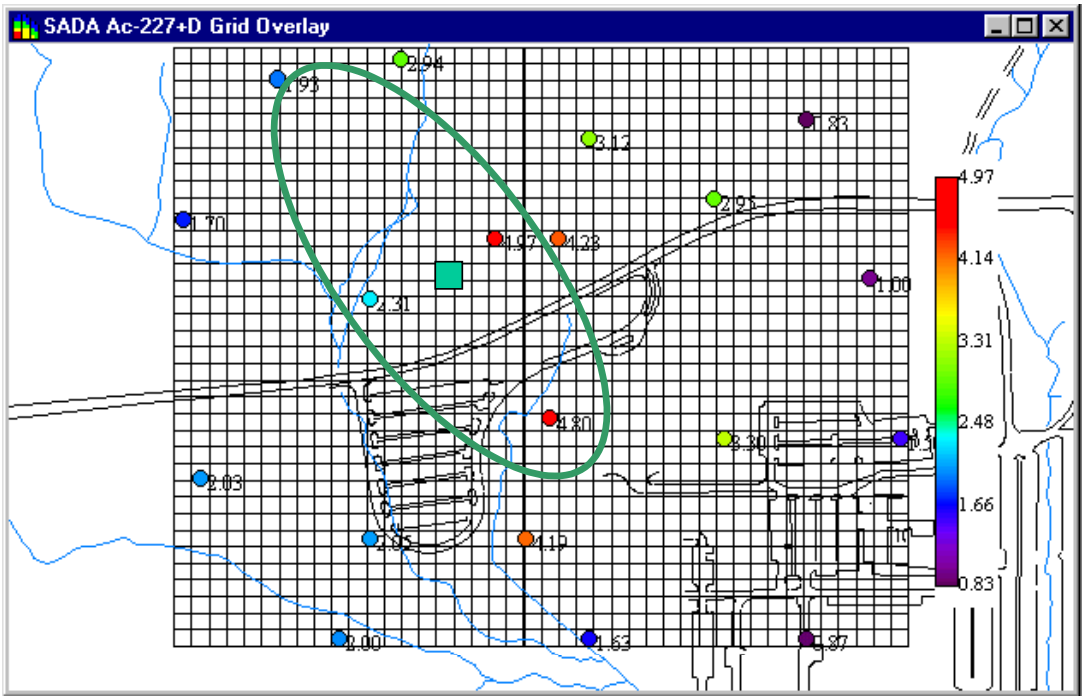


Figure 75. Search Neighborhood for a Single Unsampled Point

Inverse Distance

The basic premise of inverse distance is that the value V_o at an unsampled location is estimated as the weighted average of nearby values.

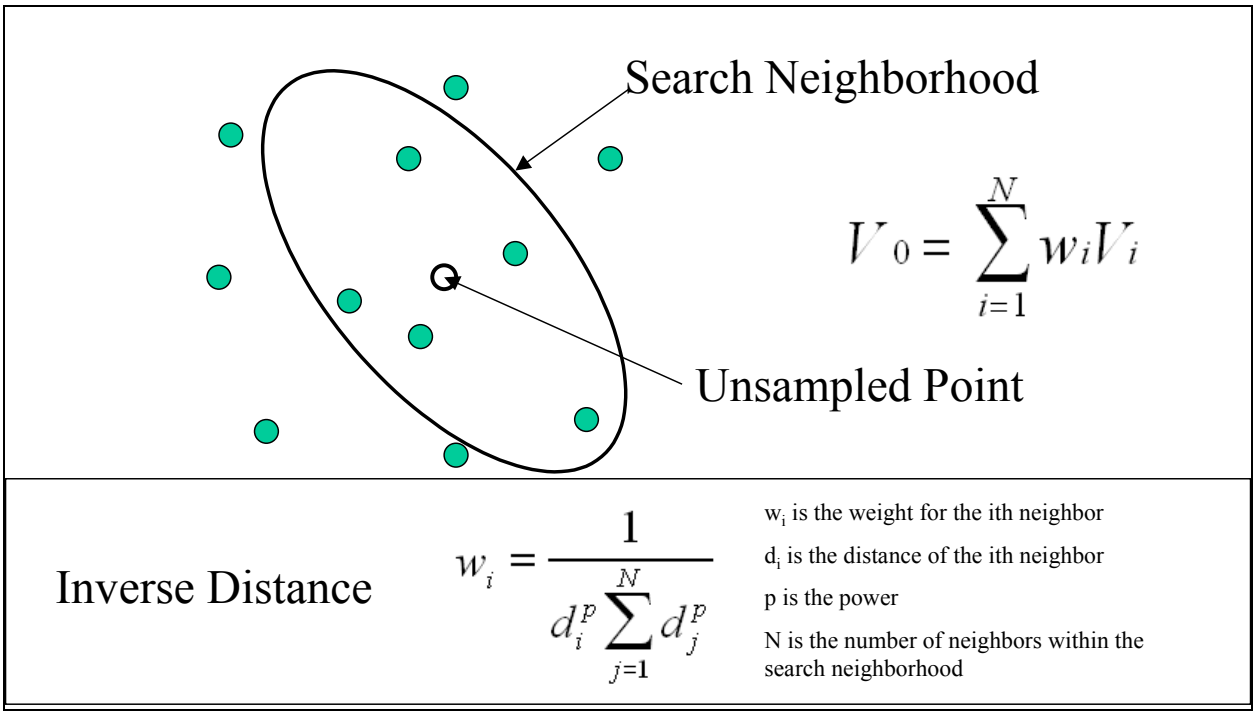


Figure 76. Inverse Distance

Step 1. Select the contaminant of interest from the drop down box of the main toolbar.

Step 2. Choose Inverse Distance from the list of available interpolants on the **Geo** tab of the **Control Panel**.

Step 3. Define a grid, setup an appropriate search neighborhood, and specify the power parameters in the **Geo** tab of the **Control Panel**.

Step 4. Press the **Estimates** map button on the main toolbar.

Ordinary Kriging and Indicator Kriging Overview

Rather than producing a single estimate, a distribution of possible values is constructed for ordinary or indicator kriging. This permits a model of uncertainty about the true value. One can also choose a point of the distribution as a single estimate.

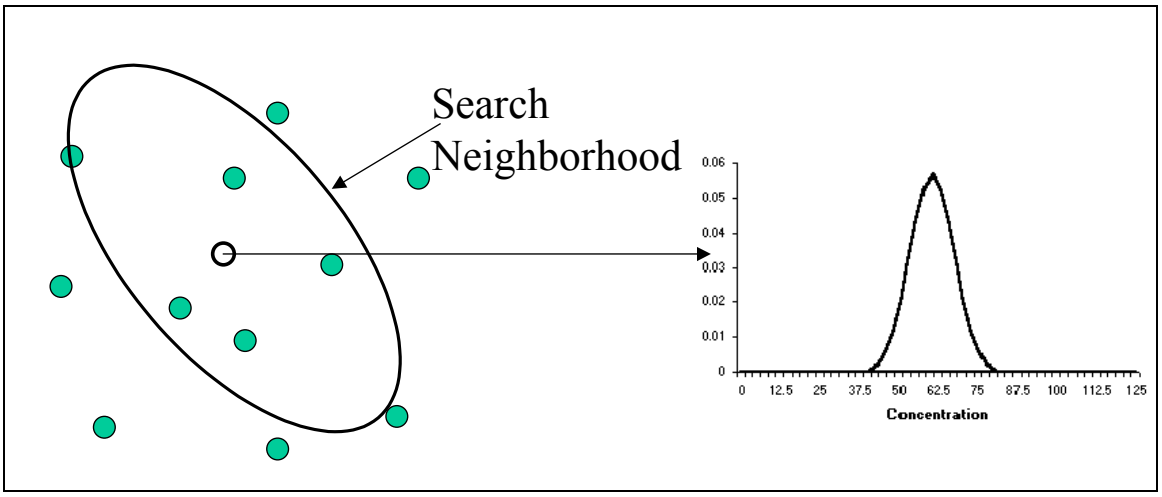


Figure 77. OK and IK

A full explanation of ordinary kriging and indicator kriging is beyond the scope of this manual. Only the basic concepts will be presented as well as a demonstration of how to set up such an interpolant in SADA.

In simple terms, geostatistical methods approach interpolation from a weighting of nearby samples; however, the influence of nearby samples is based on a covariance model rather than distance alone. A covariance model describes how data separated by various distances vary in magnitude.

Spatial Covariance

Geostatistics are built upon a model of spatial variability. Spatial covariance models are used to describe how variable data are across space. (Data sampled closely together are more alike than samples taken farther apart.)

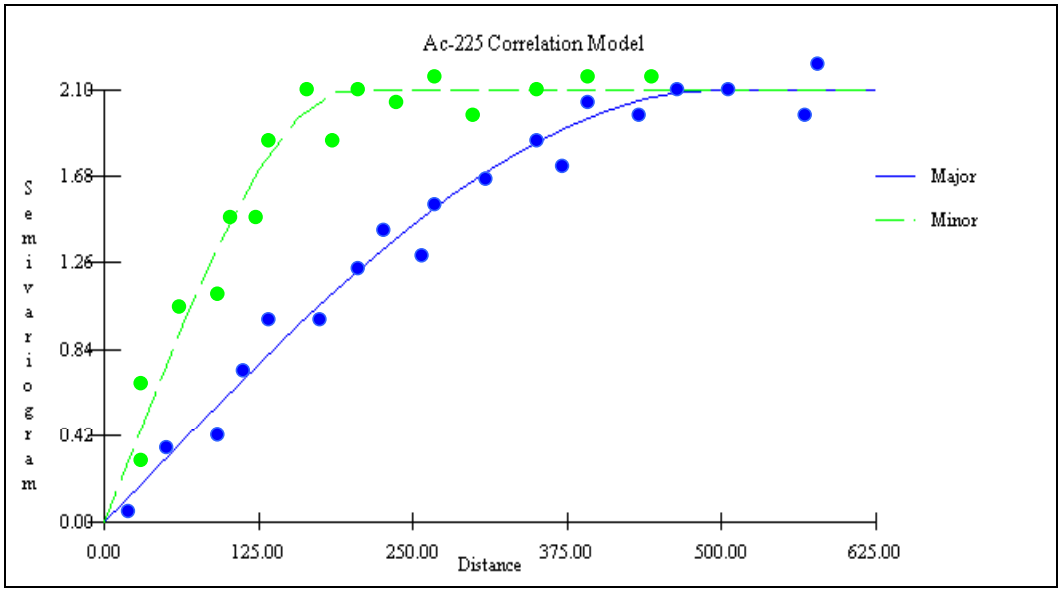


Figure 78. Spatial Covariance

Setting Variography and Correlation Models

Step 1. Select a single contaminant (not polled) the contaminant drop down box of the main toolbar.

Step 2. Press the **Semivariograms** button on the **Geo** tab of the **Control Panel**. (See Figure 79 for the resulting screen.)

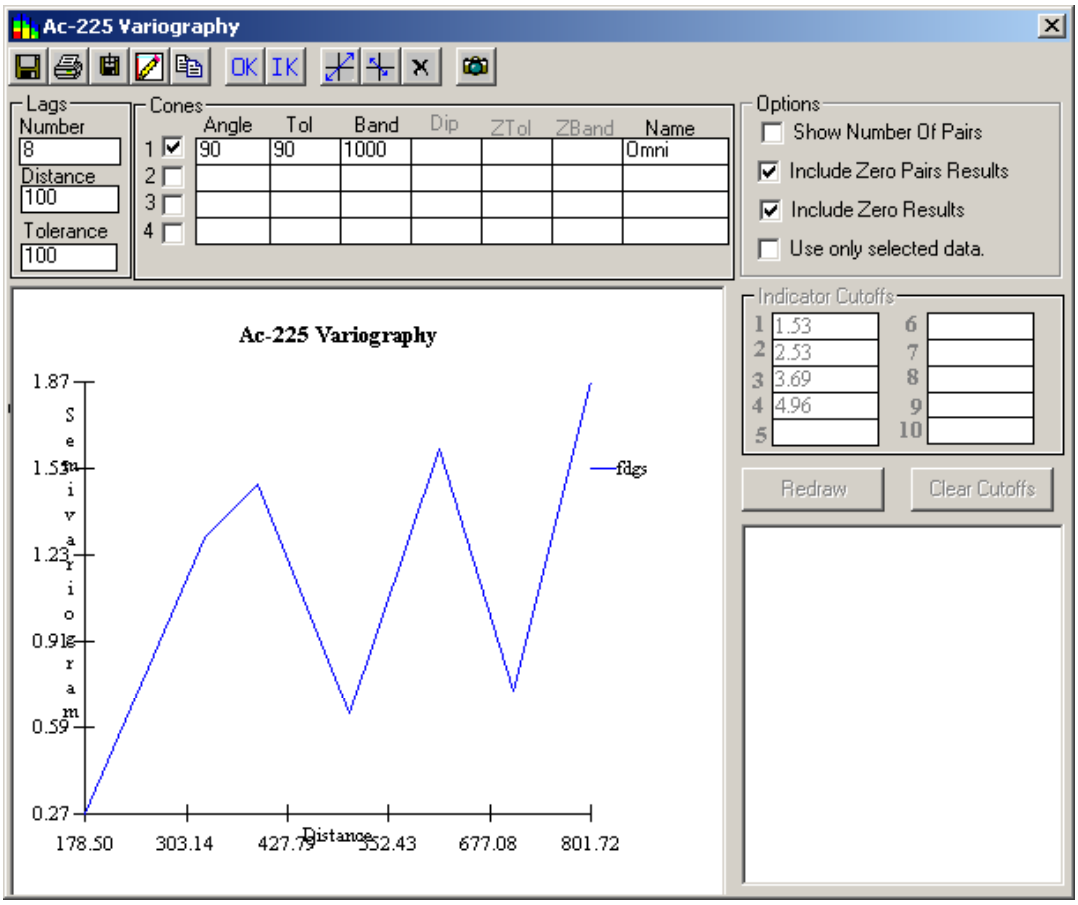


Figure 79. Variography

Step 3. To model Spatial Covariance, press the **Correlation Modeling** Button on the **Geo** tab of the **Control Panel**. (See Figure 90 for the resulting screen.)

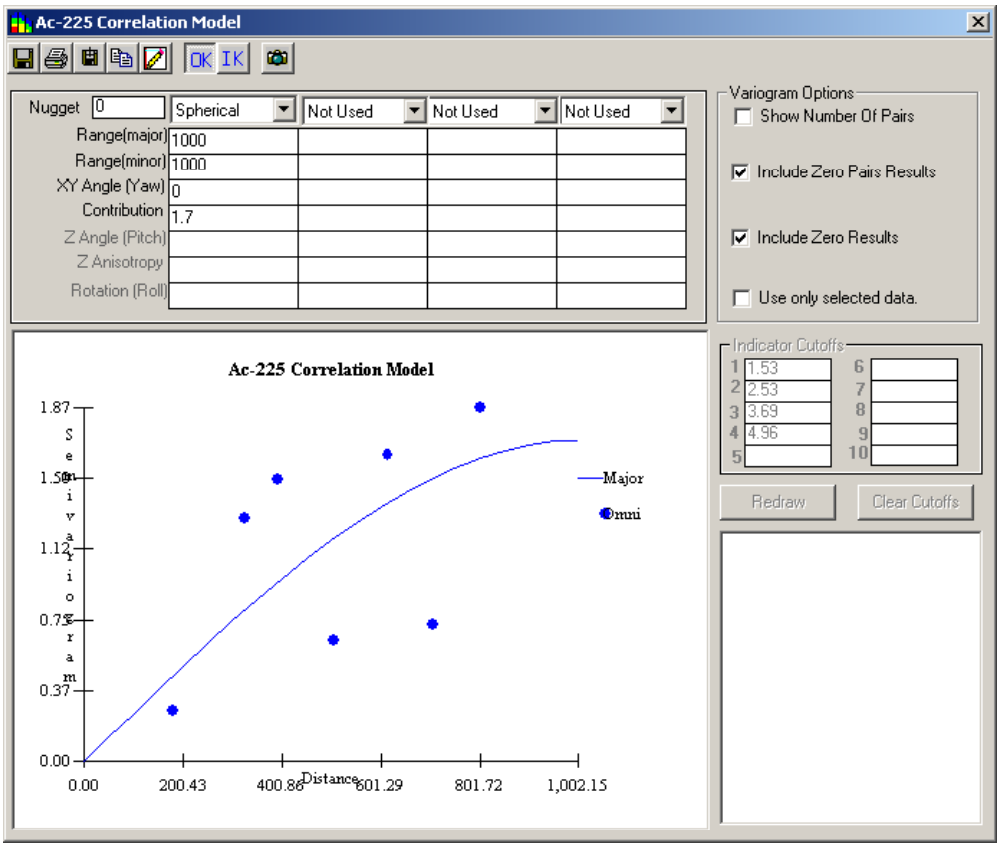


Figure 80. Correlation Model

Detailed explanations of variography and correlation modeling are contained in the help file.

Ordinary Kriging (OK) and Indicator Kriging (IK) in SADA

Step 1. Select the contaminant of interest from the contaminant drop down box of the main toolbar.

Step 2. Define a grid in the **Geo** tab of the **Control Panel**.

Step 3. Perform experimental variography (Figure 79).

Step 4. Fit experimental variography results with correlation model (figure 80).

Step 5. On the **Geo** tab of the **Control Panel**, select **Ordinary Kriging** or **Indicator Kriging** from the list of available interpolants.

Step 6. Setup an appropriate search neighborhood in the **Geo** tab of the **Control Panel**.

Step 7. Press the **Estimates** map button (or any other spatial model map.)

Under OK, variance maps, probability maps, block scale confidence maps, and uncertainty based secondary sample design become available. Under IK, probability maps, block scale confidence maps, and uncertainty based secondary sample design become available.

GEOMETRIC APPROACHES

Nearest Neighbor

This is the simplest of all interpolants in SADA. In Nearest Neighbor, any unsampled point is simply equal to the data point closest to it.

Step 1. Select the contaminant of interest from the contaminant drop down box of the main toolbar.

Step 2. Define a grid in the **Geo** tab of the **Control Panel**.

Step 3. Choose **Nearest Neighbor** from the interpolants list on the **Geo** tab of the **Control Panel**.

Step 4. Press the **Estimates** map button.

Natural Neighbor

In Natural Neighbor, areas of influence for existing data points are overlapped with the area of influence for the unestimated point. The area of overlap with the sampled data's area of influence becomes the weighting factor.

Step 1. Select the contaminant of interest from the contaminant drop down box of the main toolbar.

Step 2. Define a grid in the **Geo** tab of the **Control Panel**.

Step 3. Choose **Natural Neighbor** from the interpolants list on the **Geo** tab of the **Control Panel**.

Step 4. Press the **Estimates** map button.

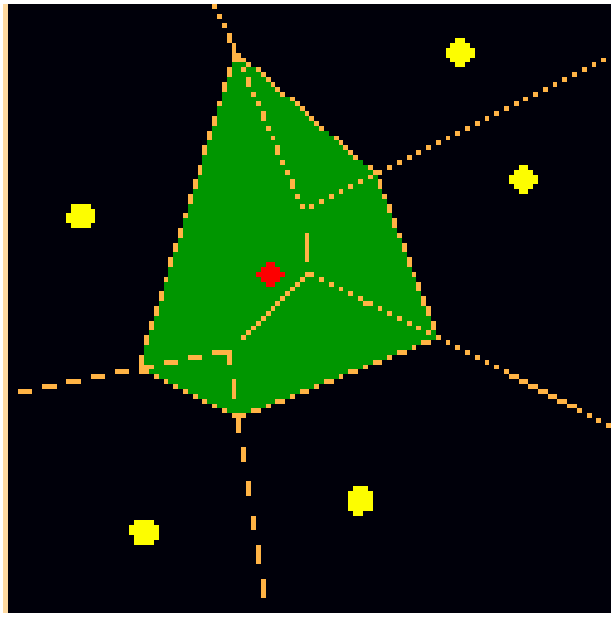


Figure 81. Natural Neighbor

PROBABILITY MAPS

The following statements summarize probability maps.

- A probability map spatially delineates the probability of exceeding a specified threshold.
- The probability of the center of each block exceeding the threshold value is calculated.
- Probability maps can only be created when using ordinary kriging or indicator kriging.

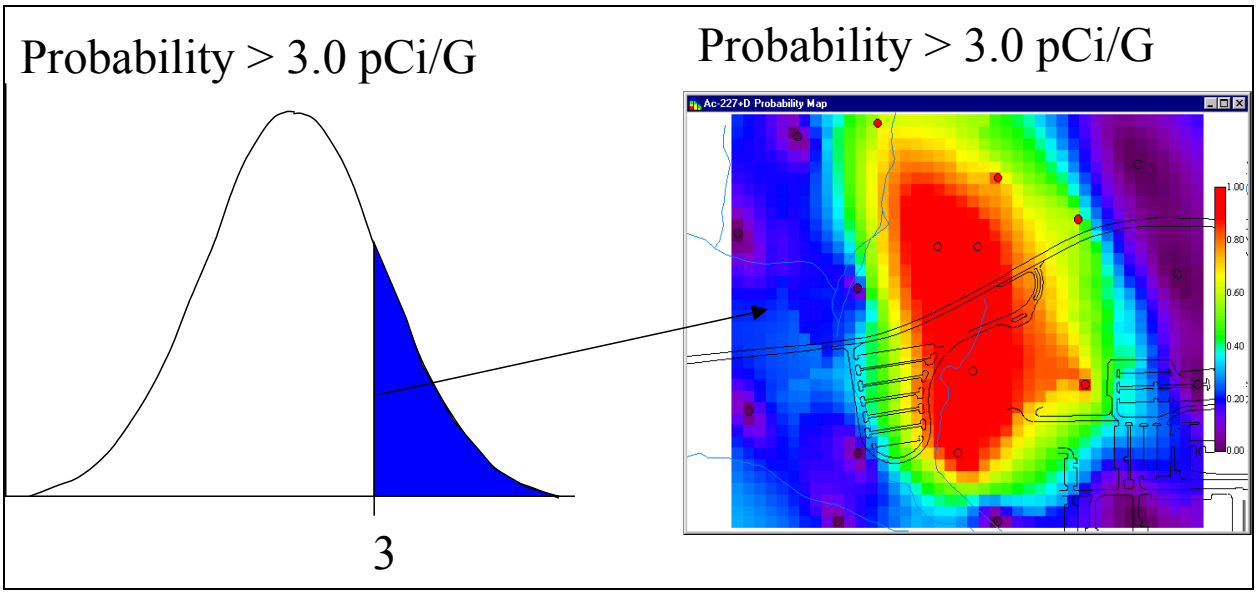


Figure 82. Probability Map Overview

Creating Probability Maps

Step 1. Setup ordinary or indicator kriging and select this interpolant from the interpolant list on the **Geo** tab of the **Control Panel**.

Step 2. Define a grid in the **Geo** tab of the **Control Panel**.

Step 3. Choose a decision basis in the **Decision** tab of the **Control Panel**.

Step 4. Press the **Probability** map button. *Note: If you use a decision basis other than concentration, then you will be prompted to choose a particular decision criteria from that analysis.*

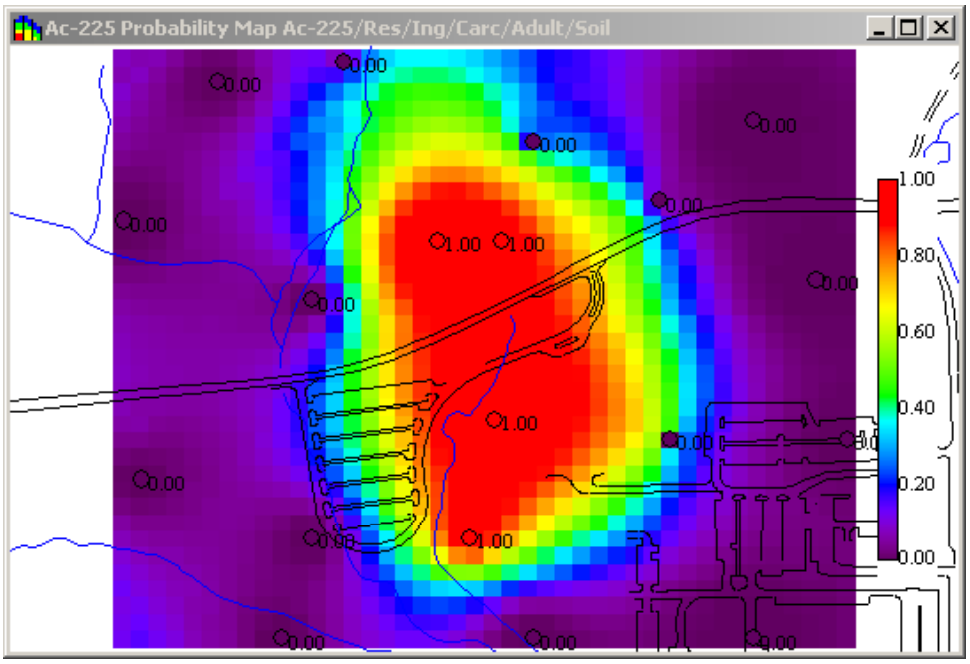


Figure 83. Probability Map Example

AREA OF CONCERN MAPS

The following statements summarize area of concern maps.

- The area of concern is drawn based on the modeled values, a threshold value, and a decision framework.
- Area of Concern maps can be drawn with any of the five available interpolants.
- Threshold values can come from user-defined concentrations, human health risk, ecological risk, or custom analysis.
- Three decision frameworks are available.

Decision Frameworks

Block Scale (Nearest Neighbor, Natural Neighbor, Inverse Distance)

The decision criteria is applied to individual blocks. If the estimated block value is above the threshold value, it must be remediated. For ordinary and indicator kriging, set the confidence parameter equal to .5.

Confidence Based Block Scale (Ordinary and Indicator Kriging)

The decision criteria, which now includes a remedial confidence parameter, is applied to individual blocks. Given a threshold value, if the 95th percentile is greater than the threshold value, then remediation is

required. Otherwise, there is at least a 95% chance the true value falls below the threshold. (See Figure 84).

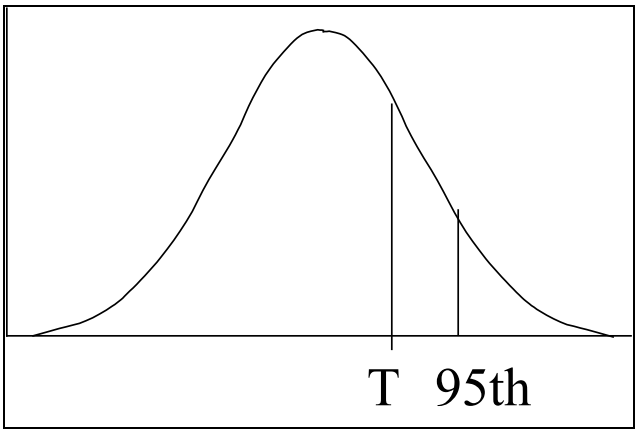


Figure 84. Block Scale

Site Scale (All Five Interpolants)

The decision criteria is applied to the site. Individual blocks are “remediated” until the site-wide model average satisfies the specified threshold. If the site-wide model average is above the threshold value, “remediate” the individual blocks from worst to least contaminated until the average, including post remedial concentrations, drops below the threshold value.

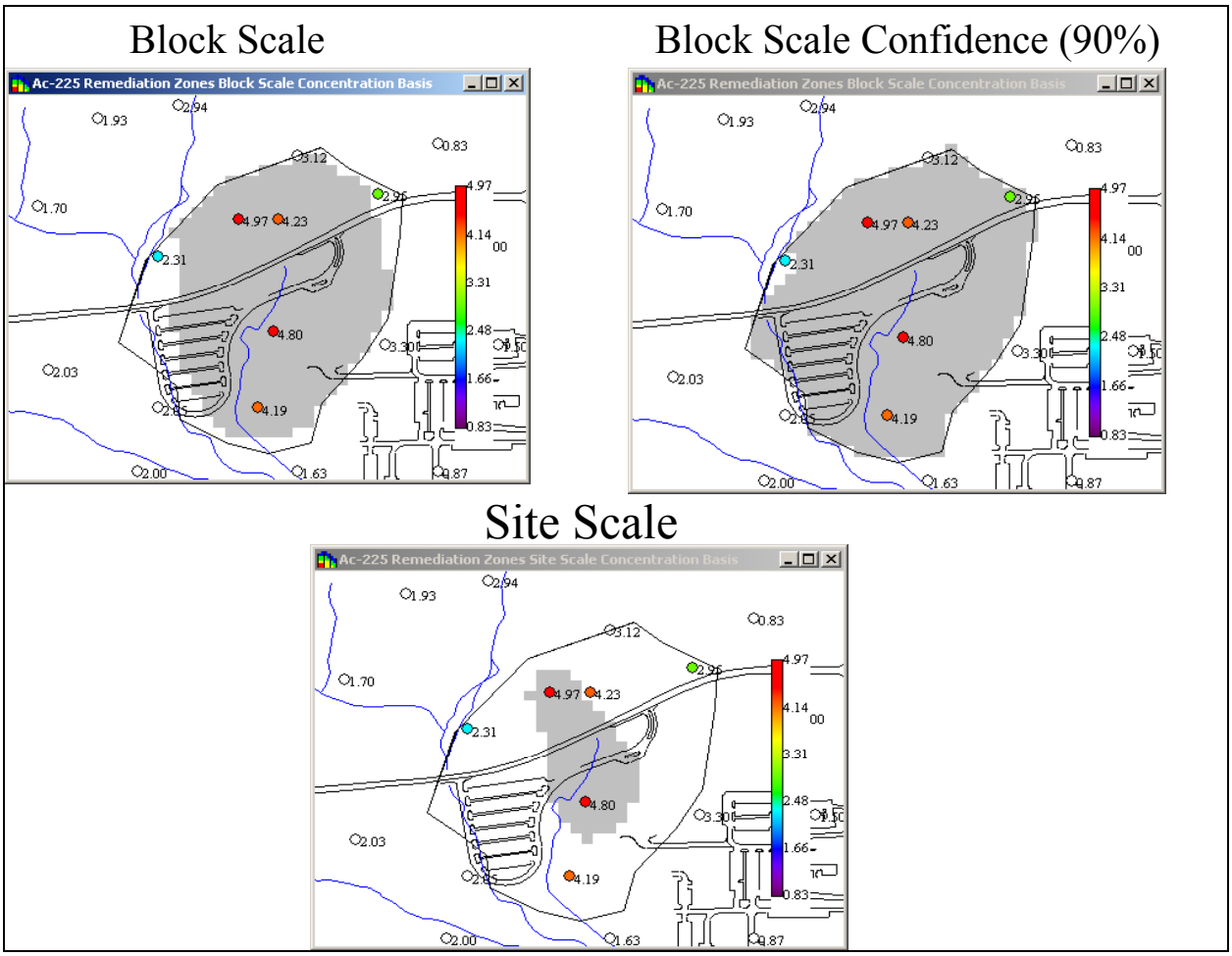


Figure 85. Decision Framework Results

Creating Area of Concern Maps

Step 1. On the **Geo** tab of the **Control Panel**, select an appropriate interpolation scheme and define a grid.

Step 2. Select the decision basis and decision framework on the **Decision** tab of the **Control Panel**.

Step 3. Press the **Area Of Concern** button. *Note: If you choose an analysis basis rather than concentration, you will be prompted to make a choice for the decision criteria.*

COST BENEFIT ANALYSIS

The following statements summarize Cost Benefit Analysis.

- The decision framework (block, block confidence, site) determines the associated cost for a range of cleanup goals.
- Cost is calculated by determining the area of concern (or volume for 3d) for a threshold value, then multiplying the number of blocks in this area by the remedial cost per block.

- The threshold value range is calculated, and then cost is calculated for each incremental value in this range.

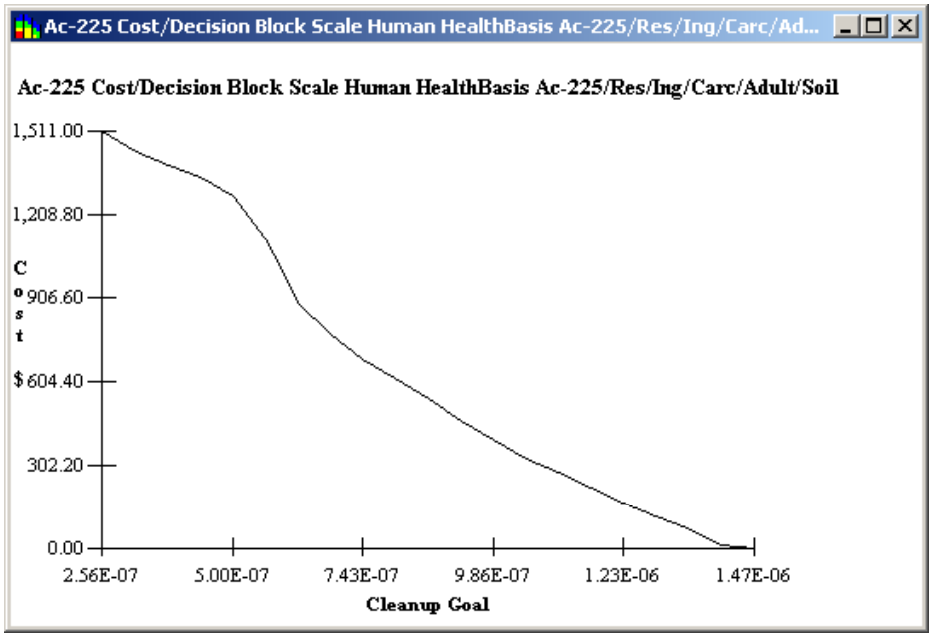


Figure 86. Cost Benefit Analysis Example

Performing a Cost Benefit Analysis

Step 1. Select an appropriate interpolation method and set all needed parameters on the **Geo** tab of the **Control Panel**.

Step 2. Select a decision basis and decision framework.

Step 3. Enter the cost per block on the **Decision** tab of the **Control Panel**.

Step 4. If using site scale, enter the post remediation value on the **Decision** tab of the **Control Panel**.

Step 5. Press the **Cost** button

Cost Lines

Step 1. Right mouse click over the picture and a popup menu will appear.

Step 2. Select **Cost Line Pointer On**. You will now see two blue lines which will help guide you as you interpret the graph. On the bottom Status bar, the actual XY's are displayed.

Step 3. Right mouse click and deselect this option to turn it off.

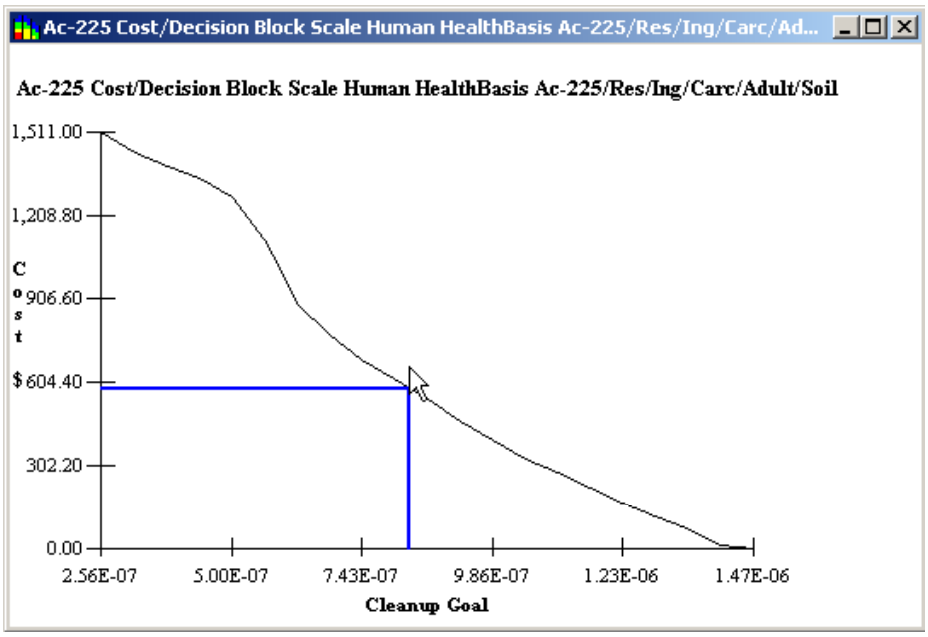


Figure 87. Cost Lines

Cost Line Query

Step 1. Right mouse click over the picture and a popup menu will appear.

Step 2. Select **Cost Line Query**. The following window appears.

Step 3. Type a specific cleanup concentration into one of the top boxes and leave the corresponding cost box below it empty.

Step 4. Press the Calculate button. SADA reads the cost value from the graph. Conversely, by leaving the concentration box empty and entering a cost value, SADA will report the cleanup concentration.

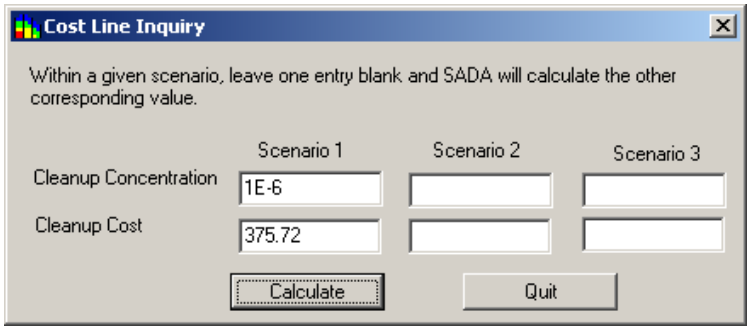


Figure 88. Cost Line Query

SAMPLE DESIGN

There are six types of sample design in SADA:

- Judgmental
- Adaptive Fill
- Estimate Rank
- Variance Rank
- Percentile Rank
- Uncertainty Rank

All sample designs, with the exception of Judgmental, are based on a specified grid definition. Within this grid, the center of each block becomes a candidate for a new sample location.

IMPLEMENTING SAMPLE DESIGNS IN SADA

Before implementing a sample design:

- Define a grid if using any design other than judgmental.
- Select an interpolation scheme if using estimate rank.
- Select and setup ordinary kriging if using variance rank.
- Select and setup ordinary kriging or indicator kriging if using percentile rank or uncertainty rank.
- Plan to use the minimum separation criteria if using estimate rank, variance rank, percentile rank, or uncertainty rank.

JUDGMENTAL

This sampling scheme simply allows the user to add and delete sample point sample points where professional judgement suggests. It is not based on any mathematical models or existing data points.

Step 1. In the **Sampling** tab of the **Control Panel**, click in the circle next to Judgmental and select **New** in the drop down box.

Step 2. Press the **New Samples** button on the main toolbar.

Step 3. With the mouse, left click onto the desired locations for new samples. (A large circle with cross hatching will appear. These points can be dragged to new locations or deleted as necessary.)

Step 4. Press the **Refresh** button to finish adding sample points or to enable other operations in SADA.

Step 5. Name the sample design and press **OK**.

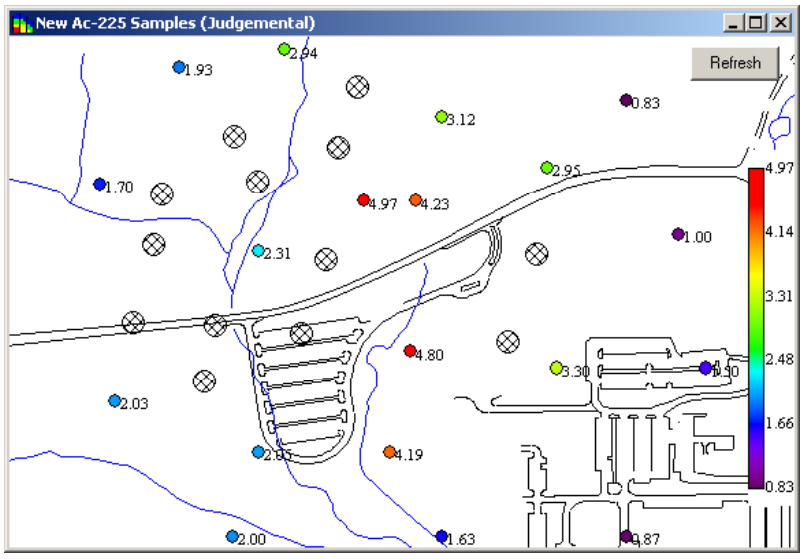


Figure 89. Judgmental Design

ADAPTIVE FILL

This approach is designed to spatially fill the holes among existing data points by suggesting locations that are the farthest from any other data point. This method is the simplest sample design to use and is independent of a geospatial analysis tool; however, it does not consider previous sample results.

Step 1. In the **Sampling** tab of the **Control Panel**, click in the circle next to Adaptive Fill.

Step 2. Enter the number of new samples to be distributed in the **Number of New Samples** box on the **Sampling** tab.

Step 3. Press the **New Samples** button on the main toolbar. (New samples will appear as larger gray circles. See Figure 90.)

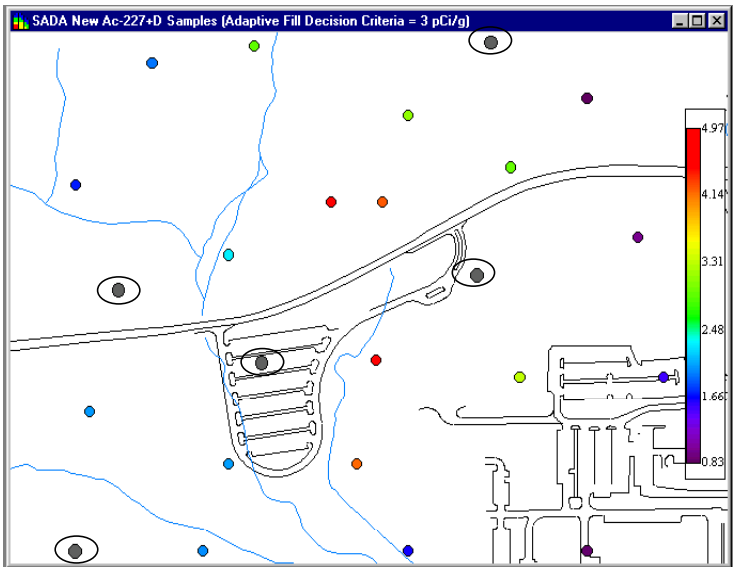


Figure 90. Adaptive Fill

ESTIMATE RANK

This approach fills new samples into unsampled locations that are modeled to have high concentration levels relative to the existing data. This approach can be useful for verifying the extent of hotspot regions and is available for any of the geospatial analyses. Estimate rank, however, does not consider model variance, may place points in a well characterized hot spot, and may need a secondary minimum distance constraint to prevent clustering.

Step 1. In the **Sampling** tab of the **Control Panel**, click in the circle next to Estimate Rank.

Step 2. Enter the number of new samples to be distributed in the **Number of New Samples** box on the **Sampling** tab.

Step 3. Define the minimum distance constraint, if necessary.

Step 4. Press the **New Samples** button on the main toolbar. (New samples will appear as larger gray circles. See Figure 91.)

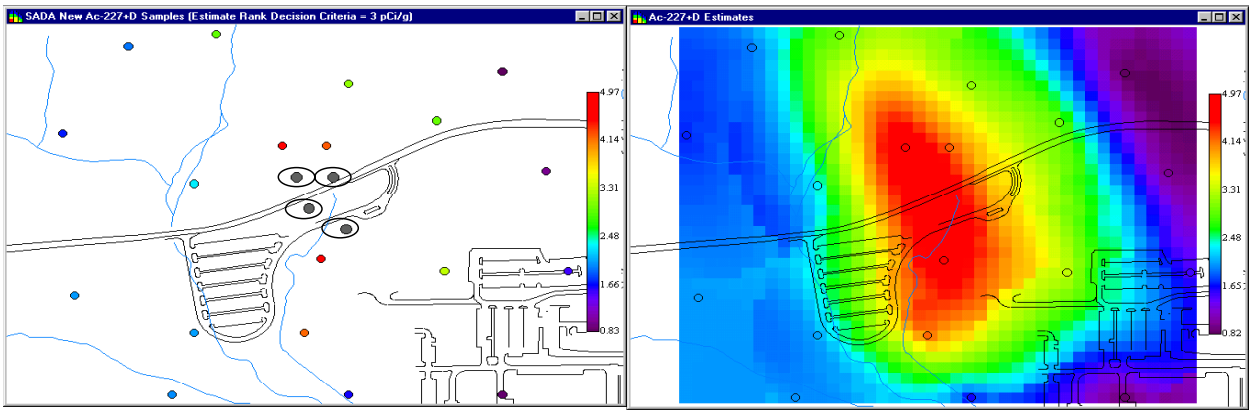


Figure 91. Estimate Rank

Secondary Minimum Distance Constraint

This constraint sets the minimum distance between any new sample data locations and any previously sampled data through a limiting sphere. All nodes within the sphere are eliminated from consideration as a new sample candidate.

Step 1. Check in the box to the left of **Separate by at Least** on the **Sampling** tab of the **Control Panel**.

Step 2. In the box to the right, enter the distance constraint value. (The unit for this distance is meters.)

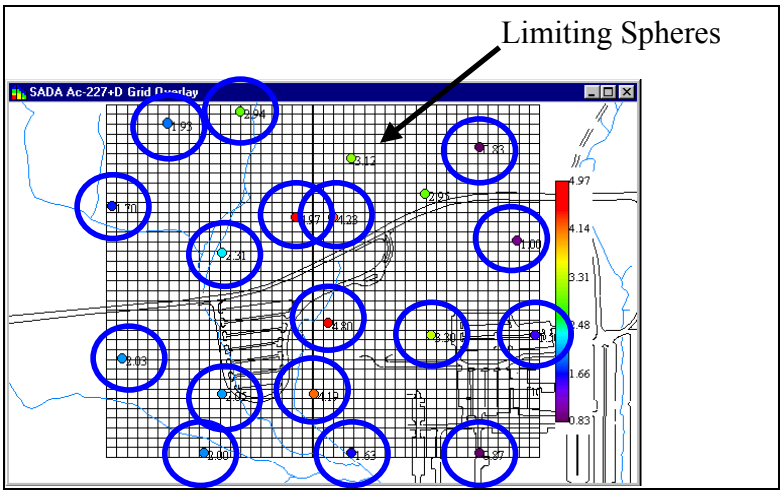


Figure 92. Secondary Minimum Distance Constraint

VARIANCE RANK

Variance Rank fills new samples into locations that have high model variances. This approach is good for reducing large variance across the site. Since this approach does not consider concentration magnitude, samples may appear in sparse areas with low values relative to a decision goal. This approach may only be used with ordinary kriging.

Step 1. In the **Sampling** tab of the **Control Panel**, click in the circle next to Variance Rank.

Step 2. Enter the number of new samples to be distributed in the **Number of New Samples** box on the **Sampling** tab.

Step 3. Define the minimum distance constraint, if necessary.

Step 4. Press the **New Samples** button on the main toolbar. (New samples will appear as larger gray circles. See Figure 93.)

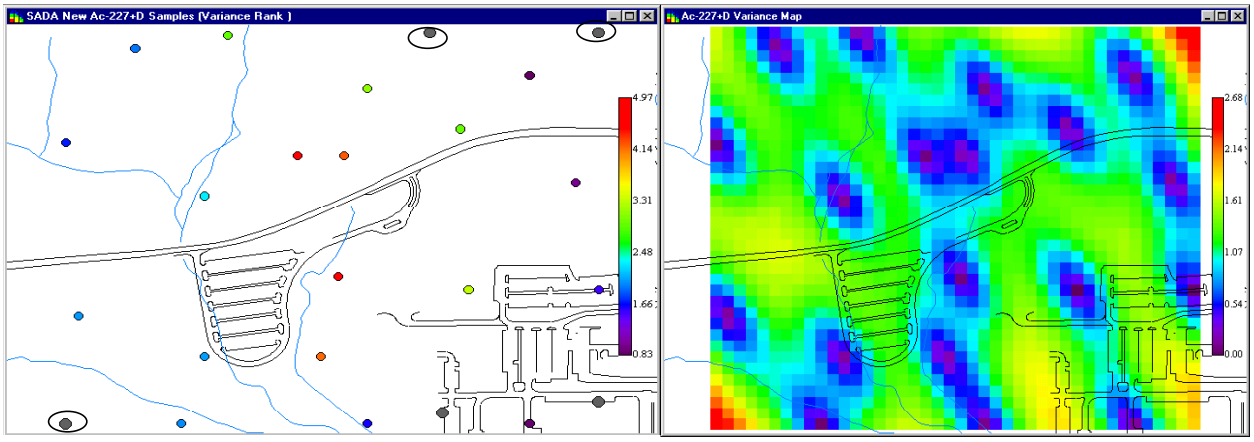


Figure 93. Variance Rank

UNCERTAINTY RANK

This approach is the only one that is connected to the decision rule. It places new sample locations is areas with the greatest uncertainty about exceeding the cleanup goal. This approach is useful for delineating the boundaries of an area of concern.

Step 1. In the **Sampling** tab of the **Control Panel**, click in the circle next to Uncertainty Rank.

Step 2. Enter the number of new samples to be distributed in the **Number of New Samples** box on the **Sampling** tab.

Step 3. Define the minimum distance constraint, if necessary.

Step 4. Press the **New Samples** button on the main toolbar. (New samples will appear as larger gray circles. See Figure 94.)

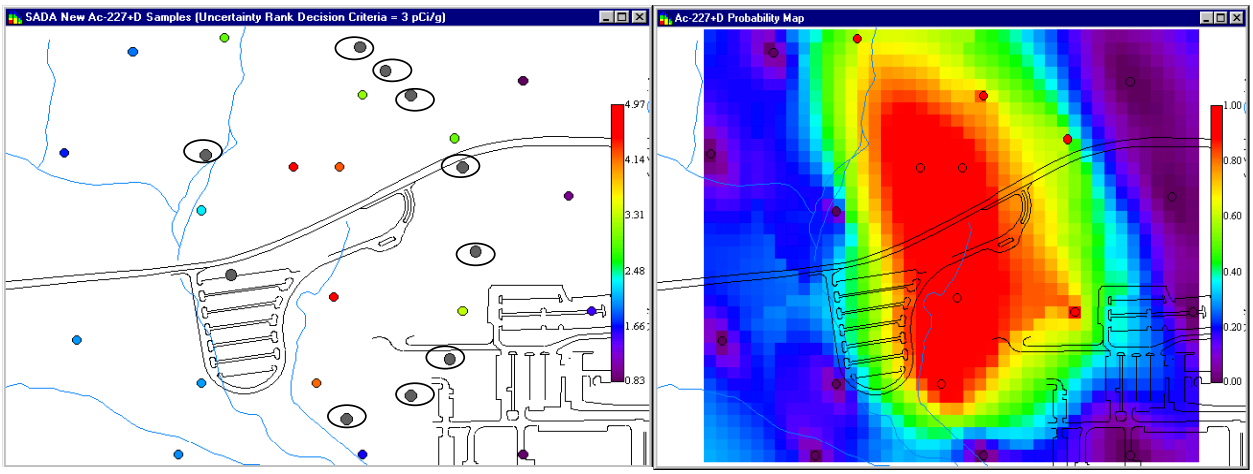


Figure 94. Uncertainty Rank

PERCENTILE RANK

This approach places new samples where a specified percentile is highest. It considers both magnitude and variability, providing a tool for reducing uncertainty across the site while at the same time giving precedence to hot areas. The secondary constraint may be needed in some cases.

Step 1. In the **Sampling** tab of the **Control Panel**, click in the circle next to Percentile Rank.

Step 2. Enter the number of new samples to be distributed in the **Number of New Samples** box on the **Sampling** tab.

Step 3. Enter the percentile parameter in the box next to **Percentile Rank**.

Step 4. Define the minimum distance constraint, if necessary.

Step 5. Press the **New Samples** button on the main toolbar. (New samples will appear as larger gray circles. See Figure 95.)

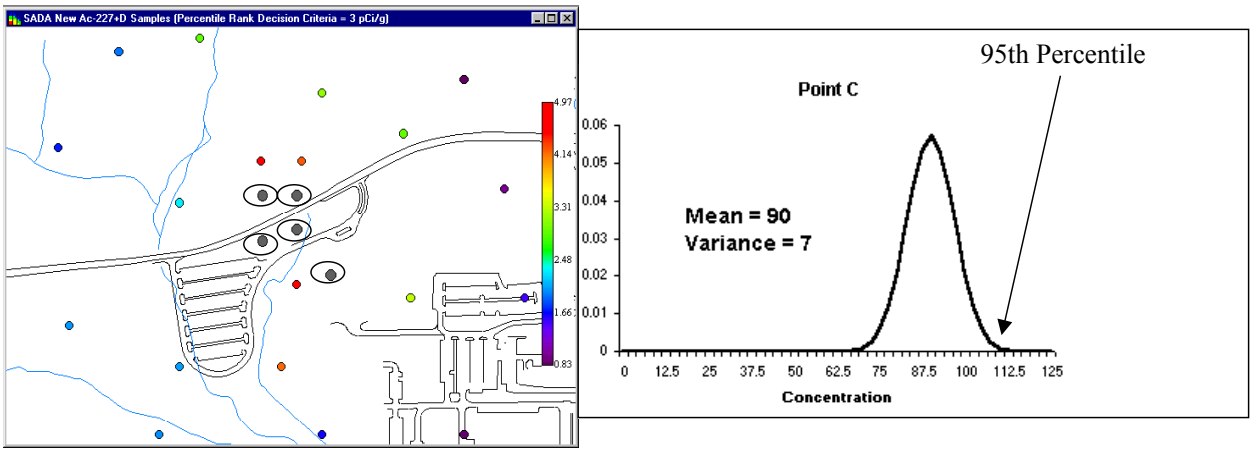


Figure 95. Percentile Rank

SADA shows 3d information by layer and in a true 3d representation.

3D BY LAYER

3D data can be viewed by layers only. SADA by layer has two views in 3D: data layer view and model layer view. Data layers are set by the users explicitly. Model layers are determined by the depth of data and the vertical size of the grid definition.

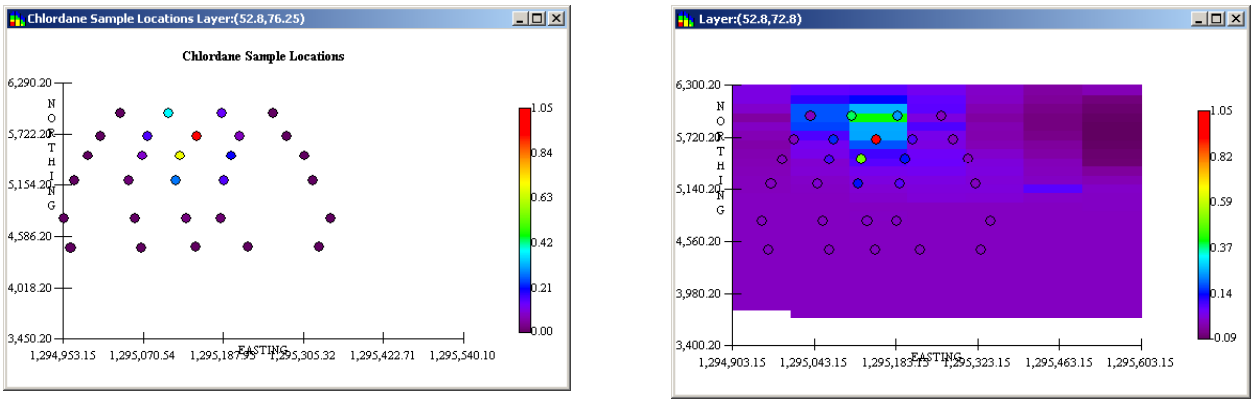


Figure 96. Layer Views: Data and Model

Polygons are directly tied to an exact layering scheme. If the layering scheme changes, SADA must ask the user to help determine where the polygon layers should now be distributed.

Setting Layers for Data View

Step 1. To set the layers for the data view, select **Graphics** from the main menu, then **Set Data Intervals**. The following window appears.

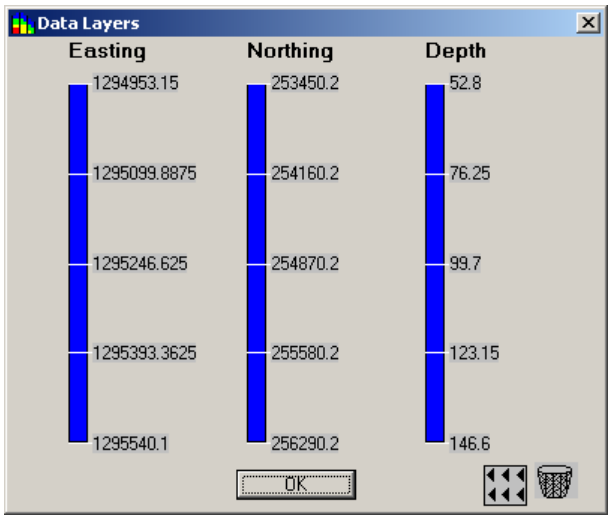


Figure 97. Setting Data Layers

Step 2. To move a data layer, left click on the layer. Then drag or right mouse click on the number and type the exact layer value you want. Press enter to apply the value you typed and remove the text box.

To delete a layer, drag the layer into the trash can.

To add a layer, drag an arrow from the arrow box and drop it on the range where you want to make a new interval.

Step 3. Press **OK** to apply the changes.

Setting Data Layers for Model View

Step 1. Define model view layers by the **Grid Block Depth** value on the **Geo** tab of the **Control Panel**.

Step 2. Click in the box at the bottom of the **Geo** tab if estimation should start at depth "Zero".

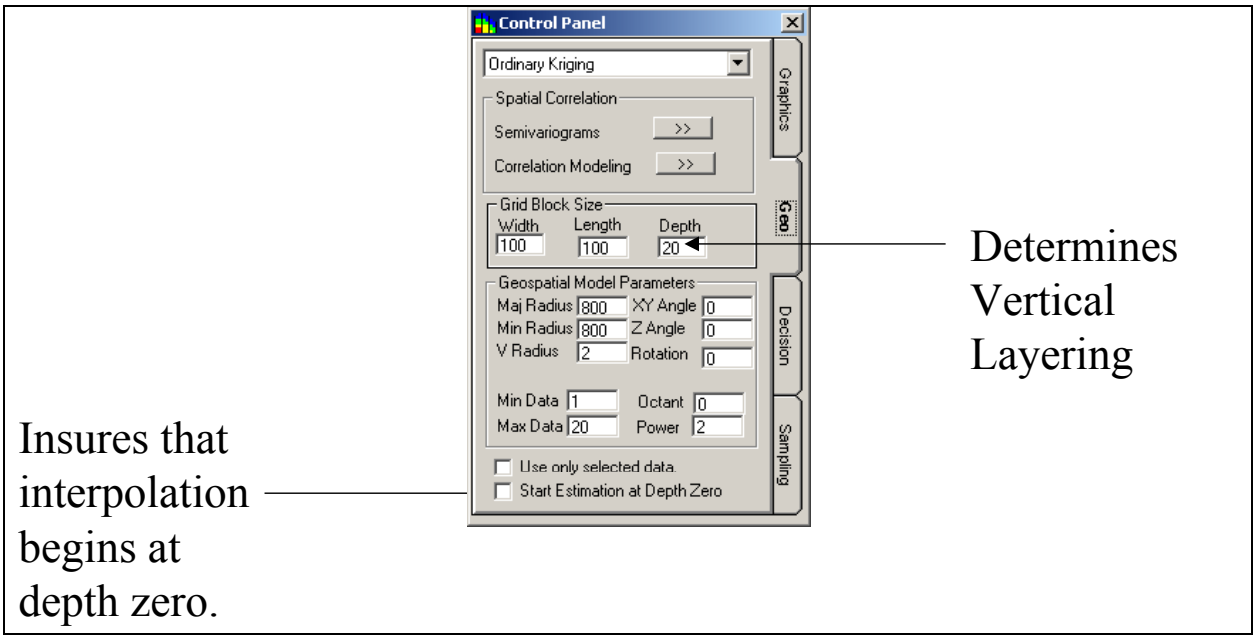


Figure 98. Setting Model View Layers

Changing Layers, Using Polygons

Step 1. Increase or decrease the layer for data or model views by pressing the **Lower Level** and **Higher Level** buttons.

Step 2. Drawing polygons in 3d is the same as in 2d. Within each layer, draw your polygon and then press **Lower Level** and **Higher Level** buttons to go to the next layer.

Step 3. If you intend to use the same polygon on every level, draw the first polygon, copy it with a right mouse click, and then choose **Copy Polygon**. Change to the next level, right mouse click, and choose **Paste Polygon**.

When a polygon is on, SADA disables the grid definition to prevent a change in layering. If you build a space definition under one layering scheme and try to apply it later to a different scheme, SADA cannot determine how you want to apply the polygonal layers. SADA responds by bringing up the Polygonal Reconciliation Window.

Polygonal Reconciliation

Step 1. When you see this window, simply drag the polygonal structures onto the spatial map one at a time. SADA will automatically place them where they should go.

Step 2. Press the **Lower Level** and **Higher Level** buttons on the main tool bar to go to the next level. Drag and drop the next polygon.

In the example below, all the polygons are the same. This depends on the user's intent with polygonal definitions and may not always be the case.

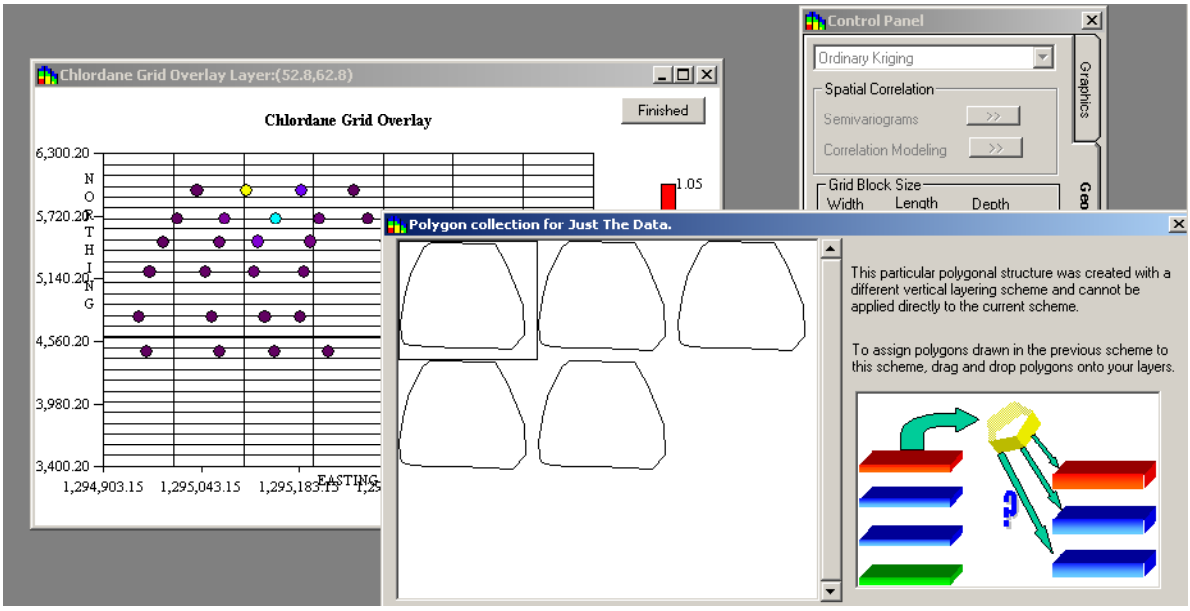


Figure 99. Polygonal Reconciliation

TRUE 3D

3D models can be viewed by layer or in true 3d. If viewed in 3d, the blocks may be viewed or the isoclines of values within the data range.

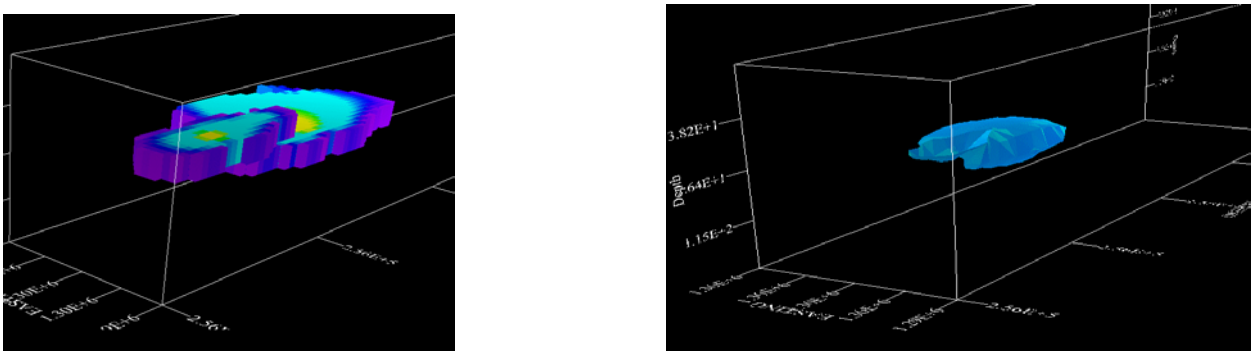


Figure 100. True 3D View: Blocks and Isoclines

Step 1. To see the results of a spatial modeling in true 3d, select **View** from the main menu and then **View True 3d Model**. [Reapply your model by pressing the associated button (e.g. Probability map).]

SADA responds with the 3d viewer (figure 101). The viewer is designed to set isoclines as the default view with an isocline value set in the middle of the total data or model range. If little or no modeled values appear in this range, the result may appear blank. Change the isocline level to view results.

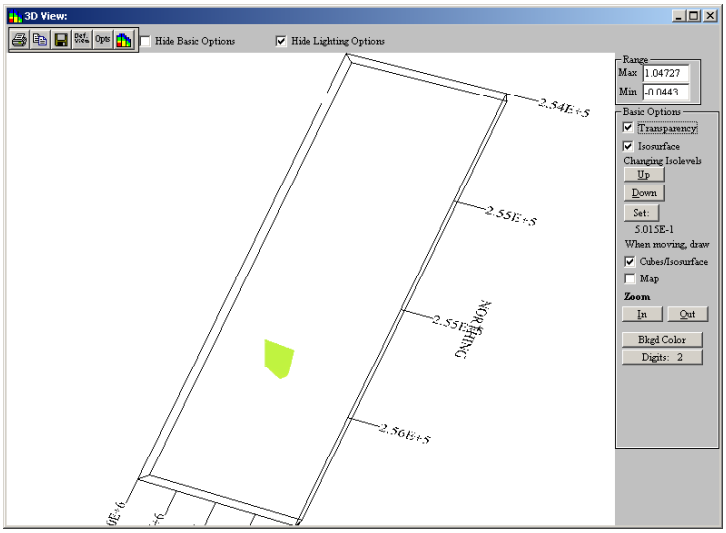


Figure 101. 3D Viewer Results - Isocline View

Step 2. Make changes to the image.

To change the background, click on the **Bkgd Color** button and select a new one. Sometimes isoclines are hard to see on dark background if the Transparency option is selected. Deselect this under these circumstances.

To rotate a picture, left click on the image and move it while holding down the mouse. The image will rotate in "trackball" style. You can shift the picture left or right by right mouse clicking (not near an axis) and dragging the image.

You can zoom in and out with the **In** and **Out** buttons

In Figure 102, the background has been changed to black and the picture has been rotated. Also, the isocline value was reduced slightly in this image.

Step 3. Anytime you want to update your view, press the **Camera** button.

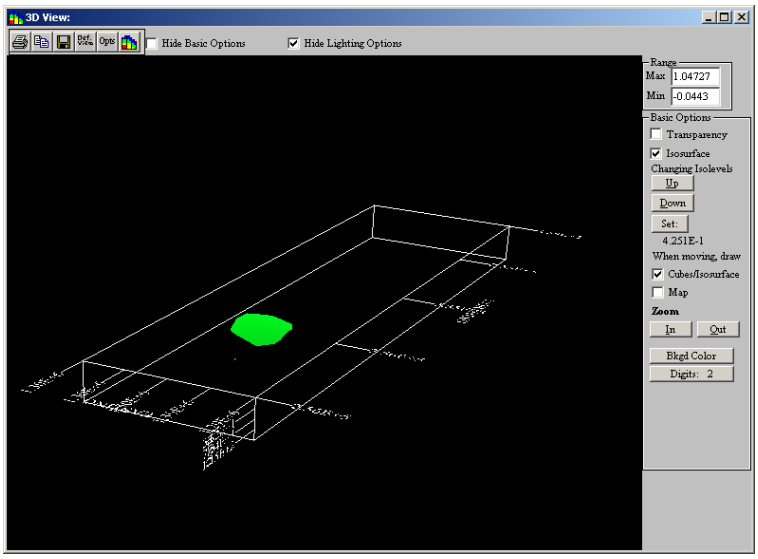


Figure 102. Isocline View With Black Background

To obtain a view of the block values on which the isoclines are based, deselect Isosurface under **Basic Options**. If Transparency is deselected, the blocks are "solid" and you cannot see the center of the plume.

Select transparency with blocks, and those with low values will appear more transparent than those with higher values. This can help you to "see through" the low concentration volumes into the higher values.

To turn axis values on and off, right mouse click on them.

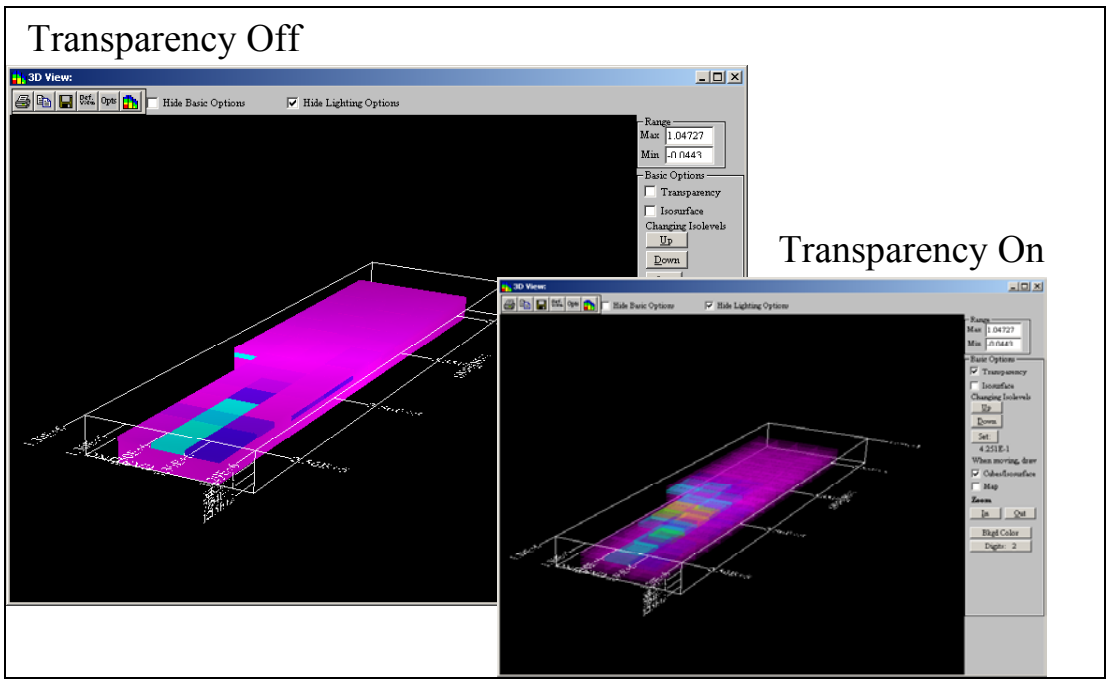


Figure 103. Transparency Option

APPENDIX A - HUMAN HEALTH 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.

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

Landuse/Pathway	Residential	Industrial	Recreational	Excavation	Agricultural
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.

$$Nonrad\ Intake_{ing} = \frac{C_{sn} CF_1 EF\ FI\ ED\ IR_{a,c}}{CF_2\ BW_{a,c}\ AT} \quad (1)$$

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

Table 2. Soil/Sediment Ingestion Parameters

Parameter	Units	Residential	Industrial	Recreational	Excavation	Agricultural
Non-radionuclide chemical concentration in soil = C_{sn}	mg/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in soil = C_{sr}	pCi/g	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Conversion factor = CF_1	kg/mg	10^{-6}	10^{-6}	10^{-6}	10^{-6}	10^{-6}
Exposure frequency = **EF**	days/yr	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	20	350 (EPA 1989a)
Fraction ingested = **FI**	unitless	1	1	1	1	1
Exposure duration = **ED**	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 = CF_8	g/mg	10^{-3}	10^{-3}	10^{-3}	10^{-3}	10^{-3}
Ingestion rate of soil = **IR**	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 = **BW**	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 == CF_2	days/yr	365	365	365	365	365
Lifetime = **LT**	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = **AT**	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, U_m/U_t, F(x), Q/C, and CF_3. The default PEF in SADA is 1.32E+9 (EPA 1996). The 1/VF term is only present if the contaminant is a volatile.

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

$$Rad\ Intake_{ink} = C_{sr}\, CF_5\, EF\, ED \left(\frac{1}{VF} + \frac{0.036\,(1-V)\,(U_m/U_t)^3\, F(x)}{(Q/C)\, CF_3} \right) IR_{air} \quad (4)$$

Table 3. Soil/Sediment Inhalation Parameters

Parameter	Units	Residential	Industrial	Recreational	Excavation	Agricultural
Non-radionuclide chemical concentration in soil = **C_{sn}**	mg/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in soil = **C_{sr}**	pCi/g	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Exposure frequency = **EF**	day/year	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	20	350 (EPA 1989a)
Exposure duration = **ED**	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	1	30 (EPA 1989a)
Conversion factor = **CF_5**	g/kg	1000	1000	1000	1000	1000
Volatilization factor = **VF**	m^3/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Fraction of vegetative cover = **V**	unitless	0.5 (EPA 1996)	0.5 (EPA 1996)	0.5 (EPA 1996)	0.5 (EPA 1996)	0.5 (EPA 1996)
Mean annual windspeed = **U_m**	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 = **U_t**	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 **U_m/U_t= F(x)**	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	(g m^3)/	90.8	90.8	90.8	90.8	90.8

center of a 0.5 acre-square source = **Q/C**	(m^2 s kg)	(EPA 1996)	(EPA 1996)	(EPA 1996)	(EPA 1996)	(EPA 1996)
Seconds in an hour = **CF_3**	s/h	3600	3600	3600	3600	3600
Total inhalation rate = **IR_{air}**	m^3/day	20 (EPA 1989a)	20 (EPA 1989a)	6.7 (8 hours) (EPA 1992)	20 (EPA 1989a)	20 (EPA 1989a)
Conversion Factor = **CF_2**	days/yr	365	365	365	365	365
Body weight = **BW**	kg	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)
Lifetime = **LT**	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = **AT**	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.

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

Table 4. Soil/Sediment Dermal Contact Parameters

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in soil = **C_{sn}**	mg/kg	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Conversion factor = **CF_4**	(kg-cm^2)/ (mg-m^2)	0.01	0.01	0.01	0.01
Surface area = **SA**	m^2/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 = **AF**	mg/cm^2	1 (EPA 1992)	1 (EPA 1992)	1 (EPA 1992)	1 (EPA 1992)

Absorption factor = **ABS**	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 = **EF**	day/yr	350 (EPA 1991)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1991)
Exposure duration = **ED**	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Body weight = **BW**	kg	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)	70 (adult) (EPA 1991a)
Conversion Factor = CF_2	days/yr	365	365	365	365
Lifetime = **LT**	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = **AT**	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.

$$Rad\ Dose_{ext} = C_{sr}(1 - S_e)\,T_e\ ED\ EF\ CF_g \qquad (6)$$

Table 5. Soil/Sediment External Exposure Parameters

Parameter	Units	Residential	Industrial	Recreational	Excavation	Agricultural
Radionuclide chemical concentration in soil = C_{sr}	pCi/g	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Gamma Shielding Factor = S_e	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 = T_e	unitless	1 (EPA 1991a)	8/24 (EPA 1991a)	1/24 (EPA 1991a)	8/24 (EPA 1991a)	1 (EPA 1991a)
Exposure frequency = **EF**	days/yr	350	250	40	20	350

		(EPA 1989a)	(EPA 1991a)	(EPA 1992)		(EPA 1989a)
Exposure duration = **ED**	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 = **CF_9**	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.

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

$$Rad\ Intake_{pring} = C_{sr}(BV_{wet} + MLF)\,CF_5\,FI_v\,IR_v\,EF\,ED \quad (8)$$

Table 6. Soil/Sediment Produce Ingestion Parameters

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in soil = **C_{sn}**	mg/kg	Chemical-specific
Radionuclide chemical concentration in soil = **C_{sr}**	pCi/g	Chemical-specific
Soil to plant uptake factor (wet) = **BV_{wet}**	kg/kg	Chemical-specific
Mass loading factor = **MLF**	unitless	0.26 (Pinder and McLeod 1989)
Conversion factor = **CF_5**	g/kg	1000
Diet fraction = **FI_v**	unitless	0.4 (EPA 1989b)
Ingestion rate = **IR_v**	kg/d	0.2 (EPA 1989b)
Exposure frequency = **EF**	d/year	350 (EPA 1989a)

Exposure duration = **ED**	years	30 (EPA 1989a)
Conversion Factor = **CF_2**	days/yr	365
Body weight (adult) = **BW**	kg	70 (EPA 1989a)
Lifetime = **LT**	years	70 (EPA 1989a)
Averaging time = **AT**	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.

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

$$Rad\ Intake_{beef\ ing} = F_f C_{sr} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s) CF_3 IR_f FI\ EF\ ED \quad (10)$$

Table 7. Soil/Sediment Beef Ingestion Parameters

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in soil = **C_{sn}**	mg/kg	Chemical-specific
Radionuclide chemical concentration in soil = **C_{sr}**	pCi/g	Chemical-specific
Beef transfer coefficient = **F_f**	day/kg	Chemical-specific
Fraction of year animal is on site = **f_p**	unitless	1 (Site-specific)
Soil to plant uptake factor (dry) = **BV_{dry}**	kg/kg	Chemical-specific
Mass loading factor = **MLF**	unitless	0.26

		(Pinder and McLeod 1989)
Quantity of pasture ingested = **Q_p**	kg/day	7.2 (IAEA 1994)
Quantity of soil ingested = **Q_s**	kg/day	1 (Darwin 1990)
Fraction of animal feed from site = **f_s**	unitless	1 (Site-specific)
Beef ingestion rate[c] = **IR_f**	kg/day	0.075 (EPA 1989b)
Conversion factor = **CF_5**	g/kg	1000
Diet fraction = **FI**	unitless	1 (Site-specific)
Exposure frequency = **EF**	day/yr	350 (EPA 1989a)
Exposure duration = **ED**	years	30 (EPA 1989a
Conversion Factor = **CF_2**	days/yr	365
Body weight = **BW**	kg	70 (EPA 1989a)
Lifetime = **LT**	years	70 (EPA 1989a)
Averaging time = **AT**	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.

$$Nonrad\ Intake_{milking} = \frac{F_m C_{sn} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s)\, IR_m\, FI\, EF\, ED}{CF_2\, BW\, AT} \quad (11)$$

$$Rad\ Intake_{milking} = F_m C_{sr} f_p (Q_p f_s (BV_{dry} + MLF) + Q_s) CF_5 IR_m FI\ EF\ ED \quad (12)$$

Table 8. Soil/Sediment Milk Ingestion Parameters

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in soil = C_{sn}	mg/kg	Chemical-specific
Radionuclide chemical concentration in soil = C_{sr}	pCi/g	Chemical-specific
Milk transfer coefficient = F_m	day/L	Chemical-specific
Fraction of year animal is on site = f_p	unitless	1 (Site-specific)
Soil to plant uptake factor (dry) = BV_{dry}	kg/kg	Chemical-specific
Mass loading factor = **MLF**	unitless	0.26 (Pinder and McLeod 1989)
Quantity of pasture ingested = Q_p	kg/day	16.1 (IAEA 1994)
Quantity of soil ingested = Q_s	kg/day	1 (Darwin 1990)
Fraction of animal feed from site = f_s	unitless	1 (Site-specific)
Conversion factor = CF_5	g/kg	1000
Diet fraction = **FI**	unitless	1 (Site-specific)
Ingestion Rate = IR_m	L/d	0.509 (adult) 0.305 (child) (EPA 1989b)
Exposure frequency = **EF**	d/year	350 (EPA 1989a)
Exposure duration = **ED**	years	24 (adult) 6 (child) (EPA 1989a)

Body weight = **BW**	kg	70 (adult) 15 (child) (EPA 1991a)
Lifetime = **LT**	years	70 (EPA 1989a)
Averaging time = **AT**	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

Landuse/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.

$$Nonrad\ Intake_{ing} = \frac{C_{wn}\, IR_w\, EF\, ED}{CF_2\, BW\, AT} \qquad (13)$$

$$Rad\ Intake_{ing} = C_{wr}\ IR_w\ EF\ ED \quad (14)$$

Table 10. Surface Water/Groundwater Ingestion Parameters

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in water = **C_{wn}**	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in water = **C_{wr}**	pCi/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Ingestion Rate = **IR_w**	L/d	2 (EPA 1989a)	1 (EPA 1991a)	.05 (EPA 1995)	2 (EPA 1989)
Exposure frequency = **EF**	d/year	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1989a)
Exposure duration = **ED**	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Body weight = **BW**	kg	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Conversion Factor = **CF_2**	days/yr	365	365	365	365
Lifetime = **LT**	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = **AT**	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^3/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 = **C_{wn}**	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in water = **C_{wr}**	pCi/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Volatilization Factor = **VF**	L/m^3	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Inhalation rate = **IR_{air}**	m^3/hour	20 (EPA 1989a)	0	0	20 (EPA 1989a)
Exposure frequency = **EF**	day/year	350 (EPA 1991)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1991)
Exposure duration = **ED**	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Inhalation exposure factor = **IEF**	(L hr)/ (m^3 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 = **BW**	kg	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Conversion Factor = **CF_9**	days/hr	1/24	1/24	1/24	1/24
Conversion Factor = **CF_2**	days/yr	365	365	365	365
Lifetime = **LT**	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = **AT**	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^3 and the exposure time is set to 0 hours.

$$Nonrad\ Intake_{der} = \frac{C_{wn}\, SA\, P_c\, CF_6\, ED\, EF\, ET}{CF_2\, BW\, AT} \quad (17)$$

Table 12. Surface Water/Groundwater Dermal Contact Parameters

Parameter	Units	Residential	Industrial	Recreational	Agricultural
Non-radionuclide chemical concentration in water = **C_{wn}**	mg/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Radionuclide chemical concentration in water = **C_{wr}**	pCi/L	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Skin surface area exposed[c] = **SA**	m^2	1.94 (EPA 1989a)	0	1.94 (EPA 1989a)	1.94 (EPA 1989a)
Skin permeability constant = **P_c**	cm/hr	Chemical-specific	Chemical-specific	Chemical-specific	Chemical-specific
Conversion Factor = **CF_6**	(L-m)/ ($cm\text{-}m^3$)	10	10	10	10
Exposure duration = **ED**	years	30 (EPA 1989a)	25 (EPA 1991a)	30 (EPA 1989a)	30 (EPA 1989a)
Exposure frequency = **EF**	events/yr	350 (EPA 1989a)	250 (EPA 1991a)	40 (EPA 1992)	350 (EPA 1989a)
Exposure time = **ET**	hrs/event	0.2 (EPA 1992)	0	2.6 (EPA 1989a)	0.2 (EPA 1992)
Body weight = **BW**	kg	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Conversion Factor = **CF_2**	days/yr	365	365	365	365
Lifetime = **LT**	years	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)	70 (EPA 1989a)
Averaging time = **AT**	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.

$$Nonrad\ Intake_{proing} = \frac{C_{wn}\, r_{irr}\, f_{irr}\left[\frac{(BV_{wet} + MLF)(1 - \exp(-\lambda_l t_b))}{P\ \lambda_l} + \frac{I_f\, T\,(1 - \exp(-\lambda_E t_v)}{Y_v\ \lambda_E}\right] FI_v\, IR_v\, EF\, ED}{CF_2\, BW\, AT}$$

(18)

$$Rad\ Intake_{proing} = C_{wr}\, r_{irr}\, f_{irr}\left[\frac{(BV_{wet} + MLF)(1 - \exp(-\lambda_l t_b))}{P\ \lambda_l} + \frac{I_f\, T\,(1 - \exp(-\lambda_E t_v)}{Y_v\ \lambda_E}\right] FI_v\, IR_v\, EF\, ED$$

(19)

Table 13. Surface Water/Groundwater Produce Ingestion Parameters

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = C_{wn}	mg/L	Chemical-specific
Radionuclide chemical concentration in water = C_{wr}	pCi/L	Chemical-specific
Irrigation rate = r_{irr}	L/m^2 day	2.08 (Kennedy and Strenge 1992)
Irrigation period = f_{irr}	unitless	0.25 (3 months)
Soil to plant uptake factor (wet) = BV_{wet}	kg/kg	Chemical-specific
Mass loading factor = **MLF**	unitless	0.26 (Pinder and McLeod 1989)
Effective removal rate = λ_r	1/day	$\lambda_l+\lambda_{hl}$
Soil leaching rate = λ_l	1/day	2.7E-5 (NCRP 1989)
Radionuclide half-life = λ_{hl}	1/day	Chemical-specific
Long-term deposition and buildup = t_b	day	10950 (NCRP 1985)

Areal density for root zone = **P**	kg/m^2	240 (Hoffman et al. 1982)
Interception fraction = $\mathbf{I_f}$	unitless	0.42 (Miller 1980)
Translocation factor = **T**	unitless	1 (McKone 1994)
Decay for removal on produce = $\mathbf{\lambda_E}$	1/day	$\mathbf{\lambda_I}+0.693/t_w$ (NCRP 1989)
Weathering half-life = $\mathbf{t_w}$	1/day	14 (NCRP 1985)
Above ground exposure time = $\mathbf{t_v}$	days	60 (NCRP 1985)
Plant yield (wet) = $\mathbf{Y_v}$	kg/m^2	2 (NCRP 1985)
Diet fraction = $\mathbf{FI_v}$	unitless	0.4 (EPA 1989b)
Ingestion rate = $\mathbf{IR_v}$	kg/d	0.2 (EPA 1989b)
Exposure frequency = **EF**	d/year	350 (EPA 1989a)
Exposure duration = **ED**	years	30 (EPA 1989a)
Body weight (adult) = **BW**	kg	70 (EPA 1989a)
Conversion Factor = $\mathbf{CF_2}$	days/yr	365
Lifetime = **LT**	years	70 (EPA 1989a)
Averaging time = **AT**	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.

$$Nonrad\ Intake_{beef\ ing} = \frac{C_{wn}\, Q_w\, Bf\ IR\ FI\ EF\ ED}{CF_2\, BW\ AT} \quad (20)$$

$$Rad\ Intake_{beef\ ing} = C_{wr}\, Q_w\, Bf\ IR\ FI\ EF\ ED \quad (21)$$

Table 14. Surface Water/ Groundwater Beef Ingestion Parameters

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = **C_{wn}**	mg/L	Chemical-specific
Radionuclide chemical concentration in water = **C_{wr}**	pCi/L	Chemical-specific
Quantity of water ingested (cattle) = **Q_w**	L/day	50 (IAEA 1994)
Beef transfer coefficient = **Bf**	day/kg	Chemical-specific
Ingestion rate[c] = **IR**	kg/day	0.075 (EPA 1989b)
Conversion factor = **CF**	g/kg	1000
Diet fraction = **FI**	unitless	1
Exposure frequency = **EF**	day/yr	350 (EPA 1989a)
Exposure duration = **ED**	years	30 (EPA 1989a)
Body weight = **BW**	kg	70 (EPA 1989a)
Conversion Factor = **CF_2**	days/yr	365

Lifetime = **LT**	years	70 (EPA 1989a)
Averaging time = **AT**	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.

$$Nonrad\ Intake_{milking} = \frac{C_{wn}\ Bm\ Q_w\ IR_m\ FI\ EF\ ED}{CF_2\ BW\ AT} \quad (22)$$

$$Rad\ Intake_{milking} = C_{wr}\ Bm\ Q_w\ IR_m\ FI\ EF\ ED \quad (23)$$

Table 15. Surface Water/Groundwater Milk Ingestion Parameters

Parameter	Units	Agricultural
Non-radionuclide chemical concentration in water = $\mathbf{C_{wn}}$	mg/L	Chemical-specific
Radionuclide chemical concentration in water = $\mathbf{C_{wr}}$	pCi/L	Chemical-specific
Quantity of water ingested (dairy) = $\mathbf{Q_w}$	L/day	75 (IAEA 1994)
Milk transfer coefficient = **Bm**	day/L	Chemical-specific
Ingestion Rate = $\mathbf{IR_m}$	L/d	0.305 (adult) (EPA 1989b) 0.509 (child) (Pao et al. 1982)
Exposure frequency = **EF**	d/year	350 (EPA 1989a)
Exposure duration = **ED**	years	24 (adult) 6 (child) (EPA 1989a)
Body weight = **BW**	kg	70 (adult) 15 (child) (EPA 1991a)

Conversion Factor = **CF_2**	days/yr	365
Lifetime = **LT**	years	70 (EPA 1989a)
Averaging time = **AT**	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.

$$Nonrad\ Intake_{fisking} = \frac{C_{wn}\, B_{fish}\, IR_{fish}\, FI\, EF\, ED}{CF_2\, BW\, AT} \quad (24)$$

$$Rad\ Intake_{fisking} = C_{wr}\, B_{fish}\, IR_{fish}\, FI\, EF\, ED \quad (25)$$

Table 16. Surface Water Fish Ingestion Parameters

Parameter	**Units**	**Agricultural**
Non-radionuclide chemical concentration in water = **C_{wn}**	mg/L	Chemical-specific
Radionuclide chemical concentration in water = **C_{wr}**	pCi/L	Chemical-specific
Fish transfer coefficient = **B_{fish}**	day/L	Chemical-specific
Ingestion Rate = **IR_m**	kg/fish meal	0.054 (adult) (EPA 1991a)
Exposure frequency = **EF**	fish meal /year	45 (EPA 1995)
Exposure duration = **ED**	years	30 (EPA 1989a)
Body weight = **BW**	kg	70 (adult) (EPA 1991a)
Conversion Factor = **CF_2**	days/yr	365
Lifetime = **LT**	years	70

			(EPA 1989a)
Averaging time = **AT**		years	LT (carcinogen) ED (noncarcinogen)

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APPENDIX B-
ECOLOGICAL BENCHMARKS

SURFACE WATER ECOLOGICAL BENCHMARKS

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. In 1999, the Canadian Council of Ministers of the Environment released Canadian Environmental Quality Guidelines (CCME 1999) which included all media (i.e., water, soil air, sediment, and tissue).

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, Ca2+, 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

I did not enter a value 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

I did not enter a value for ammonia

Cadmium is hardness dependent:

Cd value = 0.001 * [10 ^{0.86 log(hardness)-3.2}]

Formula was for ug/L, so I multiplied by 0.001 to get it to mg/L.

Copper is hardness dependent:

0.002 mg/L at hardness 0-120 mg/L CaCO3

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 CaCO3

0.002 from 60-120

0.004 from 120-180

0.007 at hardness >180

entered 0.002 as default

Nickel is hardness dependent:

0.025 mg/L at hardness from 0-60 mg/L CaCO3

0.065 from 60-120

0.11 from 120-180

0.15 at hardness >180

entered 0.065 as default

Obtained from Environment Canada's Canadian Environmental Quality Guidelines web page at http://www2.ec.gc.ca/ceqg_rcqe/water.htm.

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 (1999); the hardness equations should be the same and likely will be updated in the near future.

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 (1999); the hardness equations should be the same and likely will be updated in the near future.

EPA Region 5 EDQLs

The EDQL reference database consists of Region 5 media-specific (soil, water, sediment, and air) EDQLs for RCRA Appendix IX hazardous constituents. The EDQLs are initial screening levels with which the site contaminant concentrations can be compared. The EDQLs help to focus the investigation on those areas and chemicals that are most likely to pose an unacceptable risk to the environment. EDQLs also impact the data requirements for the planning and implementation of field investigations. The ecological risk assessment will be further refined based on the initial screening. EDQLs alone are not intended to serve as cleanup levels. http://www.epa.gov/Region5/rcraca/edql.htm

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.hsrd.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:

$$\text{Log CV} = 0.96 \log \text{LC50} - 1.08 \quad (\text{PI} = 1.56)$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.11 \log \text{LC50} - 1.30 \quad (\text{PI} = 1.35)$$

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.hsrd.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:

$$\text{Log CV} = 0.73 \log \text{LC50} - 0.70 \quad (\text{PI} = 1.2)$$

For a non-metallic contaminant:

$$\text{Log CV} = 1.07 \log \text{LC50} - 1.51 \quad (\text{PI} = 1.5)$$

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.hsrd.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.hsrd.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 $CaCO_3$/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. 1999. National Recommended Water Quality Criteria – Correction. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. April. EPA 822-Z-99-001. (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 $CaCO_3$/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. 1999. National Recommended Water Quality Criteria – Correction. Office of Water, U.S. Environmental Protection Agency, Washington, D.C. April. EPA 822-Z-99-001. (Available at http://www.epa.gov/ost/pc/revcom.pdf)

Tier II SAV

These are secondary acute values that are conservative estimates of water quality criteria for those chemicals for which available data are insufficient to derive criteria. EPA developed Final Water Quality Guidance for the Great Lakes System. The final Guidance contains numeric acute and chronic criteria to protect aquatic life for 15 pollutants, and a two_tiered methodology to derive criteria (Tier I) or values (Tier II) for additional pollutants. Tier I aquatic life criteria for each chemical are based on laboratory toxicity data for a variety of aquatic species (e.g., fish and invertebrates) representative of species in freshwater. The Guidance also includes a Tier II methodology to be used in the absence of the full set of data needed to meet Tier I data requirements. The Tier I aquatic life methodology includes data requirements similar to current guidelines for developing national water quality criteria. For example, both require acceptable toxicity data for aquatic species in at least eight different families representing differing habitats and taxonomic groups. The Tier II aquatic life methodology is used to derive Tier II values, which can be calculated with fewer

toxicity data than Tier I. Tier II values can be based on toxicity data from a single taxonomic family, provided the data are acceptable. The Tier II methodology generally produces more stringent values than the Tier I methodology, reflecting greater uncertainty in the absence of additional toxicity data. The final Guidance expresses the criteria for metals in dissolved form because the dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does the total recoverable metal. The dissolved criteria are obtained by multiplying the chronic and/or acute criterion by appropriate conversion factors.

The final Guidance also contains numeric criteria to protect wildlife for four pollutants and a methodology to derive Tier I criteria for additional persistent bioaccumulative pollutants. Wildlife criteria are derived to establish ambient concentrations of chemicals which, if not exceeded, will protect mammals and birds from adverse impacts from that chemical due to consumption of food and/or water from the Great Lakes System. The methodology focuses on endpoints related to reproduction and population survival rather than the survival of individual members of a species. The methodology incorporates pollutant_specific effect data for a variety of mammals and birds and species_specific exposure parameters for two mammals and three birds representative of mammals and birds in the Great Lakes basin that are likely to experience significant exposure to bioaccumulative contaminants through the aquatic food web.

EPA. 40 CFR Parts 9, 122, 123, 131, and 132. (http://www.mvaconsulting.com/glwqi.html#intro)

Tier II SCV

These are secondary chronic values that are conservative estimates of water quality criteria for those chemicals for which available data are insufficient to derive criteria. EPA developed Final Water Quality Guidance for the Great Lakes System. The final Guidance contains numeric acute and chronic criteria to protect aquatic life for 15 pollutants, and a two_tiered methodology to derive criteria (Tier I) or values (Tier II) for additional pollutants. Tier I aquatic life criteria for each chemical are based on laboratory toxicity data for a variety of aquatic species (e.g., fish and invertebrates) representative of species in freshwater. The Guidance also includes a Tier II methodology to be used in the absence of the full set of data needed to meet Tier I data requirements. The Tier I aquatic life methodology includes data requirements similar to current guidelines for developing national water quality criteria. For example, both require acceptable toxicity data for aquatic species in at least eight different families representing differing habitats and taxonomic groups. The Tier II aquatic life methodology is used to derive Tier II values, which can be calculated with fewer toxicity data than Tier I. Tier II values can be based on toxicity data from a single taxonomic family, provided the data are acceptable. The Tier II methodology generally produces more stringent values than the Tier I methodology, reflecting greater uncertainty in the absence of additional toxicity data. The final Guidance expresses the criteria for metals in dissolved form because the dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does the total recoverable metal. The dissolved criteria are obtained by multiplying the chronic and/or acute criterion by appropriate conversion factors.

The final Guidance also contains numeric criteria to protect wildlife for four pollutants and a methodology to derive Tier I criteria for additional persistent bioaccumulative pollutants. Wildlife criteria are derived to establish ambient concentrations of chemicals which, if not exceeded, will protect mammals and birds from adverse impacts from that chemical due to consumption of food and/or water from the Great Lakes System. The methodology focuses on endpoints related to reproduction and population survival rather than the survival of individual members of a species. The methodology incorporates pollutant_specific effect data for a variety of mammals and birds and species_specific exposure parameters for two mammals and three birds representative of mammals and birds in the Great Lakes basin that are likely to experience significant exposure to bioaccumulative contaminants through the aquatic food web.

EPA. 40 CFR Parts 9, 122, 123, 131, and 132. (http://www.mvaconsulting.com/glwqi.html#intro)

SEDIMENT ECOLOGICAL BENCHMARKS

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) based on the ranking method presented in Jones et al. (1997). It is a concentration above which adverse effects to these organisms may occur. The majority of the data are for freshwater sediments. These are no effects benchmarks.

EPA (U.S. Environmental Protection Agency) 1996. Calculation and evaluation of sediment effect concentrations for the amphipod Hyalella 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)

Jones, D.S. , G.W. Suter II, and R.N. Hull 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf)

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 Hyalella azteca and Chironomus riparius are presented in EPA (1996) based on the ranking method presented in Jones et al. (1997). It is a concentration above which adverse effects to these organisms are not expected. 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 Hyalella 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)

Jones, D.S. , G.W. Suter II, and R.N. Hull 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf)

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 Hyalella azteca and Chironomus riparius are presented in EPA (1996) based on the ranking method presented in Jones et al. (1997). It is a concentration below which adverse effects to these organisms likely to occur. 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 Hyalella 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)

Jones, D.S. , G.W. Suter II, and R.N. Hull 1997. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R3. Oak Ridge National Laboratory, Oak Ridge, Tennessee. (http://www.hsrd.ornl.gov/ecorisk/tm95r4.pdf)

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://www2.ec.gc.ca/ceqg_rcqe/sediment.htm.

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://www2.ec.gc.ca/ceqg_rcqe/sediment.htm.

EPA Region 4

The higher of two values, 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. (superceded by http://www.epa.gov/region4/wastepgs/oftecser/ecolbul.htm#tbl3)

EPA Region 5 EDQLs

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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/dwm/documents/sediment/volume1.pdf)

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NOAA ERL

1. NOAA's National Status and Trends Program. Sediment Quality Guidelines. As presented on NOAA web page at http://www_orca.nos.noaa.gov/projects/nsandt/sedimentquality.html, 4/26/2000. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, 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. As presented on NOAA web page at http://www_orca.nos.noaa.gov/projects/nsandt/sedimentquality.html, 4/26/2000. (Values for As, Cd, Cr, Cu, Pb, Hg, Ni, Ag, 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.)

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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/resources/ecotox/eco_updt.pdf)

Washington AET

A concentration above which toxic effects occurred at all sites in Puget Sound. These are probable effects benchmarks.

SOIL ECOLOGICAL BENCHMARKS

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://www.minvrom.nl/minvrom/docs/bodem/S&I2000.PDF and Annex A: Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination http://www.minvrom.nl/minvrom/docs/bodem/annexS&I2000.PDF were also consulted, but they combine the ecological and human health values.

Dutch Target

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Eco-SSL Avian

Ecological soil screening levels. Still in draft form so not included in this SADA version.

Eco-SSL Inverts

Ecological soil screening levels. Still in draft form so not included in this SADA version.

Eco-SSL Mammalian

Ecological soil screening levels. Still in draft form so not included in this SADA version.

Eco-SSL Plants

Draft Ecological Soil Screening Level (Eco-SSL) Guidance. The Eco-SSL guidance provides a set of risk-based soil screening levels (Eco-SSLs) for many of the 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. Still in draft form so not included in this SADA version.

EPA 2000. Ecological Soil Screening Level Guidance DRAFT. Office of Emergency and Remedial Response. (http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm)

EPA Region IV

EPA 1995. Supplemental Guidance to RAGS: Region 4 Bulletins No. 2. Ecological Risk Assessment. Region IV, Waste Management Division. Office of Health Assessment. Values presented are as updated Aug. 1999. (http://www.epa.gov/region4/wastepgs/oftecser/epatab4.pdf)

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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.hsrd.ornl.gov/ecorisk/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.hsrd.ornl.gov/ecorisk/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.hsrd.ornl.gov/ecorisk/tm85r3.pdf)