Chapter 22: Overview of Ecological Risk Assessment

Ecological risk assessment is the process of gaining an understanding of the likelihood of adverse effects on ecological receptors occurring as a result of exposure to one or more stressors. It is often conducted in a multi-tiered/multi-stepped process beginning with a preliminary conceptual model and site description that gathers existing information and forms the basis for a screening assessment. The purpose of the screening assessment is to focus on stressors most likely to be a concern (and eliminate those unlikely to be a concern from further consideration) and/or to focus on areas where receptors may experience unacceptable exposures. The results of the initial site description and screening are used to refine the conceptual model. If potential risks have been identified, the refined conceptual model points out the primary exposure pathways and any additional data needs necessary to evaluate potential risks. Data needs include information on the distribution and magnitude of stressors as well as effects of stressors on receptors. Ultimately the information on exposures and effects are combined to characterize potential risks.

Generally risk assessment involves a weight-of-evidence approach that takes into account results from multiple lines of evidence. For example, comparison of exposures to chemical effects data is one line of evidence used in evaluating potential risks to aquatic organisms in a stream; community survey data and site-specific surface water and sediment toxicity test results are additional lines of evidence that may or may not lead to the same conclusions indicated by the chemical toxicity data. The art of risk assessment is in the interpretation of different types of information to arrive at a final conclusion regarding conditions at the site.

Ecological risk assessment guidance from EPA includes an eight-step process (EPA 1997, 1998). The first step of the process is a screening-level problem formulation that pulls together knowledge of the site history and ecology to develop a preliminary conceptual model. This preliminary conceptual model addresses the environmental setting and stressors known or suspected to exist at the site, contaminant fate and transport mechanisms, mechanisms of ecotoxicity and likely categories of receptors that could be affected, presence of complete exposure pathways, initial endpoints to screen for ecological risks, and conservative screening ecotoxicity values.

The second step of the process is a screening-level exposure estimate and risk calculation. Maximum exposure concentrations are compared to ecotoxicity screening values to help determine if risks are negligible or if a more detailed assessment is warranted. Ideally this step eliminates at least some sites, contaminants, exposure pathways, or receptors from further evaluation.

Scientific/management decision points (SMDP) are built into the process beginning with the end of Step 2. These are points where communication/discussion among the risk assessor, risk managers, and stakeholders takes place to decide whether the information available is adequate to make a risk management decision. Open communication between the risk assessment/risk management team and regulators/stakeholders smooths the decision-making process.

Step 3 of the process is the baseline risk assessment problem formulation. This step uses the results of the screening assessment and additional site-specific information to refine the screening-level problem formulation and determine the scope and goals of the baseline assessment. It is only applied in situations where the screening-level assessment indicated a need

for further evaluation. This is the step where assessment endpoints are selected and results in a conceptual model complete with questions the site investigation will address.

Step 4 of the process works from the conceptual model developed in Step 3 to produce the study design and data quality objectives that will result in the information needed for the risk manager to incorporate ecological considerations into the site remedial process. Measurement endpoints are identified, and any additional data needs are addressed in the work plan. Step 5 is field verification of the proposed sampling design which confirms that the data needed can actually be collected (i.e., fish of the appropriate size are present and can be caught).

Steps 6 and 7 are the site investigation and analysis phase and the risk characterization phase. Step 6 specifies the assessment endpoints, risk questions, and testable hypotheses and characterizes exposures and ecological effects (the exposure assessment and effects assessment steps from previous guidance). Step 7 is the final phase of the risk assessment process and combines the exposure and effects assessments to characterize the likelihood of adverse effects on assessment endpoints. This is generally a weight-of-evidence approach where multiple types of information on possible effects are considered to arrive at an overall conclusion.

Step 8 is risk management. In risk management, the results of the risk assessment (Steps 1-7) are integrated with other considerations to make and justify risk management decisions.

SADA provides a means of implementing components of the EPA process including the screening assessment, development of a sampling plan, and exposure modeling for the baseline assessment. Just as importantly, SADA provides the user with a way to visualize results across a site, plotting data, exposure values, and risk numbers relative to features of the site and facilitating use of geospatial methods where applicable.

Ecological Capabilities in SADA

SADA was designed to address hazard assessments at environmental sites. It implements EPA methods for conducting ecological risk assessments. Chemical hazard assessment, or comparison of an environmental concentration to an estimated toxic threshold for a particular contaminant, is the most common method for examining effects of chemicals in the environment. SADA provides a media-based benchmark database for contaminant effects on ecological receptors, exposure models for 19 terrestrial species (birds and mammals), default exposure parameters for risk models (where available), tabular screening and risk results, and risk and dose mapping.

The primary ecological risk functions of SADA include:

- Setting Up Ecological Risk
- Ecological Risk Assessment Procedure
- Setting Physical Parameters
- Description of Ecological Benchmark Database
- Histograms of Benchmark Values
- Tables of Benchmark Values
- Setting Screening and Exposure Statistics
- Area Result Tables (Screens, Ratios)
- Map Result Values (Screens, Ratios)
- Rematching a Single Contaminant
- Checking Ecological Version
- Terrestrial Dose Modeling

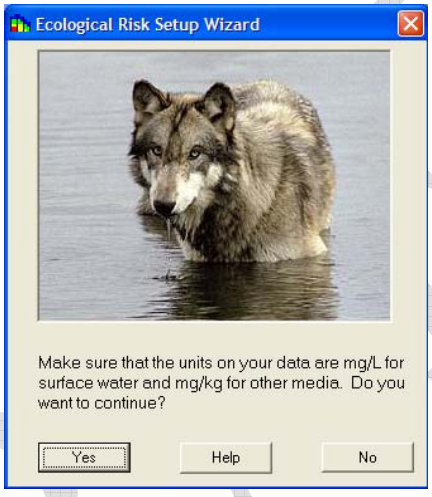
Chapters 23-28 describe how to use these functions and assume you have already created a SADA file and imported data into it.

Setting Up Ecological Risk

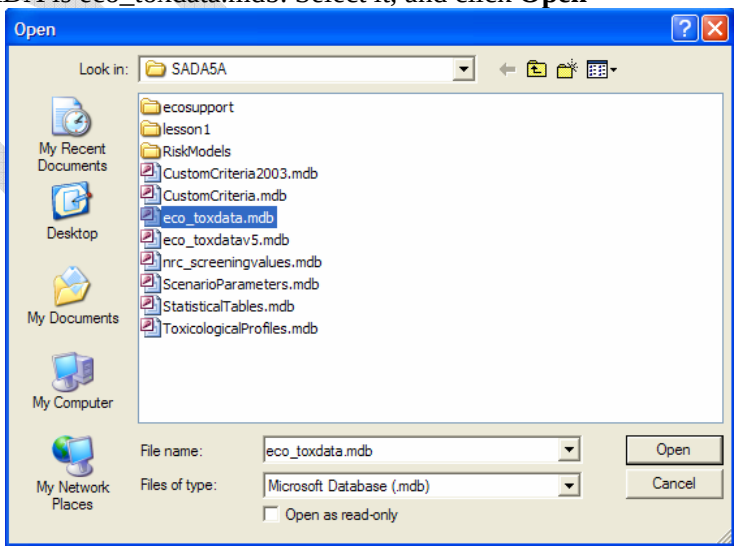
In order to use the ecological risk functions of SADA, you first have to set up the ecological risk component just as is done for human health risk assessment. The set up process identifies the source benchmarks database, matches contaminants in the site database to those in the benchmarks database, and adds ecological information to the SADA file.

To begin, select **Setup** -> **Ecological Risk** from the dropdown menus.

Click **Yes** on the Risk Setup Wizard



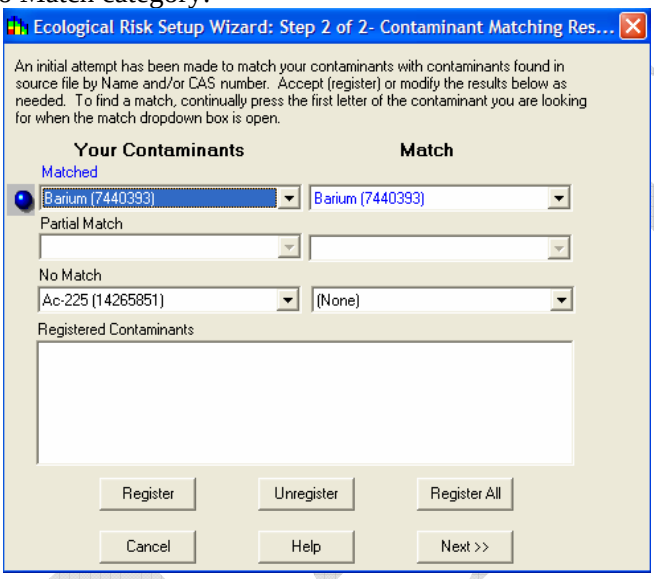
Browse for the file that contains ecotoxicity benchmarks to be used for your site. The database provided with SADA is eco_toxdata.mdb. Select it, and click **Open**>>



Then click **Next** at the Identify Source Databases window. This sets the selected file as the source of benchmarks for your SADA file. Units for benchmarks in the benchmark database are

mg/L for surface water and mg/kg for sediment and soil. It is imperative that units in your data match those in the benchmark database if you plan to use the benchmark screening capabilities of SADA.

SADA now needs to match the names of contaminants in your data file (left column) to those in the toxicity database (right column). You control this at the Contaminant Matching window. SADA attempts to match contaminants based on name and CAS number. If both match, SADA lists the contaminant as matched. If one or the other but not both match, SADA lists the contaminant as a Partial Match. If neither name nor CAS number match, SADA lists the contaminant in the No Match category.



You must go through each category and register (or unregister) each contaminant. Generally the Matched category is good to go, and you can select the matched box, then click on the **Register All** button to accept the matches. It is advisable to peruse the Partial Matches to be sure analytes in your database are matched with the appropriate contaminant in the benchmark database. If all are acceptable, you can **Register All** again, or you can use the **Register** button to accept the matches one at a time. For contaminants with no match, you need to select an analyte from your database (left column), then search the contaminant dropdown list in the right hand match column to see if the benchmark database has a corresponding contaminant, perhaps with a different CAS number and different spelling. If it does, select it and click **Register**. In some cases you might want to use a surrogate chemical to match with the one in your database.

After you have accepted matches for all analytes that you can (there are no matches for radionuclides because there are no ecotoxicity values for individual radionuclides in the benchmark database), click **Next** to save the matches to the SADA file. Unmatched analytes are not removed from your database, but they are unavailable for use on the ecological risk side of SADA.

Ecological Benchmarks

Benchmarks are environmental effects concentrations derived from toxicity testing, extrapolated from other benchmarks, or from simulations of an assessment endpoint. SADA provides a number of benchmarks for surface water, sediment, soil, and biota (tissue concentrations). SADA developers have made a point of not independently deriving benchmarks, so benchmarks in the

SADA database are all from published sources. Sources and citations are described in more detail in the SADA help file. For surface water, the SADA ecological benchmark database includes acute and chronic National Ambient Water Quality Criteria, Great Lakes Tier II secondary acute and chronic values, criteria from three EPA regions (4, 5, and 6), Canadian water quality guidelines, and lowest chronic values, EC20s, and population EC25s from Suter and Tsao (1996). Sediment values include no effects concentrations, threshold effects concentrations, and probable effects concentrations from sources such as EPA's Great Lakes Assessment and Remediation of Contaminated Sediment program, Canadian sediment quality guidelines, consensus-based values (MacDonald et al. 2000), EPA region 4, 5, and 6 values, Florida Department of Environmental Protection, the National Oceanic and Atmospheric Administration, Ontario Ministry of the Environment, and Washington state. Fewer benchmarks are available for soil, but the database includes values from EPA's ecological soil screening level program, screening levels from EPA regions 4, 5, and 6, invertebrate, microbe, and plant values from Oak Ridge National Laboratory, and Dutch target and intervention levels.

While the benchmark database includes 424 chemicals, it is important to realize that not all sources have values for every chemical in the database.

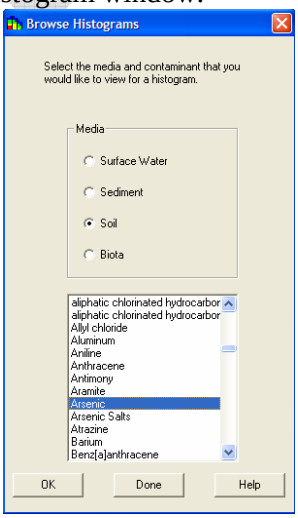
Some benchmarks (i.e., certain metals in surface water) are a function of environmental variables. SADA allows the user to enter site-specific pH, water hardness, and fraction of organic carbon and, where appropriate, calculates benchmark values associated with site-specific environmental variables.

Browsing Ecological Benchmarks – Benchmark Histograms

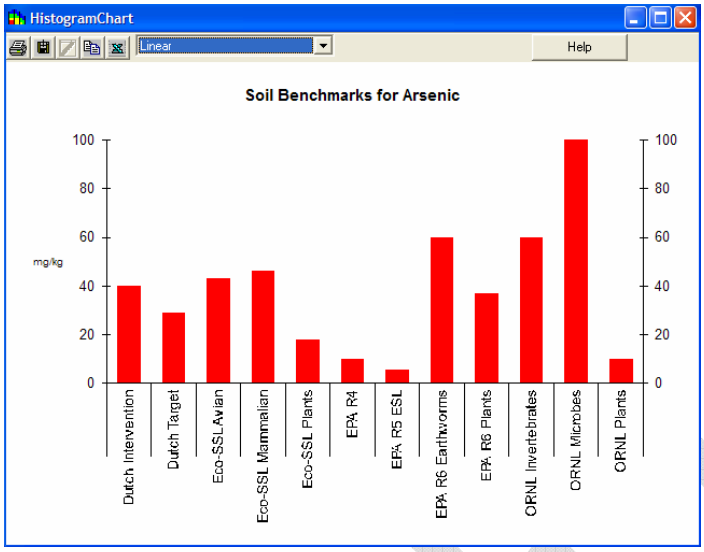
You can view benchmark values in the database in a couple of ways. One is as a histogram showing values from all benchmark sources for the selected contaminant and media type. You can browse values from any SADA file or from a master benchmark file.

Select Ecological from the Analysis list, then go to the Ecological dropdown menu and click on **Browse→Benchmark Histogram from…**. Find and select the benchmark source database you want to view, then click **Open**.

SADA responds with the Browse Histogram window.



Here you select the data type (media) and data set (i.e., arsenic) for which you want to see the benchmark histogram, then select **OK**. SADA then displays a histogram of available benchmarks for the selected media and contaminant.



You can also view a histogram of benchmarks simply by choosing a data type and data set, then selecting **Benchmark Histogram** from the Ecological dropdown menu. The difference is that **Benchmark Histogram** views benchmarks currently loaded in your .SDA file for contaminants that exist in your data set while the **Browse Histogram From …** option allows you to view benchmarks from other .SDA files or from a master benchmark database not included in your .SDA file as well as choosing contaminants that are not in your data set.

Hint: If a source appears on the histogram but appears to have no value, try selecting a log scale representation from the dropdown menu on the histogram window instead of the default linear plot.

Browsing Ecological Benchmarks – Benchmark Tables

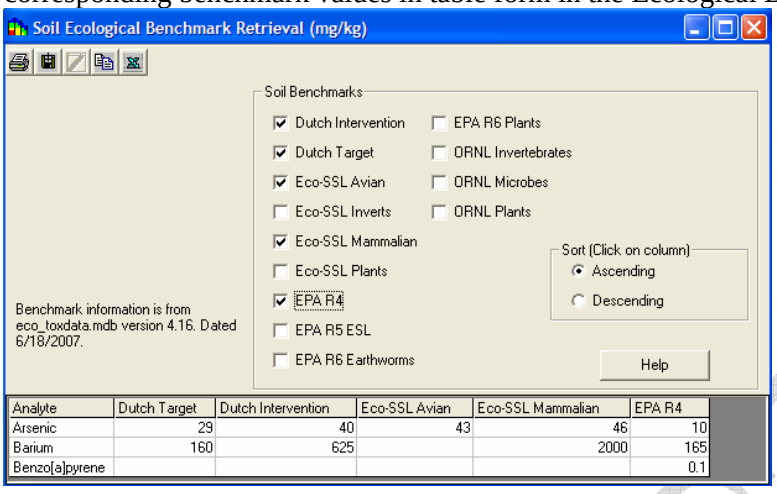
Another way to view benchmark values is in tabular form. This works the same way as for benchmark histograms. You can browse the benchmarks you've linked with your .SDA file, benchmarks from another .SDA file, or benchmarks from a master database external to SADA.

Select Ecological from the Analysis list, then go to the Ecological dropdown menu and click on **Browse→Benchmark Table From…**. Find and select the benchmark source database you want to view, then click **Open**.

SADA responds with the Browse Tables window that looks very much like the Browse Histograms window. Select the media and contaminant(s) for which you want to see a tabular display of benchmarks. Note that you can select multiple contaminants by holding the control (CTRL) key while you click on contaminant names. When you've selected the media and contaminant(s) you want, click **OK**.

Whereas the Benchmark Histogram option displayed values for all sources for a single contaminant at this stage, for a tabular display you have to select which benchmark sources you

want to view. Select them by clicking in the appropriate box, and SADA will display the corresponding benchmark values in table form in the Ecological Benchmark Retrieval window.



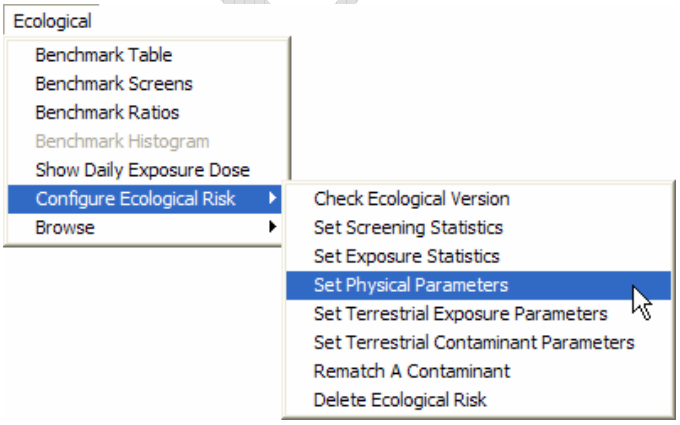
You can print the table, save it to a file, copy and paste it, or export it to Excel using the buttons in the upper left corner of the window.

As with benchmark histograms, there is a shortcut for viewing a benchmark table for the analytes in your .SDA file. Simply select a media type, an individual contaminant (or pooled if you want to see benchmarks for all analytes in your file), and then **Benchmark Table** from the Ecological dropdown menu. Next, select the benchmarks to be viewed from the Ecological Benchmark Retrieval window. Using this route also gives you the option of specifying a statistic (i.e., mean, UCL95, max detect) to be displayed for the analyte(s) of interest. This is useful when trying to get a feel for where your data fall relative to available benchmarks.

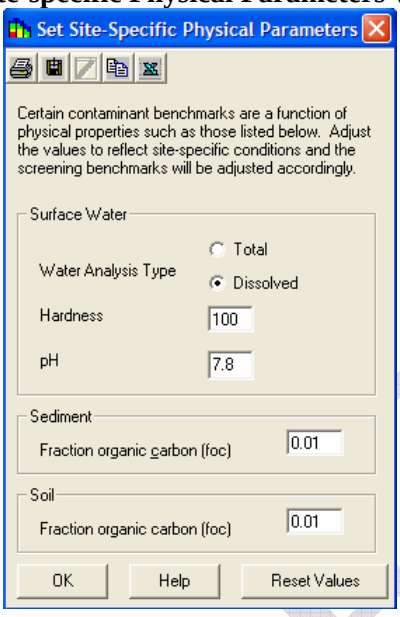
Setting Physical Parameters

As noted previously, some benchmarks are functions of environmental variables (water hardness or pH for surface water, fraction organic carbon for soil and sediment). Defaults are set at 100 mg CaCO3/L for hardness, 7.8 for pH, and 1% for fraction organic carbon. SADA allows you to use site-specific values for these variables and will recalculate benchmarks, where appropriate.

To set physical parameters, from the **Ecological** dropdown menu select **Configure Ecological Risk→Set Physical Parameters**.



SADA responds with the **Set Site-specific Physical Parameters** window.



Enter site-specific values and click **OK**. The values are now set and will be used when viewing benchmarks and when conducting functions that use benchmarks in risk calculations. Note that for surface water there is also the option of expressing concentrations as Total or Dissolved. EPA has Total to Dissolved conversion factors for some metals, and for these, benchmarks will be recalculated depending on whether Total or Dissolved is selected. Values of analytes without conversion factors will not be changed.

Values can be reset to the defaults by clicking the **Reset Values** button.

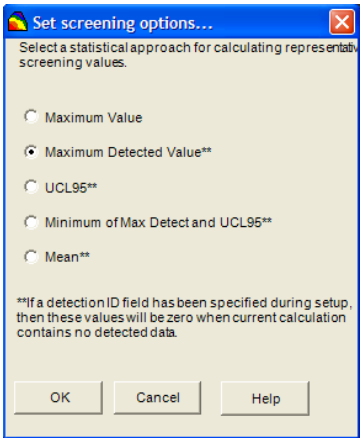
Benchmark Screening

Assuming you have already explored your data (see Chapter 11: Visualizing and Exploring Your Data), you may want to screen observed contaminant concentrations against benchmark values. This is the screening step in ecological hazard identification, or Step 2 in the EPA ecological risk assessment process.

To conduct the benchmark screening, you need to select a contaminant(s), select a screening statistic (usually the maximum detected concentration), and a benchmark(s).

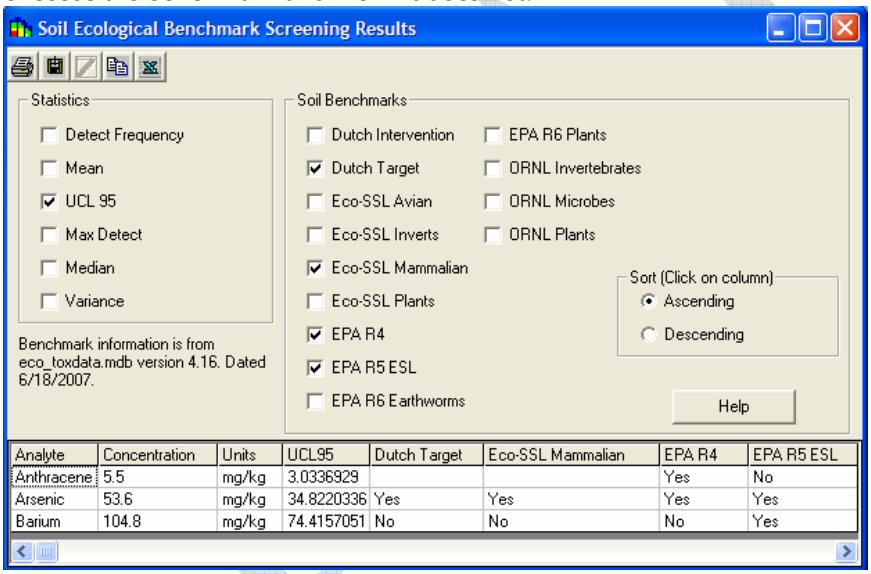
The simplest screen is a pass/fail comparison of the maximum concentration against a conservative screening benchmark. SADA allows you to specify the screening statistic (default is maximum detected value) and choose a single benchmark source.

To conduct a benchmark screen for a given media and contaminant(s) combination, first check the screening statistic to be sure it is what you want. Select **Set Screening Statistics** from the **Ecological→Configure Ecological Risk** menu. At the **Set Screening Options** window, confirm that your desired statistic is selected, then click **OK**.



Next select **Ecological→Benchmark Screens**. SADA will respond with the Soil Ecological Benchmark Screening Results window. This includes a column listing contaminants, a column showing the screening exposure concentration, a units column, the option of showing additional statistics (i.e., mean, UCL95, max detect), and columns for each benchmark selected.

You select the benchmarks you want used by clicking the appropriate box. SADA responds by comparing the exposure concentration to the benchmark and reporting Yes if the concentration exceeds the benchmark and No if it does not.



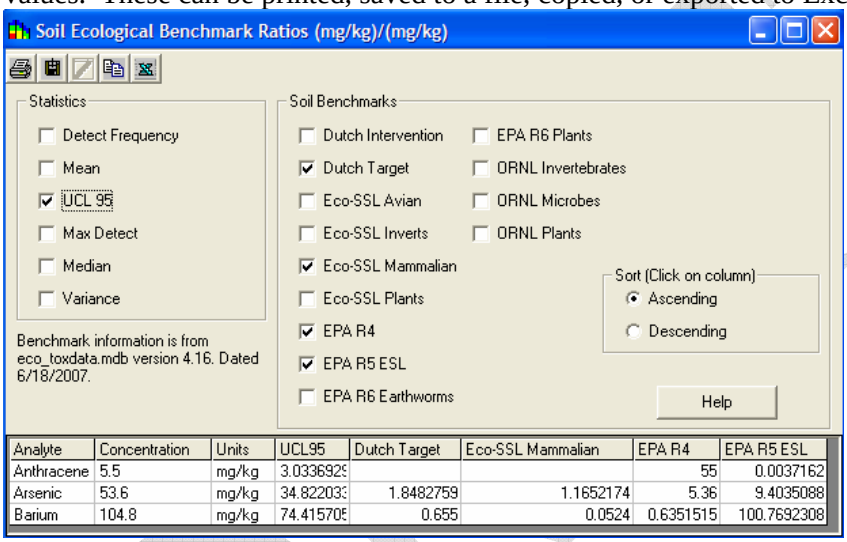
Analytes with maximum concentrations below a conservative benchmark do not need to be evaluated further in an ecological assessment. Those that failed the screen, having maximum concentrations above the benchmark, merit further investigation. If no analytes at a site exceed the screening benchmark, the entire site can be dropped from further investigation.

Tip: It is rare for a single benchmark source to have values for all analytes in a site data set. It may be desirable to create a custom analysis data set that draws from a number of benchmark sources to populate the benchmark database. This could involve selecting a primary source and then filling in the gaps using other sources. SADA allows users to select a benchmark hierarchy for single contaminants when plotting screening results but not for tabular results which can contain multiple contaminants. For tabular screens you need to create a custom analysis or edit

an existing benchmark field in the ecotox database so that it represents the screening values to be used for your site rather than the original source. Essentially you are manually creating the benchmark hierarchy. Any time you tweak SADA like this it is important to fully document what you have done, and it is best to reach agreement with regulators and stakeholders ahead of time.

A simple pass/fail screening analysis does not provide any information about the magnitude of exceedances. Often it can be more illuminating to conduct the screen similarly but output ratios of maximum concentrations to benchmark values. The interpretation of the results is similar, but instead of Yes/No, it is >1/<1. Ratios less than 1 indicate the maximum concentration was below the benchmark value; those greater than 1 indicate the concentration exceeded the benchmark value.

Tabulation of the ratios is set up the same way as for Benchmark Screens. Select **Ecological→Benchmark Ratios**, then select the benchmarks to screen against. SADA responds with the Ecological Benchmark Ratios window with numeric benchmark ratios instead of Yes/No values. These can be printed, saved to a file, copied, or exported to Excel.



Important Note: the default exposure statistic for Benchmark Ratios is the lower of the maximum detect and the UCL95. If computing ratios for screening purposes, be sure to change the exposure statistic (not the screening statistic) to that you want used for the ratio screen. To change the exposure statistic, select **Ecological→Configure Ecological Risk→Set Exposure Statistics**.

Benchmark Screening: Benchmark Screening Maps
Setting Statistics – Exposure Statistics
Benchmark Ratio Tables
Benchmark Ratio Maps
Contoured Risk Maps
Rematching a Contaminant
Check Ecological Version
Terrestrial Exposure Modeling
Exposure Pathways
BAFs
Setting Species Exposure Parameters

Setting Contaminant-specific Uptake Factors
Calculating Wildlife Exposure Doses
Point Dose Maps
Contoured Dose Maps
Area of Concern Maps

Assuming you have already explored your data (see Chapter 11: Visualizing and Exploring Your Data), you may want to screen observed contaminant concentrations against benchmark values. This is the screening step in ecological hazard identification, or Step 2 in the EPA ecological risk assessment process.

To conduct the benchmark screening, you need to select a contaminant, select a screening statistic (usually the maximum detected concentration), and a benchmark.

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Ecological risk assessment explicitly attempts to estimate the probability and magnitude of the effects of exposure of an ecological endpoint to contamination. There are 4 steps to an ecological risk assessment: Hazard Identification, Dose Response Evaluation, Exposure Assessment, and Risk Characterization. This help file only provides an overview of the process and assumes that the user is familiar with ecological risk assessment.

Step 1 - Hazard Identification

This step consists of comparing (or screening) environmental measurements to benchmarks. Benchmarks are environmental effects concentrations derived from toxicity testing. See Ecological Benchmarks.

Step 2 – Dose Response Evaluation

This step consists of generating dose responses. Since there is no central database approved for use, these can be pulled out of the same data used to generate screening benchmarks.

Step 3 – Exposure Assessment

This step consists of determining which ecological receptors and pathways to model by taking into account bioavailability, behavior, growth, and spatial distribution. A conceptual site model is used at this point.

Exposure can also be directly measured via measurements of body burdens or tissue residues.

Step 4 – Risk Characterization

Risk Characterization incorporates the outcomes of the previous activities (Hazard Identification, Dose Response Evaluation, and Exposure Assessment) to estimate the likelihood that significant effects are occurring or will occur and describe the nature, magnitude, and extent of effects on the designated assessment endpoints.