PNNL-14583

GENII Version 2
Users' Guide

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October 2004

Prepared for
U.S. Environmental Protection Agency
under Contract DE-AC06-76RLO 1830

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PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161

GENII Version 2 User's Guide

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1.0 INTRODUCTION

The GENII computer code was developed for the Environmental Protection Agency (EPA) at Pacific Northwest National Laboratory (PNNL) to incorporate the internal dosimetry models recommended by the International Commission on Radiological Protection (ICRP) and the radiological risk estimating procedures of Federal Guidance Report 13 into updated versions of existing environmental pathway analysis models. The resulting environmental dosimetry computer codes are compiled in the GENII Environmental Dosimetry System. The GENII system was developed to provide a state-of-the-art, technically peer-reviewed, documented set of programs for calculating radiation dose and risk from radionuclides released to the environment. Although the codes were initially developed at Hanford, they were designed with the flexibility to accommodate input parameters for a wide variety of generic sites. A new version of the codes, GENII Version 2, is described in this report.

1.1 GENII Capabilities and Limitations

The GENII system includes the capabilities for calculating radiation doses following chronic and acute releases. Radionuclide transport via air, water, or biological activity may be considered. Air transport options include both puff and plume models, each allow use of an effective stack height or calculation of plume rise from buoyant or momentum effects (or both). Building wake effects can be included in acute atmospheric release scenarios. The code provides risk estimates for health effects to individuals or populations; these can be obtained using the code by applying appropriate risk factors to the effective dose equivalent or organ dose. In addition, Version 2 uses cancer risk factors from Federal Guidance Report 13 to estimate risk to specific organs or tissues.

Data entry is accomplished via interactive, menu-driven user interfaces. Default exposure and consumption parameters are provided for both the average (population) and maximum individual, however these may be modified by the user. Source term information may be entered as radionuclide release quantities for transport scenarios, or as basic radionuclide concentrations in environmental media (air, water, soil). For input of basic or derived concentrations, decay of parent radionuclides and ingrowth of radioactive decay products prior to the start of the exposure scenario may be considered. A single code run can accommodate unlimited numbers of radionuclides including the source term and any radionuclides that accumulate from decay of the parent, because the system works sequentially on individual decay chains.

The code package also provides interfaces, through the Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES), for external calculations of atmospheric dispersion, geohydrology, biotic transport, and surface water transport. Target populations are identified by direction and distance (radial or square grids for Version 2) for individuals, populations, and for intruders into contained sources.

A stochastic edition of GENII Version 1, named GENII-S, was developed for the Waste Isolation Pilot Plant assessments by Sandia National Laboratory (Leigh et al. 1992). GENII Version 2 is completely stochastic, using the FRAMES SUM^3 driver.

1.2 GENII Pathways and Scenarios

Available release scenarios include chronic and acute releases to water or to air (ground level or elevated sources), and initial contamination of soil or surfaces. GENII implements the NRC models in LADTAP for surface water doses. GENII does not explicitly include modules for performing groundwater transport calculations, however the FRAMES system allows addition of other computer modules to the GENII system. Exposure pathways include direct exposure via water (swimming, boating, and fishing), soil (surface and buried sources), air (semi-infinite cloud and finite cloud geometries), inhalation and ingestion pathways. The tritium model also includes exposure via skin absorption.

GENII Version 1 implemented dosimetry models recommended by the ICRP in Publications 26, 30, and 48, and approved for use by DOE Order 5400.5. GENII Version 2 implements these models plus those of ICRP Publications 56 through 72, and the related risk factors published in Federal Guidance Report 13. Risk factors in the form of EPA developed "slope factors" are also included (these are a special subset of the FGR-13 values). These dosimetry and risk models are considered to be 'state of the art' by the international radiation protection community and have been adopted by most national and international organizations as their standard dosimetry methodology.

1.3 Hardware Requirements

GENII Version 2 requires Windows® 95, 98, NT, 2000, or XP using Pentium processors, and disk storage in excess of 60 Mbytes. FRAMES and GENII make use of the memory-swapping capabilities of Windows®, so the programs should run on any Windows®-compatible computer. However, they will generally run fastest on machines with 256 Mbytes of memory or more.

1.4 Component Programs

GENII Version 2 consists of four independent atmospheric models, one surface water model, three independent environmental accumulation models, one exposure module, and one dose/risk module, each with a specific user interface code. The computer programs are of several types: user interfaces (i.e., interactive, menu- driven programs to assist the user with scenario generation and data input), internal and external dose factor libraries, the environmental dosimetry programs, and FRAMES-supplied file-viewing routines. For maximum flexibility, the code has been divided into several interrelated, but separate, exposure and dose calculations.

1.5 Quality Assurance (QA) Issues

Both GENII versions were developed under QA plans based on the American National Standards Institute (ANSI) standard NQA-1 as implemented in the PNNL Quality Assurance Manual. All steps of the code development have been documented and tested, and hand calculations have verified the code's implementation of major transport and exposure pathways for a subset of the radionuclide library. A collection of hand calculations and other verification activities is available. A comprehensive test plan has been developed and testing is underway. The code has been reviewed by the EPA Science

Advisory Board and a separate EPA-sponsored, independent peer review panel. The QA of both GENII Version 1.485 and Version 2 have been reviewed by the US Department of Energy (DOE 2003; 2004).

GENII Version 1 has been included in the International Atomic Energy Agency's VAMP project (VAlidation of Model Predictions - an acronym for the Coordinated Research Program on Validation of Models for the Transfer of Radionuclides in Terrestrial, Urban and Aquatic Environments), an international effort to compare environmental radionuclide transport models with measured environmental data. Results for test scenario CB (based on environmental measurements following the Chernobyl accident) indicated that dose estimates from GENII were comparable to, although slightly higher than, those of other participating models, which is consistent with its primary function as a prospective analysis tool. The models included in the code have been validated to various degrees by additional studies, however these have not been compared directly to output from the code.

1.6 Documentation and Availability

The overall system design is documented in the GENII Version 2 Software Design Document (Napier et al. 2002). Specific instruction on the use of FRAMES and the SUM3 processor is available in electronic and print forms. This report explains user interactions with the GENII modules. A series of example cases are available electronically; these are described in this report.

Electronic documentation of GENII Version 2 is available, and the code, documentation, and users' manuals have been made available through the Internet by the US Environmental Protection Agency.

1.7 References for Section 1

DOE. 2003. Software Quality Assurance Plan and Criteria for the Safety Analysis Toolbox Codes, Defense Nuclear Facilities Safety Board Recommendation 2002-1 Software Quality Assurance Improvement Plan Commitment 4.2.1.2. U.S. Department of Energy, Washington, D.C.

DOE. 2004. Defense Nuclear Facilities Safety Board Recommendation 2002-1, Software Quality Assurance Improvement Plan, Commitment 4.2.1.3: Software Quality Assurance Improvement Plan: GENII Gap Analysis. DOE-EH-4.2.1.3-GENII-Gap Analysis. U.S. Department of Energy, Washington, D.C.

Napier, B. A., R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell. 1988. GENII - The Hanford Environmental Radiation Dosimetry Software System. PNL-6584, Vols. 1-3. Pacific Northwest Laboratory, Richland, Washington.

Leigh, C. D., B. M. Thompson, J. E. Campbell, D. E. Longsine, R. A. Kennedy, and B. A. Napier. 1992. User's Guide for GENII-S: A Code for Statistical and Deterministic Simulations of Radiation Doses to Humans from Radionuclides in the Environment, SAND91-0561A, Sandia National Laboratories, Albuquerque, New Mexico

Napier, B. A., D. L. Strenge, J. V. Ramsdell, Jr., P.W. Eslinger, and C. F. Fosmire. 2002. *GENII Version 2 Software Design Document*, Pacific Northwest National Laboratory, Richland Washington.

2.0 INSTALLATION

The GENII Version 2 environmental radiation dosimetry software package runs within the FRAMES Framework for Risk Analysis in Multimedia Environmental Systems. Therefore, both programs are required in order to run GENII Version 2. FRAMES and GENII are provided together in a single installation package via either CD or the EPA's Internet website. The files in the installation package will perform all the necessary checking and program installation.

You may use the CD provided, or download the information from the Internet site. If using the Internet download, copy the file from the web site to the target computer in a temporary directory.

If you have an older version of FRAMES and GENII on the target computer, please remove them. By removing the older versions, you are assured that only the newer files are in place. This can be accomplished by using START/Settings/Control Panel/Add Remove Programs. First highlight the existing FRAMES installation, and hit the Add/Remove button. Repeat this step for the existing GENII installation, if it was installed separately from FRAMES.

Next install FRAMES and GENII. The GENII Version 2 installation consists of a single file that will automatically install all the necessary FRAMES and GENII routines and support files. The file is called GENIISetup.exe for the Full Installation package. To install the package from the web site, copy the GENIISetup.exe file onto the user's computer. It may be copied into any temporary directory. Then, run the GENIISetup.exe routine. One way to do this is to use the Windows START – RUN commands, with \{user's directory}\ GENIISetup.exe in the box, where {user's directory} is the location of the file that has been copied.

A series of options will be presented by the setup program. If the user selects the "Complete" setup, all installation steps are automatic – including the destination directory. If you want GENII to be installed in a directory other than C:\FRAMES, select "Custom". It is recommended that the installation occur in the FRAMES directory suggested by the program: \FRAMES\ – several of the example problems assume that this directory is in use and will not execute properly if another is selected. (In addition, the FRAMES program does not handle long file names in directory structures, so if a different directory is selected, its name should conform to the older DOS conventions.) If the user selects "Custom" installation, the target drive and directory may be selected first. You have a selection of features to install: FRAMES is mandatory, and it is suggested that all of the GENII components be installed as well. The documentation and generic input templates may be omitted. A number of MEPAS modules will supplement GENII; the MEPAS code is also available if desired.

The installation routine will install any required Windows drivers and controls, if they are not already present on your host computer. Upon completion of the installation, it may be necessary to reboot the computer to allow the operating system to update itself to these newer components.

The file originally copied from the web site may be deleted upon successful installation; however, if it is retained on the user's system, repairs may be made to the installation if any files are lost or corrupted.

When the FRAMES and GENII programs have been successfully installed, the GENII Users Guide and Software Design Document will be found in the \GENII DOCUMENTATION subdirectory. These files comprise the GENII Version 2 Software Design Document. This is the complete technical documentation of the software algorithms. NOTE: These are Adobe Acrobat portable document (pdf) files, formatted for an HP® LaserJet 5 printer. They should print properly on other systems.

The installation package will place an icon for launching FRAMES on the desktop, as well as establish a FRAMES grouping on the Windows Start Menu.

FRAMES is invoked by double-clicking on the FRAMES 1.5 icon on the desktop, or from the same icon in the FRAMES group on the Start Menu. A simple way to test whether it is likely that the installation has been successful is to double-click the icon. A window similar to that shown in Figure 2.1 should appear. Click on the *Customize* command. A menu of several items should appear; the last item should be the word Logo followed by a small arrow indicating the availability of another submenu. Place the cursor over the word Logo, and a menu with the options Show and Select should appear. Click on Select, and a list of available logos should be presented. Click on the file geniilogo.jpg, and then hit the open button. The GENII V.2 logo should appear in the upper left portion of the FRAMES screen. This indicates that it is probable that the FRAMES and GENII components have all been loaded. The size of the FRAMES screen may be adjusted using the maximize/minimize buttons on the upper right, or by clicking and dragging on the diagonal hash marks on the lower right.

If it is desired at a later time to uninstall GENII and FRAMES, this may be done from the Windows Control Panel Add/Remove Programs command. This can be accomplished by using START/Settings/Control Panel/Add Remove Programs. Highlight the existing combined FRAMES and GENII installation, and hit the Add/Remove button. This will uninstall all of the program files originally installed; any input, intermediate, or output files generated in the interim will not be removed. It may be necessary to manually delete any remaining files and the FRAMES directory.

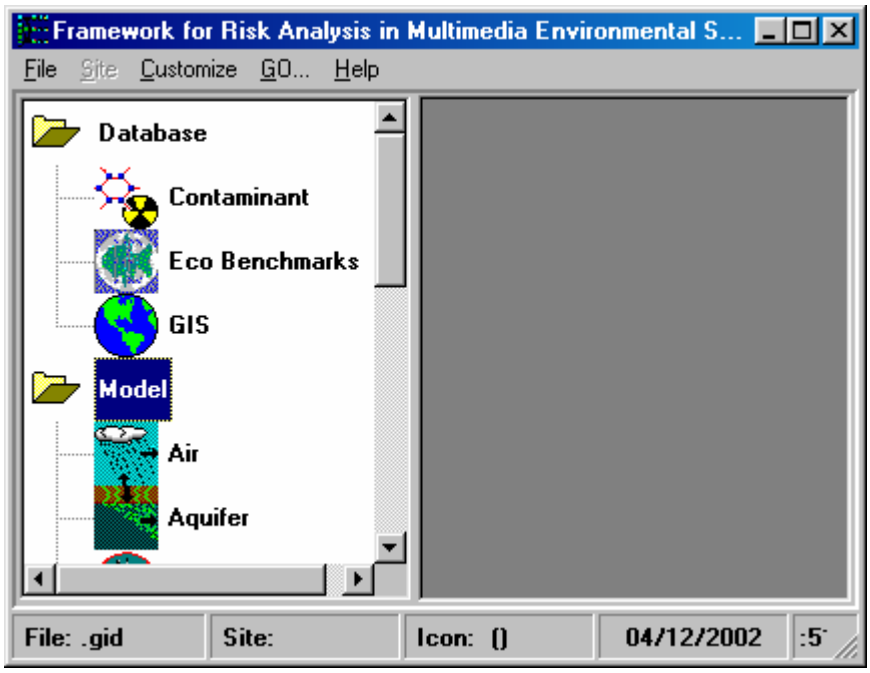


Figure 2.1. Initial FRAMES display, without the GENII logo showing.

3.0 USING FRAMES

The software platform from which different codes can be linked to communicate with each other is called the Framework for Risk Analysis in Multimedia Environmental Systems (FRAMES). FRAMES is an open-architecture, object-oriented system that provides an environmental database. This software platform aids the user in constructing a Conceptual Site Model that is real-world based. Further, the software allows the user to choose the most appropriate codes to solve simulation requirements and provides graphical packages for analyzing intermediate and final results. This section provides general information about using FRAMES.

3.1 Conceptual Site Models

The Conceptual Site Model is built by the user based on the conditions of the problem that is to be solved. The site is simulated on the screen by choosing icons to represent the various major environmental media or activities to be modeled and connecting lines that represent the real or potential flow of contamination.

Figure 3.1 illustrates the conceptual model for a specific modeling exercise as represented on the FRAMES main screen. For the hypothetical case represented in Figure 3.1, three major routes of contaminant transport are acting at a single location. Contamination is being released from a source into the atmosphere, and groundwater and surface water also are contributing contaminants to the environment at the location of interest. Contaminants are entering the food chain, individuals are being exposed, and, in this case, the effects of the contaminants on their health are being evaluated. Each icon on the Conceptual Site screen represents a real entity. For example, the River icon represents a local source of surface

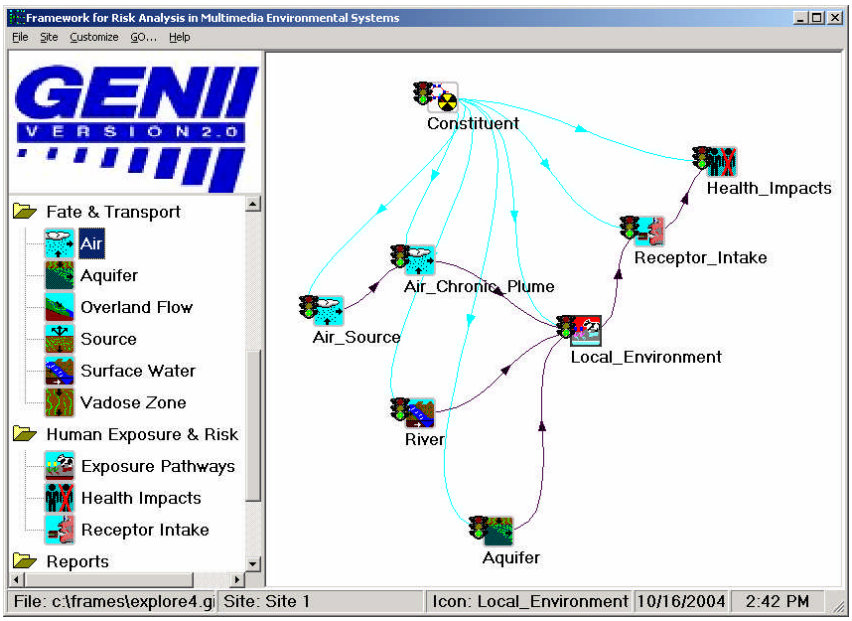


Figure 3.1. A GENII Conceptual Site Model represented in the FRAMES window

water, and the Aquifer icon represents the groundwater at this location. The dark lines connecting the icons on the screen visually show the paths that the contaminants follow. The lighter lines indicate that each icon is connected with, and has access to, information in the contaminant database. After the site model has been built and the case has been run, the user can view the results by running intermediate data viewers for each icon.

3.2 Basic FRAMES Controls

There are five standard menu items on the FRAMES menu bar. These are File, Site, Customize, GO, and Help.

The **File** menu consists of five groupings, in standard Windows® format. The first grouping includes **New, Open**, and **Close**. These are the first options invoked in creating a new input Conceptual Site Model, in editing an existing Conceptual Model, or in finishing work with one. Upon first starting FRAMES, no new activities can be started without first selecting either **New** or **Open**; either of these options activates the FRAMES workspace. For a new case, the system will prompt for a file name before the user is allowed to enter data into the first module user interface. The **Save** and **Save As** options save the current contents of the workspace in global input data (GID) files of the user's choice. The **Print** command sends information about the case displayed in the workspace to the printer. There are numerous available sub-options for printing: the Conceptual Site Model picture may be printed along with a user-prepared summary description, and for each icon in the model, summary information about the model selected, the input data entered, and any user-supplied references may be optionally selected. The user has the option of adding references to model and data selection choices throughout FRAMES and GENII; the most generally accessible place to start these descriptive additions is with the **References** and **Project Description** menu selections. Each of these menu selections opens a window in which textual information may be entered for later retrieval; the information entered is saved in ASCII files associated with the project's GID file. Such entries are a useful method of documenting decisions and data sources used in establishing the basis for an analysis. FRAMES retains links to the four most-recently accessed GID files; clicking the mouse on one of these is equivalent to using the **Open** command. Finally, the **Exit** command shuts down all FRAMES operations, after first providing the option to save any changes or additions made during the work session.

FRAMES offers several ways to organize the Conceptual Site Model. If the user so desires, several Sites may be related and saved in the same Global Input Data file. This option is available using the **Site** menu. The Site currently active is shown in the FRAMES workspace; the name of this site is displayed in the second box on the bottom of the FRAMES window, as illustrated in Figure 3.1. In Figure 3.1, the default Site name of *Scenario 1* is used. Clicking on the **Site** menu allows access to options to create a **New** Site, **Rename** the active Site, and switch between Sites. Use of multiple Sites within a single GID file may be an advantage to users with complex problems in simplifying data organization, reporting, or records holding.

The **Customize** menu provides the FRAMES user with the ability to control the overall look of the FRAMES window. Every icon in a Conceptual Site Model has an internal identifier used by FRAMES to control data flow to and from the component models. The

Show Object ID option allows the user to see the actual identifier assigned by FRAMES. This identifier is the default identifier used in the **General Info** command described below, and is stored in the project GID file. If the user will be reviewing the GID file for any reason, this is useful information; however, the display by be suppressed to simplify complex Conceptual Site Model displays. The **Show Icons** option may be used to simplify the display in the left-hand FRAMES window. Use of this option will remove the display icons from the selection window, leaving only the model type names displayed. The **Font** option allows the user to use any of the fonts available in Windows in the FRAMES display. (This option has been used throughout this Users Guide to make the reduced-size screen captures legible.) The **Colors** option gives the user the ability to change the display colors of the FRAMES background and various types of connecting lines. This capability may be used to make viewing easier under various conditions, to highlight specific features of a Conceptual Site Model, or to simplify complex diagrams in the FRAMES window. The **Logo** option, as illustrated in Section 2, allows the user to display a model logo in the box at the upper left of the FRAMES window. Generally, a FRAMES or GENII logo, or several stylized graphic depictions of contaminant transport in the environment, are available.

The **GO** command is a convenient way of running a computation after a Conceptual Site Model has been constructed. This single function starts FRAMES in completing all necessary steps in an analysis. All models are run in sequence; if data inputs are necessary, the data input is prompted before the models are run. This option will not run viewers or sensitivity/uncertainty modules. More is described about this below.

The **HELP** command will bring up a hypertext file summarizing the information in this Section of the Users Guide.

3.3 Navigating the FRAMES Window

In order to build a Conceptual Site Model in the FRAMES workspace, the user must select the appropriate model icons, connect them in the desired order, and assign models and data to them.

Icons are selected from those available in the left-had window. To select an icon, place the mouse cursor over the icon or icon label in the left window and double click the LEFT mouse button. This will add an icon of the selected type to the FRAMES workspace. Repeat until the desired icons are all selected. The only icon type required for all analyses is the Contaminant Database icon; only one of these is allowed per Conceptual Site Model.

Icons may be moved about the screen and arranged in any order. It is usually desirable to place the icons in an order that is logical from the physical description of the system and flow of data from beginning to end of the calculation, and that results in clear lines of communication. The icons are moved by placing the mouse cursor over them, clicking and holding the LEFT mouse button, and dragging the icon to the desired location.

The icons must be connected in the way that data and intermediate results will proceed. To connect icons, RIGHT-CLICK on the icon; from the menu that appears, place the cursor over the Connect-Disconnect selection, and a secondary menu listing the other available icons will appear; select the desired icon. Alternatively, the user may hold down the SHIFT

key then LEFT-CLICK and drag the arrow from one Icon to the next. Note, in FRAMES 1.5, all model icons must be connected to the Contaminant Database icon; the connecting lines for database connections will generally appear in a different color than the contaminant flow lines. To remove connector lines, use the RIGHT-CLICK Connect-Disconnect procedure or repeat the SHIFT, LEFT-CLICK, and drag used to connect the icons, tracing the same path. Lines may be added and removed as often as necessary during the Conceptual Model construction.

To delete an icon from the workspace, place the mouse cursor over the icon, click the LEFT mouse button, and select the Delete option from the menu that appears. Removing an icon will simultaneously remove any connecting lines attached to it.

All icons have an associated status indicator attached in the form of a "traffic light." The status indicator appears as an indicator on the left side of the icon. The indicator will change appearance as actions are taken during the case construction. When the icon is first placed in the workspace, and after it is first connected to other icons, it will appear all black. When a model has been selected and associated with the icon, it will display a red dot. When data entry for the model has been completed, the indicator will display a yellow dot. When the model has been successfully run, the indicator will display a green dot. The various appearances of the status indicator are illustrated in Figure 3.2.

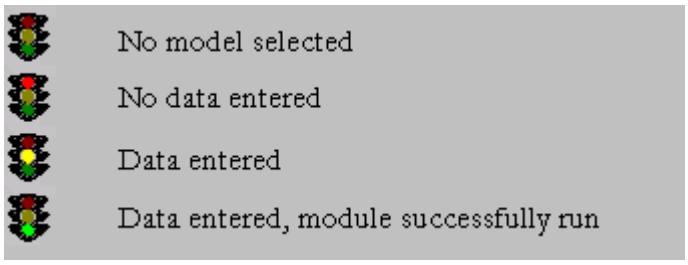


Figure 3.2. Appearance of the FRAMES icon status indicators.

When the overall design of the Conceptual Site Model is completed, individual computational models may be associated with the icons. To select a specific model from a module type icon, first ensure that all module connections are complete, then RIGHT-CLICK on the icon and choose **General Info**. The model selection screen will appear as shown in Figure 3.3. This screen will display the models that are available for assignment to this icon. The type of icon and the way that the connecting lines have been drawn will determine the models available. Two windows are shown on the left of the model selection screen, applicable and non-applicable models. The total number of models shown in both windows will be all those of this icon type available on the computer; the ones applicable to the situation as diagrammed will be listed as available. If the model desired is listed as non-available, it is usually because the connection lines have been drawn in such a way as to preclude its use, so the Conceptual Site Model may need to be reviewed or revised.

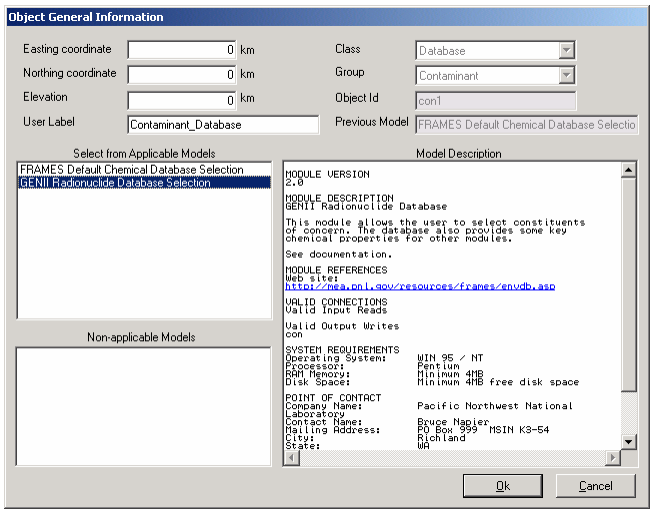


Figure 3.3. FRAMES Model Selection screen.

To select a particular model from the available list, highlight it with a LEFT click of the mouse cursor. This will place a summary description of the model in the large window on the right side of the screen. Note that default Object ID is listed on this screen and also used as the default for the User Label. This is the best time to name the icon in the User Label box if an identifier other than the default Object ID is desired to be shown on the FRAMES workspace. Other fields on this screen are associated with specific model inputs, and are described in their specific sections.

When the model has been selected, LEFT click on the OK button and the active window will return to the FRAMES workspace. If the model was selected correctly, the status light will be red.

The model selection activity should be repeated for all icons. This may be done manually for each, as described above, or the process may be speeded up using the **GO** menu.

Model selection must start with the first models in the connected string. Models available for the second, third, and subsequent icons in the chain may depend on those that have been selected earlier. Note that once a particular model has been selected, FRAMES then assumes that those further down the computational chain are dependent upon it. If, at a later time, changes are made to the **General Info** window, FRAMES will assume that subsequent modules also require review to ensure that the entire chain of calculations has not been altered. Thus, the sequence of status indicators will change from their prior state to solid black until the model selection and data entry have been reviewed.

Additional commands available with a RIGHT click of the cursor over an icon include **User Input** and **Run Model**. The User Input selection becomes available after a model has been selected. Selecting User Input will start the user interface for the specific model assigned to the icon. When all data have been entered, the Run Model selection will become available. This selection actually causes the model to run with the data input, creating whatever intermediate data it provides. Upon running the model, the Print/View User Input and

Print/View User Output options are activated. These selections start FRAMES data viewers that allow review of the input and output information for each module. These viewers are specific to the type of data being examined and are described in more detail in the specific sections for which they are applicable.

4.0 USING GENII

The GENII system includes the capabilities for calculating radiation doses following chronic and acute releases. Radionuclide transport via air, water, or biological activity may be considered. Air transport options include both puff and plume models, each allow use of an effective stack height or calculation of plume rise from buoyant or momentum effects (or both). Building wake effects can be included in acute atmospheric release scenarios. The code provides radiation dose and/or risk estimates for health effects to individuals or populations; radiation dose may be reported as either effective dose equivalent or organ dose, and health risk may be reported as cancer incidence or fatalities. GENII Version 2 uses cancer risk factors from Federal Guidance Report 13 to estimate risk to specific organs or tissues.

Data entry is accomplished via interactive, window-driven user interfaces. Default exposure and consumption parameters are provided for both the average (population) and maximum individual, however, these may be modified by the user. Source term information may be entered as radionuclide release quantities for transport scenarios, or as initial radionuclide concentrations in environmental media (air, water, soil). For input of released or initial concentrations, decay of parent radionuclides and ingrowth of radioactive decay products may be considered prior to the start of and during the exposure scenario. A single code run can accommodate unlimited numbers of radionuclides including the source term and any radionuclides that accumulate from decay of the parent, because the system works sequentially on individual decay chains.

The code package also provides interfaces, through FRAMES, for external calculations of atmospheric dispersion, geohydrology, biotic transport, and surface water transport. Target populations are identified by direction and distance (radial or cartesian grids for Version 2) for individuals, populations, and for intruders into contained sources.

GENII is intended to be used as a general-purpose package for estimating the consequences of radionuclides released into the environment. Available release scenarios include chronic and acute releases to water or to air (ground level or elevated sources), and initial contamination of soil or surfaces. GENII implements models developed for the U.S. Nuclear Regulatory Commission for surface water transport. GENII does not explicitly include modules for performing groundwater transport calculations, however the FRAMES system, in which GENII functions, allows addition of other computer modules to the GENII system. Exposure pathways include direct exposure via water (swimming, boating, and fishing), soil (surface and buried sources), air (semi-infinite cloud and finite cloud geometries), inhalation, and ingestion pathways. Special models are included for tritium and carbon-14; the tritium model includes exposure via skin absorption. An additional capability for releases of radon isotopes is included.

GENII Version 1 implemented dosimetry models recommended by the ICRP in Publications 26, 30, and 48, and approved for use by DOE Order 5400.5. GENII Version 2 implements these models plus those of ICRP Publications 56 through 72, and the related risk factors published in Federal Guidance Report 13. Risk factors in the form of EPA developed "slope factors" are also included. At the discretion of the user, different dose and risk approaches may be compared and contrasted. These dosimetry and risk models are

considered to be 'state of the art' by the international radiation protection community and have been adopted by most national and international organizations as their standard dosimetry methodology.

The GENII Version 2 system consists of four independent atmospheric models, one surface water model, three independent environmental accumulation models, one exposure module, and one dose/risk module, each with a specific user interface code. The computer programs are of several types: user interfaces (i.e., interactive, window- driven programs to assist the user with scenario generation and data input), internal and external dose factor libraries, the environmental dosimetry programs, and FRAMES-supplied file-viewing routines. For maximum flexibility, the code has been divided into several interrelated, but separate, exposure and dose calculations. The components of the system communicate with each other through a series of intermediate data files. Each of the intermediate files is accessible to the user through the FRAMES data-visualization utilities. Each module is also connected to the sensitivity/uncertainty driver SUM^3, which allows assignment of distributions to all input parameters and which will run the entire system in a Monte Carlo fashion.

Various source input modules are provided by FRAMES. The four atmospheric dispersion models are available for use depending on the nature of the problem to be solved and the quality of available data. The chronic gaussian-plume model can be run on either hourly or compiled joint-frequency data on wind speed, direction, and stability. The acute Gaussian and acute and chronic lagrangian-puff models require more-detailed hourly inputs, but provide more detailed transport modeling options. Dry and wet deposition, for gases and various types of particles, is estimated in each case. Utility programs are included to translate several types of available meteorological data into GENII input files. The single surface–water transport model incorporates simple and complex submodels for rivers, lakes, and coastal regions, and may be used for simulating either accidents or routine releases. As noted, GENII does not include a groundwater transport module, but others that function within FRAMES may be used if desired. The three terrestrial transport models are tailored for chronic accumulation, accidental releases, and defined initial contaminant distributions in surface or deep soils. The human intake module allows customization of the exposure of individuals to the environmental contamination; up to 15 categories of pathways (with as many as 4 pathways per category) for up to 6 age groups are available. The dose and risk module includes the older ICRP models (for comparison with DOE and NRC regulations), the newer ICRP models, and risk estimation using EPA slope factors, dose-to-risk conversion factors, or the latest Federal Guidance Report 13 methods. The various impacts modules are provided by FRAMES to manipulate, summarize, and organize output as desired.

General instructions for entering data into each of the necessary FRAMES and GENII modules are provided here.

4.1 Using the FRAMES Contaminant Selection/ Database Editor

A FRAMES module that is needed in all GENII scenarios is that for the contaminant database. This icon is needed in all FRAMES applications of GENII. Once the icon has been established on the scenario screen, a database must be selected. This is done by right-clicking on the contaminant icon and selecting *General Info*. This selection will open a

window similar to that in Figure 4.1. The GENII and FRAMES installation provides both a radionuclide-specific GENII database and a more general FRAMES radionuclide and chemical contaminant database. It is recommended that the user highlight the GENII Radionuclide Database and click the *OK* button. This will turn the indicator light to yellow on the contaminant database icon.

Next, right click a second time on the database icon and select the User Input option which will now be available. A screen similar to that in Figure 4.2 will open, allowing the selection of radionuclides for the case being evaluated. To select a radionuclide, the user may scroll through the list of available radionuclides in the lower left, or type the first few letters of the desired radionuclide in the *Search for* box at the bottom. When the desired radionuclide is visible, highlight it with a single left click. The radionuclide may be selected with either a double left click or by using the *Add* button. When all the desired radionuclides are selected, the user may either hit *File/Exit-Save Changes* or enquire about the nuclide properties.

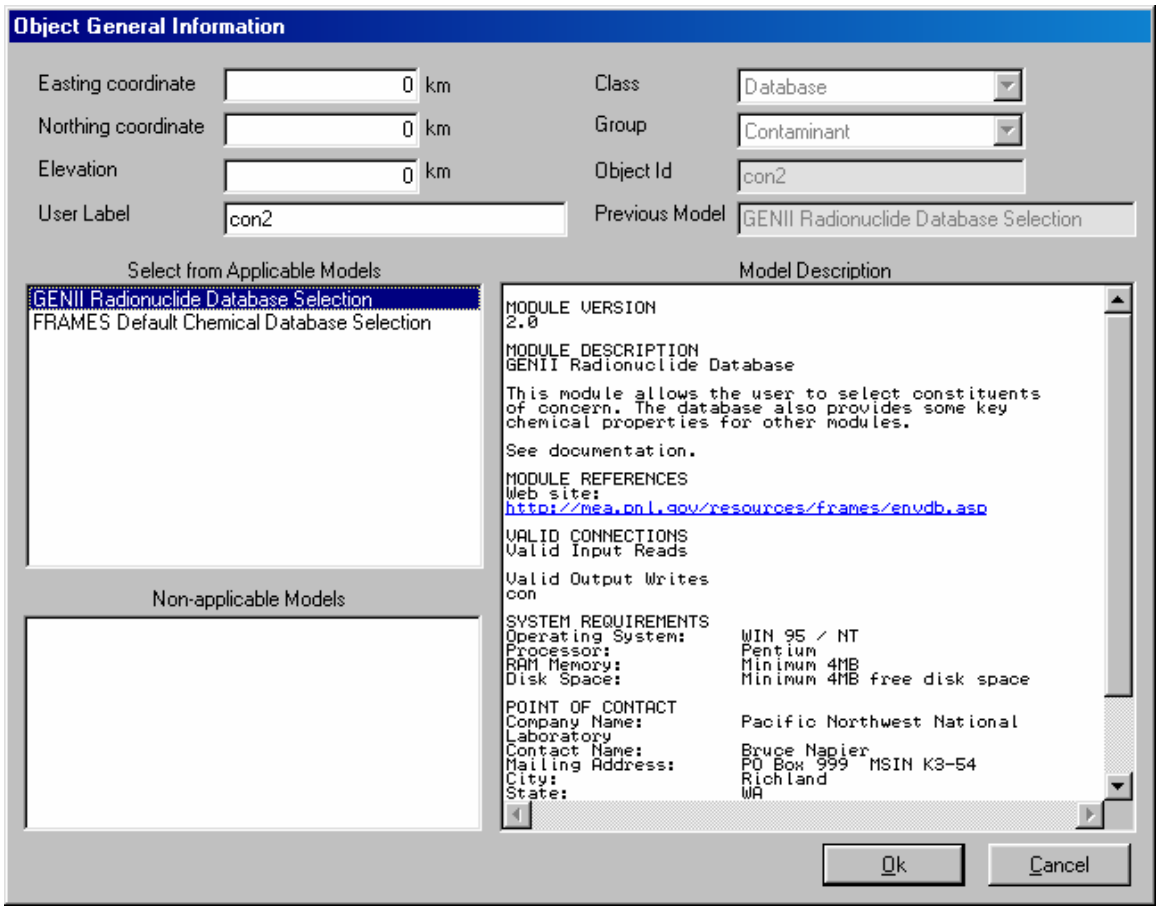


Figure 4.1. FRAMES database selection screen

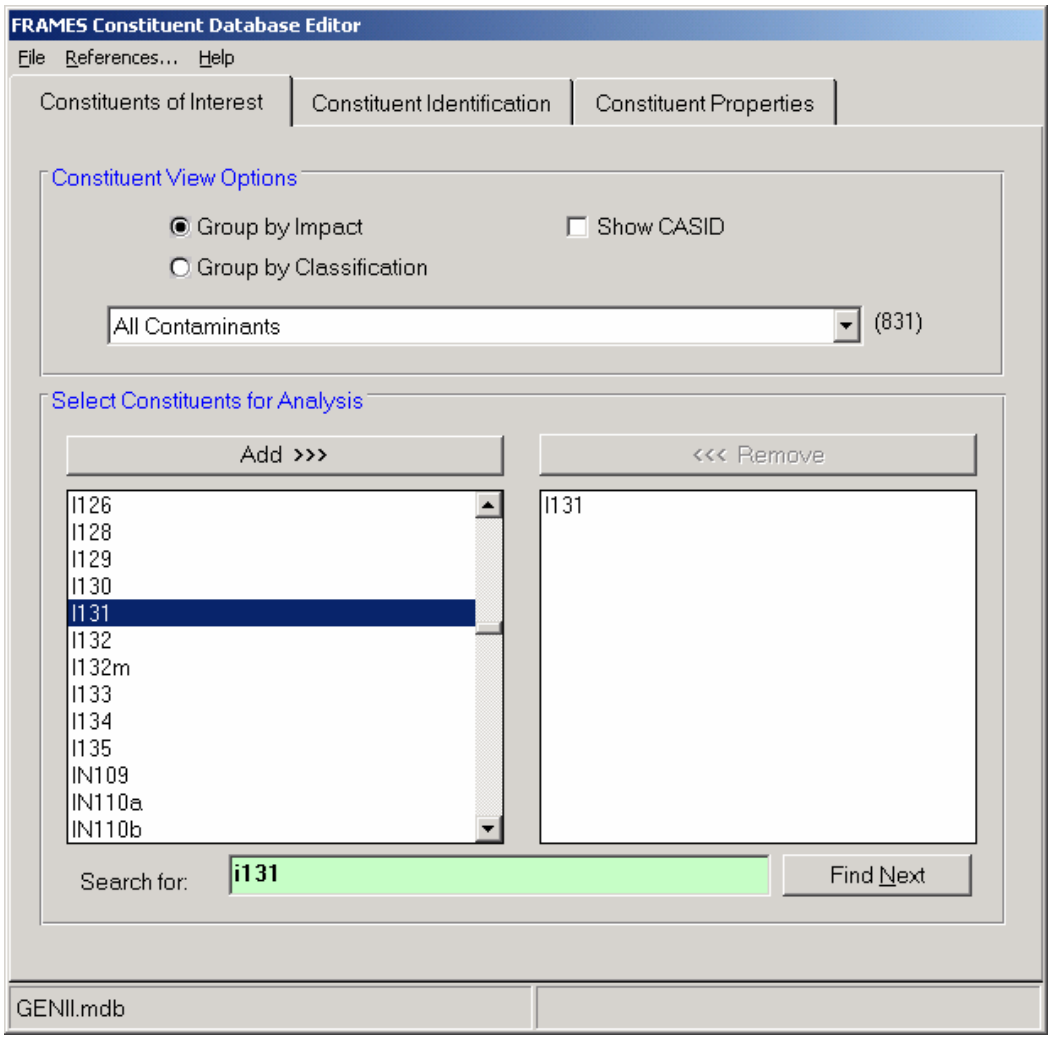


Figure 4.2. Database editor radionuclide selection screen

If the user wants to examine or modify the parameters in the database, the user should next hit the Constituent Properties tab. This will open a screen similar to that in Figure 4.3. On this screen are all of the default parameters used in the various calculations that are not accessible via the individual user interfaces. The parameters include a number of physical and chemical properties that are not used by GENII Version 2 (but may be used by other codes that are compatible with GENII). The database also includes radiation dosimetry parameters such as inhalation and ingestion dose and risk conversion factors (use of which are described in Section 11). Environmental transport parameters such as aquatic food bioaccumulation factors, soil-to-plant and feed-to-animal-product transfer parameters, and various environmental rate parameters are also shown (use of which are described in Sections 8, 9, and 10). The user may make TEMPORARY changes to the parameters for a single case using this screen from within FRAMES. PERMANENT changes to the database may only be made using the editor in stand-alone mode.

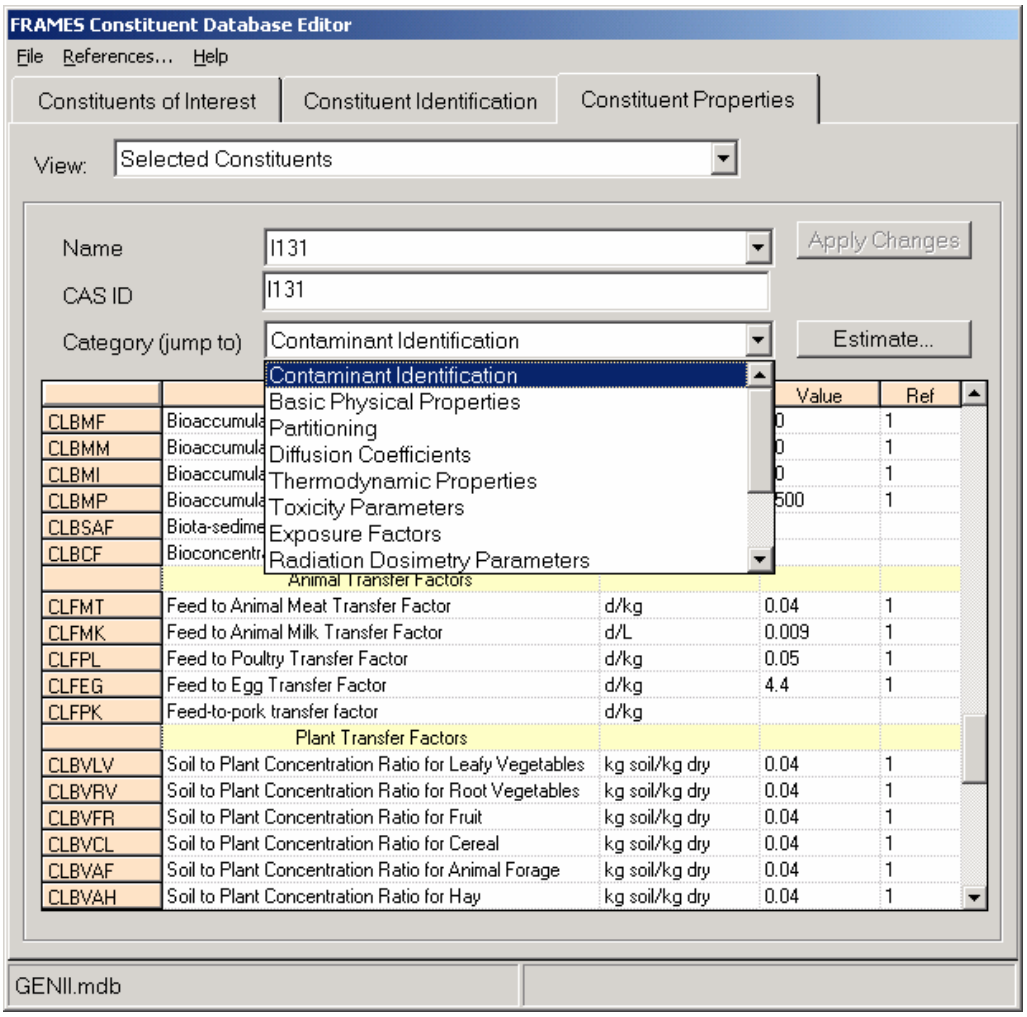


Figure 4.3. Database editor constituent properties tab

When the user has selected all radionuclides and modified all parameters required, the user should select the *File/Exit-Save Changes* tab and exit. This will set the indicator light to green on the Contaminant Database icon, and the user may proceed to the next set of inputs.

4.2 Using the FRAMES Known Source Modules

FRAMES provides utility programs for inputting data on the quantities of radionuclides emitted to the environment, along with several other related parameters that may or may not be required for GENII operations. The General Info selection will show available options based on FRAMES file type: AFF is Air Flux File, WFF is Water Flux File, SCF is Soil Concentration File, etc. An example of the type of input required is shown in Figure 4.4. The **File** menu item allows input data to be saved, or existing data to be reviewed and retained unchanged. The **Options** menu item has only one function – to allow

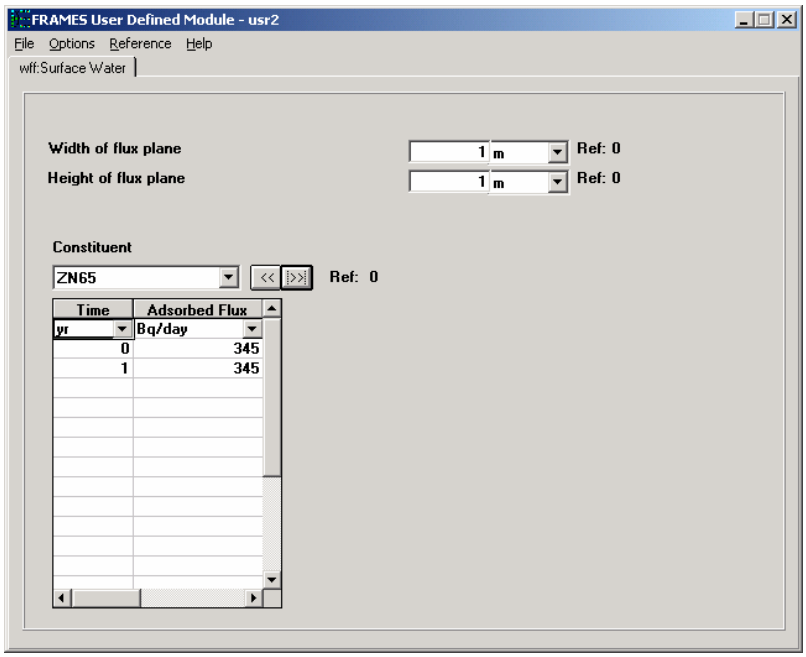


Figure 4.4. Example FRAMES Known Source Module input screen for surface water

input of decay progeny information if desired. This option may be used if the analyst wishes to set the emitted quantities of progeny to a non-zero value; the default is zero. Use of this option is illustrated in Figure 4.6 for a simple 2-member decay chain, ^{131}I.

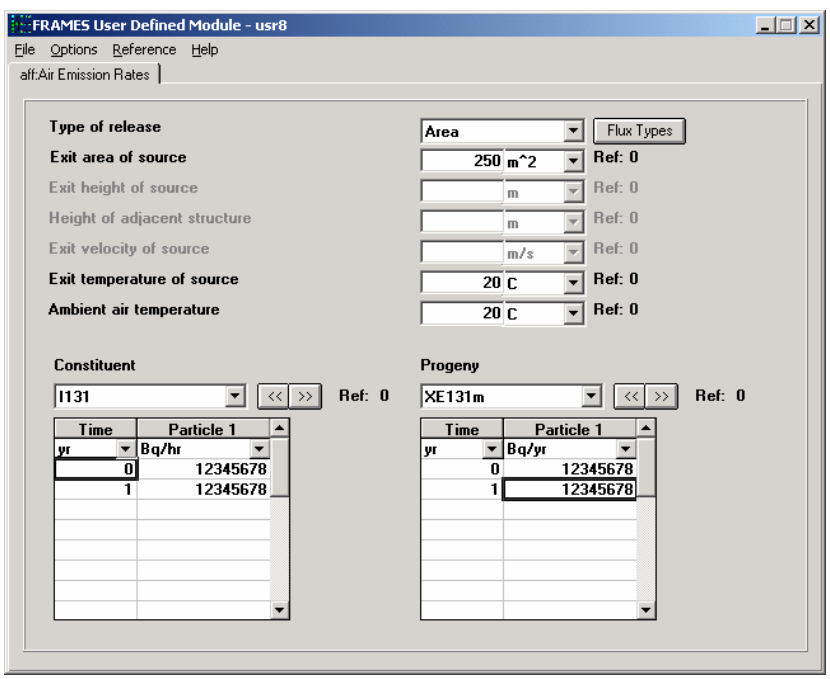


Figure 4.5. FRAMES Known Source screen for an atmospheric release, illustrating use of the **Show Progeny** Option.

The illustration in Figure 4.5 is for input of releases to the atmosphere. Input for an Area Source is illustrated; only the area of the source is required to describe the site conditions. If a point source (i.e., a stack release) were selected, the various descriptors of the source would also be required.

Note that inputs proceed for one radionuclide decay chain at a time. All progeny for the parent radionuclide, if the Show Progeny option is selected, must be entered. FRAMES allows time-dependent releases to be entered – GENII V.2 uses annual average release rates. Thus, GENII will integrate the total release entered in the Known Source module, divide by the total time, and use that as the annual average release rate. A quirk of this system is that FRAMES requires that a minimum of two time points be entered. An easy way to put in a known release over one year is to put it in as a square wave, as shown in Figure 4.5.

For releases to the atmosphere, there is a second required input screen in the FRAMES Known Source module, accessed using the **Flux Types** button. This screen is illustrated in Figure 4.6. This screen must be accessed before the Known Source module will allow input of the releases. It defines the number and type of particle sizes that the GENII atmospheric transport model will simulate. GENII will model particles, non-reactive gases (i.e., noble gases), and reactive gases such as iodine. If gases are to be simulated, the GAS 1 box must be checked. The fraction of the gases that are reactive must also be entered (this has no effect on the noble gases Ar, Kr, Xe, or Rn, or on elemental tritium). Up to three particle sizes can be modeled; information is supplied here for each particle size. When this information is entered, click on the **Done** button to return to the main input screen.

If soil contamination is to be modeled, a screen such as that illustrated in Figure 4.7 will be displayed. The only quirk to this screen is that GENII will only use the first time value entered, but FRAMES requires that 2 time points be entered. The site dimensions are not used by GENII; dummy values may be entered here.

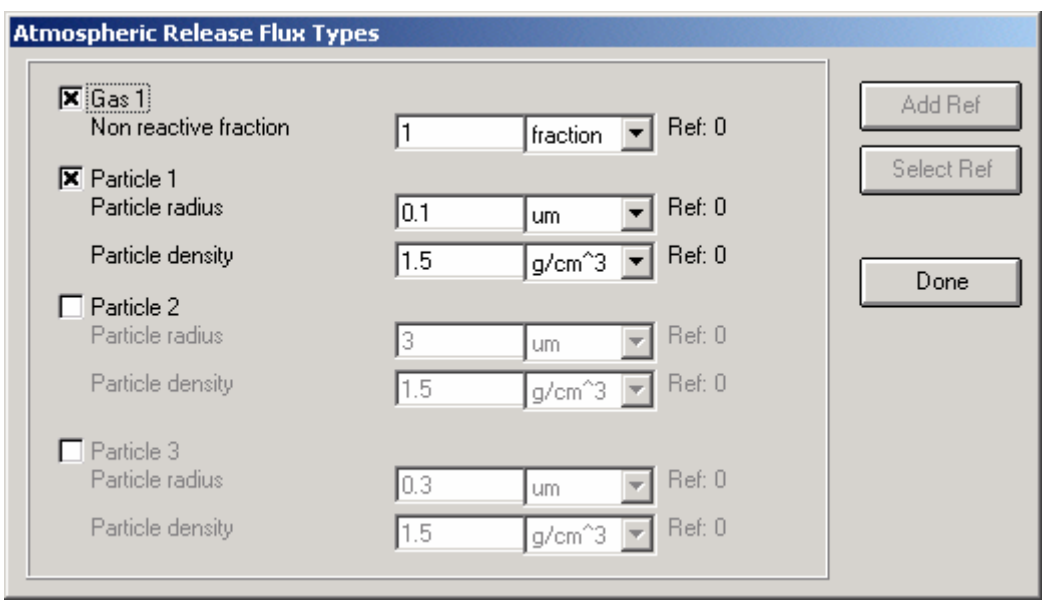


Figure 4.6. FRAMES Known Source Flux Types options.

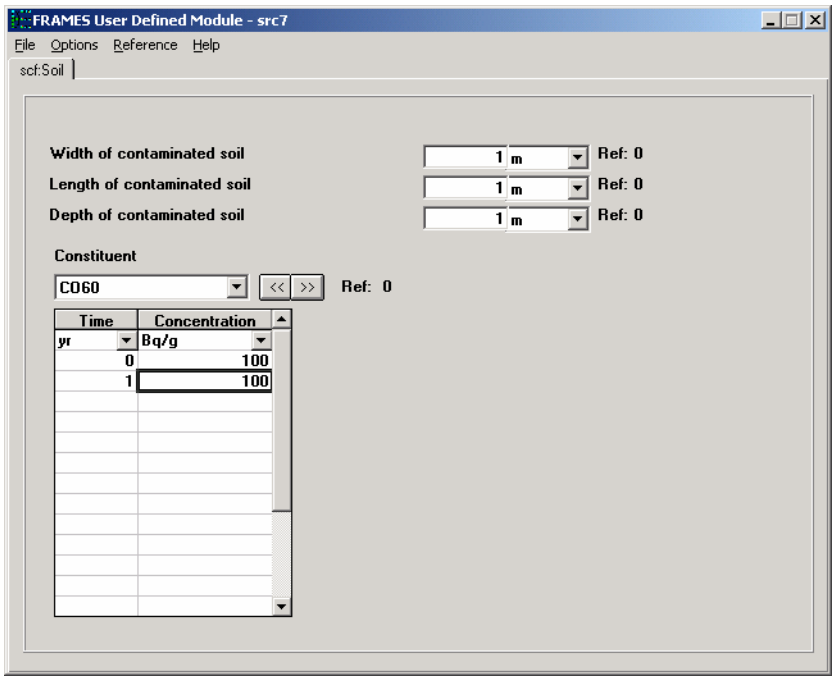


Figure 4.7. FRAMES Known Source Soil Concentration input screen.

4.3 Using the GENII Surface Water Module

The GENII surface water component allows the user to define the type of water body being modeled and necessary parameters for the selected type. The main screen of the GENII Surface Water Module User Interface is shown in Figure 4.8.

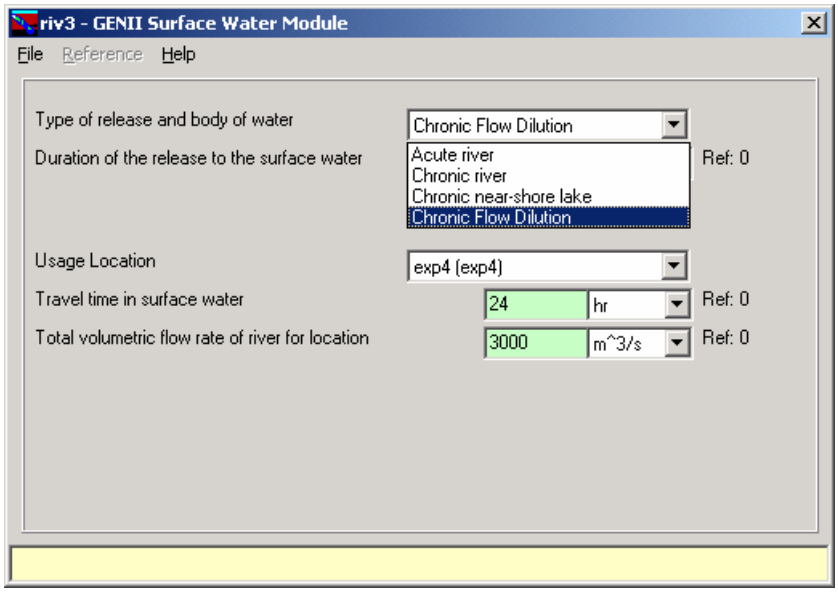


Figure 4.8 GENII Surface Water Transport Module initial screen

The File menu item allows either saving data input or exiting without saving. The Help menu item brings up a series of reminders of the nature and magnitude of the various input parameters on these screens.

Nearly all non-control parameters have the ability to associate a reference. These references are intended to help document the selection of parameters and allow traceability of assumptions. To associate a reference with a data entry, place the focus (click the cursor in the box) on the parameter of interest, click on the **Reference** menu item, and select either Add or Select. A window like that shown in Figure 4.9 will appear. If the **Add** option was selected, a blank entry will appear allowing text entry of a new reference. The entries are free formatted, so any short and long descriptor may be added. If the **Select** option is chosen, the available entries may be scrolled using the arrow buttons, or a specific entry searched for using the appropriate boxes.

Notice that all parameters requiring a numeric value have units and ranges. The code will internally convert from one set of units to another if the units tabs are selected. The allowable ranges for numerical values scroll across the bottom of the screen – values outside of these ranges will not be accepted. Unacceptable or incomplete entries are displayed with a red background; acceptable completed entries are displayed with a light green background.

Select the surface water type representative of the transport being evaluated. The current surface water types are: acute river, chronic river, chronic flow dilution (river), and near-shore lake. Click on the down arrow to see and select from the list of types.

The screen for near-shore lake environments is shown in Figure 4.10. The other model selections have similar screens.

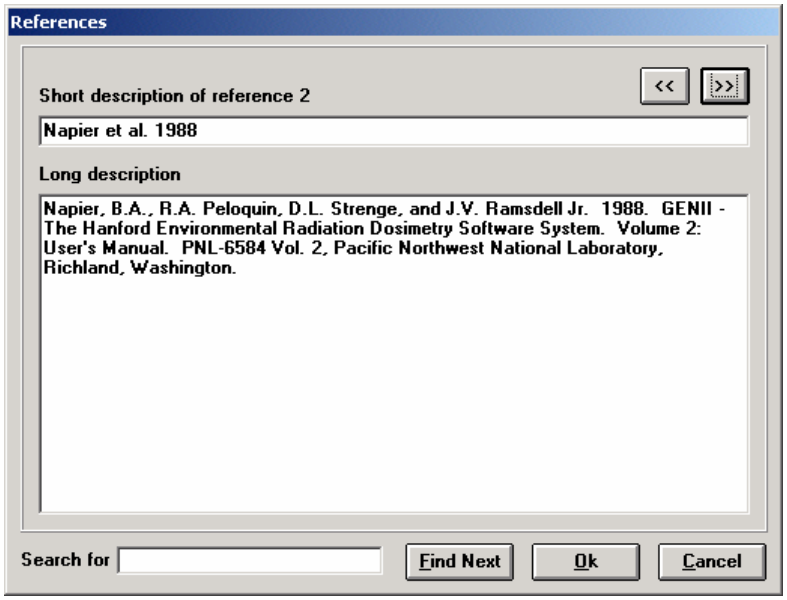


Figure 4.9. The Reference Editor window.

Enter the duration of the release to the surface water body and select the correct units. Note that the calculated water concentration is assumed to be released uniformly over this period, with zero concentration after the end of the release.

Select the exposure location associated with the surface water transport analysis. The locations shown are those currently defined and connected to this surface water transport glyph. If more that one exposure location is available (click on the down arrow to see the list of available locations), then information for all locations should be defined before saving and exiting the user interface.

Enter the time required for transport of water from the source to the exposure location and select the correct units. Note that decay and progeny radionuclide ingrowth is calculated for this period of time and included in the calculated water concentrations at the exposure location.

Enter the depth of the source discharge point to the near-shore lake environment and select the correct units. This parameter is used only for the near-shore lake model.

Enter the total volumetric discharge rate of the river at the exposure location and select the correct units. This is the dilution volume per time use to estimate the water concentration. This parameter is used only for the acute river model and the chronic flow dilution model.

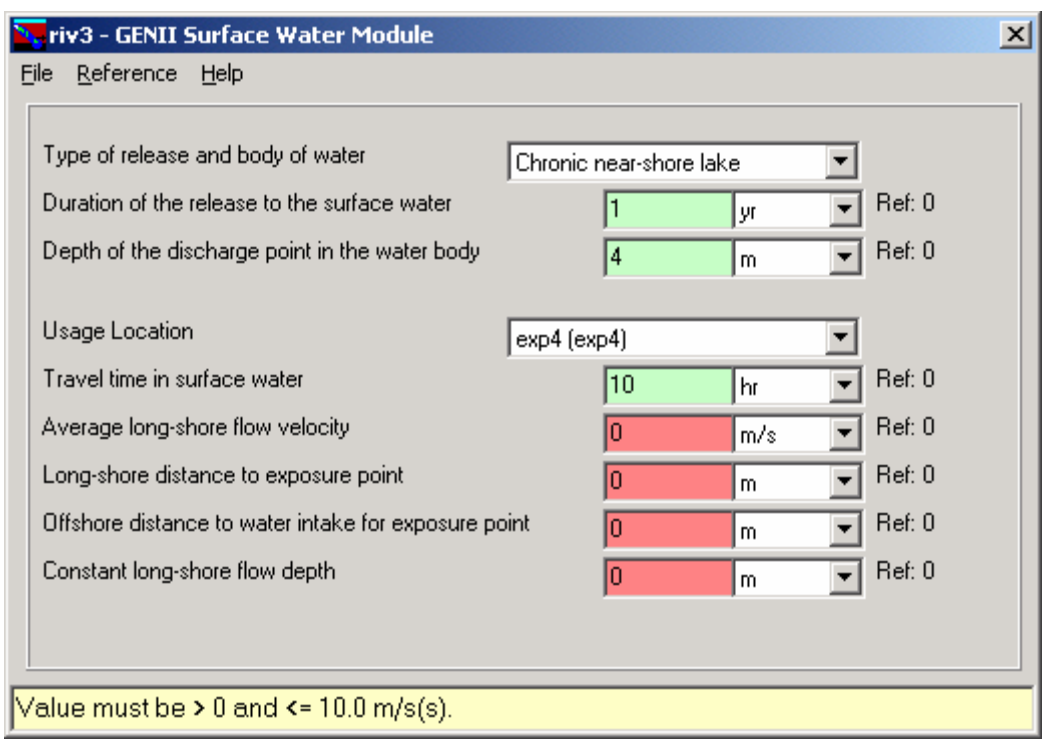


Figure 4.10. GENII Near-shore lake environment input screen

Enter the average flow velocity for the river or near-shore lake current and select the correct units. The models assume that the flow velocity is constant between the source and exposure location.

Enter the distance of flow between the source and the exposure location and the correct units. This parameter is used for the chronic river and the near-shore lake models.

Enter the perpendicular distance from the shoreline to the water intake port at the exposure location, and select the correct units. This parameter (offshore distance) is use for the chronic river and the near-shore lake models. The value entered for the offshore distance for the river model must be less than or equal to the value entered for the river width.

Enter the average depth of the river or near-shore lake flow path between the source and the exposure location, and select the correct units.

Enter the average width of the river between the source and the exposure location, and select the correct units.

When all data have been entered, click on the "File" header, and choose "Save and Exit". If the data are correct and no changes are required, the "Exit" command may be used instead – no updates to the input files will be made. If either of these techniques is not used to exit from the user interface, an error message will be generated and data will need to be re-entered.

4.4 Using the GENII Atmospheric Transport Models

Four atmospheric transport models are provided in the GENII package. These are chronic and acute plume (Straight-line Gaussian) models and chronic and acute Lagrangian puff models. Each is useful depending on the nature of the problem at hand and the data available. The puff models and acute plume model require hourly meteorological input; the chronic plume model will run with joint frequency of occurrence data as well as hourly inputs. Utility programs are provided to transform available data formats into the form required by GENII V.2 models.

The FRAMES Known Source Module is used to supply information to the GENII air transport models. The **General Info** model selection window (accessed by RIGHT clicking on the source and air transport icons) has two parameters that interact between the Known Sources and the air transport models. These are the Easting Coordinate and the Northing Coordinate for each source and for each air transport model (see Figure 3.3). These coordinates are used to describe the location of the sources relative to the center of the atmospheric dispersion grid. Figure 4.11 illustrates the effect of these parameters. For the case analyzed for Figure 4.11, two identical sources are postulated, one is at position –20 km Easting, 0 km Northing, and one is at +20 km Easting, 0 km Northing. The center of the atmospheric grid is set at 0 km Easting, 0 km Northing. Thus, the two sources are equidistant from the center of the grid to the east and west. The resulting graph of contaminant deposition (created with the FRAMES Gnuplot utility) clearly indicates two peaks of concentration surrounding the two sources, spaced to either side of the center of

the grid. This illustrates the joint use of the Easting Coordinate and Northing Coordinate in establishing release points.

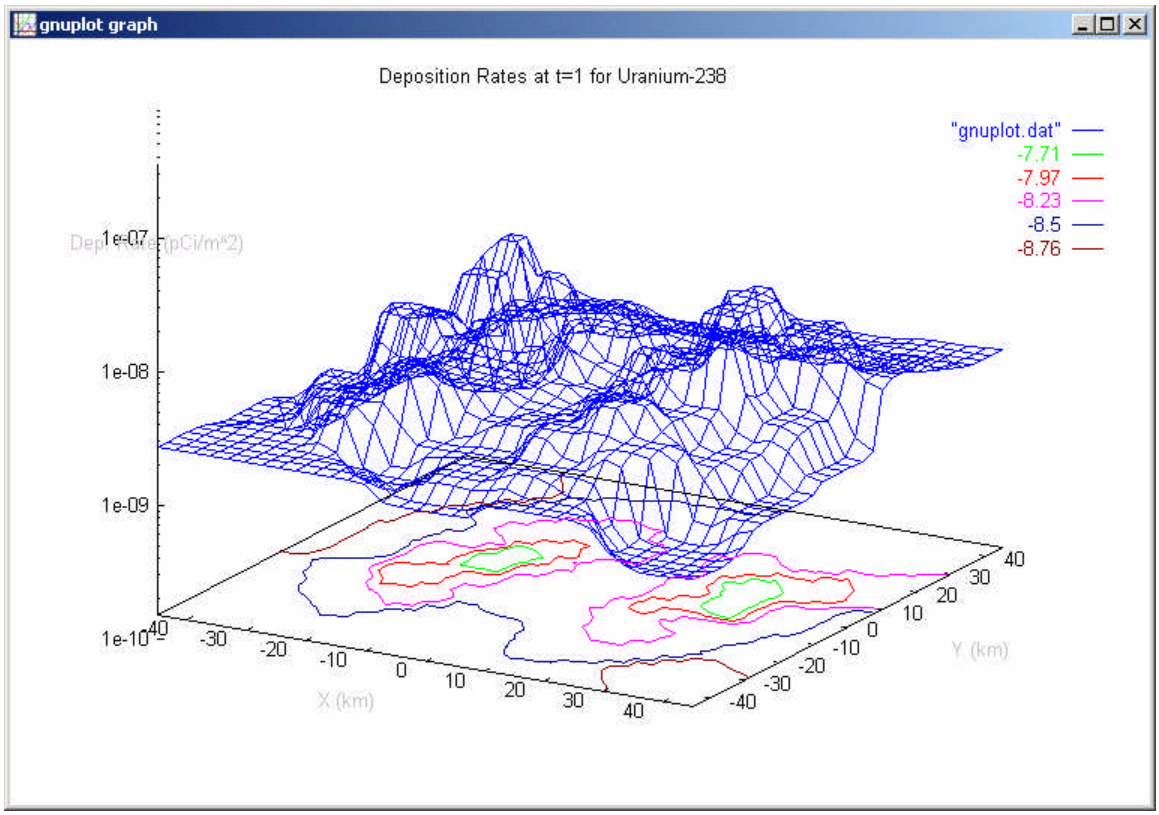


Figure 4.11. Result calculated with 2 sources 20 km east and west of atmospheric grid center

4.4.1 GENII Chronic Plume Model

The primary input screen for the chronic plume model is illustrated in Figure 4.12. The Chronic Plume model is useful for situations of moderate complexity, particularly when only averaged meteorological data are available.

The chronic plume model uses a radial grid. The number of radii is variable depending on the nature of the available data. If only compass point joint-frequency data are available, a 16-point compass can be used. If the data are available in 10s of degrees, a 36-point compass may be used. The downwind distances for calculations are user selectable. The defaults for the distances reflect 0.5, 1.5, 2.5, 3.5, 4.5, 75, 15, 25, 35, and 45 miles in meters.

Figure 4.13 illustrates the **Model Parameters** tab. These allow selection of the type of model desired for determining the magnitude of the Gaussian stability parameters. If the **Calm Wind Distribution** check box is invoked, additional information is required.

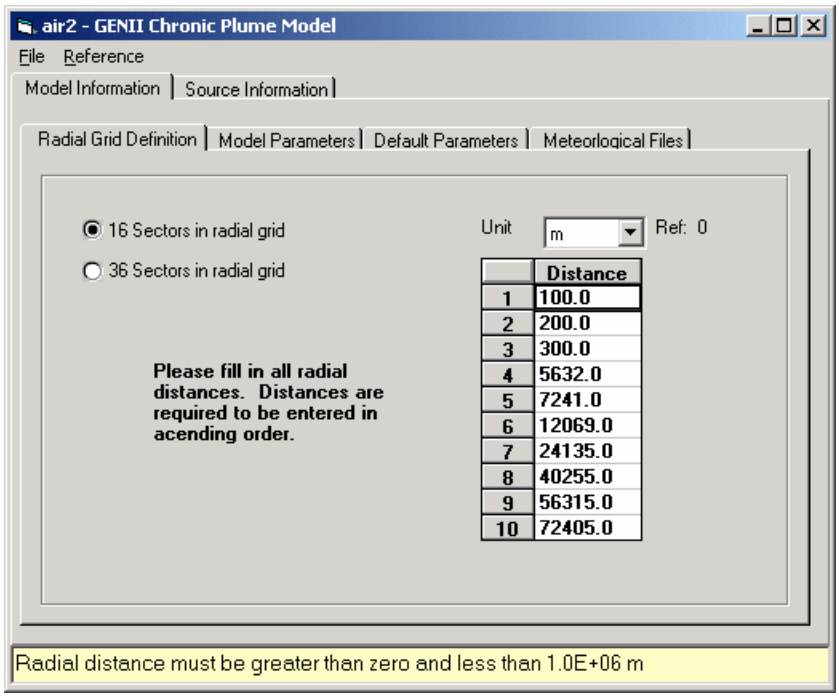


Figure 4.12. GENII Chronic Plume Model initial input screen

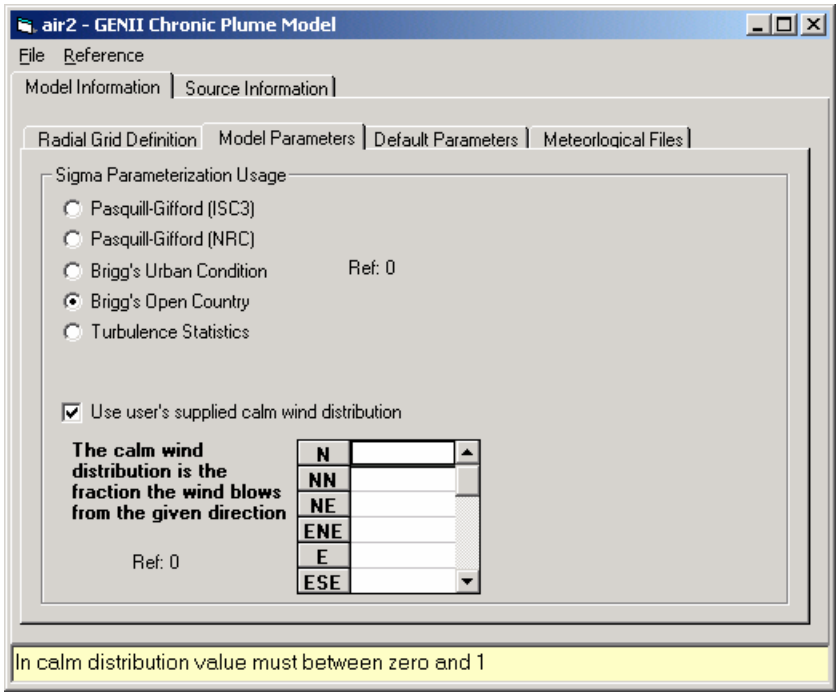


Figure 4.13. GENII Chronic Plume Model Parameters tab

The information provided on the Default Parameters tab is used inside the model. They are available here for code development and special implementation purposes. These parameters are discussed in the GENII Software Design Document; they are not typically changed by the user.

Figure 4.14 illustrates the **Meteorological Files** tab. This tab allows the user to direct the code to the appropriate meteorological data file for input. LEFT click on the Browse for Meteorological File button and a window to the file directory will be opened. If a file is available in the appropriate GENII format, simply select it here.

If a meteorological file in GENII V.2 format is not directly available for the chronic plume model, one may be created from other sources of data. If joint frequency data are available, the **Use Joint Frequency Data file** button may be chosen to activate the model to process the information into the appropriate format. If hourly data are available, the **Use SAMSON or CD144 formatted file** button is used. The necessary data types, file formats, and other processing information are described in Section 4.3.5 and the Appendix.

The submersion dose cloud shine library is generally fixed and not altered by the user.

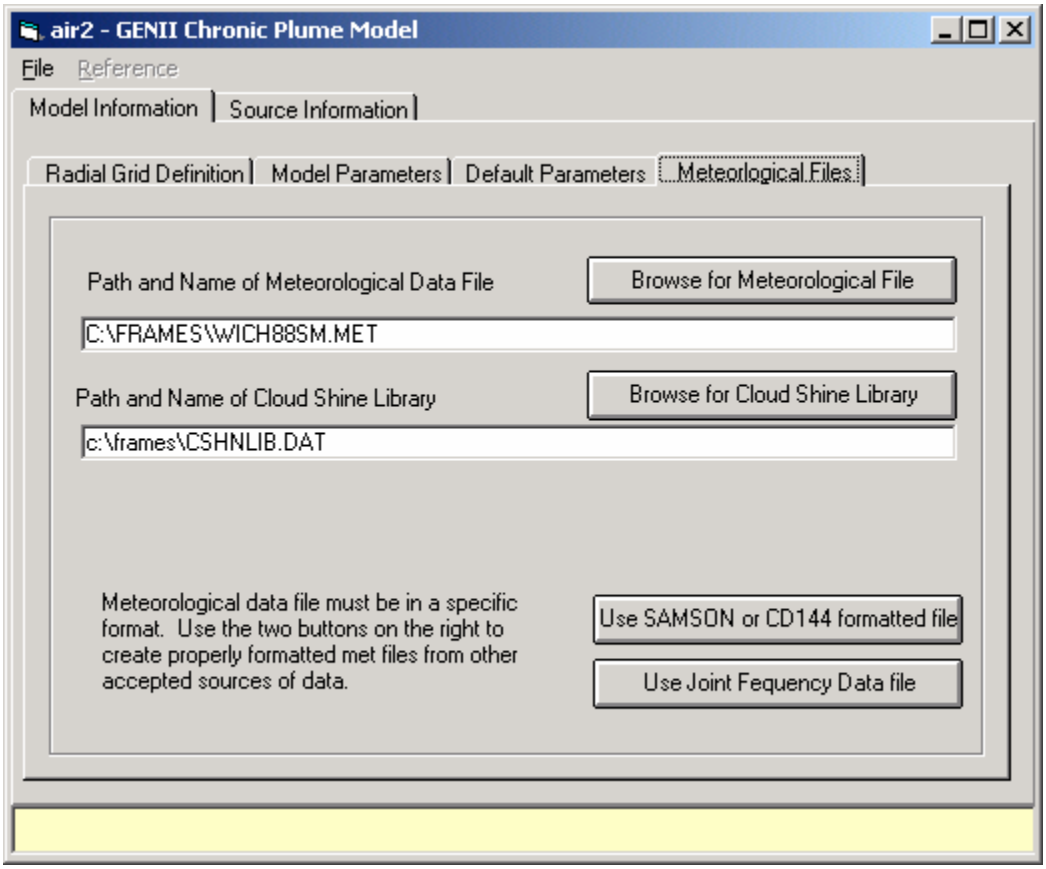


Figure 4.14. GENII Chronic Plume Meteorological Files tab

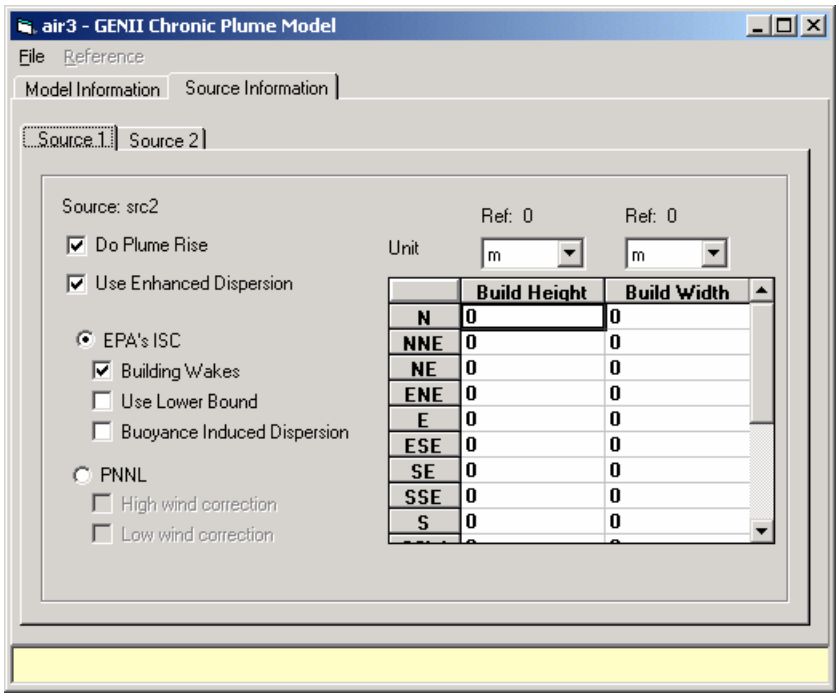


Figure 4.15. GENII Chronic Plume Source Information tab

The Source Information tab is illustrated in Figure 4.15. This tab allows selection of calculation of plume rise by the code. In addition, certain enhanced dispersion options, described in the GENII Version 2 Software Design Document, may be selected on this screen. These options require additional input describing the projected area of the buildings around the release point for building wake calculations. If multiple sources are being modeled, a separate tab is provided for each source point.

4.4.2 GENII Acute Plume Model

The primary input screens for the GENII Acute Plume model are very similar to those of the Chronic Plume model. This model also allows selection of a 16 or 36 point compass for dispersion and up to 10 distances. This model only accepts hourly input data, because it is dependent upon the time of the release. The input from the FRAMES Known Source module is a total release, not an annual average release.

The primary difference is the handling of the hourly input meteorological data. Note that the input data MUST be derived from hourly data; joint frequency data is insufficient. The **Model Parameters** tab is shown in Figure 4.16. This screen allows input of the date and time to begin the simulation. This parameter is key to the use of the atmospheric transport model in the estimation of stochastic dispersion using the SUM^3 processor. Note that the year, month, day, and time selected MUST be available in the meteorological file supplied on the Meteorological Files tab, or the simulation will not run. If the Use User's supplied Calm Wind Distribution box is checked, additional information is required on this page.

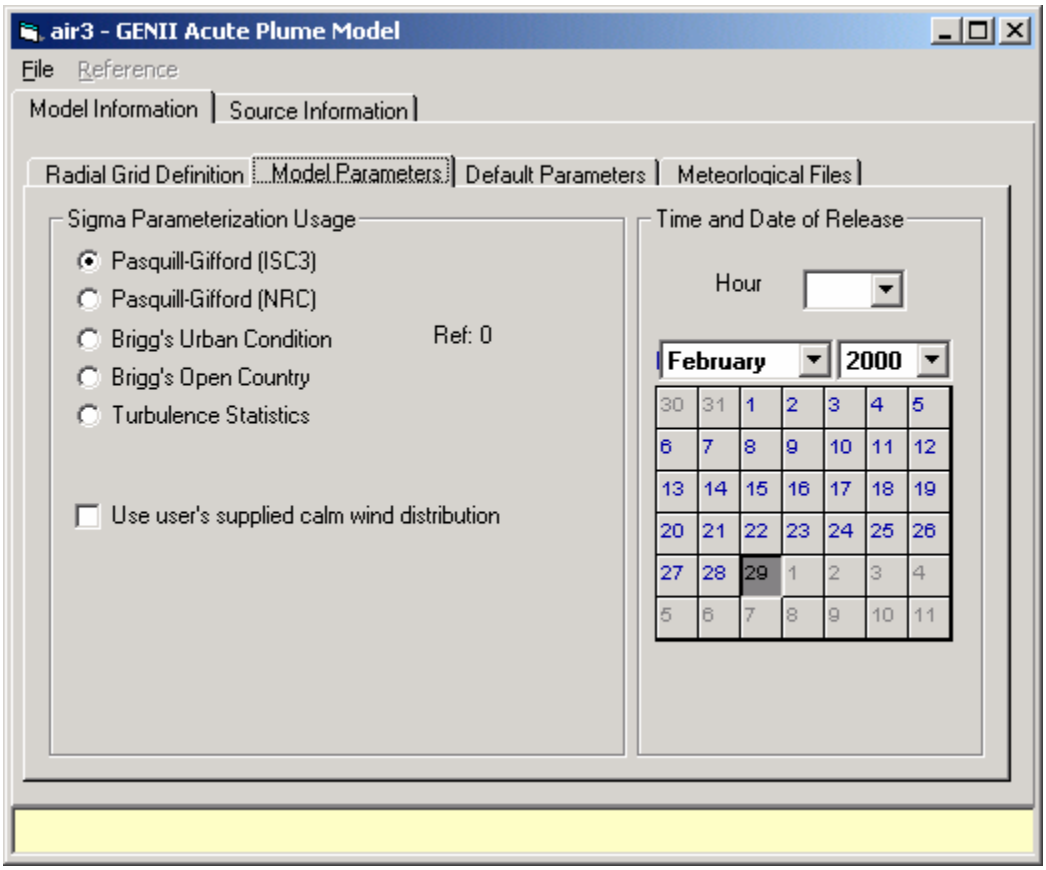


Figure 4.16. GENII Acute Puff Model Parameters input tab

4.4.3 GENII Chronic Puff Model

The initial input screen for the Chronic Puff model is illustrated in Figure 4.17. This screen is parallel in purpose to that shown in Figure 4.12 for the chronic and acute plume models. The puff models use a rectangular grid for computational purposes. The grid is defined by the number of nodes and distance between them (using an equal north-south and east-west spacing). The overall size of the resulting domain is calculated and presented in the lower boxes. This tab also contains the Set Surface Roughness box; if this is checked, the user must input an array of surface roughness values for the entire grid.

The computational complexity is directly related to the number of nodes selected. The model actually uses a somewhat larger domain for tracking puffs – some of those that go off of the grid continue to be tracked so that they may come back on again if the wind shifts. Note that numerical instabilities may occur if the domain is defined to be too small; the resolution of the answer is also dependent on the time step evaluated between puff releases. If the time step is set relatively large, puffs can blow over nodes without being considered – and if the domain is too small, the puffs can actually leave the domain without contributing to integrated concentration. This is a problem with small domains, particularly in areas with high average wind speeds. Related problems may appear for radionuclides with very short half-lives.

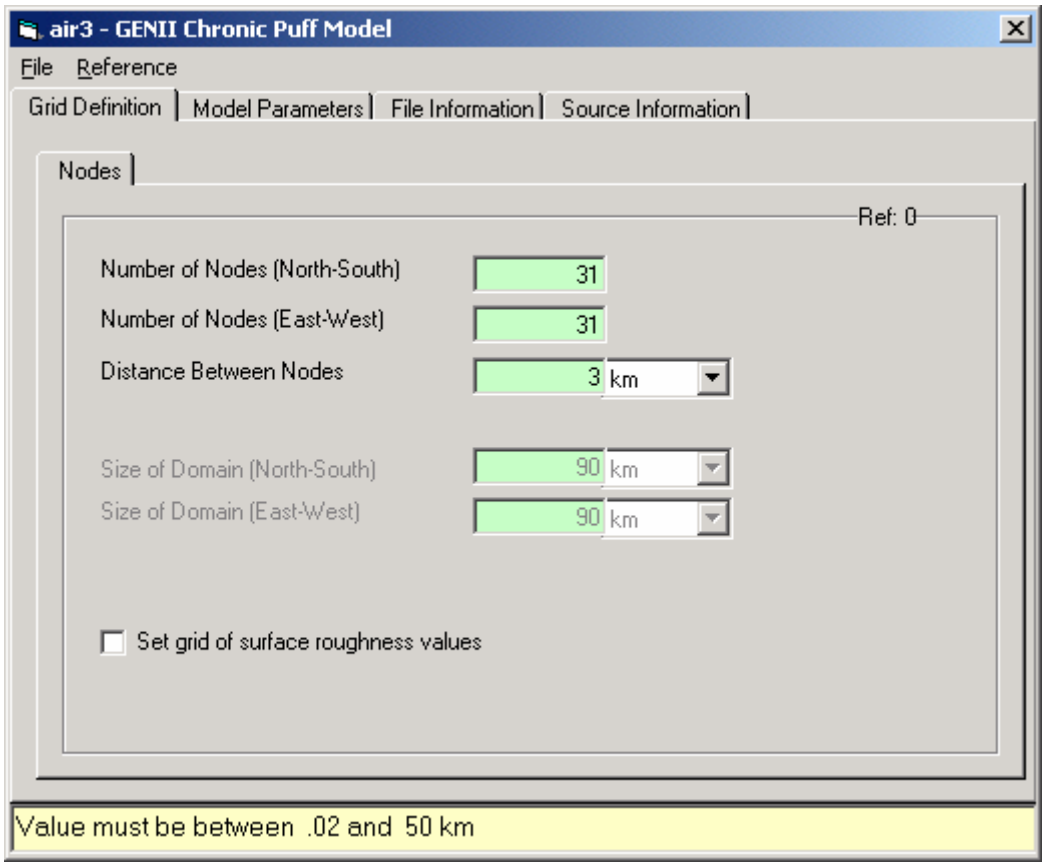


Figure 4.17. GENII Chronic Puff Model Grid Definition tab

The next tab is the **Model Parameters**. This also differs from the parallel tab in the plume models. It is illustrated in Figure 4.18. The **Other Parameters** sub-tab is essentially the same as the plume model **Other Parameter** tab. However, the **Puff Controls** tab is unique. The user will generally not need to revise these parameters. They control the size of puffs and the combining of puffs.

The **File Information** tab is similar to the equivalent tab in the plume models. Hourly data is required for input to the puff models; joint frequency information manipulated into a quasi-hourly format using the utility programs discussed in Section 4.3.5 will NOT work in the puff models.

The **Source Information** tab is similar in concept with that used with the plume models. However, rather than define a series of building dimensions for determining building wake effects, the dimension of the dispersion parameter itself is entered as a simplified method of performing the equivalent calculation. This is illustrated in Figure 4.19.

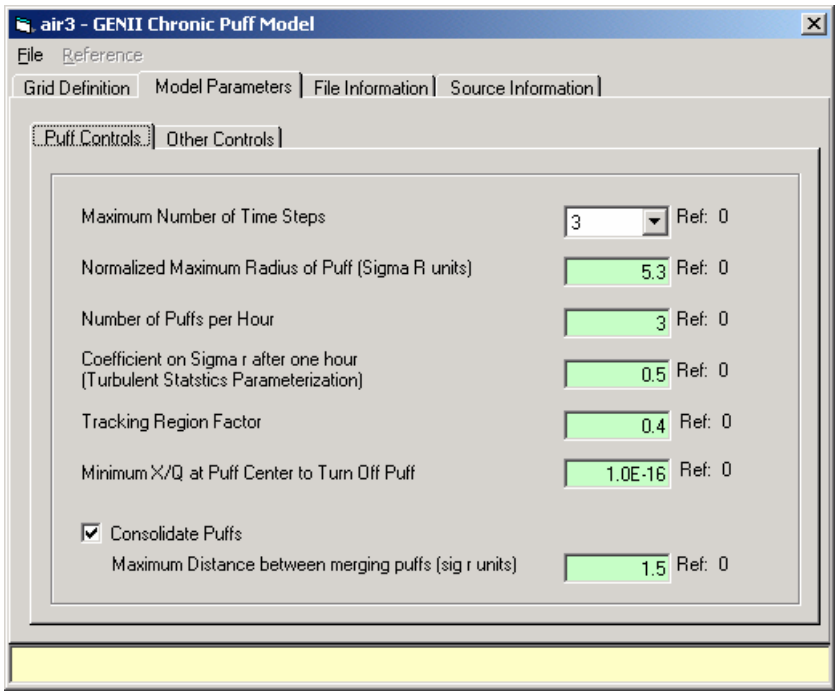


Figure 4.18. GENII Chronic Puff Model Parameters/Puff Controls tab

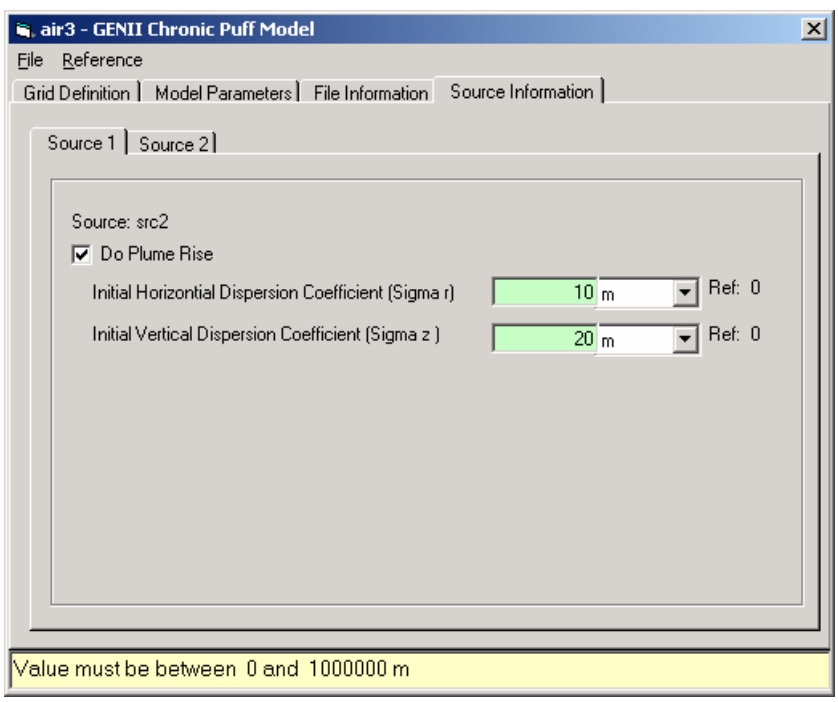


Figure 4.19. Source Information tab for approximating building wake effects.

4.4.4 Acute Puff Model

Inputs to the GENII Acute Puff model are essentially identical to those for the Chronic Puff. The **Model Parameters** tab for the Acute Plume model has one additional tab, **Time and Date of Release**, illustrated in Figure 4.20 – it tells the code at what time to begin the simulation using the hourly data, in a manner parallel to that used by the GENII Acute Plume model. It is again necessary that the starting time specified actually be included in the meteorological data supplied to the code on the **File Information** tab.

Other parameters are similar to those described above.

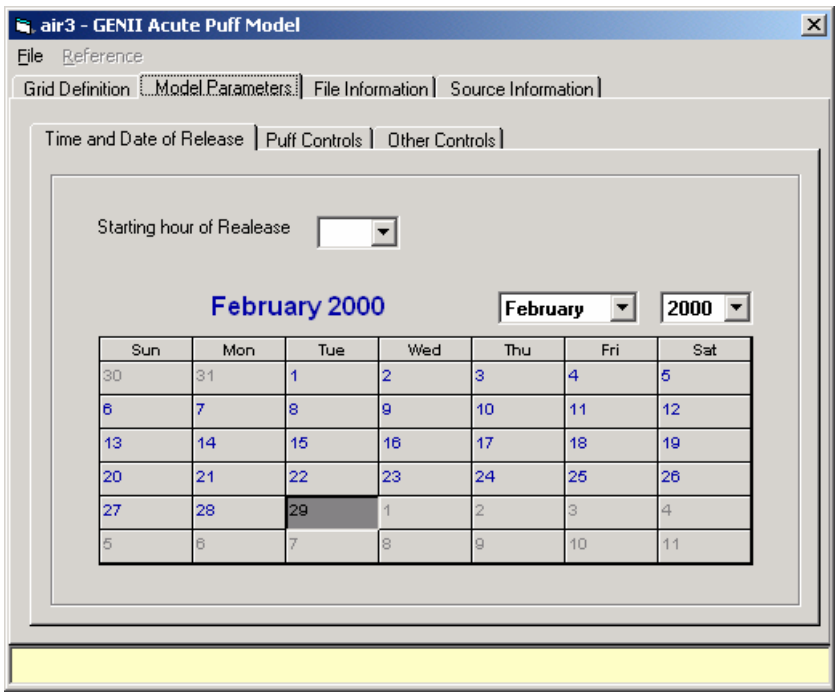


Figure 4.20. GENII Acute Puff Model start time inputs.

4.4.5 Formatting Meteorological Data for GENII

The GENII meteorological models run from files of hourly meteorological data in a specific format. If a meteorological file in GENII V.2 format is not directly available, one may be created from other sources of data. If joint frequency data are available, the **Use Joint Frequency Data file** button may be chosen to activate the model to process the information into the appropriate format for the chronic plume model. If hourly data are available, the **Use SAMSON or CD144 formatted file** button is used for the chronic and acute plume and puff models. The necessary data types, file formats, and other processing information are described in the following Sections.

4.4.5.1 Standard GENII Meteorological Data Format

The first record of the meteorological file contains the surface roughness of the site (see Section A.2.3) and the height of the wind measurements. Following the first record are the records containing the meteorological data. Each record after the first contains the year, month, day and hour of the record. Following the date and time are the stability class, the flow vector (wind direction plus 180 degrees, i.e., the direction the wind is blowing towards), the wind speed, the dry bulb temperature, the mixing height, the precipitation type (e.g, none, light rain, light snow), the precipitation rate, and a weighting factor. The format of the file is given in Appendix B.

4.4.5.2 Converting Joint Frequency Data to GENII V.2 format

Joint frequency data (JFD) may be used to simulate hourly data for the GENII chronic plume model. Two different formats of JFD are read by the GENII processing program, the format used by the EPA's Industrial Source Complex (ISC3) model (EPA 1995a) and the format used by the GENII (Napier et al. 1988).

The ISC3 format, also called the STAR summary, is described in EPA (1995a) and is summarized here. The JFD in the STAR format is normally constructed using 16 wind direction sectors, with the first 22.5-degree-wide sector centered on winds from the North (increasing clockwise), six wind speed classes, and six stability classes. Wind speed classes are usually grouped as 0-3, 3-6, 6-10, 10-16, 16-21, and greater than 21 knots. Stability classes are based on the Pasquill stability categories (A [very unstable] - F [very stable]). Thus, the JFD file in the ISC3 format normally consists of 96 records. Each record is for a specific stability class and wind direction sector. Within each record is the frequency for the six wind speed classes for the given stability class and wind direction sector. In a quasi-programming sense, the file would be read as follows

```
Loop On I = 1, Number of Stability Classes (normally 6)
  Loop On K = 1, Number of Wind Direction Sectors (normally 16)
    READ (JFDFILE,'(6F10.0)') (FREQ(I,J,K), J = 1 to Wind Speed Classes)
  End Loop On K
End Loop on I
```

where FREQ(I,J,K) = Frequency of stability class I, wind speed class J, and wind direction sector K.

Thus, in a normal STAR summary the first 16 records are for sixteen direction sectors of stability class A (or 1), the next 16 are for stability class 2, and so forth. A selection of STAR files is provided with GENII – these are listed in Appendix D.

The user provides the number of wind direction sectors, stability classes, and wind speed classes. So, as long as the JFD follows the above format (records containing the frequency by wind speed class; records ordered by wind direction sector then stability class), the number of stability classes, wind direction sectors, and wind speed classes can vary.

Table 4.1. Format of Joint Frequency Distribution of Wind Speed, Wind Direction, and Atmospheric Stability for GENII.

Record Number	Field Number	Data Type	Field Size	Description
1	1	CHARACTER	80	Descriptive Title
2	1	CHARACTER	80	Secondary Title
3	1	INTEGER	5	Number of wind speed classes in file
3	2	INTEGER	5	Number of atmospheric stability classes
3	3	INTEGER	5	(Not Used always set to 1)
3	4	INTEGER	5	(Not Used always set to 1)
3	5	REAL	10	Height at which wind speed data was collected (m)
4	1 - 10	REAL	7	Average Wind Speed for each wind speed class (m/s)
Joint Frequency Data Set				
5 till end	1-16	REAL	5	Percent of time with wind from North, North-Northeast, Northeast, etc.) Each record has the 16 sectors. Data are grouped first by atmospheric stability class and then by wind speed group.

The GENII format is different from the ISC3 format. A description of the format is given in Napier et al. (1988), and is summarized here. Unlike the ISC3 format, the GENII format contains the percentages (frequency times 100) rather than frequencies of a given stability class, wind speed class, and wind direction sector. The JFD is usually constructed based on 16 wind direction sectors like the ISC3 format, but a variable number of wind speed class and atmospheric stability classes may be used. Table 4.1 shows the format of the GENII JFD file.

The GENII format JFD file has the first four records containing information about the joint frequency data set, and the rest of the records are the joint frequency data set. In the same pseudo-programming language, the joint frequency data set would be read as:

```
LOOP ON I = 1 TO Number of Wind Speed Classes
   LOOP ON J = 1 TO Number of Stability Classes
      READ( JFDFILE, '(16f5.0)') (PREC(I,J,K), K = 1 to Number of Direction Sectors)
   END LOOP ON J
END LOOP ON I
```

As with the ISC3 format, the user provides the number of wind speed classes, wind direction sectors, and atmospheric stability classes.

In order to convert joint frequency data to the hourly format needed for the GENII chronic plume model, a utility program is provided. It is accessed from the **Use Joint Frequency Data file** button on the Chronic Plume model **Meteorological Parameters** tab (Figure 4.14). Left clicking on this button brings up the program screen illustrated in Figure 4.21.

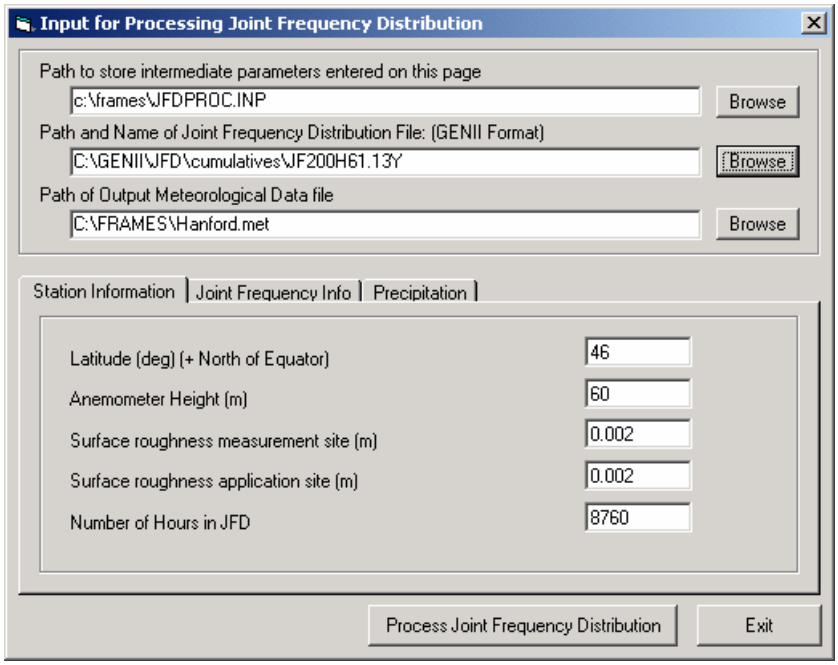


Figure 4.21. Initial input screen for processing joint frequency information

The three **Browse** buttons on the upper right allow the user to define a file in which to store the processing requirements, identify the source of the joint frequency data, and save the resulting quasi-hourly data file. The first and third fields allow the user to either select an existing file name (in which existing data will be overridden) or type in a new name. The second field allows the user to find an existing file; when the existing file is selected, the user is prompted to identify it as containing either STAR or GENII formatted data. The three tabs on the lower portion of the window allow input of data needed in the expansion of the JFD to quasi-hourly data. The **Station Information** describes the location and nature of the meteorological station from which the data are derived. The **Joint Frequency Info** tab, Figure 4.22, provides information needed in the processing. The meteorological information in the JFD file does not include date/time information. The JJFDPROC program instead creates pseudo-hourly data where there is one record for each wind speed class, wind direction sector, and stability class found in the JFD. In addition, the number of records will be expanded based on variation of the temperature and precipitation type. GENII V.2 provides representative precipitation information that may be combined with standard JFD files, via the **Precipitation** tab illustrated in Figure 4.23. How these variations expand the

number of records is explained in Appendix Sections A.3.5 and A.3.6 for temperature and precipitation, respectively.

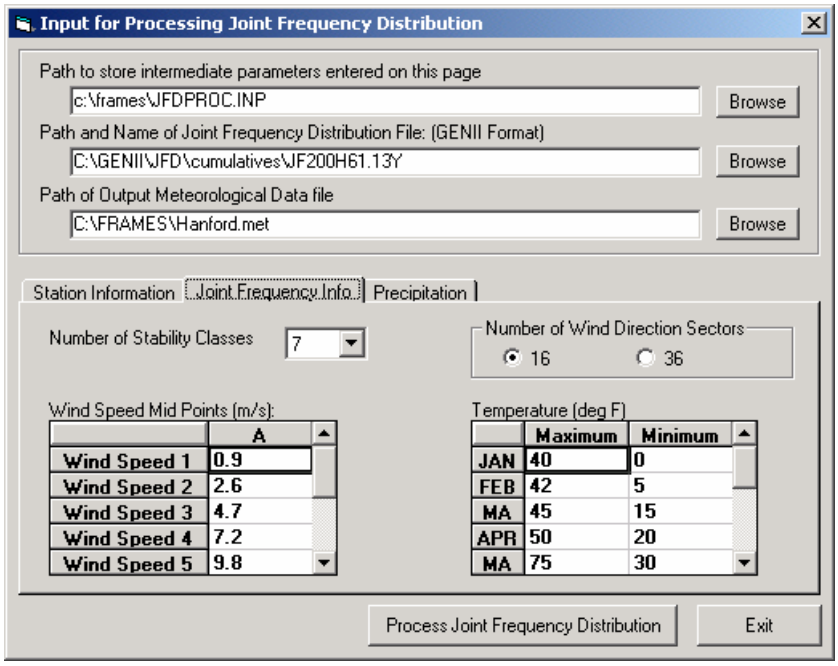


Figure 4.22. Joint Frequency Info tab inputs

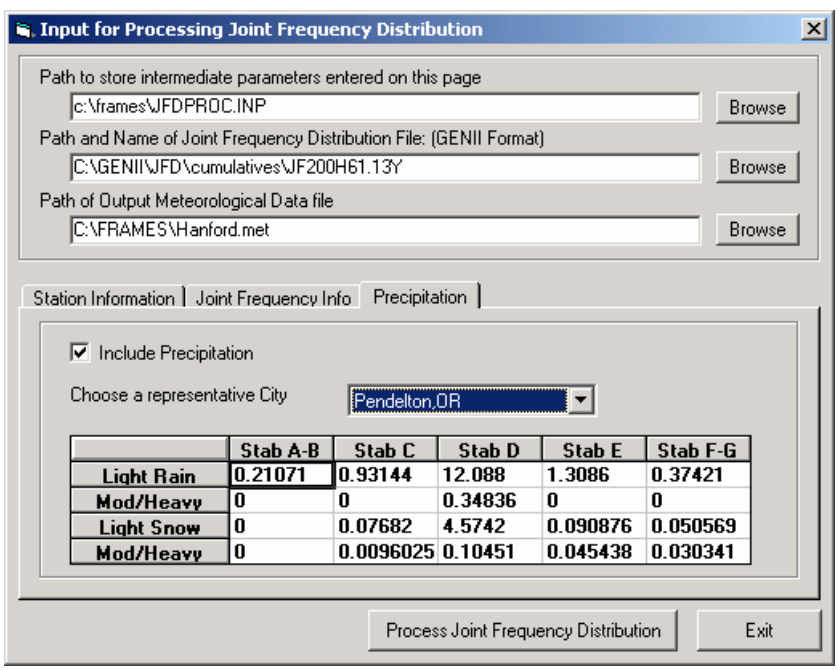


Figure 4.23. Including representative precipitation data with JFD inputs

When all data have been input, LEFT click on the **Process Joint Frequency Distribution** button. The JJFDPROC processor will create a file in the appropriate GENII V.2 hourly format. The output records have a weighting factor that is the number of hours with the meteorological data contained in the record. As there is no date/time information, the year, month, day, and hour for each record is given as -1. The data will be stored in the file assigned in the second box. Exit from the processor program back to the **Meteorological Files** tab (Figure 4.14) and enter the newly created filename in the box for **Path and Name for Meteorological Data File**.

Joint frequency data have historically been the most common form of meteorological summaries available. Joint frequency data from the CAP-88 code for are large number of locations are available; these have been modified and are provided in a STAR subdirectory of data along with the GENII V.2 installation. See Appendix B.

4.4.5.3 Converting CD144 Data to GENII V.2 format

The CD-144 format refers to the "Card Deck 144 format" available from the National Climatic Data Center (NCDC). The file is composed of one record per hour, with all weather elements reported in an 80-column block. The format of these records is described in the Card Deck 144 WBAN Hourly Surface Observation Reference Manual (NOAA 1970), also available from NCDC. Data in this file includes the year, month, day, hour, cloud ceiling height, wind direction, wind speed, dry bulb temperature, and opaque cloud cover (see Appendix A). The following describes the variables found in the CD-144 format.

- Year, Month and Day - identifies the year, month and day during which the meteorological data were observed.
- Hour - identifies the hour of the meteorological data observation. Hour is based on the 24-hour clock and is recorded as 00 through 23. Times are Local Standard Time (LST).
- Ceiling Height - the height of the cloud base above local terrain and is coded in hundreds of feet.
- Wind Direction - the direction from which the wind is blowing, rounded to the nearest 10 degrees. Calm is given by 00.
- Wind Speed - the wind speed measured in knots. Calm given by 00.
- Dry Bulb Temperature - the ambient air temperature measured in whole degrees Fahrenheit.
- Cloud Cover - There are two cloud cover parameters, opaque cloud cover and total cloud cover. Both parameters identify the amount of cloud covered measured in tens of percent, e.g. 0 = clear or less than 10%, 4 = 40 - 49%, '-' = Overcast of 100%. The model uses opaque cloud cover.

In order to convert CD144 data to the GENII V.2 hourly format, use the Use SAMSON or CD144 formatted file button on the chronic or acute puff or plume Meteorological Files tab. This will start a processing program with an input screen illustrated in Figure 4.24. The three **Browse** buttons on the upper right allow the user to define a file in which to store the processing requirements, identify the source of the CD144 data, and save the resulting hourly data file. The first and third fields allow the user to either select an existing file name

(in which existing data will be overridden) or type in a new name. The second field allows the user to find an existing file; when the existing file is selected, the user is prompted to identify it as containing either CD144 or SAMSON formatted data. If hourly precipitation data are available in the NCDC TD3240 format, checking the **Use TD3240 Data** box opens a fourth filename box, in which that filename may be entered. The inputs on the lower portion of the window allow input of data needed in the expansion, describing the location and nature of the meteorological station from which the data are derived.

When all data have been input, LEFT click on the **Process Data** button. The HRLYPROC processor will create a file in the appropriate GENII V.2 hourly format. The data will be stored in the file assigned in the second box. Exit from the processor program back to the **Meteorological Files** tab (Figure 4.14) and enter the newly created filename in the box for **Path and Name for Meteorological Data File**.

CD144 data may be purchased from the National Climatic Data Center. Alternatively, a large amount of CD144 data are available from the EPA Technology Transfer Network Support Center for Regulatory Air Models, located on the Internet at http://www.epa.gov/scram001/tt24.htm . Note that this data may require preliminary decompression and conversion to CD144 format before it can be successfully used in the GENII processing routine.

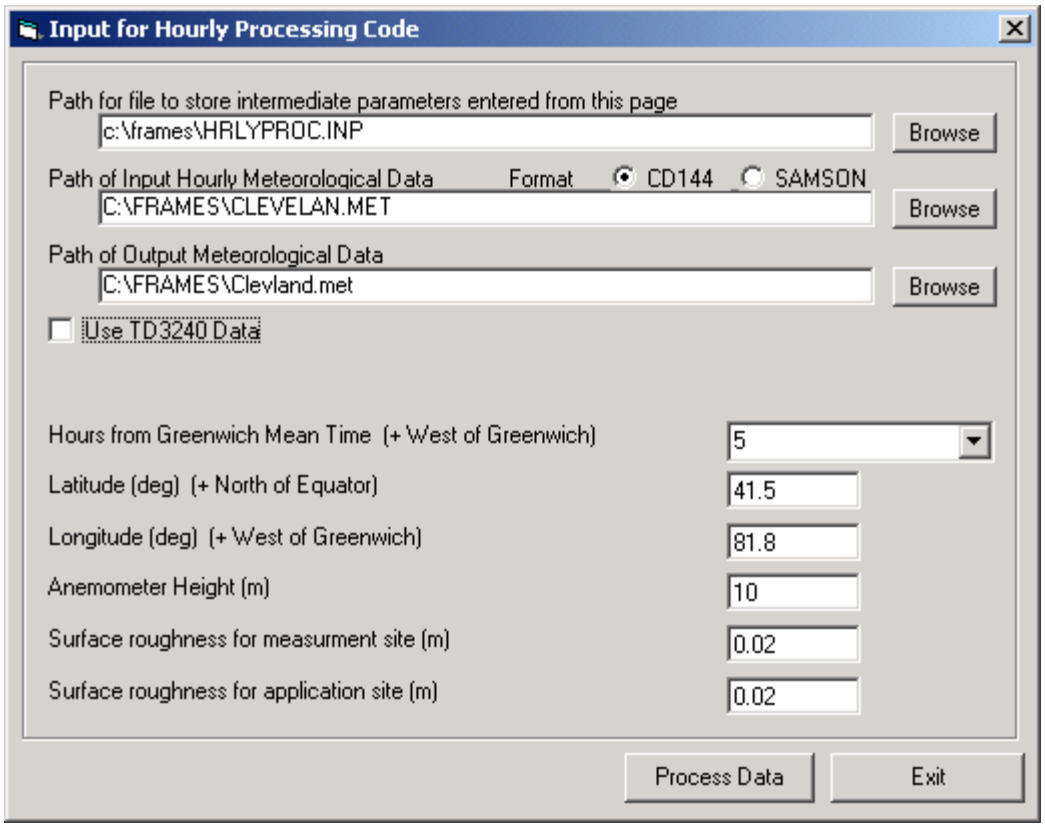


Figure 4.24. Input screen for processing CD144 or SAMSON data

4.4.5.4 Converting SAMSON and CEAM Data to GENII V.2 format

The National Climatic Data Center (NCDC) has made available solar and meteorological data form the first order stations in the United States for the period 1961 - 1990 on a set of three CD-ROMs, referred to as the SAMSON data. A second CD of data from 1991 through 1995 is also available. The GENII V.2 processors can process data retrieved from these CD-ROMs. It cannot access the data directly from the SAMSON CD-ROM, but the user can run the software provided with the data to retrieve the station, period of time and variables from the site and period to be modeled. The software is a DOS-based, interactive graphical interface.

Multiple years of data can be extracted for a single station and saved to the same file. However, the GENII processor expects a maximum of one year of data in the data file. The reason for this restriction is explained below.

Retrieving the data from the CD-ROM is completely under the control of the user. When data are retrieved from the CD-ROMs, the user has the option to specify which variables to retrieve from a list of 21 variables for each station. At a minimum, the ceiling height, wind direction, wind speed, dry bulb temperature, opaque cloud cover, and present weather must be retrieved. In most cases, the hourly precipitation amount will also be retrieved, but it is not required.

When the data are retrieved from the CD-ROM, two records are written at the beginning of the file that identify the station (first record) and the variables retrieved (second record). GENII uses both records to obtain information about the station (e.g., latitude and longitude) and to determine how to process the data that follows. There two records begin with the title character (~). If more than one year or data are retrieved from the CD-ROM, these two records will appear before each year in the file. Thus, an error will occur when the program reads these second set of header records.

The second header record is used by the model to determine if enough variables have been retrieved from the CD-ROM. If there are insufficient variables retrieved, an error will occur during the model execution. The user should return to the CD-ROM and retrieve the data once again to make sure all the necessary variables are retrieved.

Data records follow the header records in the retrieved file. There is one record for each hour of time period selected by the user. Unlike the CD-144 format which reports the hour on the 00 - 23 clock, the hour in the retrieved file is reported on the 01 - 24 hour clock. Hour 24 of a day from the SAMSON data corresponds to hour 00 of the next day for the CD-144 data.

Data stored in the SAMSON format are in different units than found in the CD-144 data. The output using either format is the same, so the SAMSON and CD-144 data are converted to a specific set of units for each meteorological variable.

The process for converting the data is the same as that described above for CD144 data; only the selection of SAMSON is different. TD3240 data are not necessary with SAMSON.

Data from SAMSON have been extracted, combined with similar data, and made available by the EPA on the CEAM (Center for Exposure Assessment Modeling) website at http://www.epa.gov/ceampubl/tools/metdata/us_met.htm The semi-processed data available on the CEAM site are in a formatted file that may be converted to GENII format using the same processor as SAMSON data. The file data format is provided in Appendix B. When the CEAM site is queried, the user may download data for a multiple-year period for a given location. Each selected location downloads a 7 Mbyte zip file which unloads into a directory with a name of the type C:\metdata\"state"\"city code"\files. The meteorological processor has been adapted so that the desired year of data may be extracted and used as described above.

4.5 Using the GENII Near Field Module

This user interface controls input for the near-field chronic terrestrial models used to estimate the radionuclide exposure media concentration for soil-based terrestrial pathways. The analysis starts with the initial concentration of each pollutant in the three soil compartments: surface soil, deep soil, and waste package.

The **File** menu item allows input data to be saved, or existing data to be reviewed and retained unchanged. The **Defaults** menu item allows the user to reset all parameters to one of two sets of preselected values, for convenience labeled as Maximum Individual and Average Individual. If the defaults are selected, any changes made earlier will be overwritten. Nearly all non-control parameters have the ability to associate a reference. These references are intended to help document the selection of parameters and allow traceability of assumptions. To associate a reference with a data entry, place the focus (click the cursor in the box) on the parameter of interest, click on the **Reference** menu item, and select either Add or Select. A window like that shown in Figure 4.9 will appear. If the **Add** option was selected, a blank entry will appear allowing text entry of a new reference. The entries are free formatted, so any short and long descriptor may be added. If the **Select** option is chosen, the available entries may be scrolled using the arrow buttons, or a specific entry searched for using the appropriate boxes.

Three kinds of **Help** are available: **General**, **Context**-specific, or allowed **Ranges** of input values. If no individual parameter has the focus of the mouse cursor, selection of Help will bring up the general help, which describes the Near Field model inputs in general terms. If a parameter has the focus, the context specific help will describe the use of the particular parameter. For a parameter with the control focus, selection of ranges will provide the lower and upper bounds that the GENII interface will allow for that particular parameter value.

4.5.1 Main Control Screen

The main control screen, Figure 4.25, for the GENII near-field chronic exposure user interface allows the user to select sources for each soil compartment, make general selections on exposure pathways to include, and to define some basic parameters for the exposure analysis.

The general selections allow inclusion (control box checked) or exclusion of general classes of exposure pathways.

- Terrestrial food ingestion
- Animal product ingestion
- The debug option flag should not be used (checked) by the average user as large output files may be generated.

The parameters entered on the control screen are for description of the timing of the exposure scenario and other parameters that are general in nature to the overall analysis.

Time from start to exposure is the time from zero to the beginning of the intake analysis. The duration of exposure begins at the end of the time to start of exposure.

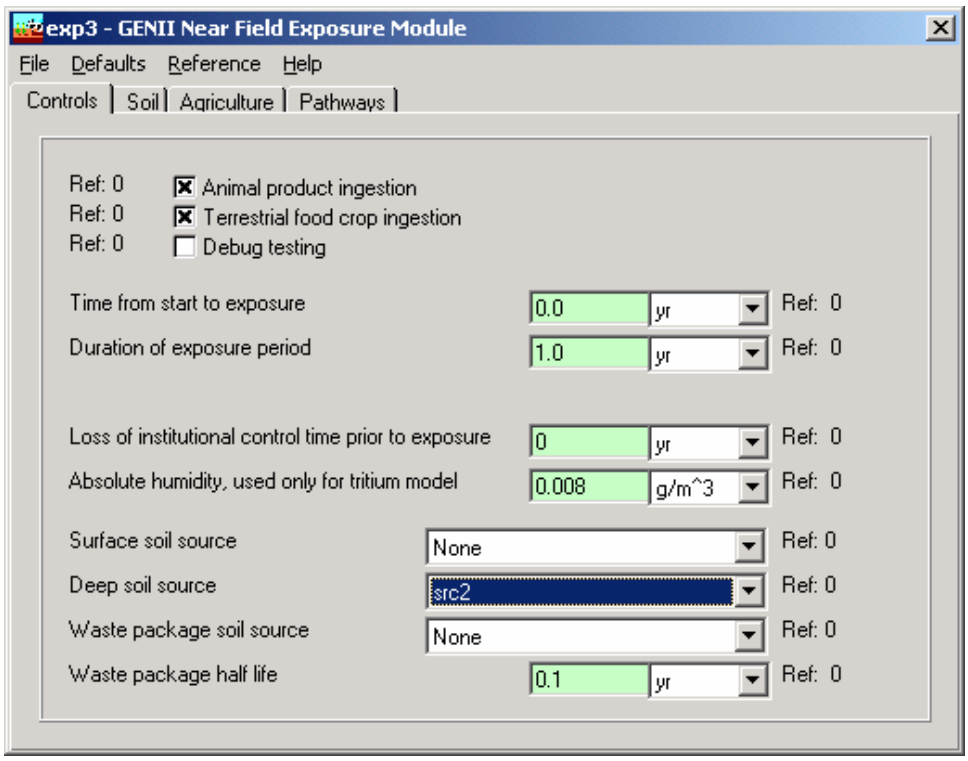


Figure 4.25. GENII Near Field Exposure Module main control screen

Duration of exposure is the time period over which the individual is exposed. It is measured from the time given for the start of exposure. A minimum value of 1 year should be provided, and the value should be in increments of 1 year. The analysis will provide results to the exposure media intermediate file (EPF extension) for each year in the duration of exposure. A longer exposure duration will result in a larger output file.

Loss of institutional control time prior to exposure is measured backward from the "time to start of exposure" and must be less than or equal to the "time to start of exposure".

Absolute humidity is used in the special tritium models for food pathways.

The next three items on the controls screen allow the user to define the source for each of the three soil compartments. The pull-down lists display the source glyph that is connected to the current exposure glyph. The user selects the source glyph to represent which of the three soil compartments is active. It is not necessary to define a source for each compartment, although a source should be assigned to at least one of the compartments. No more than one source glyph may be connected to the exposure glyph. While it is allowable to assign one source glyph to more than one soil compartment, this may not be a realistic situation – a modifier parameter (manual redistribution factor) is provided as described below.

The waste package half life defines the rate at which the waste package deteriorates and releases activity to the deep soil. A value for this parameter is needed only if a waste package source is identified. A zero value for the half life will result in total loss from the waste package in the first year.

4.5.2 Soil - Leaching Screen

The Soil/Leaching Screen is illustrated as Figure 4.26. The type of leach rate constant option allows selection of the method for specifying the soil loss rate constant for the leaching model. The rate constant may be defined in three ways: use of values in the GENII transport factor data file, calculation of rate constants from user supplied parameters, or input of rate constants (for each radionuclide). The method is selected from the pull-down list. When use of the GENII transport factor data file is selected, no additional input is needed for this screen. User supplied parameters for calculation of the leach rate constant are as follows. Numerical values and correct units must be entered for each parameter when the rate constant calculation option is selected.

Surface soil thickness is the average thickness of the surface soil for use in estimation of the leach rate constant. If the surface soil is agricultural land, the thickness should be set to represent the plow layer.

Surface soil bulk density representative of the surface soil layer at the exposure location.

Surface soil moisture content is the volume fraction of the soil that is moisture.

Total infiltration rate may be evaluated as the total annual precipitation + irrigation rate - evapotranspiration rate.

Surface absorption coefficient (Kd) for a radionuclide is set representative of conditions for the surface soil layer. A value must be entered for each radionuclide in the inventory. The radionuclide is selected from the pull-down list under the title "Parent soil absorption coefficient". If the selected parent radionuclide has any progeny, then a list of progeny will appear to the right of the parent data input boxes. Absorption coefficients should be entered for each progeny (if any) in the list for each parent.

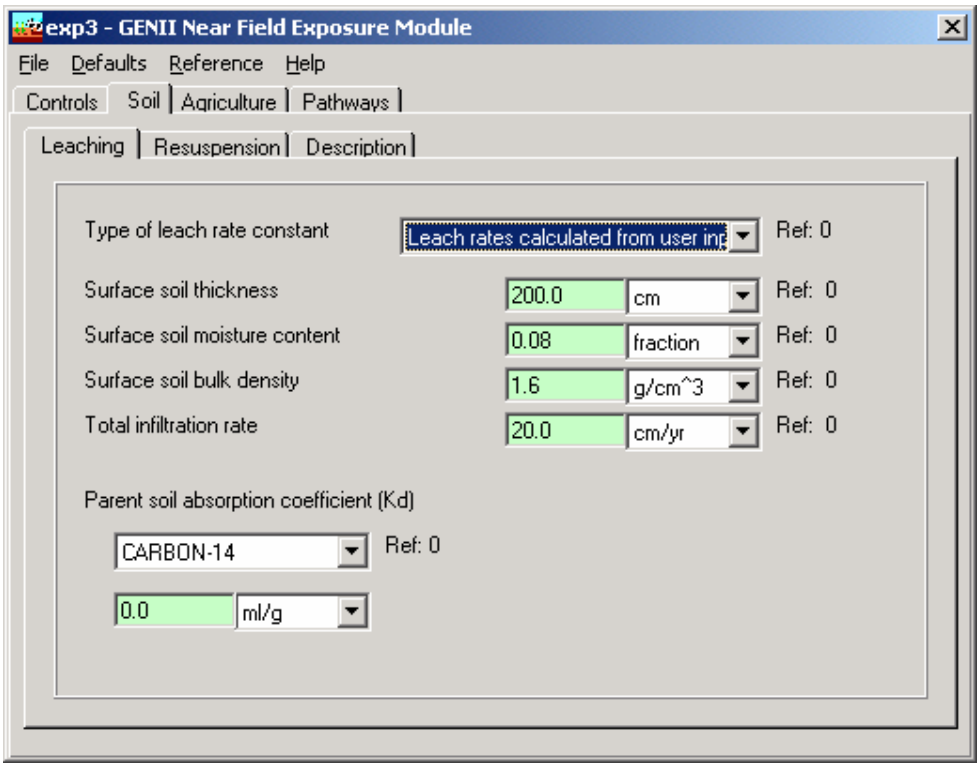


Figure 4.26. Soil/Leaching screen with user input selected

When soil leach rate constants are to be entered by the user, the values are entered for each radionuclide parent and progeny. The radionuclide is selected from the pull-down list under the title "Parent soil leach rate constant". If the selected parent radionuclide has any progeny, then a list of progeny will appear to the right of the parent data input boxes. Leach rate constants should be entered for each progeny (if any) in the list for each parent.

4.5.3 Soil - Resuspension Screen

This screen (Figure 4.27) allows the user to select the model for estimation of air concentrations above the contaminated soil. Necessary parameters for the selected model are requested.

The type of model to run selects the model to use to evaluate air concentration from calculated soil concentrations. Four options are available: none (no resuspended contamination), use mass loading model, use Anspaugh model, and user input of resuspension factor.

The mass loading factor for resuspension model parameter is entered when the mass loading option is selected. This parameter is the airborne particulate concentration at the exposure location. Contaminants in suspended soil are assumed to be at the same concentration as surface soil.

The depth of topsoil available for resuspension parameter is entered when the Anspaugh model is selected. This parameter represents the thickness of soil in which the deposited activity has been mixed that is available to be resuspended.

The resuspension factor is entered when that option has been selected. The value provided is used for all radionuclides in the analysis.

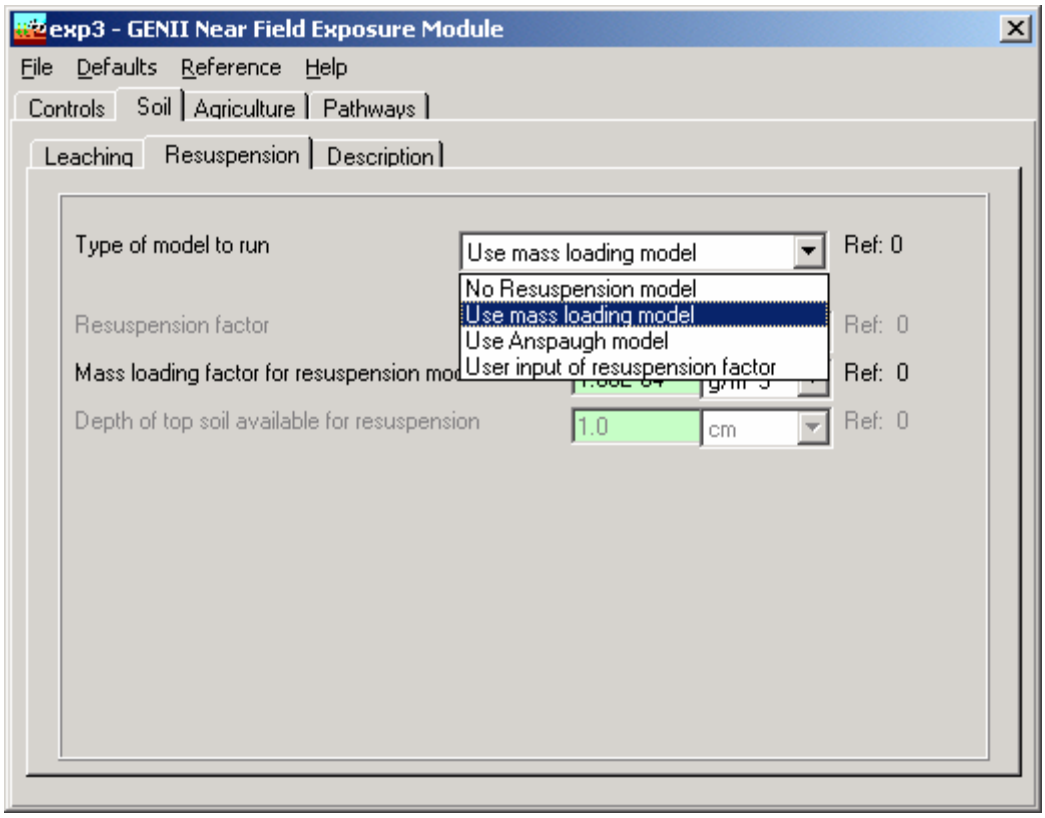


Figure 4.27. Near Field Soil/Resuspension screen

4.5.4 Soil - Description Screen

This screen (Figure 4.28) allows selection of options and input of parameters for the soil compartment model.

The option biotic transport from deep soil to surface soil allows the user to activate the biotic transport model (box checked).

The option estimate biotic transport prior to start of intake allows the user to model biotic transport prior to the start of the intake (exposure) period.

The option arid climate during period prior to intake indicates that the period prior to the start of intake is represented by an arid climate, without irrigation. Biotic transport parameters appropriate to an arid site are used for that analysis.

The surface soil areal density is used to convert concentrations expressed per unit area to concentrations expressed per unit soil mass.

The surface soil layer thickness used for density is the depth of soil used in calculation of the soil areal density.

The surface soil density is the soil mass density used to calculate the soil areal density.

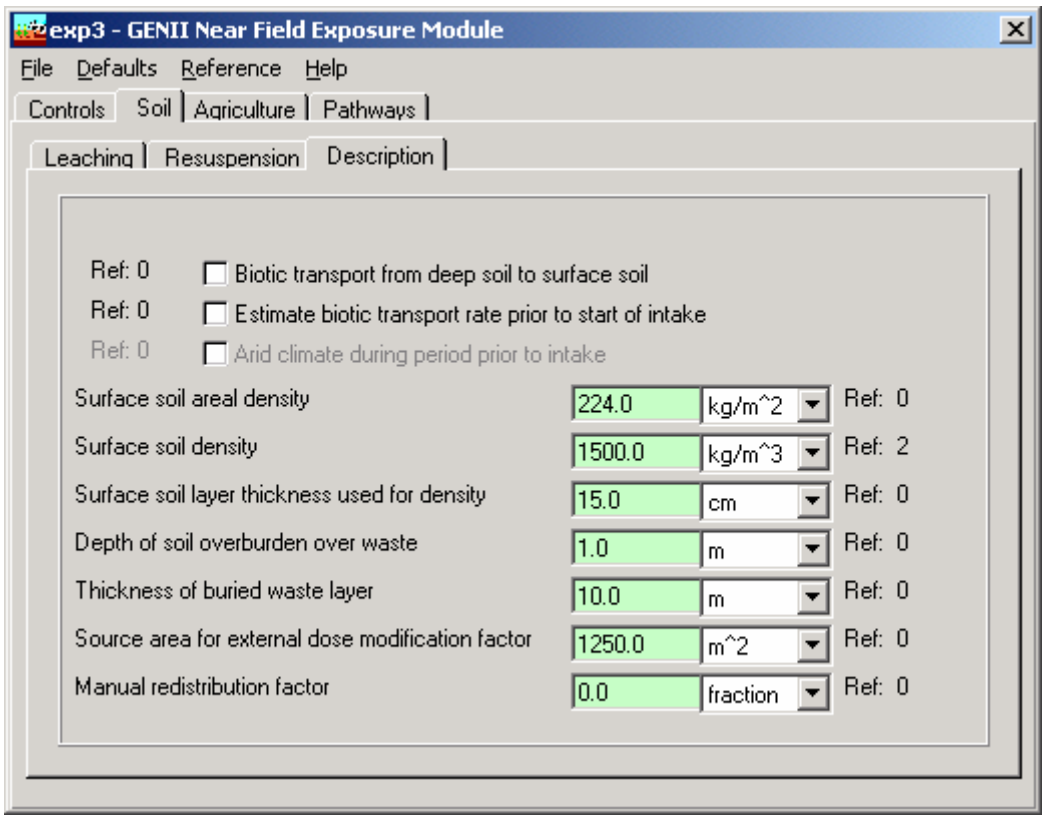


Figure 4.28. Near Field Soil/Description screen

The depth of soil overburden over waste is the distance from the top of the surface soil layer to the top of the deep soil layer.

The thickness of buried waste layer is the thickness of the layer in which the deep soil source is distributed.

The source area for external dose modification factor is the area over which the surface soil contamination is spread. The parameter is used to adjust the external dose rate factors for ground external exposure because of less than infinite size.

The manual redistribution factor relates deep soil concentration to surface soil concentration. This model represents the manual moving of deep soil to the surface and spreading it over the contaminated soil area. The factor is the ratio of concentration of resulting surface soil to the initial deep soil contamination concentration (a value of 1.0 indicates that the final surface soil is entirely made up of deep soil).

4.5.5 Agriculture - General Screen

This screen, Figure 4.29, allows the user to describe harvest removal, deposition to plants and resuspension to plant surfaces, and loss by weathering from plant surfaces.

The radionuclide removal due to harvesting option allows the user to activate ("x" in box) the calculation of radionuclide loss from soil due to harvest removal of each food crop and animal product feed. When activated, the soil concentration is depleted at the end of each year. The amount of loss is calculated from the plant concentration at harvest, the annual plant yield, the root penetration factors, and the soil concentrations at harvest.

The user defined dry deposition retention fraction to plants option allows the user to select the method for evaluating the dry deposition retention fraction. If this option is activated ("x" in box), then the user is allowed to enter the dry deposition retention fraction to plants (next parameter). The default is to allow the code to calculate this parameter as a function of biomass.

The dry deposition retention fraction to plants is entered representing the fraction of dry deposition activity that is retained on plant surfaces.

The resuspension factor from soil to plant surfaces is used to evaluate the air concentration above the plants from resuspension of particulate activity.

The deposition velocity from soil to plant surfaces is used to estimate the amount of resuspended activity deposited onto plants.

The weathering half life from plants is used to evaluate the weathering loss rate constant for loss of activity between deposition (wet or dry) and harvest.

The fraction of plant roots in surface soil is used to estimate plant uptake from contamination in the surface soil layer. Uptake is assumed to be proportional to root fraction.

The fraction of plant roots in deep soil is used to estimate plant uptake from contamination in the deep soil layer.

The Agriculture tab, Figure 4.29, has a large number of sub-screens, described in the following sections. Illustrative figures are not provided; each screen consists of a series of data entry boxes with associated units and referencing capabilities.

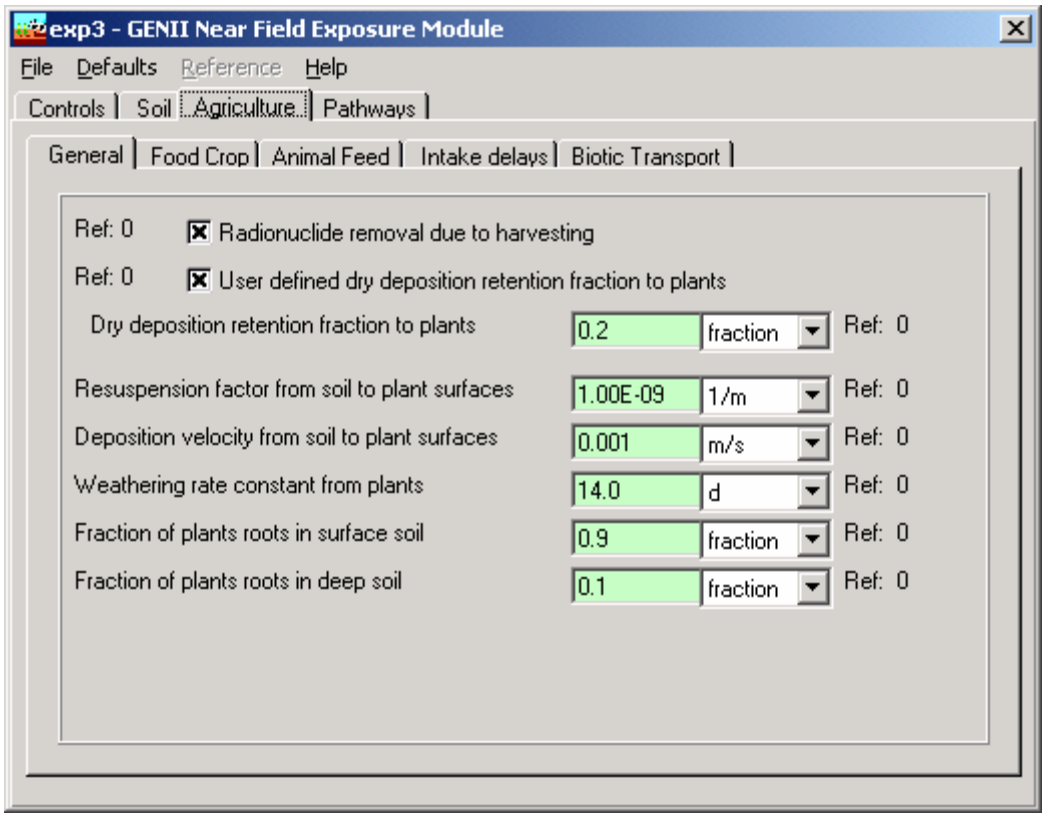


Figure 4.29. Near Field Agriculture/General Screen

4.5.5.1 Agriculture - Animal Feed - Biomass Screen

The standing biomass for each animal feed type is the total above-ground plant mass (wet weight) used to estimate the foliar deposition interception fraction.

4.5.5.2 Agriculture - Animal Feed - Consumption Screen

The feed consumption rate for each animal feed is entered. The value for each feed type represents the amount of feed the animal consumes. These values are multiplied by the contaminated fraction to determine the total intake of each feed type.

4.5.5.3 Agriculture - Animal Feed - Storage Time Screen

The storage time between harvest and feeding to the animal is used to evaluate radioactive decay during the storage period.

4.5.5.4 Agriculture - Animal Feed - Contaminated Fraction Screen

The contaminated fraction of feed for each animal type is the fraction of the feed type fed to the animal that is contaminated. This fraction is multiplied by the feed consumption rate to determine the total contaminated intake of each feed type.

4.5.5.5 Agriculture - Animal Feed - Growing Period Screen

The growing period for each animal feed type defines the period for resuspended deposition to plants.

4.5.5.6 Agriculture - Animal Feed - Yield Screen

The yield of each animal feed type gives the total annual production of edible feed crops per unit area of farmland. This value is used to estimate harvest removal.

4.5.5.7 Agriculture - Animal Feed - Translocation Factor Screen

The translocation factor for each animal feed type is the fraction of activity reaching the plant surface that is transferred to the edible part of the plant.

4.5.5.8 Agriculture - Animal Feed - Dry/wet Ratio Screen

The dry/wet ratio for each animal feed type is used to convert between dry and wet weight bases.

4.5.5.9 Agriculture - Food Crop - Biomass Screen

The standing biomass for each food crop is used to estimate foliar interception.

4.5.5.10 Agriculture - Food Crop - Growing Period Screen

The growing period for each food crop defines the foliar deposition period for plants.

4.5.5.11 Agriculture - Food Crop - Yield Screen

The yield of each food crop gives the total annual production of edible food crops per unit area of farmland. This value is used for estimating harvest removal.

4.5.5.12 Agriculture - Food Crop - Translocation Factor Screen

The translocation factor for each food crop is the fraction of activity reaching the plant surface that is transferred to the edible part of the plant.

4.5.5.13 Agriculture - Food Crop - Dry/wet Ratio Screen

The dry/wet ratio for each food crop is used to convert between dry and wet weight bases.

4.5.5.14 Agriculture - Intake Delays Screen

The intake delay for each food crop and animal product is the average time between harvest and consumption of the food by the exposed individual. The time period is used to account for radioactive decay prior to consumption.

4.5.5.15 Agriculture - Production Screen

This screen is for input of vegetative yield during the optional period prior to the start of intake. Three vegetative yield values may be entered representing the three options for the prior buildup period.

The yearly vegetative production for arid lands during the optional buildup period represents an arid site without irrigation during the period.

The yearly vegetative production for humid lands during the optional buildup period represents a humid site (without or without) irrigation during the period.

The yearly vegetative production for agricultural lands during the optional buildup period represents farming at a humid site, or an arid site with irrigation, during the period.

4.5.6 Pathways Screen

The selection of exposure pathways is controlled on this screen (Figure 4.30). Each pathway may be selected for inclusion in the analysis for the current exposure location. The following pathways may be selected.

- Animal product (beef, poultry, milk, eggs) ingestion
- Food crop (leafy vegetables, root vegetables, fruit, grains) ingestion
- Inadvertent soil ingestion
- Inhalation of suspended soil
- External exposure from soil activity

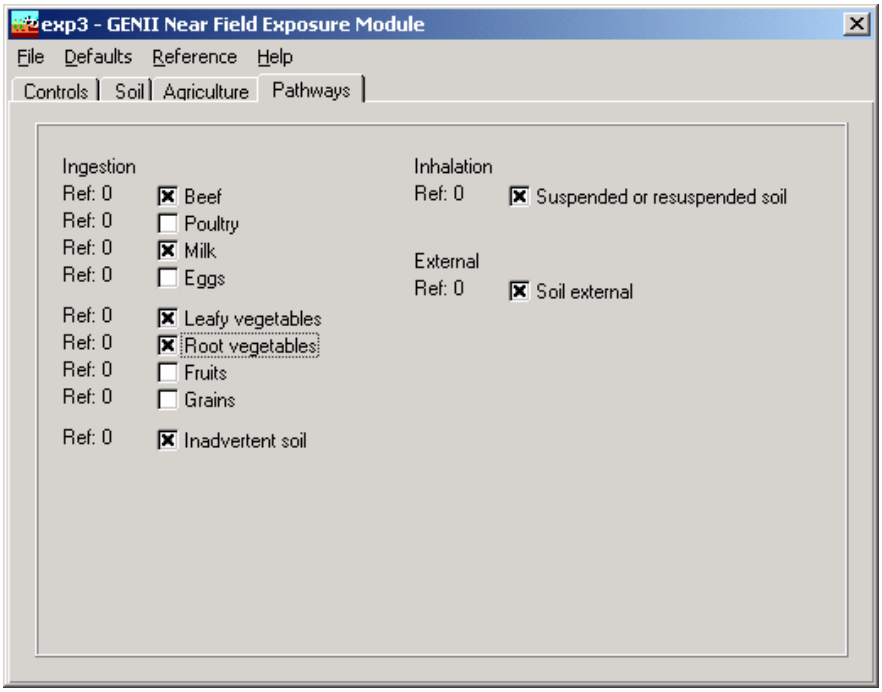


Figure 4.30 Near Field Pathways selection screen

4.6 Using the GENII Chronic Exposure Module

This user interface controls input for the chronic terrestrial and aquatic models used to estimate the radionuclide exposure media concentration for soil, terrestrial, and aquatic exposure pathways. The deposition from prior years of deposition (air and water) is evaluated using atmospheric deposition and water concentration data provided as a function of time.

The various GENII or other FRAMES-compatible atmospheric transport modules may be used to supply information to the GENII chronic exposure model. The **General Info** model selection window (accessed by RIGHT clicking on the exposure icon) has two parameters that interact between the air transport models and the GENII chronic exposure model. These are the Easting Coordinate and the Northing Coordinate for the GENII exposure model (see Figure 3.3). These coordinates are used to describe the location of the location of interest relative to the center of the atmospheric dispersion grid. If the defaults of (0,0) Easting and Northing are used, it is assumed that ALL points on the atmospheric grid are desired. If any other pair of values is used, the GENII model will determine the CLOSEST atmospheric grid point, and use the values appropriate to that location.

The **File** menu item allows input data to be saved, or existing data to be reviewed and retained unchanged. The **Defaults** menu item allows the user to reset all parameters to one of two sets of preselected values, for convenience labeled as Maximum Individual and Average Individual. If the defaults are selected, any changes made earlier will be overwritten. Nearly all non-control parameters have the ability to associate a reference. These references are intended to help document the selection of parameters and allow traceability of assumptions. To associate a reference with a data entry, place the focus (click the cursor in the box) on the parameter of interest, click on the **Reference** menu item, and select either Add or Select. A window like that shown in Figure 4.9 will appear. If the **Add** option was selected, a blank entry will appear allowing text entry of a new reference. The entries are free formatted, so any short and long descriptor may be added. If the **Select** option is chosen, the available entries may be scrolled using the arrow buttons, or a specific entry searched for using the appropriate boxes.

Three kinds of **Help** are available: **General**, **Context**-specific, or allowed **Ranges** of input values. If no individual parameter has the focus of the mouse cursor, selection of Help will bring up the general help, which describes the Near Field model inputs in general terms. If a parameter has the focus, the context specific help will describe the use of the particular parameter. For a parameter with the control focus, selection of ranges will provide the lower and upper bounds that the GENII interface will allow for that particular parameter value.

4.6.1 Main Control Screen

The main control screen for the GENII chronic exposure user interface, Figure 4.31, allows the user to make general selections on exposure pathways to include, and to define some basic parameters for the exposure analysis.

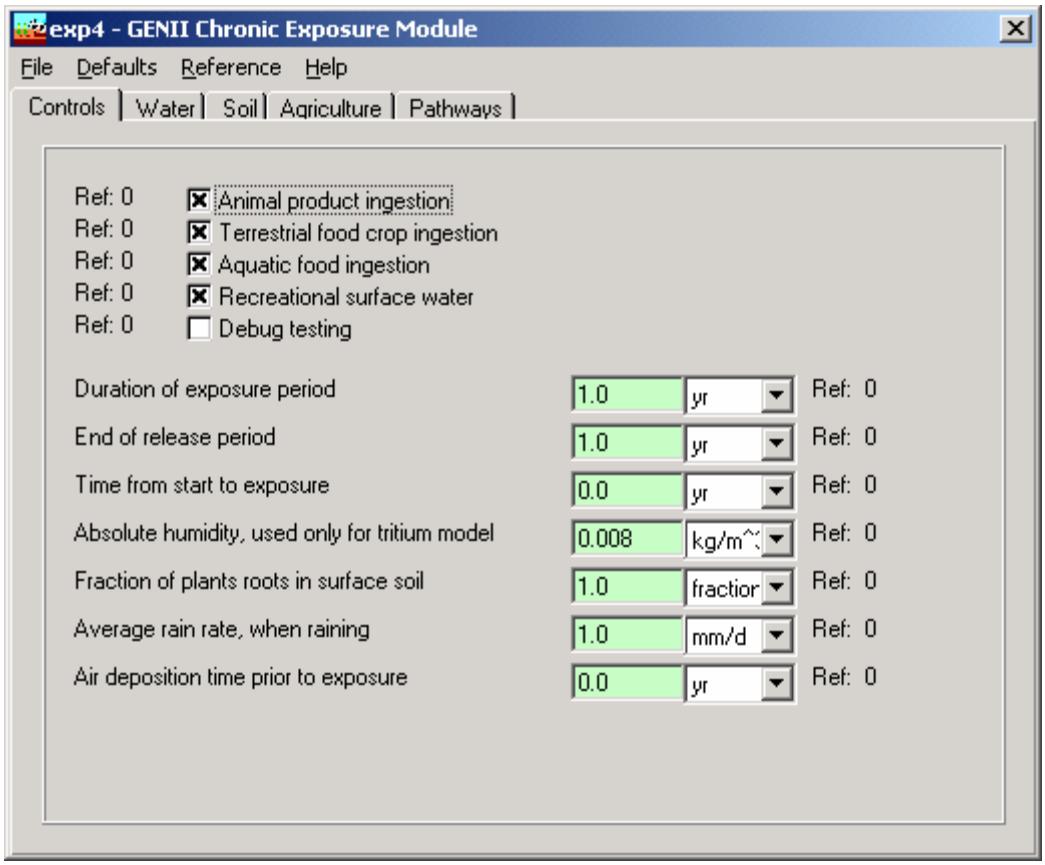


Figure 4.31. GENII Chronic Exposure Module Main Controls screen

The general selections allow inclusion (control box checked) or exclusion of general classes of exposure pathways.

- Animal product ingestion
- Terrestrial food ingestion
- Aquatic food ingestion
- Recreational surface water exposures
- The debug option flag should not be used (checked) by the average user as large output files may be generated.

The parameters entered on the control screen are for description of the timing of the exposure scenario and other parameters that are general in nature to the overall analysis.

Duration of exposure period is the time period over which the individual is exposed. It is measured from the time given for the start of exposure. A minimum value of 1 year should be provided, and the value should be in increments of 1 year. The analysis will provide results (to the exposure media intermediate file (EPF extension) for each year in the duration of exposure. A longer exposure duration will result in a larger output file.

End of release period is the elapsed time measured from time zero to the end of the release (from air, surface water, or groundwater). Exposures may be evaluated beyond this time period for exposure to residual activity.

Time from start to exposure is the time from zero to the beginning of the intake analysis. The duration of exposure begins at the end of the "time from start to exposure."

Air deposition time prior to exposure is used when atmospheric releases are being evaluated. This time period is measured backwards from the "time from start to exposure" and must be less than or equal to that time parameter.

Other parameters on the control screen are as follows.

Absolute humidity is used in the special tritium models for food pathways.

Fraction of plant roots in surface soil is used in the food crop and animal feed analyses and represents the fraction of plant roots that are in the contaminated soil layer. The uptake by plants is assumed to be proportional to this fraction.

Average daily rain rate is used to estimate the interception fraction from rain when wet deposition rates are provided in the atmospheric transport output file (ATO), and the user has selected the option to allow the code to calculate the wet deposition interception fraction.

4.6.2 Water - General Screen

This screen, Figure 4.32, is accessible when a waterborne source (groundwater or surface water) is connected to the exposure location glyph. If no groundwater or surface water source is attached to the Chronic Exposure icon, this screen will not be visible. On this screen the user makes selections related to waterborne exposure pathways.

The aquatic foods from salt water selection box is activated ("x" in box) if the surface water body is salt water. This causes the calculation of aquatic foods to use bioaccumulation factors representative of marine environments. Otherwise, fresh water factors are used.

The treatment plant purification factor selection box is activated ("x" in box) if reduction of water concentration is to be included for a water treatment plant, prior to domestic use. If selected, the water concentration for domestic pathways is reduced by the water purification factors from the GENII transport factor database.

The residential irrigation selection box is activated ("x" in box) if a home lawn or garden is represented in the exposure analysis. Parameters related to residential irrigation are used to estimate the soil concentration that individuals are exposed to from irrigation in the home lawn or garden.

The source of residential irrigation is selected using the pull-down list. The options available depend on the waterborne sources connected to the exposure glyph.

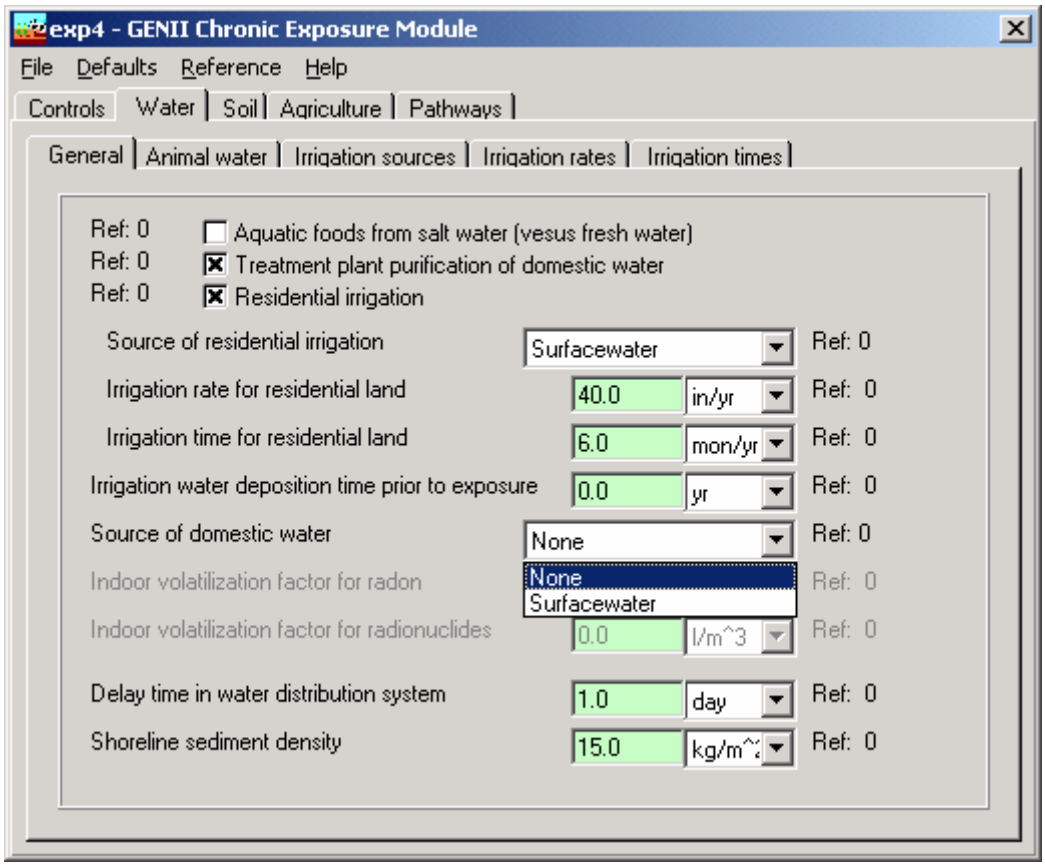


Figure 4.32. Chronic Exposure Water/General screen

The irrigation rate for residential land is the irrigation water application rate to residential land.

The irrigation time for residential land is the total time that irrigation occurs on residential land during a year.

The irrigation water deposition time prior to exposure is used when waterborne releases with irrigation are being evaluated. This time period is measured backwards from the "time from start to exposure" and must be less than or equal to that time parameter.

The source of domestic water is selected from the pull-down list. The options available depend on the waterborne sources connected to the exposure glyph.

The volatilization factor for radon and the volatilization factor for radionuclides must be provided when the exposure pathway of indoor inhalation from water use is included. These factors are used to relate the domestic water concentration to the indoor air concentration of radionuclides present in the water.

The delay time in water distribution system is used to account for radioactive decay in transit from the water exposure point to the usage point for domestic water.

The shoreline sediment density is provided if the shoreline sediment exposure pathway has been selected. It is used to convert the radionuclide transfer per unit area to sediment concentration per unit mass. The sediment density is expressed as mass of sediment per unit area of shoreline and should be based on the layer of sediment in which the contamination is mixed.

4.6.3 Water - Animal Water Screen

This screen contains parameters for the animal drinking water route. Values are provided for the four animal products: beef, poultry, milk, and eggs.

The contaminated fraction of water for each animal type represents the fraction of the animal's water that is from the contaminated waterborne source.

The intake rate of water for each animal type is the total water ingestion rate for the animal.

4.6.4 Water - Irrigation Sources Screen

This screen allows the user to define the source of irrigation (none, surface water, or aquifer) for each food crop and animal feed crop. Selections are made from the drop-down boxes for each possible pathway. The options available depend on the waterborne sources connected to the exposure glyph. In order to have access to these parameters, the appropriate selection flags on the control screen must be set properly ("x" in box).

4.6.5 Water - Irrigation Rates Screen

This screen allows the user to define the irrigation rate for each food crop and animal product crop. In order to have access to these parameters, the appropriate selection flags on the Control screen must be set properly ("x" in box).

4.6.6 Water - Irrigation Times Screen

This screen allows the user to define the irrigation time for each food crop and animal product crop. This is the time period that irrigation occurs during a typical year. In order to have access to these parameters, the appropriate selection flags on the Control screen must be set properly ("x" in box).

4.6.7 Soil Tab

The soil tab has several sub-screens. The details of each screen are similar to those described in Sections 4.4.2, 4.4.3, and 4.4.4 for the Near Field module.

4.6.7.1 Soil - Leaching Screen

The soil screens are similar in format and content to those of Figure 4.26.

The type of leach rate constant option allows selection of the method for specifying the soil loss rate constant for the leaching model. The rate constant may be defined in three ways: use of values in the GENII transport factor data file, calculation of rate constants from user supplied parameters, or input of rate constants (for each radionuclide). The method is selected from the pull-down list. When use of the GENII transport factor data file is selected, no additional input is needed for this screen.

User supplied parameters for calculation of the leach rate constant are as follows. Numerical values and correct units must be entered for each parameter when the rate constant calculation option is selected.

Surface soil thickness is the average thickness of the surface soil for use in estimation of the leach rate constant. If the surface soil is agricultural land, the thickness should be set to represent the plow layer.

Surface soil bulk density representative of the surface soil layer at the exposure location.

Surface soil moisture content is the volume fraction of the soil that is moisture.

Total infiltration rate may be evaluated as the total annual precipitation + irrigation rate - evapotranspiration rate.

Surface absorption coefficient (Kd) for a radionuclide is set representative of conditions for the surface soil layer. A value must be entered for each radionuclide in the inventory. The radionuclide is selected from the pull-down list under the title "Parent soil absorption coefficient". If the selected parent radionuclide has any progeny, then a list of progeny will appear to the right of the parent data input boxes. Absorption coefficients should be entered for each progeny (if any) in the list for each parent.

When soil leach rate constants are to be entered by the user, the values are entered for each radionuclide parent and progeny. The radionuclide is selected from the pull-down list under the title "Parent soil leach rate constant". If the selected parent radionuclide has any progeny, then a list of progeny will appear to the right of the parent data input boxes. Leach rate constants should be entered for each progeny (if any) in the list for each parent.

4.6.7.2 Soil - Resuspension Screen

This screen is similar to the equivalent screen for the Near Field module, Figure 4.27.

The type of model to run selects the model to use to evaluate air concentration from calculated soil concentrations. Four options are available: none (no resuspended contamination), use mass loading model, use Anspaugh model, and user input of resuspension factor.

The mass loading factor for resuspension model parameter is entered when the mass loading option is selected. This parameter is the airborne particulate concentration at the exposure location.

The depth of topsoil available for resuspension parameter is entered when the Anspaugh model is selected. This parameter represents the thickness of soil in which the deposited activity has been mixed.

The resuspension factor is entered when that option has been selected. The value provided is used for all radionuclides in the analysis.

4.6.7.3 Soil - Surface Soil Screen

This screen, equivalent to that for the Near Field module (Figure 2.28) allows input of parameters describing the surface soil layer. These parameters are related.

The surface soil areal density is used to convert concentrations expressed per unit area to concentrations expressed per unit soil mass.

The surface soil layer used for density is the depth of soil used in calculation of the soil areal density.

The surface soil density is the soil mass density used to calculate the soil areal density.

4.6.8 Agriculture - General Screen

This screen, similar to that for the Near Field module, Figure 4.29, allows the user to describe harvest removal, deposition to plants, and resuspension to plant surfaces, and loss by weathering from plant surfaces.

The radionuclide removal due to harvesting option allows the user to activate ("x" in box) the calculation of radionuclide loss due to harvest removal of each food crop and animal product feed. When activated, the soil concentration is depleted at the end of each year. The amount of loss is calculated from the plant concentration at harvest, the annual plant yield, the root penetration factors, and the soil concentrations at harvest.

The user defined dry deposition retention fraction to plants option allows the user to select the method for evaluating the dry deposition retention fraction. If this option is activated ("x" in box), then the user is allowed to enter the dry deposition retention fraction to plants (next parameter). If not activated, the code uses the default method based on plant biomass.

The dry deposition retention fraction to plants is entered to define the fraction of dry deposition activity that is retained on plant surfaces during initial dry deposition from the air.

The user defined wet deposition retention fraction to plants option allows the user to select the method for evaluating the wet deposition retention fraction. If this option is activiated ("x" in box), then the user is allowed to enter the wet deposition retention fraction to plants (next parameter). If not activated, the code uses the default method based on biomass and rainfall rate.

The wet deposition retention fraction to plants is entered representing the fraction of wet deposition activity that is retained on plant surfaces during initial wet deposition.

The resuspension factor from soil to plant surfaces is used to evaluate the air concentration above the plants from resuspension of particulate activity.

The deposition velocity from soil to plant surfaces is used to estimate the amount of resuspended activity deposited onto plants.

The weathering half life from plants is used to evaluate the weathering loss rate constant for loss of activity between deposition (wet or dry) and harvest.

4.6.8.1 Agriculture - Animal Feed - Biomass Screen

The standing biomass for each animal feed type is the total above-ground plant mass (wet weight) used to estimate interception fractions for wet and dry deposition.

4.6.8.2 Agriculture - Animal Feed - Consumption Screen

The feed consumption rate for each animal feed is entered. The value for each feed type represents the total intake of this type of feed. These values are multiplied by their respective contaminated fraction to determine the contaminated portion of the intake of each feed type.

4.6.8.3 Agriculture - Animal Feed - Storage Time Screen

The storage time between harvest and feeding to the animal is used to evaluate radioactive decay during the storage period.

4.6.8.4 Agriculture - Animal Feed – Diet Fraction Screen

The contaminated fraction of feed for each animal type is the fraction of the feed type eaten by the animal that is contaminated. This fraction is multiplied by the feed consumption rate to determine the total contaminated intake of each feed type.

4.6.8.5 Agriculture - Animal Feed - Growing Period Screen

The growing period for each animal feed type defines the deposition period for irrigation and atmospheric deposition to plants.

4.6.8.6 Agriculture - Animal Feed - Yield Screen

The yield of each animal feed type gives the total annual production of edible feed crops per unit area of farmland. The yield is used to calculate the harvest removal losses from the soil.

4.6.8.7 Agriculture - Animal Feed - Dry/wet Ratio Screen

The dry/wet ratio for each animal feed type is used to convert between dry and wet weight bases.

4.6.8.8 Agriculture - Animal Feed - Translocation Factor Screen

The translocation factor for each animal feed type is the fraction of activity reaching the plant surface that is transferred to the edible part of the plant.

4.6.9 Agriculture – Food Crop

The Food Crop screen has several sub-screens used to input the parameters necessary to describe agricultural practices for foods consumed directly by people.

4.6.9.1 Agriculture - Food Crop - Biomass Screen

The standing biomass for each food crop is used to estimate soil losses from harvest removal.

4.6.9.2 Agriculture - Food Crop - Growing Period Screen

The growing period for each food crop defines the deposition period for irrigation and atmospheric deposition to plants.

4.6.9.3 Agriculture - Food Crop - Yield Screen

The yield of each food crop gives the total annual production of edible food crops per unit area of farmland.

4.6.9.4 Agriculture - Food Crop - Dry/wet Ratio Screen

The dry/wet ratio for each food crop is used to convert between dry and wet weight bases.

4.6.9.5 Agriculture - Food Crop - Translocation Factor Screen

The translocation factor for each food crop is the fraction of activity reaching the plant surface that is transferred to the edible part of the plant.

4.6.10 Agriculture - Intake Delays Screen

This screen is similar to that in the Near Field module.

The intake delay for each food crop, animal product, and aquatic food is the average time between harvest and consumption of the food by the exposed individual. The time period is used to account for radioactive decay prior to consumption.

4.6.11 Pathways Screen

This screen, Figure 4.33, is similar to that for the Near Field module, Figure 4.30.

The selection of exposure pathways is controlled on this screen. Each pathway may be selected for inclusion in the analysis for the current exposure location. The following pathways may be selected.

- Animal product (beef, poultry, milk, eggs) ingestion
- Food crop (leafy vegetables, root vegetables, fruit, grains) ingestion
- Aquatic food (fish, mollusks, crustacea, aquatic plants) ingestion
- Drinking water ingestion
- Inadvertent shower water ingestion
- Inadvertent swimming water ingestion
- Inadvertent soil ingestion
- Air inhalation from atmospheric transport or resuspension outdoors
- Indoor inhalation of contaminants released from domestic water during showering and other uses, and infiltration from outdoors
- Inhalation of suspended soil from prior air or irrigation deposition
- External exposure from waterborne activity while swimming
- External exposure from waterborne activity while boating
- External exposure from sediment activity while on shoreline
- External exposure from soil activity
- External exposure to airborne activity from atmospheric transport

The external exposure to air may be evaluated using the finite plume model or the semi-infinite plume model. When the finite plume model is checked, the external dose values are read directly from the atmospheric transport file (ATO) and no calculations are performed for this pathway in the GENII chronic exposure module. Otherwise, a semi-infinite plume is assumed and the dose is to be based on the air concentration.

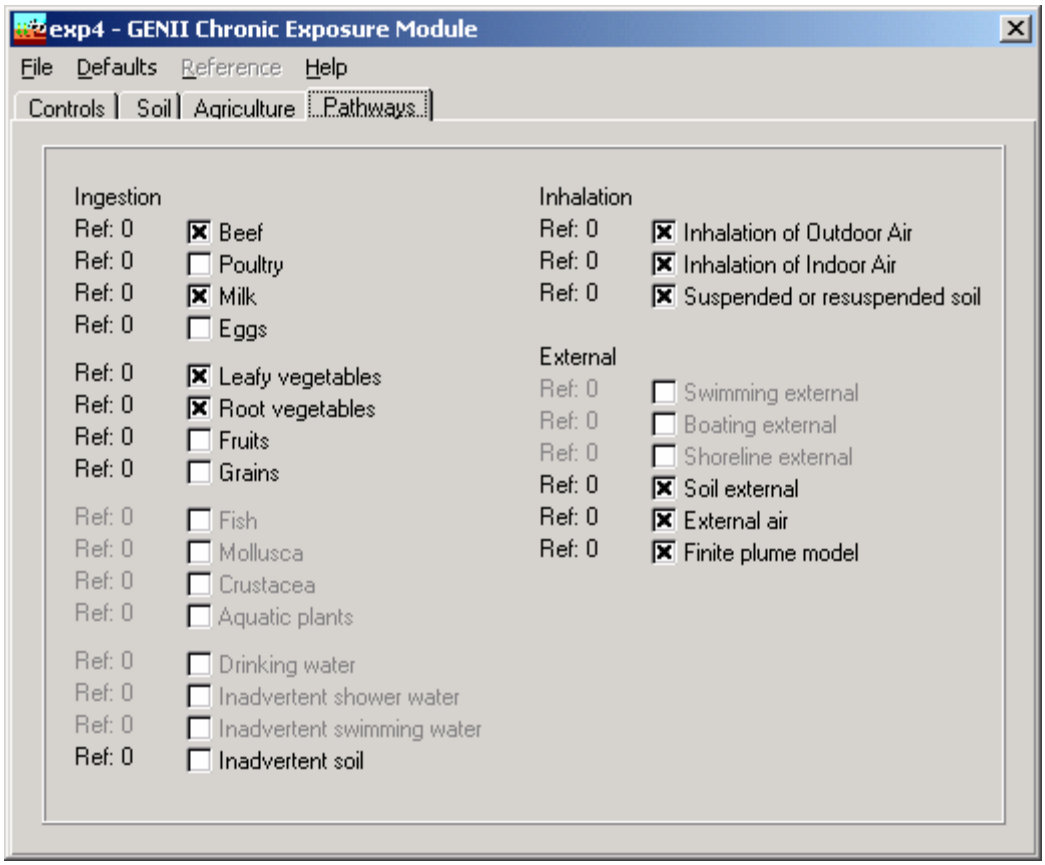


Figure 4.33. Chronic Exposure Pathways Selection screen

4.7 Using the GENII Acute Exposure Module

This user interface controls input for the GENII acute terrestrial and aquatic models used to estimate the radionuclide exposure media concentrations for soil, terrestrial, and aquatic exposure pathways. The deposition from air and water is evaluated using integrated atmospheric deposition and water concentration data provided as input from prior modules. The model assumes an acute initial deposition followed by chronic exposure to the residual environmental contamination.

The various GENII or other FRAMES-compatible atmospheric transport modules may be used to supply information to the GENII acute exposure model. The **General Info** model selection window (accessed by RIGHT clicking on the exposure icon) has two parameters that interact between the air transport models and the GENII acute exposure model. These are the Easting Coordinate and the Northing Coordinate for the GENII exposure model (see Figure 3.3). These coordinates are used to describe the location of the location of interest relative to the center of the atmospheric dispersion grid. If the defaults of (0,0) Easting and Northing are used, it is assumed that ALL points on the atmospheric grid are desired. If any other pair of values is used, the GENII model will determine the CLOSEST atmospheric grid point, and use the values appropriate to that location.

The **File** menu item allows input data to be saved, or existing data to be reviewed and retained unchanged. The **Defaults** menu item allows the user to reset all parameters to one of two sets of preselected values, for convenience labeled as Maximum Individual and Average Individual. If the defaults are selected, any changes made earlier will be overwritten. Nearly all non-control parameters have the ability to associate a reference. These references are intended to help document the selection of parameters and allow traceability of assumptions. To associate a reference with a data entry, place the focus (click the cursor in the box) on the parameter of interest, click on the **Reference** menu item, and select either Add or Select. A window like that shown in Figure 4.9 will appear. If the **Add** option was selected, a blank entry will appear allowing text entry of a new reference. The entries are free formatted, so any short and long descriptor may be added. If the **Select** option is chosen, the available entries may be scrolled using the arrow buttons, or a specific entry searched for using the appropriate boxes.

Three kinds of **Help** are available: **General**, **Context**-specific, or allowed **Ranges** of input values. If no individual parameter has the focus of the mouse cursor, selection of Help will bring up the general help, which describes the Near Field model inputs in general terms. If a parameter has the focus, the context specific help will describe the use of the particular parameter. For a parameter with the control focus, selection of ranges will provide the lower and upper bounds that the GENII interface will allow for that particular parameter value.

4.7.1 Main Control Screen

The main control screen, Figure 4.34, for the GENII acute exposure user interface allows the user to make general selections on exposure pathways to include, and to define some basic parameters for the exposure analysis.

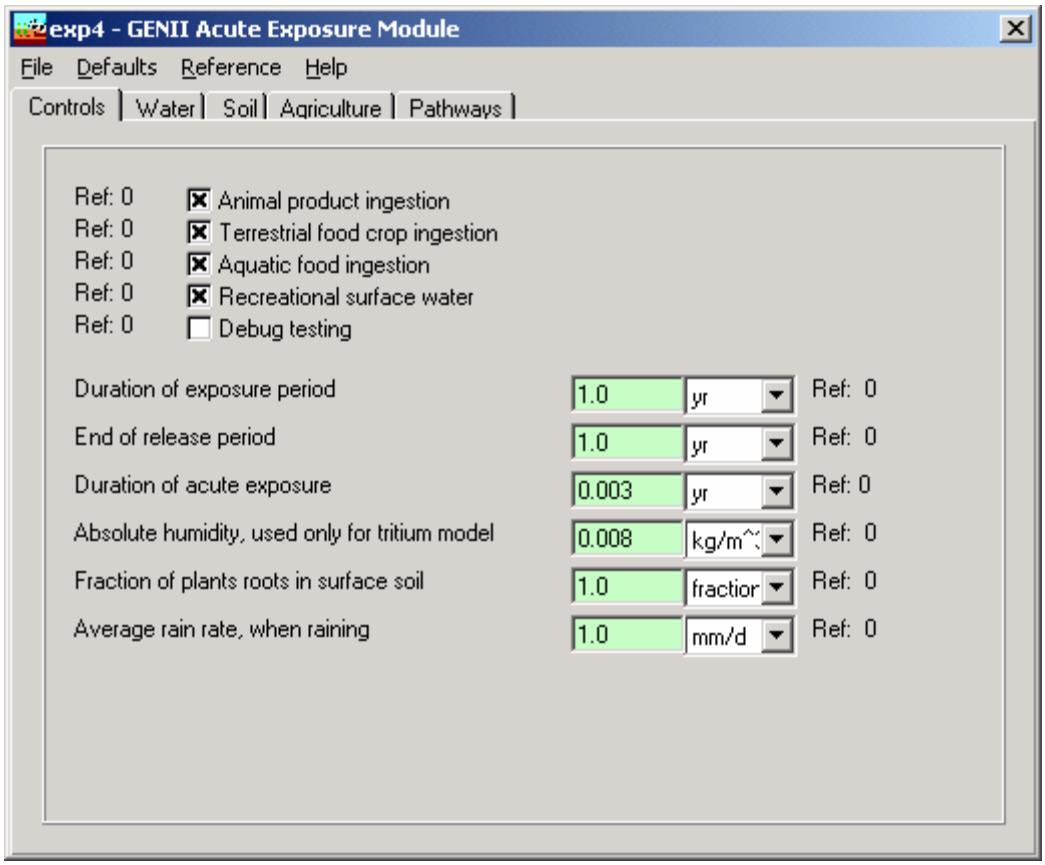


Figure 4.34. GENII Acute Exposure Module Main Control Screen

The general selections allow inclusion (control box checked) or exclusion of general classes of exposure pathways.

- Terrestrial food ingestion
- Animal product ingestion
- Aquatic food ingestion
- Recreational surface water exposures
- The debug option flag should not be used (checked) by the average user as large output files may be generated.

The parameters entered on the control screen are for description of the timing of the exposure scenario and other parameters that are general in nature to the overall analysis.

Duration of exposure is the time period over which the individual is exposed. It is measured from time zero. A minimum value of 1 year should be provided, and the value should be in increments of 1 year. The analysis will provide results (to the exposure media intermediate file, EPF extension) for each year in the duration of exposure. A longer exposure duration will result in a larger output file.

End of release period is the elapsed time measured from time zero to the end of the time of dose calculations from air or surface water. Exposures are evaluated up to this time for exposure to residual activity. This term is of limited relevance to the acute calculation.

The duration of acute exposure is the time over which the air or surface water is contaminated at the current exposure location. This value is used to integrate the water concentration data in determining the average water concentration for the acute exposure period. The value may be different from the total period of contamination in the surface water input file if only part of the data is to be used.

Other parameters on the control screen are as follows.

Absolute humidity is used in the special tritium models for food pathways.

Fraction of plant roots in surface soil is used in the food crop and animal feed analyses and represent the fraction of plant roots that are in the contaminated soil layer. The uptake by plants is assumed to be proportional to this fraction.

Average daily rain rate is used to estimate the interception fraction from rain when wet deposition rates are provided in the atmospheric transport output file (ATO), and the user has selected the option to allow the code to calculate the wet deposition interception fraction.

4.7.2 Water - General Screen

This screen, very similar to the Chronic Exposure/Water screen shown in Figure 4.32, is accessible when a surface water source is connected to the exposure location glyph. On this screen the user makes selections related to waterborne exposure pathways.

The aquatic foods from salt water selection box is activated ("x" in box) if the surface water body is salt water. This causes the calculation of aquatic foods to use bioaccumulation factors representative of marine environments. Otherwise, fresh water factors are used.

The treatment plant purification factor selection box is activated ("x" in box) if reduction of water concentration is to be included for a water treatment plant, prior to domestic use. If selected, the water concentration for domestic pathways is reduced by the water purification factors from the GENII transport factor data file.

The residential irrigation selection box is activated ("x" in box) if a home lawn is represented in the exposure analysis. Parameters related to residential irrigation are used to estimate the soil concentration that individuals are exposed to from irrigation of the land upon which outdoor time is spent.

The source of residential irrigation is selected using the pull-down list. The options available depend on the waterborne sources connected to the exposure glyph.

The irrigation rate for residential land is the irrigation water application rate to residential land.

The irrigation time for residential land is the total time that irrigation occurs on residential land during a year.

The source of domestic water is selected from the pull-down list. The options available depend on the waterborne sources connected to the exposure glyph.

The volatilization factor for radon and the volatilization factor for radionuclides must be provided when the exposure pathway of indoor inhalation from water use is included. These factors are used to relate the domestic water concentration to the indoor air concentration of radionuclides present in the water.

The delay time in water distribution system is used to account for radioactive decay in transit from the water exposure point to the usage point for domestic water (e.g., travel time from water treatment plant to faucet).

The shoreline sediment density is used to convert the radionuclide transfer per unit area to sediment concentration per unit mass. The sediment density is expressed as mass of sediment per unit area of shoreline and should be based on the layer of sediment in which the contamination is mixed.

4.7.2.1 Water - Animal Water Screen

This screen contains parameters for the animal drinking water route. Values are provided for the four animal products: beef, poultry, milk, and eggs.

The contaminated fraction of water for each animal type represents the fraction of the animal's water that is from the contaminated waterborne source.

The intake rate of water for each animal type is the total water ingestion rate for the animal.

4.7.2.2 Water - Irrigation Sources Screen

This screen allows the user to define the source of irrigation (none, surface water, or aquifer) for each food crop and animal feed crop. The options available depend on the waterborne sources connected to the exposure glyph. In order to have access to these parameters, the appropriate selection flags on the control screen must be set properly ("x" in box).

4.7.2.3 Water - Irrigation Rates Screen

This screen allows the user to define the irrigation rate for each food crop and animal product crop. In order to have access to these parameters, the appropriate selection flags on the Control screen must be set properly ("x" in box).

4.7.2.4 Water - Irrigation Times Screen

This screen allows the user to define the irrigation time for each food crop and animal product crop. This is the time period that irrigation occurs during a typical year. In order to have access to these parameters, the appropriate selection flags on the Control screen must be set properly ("x" in box).

4.7.3 Soil Tab

The soil tab has several subscreens.

4.7.3.1 Soil - Leaching Screen

The type of leach rate constant option allows selection of the method for specifying the soil loss rate constant for the leaching model. The rate constant may be defined in three ways: use of values in the GENII transport factor data file, calculation of rate constants from user supplied parameters, or input of rate constants (for each radionuclide). The method is selected from the pull-down list. When use of the GENII transport factor data file is selected, no additional input is needed for this screen.

User supplied parameters for calculation of the leach rate constant are as follows. Numerical values and correct units must be entered for each parameter when the rate constant calculation option is selected.

Surface soil thickness is the average thickness of the surface soil for use in estimation of the leach rate constant. If the surface soil is agricultural land, the thickness should be set to represent the plow layer.

Surface soil bulk density representative of the surface soil layer at the exposure location.

Surface soil moisture content is the volume fraction of the soil that is moisture.

Total infiltration rate may be evaluated as the total annual precipitation + irrigation rate - evapotranspiration rate.

Surface absorption coefficient (Kd) for a radionuclide is set representative of conditions for the surface soil layer. A value must be entered for each radionuclide in the inventory. The radionuclide is selected from the pull-down list under the title "Parent soil absorption coefficient". If the selected parent radionuclide has any progeny, then a list of progeny will appear to the right of the parent data input boxes. Absorption coefficients should be entered for each progeny (if any) in the list for each parent.

When soil leach rate constants are to be entered by the user, the values are entered for each radionuclide parent and progeny. The radionuclide is selected from the pull-down list under the title "Parent soil leach rate constant". If the selected parent radionuclide has any progeny, then a list of progeny will appear to the right of the parent data input boxes. Leach rate constants should be entered for each progeny (if any) in the list for each parent.

4.7.3.2 Soil - Resuspension Screen

The type of model to run selects the model to use to evaluate air concentration from calculated soil concentrations. Four options are available: none (no resuspended contamination), use mass loading model, use Anspaugh model, and user input of resuspension factor.

The mass loading factor for resuspension model parameter is entered when the mass loading option is selected. This parameter is the airborne particulate concentration at the exposure location.

The depth of topsoil available for resuspension parameter is entered when the Anspaugh model is selected. This parameter represents the thickness of soil in which the deposited activity has been mixed.

The resuspension factor is entered when that option has been selected. The value provided is used for all radionuclides in the analysis.

4.7.3.3 Soil - Surface Soil Screen

This screen allows input of parameters describing the surface soil layer. These parameters are related.

The surface soil areal density is used to convert concentrations expressed per unit area to concentrations expressed per unit soil mass.

The surface soil layer used for density is the depth of soil used in calculation of the soil areal density.

The surface soil density is the soil mass density used to calculate the soil areal density.

4.7.4 Agriculture - General Screen

This screen, similar to that for the Near Field module, Figure 4.29, allows the user to describe handling of harvest removal, deposition to plants, resuspension to plant surfaces, and loss by weathering from plant surfaces.

The radionuclide removal due to harvesting option allows the user to activate ("x" in box) the calculation of soil loss due to harvest removal of each food crop and animal product feed. When activated, the soil concentration is depleted at the end of each year. The amount of loss is calculated from the plant concentration at harvest, the annual plant yield, the root penetration factors, and the soil concentrations at harvest.

The user defined dry deposition retention fraction to plants option allows the user to select the method for evaluating the dry deposition retention fraction. If this option is activated ("x" in box), then the user is allowed to enter the dry deposition retention fraction to plants (next parameter). The default is to allow the code to estimate the retention fraction using plant biomass.

The dry deposition retention fraction to plants is entered representing the fraction of dry deposition activity that is retained on plant surfaces during initial dry deposition from the air.

The user defined wet deposition retention fraction to plants option allows the user to select the method for evaluating the wet deposition retention fraction. If this option is activiated ("x" in box), then the user is allowed to enter the wet deposition retention fraction to plants

(next parameter). If this is not selected, the code will estimate the retention fraction using plant biomass.

The wet deposition retention fraction to plants is entered representing the fraction of wet deposition activity that is retained on plant surfaces during initial wet deposition from air.

The resuspension factor from soil to plant surfaces is used to evaluate the air concentration above the plants from resuspension of particulate activity.

The deposition factor from soil to plant surfaces is the interception fraction used to estimate the amount of resuspended activity deposited onto plants.

The weathering half life from plants is used to evaluate the weathering loss rate constant for loss of activity between deposition (wet or dry) and harvest.

4.7.4.1 Agriculture - Animal Feed - Biomass Screen

The standing biomass for each animal feed type is the total above-ground plant mass (wet weight) used to estimate soil losses from harvest removal.

4.7.4.2 Agriculture - Animal Feed - Consumption Screen

The feed consumption rate for each animal feed is entered. The value for each feed type represents the amount of feed of this type that the animal consumes. These values are multiplied by the contaminated fraction to determine the total intake of contaminated feed of each feed type.

4.7.4.3 Agriculture - Animal Feed - Storage Time Screen

The storage time between harvest and feeding to the animal is used to evaluate radioactive decay during the storage period.

4.7.4.4 Agriculture - Animal Feed - Contaminated Fraction Screen

The contaminated fraction of feed for each animal type is the fraction of the feed type fed to the animal that is contaminated. This fraction is multiplied by the feed consumption rate to determine the total contaminated intake of each feed type.

4.7.4.5 Agriculture - Animal Feed - Growing Period Screen

The growing period for each animal type defines the deposition period for irrigation and atmospheric deposition to plants.

4.7.4.6 Agriculture - Animal Feed - Yield Screen

The yield of each animal feed type gives the total annual production of edible feed crops per unit area of farmland. This value is used in the Harvest Removal calculations.

4.7.4.7 Agriculture - Animal Feed - Dry/wet Ratio Screen

The dry/wet ratio for each animal feed type is used to convert between dry and wet weight bases.

4.7.4.8 Agriculture - Animal Feed - Translocation Factor Screen

The translocation factor for each animal feed type is the fraction of activity reaching the plant surface that is transferred to the edible part of the plant.

4.7.4.9 Agriculture - Animal Feed - Acute Forage Screen

This is the only screen unique to the acute animal models. The acute forage diet fraction for beef or milk cows is the fraction of the animals' diet that is forage at the time the acute release occurs.

4.7.5 Food Crops

The Agriculture/Food Crops tab has several sub-screens. They are parallel in nature to those of the Near Field and Chronic modules.

4.7.5.1 Agriculture - Food Crop - Biomass Screen

The standing biomass for each food crop is used to estimate the wet and dry interception fractions.

4.7.5.2 Agriculture - Food Crop - Growing Period Screen

The growing period for each food crop defines the deposition/interception period for irrigation and atmospheric deposition to plants.

4.7.5.3 Agriculture - Food Crop - Yield Screen

The yield of each food crop gives the total annual production of edible food crops per unit area of farmland. This value is used in the Harvest Removal calculations.

4.7.5.4 Agriculture - Food Crop - Dry/wet Ratio Screen

The dry/wet ratio for each food crop is used to convert between dry and wet weight bases.

4.7.5.5 Agriculture - Food Crop - Translocation Factor Screen

The translocation factor for each food crop is the fraction of activity reaching the plant surface that is transferred to the edible part of the plant.

4.7.6 Agriculture - Intake Delays Screen

The intake delay for each food crop, animal product, and aquatic food is the average time between harvest and consumption of the food by the exposed individual. The time period is used to account for radioactive decay prior to consumption.

4.7.8 Pathways Screen

The selection of exposure pathways is controlled on this screen, which is similar to those of the Near Field and Chronic modules, Figures 4.30 and 4.33. Each pathway may be selected for inclusion in the analysis for the current exposure location. The following pathways may be selected.

Animal product (beef, poultry, milk, eggs) ingestion
Food crop (leafy vegetables, root vegetables, fruit, grains) ingestion
Aquatic food (fish, mollusks, crustacea, aquatic plants) ingestion
Drinking water ingestion
Inadvertent shower water ingestion
Inadvertent swimming water ingestion
Inadvertent soil ingestion
Air inhalation from atmospheric transport
Indoor inhalation of contaminants released from domestic water during showering and other uses
Inhalation of suspended soil from prior air or irrigation deposition
External exposure from waterborne activity while swimming
External exposure from waterborne activity while boating
External exposure from sediment activity while on shoreline
External exposure from soil activity
External exposure to airborne activity from atmospheric transport

The external exposure to air may be evaluated using the finite plume model or the semi-infinite plume model. When the finite plume model is used, the external dose values are read directly from the atmospheric transport file (ATO) and no calculations are performed for this pathway in the GENII acute exposure module. If the finite plume model box is checked, then the module expects to read the external dose values from the atmospheric transport file. Otherwise, the dose is to be based on the air concentration.

4.8 Using the GENII Receptor Intake Module

This user interface allows the user to specify the number of age groups to be considered, and parameters necessary to estimate the intake or exposure to radionuclides. The single screen for this user interface has three divisions: 1) number of age groups (upper left), 2) age group and exposure pathway selection (lower left), and 3) parameter value entry for the selected age group and exposure pathway (right).

The various GENII or other FRAMES-compatible exposure modules may be used to supply information to the GENII receptor intake model. The two parameters in the **General Info** model selection window (accessed by RIGHT clicking on the exposure icon), Easting Coordinate and the Northing Coordinate for the GENII exposure model (see Figure 3.3), have *no impact* on the calculation – all locations transmitted by the EPF file are processed.

The **File** menu item allows input data to be saved, or existing data to be reviewed and retained unchanged. The **Defaults** menu item allows the user to reset all parameters to one of two sets of pre-selected values, for convenience labeled as Maximum Individual and Average Individual. If the defaults are selected, any changes made earlier will be overwritten. Note that the defaults are NOT age-specific, and are provided only for reference adults. This is because GENII cannot know beforehand how many, and of what structure, the age groups selected will be. Nearly all non-control parameters have the ability to associate a reference. These references are intended to help document the selection of parameters and allow traceability of assumptions. To associate a reference with a data entry, place the focus (click the cursor in the box) on the parameter of interest, click on the **Reference** menu item, and select either Add or Select. A window like that shown in Figure 4.9 will appear. If the **Add** option was selected, a blank entry will appear allowing text entry of a new reference. The entries are free formatted, so any short and long descriptor may be added. If the **Select** option is chosen, the available entries may be scrolled using the arrow buttons, or a specific entry searched for using the appropriate boxes.

Three kinds of **Help** are available: **General**, **Context-**specific, or allowed **Ranges** of input values. If no individual parameter has the focus of the mouse cursor, selection of Help will bring up the general help, which describes the Near Field model inputs in general terms. If a parameter has the focus, the context specific help will describe the use of the particular parameter. For a parameter with the control focus, selection of ranges will provide the lower and upper bounds that the GENII interface will allow for that particular parameter value.

4.8.1 Initial Entries

Some initial selections must be made to define the nature of the analysis desired before any of the other parameters will become available.

4.8.1.1 Number of Age Groups

The <u>number of age groups</u> is set to the number of age groups to be evaluated in the current intake assessment. Most parameters to be provided are a function of age. A maximum of 6 groups can be defined.

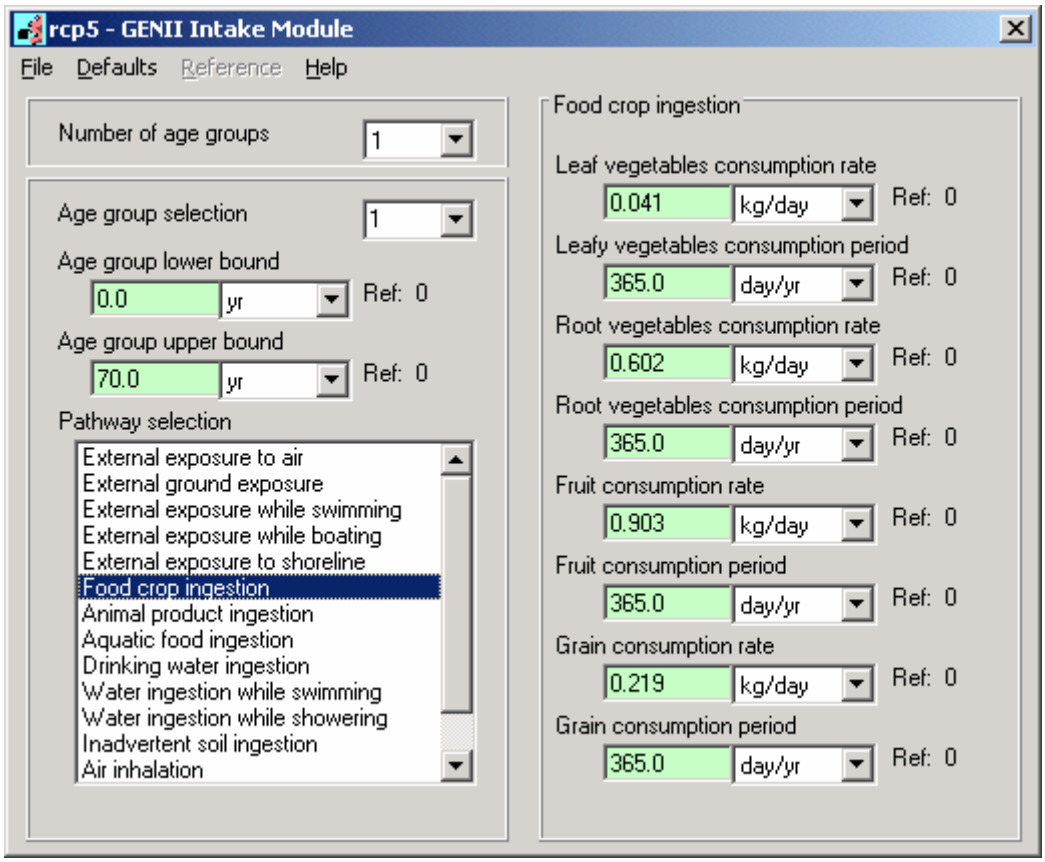


Figure 4.35. GENII Intake Module Screen

4.8.1.2 Age Group and Exposure Pathway Selection

The age group selection pull-down box is used to identify the age group associated with input parameters to be entered. Values for all parameters should be entered for all of the number of age groups defined.

The age group lower bound is the youngest age of individuals in the currently selected age group. The minimum value for this parameter is 0 years (birth).

The age group upper bound is the oldest age of individuals in the receptor population group for the current intake scenario. There is a practical upper bound of 100 years; the value must be greater than the lower bound selected.

The exposure pathway selection pull-down list allows the user to select the exposure pathway for which parameters are to be entered. A specific pathway is selected by clicking on the desired pathway, or by scrolling up or down using the arrow keys on the keyboard. The parameters are entered in the input area on the right side of the screen.

The right side of the screen is used for parameter value entry. The parameters displayed for entry correspond to the exposure pathway and age group selected. For the two swimming pathways (external and ingestion) all parameters are displayed when either of the pathways is selected. Changing them in one place changes them in the other.

4.8.2 Pathway Parameters

The parameters for each exposure pathway are described below in the order in which the pathways appear in the exposure pathway pull-down list.

4.8.2.1 External Exposure to Air

Parameters for external exposure to air define the time the individual is exposed to contaminated air during a day and the year.

The daily plume immersion exposure time is the average number of hours in a day that the individual is exposed during a year.

The yearly plume immersion exposure time is the number of days in a year that the individual is exposed to the contaminated airborne plume.

4.8.2.2 External Ground Exposure

Parameters for external ground exposure allow definition of the time the individual is exposed to ground during a year, and shielding factors and time fractions for indoor and outdoor exposures.

The indoor shielding factor is the fractional reduction applied to the external dose rate factor for ground exposure for the time the individual is indoors.

The outdoor shielding factor is the fractional reduction applied to the external dose rate factor for ground exposure for the time the individual is outdoors.

The daily external ground exposure time is the total time (per day) that an individual is exposed to contaminated ground. This is an average value over the exposure duration.

The yearly external ground exposure time is the number of days in a year that the individual is exposed to contaminated ground.

The fraction of time spent indoors is the average time fraction during a typical day that the individual spends indoors.

The fraction of time spent outdoors is the average time fraction during a typical day that the individual spends outdoors.

4.8.2.3 External Exposure While Swimming

Parameters for swimming include the frequency of swimming, the duration of each swimming event, and the number of days in a year that the individual swims. Note that these three parameter values are also used for the water ingestion while swimming pathway. If one of the parameters is changed during entry of values for the other pathway, the value for this pathway will also be changed.

The frequency of swimming event is the number of times the individual swims per day on the days in which swimming occurs.

The duration of swimming event is the time the individual spends swimming during each swimming event.

The swimming days is the number of days in a year that swimming occurs. On each of these days it is assumed that the individual swim the number of times specified by the frequency of swimming event and for the duration of swimming event for each of these event.

4.8.2.4 External Exposure While Boating

The shielding factor for boating is the reduction factor to be applied to the external dose rate while boating because of shielding by the boat. This is in addition to the geometry factor of 0.5.

The frequency of boating event is the number of times a day (during the days in which boating occurs) that the individual is involved in a boating event.

The duration of boating event is the length of time the individual is boating during the typical boating event.

The boating days are the number of days in a year that the individual is involved in boating. During each of these days, the individual is assumed to be involved in the number of events given by the frequency of boating events with each event lasting for the duration of boating events hours.

4.8.2.5 External Exposure to Shoreline

The frequency of shoreline use is the number of times a day the individual uses the shoreline.

The duration of shoreline event is the average time the individual spends on the shoreline during one visit to the shoreline.

The shoreline days are the number of days in a year during which the individual visits the shoreline exposure location.

The shore width factor is a factor for reduction of the external dose rate factor for exposure to the shoreline. The external dose rate factors are based on exposure to an infinite flat

plane of contamination. Because most shorelines do not represent an infinite plane, a reduction is allowed to address this difference in geometry.

4.8.2.6 Food Crop Ingestion

This screen allows input of consumption rates and periods for each of the four food crops pathways (leafy vegetables, root vegetables, fruit, and grain). The root crops include all vegetable crops not considered to be leafy vegetables. The grain crops represent breads and cereals.

The food crop consumption rate is the average amount of food crop consumed in a day for those days in which the food crop is eaten by the exposed individual.

The food crop consumption period is the number of days in a year that the food crop is consumed at the average rate.

4.8.2.7 Animal Product Ingestion

This screen allows input of consumption rates and periods for each of the four animal product food pathways (beef, poultry meat, milk, and eggs).

The animal product consumption rate is the average amount of animal product consumed in a day for those days in which the animal product is eaten by the exposed individual.

The animal product consumption period is the number of days in a year that the animal product is consumed at the average rate.

4.8.2.8 Aquatic Food Ingestion

This screen allows input of consumption rates and periods for each of the four aquatic food product pathways (fish, mollusks, crustacea, and aquatic plants).

The aquatic food product consumption rate is the average amount of aquatic food product consumed in a day for those days in which the aquatic food product is eaten by the exposed individual.

The aquatic food product consumption period is the number of days in a year that the aquatic food product is consumed at the average rate.

4.8.2.9 Drinking Water Ingestion

The drinking water ingestion rate is the average daily consumption rate of water on those days that the contaminated water is consumed by the exposed individual.

The drinking water ingestion period is the number of days in a year that water is consumed at the average rate.

4.8.2.10 Water Ingestion While Swimming

The exposure parameters for this pathway include the three parameters for the external exposure while swimming pathway plus the ingestion rate of water while swimming. The three parameters common to all swimming pathways are the frequency of swimming events, the duration of swimming event, and the swimming days.

The ingestion rate of water while swimming is the amount of water inadvently swallowed by the exposed individual during an hour of swimming.

4.8.2.11 Water Ingestion While Showering

The frequency of showering event is the number of times a day (during the days in which showering occurs) that the individual is showers.

The duration of showering event is the length of time the individual is showers during one shower.

The showering days is the number of days in a year that the individual showers. During each of these days, the individual is assumed to be involved in the number of events given by the frequency of showering events.

The ingestion rate of water while showering is the rate of inadvertent water intake by the exposed individual during each hour of showering.

4.8.2.12 Inadvertent Soil Ingestion

The soil contact days is the number of days in a year that the exposed individual contacts soil.

The inadvertent soil ingestion rate is the average daily rate of ingestion of soil on the days in which soil is contacted.

4.8.2.13 Air Inhalation

The air inhalation rate is the volume of air inhaled outdoors per day on those days in which the individual is exposed to contaminated air.

The air inhalation period is the number of days in a year that the individual is exposed to contaminated outdoor air.

4.8.2.14 Resuspended Soil Inhalation

Suspension of contaminants previously deposited to soil represents a possible pathway for inhalation exposure. The parameters for this pathway include the inhalation rate, inhalation period (days per year) and the fraction of a day that the individual is exposed to the resuspended soil.

The resuspended soil inhalation rate is the daily inhalation rate during the exposure period to the resuspended contamination. This may be the same as the inhalation rate of air from section 4.7.2.13 above – only the resuspended portion is considered here.

The resuspended soil inhalation period is the number of days in a year that the individual is exposed to resuspended contamination.

The fraction of a day inhalation occurs is the fraction of time in an average day that the individual is exposed to the resuspended contamination.

4.8.2.15 Indoor Inhalation

The indoor inhalation rate is the daily inhalation rate during the exposure period to the indoor air contamination. Total hours distributed between indoor and outdoor inhalation should not total more than the number of hours in a day.

The indoor inhalation period is the number of days in a year that the individual is exposed to indoor air contamination.

The fraction of a day inhalation occurs is the fraction of time in an average day that the individual is exposed to the indoor contamination.

The consider radon and progeny check box is a flag to allow consideration of indoor radon progeny at a constant fraction of their decay equilibrium with the radon parent. If this box is checked, the inhalation calculations performed subsequently assume that the radon progeny are in a fixed activity ratio determined by the radon equilibrium fraction parameter.

4.9 Using the GENII Health Impacts Module

This user interface allows the selection of the type of dose and/or risk calculation to be performed, and provides the necessary additional parameters for each. The GENII Health Impacts main screen is illustrated in Figure 4.36.

The GENII or other FRAMES-compatible receptor intake modules may be used to supply information to the GENII health impacts model. The two parameters in the **General Info** model selection window (accessed by RIGHT clicking on the exposure icon), Easting Coordinate and the Northing Coordinate for the GENII exposure model (see Figure 3.3), have *no impact* on the calculation – all locations transmitted by the RIF file are processed.

The **File** menu item allows input data to be saved, or existing data to be reviewed and retained unchanged. Nearly all non-control parameters have the ability to associate a reference. These references are intended to help document the selection of parameters and allow traceability of assumptions. To associate a reference with a data entry, place the focus (click the cursor in the box) on the parameter of interest, click on the **Reference** menu item, and select either Add or Select. A window like that shown in Figure 4.9 will appear. If the **Add** option was selected, a blank entry will appear allowing text entry of a new reference. The entries are free formatted, so any short and long descriptor may be added. If the **Select** option is chosen, the available entries may be scrolled using the arrow buttons, or a specific entry searched for using the appropriate boxes. In this module, only one kind of **Help** is available, general help.

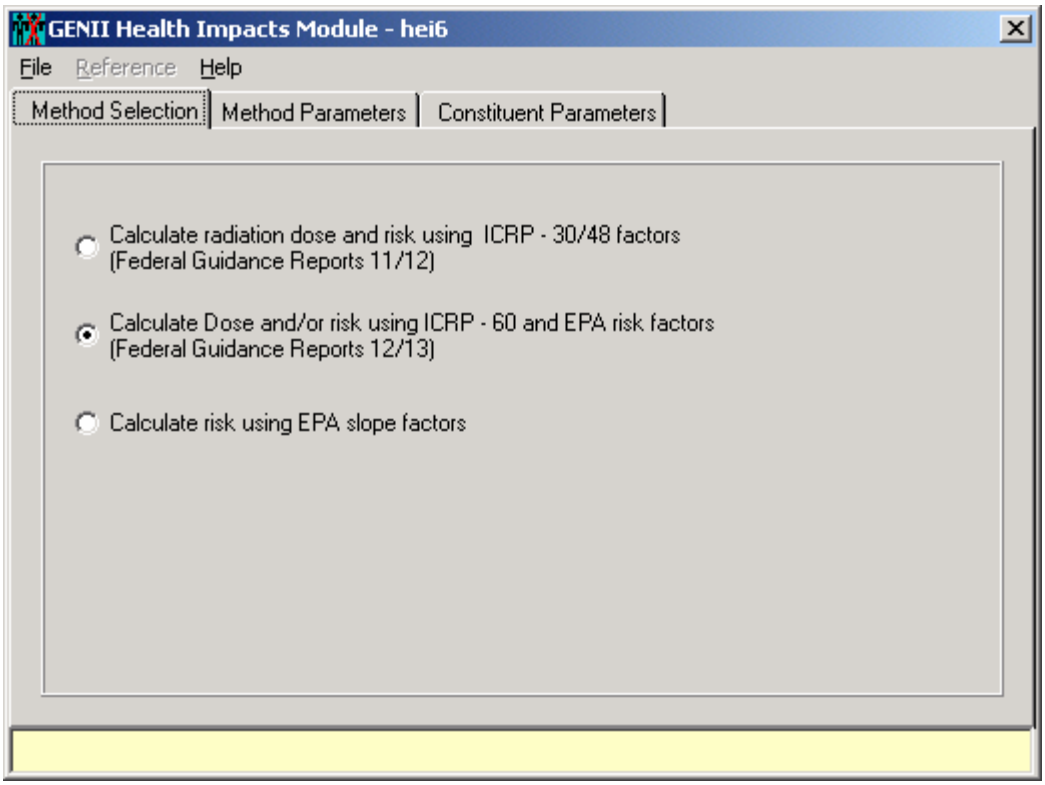


Figure 4.36. GENII Health Impacts Module Method Selection screen

4.9.1 Method Selections

Three options are available. Check the appropriate box for the method desired.

Calculate dose and risk using ICRP-30/48 factors (Federal Guidance Reports 11 and 12): This option allows calculation of doses and/or risks using DOE-approved methods. The radiation dosimetry is based on ICRP Publication 30 (as updated), as provided in Federal Guidance Reports 11 and 12 or DOE compilations DOE/EH-0070 and DOE/EH-0071.

Selection of this option activates a "Method Parameters" tab, Figure 4.37. Options for calculating radiation dose, fatal cancers, or cancer incidence are available. Select one or more. The cancer calculations are performed using effective doses and a dose-to-risk conversion factor. Defaults are provided for each, and the allowable range (in the appropriate units) will scroll across the bottom of the screen.

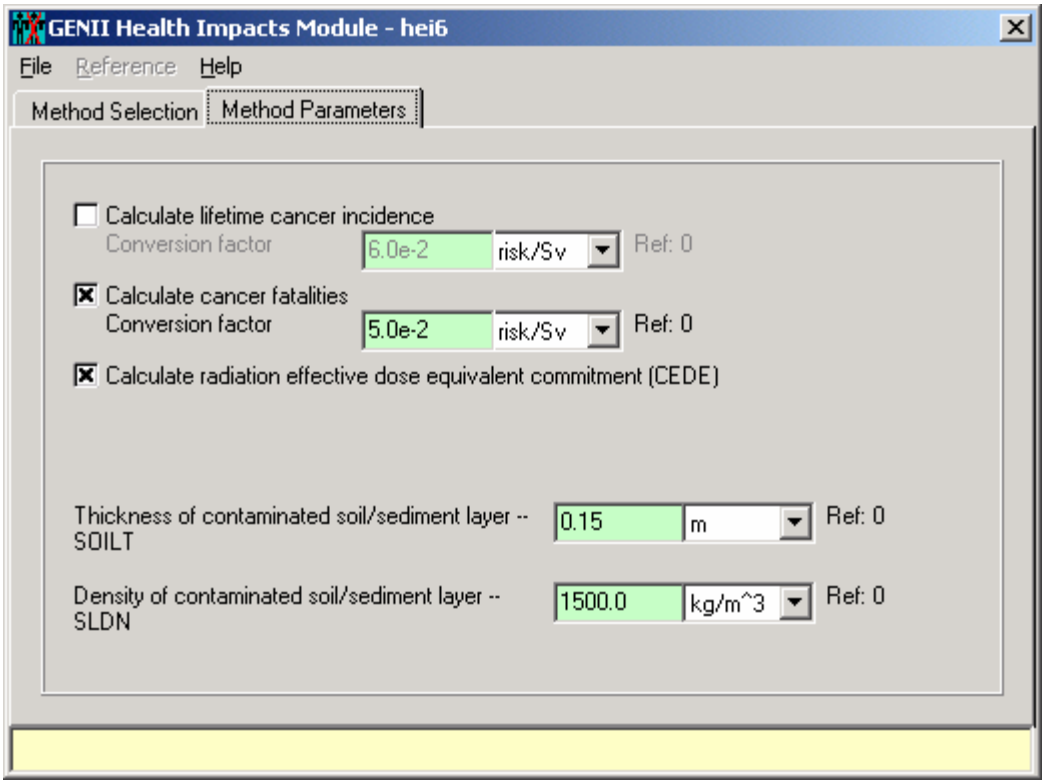


Figure 4.37. Dose and Risk Method Parameters screen

Two additional parameters related to the estimation of external dose rates are also required. These should be set with the values used in preceding modules.

Calculate dose and/or risk using ICRP-60 and EPA risk factors: This option allows calculation of doses and/or risks using EPA-approved methods. The radiation dosimetry is based on ICRP Publication 60, as provided in Federal Guidance Reports 12 and 13.

Selection of this option activates a "Method Parameters" tab, similar to that for the ICRP-30 methods, Figure 4.37. Options for calculating radiation dose, fatal cancers, or cancer incidence are available. Select one or more. The cancer calculations are performed using the Federal Guidance Report 13 factors – the dose-to-risk conversions may be ignored, as indicated by the scrolling message. Two additional parameters related to the estimation of external dose rates are also required. These should be set with the values used in preceding modules.

Selection of this option also activates a "Constituent Parameters" tab Figure 4.38. All fields under this tab must be filled in. Each radionuclide in the case will be displayed using the advance arrows; for each select the appropriate values of inhalation class desired.

Calculate risk using EPA slope factors: This option allows calculation of radiation risk using EPA HEAST slope factors (a subset of information from Federal Guidance Report 13). No additional method or parameter information is required.

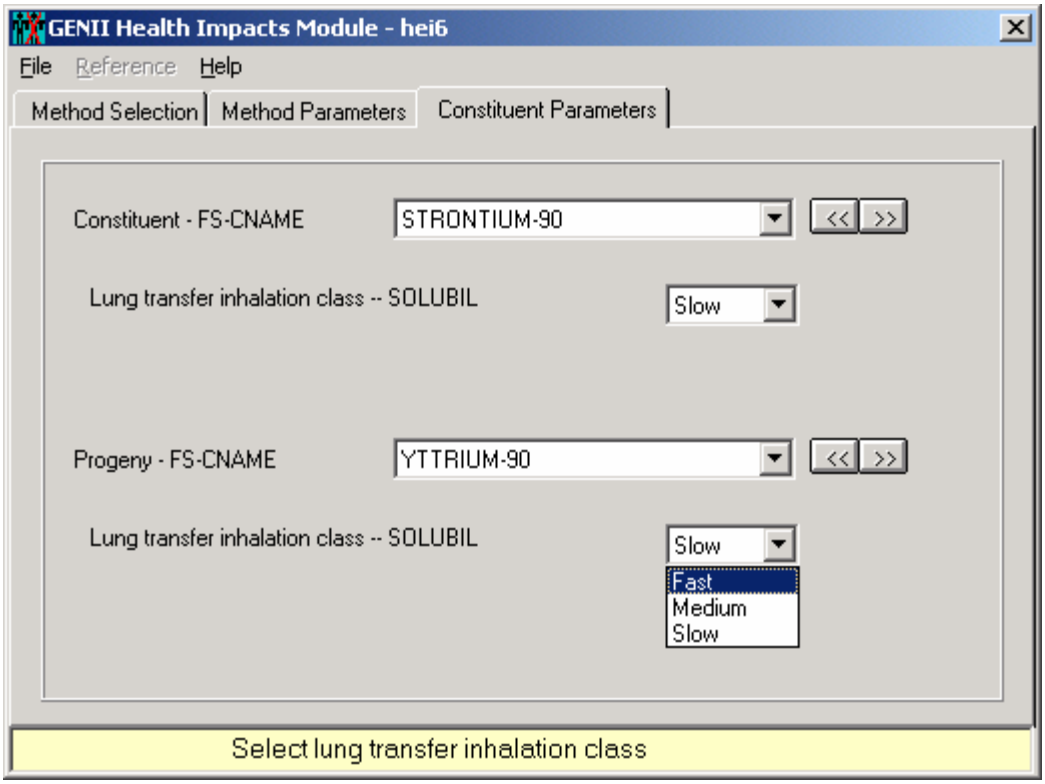


Figure 4.38. Constituent Parameters tab

4.10 Using Specialized Output Processors

FRAMES provides a number of viewers for examining intermediate and final output data. For each icon, these are invoked using a RIGHT click of the mouse cursor over the icon. This action will bring up a menu on which the lower two options are always **View/Print User Input** and **View/Print Module Output**. The **View/Print User Input** selection always results in a screen such as that illustrated in Figure 4.39. This screen allows the user to review the input parameters, as they are stored in the GID file. It also allows the user to review the summary description of the model being used. Either of the windows displayed may also be printed.

Selecting the View/Print Module Output option results in a further selection of two or more possible viewers. All FRAMES modules have the option for a Text View of the intermediate data file. Selection of this option opens a window identical to that shown in Figure 4.39 for the user input, but with the actual output file available for examination. This provides the most direct and immediate capability for examining the files. However, in most instances, the FRAMES intermediate files can be very large and relatively obtuse for novice users. For this reason, the alternative summary output viewers can often be more useful for determining the value of selected parameters.

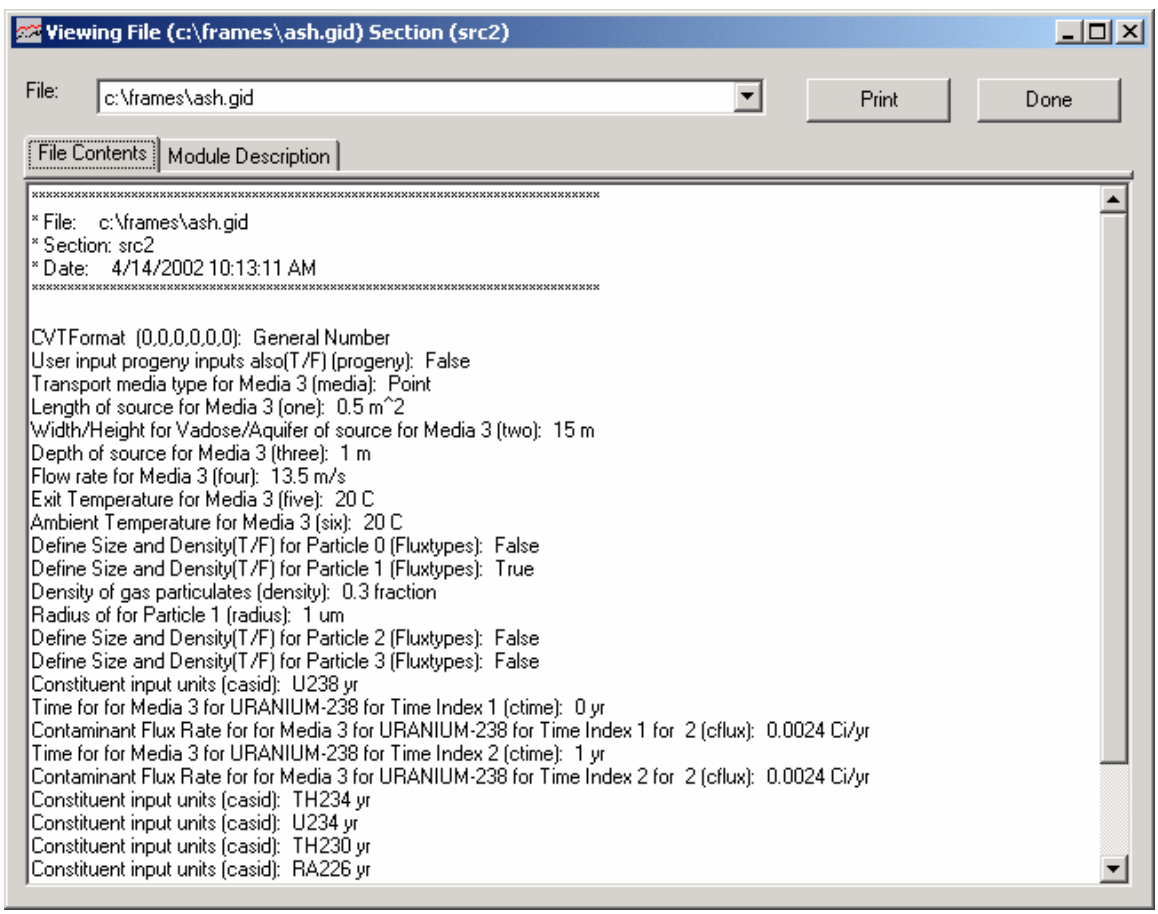


Figure 4.39. Typical View/Print User Input screen

For the FRAMES Known Source module, a graphical output viewer option is provided. This option will take the output file generated and convert it to a series of EXCEL® tables and figures for each constituent radionuclide, such as that shown in Figure 4.40. Complete functionality of this option requires that the user's computer have Microsoft Office programs installed. Separate entries will be made for each particle size and for gases for atmospheric releases. Similar tables and figures can be made for surface water release histories.

For the atmospheric transport modules, a different graphical viewer is available. This is an adaptation of the commercially-available program Gnuplot. This viewer currently only works with outputs that are structured as a radial grid; therefore with GENII it only works for the acute and chronic plume models, not the puff models. Invoking this viewer first opens a screen shown in Figure 4.41, which provides Gnuplot with some minimal starting parameters for the graph. Running the viewer will generate a series of three-dimensional plots of air concentration and deposition for each radionuclide in the input inventory. An example of such a plot has been presented as Figure 4.11.

Figure 4.41 is and example of the graphical option for the exposure and receptor intake modules. This viewer allows the user to select location, time period, radionuclide, and environmental pathway and displays the intermediate parameter of interest, either concentration or quantity taken in.

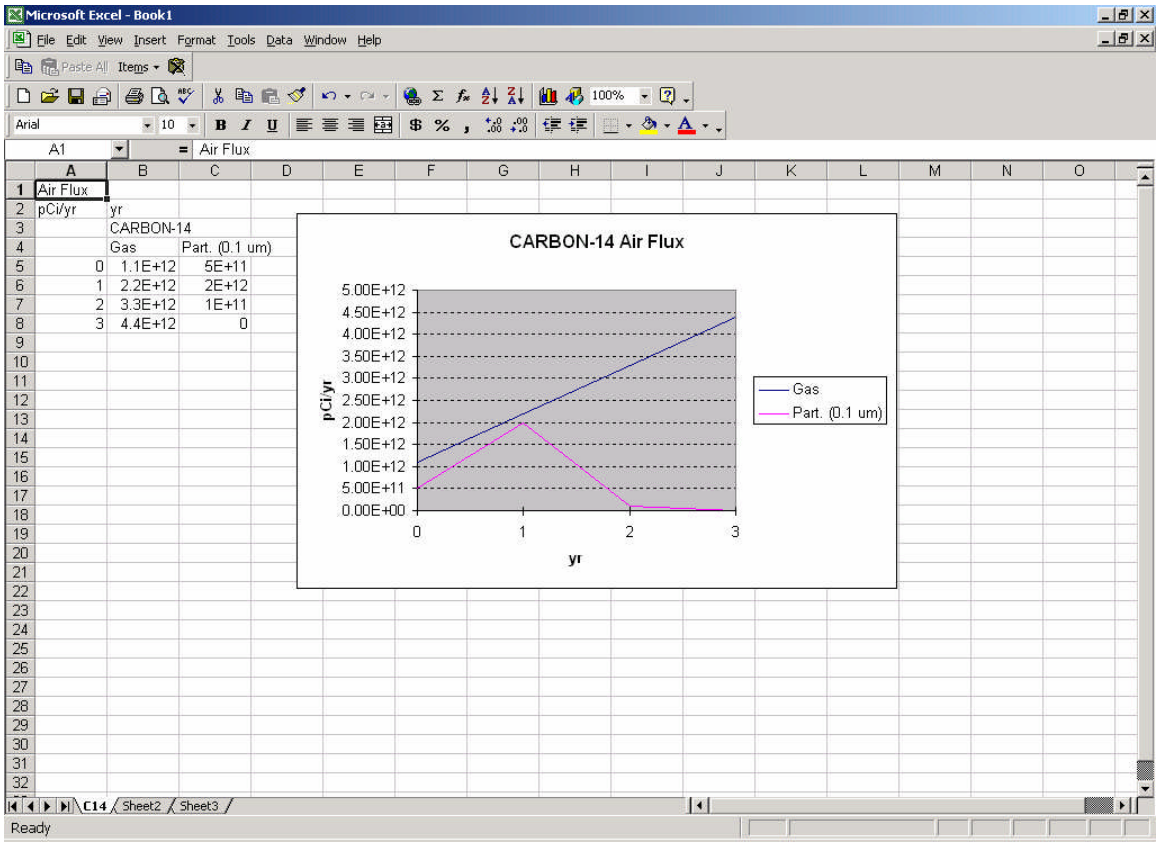


Figure 4.40. Source term graphical viewer output

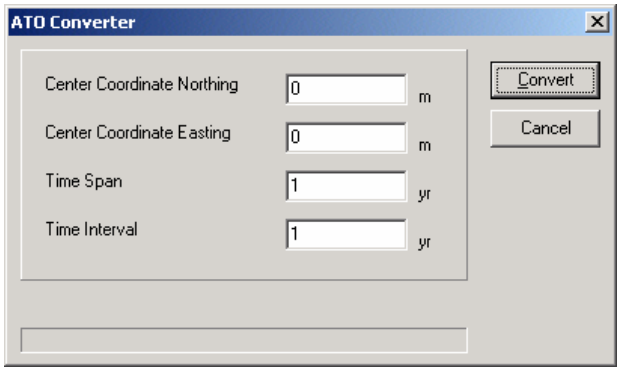


Figure 4.41. Atmospheric output viewer input screen

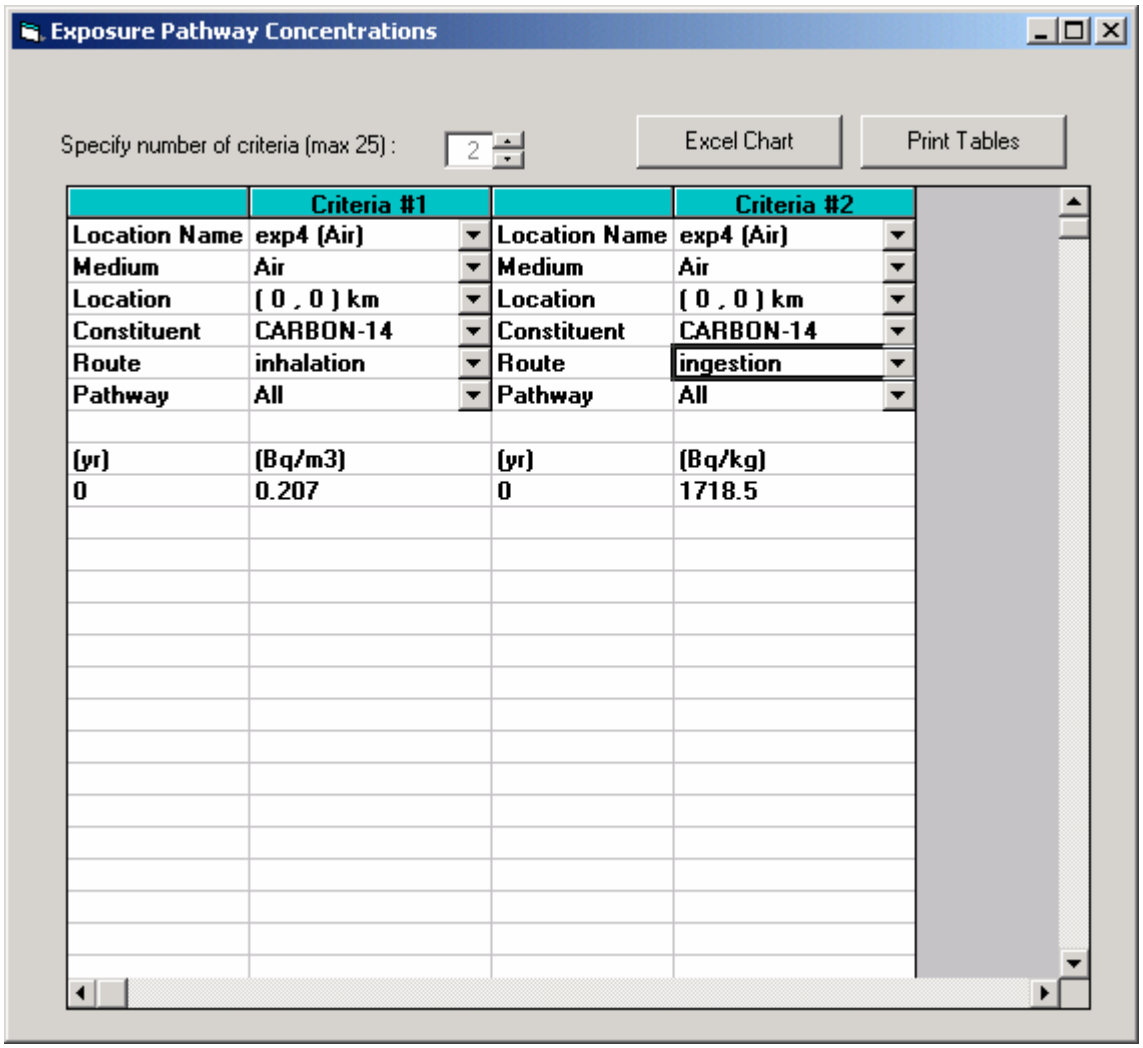


Figure 4.42. Graphical viewer screen for exposure and receptor intake modules

The **View/Print Model Output** option for the Health Impacts module provides a large number of specialized viewers. Some are similar to that shown in Figure 4.42, and others are more specialized. The user is encouraged to experiment with these viewers to find one that is most useful for his or her purpose. One output formatter has been specifically written for GENII output – the **NESHAPS Viewer for GENII**. This viewer is intended for use with problems involving chronic atmospheric releases. Invoking this viewer opens an input screen shown in Figure 4.43. The input screen may be used to structure the output file that is generated to provide selected kinds of information. The FRAMES structure is such that doses and risks to individuals of varying location, age, diet, and behavior may all be calculated in a single run. This utility will summarize the results for all age groups and locations by total dose and risk, dose and risk by exposure pathway, and dose and risk by radionuclide. If the user has a file structured in a way that matches the atmospheric dispersion grid used and the population structure defined, it may be accessed at this time to provide population summaries of the same nature. If the population file is not available, the code simply provides individual summaries. The user is prompted to put in a population file on the Population File Name screen. The NESHAPS summary may also include the atmospheric transport intermediate results from the FRAMES ATO file if desired. Depending on the number of radionuclides, the number of nodes on the atmospheric grid, the number of age groups, and the amount of physical memory installed on the user's computer, the elapsed time for the summarization step can extend several seconds. The code occasionally prints status information before relinquishing control to a standard FRAMES text viewer.

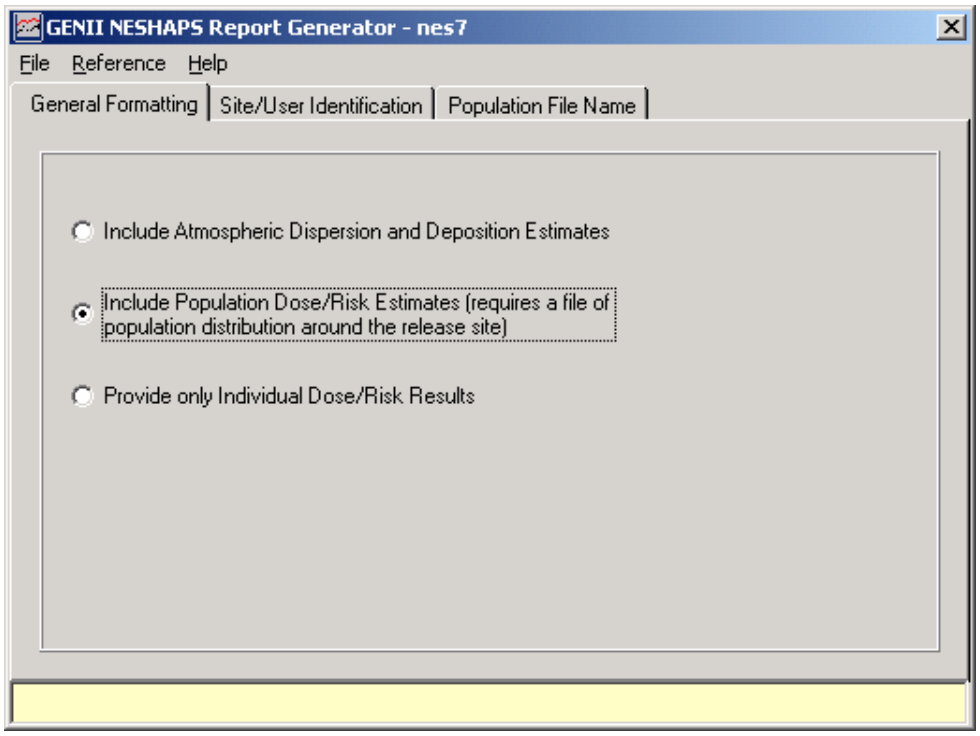
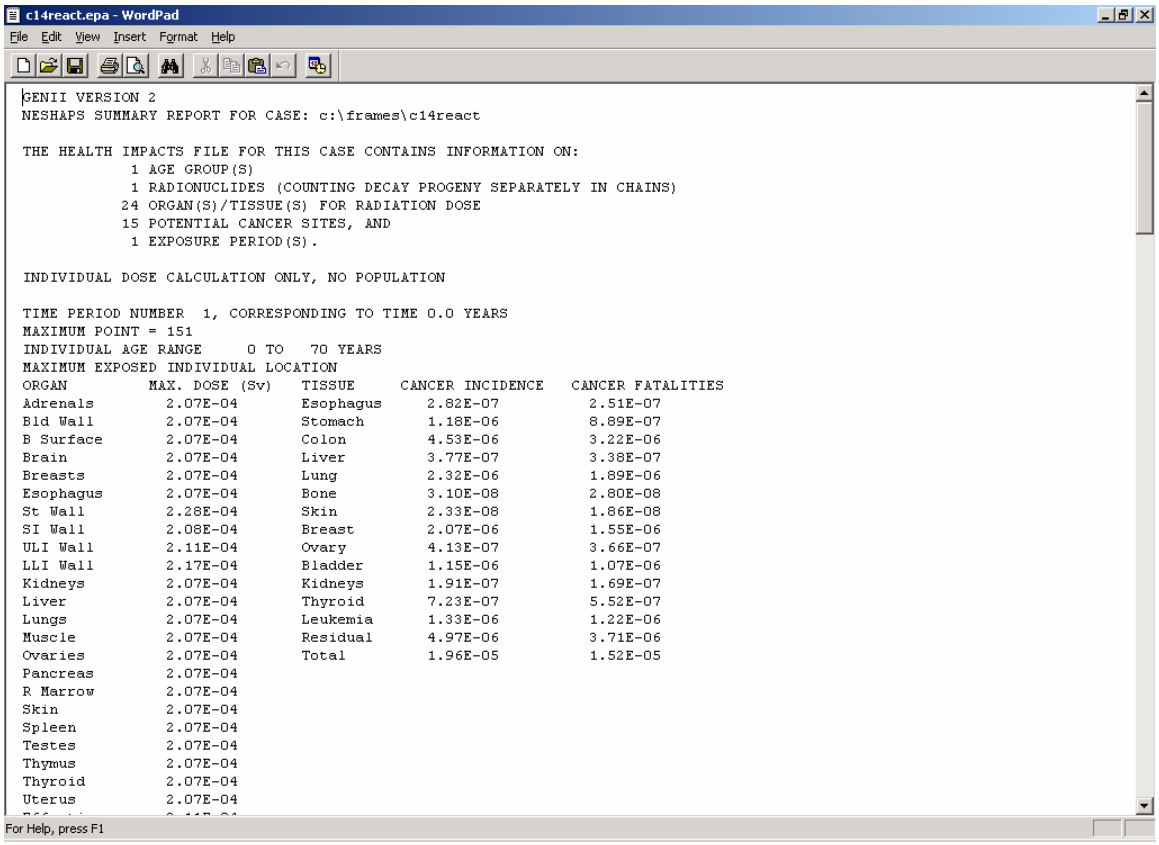


Figure 4.43. GENII NESHAPS Viewer input screen

The GENII NESHAPS viewer prepares an output file that is given the name of the FRAMES GID file (the current case name) with the extension .EPA. This file may be viewed or printed from any word processor or text viewer. A sample output file is provided with the GENII distribution files. It will typically look like the example shown in Figure 4.44. Data are summarized for each time period, for each grid point, and for each age group. The maximally exposed individual location is indicated.



```
GENII VERSION 2
NESHAPS SUMMARY REPORT FOR CASE: c:\frames\c14react

THE HEALTH IMPACTS FILE FOR THIS CASE CONTAINS INFORMATION ON:
            1 AGE GROUP(S)
            1 RADIONUCLIDES (COUNTING DECAY PROGENY SEPARATELY IN CHAINS)
           24 ORGAN(S)/TISSUE(S) FOR RADIATION DOSE
           15 POTENTIAL CANCER SITES, AND
            1 EXPOSURE PERIOD(S).

INDIVIDUAL DOSE CALCULATION ONLY, NO POPULATION

TIME PERIOD NUMBER  1, CORRESPONDING TO TIME 0.0 YEARS
MAXIMUM POINT = 151
INDIVIDUAL AGE RANGE     0 TO   70 YEARS
MAXIMUM EXPOSED INDIVIDUAL LOCATION
ORGAN          MAX. DOSE (Sv)   TISSUE     CANCER INCIDENCE   CANCER FATALITIES
Adrenals         2.07E-04       Esophagus     2.82E-07          2.51E-07
Bld Wall         2.07E-04       Stomach       1.18E-06          8.89E-07
B Surface        2.07E-04       Colon         4.53E-06          3.22E-06
Brain            2.07E-04       Liver         3.77E-07          3.38E-07
Breasts          2.07E-04       Lung          2.32E-06          1.89E-06
Esophagus        2.07E-04       Bone          3.10E-08          2.80E-08
St Wall          2.28E-04       Skin          2.33E-08          1.86E-08
SI Wall          2.08E-04       Breast        2.07E-06          1.55E-06
ULI Wall         2.11E-04       Ovary         4.13E-07          3.66E-07
LLI Wall         2.17E-04       Bladder       1.15E-06          1.07E-06
Kidneys          2.07E-04       Kidneys       1.91E-07          1.69E-07
Liver            2.07E-04       Thyroid       7.23E-07          5.52E-07
Lungs            2.07E-04       Leukemia      1.33E-06          1.22E-06
Muscle           2.07E-04       Residual      4.97E-06          3.71E-06
Ovaries          2.07E-04       Total         1.96E-05          1.52E-05
Pancreas         2.07E-04
R Marrow         2.07E-04
Skin             2.07E-04
Spleen           2.07E-04
Testes           2.07E-04
Thymus           2.07E-04
Thyroid          2.07E-04
Uterus           2.07E-04
```

Figure 4.44. Example of a portion of the GENII NESHAPS summary output file.

4.11 Additional Specialized FRAMES Input Modules

In addition to the FRAMES Known Source Modules (discussed in Section 4.2), and the standard GENII components, there are several additional FRAMES-provided utility programs that allow the user to bypass portions of the modeling process when concentrations of contaminants are known in the environment. These utilities allow the user to input concentrations in air, surface water, groundwater, soil, and plant and/or animal products.

Brief descriptions of these input options are provided below. These modules do not compute the ingrowth of progeny because the user is assumed to know everything about the source, including progeny emission. Therefore, these modules assume that the progeny emissions are input along with the parent emissions.

FRAMES ATO Chronic Air Module: This module is used if the concentrations, deposition rates and/or external dose in the air are known. The radionuclide concentrations, deposition rates, external doses are entered directly through the interface.

FRAMES ATO Acute Air Module: This module is used if the concentrations, deposition rates and/or external dose in the air are known for short-term accidental releases. The radionuclide concentrations, deposition rates, external doses are entered directly through the interface.

FRAMES WCF Surface Water Module: This module is used if the concentrations and/or fluxes in the surface water are known. The radionuclide concentrations/fluxes are entered directly through the interface.

FRAMES ACF Aquifer Module: This module is used if the concentrations and/or fluxes in groundwater are known. The radionuclide concentrations/fluxes are entered directly through the interface.

FRAMES EPF Exposure Pathways Concentration Module: This module is used if the concentrations in components of various human exposure pathways such as plant products, animal products, or aquatic foods are known. The radionuclide concentrations are entered directly through the interface.

FRAMES RIF Receptor Intakes Module: This module is used if the intakes of radionuclides by individual humans are known for the different exposure pathways. The radionuclide intake rates are entered directly through the interface.

The input format of each of these utilities is similar. A portion of that for the Known Exposure Pathways Module is shown in Figure 4.45. The utility program will already know the radionuclides selected from the Contaminant Database (Section 4.1). Highlight each item in the "directory structure" in turn, and the necessary inputs will be shown. For example, for the EPF Exposure Pathways Concentration module, the user picks the appropriate contaminating medium (air, soil, water, etc.) and then highlights the desired pathways. Then, by clicking on each pathway, screens similar to that in Figure 4.46 are opened, allowing the input of the known input concentration values.

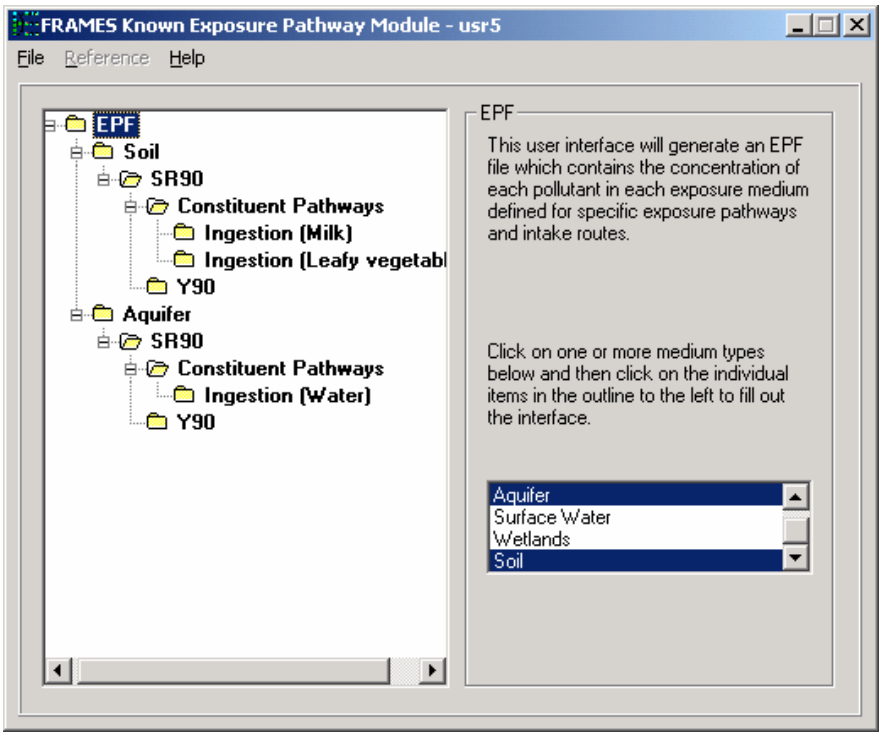


Figure 4.45. Pathway input screen for FRAMES Known Exposure Pathway Module

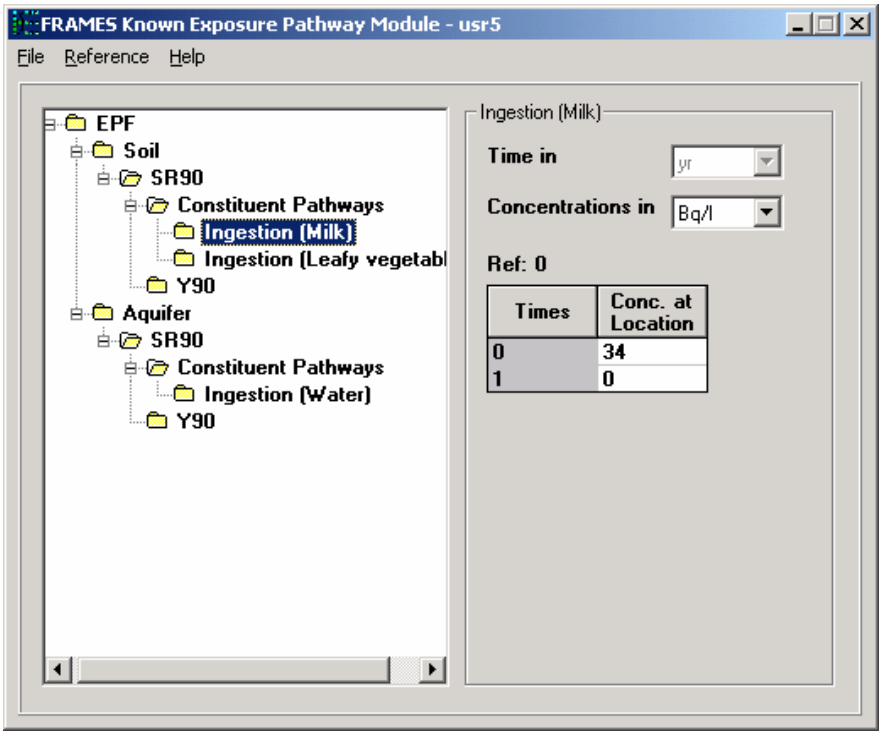


Figure 4.46. Concentration input screen for FRAMES Known Exposure Pathway Module

5. SENSITIVITY/UNCERTAINTY ANALYSIS

FRAMES is currently designed for deterministic environmental and human health impact models. The Sensitivity/Uncertainty Multimedia Modeling Module (SUM^3) software product was designed to allow statistical analysis using the existing deterministic models available in FRAMES. SUM^3 is an available option under the Sensitivity/Uncertainty Module in FRAMES. SUM^3 randomly samples input variables and preserves the associated output values in an external file available to the user for evaluation. This enables the user to calculate deterministic values with variable inputs, producing a statistical distribution of results. A typical application of the uncertainty analysis is to indicate the relative conservatism of the deterministic result.

Within FRAMES, SUM^3 allows the user to conduct a sensitivity and/or uncertainty analysis to understand the influence and importance of the variability/uncertainty input parameters on contaminant flux, concentration, and human-health impacts. The sensitivity analysis can identify the key parameters that dominate the overall uncertainty. Statistical methods used in SUM^3 are based on Monte Carlo sampling using Latin Hypercube random numbers. The file contains cumulative distribution function (CDF) data and can be graphically displayed through the FRAMES Viewer option.

5.1 Using the SUM^3 Module

There are four steps to starting the S/U Module: before using the S/U Module, connecting the S/U Module, choosing the SUM^3 model and opening the SUM^3 user interface.

Before using the S/U Module:

- First set up the deterministic FRAMES analysis, entering a value for each parameter requested.
- Run the deterministic model to ensure there are not errors in the base case.
- There should be green lights on all module icons prior to running the S/U Module.

Connecting the S/U Module:

- Drop a single S/U Module icon onto the FRAMES conceptual model screen by double clicking on the **sensitivity** icon on the left side of the window. The S/U Module Icon is a bell curve on a green background (see, for instance, Figure 5.1).
- Using the Connect-Disconnect or right-click and drag feature of FRAMES, connect the S/U Module icon to each deterministic module icon containing an input variable of interest. Note the connection path starts at the deterministic module icon and goes to the S/U Module icon. Figure 5.1 is an example a GENII conceptual model created for an atmospheric transport and exposure case. In this example all of the icons between the source term icon and the chronic exposure icon have been connected to the S/U module icon, thereby allowing all input and outputs produced by those modules to be available for selection in the SUM^3 user interface.

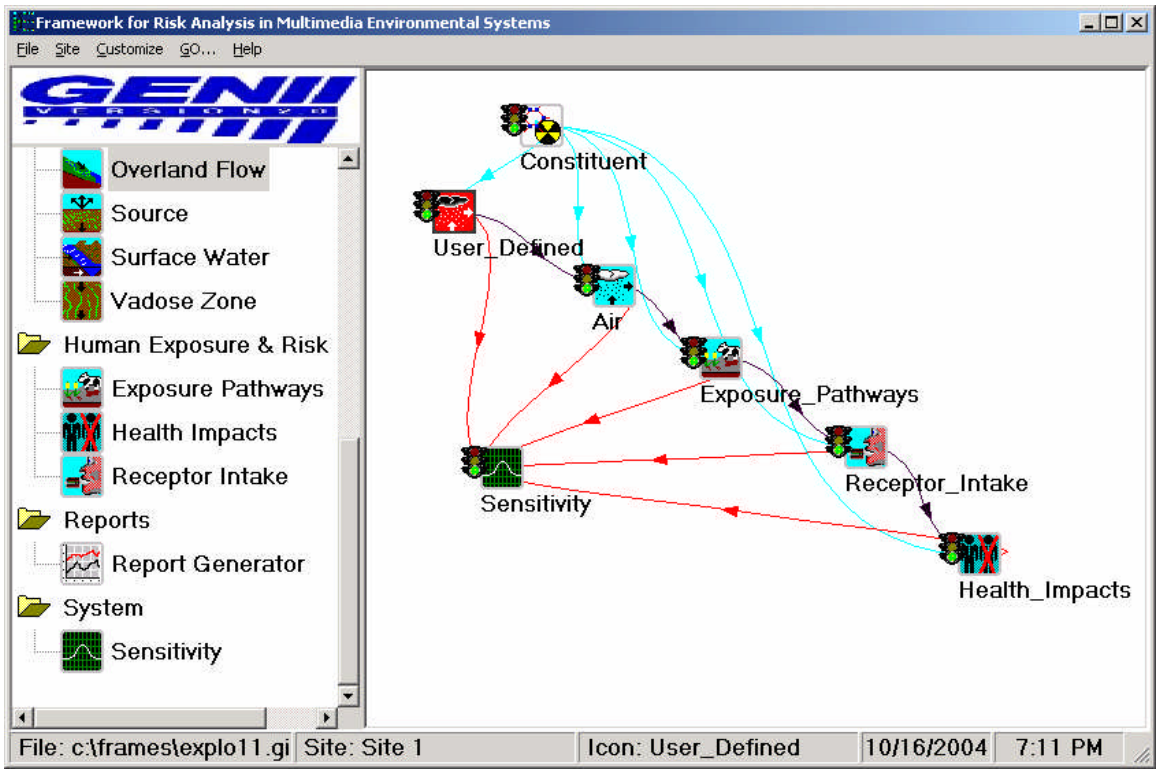


Figure 5.1. Attaching the SUM^3 icon to an existing analysis

Choosing the SUM^3 Model:

- Right Click on the S/U Module icon and choose the **General Info** option.
- From the **General Info** screen choose the **Sensitivity/Uncertainty** module. The available statistical models are listed in the left column, and a description and contact information for the highlighted model is displayed in the right column.
- Give the S/U Module icon a Label
- Click the OK button

Opening the SUM^3 Model User Interface:

- Shift click on the S/U Module icon and choose the 'User Input' option. This starts the SUM^3 user interface.
- From the SUM^3 User Interface, users are able to:
  - select variables of interest
  - choose a distribution for variables of interest
  - enter correlation information to describe dependencies between variables
  - enter an equation to describe dependencies between two or more variables.
  - select output values of interest.

Figure 5.2 illustrates the initial user interface for SUM^3, the **Variables** input tab. There are three main tabs in the SUM^3 user interface: **Variables**, **Parameters**, and **Outputs**. The **Variables** tab allows the user to select variables of interest. The **Parameters** tab allows the user to describe and relate variables through distributions, correlation, and equations. The **Outputs** tab allows the user to select the output values of interest. The following sections describe each tab and it's use in more detail.

5.2 Selecting Variables

The Variables tab enables the user to specify the stochastic parameters that are to be randomly sampled and varied. A variable list is provided for the user with the description that is consistent with the descriptions given in the deterministic module's input screen. This list of variables is derived from all possible stochastic parameters found in all deterministic modules connected to the S/U Module icon. The description provides the user with the variable name and the associated module name (both the module name given by the user and the FRAMES icon name are displayed). Figure 5.2 demonstrates a portion of the listing of stochastic parameters from the Known Source module and the GENII chronic exposure module that have been connected to the S/U Module icon. A scroll bar is provided on the far right of the listing to enable the user to move through the list when it is longer than the length.

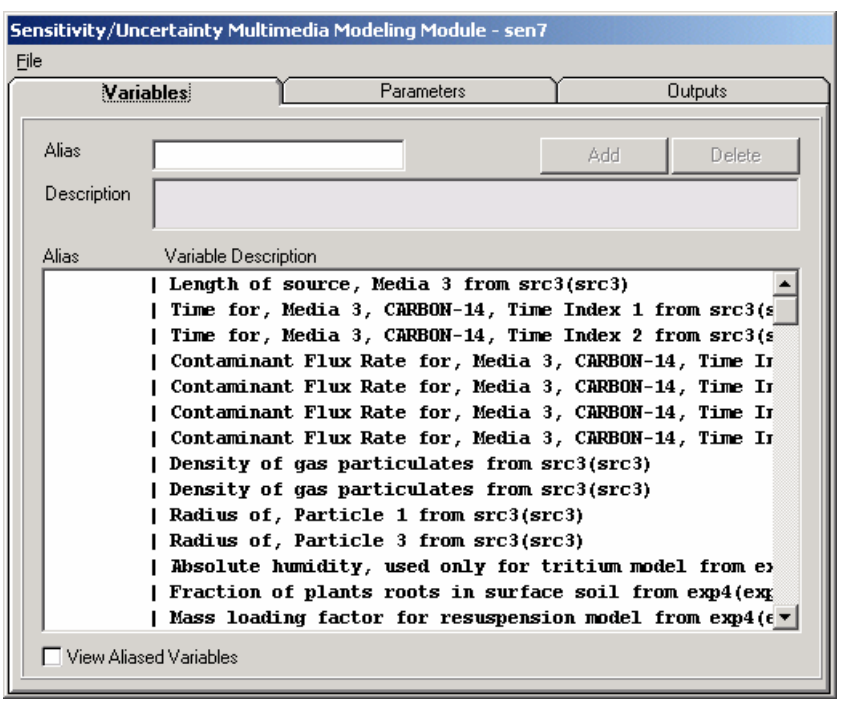


Figure 5.2. SUM^3 Variables input tab

Adding an Alias:

In order to reduce this list to just those parameters the user wishes to vary, the user is asked to provide a unique alias for each parameter of interest. A parameter of interest may be one that is given a distribution, correlation, or used in an equation to describe another parameter of interest. To add an alias, click on the white entry box to the right of the word "Alias." The alias should be one word and is limited to eight (8) digits, capitalization is preserved but is not used to distinguish between aliases, the underscore symbol (_) is not allowed. After typing the alias, click the Add button to enter the alias into the variable list. The variable description list will display the alias to the far left with a line (|) separating the alias from the description. This alias will be used to create a selection list for distributions, correlation, and equations.

Changing an Alias:

To change an alias, the user must first delete the old alias then add in the new alias. Following the instructions given for deleting an alias the user should remove the alias from all distributions and equations before selecting the alias to be deleted from the variables screen. A warning will appear if any correlation or equation dependencies exist. To add the new alias, follow the guidance given for adding an alias.

Deleting an Alias:

To delete an alias the alias must first be removed from all parameter dependencies. The user must first delete any correlation and/or equation where the alias has been assigned. A Delete button is provided in the variables tab to remove the variable from the alias selection list. A warning will appear if any correlation or equation dependencies exist. By removing the alias from the variable list, the variable will no longer be available for distributions, correlation, or equations. This allows the user to reduce an alias listing to only those currently of interest.

5.3 Entering Distributions for Selected Parameters

The Parameters Tab enables the user to describe the variables of interest. There are three options for describing the variables statistically. Figure 4.1 demonstrates the Parameters Tab and the three sub-tabs options found within it, distribution, correlation, and equation. There are several combinations of these options to aid the user in describing the variables of interest. Some combinations available to the user are:

- giving the variable a statistical distribution only,
- giving the variable a statistical distribution and correlating it to another variable,
- giving the variable a statistical distribution and using it in an equation to describe another variable, and
- using an equation to describe the variable.

To assign a distribution to a variable the user must first have assigned the variable an alias. The distributions available in SUM^3 are: Uniform, Log Uniform, Normal, and Log Normal (additional distribution types are planned for future versions of SUM^3). Figure 5.3 shows the dropdown menu of distribution types available in SUM^3. The listing of available variable aliases, with their default units, is given in a selection listing on the far-left side of the screen. The variable description for the highlighted alias is given at the top of the screen. The user

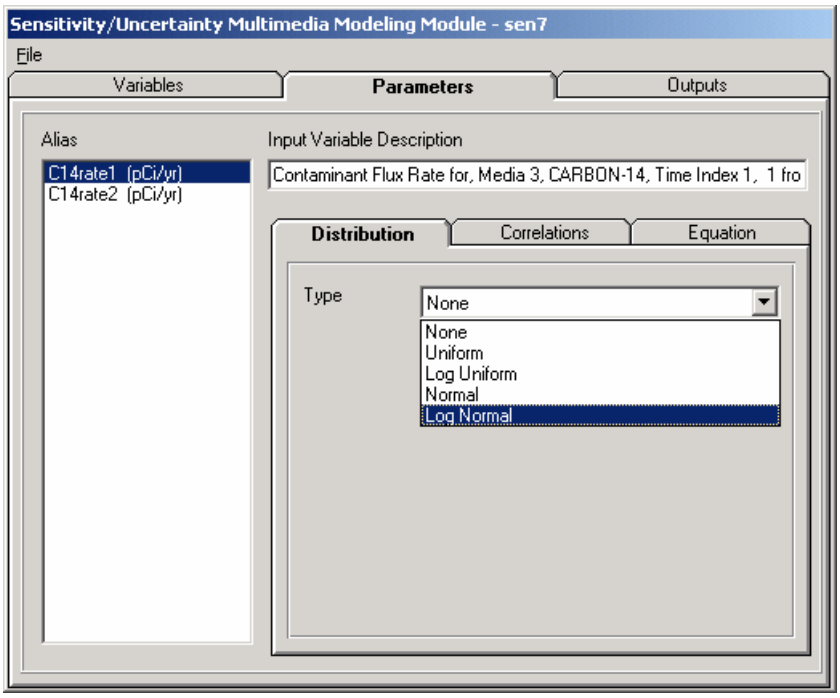


Figure 5.3. SUM[3] Parameters Tab for selecting distribution parameters

will be given the option to select preferred units for the distribution input parameters after a specific distribution is selected. SUM[3] will convert all units to the default units before initiating the simulation.

In order to assign a distribution to an alias, the user must highlight the alias. Then click the arrow in to the far left of the 'Type' box located on the distribution tab. This will bring down a selection list. The user can select the distribution type by highlighting and clicking on it. The user will be given the opportunity to enter the statistical input necessary for the selected distribution. When the distribution parameters are entered they are preserved specifically for that alias and distribution type.

Uniform: For the uniform distribution all values between the minimum value and maximum value are equally likely to be sampled. Figure 4.5 is a view of the input screen for a Uniform Distribution, where the Upper bound and Lower bound are entered in linear space. The system requires that the upper bound be larger than the lower bound. Clicking to the right of the units box will activate a selection listing of units. The user can select the units for the upper and lower bounds. Note that the user should be careful to adjust both upper and lower bounds to the appropriate units to ensure consistency.

Log Uniform: The Log Uniform distribution is like the Uniform Distribution in that all values between the lower bound and upper bound are equally as likely to be selected. The additional feature of the Log Uniform distribution is the ability to sample the data in Log space or E space. The Upper bound and Lower bound, however, are entered in the linear space. This screen is similar to the uniform screen, with the addition of the Log Base selection option at the bottom of the tab screen.

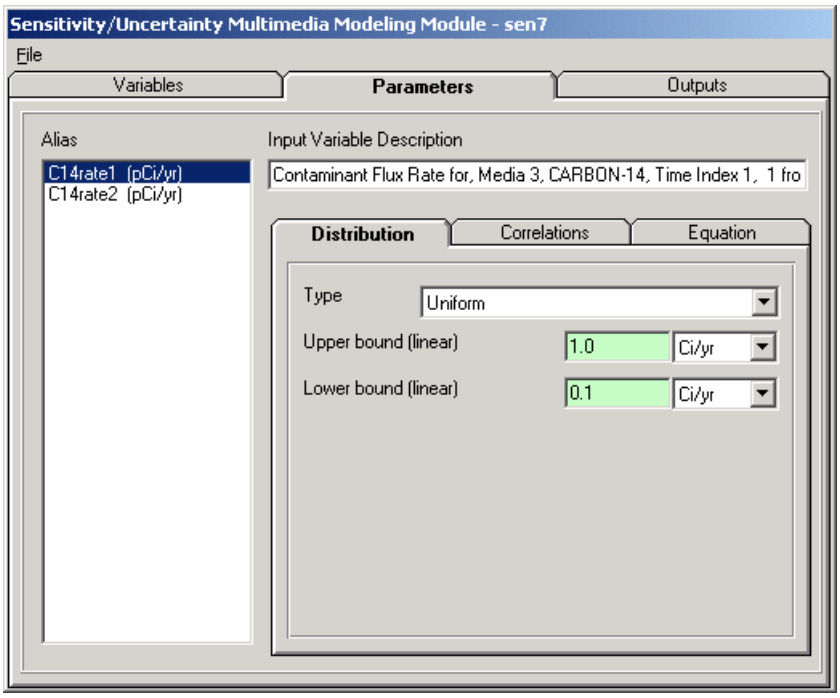


Figure 5.4. SUM^3 Uniform Distribution parameter entry screen

Normal: The Normal distribution is the most used distribution in probability theory because it describes many natural phenomena and is useful in describing uncertain variables. This distribution is often described as the bell curve. There are several assumptions common to a normal distribution. First, that there is a mean, (i.e. some value of the variable is the most likely). Second, the value is symmetrical about the mean, and the uncertain variable could as likely be above the means as it could be below the mean. And finally, the uncertain variable is more likely to be in the vicinity of the mean than far away (i.e. 68% of the values are within 1 standard deviation from the mean). SUM^3 allows the distribution to be truncated. The bounds, mean, and standard deviation are entered on the Normal input screen.

Log Normal: The Log Normal distribution is widely used when most of the values occur near the minimum value, or are positively skewed. The mean and standard deviation for the Log Normal distribution should be calculated in log space. There are some assumptions common to a normal distribution. The variable cannot go below zero and the natural Logarithm of the variable is a normal distribution. SUM^3 allows truncation of the distribution. The input screen for the Log Normal distribution accepts the required upper bound, lower bound, mean, standard deviation, and Log Base. The upper and lower bounds are expected in the linear space. The Mean and Standard Deviation are expected in the Log space. There are two choices for Base available: Base 10 and Base E. To choose the Base, click the arrow to the right of the Log Base box. A selection listing will be displayed. Select the Base for the distribution

5.4 Correlating Variables

A correlation option is available in SUM[3] to account for dependencies (correlation) between two parameters. The correlation of two variables allows the user to ensure the preservation of a relationship between the variables. The correlation parameter is a ratio of one variable to the other. Therefore the correlation parameter can range from –1 to +1. A correlation of –1 represents a strong negative correlation, meaning one variable increases while the second variable decreases. A correlation of +1 represents a strong positive correlation, meaning one variable increases while the second variable increases. Likewise a correlation of 0 implies no correlation between the variables. Figure 5.5 illustrates the input screen for variable correlation.

To assign a correlation, highlight the first alias to be correlated from the alias listing on left of the screen. Then click the arrow on the alias box on the correlation tab. Select the second variable from the drop down listing. Enter a correlation value in the space provided and click the add button. The second variable alias and associated correlation will be displayed in the Current Correlation box on the left. A correlation from variable A to variable B will automatically be entered as a correlation between variable B to variable A. This means, if a variable sequence A->B->C is assigned by the user, then the correlation A->B, B->C, B->A, and C->B are all assigned, however, the correlation A->C is not.

To delete a correlation, highlight the first alias to be correlated from the alias listing on the left of the screen. Then click the arrow on the alias box on the correlation tab. Select the second variable from the drop down listing. Confirm that the correlation to be deleted appears in the Current Correlation box to the left and click the Delete button.

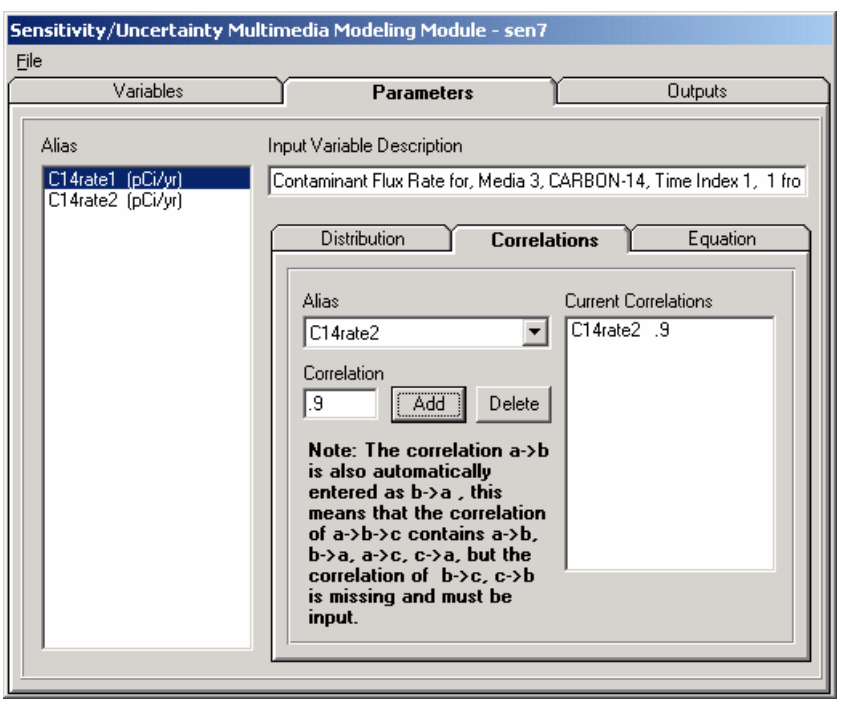


Figure 5.5. SUM correlation input screen

5.5 Assigning an Equation

An Equation feature has been added to SUM^3 to enable a user to relate two or more variables. To assign an equation to a variable the user must first have assigned the variable, and all variables used in the equation, an alias (to learn how to assign an alias, go to Section 3.0 Selecting Sampling of Interest). This equation option allows the user to represent a variable as a function of other variables. This feature is convent for equations relating several variables to a single variable. All independent variables will be sampled, and then the dependent variable will be calculated.

To add an equation, first resolve the equation by solving for one variable in terms of the others. Highlight the dependent variable to be represented by the equation from the alias listing on left of the screen. Then enter the equation, the right side only, in the box labeled "Enter an equation." Be sure that the equation has been resolved to match the units displayed next to the dependent alias. The equation can contain most arithmetic operators (e.g. - + / * exp). Click the Add button.

To edit an equation, highlight the dependent variable represented by the equation from the alias listing on left of the screen. Then edit the equation in the box labeled "Enter an equation." Note that the current equation will be displayed in the "Current Equation" box. Be sure that the equation has been resolved to match the units displayed next to the dependent alias. Click the Add button.

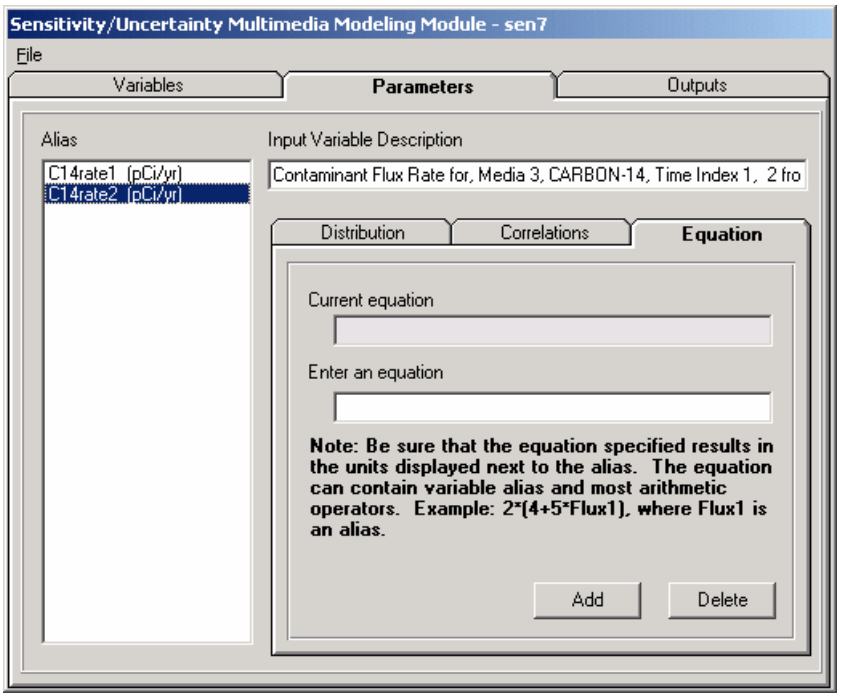


Figure 5.6. SUM^3 Equation assignment screen

5.6 Selecting the outputs to monitor

The Output tab enables the user to specify the results to be preserved from the simulation. An output list is provided for the user with descriptions describing what the results are and what module it is output from. This list of outputs is derived from all possible results produced from all media connected to the S/U icon. The description provides the user with the output name and the module it is from (both the module name given by the user and the FRAMES icon name are displayed). Figure 5.7 demonstrates a portion of the listing of outputs from the input and output modules that have been connected to the S/U Module icon. A scroll bar is provided on the far right of the listing to enable the user to move through the list when it is larger than the window length.

The user is asked to provide a unique alias for each output of interest. To add an alias, click on the white entry box to the right of the word "Alias". The alias should be one word and is limited to eight (8) digits, capitalization is preserved but is not used to distinguish between aliases, the underscore symbol (_) is not allowed. After typing the alias, click the Add button to enter the alias into the variable list. The output list will display the alias to the far left with a line (|) separating the alias from the description. The Add/Change button has been provided to allow a user to change an existing alias. First select the output to be changed. The existing alias will appear in the alias box. Enter the new alias, and click the Add/Change button. The variable list will be updated with the new alias.

A Delete button is provided to eliminate outputs from the alias list for distributions. By removing the alias from the output list, the output will no longer be preserved

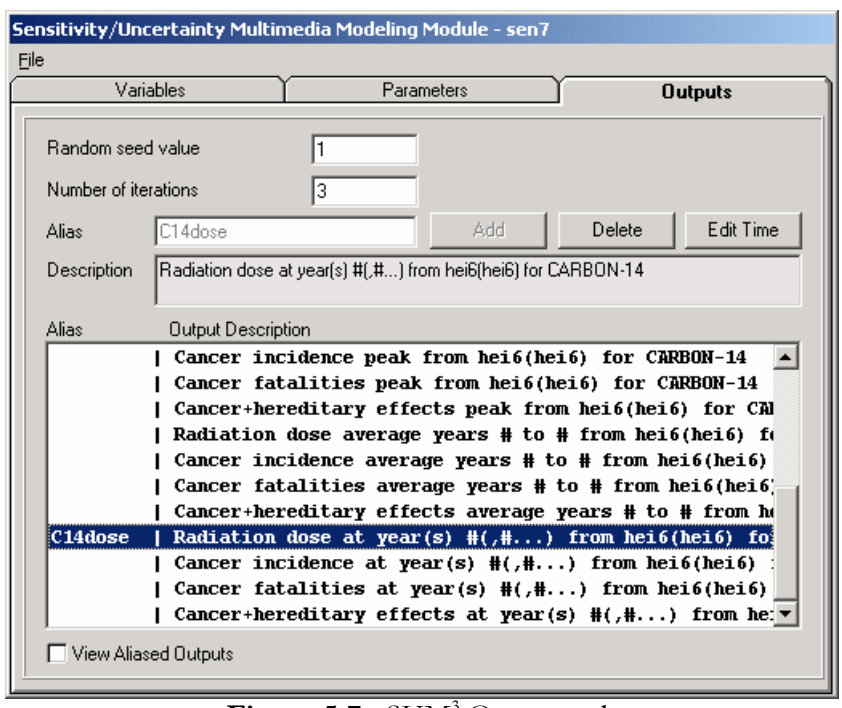


Figure 5.7. SUM[3] Outputs tab

It is important to remember that only those outputs expected from the modules connected to the S/U module will be listed in this screen (i.e. the user needs to be connected to the surface water icon if interested in waterborne concentration results from that media). In addition to the alias information, the output screen also provides the user with the option to select the seed value to be used in the random sampling algorithm, thereby allowing the user to reproduce an analysis if necessary. The number of iterations (realizations) to be run is selected in on this tab also. The number of iterations is the number of sampling runs the user would like to make. The maximum number of iterations for a single simulation is 500.

When all variable distributions, correlation, equations, and outputs have been selected and entered, the SUM^3 model user interface can be closed.

Closing SUM^3 Module: To close the SUM^{3}module user interface, click the file menu and choose the save & exit option. Choosing the Exit only option will not save any data changes made since the last time the users choose the exit & save option. This will return the user to the FRAMES interface.

Running the S/U Module: To run the S/U Module, right click the S/U Icon and select Run. A DOS screen that appears to indicate the Latin Hypercube sampling tool has been activated and completed successfully. While running, the SUM^3 model a status screen will appear, and the desired programs will be run.

5.7 Examining Results

Results from a sensitivity/uncertainty analysis can be used to derive confidence limits and intervals to provide a quantitative statement about the effect of varying a parameter on the model prediction. The sampled variables along with their associated outputs of interest are stored in a file. This data is stored in a comma separated format and can is stored in a file named "runname".SUF. Where "runname" is the filename given to the FRAMES case analysis. Figure 5.8 illustrates an example SUF file with notations identifying key information.

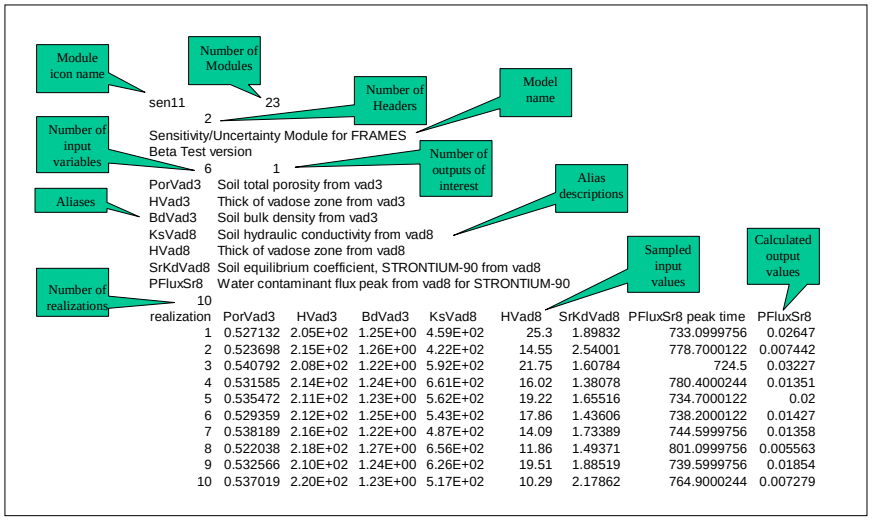


Figure 5.8. Example SUF file with key information highlighted.

The SUM[3] results may be viewed using the Print/View Model Output command, the SUF Graphical View options. The complementary cumulative distribution functions of all sampled and output variables are provided via an export to Excel®. An example cumulative distribution created with FRAMES is illustrated in Figure 5.9.

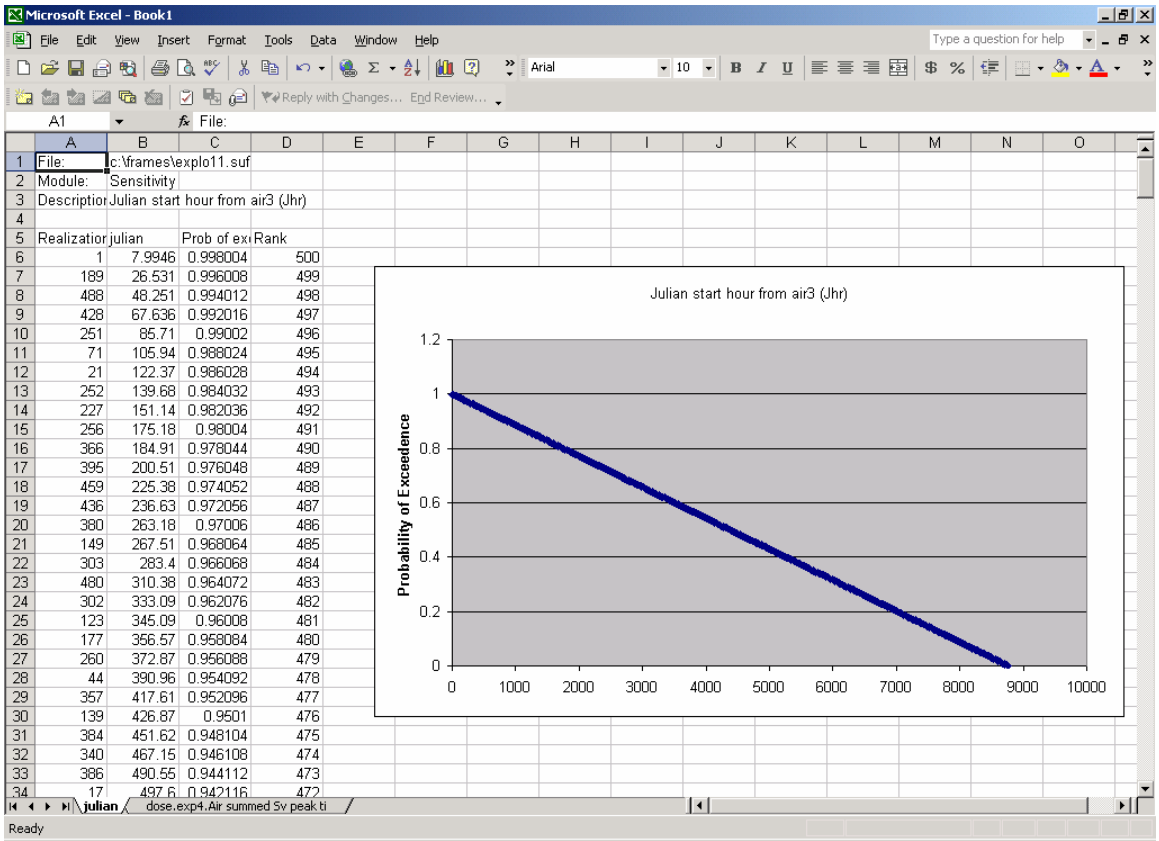


Figure 5.9. Example SUM[3] output from a GENII run demonstrating the cumulative distribution of an uniformly-distributed input parameter.

6. Example Problem

As an example of the use of GENII V.2, the sample problem of Chaki and Parks (2000) for the CAP-88 PC code is replicated. This sample demonstrates the use of the GENII V.2 chronic plume model and its ancillary joint frequency adaptation utility.

The sample of Chaki and Parks (2000) is for an example site in Ohio, using the STAR-formatted joint frequency file for Erie, Pennsylvania. This site has 6 co-located emission points of varying characteristics. One of the 6 emission points has a much smaller release than the others, so because GENII V.2 only handles 5 release points, this one is combined with one of the others in this example (Chaki and Parks source 4 is combined with their source 5). The source information for the example is summarized in Table 6.1. All radionuclides are assumed to be 1 micron AMAD particles, inhalation Class Y. The ambient temperature is assumed to average 10 celsius. No nearby buildings contribute to building wake effects.

Other parameters of importance to the example are described in the following sections to illustrate how they are entered into the GENII V.2 screens.

The basic conceptual model for this case is illustrated in Figure 6.1. Five sources are feeding the GENII chronic, annual average Gaussian plume atmospheric transport model. (This model is preferred because the available data for this location exist in the form of a STAR file, not hourly data.) The resulting concentrations and deposition rates of the released radionuclides are used in the GENII chronic exposure module to estimate accumulation in the soil, farm products, and other media to which people could be exposed. Individual exposures to these contaminated media are modeled with the GENII receptor intake module. The GENII health impacts module is used to estimate the radiation doses and risks to the people living around the release point. Multiple uses of this last module will be demonstrated.

Input of the source data is illustrated in Figure 6.2 for Source 1. It can be seen from this figure that the data in Table 1 are entered in the appropriate locations. One-micron particulates have been selected using the **Flux Types** button. The data for sources 2 through 4 are entered in similar fashion in the other icons.

Table 6.1. Sample Problem Release Data Summary

	Source 1	Source 2	Source 3	Source 4	Source 5
Area (m^2)	0.13	0.17	0.26	0.05	0.13
Height (m)	15.24	15.24	15.24	7.62	10.0
Exit velocity (m/s)	13.5	9.25	19.54	7.94	15.04
Release (Ci/year)					
U-234	2.4E-4	3.2E-4	3.2E-9	9.6E-13	2.7E-8
U-325	1.7E-6	2.3E-6	8.0E-7	5.5E-6	3.4E-5
U-236	0	0	0	0	1.8E-6
U-238	2.4E-4	3.2E-4	4.0E-4	7.6E-4	3.6E-3

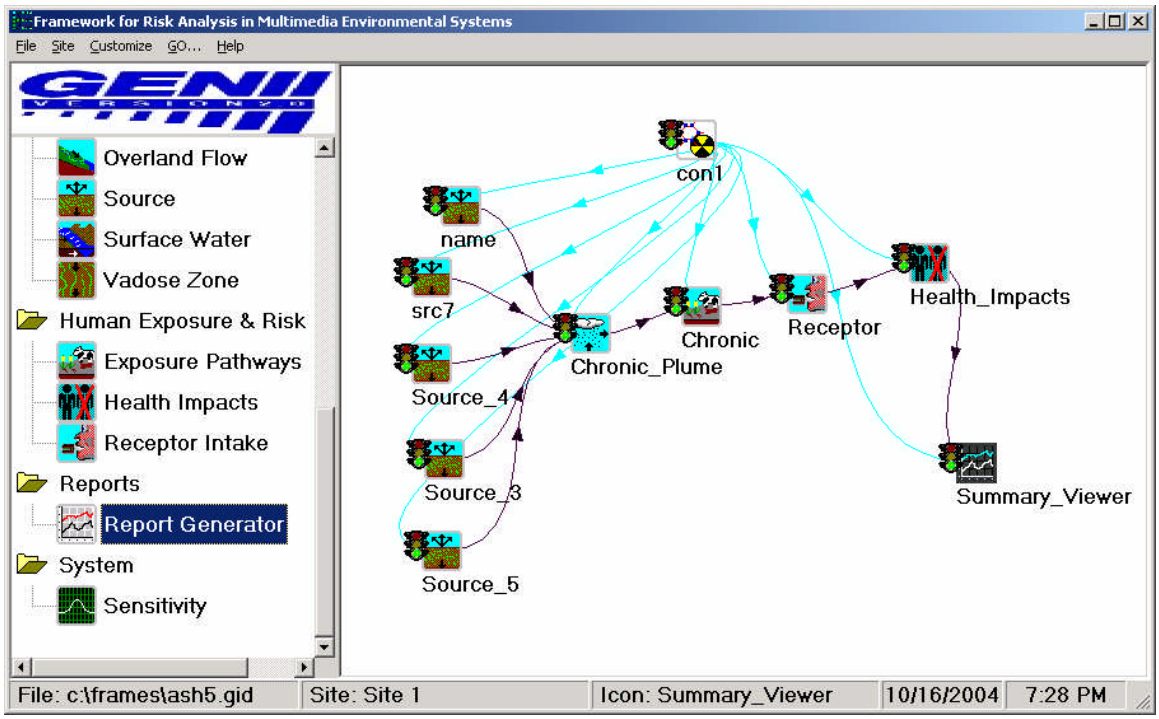


Figure 6.1. The GENII V.2 Conceptual Site Model for the Example Problem

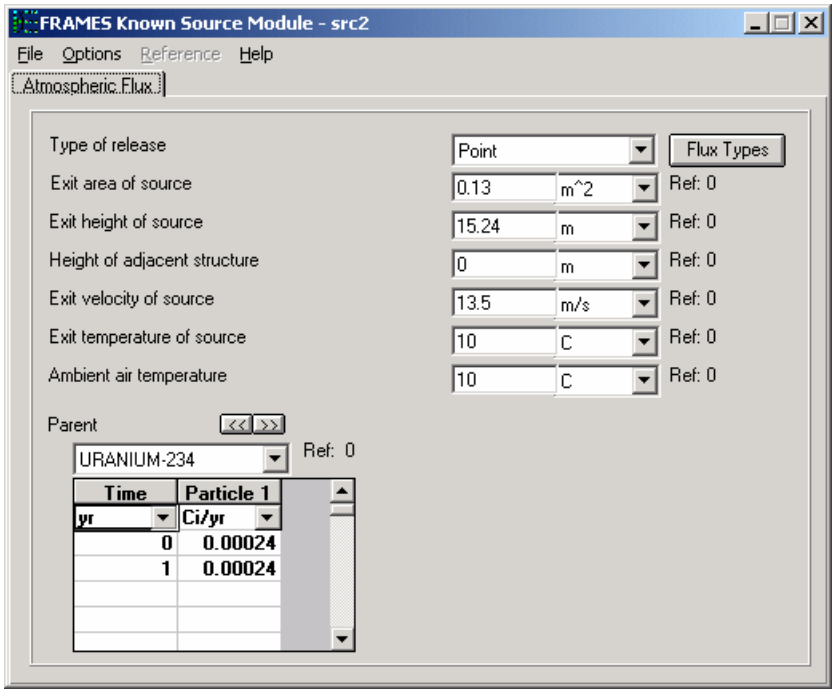


Figure 6.2. Entry of the source term data for Source 1

Figure 6.3 shows the definition of the radial grid used to match the Chaki and Parks (2000) distances and directions. The Chaki and Parks example uses 12 distances, only 10 are available in GENII V.2 so the most important 10 close ones are selected. On the **Model Parameters** tab, the dispersion coefficients for the EPA ISC model are selected as being the most compatible with the CAP-88 capabilities. No changes are made on the **Default Parameters** tab.

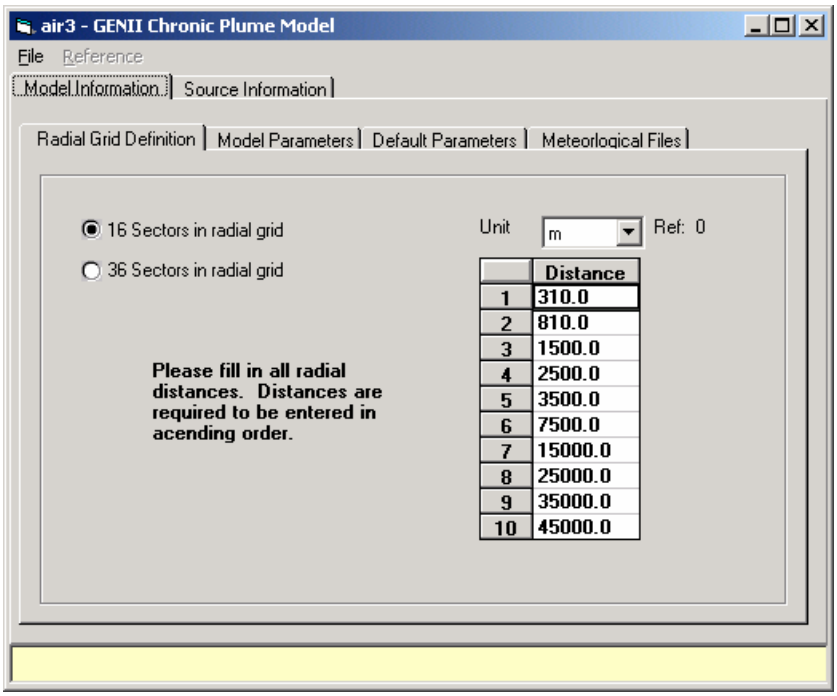


Figure 6.3. Defining the radial atmospheric transport grid

A Stability Array data set is available for Erie, Pennsylvania from the GENII library. The data in this file, which is called ERI0610.STR, are shown in Table 6.2. This file contains data for stability classes A-F, 6 standard wind speed groups (the 6 columns), for 16 directions. This data is converted to quasi-hourly information starting with the **Use Joint Frequency Data File** button on the **Meteorological Files** tab.

Table 6.2. Joint frequency of occurrence of meteorological conditions for Erie, PA

N	A	0.00001	0.00017	0	0	0	0
NNE	A	0	0	0	0	0	0
NE	A	0	0.00003	0	0	0	0
ENE	A	0	0	0	0	0	0
E	A	0	0	0	0	0	0
ESE	A	0	0	0	0	0	0
SE	A	0	0	0	0	0	0
SSE	A	0	0	0	0	0	0
S	A	0	0	0	0	0	0
SSW	A	0	0.00003	0	0	0	0

SW	A	0	0	0	0	0	0
WSW	A	0	0	0	0	0	0
W	A	0	0.00003	0	0	0	0
WNW	A	0.00001	0.00014	0	0	0	0
NW	A	0	0.00007	0	0	0	0
NNW	A	0	0.00003	0	0	0	0
N	B	0.00022	0.00192	0.00349	0	0	0
NNE	B	0.00002	0.00051	0.00048	0	0	0
NE	B	0.00008	0.00034	0.00024	0	0	0
ENE	B	0.00005	0.00024	0.0001	0	0	0
E	B	0.00011	0.00021	0.00021	0	0	0
ESE	B	0.00015	0.00017	0.00007	0	0	0
SE	B	0.00019	0.00031	0.00003	0	0	0
SSE	B	0.00005	0.00024	0.0001	0	0	0
S	B	0.00048	0.00045	0.00055	0	0	0
SSW	B	0.00026	0.00021	0.00031	0	0	0
SW	B	0.00005	0.00038	0.00027	0	0	0
WSW	B	0.00002	0.00048	0.00041	0	0	0
W	B	0.00013	0.00048	0.00147	0	0	0
WNW	B	0.00016	0.00137	0.00202	0	0	0
NW	B	0.00014	0.00168	0.00301	0	0	0
NNW	B	0.00016	0.00226	0.00356	0	0	0
N	C	0.00011	0.00137	0.00781	0.00134	0	0
NNE	C	0.00005	0.00072	0.00305	0.00113	0.00007	0
NE	C	0.00009	0.00075	0.00315	0.00137	0.00024	0
ENE	C	0.00016	0.00065	0.00171	0.0001	0	0
E	C	0.00009	0.00065	0.00089	0.00003	0	0
ESE	C	0.00001	0.00034	0.00075	0.00003	0	0
SE	C	0.00005	0.00051	0.00093	0.00014	0	0
SSE	C	0.00005	0.00062	0.00161	0.0001	0	0
S	C	0.00037	0.00322	0.00675	0.00082	0.00014	0.00007
SSW	C	0.00007	0.0011	0.00315	0.00051	0.00017	0.00003
SW	C	0.00005	0.00065	0.00243	0.00072	0.00014	0
WSW	C	0.00005	0.00051	0.00377	0.00069	0.00014	0.00003
W	C	0.00005	0.00055	0.00839	0.00353	0.00062	0
WNW	C	0.00009	0.00075	0.0075	0.00219	0.00014	0
NW	C	0.00008	0.00182	0.00497	0.00048	0	0
NNW	C	0.00007	0.00116	0.00541	0.00038	0	0
N	D	0.00052	0.005	0.01288	0.01072	0.00175	0.00014
NNE	D	0.00033	0.0026	0.00737	0.00911	0.0013	0.00017
NE	D	0.00059	0.00356	0.01172	0.01552	0.00339	0.00062
ENE	D	0.00039	0.00387	0.01199	0.00939	0.00185	0.00027
E	D	0.00076	0.00404	0.00675	0.00171	0.00007	0
ESE	D	0.00054	0.00243	0.00322	0.0012	0.00007	0
SE	D	0.00046	0.00216	0.00428	0.00408	0.00171	0.00086
SSE	D	0.00061	0.00233	0.01055	0.01823	0.01052	0.00349
S	D	0.00141	0.01113	0.03751	0.05509	0.02021	0.00329

SSW	D	0.00057	0.00531	0.01778	0.02998	0.01247	0.00192
SW	D	0.00061	0.00545	0.01425	0.02398	0.00747	0.0011
WSW	D	0.00037	0.00408	0.01692	0.02402	0.00915	0.00182
W	D	0.00046	0.00459	0.02011	0.03936	0.01559	0.00288
WNW	D	0.00041	0.00349	0.01209	0.02323	0.00894	0.00151
NW	D	0.00035	0.00295	0.00942	0.01206	0.00356	0.00038
NNW	D	0.0004	0.00332	0.00863	0.0097	0.00236	0.00027
N	E	0	0.00127	0.00168	0	0	0
NNE	E	0	0.00089	0.00116	0	0	0
NE	E	0	0.00223	0.0023	0	0	0
ENE	E	0	0.00274	0.00291	0	0	0
E	E	0	0.00356	0.00158	0	0	0
ESE	E	0	0.00281	0.00072	0	0	0
SE	E	0	0.00212	0.00099	0	0	0
SSE	E	0	0.00278	0.00428	0	0	0
S	E	0	0.01199	0.02052	0	0	0
SSW	E	0	0.00377	0.0062	0	0	0
SW	E	0	0.00298	0.00401	0	0	0
WSW	E	0	0.00247	0.00343	0	0	0
W	E	0	0.0014	0.00301	0	0	0
WNW	E	0	0.00089	0.00096	0	0	0
NW	E	0	0.00116	0.00089	0	0	0
NNW	E	0	0.00096	0.00161	0	0	0
N	F	0.00062	0.00123	0	0	0	0
NNE	F	0.00033	0.00106	0	0	0	0
NE	F	0.00037	0.0014	0	0	0	0
ENE	F	0.00075	0.00257	0	0	0	0
E	F	0.00186	0.00418	0	0	0	0
ESE	F	0.00188	0.00288	0	0	0	0
SE	F	0.00164	0.00278	0	0	0	0
SSE	F	0.00209	0.00418	0	0	0	0
S	F	0.00804	0.02741	0	0	0	0
SSW	F	0.0017	0.00815	0	0	0	0
SW	F	0.00099	0.00271	0	0	0	0
WSW	F	0.00082	0.0025	0	0	0	0
W	F	0.00036	0.00127	0	0	0	0
WNW	F	0.00052	0.00106	0	0	0	0
NW	F	0.00041	0.00069	0	0	0	0
NNW	F	0.00037	0.00099	0	0	0	0

The data processor screen appears as shown in Figure 6.4. This screen indicates that the information put into it will be retained in a file named JFDPROC.INP. The data are coming from the file ERI0610.STR, and the quasi-hourly information generated will be stored in the meteorological data file eriePA.met. Basic descriptive data for the Erie site are entered on the **Station Information** tab at the bottom of the window.

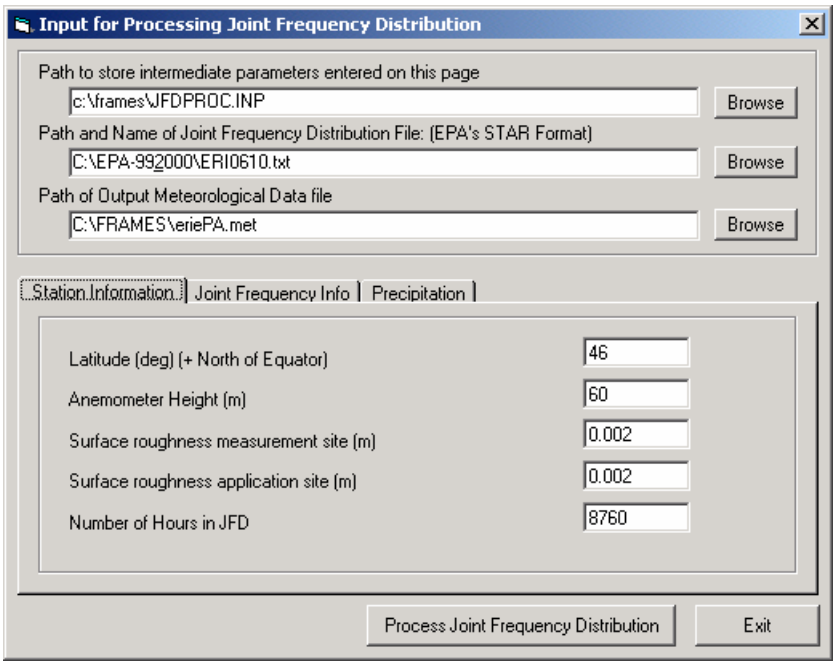


Figure 6.4. Joint frequency data processor window for example problem

The supplementary information for the JFD file is entered on the Joint Frequency Info tab illustrated in Figure 6.5. The wind speeds entered are the standard midpoints of the normal STAR ranges:

Wind Speed Range (knots)	Range Mid-point (m/s)
1 - 3	0.9
4 – 6	2.6
7 – 10	4.7
11 – 16	7.2
17 – 21	9.8
>21	12.7

The monthly temperature extremes may be obtained from climatic records. (Those entered here are user-defined approximations.) The ability to handle precipitation as a series of discrete events is one of the strengths of GENII V.2. Joint Frequency of wind data do not include information on precipitation, thus it is necessary to approximate the inputs. This is done on the **Precipitation** tab, using a surrogate location. Because it is nearby and on the lake, Buffalo, NY has been selected for this example problem. This is input using the drop-down box on the **Precipitation** tab, as illustrated in Figure 6.6. A large number of representative cities are included in the GENII V.2 database.

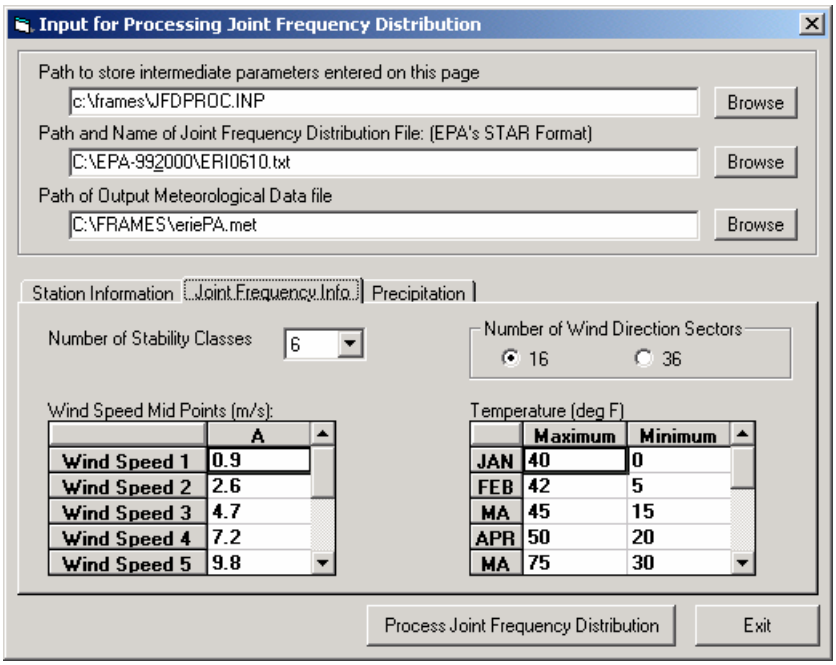


Figure 6.5. Joint Frequency Info tab for example problem

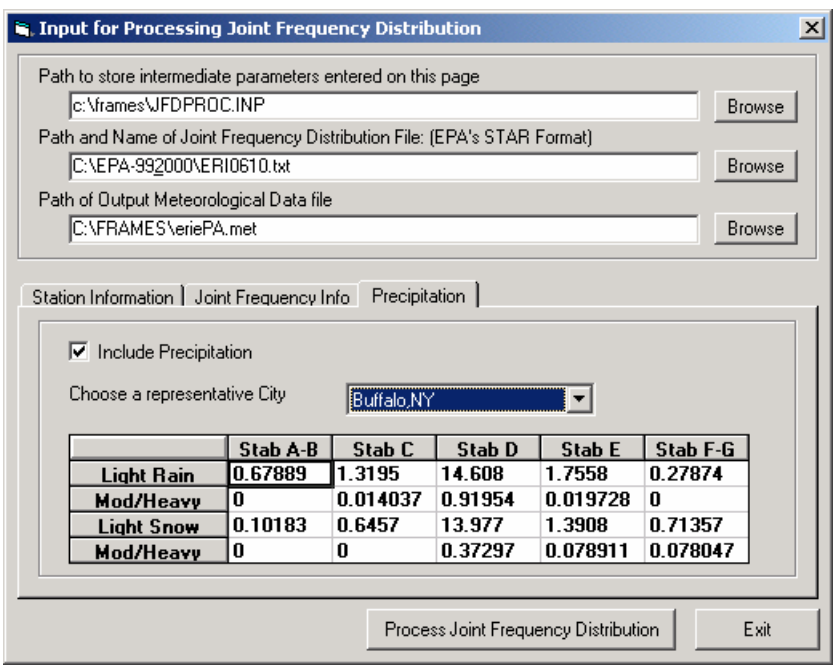


Figure 6.6. Precipitation tab for the example problem

The joint frequency data and associated information are converted to quasi-hourly data by using the Process Joint Frequency Distribution button. When the processing is completed, the eriePA.met file is entered on the Meteorological Files tab.

For the sample problem, all 5 sources have simple plume rise selected with the check boxes on the **Source Information** tab as well.

The chronic atmospheric transport user interface is closed, saving the data, and the model is run, producing a table of annual average concentrations in air of each radionuclide, and its decay progeny.

The CAP-88 code is used to estimate a conservative upper bound on doses from continuous releases. In order to do this, an interesting modeling assumption is made: The release continues for 100 years, allowing contamination to accumulate in the environment. The dose to an exposed individual is estimated for the 100th year of the release. (This is the parameter TSUBB in the CAP-88 manual.) In order to simulate an equivalent condition with GENII, a continuous air deposition is indicated in the **Air deposition time prior to exposure** parameter. In order to note the source for this parameter, the reference indicator has been updated; reference 1 for this problem is now Chaki and Parks (2000), as illustrated in Figure 6.8.

GENII V.2 has a greater variety of exposure pathways available than CAP-88. Those most closely resembling the CAP-88 pathways are selected for the example problem as illustrated in Figure 6.9. One other key parameter changed in GENII is the surface soil areal density on the **Soil/Surface Soil** tab; it is set to 215 kg/m^2. Also, on the **Agriculture/General** tab, the crop weathering time is set to 10 days. No other GENII Chronic Exposure defaults are revised for this example.

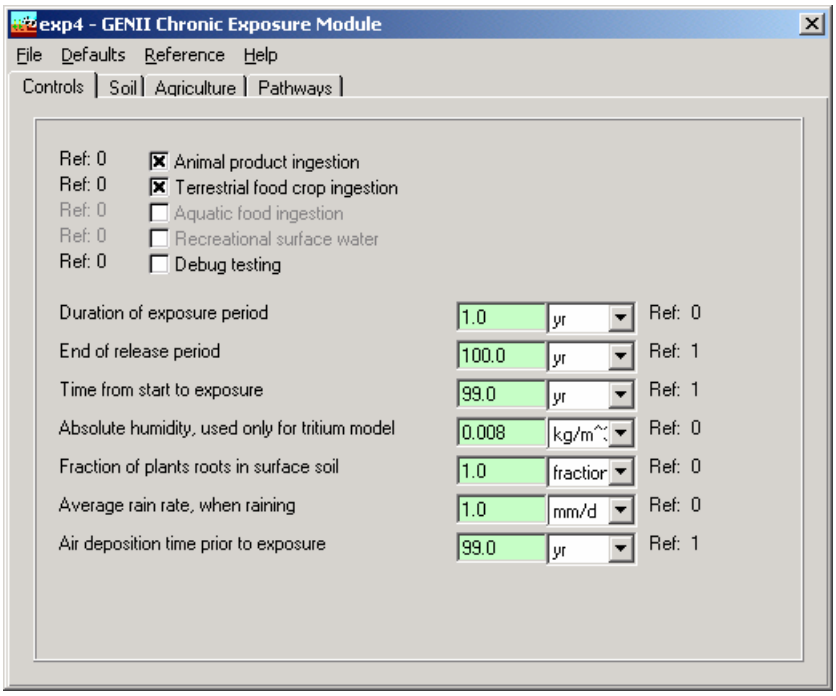


Figure 6.7. GENII Chronic Exposure Module Control screen, illustrating time line

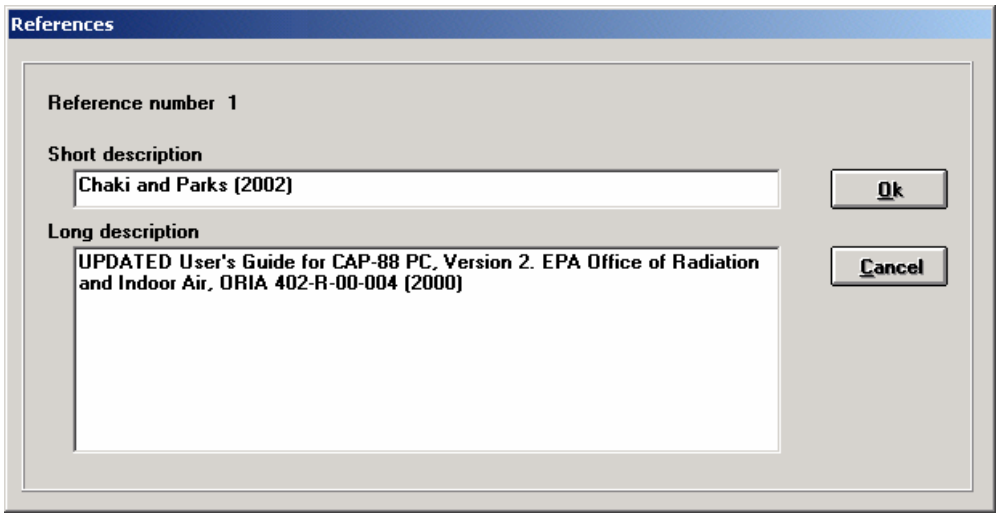


Figure 6.8. Input screen for references

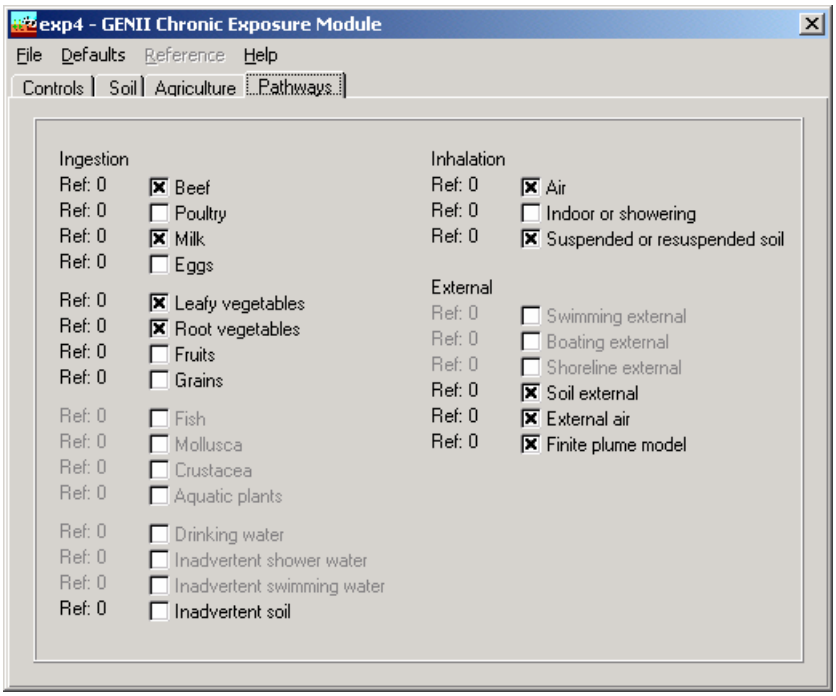


Figure 6.9. Exposure pathways selected for the example problem

The GENII Receptor Intakes module is next accessed. One age group – adults – is used to match the CAP-88 limitation. The parameters adjusted to match the CAP-88 values in this module include the consumption rates of leafy vegetables, other vegetables, meat, and milk. The air inhalation rate is reduced to match. The other pathways, because they were not turned on in the GENII Chronic Exposure module, have no effect. The values used for each pathway are:

Parameter	CAP-88	GENII V.2
Leafy Vegetable Intake	18 kg/yr	0.049 kg/d
Other Vegetable Intake	176 kg/yr	0.482 kg/d
Meat Intake	85 kg/yr	0.233 kg/d
Milk Intake	112 L/yr	0.307 L/d
Breathing Rate	9.167E5 cm^3/hr	22 m^3/day

Finally, the GENII Health Impacts module is used to calculate dose and risk to the individuals around the example source point. To match CAP-88, the ICRP-30 (Federal Guidance Reports 11 and 12) conversion factors are used. The GENII NESHAPS summary generator is used to create an output file to compare with the CAP-88 results of Chaki and Parks (2000). A population distribution file is needed to complete the comparison; a file with equivalent information to that input to CAP-88 is illustrated in Table 6.3. A GENII population file must match the format of the atmospheric model output generated. In this case, the atmospheric model created a grid of 16 directions and 10 distances. A block of population data is needed for each age group. Since only one age group was used, a population file of dimensions 10 by 16 is sufficient. The major difference between a GENII population file and an equivalent CAP-88 file is that GENII directions begin at NNE and continue clockwise around the compass while CAP-88 files begin at N and go counter-clockwise. Thus, a CAP-88 population file must be inverted before being used with GENII.

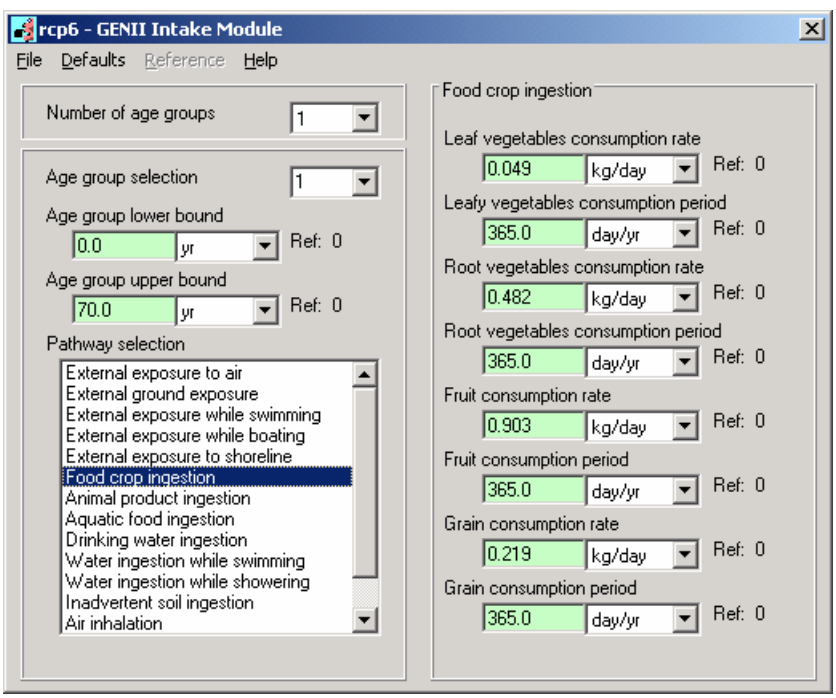


Figure 6.10. Example problem food crop ingestion input. Only Leaf vegetables and Root vegetables (equivalent to CAP-88 Produce) are used

Table 6.3. Population file for example calculation

0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0	0	0
1	0	0	55	0	0	14641	6332	5986	13324
0	0	0	780	89	793	265	1693	5397	1338
0	0	0	851	0	125	3161	827	3252	3712
0	0	0	0	0	974	1388	2021	3148	5123
0	0	101	0	0	0	984	1792	3659	3759
0	0	0	0	2002	534	8224	2252	2388	5752
0	0	0	4350	4630	3024	3059	3396	3128	6847
0	0	0	0	2435	1688	3376	3448	7591	6999
0	0	421	810	293	1108	779	15354	8786	48943
0	0	0	2435	3302	183	380	0	0	0
0	0	0	2218	0	0	0	0	0	0
0	0	1987	0	0	0	0	0	0	0
0	6	0	113	0	0	0	0	0	0
0	0	0	1043	0	0	0	0	0	0

Exhibit 6.1

```
GENII VERSION 2
NESHAPS SUMMARY REPORT FOR CASE: c:\frames\ash5a

THE HEALTH IMPACTS FILE FOR THIS CASE CONTAINS INFORMATION ON:
        1 AGE GROUP(S)
        4 RADIONUCLIDES (COUNTING DECAY PROGENY SEPARATELY IN CHAINS)
        1 ORGAN(S)/TISSUE(S) FOR RADIATION DOSE
        1 POTENTIAL CANCER SITES, AND
        1 EXPOSURE PERIOD(S).

POPULATION DATA FROM FILE ashtapop.csv

TIME PERIOD NUMBER  1, CORRESPONDING TO TIME 99.0 YEARS
MAXIMUM POINT = 151
INDIVIDUAL AGE RANGE     0 TO   70 YEARS
MAXIMUM EXPOSED INDIVIDUAL LOCATION
ORGAN        MAX. DOSE (Sv)   TISSUE     CANCER INCIDENCE   CANCER FATALITIES
total body     1.75E-05       all sites     1.05E-06          8.74E-07

TIME PERIOD NUMBER  1, CORRESPONDING TO TIME 99.0 YEARS
INDIVIDUAL AGE RANGE  0 TO 70 YEARS

INDIVIDUAL EFFECTIVE DOSE BY DISTANCE AND DIRECTION (SV)
        310.0     810.0    1500.0    2500.0    3500.0    7500.0   15000.0   25000.0   35000.0   45000.0
  22.5  8.93E-06  3.07E-06  1.21E-06  5.39E-07  3.54E-06  8.24E-08  2.30E-08  8.68E-09  4.56E-09  2.83E-09
  45.0  7.09E-06  2.48E-06  9.81E-07  4.35E-07  2.71E-06  6.59E-08  1.83E-08  6.97E-09  3.70E-09  2.31E-09
  67.5  7.40E-06  2.54E-06  9.93E-07  4.43E-07  2.82E-06  6.67E-08  1.85E-08  6.89E-09  3.61E-09  2.27E-09
  90.0  1.06E-05  3.53E-06  1.38E-06  6.17E-07  4.57E-06  9.23E-08  2.57E-08  9.52E-09  4.97E-09  3.08E-09
 112.5  6.42E-06  2.17E-06  8.58E-07  3.85E-07  2.70E-06  5.73E-08  1.60E-08  5.96E-09  3.11E-09  1.93E-09
 135.0  3.93E-06  1.38E-06  5.53E-07  2.49E-07  1.38E-06  3.60E-08  1.00E-08  3.78E-09  2.01E-09  1.27E-09
 157.5  3.50E-06  1.25E-06  5.04E-07  2.30E-07  1.10E-06  3.28E-08  9.15E-09  3.51E-09  1.87E-09  1.18E-09
 180.0  4.55E-06  1.67E-06  6.75E-07  3.04E-07  1.21E-06  4.30E-08  1.19E-08  4.58E-09  2.47E-09  1.58E-09
 202.5  2.95E-06  1.06E-06  4.19E-07  1.88E-07  9.74E-07  2.77E-08  7.70E-09  2.93E-09  1.56E-09  9.82E-10
 225.0  4.91E-06  1.73E-06  6.87E-07  3.06E-07  1.71E-06  4.58E-08  1.28E-08  4.84E-09  2.57E-09  1.61E-09
 247.5  4.04E-06  1.47E-06  5.89E-07  2.60E-07  1.07E-06  3.86E-08  1.07E-08  4.08E-09  2.18E-09  1.39E-09
 270.0  2.28E-06  9.42E-07  3.85E-07  1.73E-07  2.65E-07  2.61E-08  7.62E-09  3.06E-09  1.66E-09  1.04E-09
 292.5  1.32E-06  5.52E-07  2.29E-07  1.04E-07  1.74E-07  1.61E-08  4.81E-09  1.94E-09  1.04E-09  6.43E-10
 315.0  1.96E-06  7.40E-07  3.00E-07  1.34E-07  5.38E-07  2.09E-08  6.05E-09  2.37E-09  1.26E-09  7.75E-10
 337.5  5.83E-06  1.97E-06  7.80E-07  3.48E-07  2.36E-06  5.46E-08  1.55E-08  5.83E-09  3.01E-09  1.85E-09
 360.0  1.75E-05  6.16E-06  2.46E-06  1.10E-06  6.45E-06  1.69E-07  4.74E-08  1.79E-08  9.41E-09  5.86E-09
```

Exhibits 6.1 and 6.2 are portions of the GENII NESHAPS output file that are comparable with the CAP-88 results presented in Chaki and Parks (2000). The CAP-88 determined location inhabited by an individual is 310 m ENE of the release point; at that point, CAP-88 determined the annual

radiation dose to be 0.75 mrem, dominated by inhalation of U-238. For that same location, GENII V.2 indicates a dose of 0.74 mrem (7.40E-6 Sv in Exhibit 6.1), dominated by inhalation of U-238. The CAP-88 estimate of total population dose is 1.35 person-rem; the GENII V.2 estimate is 1.86 person-rem (1.86E-2 Person-Sv in Exhibit 6.2). The GENII population estimate is slightly higher, because the population for the 4500 meter distant ring in CAP-88 was compressed into the 3500 meter ring for GENII to make the population file match. A more exact correspondence of the population geometries would lead to an even better match in the doses.

Exhibit 6.2

TIME PERIOD NUMBER 1, CORRESPONDING TO TIME 99.0 YEARS
POPULATION AGE RANGE 0 70 YEARS

ORGAN	DOSE (PERSON-SV)	TISSUE	CANCER INCIDENCE	CANCER FATALITIES
total body	1.86E-02	all sites	1.12E-03	9.32E-04

TIME PERIOD NUMBER 1, CORRESPONDING TO TIME 99.0 YEARS
POPULATION GROUP AGE RANGE 0 TO 70 YEARS

POPULATION EFFECTIVE DOSE BY DISTANCE AND DIRECTION (PERSON-SV)

	310.0	810.0	1500.0	2500.0	3500.0	7500.0	15000.0	25000.0	35000.0	45000.0
22.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67.5	7.40E-06	0.00E+00	0.00E+00	2.43E-05	0.00E+00	0.00E+00	2.70E-04	4.37E-05	2.16E-05	3.02E-05
90.0	0.00E+00	0.00E+00	0.00E+00	4.82E-04	4.07E-04	7.32E-05	6.81E-06	1.61E-05	2.68E-05	4.12E-06
112.5	0.00E+00	0.00E+00	0.00E+00	3.28E-04	0.00E+00	7.16E-06	5.05E-05	4.93E-06	1.01E-05	7.17E-06
135.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.51E-05	1.39E-05	7.65E-06	6.33E-06	6.49E-06
157.5	0.00E+00	0.00E+00	5.09E-05	0.00E+00	0.00E+00	0.00E+00	9.01E-06	6.30E-06	6.84E-06	4.45E-06
180.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-03	2.30E-05	9.80E-05	1.03E-05	5.90E-06	9.06E-06
202.5	0.00E+00	0.00E+00	0.00E+00	8.19E-04	4.51E-03	8.36E-05	2.36E-05	9.96E-06	4.88E-06	6.73E-06
225.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.16E-03	7.73E-05	4.33E-05	1.67E-05	1.95E-05	1.13E-05
247.5	0.00E+00	0.00E+00	2.48E-04	2.11E-04	3.14E-04	4.27E-05	8.30E-06	6.27E-05	1.92E-05	6.80E-05
270.0	0.00E+00	0.00E+00	0.00E+00	4.20E-04	8.74E-04	4.78E-06	2.89E-06	0.00E+00	0.00E+00	0.00E+00
292.5	0.00E+00	0.00E+00	0.00E+00	2.30E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
315.0	0.00E+00	0.00E+00	5.95E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
337.5	0.00E+00	1.18E-05	0.00E+00	3.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
360.0	0.00E+00	0.00E+00	0.00E+00	1.15E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

An interesting comparison is the difference between the GENII V.2 dose and risk results calculated using the ICRP-30 methods with the same inputs used to calculate dose and risk results with the ICRP-60 (Federal Guidance Report 13) methods. This requires one additional type of input, illustrated in Figure 6.11. The lung inhalation clearance class (Fast, Medium, or Slow) must be selected for each radionuclide and all their progeny. The ICRP Class Y materials are represented by the newer ICRP "Slow" clearance class.

If the calculations are rerun, the equivalent doses and risks are estimated and tabulated using the GENII NESHAPS viewer. The results are tabulated as Exhibits 6.3 and 6.4. It can be seen that the results are approximately one-fourth as large as with the older dose conversion factors. This differenced is entirely due to changes in the dose conversion factors between the earlier and later ICRP and FGR 13 compilations.

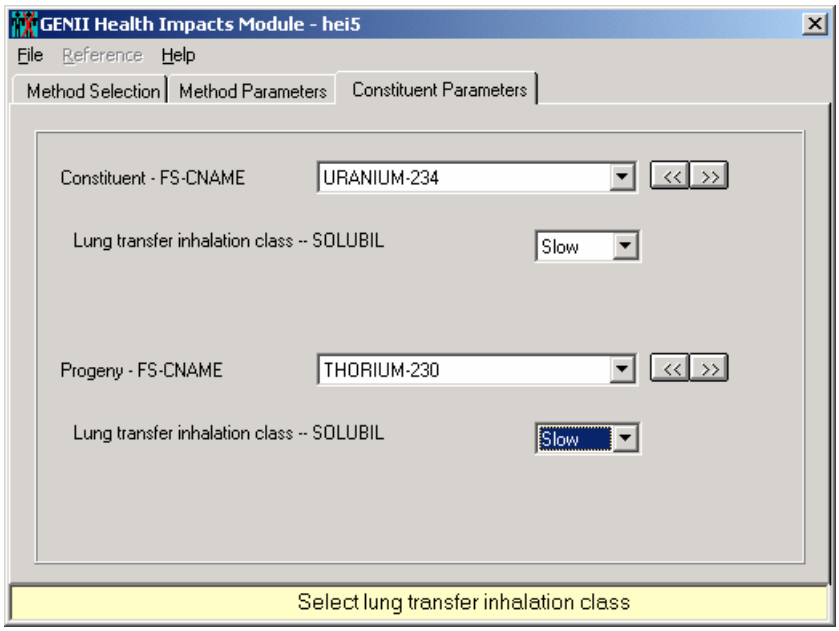


Figure 6.11. Input of Lung inhalation class for FGR 13 methods

Exhibit 6.3.

```
GENII VERSION 2
NESHAPS SUMMARY REPORT FOR CASE: c:\frames\ash5a

THE HEALTH IMPACTS FILE FOR THIS CASE CONTAINS INFORMATION ON:
            1 AGE GROUP(S)
            4 RADIONUCLIDES (COUNTING DECAY PROGENY SEPARATELY IN CHAINS)
           24 ORGAN(S)/TISSUE(S) FOR RADIATION DOSE
           15 POTENTIAL CANCER SITES, AND
            1 EXPOSURE PERIOD(S).

POPULATION DATA FROM FILE ashtapop.csv

TIME PERIOD NUMBER  1, CORRESPONDING TO TIME 99.0 YEARS
MAXIMUM POINT = 151
INDIVIDUAL AGE RANGE     0 TO   70 YEARS

MAXIMUM EXPOSED INDIVIDUAL LOCATION
ORGAN          MAX. DOSE (Sv)   TISSUE     CANCER INCIDENCE   CANCER FATALITIES
Adrenals         1.00E-06       Esophagus     3.96E-09          3.53E-09
Bld Wall         1.05E-06       Stomach       1.56E-08          1.38E-08
B Surface        1.75E-05       Colon         8.93E-08          5.32E-08
Brain            1.02E-06       Liver         8.29E-09          7.53E-09
Breasts          1.19E-06       Lung          3.47E-07          3.29E-07
Esophagus        9.75E-07       Bone          3.80E-09          2.98E-09
St Wall          1.07E-06       Skin          1.06E-07          1.06E-07
SI Wall          1.09E-06       Breast        4.12E-08          2.09E-08
ULI Wall         1.46E-06       Ovary         6.78E-09          4.83E-09
LLI Wall         2.31E-06       Bladder       1.76E-08          9.49E-09
Kidneys          6.35E-06       Kidneys       7.95E-09          6.29E-09
Liver            2.68E-06       Thyroid       1.20E-08          1.77E-09
Lungs            3.33E-05       Leukemia      1.97E-08          1.94E-08
Muscle           1.16E-06       Residual      7.35E-08          5.22E-08
Ovaries          1.01E-06       Total         7.52E-07          6.31E-07
Pancreas         9.94E-07
R Marrow         2.22E-06
Skin             1.61E-04
Spleen           1.05E-06
Testes           1.18E-06
Thymus           1.04E-06
Thyroid          1.09E-06
Uterus           1.01E-06
Effective        7.03E-06
```

TIME PERIOD NUMBER 1, CORRESPONDING TO TIME 99.0 YEARS
INDIVIDUAL AGE RANGE 0 TO 70 YEARS

INDIVIDUAL EFFECTIVE DOSE BY DISTANCE AND DIRECTION (SV)

	310.0	810.0	1500.0	2500.0	3500.0	7500.0	15000.0	25000.0	35000.0	45000.0
22.5	3.57E-06	1.23E-06	5.16E-07	2.45E-07	3.38E-06	4.10E-08	1.14E-08	3.98E-09	1.94E-09	1.14E-09
45.0	2.85E-06	9.97E-07	4.17E-07	1.97E-07	2.57E-06	3.25E-08	8.92E-09	3.12E-09	1.53E-09	9.04E-10
67.5	2.96E-06	1.02E-06	4.24E-07	2.03E-07	2.69E-06	3.37E-08	9.24E-09	3.20E-09	1.55E-09	9.16E-10
90.0	4.20E-06	1.42E-06	5.91E-07	2.89E-07	4.39E-06	4.74E-08	1.33E-08	4.60E-09	2.22E-09	1.29E-09
112.5	2.56E-06	8.74E-07	3.74E-07	1.81E-07	2.58E-06	2.89E-08	8.07E-09	2.81E-09	1.36E-09	7.94E-10
135.0	1.58E-06	5.55E-07	2.42E-07	1.18E-07	1.31E-06	1.78E-08	4.86E-09	1.69E-09	8.27E-10	4.92E-10
157.5	1.42E-06	5.01E-07	2.19E-07	1.09E-07	1.04E-06	1.59E-08	4.31E-09	1.51E-09	7.43E-10	4.46E-10
180.0	1.85E-06	6.67E-07	2.95E-07	1.43E-07	1.13E-06	2.06E-08	5.49E-09	1.91E-09	9.53E-10	5.79E-10
202.5	1.19E-06	4.23E-07	1.78E-07	8.64E-08	9.18E-07	1.35E-08	3.63E-09	1.26E-09	6.20E-10	3.71E-10
225.0	1.97E-06	6.95E-07	2.91E-07	1.39E-07	1.62E-06	2.24E-08	6.11E-09	2.12E-09	1.04E-09	6.18E-10
247.5	1.64E-06	5.87E-07	2.47E-07	1.16E-07	9.91E-07	1.85E-08	4.91E-09	1.71E-09	8.48E-10	5.13E-10
270.0	9.56E-07	3.72E-07	1.58E-07	7.37E-08	2.09E-07	1.11E-08	2.95E-09	1.08E-09	5.58E-10	3.43E-10
292.5	5.54E-07	2.17E-07	9.31E-08	4.36E-08	1.40E-07	6.60E-09	1.80E-09	6.62E-10	3.43E-10	2.08E-10
315.0	8.07E-07	2.94E-07	1.24E-07	5.86E-08	4.95E-07	9.44E-09	2.61E-09	9.44E-10	4.72E-10	2.81E-10
337.5	2.33E-06	7.93E-07	3.30E-07	1.57E-07	2.25E-06	2.70E-08	7.64E-09	2.70E-09	1.31E-09	7.59E-10
360.0	7.03E-06	2.46E-06	1.04E-06	4.93E-07	6.11E-06	8.18E-08	2.26E-08	7.91E-09	3.86E-09	2.28E-09

Exhibit 6.4

TIME PERIOD NUMBER 1, CORRESPONDING TO TIME 99.0 YEARS
POPULATION GROUP AGE RANGE 0 TO 70 YEARS

POPULATION EFFECTIVE DOSE BY DISTANCE AND DIRECTION (PERSON-SV)

	310.0	810.0	1500.0	2500.0	3500.0	7500.0	15000.0	25000.0	35000.0	45000.0
22.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
45.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
67.5	2.96E-06	0.00E+00	0.00E+00	1.12E-05	0.00E+00	0.00E+00	1.35E-04	2.02E-05	9.30E-06	1.22E-05
90.0	0.00E+00	0.00E+00	0.00E+00	2.25E-04	3.91E-04	3.76E-05	3.51E-06	7.79E-06	1.20E-05	1.73E-06
112.5	0.00E+00	0.00E+00	0.00E+00	1.54E-04	0.00E+00	3.62E-06	2.55E-05	2.33E-06	4.41E-06	2.95E-06
135.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.74E-05	6.74E-06	3.41E-06	2.60E-06	2.52E-06
157.5	0.00E+00	0.00E+00	2.22E-05	0.00E+00	0.00E+00	0.00E+00	4.24E-06	2.70E-06	2.72E-06	1.68E-06
180.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.25E-03	1.10E-05	4.52E-05	4.31E-06	2.28E-06	3.33E-06
202.5	0.00E+00	0.00E+00	0.00E+00	3.76E-04	4.25E-03	4.07E-05	1.11E-05	4.28E-06	1.94E-06	2.54E-06
225.0	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E-03	3.78E-05	2.06E-05	7.32E-06	7.90E-06	4.32E-06
247.5	0.00E+00	0.00E+00	1.04E-04	9.43E-05	2.90E-04	2.05E-05	3.82E-06	2.62E-05	7.45E-06	2.51E-05
270.0	0.00E+00	0.00E+00	0.00E+00	1.80E-04	6.90E-04	2.04E-06	1.12E-06	0.00E+00	0.00E+00	0.00E+00
292.5	0.00E+00	0.00E+00	0.00E+00	9.66E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
315.0	0.00E+00	0.00E+00	2.47E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
337.5	0.00E+00	4.76E-06	0.00E+00	1.77E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
..360.0	0.00E+00	0.00E+00	0.00E+00	5.14E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

7. TEMPLATE FILES

The GENII V.2 process for setting up a calculation can be tedious for the first-time user, although it rapidly becomes second nature. To help the beginning or infrequent user, as series of "template" files are included with the FRAMES/GENII distribution. These files are blank Conceptual Site Models for selected conditions.

A series of basic templates are provided are for routine atmospheric releases from a number of discrete release points. Thus, templates are provided for one, two, three, four, and five sources that continuously release materials into the air. Use of these templates is simple – just open them from the FRAMES File/Open menu and save them with a unique filename. These are named TEMPLTx.GID, where "x" is the number of atmospheric sources attached.

Additional templates are supplied for other starting points.

- For a case with known intakes, the template is named TmpRIF.GID
- For a case with known environmental concentrations, the template is named TmpEPF.GID
- For a case with initial soil contamination, the file is named TmpNEAR.GID
- For a case with known concentrations in air, surface water, and/or groundwater, the template is named TmpKNOWN.GID (if fewer than 3 known sources are available, delete the unused ones before continuing)
- For a case with a source releasing to surface water, the template is named TmpRiver.GID
- As an example case using the Uncertainty/Sensitivity module, a case paralleling TEMPLT1 is available named TmpSU

The template files included are listed in Table 7.1. The blank template for three sources, TEMPLT3.GID, is illustrated in Figure 7.1. The other templates are similar, but with more or fewer source modules attached. Additional templates may be acquired as needed from the GENII code author.

Table 1. GENII V.2 Template Files available

Template Name	Number of Source Modules
TEMPLT1.GID	1
TEMPLT2.GID	2
TEMPLT3.GID	3
TEMPLT4.GID	4
TEMPLT5.GID	5
TmpRIF.GID	1
TmpEPF.GID	1
TmpNEAR.GID	1
TmpKNOWN.GID	3
TmpRiver.GID	1
TmpUS.GID	1

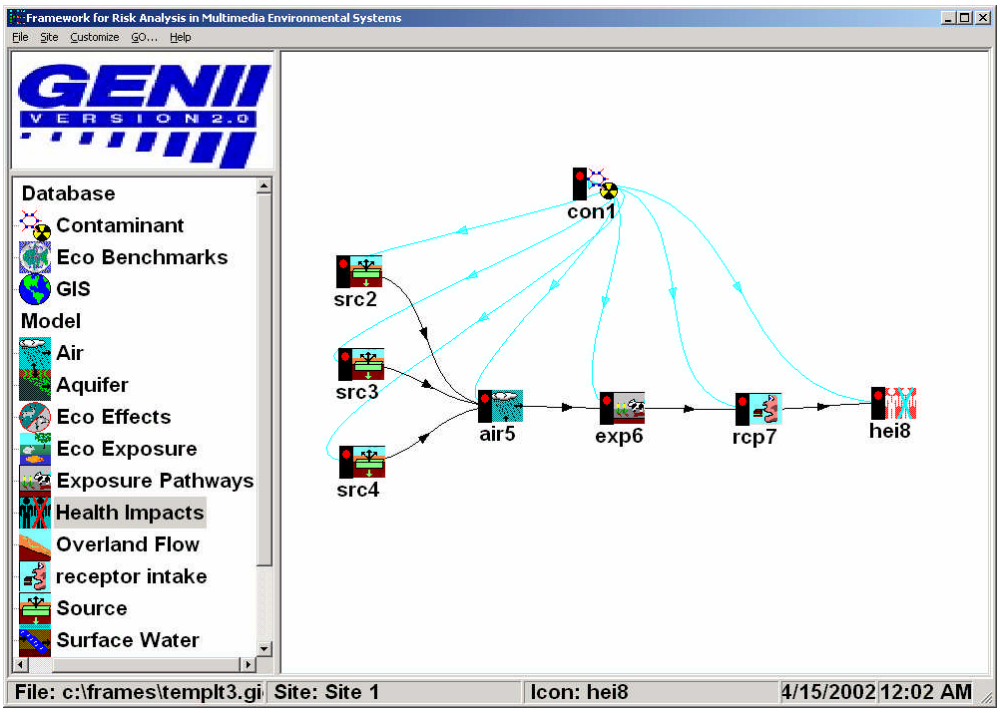


Figure 7.1. Example GENII V.2 Blank Template

APPENDIX A
Meteorological Processor Technical Basis

APPENDIX A
Meteorological Processor Technical Basis

The GENII atmospheric models ACUTESRC, CHRONSRC, PUFCHRON, and PUFACUTE are a suite of codes to account for the transport, diffusion, deposition, depletion, and decay of radionuclides while in the atmosphere. These calculations are based on the use of observed meteorological data. Observed meteorological data can occur in two general forms, hourly meteorological data where the data the meteorological information is recorded every hour, and a joint frequency distribution of wind speed, wind direction, and atmospheric stability, in which the hourly meteorological data has been summarized. Two programs, HRLYPROC and JJFDPROC, were developed that takes meteorological data stored in the hourly (HRLYPROC) or joint frequency distribution (JJFDPROC) and manipulates the data into a single format that can be read by the atmospheric models. The rest of this section discusses the input data required by the model, adjustments to the data, and calculation of meteorological variables that are not directly measured.

Section A.1 describes the input and output data that can be read by the two programs. The methods used to take the input data and created the output file are described for HRLYPROC and JJFDPROC are presented in Sections A.2 and A.3, respectively.

A.1 Input/Output of Meteorological Data

This section describes the type of meteorological data that can used as input into the two meteorological processing programs, HRLYPROC and JJFDPROC. Also described is the format of the data that is read by the atmospheric models.

A.1.1 Hourly Meteorological Data Input

HRLYPROC can process three types of input data format: 1) CD-144 hourly surface observations, 2) hourly surface observations archived in the SAMSON format, and 3) precipitation data in the TD-3240 format. File structures are provided in Appendix A.

CD-144 - The CD-144 format refers to the "Card Deck 144 format" available from the National Climatic Data Center (NCDC). The file is composed of one record per hour, with all weather elements reported in an 80-column block. The format of these records is described in the Card Deck 144 WBAN Hourly Surface Observation Reference Manual (NOAA 1970), also available from NCDC. Data in this file includes the year, month, day, hour, cloud ceiling height, wind direction, wind speed, dry bulb temperature, and opaque cloud cover (see Appendix A). The following describes the variables found in the CD-144 format.

- Year, Month and Day - identifies the year, month and day during which the meteorological data were observed.
- Hour - identifies the hour of the meteorological data observation. Hour is based on the 24-hour clock and is recorded as 00 through 23. Times are Local Standard Time (LST).

- Ceiling Height - the height of the cloud base above local terrain and is coded in hundreds of feet.
- Wind Direction - the direction from which the wind is blowing, rounded to the nearest 10 degrees. Calm is given by 00.
- Wind Speed - the wind speed measured in knots. Calm given by 00.
- Dry Bulb Temperature - the ambient air temperature measured in whole degrees Fahrenheit.
- Cloud Cover - There are two cloud cover parameters, opaque cloud cover and total cloud cover. Both parameters identify the amount of cloud covered measured in tens of percent, e.g. 0 = clear or less than 10%, 4 = 40 - 49%, "-" = Overcast of 100%. The model uses opaque cloud cover.

SAMSON - NCDC has made available solar and meteorological data form the first order stations in the United States for the period 1961 - 1990 on a set of three CD-ROMs, referred to as the SAMSON data. Additional data from 1991 through 1995 are also available. HRLYPROC can processes data retrieved from these CD-ROMs. It cannot access the data directly from the SAMSON CD-ROM, but the user can run the software provided with the data to retrieve the station, period of time and variables from the site and period to be modeled. The software is a DOS-based, interactive graphical interface.

Multiple years of data can be extracted for a single station and saved to the same file. However, HRLYPROC expects a maximum of one year of data in the data file. The reason for this restriction is explained below.

Retrieving the data from the CD-ROM is completely under the control of the user. When data are retrieved from the CD-ROMs, the user has the option to specify which variables to retrieve from a list of 21 variables for each station. At a minimum, the ceiling height, wind direction, wind speed, dry bulb temperature, opaque cloud cover, and present weather must be retrieved. In most cases, the hourly precipitation amount will also be retrieved, but it is not required to run HRLYPROC.

When the data are retrieved from the CD-ROM, two records are written at the beginning of the file that identify the station (first record) and the variables retrieved (second record). HRLYPROC uses both records to obtain information about the station (e.g., latitude and longitude) and to determine how to process the data that follows. There two records begin with the title character (~). If more than one year or data are retrieved from the CD-ROM, these two records will appear before each year in the file. Thus, an error will occur when the program reads these second set of header records.

The second header record is used by the model to determine if enough variables have been retrieved from the CD-ROM. If there are insufficient variables retrieved, an error will occur during the model execution. The user should return to the CD-ROM and retrieve the data once again to make sure all the necessary variables are retrieved.

Data records follow the header records in the retrieved file. There is one record for each hour of time period selected by the user. Unlike the CD-144 format which reports the hour on the 00 - 23 clock, the hour in the retrieved file is reported on the 01 - 24 hour clock.

Hour 24 of a day from the SAMSON data corresponds to hour 00 of the next day for the CD-144 data.

Data stored in the SAMSON format are in different units than found in the CD-144 data. The output using either format is the same, so the SAMSON and CD-144 data are converted to a specific set of units for each meteorological variable.

Center for Eexposure Assessment Modeling (CEAM) - Data from SAMSON have been extracted, combined with similar data, and made available by the EPA on the CEAM (Center for Exposure Assessment Modeling) website at http://www.epa.gov/ceampubl/tools/metdata/us_met.htm The semi-processed data available on the CEAM site are in a formatted file that may be converted to GENII format using the same processor as SAMSON data. The file data format is provided in Appendix B. The CEAM data are a subset of the full SAMSON data in a fixed format.

TD-3240 - Precipitation amounts are available from the NCDC in the TD-3240 format. A description of the TD-3240 data is found in NCDC (1990). These files can be used with hourly data in either the CD-144 format or the SAMSON format. In the case of the SAMSON file, hourly precipitation amount may already be included in the file. The data in the TD-3240 file would be used to supplement this data.

The TD-3240 data as received from NCDC are usually in a variable-length format. In this format, precipitation data for the entire day is stored in one record, and only for those hours during which precipitation was reported. A fixed-length format is also available in which one record contains the precipitation amount for one hour. As with the variable-length files, data are stored only for those days and hours for which precipitation was reported. HRLYPROC can process both types of TD-3240 data. Precipitation is reported in inches and hundredths of an inch in the TD-3240 format. These units are converted to millimeters for use in the atmospheric codes.

A.1.2 Joint Frequency Data Input

The JJFDPROC program processes joint frequency distributions of wind direction, wind speed and atmospheric stability (JFD). Two different formats of JFD are read by the JJFDPROC program, the format used by the EPA's Industrial Source Complex (ISC3) model (EPA 1995a) and the format used by the GENII (Napier et al. 1988).

The ISC3 format, also called the STAR summary, is described in EPA(1995a) and is summarized here. The JFD in the STAR format is normally constructed using 16 wind direction sectors, with the first 22.5 sector centered on winds from the North (increasing clockwise), six wind speed classes, and six stability classes. Wind speed classes are usually grouped as 0-3, 3-6, 6-10, 10-16, 16-21, and greater than 21 knots. Stability classes are based on the Pasquill stability categories (A [very unstable] - F [very stable]). Thus, the JFD file in the ISC3 format normally consists of 96 records. Each record is for a specific stability class and wind direction sector. Within each record is the frequency for the six wind speed classes for the given stability class and wind direction sector. In a quasi-programming sense, the file would be read as follows

```
Loop On I = 1, Number of Stability Classes (normally 6)
  Loop On K = 1, Number of Wind Direction Sectors (normally 16)
READ (JFDFILE,'(6F10.0)') (FREQ(I,J,K), J = 1 to Wind Speed Classes)
  End Loop On K
End Loop on I
```

where FREQ(I,J,K) = Frequency of stability class I, wind speed class J, and wind direction sector K

Thus, in a normal STAR summary the first 16 records are for sixteen direction sectors of stability class A (or 1), the next 16 are for stability class 2, and so forth.

The user provides the number of wind direction sectors, stability classes, and wind speed classes. So, as long as the JFD follows the above format (records containing the frequency by wind speed class; records ordered by wind direction sector then stability class), the number of stability classes, wind direction sectors, and wind speed classes can vary.

The GENII format is different from the ISC3 format. A description of the format is given in Napier et al. (1988), and is summarized here. Unlike the ISC3 format, the GENII format contains the percentages (frequency times 100) rather than frequencies of a given stability class, wind speed class, and wind direction sector. The JFD is usually constructed based on 16 wind direction sectors like the ISC3 format, but a variable number of wind speed class and atmospheric stability classes may be used. Table A.1 shows the format of the GENII JFD file.

The GENII format JFD file has the first four records containing information about the joint frequency data set, and the rest of the records are the joint frequency data set. In the same pseudo-programming language, the joint frequency data set would be read as:

```
LOOP ON I = 1 TO Number of Wind Speed Classes
   LOOP ON J = 1 TO Number of Stability Classes
      READ( JFDFILE, '(16f5.0)') (PREC(I,J,K), K = 1 to Number of Direction Sectors)
   END LOOP ON J
END LOOP ON I
```

As with the ISC3 format, the user provides the number of wind speed classes, wind direction sectors, and atmospheric stability classes.

A.1.3 Output File

Both HRLYPROC and JJFDPROC create the same type of output file. The first record of the output file contains the surface roughness of the site (see Section A.2.3) and the height of the wind measurements. Following the first record are the records containing the meteorological data.. Each record after the first contains the year, month, day and hour of the record. Following the date and time is the stability class, the flow vector (wind direction plus 180 degrees, the direction the wind is blowing towards), the wind speed, the dry bulb temperature, the mixing height, the precipitation type (e.g, none, light rain, light snow), the precipitation rate, and a weighting factor. The format of the file is given in Appendix A.

Table A.1. Format of Joint Frequency Distribution of Wind Speed, Wind Direction, and Atmospheric Stability for GENII.

Record Number	Field Number	Data Type	Field Size	Description
1	1	CHARACTER	80	Descriptive Title
2	1	CHARACTER	80	Secondary Title
3	1	INTEGER	5	Number of wind speed classes in file
3	2	INTEGER	5	Number of atmospheric stability classes
3	3	INTEGER	5	(Not Used always set to 1)
3	4	INTEGER	5	(Not Used always set to 1)
3	5	REAL	10	Height at which wind speed data was collected (m)
4	1 - 10	REAL	7	Average Wind Speed for each wind speed class (m/s)
Joint Frequency Data Set				
5 till end	1-16	REAL	5	Percent of time with wind from North, North-Northeast, Northeast, etc.) Each record has the 16 sectors. Data are grouped first by atmospheric stability class and then by wind speed group.
Last	1	EOF		The final JFD entry should be followed by a carriage return/line feed so that the EOF is on the final line.

For HRLYPROC, the meteorological information is based on the hourly observations found in the input files. The output of HRLYPROC will have one output record for each input record that is read in. The weighting factor for each record from HRLYPROC is always one.

For JJFDPROC, the meteorological information in the JFD file does not include date/time information. The JJFDPROC program instead creates pseudo-hourly data where there is one record for each wind speed class, wind direction sector, and stability class found in the JFD. In addition, the number of records will expanded based on variation of the temperature and precipitation type. How these variations expand the number of records is explained in Sections A.3.5 and A.3.6 for temperature and precipitation, respectively. The output records from JJFDPROC have a weighting factor that is the number of hours with

the meteorological data contained in the record. As there is no date/time information, the year, month, day, and hour for each record is given as -1.

All four atmospheric model, CHRONSRC, ACUTESRC, PUFCHRON, PUFACUTE, can read the output file if it has been produced by the HRLYPROC program. Only the chronic plume model, CHRONSRC, can read an output file produced by the JJFDPROC program.

A.2 Meteorological Processing Methods for HRLYPROC

In this section the methods used to process the hourly meteorological data are discussed. These issues include simple data manipulation (e.g. converting data to the correct unit) and methods for computing mixing heights and atmospheric stability. The HRLYPROC program is based on the PC-RAMMET (EPA 1995b) meteorological processing code.

A.2.1 Time of Day

The HRLYPROC program uses the same convention as the PC-RAMMET code (EPA 1995b) and it is summarized here. When reading the CD-144 format, HRLYPROC skips the first hourly record of the data in the year because the 24-hour period for a year starts with the 1-hour period ending at 0100 LST (Local Standard Time) and the observations in the CD-144 files begin with the observations reported at 0000 LST. Sequential reading of the remaining data automatically make this adjustment for each succeeding day. Meteorological data for the last hour in the year are assumed equal to that for the next to the last hour because the data for a day always ends with hour 23. Data on the SAMSON CD-ROM begin with hour 1 and end with hour 24, eliminating the need to skip a record. However, the last hour of the year may contain missing data and are processed similarly to the CD-144 formatted data.

A.2.2 Atmospheric Stability

The HRLYPROC code recognizes the seven stability classes. The first six categories correspond to Pasquill's (1974) classification (A-F). The seventh category corresponds to the 'dashes' in the original classification by Pasquill and indicated a strong, ground-based nocturnal temperature inversion with non-definable wind flow.

The stability classes are calculated based on the method proposed by Turner (1964). The method involves basing the stability class on the cloud cover, ceiling height, solar elevation, and the wind speed. During the day, the cloud cover, ceiling height, and solar elevation give an estimation of the net radiation that is reaching the ground. The net radiation index is used with the wind speed to determine the stability class. At night, the cloud cover is used to determine the net radiation index. The following procedure is used to obtain the net radiation index.

- If the cloud cover is 10/10 and the ceiling is less than 7,000 feet, use net radiation index equal to 0 (whether day or night)
- For night-time (between sunset and sunrise):
  a. If total cloud cover < 4/10, use net radiation index equal to -2

b. If total cloud cover > 4/10, use net radiation index equal to -1
c. If precipitation occurring, use net radiation index equal to 0

- For daytime:
  a. Determine the net radiation index as a function of solar elevation angle from Table A.2.
  b. If total cloud cover > 5/10, modify the net radiation number as follows:
     A. If ceiling height < 7,000 ft subtract 2 (except for 10/10)
     B. If ceiling height □ 7,000ft but < 16,000 ft, subtract 1
     C. If total cloud cover equal 10/10, subtract 1. (i.e., if ceiling height is >7,000 and < 16,000 ft then would subtract 2; if > 16,000 ft, subtract 1. If >7,000 ft, already covered by 1).
     D. If modified net radiation number is less than 1, set equal to 1.
     E. If precipitation, subtract 2 from net radiation index calculated from Table A.1.
     F. If precipitation and net radiation number is less than 0, set equal to 0.

Table A.2. Insolation Class as a Function of Solar Elevation Angle

Solar Elevation Angle (a)	Insolation Class	Net Radiation Index[a]
$0 < a \leq 15°$	Weak	1
$15 < a \leq 35°$	Slight	2
$35 < a \leq 60°$	Moderate	3
$60° < a$	Strong	4

The stability class is determined using Table A.3 using the corresponding net radiation index and the wind speed.

Solar elevation angle (a) is calculated based on the day of the year, the hour of the day, and the latitude of the station where

$$\Psi = \sin^{-1}[\sin(\phi)\sin(\delta_s) + \cos(\phi)\cos(\delta_s)\cos(h_a)]$$

where Ψ = local solar elevation angle (deg)
ϕ = latitude of the station (deg)
δ_s = solar declination angle (angle of the sun above the equator)
h_a = local hour angle of the sun (= 180 - (h/12)*180 where h is the local hour) (deg)

The solar declination angle is calculated by

Table A.3. Stability Class as a Function of Wind Speed and Net Radiation Index

Wind Speed (Knots)	Net Radiation Index						
	4	3	2	1	0	-1	-2
0-1	1	1	2	3	4	6	7
2-3	1	2	2	3	4	6	7
4-5	1	2	3	4	4	5	6
6	2	2	3	4	4	5	6
7	2	2	3	4	4	4	5
8-9	2	3	3	4	4	4	5
10	3	3	4	4	4	4	5
11	3	3	4	4	4	4	4
≥ 12	3	4	4	4	4	4	4

$$\delta_s = -\phi_r \cos[\frac{\pi\, d}{d_r}]$$

where ϕ_r is the latitude of the Tropic of Cancer (23.5), d is the Julian day, and d_r is the Julian day for the summer solstice (= 173).

The following assumptions are used if the various variables are missing.

- If the wind speed is missing, the stability class is missing.
- If the total sky cover is missing, a total sky cover of 10/10 is assumed.
- If the ceiling height is missing, an unlimited ceiling (> 16,000 feet) is assumed.

A.2.3 Surface Winds

The wind direction and wind speed are read in through the input data file by HRLYPROC. The user provides the height of the wind measurements and the surface roughness length where the measurements took place and where the data is to be applied. In some cases wind data is collected over one type of surface, but where the meteorological data will be applied is over a different type of surface. For example, the wind data may be collected over an area with cut grass and relatively small surface roughness, and the data would be applied to area which is forested and has a high surface roughness. The change in surface roughness would change the wind speed seen at the measurement height. Wind direction would be unaffected by the change in surface roughness.

To estimate the change in wind speed due to the variation is surface roughness, the diabatic wind profile is used. No attempt is made to model the variation of wind direction with height above the ground. Diabatic profiles account for the effect of surface roughness and atmospheric stability on the variation of wind speed with height.

The diabatic profile model is derived from the atmospheric boundary layer similarity theory proposed by Monin and Obukhov (1954). The basic hypothesis of similarity theory is that a number of parameters in the atmospheric layer near the ground, including the wind profiles, should be universal functions of the friction velocity, a length scale, and the height above ground. The length scale, L, is referred to as the Monin-Obukhov length and the ratio z/L is related to atmospheric stability. When z/L is negative and large (e.g., < -2), the atmosphere is extremely unstable (convective). When z/L is near zero, the atmosphere is neutral, and when it is positive and large (e.g., > 1), the atmosphere is extremely stable. A large body of experimental data supports Monin-Obukhov similarity theory.

The diabatic wind profile is

$$U(z) = \frac{u_*}{k}[\ln(\frac{z}{z_0}) - \psi(\frac{z}{L})]$$

where $U(z)$ = wind speed at height z (m/s)
u_* = friction velocity (boundary-layer turbulence scaling velocity) (m/s)
k = von Karman constant, which has a value of about 0.4 (no units)
z = height (m)
z_0 = measure of local surface roughness (roughness length) (m)
ψ = stability correction factor
L = Monin-Obukhov Length (m)

The term $\psi(z/L)$ accounts for the effects of stability of the wind profile. In stable atmospheric conditions, $\psi(z/L)$ has the form $-\alpha z/L$, where α is a value between 4.7 and 5.2. For the program, a value of 5 is used for α. In neutral conditions it $\psi(z/L)$ is zero, and the diabatic profile simplifies to a logarithmic profile.

In unstable air, $\psi(z/L)$ is more complicated. According to Panfosky and Dutton (1984), the most common form of $\psi(z/L)$ for unstable conditions is based on the work by Businger et al. (1971) and Paulson (1970). It is

$$\psi(\frac{z}{L}) = \ln([\frac{1+x^2}{2}][\frac{1+x}{2}]^2) - 2\tan^{-1}x + \frac{\pi}{2}$$

where $x = (1- 16z/L)^{1/4}$. Equation (3) is used to estimate the friction velocity (u_*) from wind speed, surface roughness, and the Monin Obukhov Length. In unstable and neutral conditions, the use of Equation (3) is limited to the lowest 100 meters of the atmosphere. In stable conditions, the upper limit of application of Equation (3) is the smaller of 100 meters

or three times the Monin-Obukhov length. Skibin and Businger (1985) provide the rationale for limiting application of Equation (3) to three times the Monin-Obukhov length in stable conditions.

The Monin-Obukhov length is a measure atmospheric stability. It varies from small negative values (a few meters) in extremely unstable atmospheric conditions to negative infinite as the atmospheric stability approaches neutral from unstable. In extremely stable conditions, the Monin-Obukhov length is small and positive. As neutral conditions are approached from stable conditions, the Monin-Obukhov length approaches infinity. Thus, there is a discontinuity in the Monin-Obukhov length at neutral. However, this discontinuity is not a problem because the Monin-Obukhov length is found in the denominator of expressions.

Golder (1972) provides a means for converting from stability class estimates to Monin-Obukhov lengths. Figure 1 derived from Golder (1972, Figure 5) shows the range for 1/L as a function of stability classes and surface roughness. Mid-range values for 1/L from this figure are used by the model to estimate 1/L.

The following method is used to estimate the wind speed at the application surface roughness. First, the friction velocity is calculated from the input wind speed, measurement height and measurement site surface roughness using Equation (3). Using the friction velocity obtained for the measurement site, the wind speed at the upper height limit (100 meters or the smaller of 100 meters and three times the Monin-Obukhov for stable conditions) is calculated using Equation (3). A new friction velocity is calculated using the wind speed at the upper height limit and the application's surface roughness again from Equation (3). From the new friction velocity, the wind speed at the measurement height is calculated using Equation (3). This new wind speed is used as output, and the surface roughness at the application site along with the wind measurement height are outputted as the first record.

A.2.4 Mixing Height

In the layer of the atmosphere next to the earth's surface, friction caused by surface roughness and heating of the surface combine to generate turbulence that efficiently mixes material released at or near the surface through the layer. This layer is referred to as the mixing layer. The top of the mixing layer is marked by a decrease in turbulence brought about by stable atmospheric conditions above. The depth of the mixing layer, also referred to as the thickness of the mixing layer, changes with atmospheric conditions. The mixing layer is generally thickest during the day and during periods with high wind speeds, and it is thinnest at night during the periods with low wind speeds. In either case, the mixing layer depth tends to increase with surface roughness.

The mixing layer depth is not a variable that is read in by HRLYPROC, but must be estimated based on the reported meteorological conditions. Mixing depths are calculated in HRLYPROC using the relationships derived by Zilitinkevich (1972) for stable and neutral conditions. For stable atmospheric conditions, his relationship is

$$H = k\sqrt{\frac{u_* L}{f}}$$

where H = mixing-layer depth (m)
k = von Karman constant (dimensionless, 0.4)
u_* = friction velocity (m/s)
L = Monin-Obukhov Length (m)
f = Coriolis parameter (= $1.46 \times 10^{-5} \sin \phi$, where ϕ is the latitude) (s^{-1})

For neutral and unstable conditions, the mixing layer depth is estimated using

$$H = \beta \frac{u_*}{f}$$

where H = mixing layer depth (m)
β = constant (dimensionless)
u_* = friction velocity (m/s)
f = Coriolis parameter

Zilitinkevich (1972) assumes that β is equal to k; Pasquill and Smith (1983) suggest β has a value in the range of 0.2 to 0.3; and Panfosky and Dutton (1984) suggest its range is 0.15 to 0.25. In HRLYPROC, β is assumed to be 0.2.

Using either formula, the mixing layer depth is not allowed to exceed 2,000 meters or fall under 10 meters.

A.2.5 Temperature

For the CD-144 data, hourly ambient temperature data are converted from the NWS reporting units of degrees Fahrenheit to Kelvin. For the SAMSON data, the reporting units are degrees Celsius and are converted to Kelvin.

A.2.6 Precipitation

Both the CD-144 and the SAMSON data include codes for the current weather at the meteorological station. These codes are based on the type of precipitation (e.g., rain, snow, hail) and the intensity of the precipitation (e.g., light, moderate, or heavy). These codes are used to determine a precipitation code and rate that are output by HRLYPROC.

In the output, the weather code is convert to a precipitation code which ranges from 0 to 6. A zero is used when there is no precipitation. Precipitation codes 1, 2, and 3 indicate light, moderate, and heavy liquid precipitation, respectively. Liquid precipitation includes rain, drizzle, freezing rain, and freezing drizzle. All drizzle intensities are coded as 1. Codes 4, 5, 6 indicate light, moderate, and heavy frozen precipitation, respectively. Frozen precipitation include snow, snow grains, snow pellets, ice pellets, ice crystals, and hail. If a mixture of liquid and frozen precipitation is occurring (e.g., rain and snow reported at the same time),

liquid precipitation is assumed unless the intensity of the frozen precipitation is greater than the liquid precipitation. For example, if both moderate rain and moderate snow where reported for the hour, the precipitation code would be 2. If moderate rain and heavy snow were reported for the hour, the precipitation code would be 6.

For the CD-144 data, the precipitation rate is either the value obtain from the TD-3240 date (if available) or a default value. For the SAMSON data, the precipitation rate may be either the precipitation rate found in the SAMSON data, the rate obtained from the TD-3240 data if available and no rate given by the SAMSON data, or a default value. The default value is based on the precipitation code. Table A.4 shows the default precipitation rate as a function of the precipitation code. All precipitation rates (whether from SAMSON, TD-3240 or default) are outputted in units of mm/hr.

Table A.4. Default Precipitation Rates Based on Precipitation Code

Precipitation Code	Precipitation Rate (mm/hr)
1	1
2	5
3	10
4	0.25
5	1.25
6	2.5

A.3 Meteorological Processing for JJFDPROC

This section described the methods used to processing the joint frequency distribution (JFD) of wind speed, wind direction, and atmospheric stability. The issues covered include data manipulation (converting units), how mixing heights are calculated, and how to account for variations in temperature and precipitation.

A.3.1 Date and Time

A JFD does not contain any information about the date and time associated with meteorological variables that are summarized. Thus, the output from the JJFDPROC program does not include any date and time information. The year, month, day, and hour for the output record from the JJFDPROC program are set to -1. This allows the program using the output of the JJFDPROC program to know that the data was created from a JFD.

A.3.2 Atmospheric Stability

Atmospheric stability comes obtained the JFD read in by the JJFDPROC program. Thus, no data manipulation is required to estimate the atmospheric stability.

A.3.3 Surface Winds

The wind direction and wind speed are obtained from the JFD read in by the JJFDPROC program. The user provides the midpoints of the wind speed classes, whether the wind directions are given in 16 or 36 sectors, the height of the wind measurement, and the surface roughness at the measurement site and the application site.

Most JFD are calculated using 16 sectors. The 22.5° sectors are used because wind directions were record using these sectors (i.e., North, North-Northeast, ...North-Northwest). However, since 1965 directions have been recorded in tens of degrees. Thus, it is possible to produce a JFD that uses 36 sectors, where the sectors would be centered around the multiples of 10 degrees (e.g., 10, 20, 30). Whether the 16 or 36 sectors are used, the flow vector (where the wind is blow towards) is based on the direction associated with the center of the sector (e.g., 0, 22.5, 45, ... degrees for the 16 sectors, and 0, 10, 20, 30, ... degrees for the 36 sectors).

The wind speed midpoints are used as the wind speed. Similar to the hourly data, the wind speed can be corrected when the surface roughness at the measurement site is different from the application site (see Section A.2.3). The wind speed midpoints input by the user are converted to m/s, if they are not already in these units.

A.3.4 Mixing Height

Mixing height is calculated in the same way as for the hourly meteorological data. Section A.2.4 describes how the mixing height is calculated.

A.3.5 Temperature

The ambient temperature is a variable not found in the JFD. To provide temperature information, which may be used by the atmospheric models for plume rise and deposition calculation, the user must supply the temperature information. For the JJFDPROC program, the user inputs maximum and minimum temperatures for each month. The maximum and minimum temperature are available in Local Climatological Data summaries available from the National Climatic Data Center.

The variation in temperature is added to the output by dividing the frequency of a given wind speed class, wind direction sector, and atmospheric stability class by 12 (for the 12 months) and using the maximum temperature if the stability class is 1 or 2 (extremely unstable or very unstable), the minimum temperature if the stability class is 6 or 7 (very stable or extremely stable), and the average, (max + min)/2, for the other stability classes. This method is based on the assumption that unstable condition occur during the middle of the day when maximum temperature occur and stable condition occur during the night when minimum temperatures occur. This method does not take into account that frequency of stability classes by month. That is, normally, neutral and stable condition occur more often in winter months than during summer months.

A.3.6 Precipitation

Precipitation (type and rate) variables are not found in the JFD and must be provided by the user. The user has an option to include precipitation or not. If the user wants to include precipitation, the user must provide the fraction of time precipitation occurs for the various stability classes. As the precipitation rarely occurs during the extremes of stability, stability class 1 and 2 (extremely unstable and very unstable) are combined into a single class and stability class 6 and 7 (very stable and extremely stable) are combined into another class. In addition, heavy rain does not occur very often, so the moderate and heavy categories of precipitation (rain or snow) are also combined into a single class. Appendix C presents the fractions of time of the various precipitation type based on stability class for a number of stations. For a station not on the list, the precipitation can be estimated by choosing a representative station (which may not be the nearest station) from the list in Appendix C.

The precipitation is added to the records by dividing the frequency of a given wind speed class, wind direction sector and stability class into a percent of time with a precipitation type including no precipitation. The percent of time with a given precipitation type is based on the fractions provided by the user, and are applied after the frequencies have been modified to account for temperature (see Section A.3.5). Because the moderate and heavy intensity have been converted to a single category, the precipitation that occurs is always assumed to be moderate.

A.3.7 Weighting

The weight that is found at the end of each output record is the number of hours for the given meteorological data (wind speed, wind direction, atmospheric stability class, etc). It is calculated by multiplying the number of hours that represent the data in the JFD (usually 1 year = 8760 hours) times the frequency of the wind speed class, wind direction sector, atmospheric stability, temperature, and (if selected) the precipitation type and rate. If the resulting number of hours (weight factor) is too small, (less than 0.01 hours), the record is not written to the file. This is to prevent records were the time of occurrence is essentially zero.

A.4 References

Businger, J.A., J.C. Wyngaard, Y. Izumi, and E.F. Bradley. 1971. "Flux-Profile Relationships in the Atmospheric Surface Layer." *Journal of the Atmospheric Sciences* 28(2):181-189.

EPA (U.S. Environmental Protection Agency). 1995a. *User's Guide for the Industrial Source Complex (ISC3) Dispersion Models Volume II - Description of Model Algorithms*. EPA-454/B-95-003b. Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency). 1995b. *PCRAMMET User's Guide*. Research Triangle Park, North Carolina.

Golder, D. 1982. "Relations Among Stability Parameters in the Surface Layer." *Boundary-Layer Meteorology* 3(1):47-58.

Monin, A.S. and A.M. Obukhov. 1954. "Basic Laws of Turbulent Mixing in the Ground Layer of the Atmosphere." *Trans. Geophys, Inst. Akad. Nauk*, USSR 151:163-187.

Napier, B.A., R.A. Peloquin, D.L. Strenge, and J.V. Ramsdell Jr. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System. Volume 2: User's Manual.* PNL-6584 Vol. 2, Pacific Northwest National Laboratory, Richland, Washington.

NCDC. 1990. *Hourly Precipitation Data TD-3240*. National Climatic Data Center, Asheville, North Carolina.

NOAA. 1970. *Card Deck 144 WBAN Hourly Surface Observations Reference Manual.* available from the National Climatic Data Center, Asheville, North Carolina.

Panofsky, H.A. and J.A. Dutton. 1984. *Atmospheric Turbulence.* J. Wiley & Sons, New York.

Pasquill, F. 1974. *Atmospheric Diffusion*. D.Van Nostrand Company, Ltd., London 2nd Edition.

Pasquill, F. and F. B. Smith. 1983. *Atmospheric Diffusion*, 3rd Edition. Halsted Press, New York.

Paulson, C.A. 1970. "The Mathematical Representation of Wind Speed and Temperature Profiles in the Unstable Atmospheric Surface Layer." *Journal of Applied Meteorology* 9(6):857-861.

Skibin, D. and J.A. Businger. 1985. "The Vertical Extent of the Log-Linear Wind Profile Under Stable Stratification." *Atmospheric Environment* 19(1):27-30.

Turner, D.B. 1964. "A Diffusion Model for an Urban Area." *Journal of Applied Meteorology*, 3:83-91.

Zilitinkevich, S.S. 1972. "On the Determination of the Height of the Ekman Boundary Layer." *Boundary-Layer Meteorology* 3(2):141-145.

APPENDIX B

Meteorological File Formats

Appendix B

Meteorological File Formats

This appendix contains the file formats for the hourly meteorological data files that can be used as input and the format of the output file. The input file formats are taken from the PCRAMMET User's Guide (EPA 1995b).

Surface Data Record - CD144 Format

The CD-144 format is given in the following table. Note: only the variables of interest are provided in the following table.

Element	Column(s)
Surface Station Number	1-5
Year	6-7
Month	8-9
Day	10-11
Hour	12-13
Ceiling Height (hundreds of feet)	14-16
Present Weather	25-29
Wind Direction (tens of degrees)	39-40
Wind Speed (knots)	41-42
Dry Bulb Temperature	47-49
Opaque Cloud Cover	79

Exhibit 1 shows a sample file in the CD-144 format.

Exhibit 1 Sample File in the CD-144 format.

```
0392888010100---10002000000000003430110105290301601408144925 0                1
0392888010101---00002000000000003430113605290301401308 80                      0
0392888010102---00002000000000003490100208290501601407 70                      0
0392888010103---00002000000000003520080608290601501307 40                      0
0392888010104---00002000000000003530060606290601301107 30                      0
0392888010105---00002000000000003540063603290601201007 70                      0
0392888010106---00002000000000003580040606290701201007 00                      0
0392888010107---00002000000000003690040207291001201007 00                      0
0392888010108---00002000000000003800053606291301100907 70                      0
0392888010109---00002000000000003880043610291501301106 70                      0
0392888010110---10002000000000003930043209291701501206 22                      0
0392888010111120500020000000000040200403092920018014054 8                      6
```

```
0392888010112---000020000000000003980050000291902101605007120                 0
0392888010113---100020000000000003950063003291802301804 81                    0
0392888010114---100020000000000003870062406291602301804 81                    0
0392888010115---100020000000000003840073007291502401904 8118250               0
0392888010116---100020000000000003810082406291402401905 02                    0
0392888010117---100015000000000003780102304291302402005 52                    1
0392888010118---100015000000000003830112107291402001706 8207120282502         1
0392888010119---200015000000000003800102105291301901606 82                    2
0392888010120---200015000000000003850102204291401601407 72                    2
0392888010121---200015000000000003850092304291401401208 0228250               2
0392888010122---000015000000000003840102403291401501308 10                    0
0392888010123---000015000000000003870102407291501501308 10                    0
0392888010200---000015000000000003820102305291401401308 40                    0
```

Surface Data Record - SAMSON Format

Information about the file obtained from PCRAMMET Users Guide (EPA 1995b) and summarized here.

The first record in the file retrieved from the SAMSON CD-ROMs contains station data. The format for this record is

Columns	Element	Definition
001	Indicator	~ to indicate header record
002-006	WBAN number	Station Number
008-029	City	City where station is located
031-032	State	State where station is located
033-036	Time Zone	Number of hours by which local standard time lags or leads Universal Time
039-044 (039 040-041 043-044)	Latitude	Station Latitude N or S = North or South Degrees Minutes
047-053 (047 048-050 052-053)	Longitude	Station Longitude E or W = East or West Degrees Minutes
056-059	Elevation	Elevation of Station in meters above sea level.

The FORTRAN format of this record is:
(1x, a5, 1x, a22, 1x, a2, 1x, i3, 2x, a1, i2, 1x, i2, 2x, a1, i3, 1x, i2, 2x, i4)

Each variable in the SAMSON data is represented by a position number. This position number **always** corresponds to that variable, no matter how many or how few variables are retrieved. The second record in the file retrieved from the SAMSON-CD contains the list of variables (by a position number) that appear in the data file. There is no particular format; the variable number appears above the column of data it represents with at least one space (and usually many more) between the position numbers.

The rest of the records contain the weather elements retrieved from the SAMSON CD-ROMs. The data are in free-format (i.e., there is at least one space between each element in the record). The year, month, day, hour, and observation indicator always appear on each record. These are followed by the variables retrieved by the user. If all the variables were retrieved, they would appear in the following order:

Position Number	Description
	Year, month, day, hour (LST), observation indicator
1	Extraterrestrial horizontial radiation
2	Extraterrestrial direct normal radiation
3	Global horizontial radiation
4	Direct normal radiation
5	Diffuse horizontial radiation
6	Total cloud cover
7	Opaque cloud cover
8	Dry bulb temperature
9	Dew point temperature
10	Relative humidity
11	Station pressure
12	Wind direction
13	Wind speed
14	Visibility
15	Ceiling height
16	Present weather
17	Precipitable water

18	Broadband aerosol optical depth
19	Snow depth
20	Days since last snowfall
21	Hourly precipitation amount and flag

The on-line help that accompanies the CD-ROMs contains a complete discussion of these variables, including the units, missing value indicators and any special considerations or comments.

Exhibit 2 shows a sample file in the SAMSON format. Note the SAMSON file does not contain all the possible variables, but the ones required by HRLYPROC.

Exhibit 2 Sample File in the SAMSON format.

```
~03928 WICHITA                KS  -6  N37 39  W097 25   408
~YR MO DA HR I  6  7     8     9  10   11  12    13     14     15        16      21
 88  1  1  1 0  0  0 -10.0 -11.7  88  983 360   2.6   32.2  77777 999999999      0
 88  1  1  2 0  0  0  -8.9 -12.2  77  984  20   4.1   32.2  77777 999999999
 88  1  1  3 0  0  0  -9.4 -13.3  74  984  60   4.1   32.2  77777 999999999
 88  1  1  4 0  0  0 -10.6 -14.4  73  984  60   3.1   32.2  77777 999999999
 88  1  1  5 0  0  0 -11.1 -14.4  77  984 360   1.5   32.2  77777 999999999
 88  1  1  6 0  0  0 -11.1 -15.6  70  985  60   3.1   32.2  77777 999999999
 88  1  1  7 0  0  0 -11.1 -15.6  70  986  20   3.6   32.2  77777 999999999
 88  1  1  8 0  0  0 -11.7 -15.0  77  987 360   3.1   32.2  77777 999999999
 88  1  1  9 0  0  0 -10.6 -15.6  67  987 360   5.2   32.2  77777 999999999
 88  1  1 10 0  2  0  -9.4 -15.6  62  988 320   4.6   32.2  77777 999999999
 88  1  1 11 0  8  6  -7.8 -15.6  54  989  30   4.6   32.2   3660 999999999
 88  1  1 12 0  0  0  -6.1 -15.0  50  989   0    .0   32.2  77777 999999999
 88  1  1 13 0  1  0  -5.0 -14.4  48  988 300   1.5   32.2  77777 999999999
 88  1  1 14 0  1  0  -5.0 -14.4  48  988 240   3.1   32.2  77777 999999999
 88  1  1 15 0  1  0  -4.4 -13.9  48  987 300   3.6   32.2  77777 999999999
 88  1  1 16 0  2  0  -4.4 -13.3  50  987 240   3.1   32.2  77777 999999999
 88  1  1 17 0  2  1  -4.4 -12.2  55  987 230   2.1   24.1  77777 999999999
 88  1  1 18 0  2  1  -6.7 -11.7  68  987 210   3.6   24.1  77777 999999999
 88  1  1 19 0  2  2  -7.2 -12.2  68  987 210   2.6   24.1  77777 999999999
 88  1  1 20 0  2  2  -8.9 -12.2  77  987 220   2.1   24.1  77777 999999999
 88  1  1 21 0  2  2 -10.0 -12.8  80  987 230   2.1   24.1  77777 999999999
 88  1  1 22 0  0  0  -9.4 -12.2  81  987 240   1.5   24.1  77777 999999999
 88  1  1 23 0  0  0  -9.4 -12.2  81  987 240   3.6   24.1  77777 999999999
 88  1  1 24 0  0  0 -10.0 -12.2  84  987 230   2.6   24.1  77777 999999999
```

<u>CEAM Format</u>

The hourly values file has a header containing identifying information.
Example:
25501 Kodiak AK +9 N 57 45 W 152 30 5 2002-05-17 22:47:31

Header

Field	Columns	Description	Type	Format
---	---	---	---	---

1	1	blank	Character	1x
2	02 - 06	WBAN id	Character	a5
3	08 - 37	City where the station is located.	Character	a30
4	39 - 40	State where the station is located.	Character	a2
5	42 - 44	Time Zone	Character	a3
6	47 - 54	Latitude of the station		
	47 - 47	N: North of the Equator S: South	Character	a1
	48 - 51	Degrees	Integer	i4
	53 - 54	Minutes	Integer	i2
7	57 - 64	Longitude of the station		
	57 - 57	W: West E: East	Character	a1
	58 - 61	Degrees	Integer	i4
	63 - 64	Minutes	Integer	i2
8	67 - 70	Station Elevation(meter)	Integer	i4
9	74 - 92	Generation date of the file, i.e, yyyy-mm-dd hh:mm:ss where yyyy: year mm: month dd: day of the month hh: hour (24-hour clock) mm: minutes ss: seconds	Character	a19

Header format: (1x, a5, 1x, a30, 1x, a2, 1x, a3, &
2x, a1, i4, 1x, i2, &
2x, a1, i4, 1x, i2, &
2x, i4, 3x, a19)

Field	Columns	Description	Units	Type	Format
1	1	blank	N/A	Character	1x
2	002 - 011	Date	yyyy-mm-dd	Integer	i4,1x,i2,1x,i2
3	012 - 014	*Hour of the day	Hour	Integer	i3
4	016 - 021	Extraterrestrial Horizontal Radiation (Ra)	*Wh/m2	Integer	i5,a1
5	023 - 028	Extraterrestrial Direct Normal Radiation	Wh/m2	Integer	i5,a1
6	030 - 037	Global Horizontal Radiation (Rs)	Wh/m2	Integer	i5,a3
7	039 - 046	Direct Normal	Wh/m2	Integer	i5,a3

		Radiation			
8	048 - 055	Diffuse Horizontal Radiation	Wh/m2	Integer	i5,a3
9	057 - 059	Total Sky Cover	tenths of sky covered	Integer	i2,a1
10	061 - 063	Opaque_Sky_Cover	tenths of sky covered	Integer	i2,a1
11	065 - 070	Dry Bulb Temperature	degrees Centigrade	Real	f5.1,a1
12	072 - 077	Dew Point Temperature	degrees Centigrade	Real	f5.1,a1
13	079 - 082	Relative_Humidity	percent	Integer	i3,a1
14	084 - 089	Station_Pressure	*kPa	Real	f5.1,a1
15	091 - 094	Wind_Direction	degrees(N=0,E=90,...)	Integer	i3,a1
16	096 - 101	Wind_Speed @10meter	m/s	Real	f5.1,a1
17	103 - 109	Horizontal Visibility	km	Real	f6.1,a1
18	111 - 117	Ceiling Height	m	Integer	i6,a1
19	119 - 120	Observation Indicator	N/A	Integer	i1,a1
20	122 - 131	Present_weather	N/A	Character	a9,a1
21	133 - 136	Precipitable Water	mm	Integer	i3,a1
22	138 - 144	Broadband Aerosol	Optical_Depth	Real	f6.3,a1
23	146 - 150	Snow Depth	cm	Integer	i4,a1
24	152 - 155	Days since last Snowfall	day	Integer	i3,a1
25	157 - 164	Hourly Precipitation	cm	Real	f6.2,a2
26	166 - 172	Eto, FAO Short Grass	mm/day	Real	f6.2,a1
27	174 - 180	Ep, Class A pan Evaporation	mm/day	Real	f6.2,a1

*Hour of the day: The range of the hour of the day is 1h to 25h:
1h-24h: line contains data for the hour 25: line contains daily values

*Wh/m2: Watt hour meter^-2
Watt hour meter^-2 is equivalent to 3.6e-3 MJoule meter^-2
Watt hour meter^-2 is equivalent to 8.59845e-02 Langley

*kPa: kiloPascal
1 kiloPascal is equivalent to 10 millibar

Fields 26 and 27 represent daily totals. These fields are present only when the hour of the day (field 3) is 25.

Generally, each value has one or more character flags associated with it.

Missing values are denoted by '---' in the numeric value field and flag values of '-'

Hourly values file format: (1x,i4,1x,i2,1x,i2, i3, t16,i5,a1, t23,i5,a1, &
t30,i5,a3, t39,i5,a3, t48,i5,a3, &
t57,i2,a1, t61,i2,a1, t65,f5.1,a1, t72,f5.1,a1, &
t79,i3,a1, t84,f5.1,a1, t91,i3,a1, t96,f5.1,a1, &
t103,f6.1,a1, t111,i6,a1, t119,i1,a1, t122,a9,a1, &
t133,i3,a1, t138,f6.3,a1, t146,i4,a1, t152,i3,a1, &

t157,f6.2,a2, t166,f6.2,a1, t174,f6.2,a1)

Hourly Precipitation - TD-3240 Format

Precipitation data are reported only for those hours during which precipitation occurred. Variable-length blocks contain a station's precipitation record for one day on a physical record. The format of the precipitation data for variable-length blocks is as follows.

Field	Column(s)	Description
001	001-003	Record Type
002	004-011	Station indentifier
003	012-015	Meteorological element type
004	016-017	Measurement units
005	018-021	Year
006	022-023	Month
007	024-027	Day (right justified, zero filled)
008	028-030	Number of data groups to follow
009	031-034	Hour (left justified, zero filled)
010	035-040	Value of meteorological element
011	041	Measurement flag #1
012	042	Quality flag #2 (not used, blank)

Data groups in the same form as field 009 through 012 are repeated as many times as necessary to contain one day of values on one record. These data would occupy fields 013 through 108, the maximum number of fields.

Fixed length block contain a stations's precipitation record for one hour on a physical record. The structure is indentical to the variable-length blocks, except that only one hour of data appearas on the record (i.e., fields 001 through 012 on one record).

Output File

The first record in the output file is the surface roughness length and measurement height for the site. The two variables are read in free format, so they only need to be seperated by a space or a comma. The rest of the records are as follows

Column(s)	Variable	Description
002-005	Year	Is a four digit year (or two digits if from CD-144) or -1 if from JJFDPROC
007-008	Month	Is the month or -1 if from JJFDPROC
010-011	Day	Is the day or -1 if from JJFDPROC
013-014	Hour	Is the hour or -1 if from JJFDPROC
016	Stability Class	Stability Class (if > 7 then missing)
018-022	Flow Vector	The direction the wind is blowing towards (in degrees). If greater than 360, then missing.
024-028	Wind Speed	Wind Speed in m/s. If less than zero or greater than 90, then missing.
030-035	Temperature	Dry bulb temperature in degrees K. If less than zero or greater than 385, then missing.
037-042	Mixing Height	Height of mixing layer in meters. If less than zero or greater than 8000 than missing.
044	Precipitation Code	Code for Precipitation (0 - none, 1, 2, 3 - light, moderate, and heavy rain, 4,5,6 - light, moderate, and heavy snow). If > 6, then missing.
046-051	Precipitation Rate	Precipitation Rate in mm/hr. Missing if less than zero.
053-058	Weight	Weighting Factor (1 if from HRLYPROC) which is the number of hours with meteorological data as given in the record.

The FORTRAN format of the record would be as follows:
(1x,I4,1x,I2,1x,I2,1x,I2,1x,I1,1x,F5.0,1x,F5.1,1x,F6.2,1x,F6.0,1x,I1,1x,F6.2,1x,F6.0)

Exhibt 3 shows a sample output file from HRLYPROC. Exhibit 4 show a sample output file from JJFDPROC.

Exhibit 3 Sample Output File from HRLYPROC

```
.200, 10.0
88  1  1  1 6  180.   2.6 263.15   151. 0    .00     1.
88  1  1  2 5  200.   4.1 264.26   367. 0    .00     1.
88  1  1  3 5  240.   4.1 263.70   367. 0    .00     1.
88  1  1  4 6  240.   3.1 262.59   165. 0    .00     1.
88  1  1  5 7  180.   1.5 262.04    45. 0    .00     1.
88  1  1  6 6  240.   3.1 262.04   165. 0    .00     1.
88  1  1  7 5  200.   3.6 262.04   343. 0    .00     1.
88  1  1  8 4  180.   3.1 261.48   709. 0    .00     1.
```

```
88  1  1  9 4  180.   5.1 262.59  1181. 0    .00     1.
88  1  1 10 3  140.   4.6 263.70  1204. 0    .00     1.
88  1  1 11 4  210.   4.6 265.37  1063. 0    .00     1.
88  1  1 12 2  210.   1.0 267.04   289. 0    .00     1.
88  1  1 13 2  120.   1.5 268.15   445. 0    .00     1.
88  1  1 14 3   60.   3.1 268.15   803. 0    .00     1.
88  1  1 15 3  120.   3.6 268.71   937. 0    .00     1.
88  1  1 16 4   60.   3.1 268.71   709. 0    .00     1.
88  1  1 17 4   50.   2.1 268.71   472. 0    .00     1.
88  1  1 18 5   30.   3.6 266.48   343. 0    .00     1.
88  1  1 19 6   30.   2.6 265.93   151. 0    .00     1.
88  1  1 20 6   40.   2.1 264.26   135. 0    .00     1.
88  1  1 21 6   50.   2.1 263.15   135. 0    .00     1.
88  1  1 22 7   60.   1.5 263.70    45. 0    .00     1.
88  1  1 23 5   60.   3.6 263.70   343. 0    .00     1.
88  1  1 24 6   50.   2.6 263.15   151. 0    .00     1.
```

Exhibit 4 Sample Output File from JJFDPROC

```
2.000, 10.0
  -1 -1 -1 -1 1  180.   5.3 277.65  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 281.65  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 285.54  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 289.93  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 294.76  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 299.43  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 304.71  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 303.15  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 298.32  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 290.93  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 282.59  2000. 0    .00   2.62
  -1 -1 -1 -1 1  180.   5.3 279.26  2000. 0    .00   2.62
  -1 -1 -1 -1 1  203.   5.3 277.65  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 281.65  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 285.54  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 289.93  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 294.76  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 299.43  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 304.71  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 303.15  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 298.32  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 290.93  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 282.59  2000. 0    .00   1.46
  -1 -1 -1 -1 1  203.   5.3 279.26  2000. 0    .00   1.46
  -1 -1 -1 -1 1  225.   5.3 277.65  2000. 0    .00   1.68
  -1 -1 -1 -1 1  225.   5.3 281.65  2000. 0    .00   1.68
  -1 -1 -1 -1 1  225.   5.3 285.54  2000. 0    .00   1.68
  -1 -1 -1 -1 1  225.   5.3 289.93  2000. 0    .00   1.68
  -1 -1 -1 -1 1  225.   5.3 294.76  2000. 0    .00   1.68
  -1 -1 -1 -1 1  225.   5.3 299.43  2000. 0    .00   1.68
```

APPENDIX C

PRECIPITATION PROBABILITIES FOR SELECT UNITED STATES STATIONS

Appendix C

Precipitation Probabilities for Select United State Stations

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Fairbanks International AP	AK	Light Rain	3.91E-03	8.62E-03	9.68E-02	1.15E-02	2.53E-03	4.55E-02
Fairbanks International AP	AK	Mod/Hvy Rain	0.00E+00	9.07E-05	7.08E-04	0.00E+00	0.00E+00	3.20E-04
Fairbanks International AP	AK	Light Snow	1.30E-03	1.40E-02	2.13E-01	3.31E-02	2.55E-02	1.05E-01
Fairbanks International AP	AK	Mod/Hvy Snow	0.00E+00	4.81E-03	9.70E-03	5.68E-03	3.87E-02	1.57E-02
Fairbanks International AP	AK	All	5.21E-03	2.75E-02	3.20E-01	5.03E-02	6.68E-02	1.67E-01
Kodiak State CG Base	AK	Light Rain	1.36E-03	1.16E-02	3.21E-01	1.41E-02	9.35E-03	2.49E-01
Kodiak State CG Base	AK	Mod/Hvy Rain	0.00E+00	2.47E-04	2.13E-02	0.00E+00	0.00E+00	1.64E-02
Kodiak State CG Base	AK	Light Snow	0.00E+00	2.72E-03	6.61E-02	1.03E-02	3.29E-03	5.21E-02
Kodiak State CG Base	AK	Mod/Hvy Snow	0.00E+00	0.00E+00	1.08E-03	0.00E+00	0.00E+00	8.33E-04
Kodiak State CG Base	AK	All	1.36E-03	1.46E-02	4.10E-01	2.44E-02	1.26E-02	3.19E-01
Mobile Bates Field AP	AL	Light Rain	1.76E-02	2.47E-02	1.32E-01	2.18E-02	3.43E-03	6.47E-02
Mobile Bates Field AP	AL	Mod/Hvy Rain	3.08E-04	9.03E-04	2.01E-02	5.07E-04	0.00E+00	8.77E-03
Mobile Bates Field AP	AL	Light Snow	0.00E+00	0.00E+00	4.82E-04	0.00E+00	0.00E+00	2.05E-04
Mobile Bates Field AP	AL	Mod/Hvy Snow	0.00E+00	0.00E+00	2.68E-05	0.00E+00	0.00E+00	1.14E-05

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Mobile Bates Field AP	AL	All	1.79E-02	2.56E-02	1.52E-01	2.23E-02	3.43E-03	7.37E-02
Fort Smith Municipal AP	AR	Light Rain	7.84E-03	1.35E-02	1.37E-01	1.93E-02	3.57E-03	6.24E-02
Fort Smith Municipal AP	AR	Mod/Hvy Rain	0.00E+00	0.00E+00	1.61E-02	1.85E-04	0.00E+00	6.67E-03
Fort Smith Municipal AP	AR	Light Snow	0.00E+00	0.00E+00	1.06E-02	1.85E-04	0.00E+00	4.40E-03
Fort Smith Municipal AP	AR	Mod/Hvy Snow	0.00E+00	0.00E+00	3.03E-04	0.00E+00	0.00E+00	1.26E-04
Fort Smith Municipal AP	AR	All	7.84E-03	1.35E-02	1.64E-01	1.96E-02	3.57E-03	7.36E-02
Little Rock Adams Field	AR	Light Rain	5.23E-03	1.02E-02	1.61E-01	1.69E-02	2.93E-03	6.69E-02
Little Rock Adams Field	AR	Mod/Hvy Rain	0.00E+00	3.54E-04	1.61E-02	6.39E-04	4.24E-05	6.38E-03
Little Rock Adams Field	AR	Light Snow	0.00E+00	0.00E+00	8.33E-03	2.74E-04	4.24E-05	3.27E-03
Little Rock Adams Field	AR	Mod/Hvy Snow	0.00E+00	0.00E+00	4.12E-04	0.00E+00	0.00E+00	1.60E-04
Little Rock Adams Field	AR	All	5.23E-03	1.05E-02	1.85E-01	1.78E-02	3.01E-03	7.67E-02
Tucson International AP	AZ	Light Rain	1.21E-03	6.41E-03	7.88E-02	6.23E-03	1.62E-03	2.83E-02
Tucson International AP	AZ	Mod/Hvy Rain	0.00E+00	8.33E-05	6.36E-03	1.05E-04	0.00E+00	2.10E-03
Tucson International AP	AZ	Light Snow	0.00E+00	0.00E+00	1.58E-03	0.00E+00	0.00E+00	5.14E-04
Tucson International AP	AZ	Mod/Hvy Snow	0.00E+00	0.00E+00	3.16E-04	0.00E+00	0.00E+00	1.03E-04
Tucson International AP	AZ	All	1.21E-03	6.50E-03	8.71E-02	6.34E-03	1.62E-03	3.10E-02
Fresno Air Terminal	CA	Light Rain	4.13E-04	5.07E-03	9.25E-02	9.10E-03	2.10E-03	2.75E-02
Fresno Air Terminal	CA	Mod/Hvy Rain	0.00E+00	0.00E+00	5.03E-03	1.60E-04	0.00E+00	1.37E-03
Fresno Air Terminal	CA	Light Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fresno Air Terminal	CA	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Fresno Air Terminal	CA	All	4.13E-04	5.07E-03	9.75E-02	9.26E-03	2.10E-03	2.88E-02
Los Angeles International AP	CA	Light Rain	8.49E-04	1.98E-03	5.31E-02	8.52E-03	1.51E-03	2.40E-02
Los Angeles International AP	CA	Mod/Hvy Rain	0.00E+00	0.00E+00	4.10E-03	8.19E-05	0.00E+00	1.72E-03
Los Angeles International AP	CA	Light Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Los Angeles International AP	CA	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Los Angeles International AP	CA	All	8.49E-04	1.98E-03	5.72E-02	8.60E-03	1.51E-03	2.58E-02
San Diego Miramar NAS	CA	Light Rain	1.13E-03	2.30E-03	5.09E-02	8.08E-03	1.33E-03	2.38E-02
San Diego Miramar NAS	CA	Mod/Hvy Rain	0.00E+00	0.00E+00	5.65E-03	0.00E+00	0.00E+00	2.45E-03
San Diego Miramar NAS	CA	Light Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
San Diego Miramar NAS	CA	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
San Diego Miramar NAS	CA	All	1.13E-03	2.30E-03	5.65E-02	8.08E-03	1.33E-03	2.63E-02
San Francisco International AP	CA	Light Rain	2.15E-04	2.90E-03	8.49E-02	8.85E-03	3.08E-03	4.99E-02
San Francisco International AP	CA	Mod/Hvy Rain	0.00E+00	0.00E+00	6.46E-03	1.75E-04	8.10E-05	3.69E-03
San Francisco International AP	CA	Light Snow	0.00E+00	0.00E+00	2.02E-05	0.00E+00	0.00E+00	1.14E-05
San Francisco International AP	CA	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
San Francisco International AP	CA	All	2.15E-04	2.90E-03	9.13E-02	9.02E-03	3.16E-03	5.36E-02
Denver Stapleton International AP	CO	Light Rain	1.91E-03	9.34E-03	7.78E-02	7.98E-03	1.64E-03	3.22E-02
Denver Stapleton International AP	CO	Mod/Hvy Rain	0.00E+00	8.42E-05	3.33E-03	0.00E+00	0.00E+00	1.26E-03
Denver Stapleton International AP	CO	Light Snow	1.12E-04	1.35E-03	1.11E-01	6.05E-03	2.46E-03	4.32E-02
Denver Stapleton International AP	CO	Mod/Hvy Snow	2.24E-04	8.42E-05	9.38E-03	1.24E-03	1.38E-03	4.05E-03
Denver Stapleton International AP	CO	All	2.24E-03	1.09E-02	2.01E-01	1.53E-02	5.47E-03	8.07E-02
Grand Junction Walker Field AP	CO	Light Rain	2.57E-03	6.12E-03	7.32E-02	5.42E-03	1.16E-03	2.95E-02
Grand Junction Walker Field AP	CO	Mod/Hvy Rain	0.00E+00	0.00E+00	1.25E-03	0.00E+00	0.00E+00	4.60E-04
Grand Junction Walker Field AP	CO	Light Snow	1.17E-04	7.06E-04	4.68E-02	1.22E-03	1.61E-03	1.79E-02
Grand Junction Walker Field AP	CO	Mod/Hvy Snow	0.00E+00	1.57E-04	1.81E-03	1.11E-04	6.45E-05	7.24E-04
Grand Junction Walker Field AP	CO	All	2.69E-03	6.98E-03	1.23E-01	6.75E-03	2.84E-03	4.86E-02
Washington National AP	DC	Light Rain	4.12E-03	1.09E-02	1.40E-01	1.25E-02	5.12E-03	8.31E-02
Washington National AP	DC	Mod/Hvy Rain	0.00E+00	3.15E-04	1.44E-02	1.47E-04	9.30E-05	8.20E-03
Washington National AP	DC	Light Snow	0.00E+00	1.05E-04	1.42E-02	2.93E-04	0.00E+00	8.04E-03

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Washington National AP	DC	Mod/Hvy Snow	0.00E+00	0.00E+00	1.11E-03	0.00E+00	0.00E+00	6.28E-04
Washington National AP	DC	All	4.12E-03	1.14E-02	1.70E-01	1.30E-02	5.21E-03	9.99E-02
Miami International AP	FL	Light Rain	2.84E-02	2.76E-02	7.10E-02	1.68E-02	7.76E-03	4.04E-02
Miami International AP	FL	Mod/Hvy Rain	3.71E-03	3.27E-03	1.65E-02	5.31E-04	3.13E-04	7.85E-03
Miami International AP	FL	Light Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Miami International AP	FL	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Miami International AP	FL	All	3.21E-02	3.09E-02	8.75E-02	1.74E-02	8.07E-03	4.82E-02
Orlando International AP	FL	Light Rain	6.61E-03	1.85E-02	1.05E-01	1.87E-02	3.22E-03	4.77E-02
Orlando International AP	FL	Mod/Hvy Rain	0.00E+00	7.77E-04	1.46E-02	3.01E-04	0.00E+00	5.82E-03
Orlando International AP	FL	Light Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Orlando International AP	FL	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Orlando International AP	FL	All	6.61E-03	1.93E-02	1.19E-01	1.90E-02	3.22E-03	5.35E-02
Atlanta Hartsfield International AP	GA	Light Rain	5.36E-02	5.93E-02	7.53E-02	7.08E-02	7.66E-02	7.19E-02
Atlanta Hartsfield International AP	GA	Mod/Hvy Rain	1.01E-02	1.01E-02	8.42E-03	8.57E-03	8.66E-03	8.77E-03
Atlanta Hartsfield International AP	GA	Light Snow	1.55E-03	1.34E-03	1.29E-03	2.41E-03	1.56E-03	1.52E-03
Atlanta Hartsfield	GA	Mod/Hvy Snow	9.68E-04	2.06E-04	9.08E-05	0.00E+00	3.61E-04	1.94E-04

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
International AP								
Atlanta Hartsfield International AP	GA	All	6.62E-02	7.09E-02	8.51E-02	8.18E-02	8.71E-02	8.24E-02
Savannah Municipal AP	GA	Light Rain	9.62E-03	1.93E-02	1.34E-01	2.71E-02	5.75E-03	6.34E-02
Savannah Municipal AP	GA	Mod/Hvy Rain	2.75E-04	5.52E-04	1.63E-02	3.79E-04	4.92E-05	6.83E-03
Savannah Municipal AP	GA	Light Snow	0.00E+00	0.00E+00	1.84E-03	7.58E-05	0.00E+00	7.66E-04
Savannah Municipal AP	GA	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Savannah Municipal AP	GA	All	9.89E-03	1.99E-02	1.52E-01	2.76E-02	5.80E-03	7.10E-02
Honolulu International AP	HI	Light Rain	2.70E-03	9.74E-03	1.01E-01	2.86E-02	9.05E-03	5.83E-02
Honolulu International AP	HI	Mod/Hvy Rain	0.00E+00	0.00E+00	5.18E-03	3.87E-04	2.25E-04	2.69E-03
Honolulu International AP	HI	Light Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Honolulu International AP	HI	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Honolulu International AP	HI	All	2.70E-03	9.74E-03	1.06E-01	2.90E-02	9.28E-03	6.10E-02
Des Moines Municipal AP	IA	Light Rain	1.11E-02	1.82E-02	1.18E-01	1.62E-02	2.87E-03	7.14E-02
Des Moines Municipal AP	IA	Mod/Hvy Rain	0.00E+00	2.20E-04	1.05E-02	3.22E-04	0.00E+00	5.95E-03
Des Moines Municipal AP	IA	Light Snow	2.77E-04	7.69E-04	6.67E-02	4.18E-03	1.13E-03	3.83E-02

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Des Moines Municipal AP	IA	Mod/Hvy Snow	0.00E+00	4.40E-04	1.93E-03	4.02E-04	2.26E-03	1.53E-03
Des Moines Municipal AP	IA	All	1.14E-02	1.97E-02	1.97E-01	2.11E-02	6.26E-03	1.17E-01
Boise Air Terminal	ID	Light Rain	2.46E-03	7.87E-03	1.07E-01	9.49E-03	2.41E-03	4.81E-02
Boise Air Terminal	ID	Mod/Hvy Rain	0.00E+00	0.00E+00	2.04E-03	1.35E-04	0.00E+00	8.79E-04
Boise Air Terminal	ID	Light Snow	4.10E-04	9.73E-04	5.72E-02	1.75E-03	8.03E-04	2.46E-02
Boise Air Terminal	ID	Mod/Hvy Snow	2.74E-04	7.07E-04	2.61E-03	5.38E-04	1.09E-03	1.52E-03
Boise Air Terminal	ID	All	3.15E-03	9.55E-03	1.69E-01	1.19E-02	4.30E-03	7.51E-02
Chicago-O'Hare International AP	IL	Light Rain	3.26E-03	6.88E-03	1.17E-01	5.61E-03	1.39E-03	7.50E-02
Chicago-O'Hare International AP	IL	Mod/Hvy Rain	0.00E+00	0.00E+00	3.96E-03	1.84E-04	9.25E-05	2.51E-03
Chicago-O'Hare International AP	IL	Light Snow	0.00E+00	6.04E-04	5.75E-02	1.56E-03	5.55E-04	3.64E-02
Chicago-O'Hare International AP	IL	Mod/Hvy Snow	0.00E+00	0.00E+00	1.31E-03	0.00E+00	1.85E-04	8.45E-04
Chicago-O'Hare International AP	IL	All	3.26E-03	7.48E-03	1.80E-01	7.36E-03	2.22E-03	1.15E-01
Peoria - Greater Peoria AP	IL	Light Rain	9.48E-03	1.54E-02	1.24E-01	1.25E-02	2.63E-03	7.19E-02
Peoria - Greater Peoria AP	IL	Mod/Hvy Rain	2.37E-04	4.28E-04	1.11E-02	3.68E-04	6.56E-05	6.21E-03
Peoria - Greater Peoria AP	IL	Light Snow	0.00E+00	2.14E-04	5.08E-02	1.47E-03	1.97E-04	2.81E-02

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Peoria - Greater Peoria AP	IL	Mod/Hvy Snow	0.00E+00	1.07E-04	1.81E-03	2.76E-04	0.00E+00	1.04E-03
Peoria - Greater Peoria AP	IL	All	9.72E-03	1.62E-02	1.88E-01	1.46E-02	2.89E-03	1.07E-01
Evansville Dress Regional AP	IN	Light Rain	6.46E-03	1.33E-02	1.68E-01	1.97E-02	3.75E-03	8.09E-02
Evansville Dress Regional AP	IN	Mod/Hvy Rain	0.00E+00	9.91E-05	8.10E-03	1.15E-04	8.94E-05	3.70E-03
Evansville Dress Regional AP	IN	Light Snow	1.43E-04	1.98E-04	3.90E-02	9.22E-04	2.23E-04	1.78E-02
Evansville Dress Regional AP	IN	Mod/Hvy Snow	0.00E+00	0.00E+00	8.61E-04	0.00E+00	0.00E+00	3.88E-04
Evansville Dress Regional AP	IN	All	6.60E-03	1.36E-02	2.16E-01	2.07E-02	4.07E-03	1.03E-01
Russell Municipal AP	KS	Light Rain	3.67E-03	4.20E-03	7.13E-02	2.79E-03	1.57E-03	4.57E-02
Russell Municipal AP	KS	Mod/Hvy Rain	0.00E+00	1.27E-04	3.56E-03	1.39E-04	0.00E+00	2.26E-03
Russell Municipal AP	KS	Light Snow	0.00E+00	0.00E+00	2.88E-02	4.87E-04	3.94E-04	1.81E-02
Russell Municipal AP	KS	Mod/Hvy Snow	0.00E+00	0.00E+00	1.26E-03	0.00E+00	0.00E+00	7.87E-04
Russell Municipal AP	KS	All	3.67E-03	4.33E-03	1.05E-01	3.41E-03	1.97E-03	6.69E-02
Lake Charles Municipal AP	LA	Light Rain	2.11E-02	2.42E-02	1.34E-01	1.88E-02	3.58E-03	6.61E-02
Lake Charles Municipal AP	LA	Mod/Hvy Rain	0.00E+00	1.05E-03	1.52E-02	4.96E-04	0.00E+00	6.81E-03
Lake Charles Municipal	LA	Light Snow	0.00E+00	0.00E+00	1.85E-04	0.00E+00	0.00E+00	8.04E-05

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
AP								
Lake Charles Municipal AP	LA	Mod/Hvy Snow	0.00E+00	0.00E+00	5.27E-05	0.00E+00	0.00E+00	2.30E-05
Lake Charles Municipal AP	LA	All	2.11E-02	2.53E-02	1.49E-01	1.93E-02	3.58E-03	7.31E-02
Boston Logan International AP	MA	Light Rain	8.97E-03	1.06E-02	1.28E-01	7.29E-03	2.97E-03	9.84E-02
Boston Logan International AP	MA	Mod/Hvy Rain	0.00E+00	1.49E-04	8.25E-03	0.00E+00	0.00E+00	6.21E-03
Boston Logan International AP	MA	Light Snow	0.00E+00	1.49E-04	3.43E-02	7.77E-04	0.00E+00	2.59E-02
Boston Logan International AP	MA	Mod/Hvy Snow	0.00E+00	0.00E+00	2.06E-03	0.00E+00	0.00E+00	1.55E-03
Boston Logan International AP	MA	All	8.97E-03	1.09E-02	1.73E-01	8.06E-03	2.97E-03	1.32E-01
Bangor International AP	ME	Light Rain	2.77E-03	9.46E-03	1.52E-01	9.49E-03	3.14E-03	8.26E-02
Bangor International AP	ME	Mod/Hvy Rain	0.00E+00	1.15E-04	7.30E-03	3.24E-04	5.32E-05	3.90E-03
Bangor International AP	ME	Light Snow	0.00E+00	1.96E-03	6.33E-02	3.99E-03	1.44E-03	3.43E-02
Bangor International AP	ME	Mod/Hvy Snow	0.00E+00	0.00E+00	4.62E-03	1.08E-04	1.59E-04	2.48E-03
Bangor International AP	ME	All	2.77E-03	1.15E-02	2.27E-01	1.39E-02	4.78E-03	1.23E-01
Detroit Metropolitan AP	MI	Light Rain	5.16E-03	1.22E-02	1.18E-01	9.58E-03	1.38E-03	7.82E-02
Detroit Metropolitan AP	MI	Mod/Hvy Rain	0.00E+00	1.33E-04	5.05E-03	9.30E-05	0.00E+00	3.25E-03
Detroit Metropolitan AP	MI	Light Snow	0.00E+00	9.29E-04	7.13E-02	1.49E-03	1.97E-04	4.59E-02

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Detroit Metropolitan AP	MI	Mod/Hvy Snow	0.00E+00	0.00E+00	1.48E-03	1.86E-04	0.00E+00	9.70E-04
Detroit Metropolitan AP	MI	All	5.16E-03	1.33E-02	1.96E-01	1.14E-02	1.58E-03	1.28E-01
Sault Ste Marie Wx Station Office	MI	Light Rain	4.49E-03	7.87E-03	1.28E-01	6.86E-03	2.61E-03	7.71E-02
Sault Ste Marie Wx Station Office	MI	Mod/Hvy Rain	0.00E+00	1.29E-04	3.81E-03	0.00E+00	0.00E+00	2.25E-03
Sault Ste Marie Wx Station Office	MI	Light Snow	3.37E-03	1.12E-02	1.80E-01	2.62E-02	1.10E-02	1.12E-01
Sault Ste Marie Wx Station Office	MI	Mod/Hvy Snow	0.00E+00	5.16E-04	6.67E-03	1.06E-04	4.80E-04	4.05E-03
Sault Ste Marie Wx Station Office	MI	All	7.87E-03	1.98E-02	3.19E-01	3.31E-02	1.41E-02	1.95E-01
International Falls AP	MN	Light Rain	7.50E-03	1.30E-02	9.91E-02	1.24E-02	2.11E-03	5.97E-02
International Falls AP	MN	Mod/Hvy Rain	0.00E+00	1.23E-04	1.83E-03	1.93E-04	0.00E+00	1.07E-03
International Falls AP	MN	Light Snow	0.00E+00	3.57E-03	1.77E-01	1.87E-02	3.84E-03	1.04E-01
International Falls AP	MN	Mod/Hvy Snow	3.44E-03	4.80E-03	7.50E-03	1.76E-02	1.46E-02	9.61E-03
International Falls AP	MN	All	1.09E-02	2.15E-02	2.85E-01	4.88E-02	2.06E-02	1.74E-01
Minneapolis-St.Paul International AP	MN	Light Rain	7.98E-03	1.35E-02	8.78E-02	8.86E-03	2.44E-03	5.74E-02
Minneapolis-St.Paul International AP	MN	Mod/Hvy Rain	0.00E+00	0.00E+00	5.11E-03	1.81E-04	0.00E+00	3.20E-03
Minneapolis-St.Paul International AP	MN	Light Snow	6.94E-04	2.04E-03	8.21E-02	6.14E-03	2.27E-03	5.23E-02
Minneapolis-St.Paul	MN	Mod/Hvy Snow	0.00E+00	4.09E-04	2.63E-03	1.90E-03	2.94E-03	2.31E-03

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
International AP								
Minneapolis-St.Paul International AP	MN	All	8.67E-03	1.59E-02	1.78E-01	1.71E-02	7.66E-03	1.15E-01
Kansas City International AP	MO	Light Rain	5.90E-03	1.02E-02	1.03E-01	8.17E-03	2.85E-03	6.26E-02
Kansas City International AP	MO	Mod/Hvy Rain	0.00E+00	0.00E+00	4.25E-03	1.51E-04	0.00E+00	2.49E-03
Kansas City International AP	MO	Light Snow	0.00E+00	0.00E+00	2.79E-02	3.03E-04	8.90E-05	1.62E-02
Kansas City International AP	MO	Mod/Hvy Snow	0.00E+00	0.00E+00	9.05E-04	7.56E-05	4.45E-04	5.93E-04
Kansas City International AP	MO	All	5.90E-03	1.02E-02	1.36E-01	8.70E-03	3.38E-03	8.19E-02
Meridian Naval Air Station	MS	Light Rain	5.93E-03	1.81E-02	1.91E-01	3.69E-02	8.41E-03	6.37E-02
Meridian Naval Air Station	MS	Mod/Hvy Rain	1.14E-03	4.09E-03	4.86E-02	5.61E-03	8.84E-04	1.55E-02
Meridian Naval Air Station	MS	Light Snow	0.00E+00	2.10E-04	3.22E-03	4.01E-04	0.00E+00	9.86E-04
Meridian Naval Air Station	MS	Mod/Hvy Snow	0.00E+00	0.00E+00	5.79E-04	0.00E+00	0.00E+00	1.70E-04
Meridian Naval Air Station	MS	All	7.07E-03	2.24E-02	2.43E-01	4.29E-02	9.30E-03	8.03E-02
Billings Logan International AP	MT	Light Rain	2.22E-03	4.55E-03	5.92E-02	5.18E-03	9.00E-04	3.77E-02
Billings Logan	MT	Mod/Hvy Rain	0.00E+00	0.00E+00	1.43E-03	0.00E+00	0.00E+00	8.79E-04

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
International AP								
Billings Logan International AP	MT	Light Snow	0.00E+00	2.16E-03	8.44E-02	5.99E-03	3.60E-03	5.31E-02
Billings Logan International AP	MT	Mod/Hvy Snow	6.06E-04	5.69E-04	2.34E-03	1.62E-03	1.41E-03	1.88E-03
Billings Logan International AP	MT	All	2.83E-03	7.28E-03	1.47E-01	1.28E-02	5.91E-03	9.36E-02
Missoula Johnson-Bell Field	MT	Light Rain	1.78E-03	1.02E-02	1.05E-01	1.03E-02	1.40E-03	5.28E-02
Missoula Johnson-Bell Field	MT	Mod/Hvy Rain	0.00E+00	0.00E+00	1.86E-03	0.00E+00	0.00E+00	8.90E-04
Missoula Johnson-Bell Field	MT	Light Snow	5.56E-04	4.64E-03	9.16E-02	5.52E-03	3.09E-03	4.55E-02
Missoula Johnson-Bell Field	MT	Mod/Hvy Snow	0.00E+00	5.01E-04	9.31E-04	3.45E-04	9.47E-04	7.42E-04
Missoula Johnson-Bell Field	MT	All	2.33E-03	1.53E-02	2.00E-01	1.62E-02	5.43E-03	1.00E-01
Asheville Regional AP	NC	Light Rain	7.83E-03	1.44E-02	1.75E-01	1.88E-02	5.20E-03	9.12E-02
Asheville Regional AP	NC	Mod/Hvy Rain	1.37E-04	2.23E-04	1.11E-02	0.00E+00	0.00E+00	5.50E-03
Asheville Regional AP	NC	Light Snow	0.00E+00	1.12E-04	1.99E-02	7.45E-04	1.06E-04	9.89E-03
Asheville Regional AP	NC	Mod/Hvy Snow	0.00E+00	0.00E+00	9.73E-04	0.00E+00	0.00E+00	4.79E-04
Asheville Regional AP	NC	All	7.96E-03	1.47E-02	2.06E-01	1.96E-02	5.31E-03	1.07E-01
Raleigh-Durham AP	NC	Light Rain	5.27E-03	9.12E-03	1.76E-01	1.78E-02	3.99E-03	8.16E-02
Raleigh-Durham AP	NC	Mod/Hvy Rain	0.00E+00	0.00E+00	1.74E-02	1.56E-04	5.12E-05	7.60E-03

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Raleigh-Durham AP	NC	Light Snow	0.00E+00	0.00E+00	6.08E-03	0.00E+00	0.00E+00	2.65E-03
Raleigh-Durham AP	NC	Mod/Hvy Snow	0.00E+00	0.00E+00	6.81E-04	0.00E+00	0.00E+00	2.97E-04
Raleigh-Durham AP	NC	All	5.27E-03	9.12E-03	2.00E-01	1.80E-02	4.04E-03	9.22E-02
Bismark Municipal AP	ND	Light Rain	6.37E-03	1.55E-02	7.00E-02	1.17E-02	2.21E-03	4.20E-02
Bismark Municipal AP	ND	Mod/Hvy Rain	0.00E+00	4.86E-04	4.18E-03	0.00E+00	1.20E-04	2.36E-03
Bismark Municipal AP	ND	Light Snow	5.10E-04	3.16E-03	1.22E-01	9.11E-03	2.75E-03	6.86E-02
Bismark Municipal AP	ND	Mod/Hvy Snow	1.02E-02	1.11E-02	1.65E-02	1.67E-02	2.12E-02	1.66E-02
Bismark Municipal AP	ND	All	1.71E-02	3.02E-02	2.12E-01	3.76E-02	2.62E-02	1.30E-01
North Platte Lee Bird Field AP	NE	Light Rain	2.58E-03	5.25E-03	7.76E-02	7.09E-03	1.43E-03	4.23E-02
North Platte Lee Bird Field AP	NE	Mod/Hvy Rain	0.00E+00	1.12E-04	5.11E-03	8.35E-05	0.00E+00	2.68E-03
North Platte Lee Bird Field AP	NE	Light Snow	2.35E-04	7.82E-04	7.05E-02	3.25E-03	8.94E-04	3.75E-02
North Platte Lee Bird Field AP	NE	Mod/Hvy Snow	0.00E+00	0.00E+00	3.22E-03	0.00E+00	5.96E-05	1.69E-03
North Platte Lee Bird Field AP	NE	All	2.82E-03	6.14E-03	1.56E-01	1.04E-02	2.38E-03	8.41E-02
Albuquerque International AP	NM	Light Rain	1.77E-03	5.51E-03	7.46E-02	9.66E-03	8.61E-04	2.82E-02
Albuquerque International AP	NM	Mod/Hvy Rain	0.00E+00	1.75E-04	3.48E-03	4.20E-04	0.00E+00	1.28E-03
Albuquerque International AP	NM	Light Snow	0.00E+00	6.12E-04	2.53E-02	2.80E-04	5.06E-05	8.76E-03

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Albuquerque International AP	NM	Mod/Hvy Snow	0.00E+00	0.00E+00	7.43E-04	0.00E+00	0.00E+00	2.53E-04
Albuquerque International AP	NM	All	1.77E-03	6.29E-03	1.04E-01	1.04E-02	9.11E-04	3.84E-02
Las Vegas McCarran International AP	NV	Light Rain	9.81E-04	3.91E-03	4.30E-02	3.28E-03	9.43E-04	1.74E-02
Las Vegas McCarran International AP	NV	Mod/Hvy Rain	0.00E+00	0.00E+00	1.24E-03	5.65E-05	0.00E+00	4.68E-04
Las Vegas McCarran International AP	NV	Light Snow	0.00E+00	0.00E+00	6.18E-04	0.00E+00	0.00E+00	2.28E-04
Las Vegas McCarran International AP	NV	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Las Vegas McCarran International AP	NV	All	9.81E-04	3.91E-03	4.49E-02	3.33E-03	9.43E-04	1.81E-02
Reno Cannon International AP	NV	Light Rain	1.39E-03	6.67E-03	7.25E-02	7.95E-03	1.54E-03	2.51E-02
Reno Cannon International AP	NV	Mod/Hvy Rain	0.00E+00	1.99E-04	2.22E-03	9.58E-05	0.00E+00	7.30E-04
Reno Cannon International AP	NV	Light Snow	7.70E-05	3.68E-03	4.42E-02	4.50E-03	7.88E-04	1.51E-02
Reno Cannon International AP	NV	Mod/Hvy Snow	7.70E-05	3.98E-04	3.64E-03	1.92E-04	1.13E-04	1.26E-03
Reno Cannon International AP	NV	All	1.54E-03	1.09E-02	1.23E-01	1.27E-02	2.44E-03	4.22E-02
Binghamton Link Field AP	NY	Light Rain	3.84E-03	1.02E-02	1.33E-01	7.93E-03	2.06E-03	8.81E-02

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Binghamton Link Field AP	NY	Mod/Hvy Rain	0.00E+00	1.36E-04	8.48E-03	0.00E+00	0.00E+00	5.50E-03
Binghamton Link Field AP	NY	Light Snow	0.00E+00	1.90E-03	1.43E-01	1.39E-02	5.96E-03	9.53E-02
Binghamton Link Field AP	NY	Mod/Hvy Snow	0.00E+00	4.07E-04	2.66E-03	1.67E-04	2.29E-04	1.80E-03
Binghamton Link Field AP	NY	All	3.84E-03	1.26E-02	2.87E-01	2.20E-02	8.25E-03	1.91E-01
Buffalo Greater International AP	NY	Light Rain	6.79E-03	1.32E-02	1.46E-01	1.76E-02	2.79E-03	1.01E-01
Buffalo Greater International AP	NY	Mod/Hvy Rain	0.00E+00	1.40E-04	9.20E-03	1.97E-04	0.00E+00	6.16E-03
Buffalo Greater International AP	NY	Light Snow	1.02E-03	6.46E-03	1.40E-01	1.39E-02	7.14E-03	9.60E-02
Buffalo Greater International AP	NY	Mod/Hvy Snow	0.00E+00	0.00E+00	3.73E-03	7.89E-04	7.80E-04	2.66E-03
Buffalo Greater International AP	NY	All	7.81E-03	1.98E-02	2.99E-01	3.25E-02	1.07E-02	2.06E-01
New York JFK International AP	NY	Light Rain	6.33E-03	7.93E-03	1.27E-01	1.15E-02	5.24E-03	8.43E-02
New York JFK International AP	NY	Mod/Hvy Rain	0.00E+00	1.09E-04	9.63E-03	0.00E+00	1.25E-04	6.19E-03
New York JFK International AP	NY	Light Snow	0.00E+00	1.09E-04	1.90E-02	4.24E-04	0.00E+00	1.22E-02
New York JFK International AP	NY	Mod/Hvy Snow	0.00E+00	0.00E+00	7.85E-04	0.00E+00	0.00E+00	5.02E-04

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
New York JFK International AP	NY	All	6.33E-03	8.14E-03	1.56E-01	1.19E-02	5.36E-03	1.03E-01
Dayton Cox International AP	OH	Light Rain	6.28E-03	1.47E-02	1.55E-01	2.00E-02	3.89E-03	8.98E-02
Dayton Cox International AP	OH	Mod/Hvy Rain	0.00E+00	2.37E-04	1.04E-02	3.43E-04	1.39E-04	5.77E-03
Dayton Cox International AP	OH	Light Snow	0.00E+00	7.11E-04	8.18E-02	4.37E-03	9.73E-04	4.55E-02
Dayton Cox International AP	OH	Mod/Hvy Snow	1.90E-04	0.00E+00	1.57E-03	6.85E-04	6.95E-05	9.70E-04
Dayton Cox International AP	OH	All	6.47E-03	1.56E-02	2.49E-01	2.54E-02	5.08E-03	1.42E-01
Medford Jackson County AP	OR	Light Rain	2.51E-03	1.77E-02	2.06E-01	3.45E-02	6.63E-03	7.71E-02
Medford Jackson County AP	OR	Mod/Hvy Rain	0.00E+00	0.00E+00	3.70E-03	1.34E-04	3.59E-05	1.28E-03
Medford Jackson County AP	OR	Light Snow	7.60E-05	2.13E-03	1.49E-02	2.41E-03	1.11E-03	5.85E-03
Medford Jackson County AP	OR	Mod/Hvy Snow	7.60E-05	0.00E+00	1.01E-04	0.00E+00	3.59E-05	5.71E-05
Medford Jackson County AP	OR	All	2.66E-03	1.98E-02	2.24E-01	3.70E-02	7.82E-03	8.43E-02
Pendelton Municipal AP	OR	Light Rain	2.11E-03	9.31E-03	1.21E-01	1.31E-02	3.74E-03	5.54E-02
Pendelton Municipal AP	OR	Mod/Hvy Rain	0.00E+00	0.00E+00	3.48E-03	0.00E+00	0.00E+00	1.49E-03
Pendelton Municipal AP	OR	Light Snow	0.00E+00	7.68E-04	4.57E-02	9.09E-04	5.06E-04	1.98E-02

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Pendelton Municipal AP	OR	Mod/Hvy Snow	0.00E+00	9.60E-05	1.05E-03	4.54E-04	3.03E-04	5.83E-04
Pendelton Municipal AP	OR	All	2.11E-03	1.02E-02	1.71E-01	1.44E-02	4.55E-03	7.72E-02
Pittsburgh-Greater International AP	PA	Light Rain	1.13E-03	5.22E-03	1.53E-01	9.24E-03	2.14E-03	9.00E-02
Pittsburgh-Greater International AP	PA	Mod/Hvy Rain	0.00E+00	0.00E+00	1.01E-02	1.99E-04	0.00E+00	5.82E-03
Pittsburgh-Greater International AP	PA	Light Snow	6.77E-04	1.43E-03	1.10E-01	6.26E-03	1.13E-03	6.43E-02
Pittsburgh-Greater International AP	PA	Mod/Hvy Snow	0.00E+00	1.30E-04	2.75E-03	5.96E-04	0.00E+00	1.67E-03
Pittsburgh-Greater International AP	PA	All	1.81E-03	6.78E-03	2.75E-01	1.63E-02	3.27E-03	1.62E-01
Rapid City Regional AP	SD	Light Rain	4.01E-03	7.74E-03	7.46E-02	4.81E-03	5.55E-04	4.25E-02
Rapid City Regional AP	SD	Mod/Hvy Rain	0.00E+00	1.07E-04	2.22E-03	0.00E+00	6.93E-05	1.23E-03
Rapid City Regional AP	SD	Light Snow	0.00E+00	2.15E-03	1.06E-01	3.97E-03	2.29E-03	5.88E-02
Rapid City Regional AP	SD	Mod/Hvy Snow	1.00E-03	7.52E-04	6.59E-03	2.14E-03	1.59E-03	4.29E-03
Rapid City Regional AP	SD	All	5.01E-03	1.07E-02	1.89E-01	1.09E-02	4.51E-03	1.07E-01
Nashville Metropolitan AP	TN	Light Rain	3.00E-03	8.64E-03	1.53E-01	1.80E-02	4.40E-03	7.16E-02
Nashville Metropolitan AP	TN	Mod/Hvy Rain	2.73E-04	1.88E-04	1.36E-02	5.95E-04	5.50E-05	6.06E-03
Nashville Metropolitan AP	TN	Light Snow	0.00E+00	0.00E+00	1.57E-02	5.21E-04	0.00E+00	6.89E-03
Nashville Metropolitan	TN	Mod/Hvy Snow	1.36E-04	0.00E+00	6.84E-04	0.00E+00	0.00E+00	3.08E-04

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
AP								
Nashville Metropolitan AP	TN	All	3.41E-03	8.83E-03	1.83E-01	1.91E-02	4.45E-03	8.48E-02
Austin Mueller Municipal AP	TX	Light Rain	8.28E-03	1.01E-02	1.23E-01	1.43E-02	3.53E-03	6.37E-02
Austin Mueller Muncipal AP	TX	Mod/Hvy Rain	1.53E-04	1.91E-04	1.09E-02	5.10E-04	1.20E-04	5.35E-03
Austin Mueller Muncipal AP	TX	Light Snow	0.00E+00	0.00E+00	2.09E-03	0.00E+00	0.00E+00	1.00E-03
Austin Mueller Muncipal AP	TX	Mod/Hvy Snow	0.00E+00	0.00E+00	4.74E-05	0.00E+00	0.00E+00	2.28E-05
Austin Mueller Muncipal AP	TX	All	8.44E-03	1.03E-02	1.36E-01	1.48E-02	3.65E-03	7.00E-02
Corpus Christi NAAS	TX	Light Rain	1.37E-02	1.27E-02	8.16E-02	7.33E-03	6.20E-03	5.15E-02
Corpus Christi NAAS	TX	Mod/Hvy Rain	1.05E-03	1.10E-03	1.14E-02	5.79E-04	3.00E-04	6.96E-03
Corpus Christi NAAS	TX	Light Snow	0.00E+00	0.00E+00	1.92E-04	0.00E+00	0.00E+00	1.12E-04
Corpus Christi NAAS	TX	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Corpus Christi NAAS	TX	All	1.47E-02	1.38E-02	9.32E-02	7.91E-03	6.50E-03	5.86E-02
Dallas Hensley Field NAS	TX	Light Rain	1.25E-04	8.11E-04	4.54E-03	1.05E-04	0.00E+00	2.08E-03
Dallas Hensley Field NAS	TX	Mod/Hvy Rain	7.50E-04	1.16E-03	1.68E-02	1.05E-03	3.19E-04	7.66E-03
Dallas Hensley Field NAS	TX	Light Snow	0.00E+00	0.00E+00	4.94E-04	0.00E+00	0.00E+00	2.14E-04

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Dallas Hensley Field NAS	TX	Mod/Hvy Snow	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dallas Hensley Field NAS	TX	All	8.75E-04	1.97E-03	2.18E-02	1.16E-03	3.19E-04	9.96E-03
El Paso International AP	TX	Light Rain	2.20E-03	6.68E-03	8.39E-02	1.43E-02	3.12E-03	2.62E-02
El Paso International AP	TX	Mod/Hvy Rain	0.00E+00	7.68E-05	5.11E-03	6.73E-05	0.00E+00	1.34E-03
El Paso International AP	TX	Light Snow	7.59E-05	1.54E-04	1.15E-02	6.06E-04	0.00E+00	3.09E-03
El Paso International AP	TX	Mod/Hvy Snow	0.00E+00	0.00E+00	9.33E-04	0.00E+00	0.00E+00	2.40E-04
El Paso International AP	TX	All	2.28E-03	6.91E-03	1.01E-01	1.50E-02	3.12E-03	3.08E-02
Lubbock International AP	TX	Light Rain	4.86E-03	3.72E-03	6.29E-02	3.72E-03	7.55E-04	3.92E-02
Lubbock International AP	TX	Mod/Hvy Rain	3.47E-04	1.10E-04	3.97E-03	6.76E-05	0.00E+00	2.43E-03
Lubbock International AP	TX	Light Snow	0.00E+00	0.00E+00	1.36E-02	6.76E-05	0.00E+00	8.21E-03
Lubbock International AP	TX	Mod/Hvy Snow	0.00E+00	0.00E+00	7.19E-04	6.76E-05	0.00E+00	4.45E-04
Lubbock International AP	TX	All	5.21E-03	3.83E-03	8.12E-02	3.92E-03	7.55E-04	5.03E-02
Cedar City Municipal AP	UT	Light Rain	1.80E-03	5.31E-03	6.34E-02	4.14E-03	1.61E-03	2.43E-02
Cedar City Municipal AP	UT	Mod/Hvy Rain	0.00E+00	0.00E+00	1.30E-03	0.00E+00	0.00E+00	4.60E-04
Cedar City Municipal AP	UT	Light Snow	4.00E-04	2.82E-03	7.83E-02	3.35E-03	2.08E-03	2.91E-02

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Cedar City Municipal AP	UT	Mod/Hvy Snow	4.00E-04	1.08E-04	5.19E-03	3.52E-04	3.13E-04	2.04E-03
Cedar City Municipal AP	UT	All	2.60E-03	8.24E-03	1.48E-01	7.84E-03	3.99E-03	5.59E-02
Salt Lake City International AP	UT	Light Rain	1.85E-03	6.22E-03	8.42E-02	5.66E-03	1.88E-03	4.12E-02
Salt Lake City International AP	UT	Mod/Hvy Rain	1.85E-04	2.59E-04	5.28E-03	6.36E-05	0.00E+00	2.50E-03
Salt Lake City International AP	UT	Light Snow	2.22E-03	2.16E-03	7.26E-02	4.07E-03	2.85E-03	3.52E-02
Salt Lake City International AP	UT	Mod/Hvy Snow	0.00E+00	2.59E-04	5.99E-03	1.27E-04	4.17E-04	2.90E-03
Salt Lake City International AP	UT	All	4.26E-03	8.90E-03	1.68E-01	9.92E-03	5.15E-03	8.18E-02
Norfolk Naval Air Station	VA	Light Rain	3.08E-03	1.13E-02	1.46E-01	1.24E-02	5.73E-03	8.07E-02
Norfolk Naval Air Station	VA	Mod/Hvy Rain	1.93E-04	6.53E-04	2.02E-02	1.24E-03	3.45E-04	1.09E-02
Norfolk Naval Air Station	VA	Light Snow	1.93E-04	0.00E+00	7.33E-03	3.09E-04	6.91E-05	3.92E-03
Norfolk Naval Air Station	VA	Mod/Hvy Snow	0.00E+00	0.00E+00	1.38E-03	0.00E+00	0.00E+00	7.25E-04
Norfolk Naval Air Station	VA	All	3.47E-03	1.20E-02	1.75E-01	1.39E-02	6.15E-03	9.63E-02
Burlington International AP	VT	Light Rain	4.87E-03	1.19E-02	1.28E-01	1.43E-02	2.87E-03	8.41E-02
Burlington International AP	VT	Mod/Hvy Rain	3.25E-04	0.00E+00	6.21E-03	0.00E+00	0.00E+00	3.94E-03
Burlington International AP	VT	Light Snow	6.50E-04	3.24E-03	9.90E-02	1.02E-02	3.42E-03	6.44E-02
Burlington International	VT	Mod/Hvy Snow	0.00E+00	0.00E+00	4.98E-03	4.52E-04	7.77E-04	3.31E-03

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
AP								
Burlington International AP	VT	All	5.85E-03	1.51E-02	2.38E-01	2.50E-02	7.07E-03	1.56E-01
Seattle-Tacoma International AP	WA	Light Rain	4.93E-03	1.03E-02	2.14E-01	1.13E-02	4.37E-03	1.32E-01
Seattle-Tacoma International AP	WA	Mod/Hvy Rain	0.00E+00	0.00E+00	4.47E-03	0.00E+00	0.00E+00	2.68E-03
Seattle-Tacoma International AP	WA	Light Snow	0.00E+00	0.00E+00	7.17E-03	2.47E-04	0.00E+00	4.34E-03
Seattle-Tacoma International AP	WA	Mod/Hvy Snow	0.00E+00	0.00E+00	3.99E-04	0.00E+00	0.00E+00	2.40E-04
Seattle-Tacoma International AP	WA	All	4.93E-03	1.03E-02	2.26E-01	1.16E-02	4.37E-03	1.39E-01
Green Bay Austin Straubel Field	WI	Light Rain	3.86E-03	8.76E-03	1.06E-01	1.05E-02	2.98E-03	6.21E-02
Green Bay Austin Straubel Field	WI	Mod/Hvy Rain	0.00E+00	0.00E+00	2.73E-03	0.00E+00	0.00E+00	1.52E-03
Green Bay Austin Straubel Field	WI	Light Snow	2.76E-04	1.71E-03	8.79E-02	6.59E-03	1.22E-03	5.02E-02
Green Bay Austin Straubel Field	WI	Mod/Hvy Snow	0.00E+00	2.28E-04	2.71E-03	0.00E+00	0.00E+00	1.53E-03
Green Bay Austin Straubel Field	WI	All	4.14E-03	1.07E-02	2.00E-01	1.71E-02	4.20E-03	1.15E-01
Huntington Tri-City AP	WV	Light Rain	4.98E-03	1.36E-02	1.95E-01	2.76E-02	3.50E-03	9.46E-02
Huntington Tri-City AP	WV	Mod/Hvy Rain	0.00E+00	0.00E+00	6.33E-03	8.69E-05	0.00E+00	2.88E-03

Station Name	State	Precip Type	Stab A-B	Stab C	Stab D	Stab E	Stab F-G	All Stab
Huntington Tri-City AP	WV	Light Snow	0.00E+00	1.34E-03	7.09E-02	3.74E-03	0.00E+00	3.27E-02
Huntington Tri-City AP	WV	Mod/Hvy Snow	0.00E+00	0.00E+00	3.39E-03	0.00E+00	5.07E-05	1.55E-03
Huntington Tri-City AP	WV	All	4.98E-03	1.49E-02	2.76E-01	3.15E-02	3.55E-03	1.32E-01
Lander Hunt Field AP	WY	Light Rain	2.14E-03	4.53E-03	7.72E-02	2.24E-03	4.07E-04	2.54E-02
Lander Hunt Field AP	WY	Mod/Hvy Rain	0.00E+00	0.00E+00	1.76E-03	6.80E-05	0.00E+00	5.61E-04
Lander Hunt Field AP	WY	Light Snow	7.41E-04	3.29E-03	1.40E-01	5.30E-03	2.90E-03	4.58E-02
Lander Hunt Field AP	WY	Mod/Hvy Snow	3.29E-04	3.55E-04	8.97E-03	2.72E-04	3.62E-04	3.02E-03
Lander Hunt Field AP	WY	All	3.21E-03	8.17E-03	2.28E-01	7.89E-03	3.67E-03	7.48E-02

APPENDIX D

STABILITY DISTRIBUTIONS FOR SELECT UNITED STATES STATIONS

APPENDIX D
STABILITY DISTRIBUTIONS FOR SELECT UNITED STATES STATIONS

A compact method of storing meteorological information is use of STability ARray (STAR) format files. This type of file format is described in Section 4.4.5.

A large database of STAR files was provided for the GENII Version 2 development by Mr. Barry Parks, US Department of Energy. These STAR files are provided in a subdirectory under FRAMES when the GENII package is installed. Each of these files has 6 windspeeds; the standard 1-3 knot, 3-6 knot, 6-10 knot, 10-16 knot, 17-21 knot, and 21+ knots grouping. Depending on the manner in which the data were collected, the number of stability classes represented may range from 5 (A-E) through 7 (A-G). The data available in this collection are listed in Table C.1. All file names end with the extension *.STR.

Table C.1. STAR files available with the GENII Version 2 installation package.

City	State	Dates	File Name
ANCHORAGE	AK	65/1-69/12	XXX0372
BARTER ISLAND	AK	68/1-77/12	XXX1517
BIG DELTA	AK	67/1-71/12	XXX0370
CORDOVA	AK	59/1-62/12	XXX0627
EIELSON	AK	61/1-70/12	XXX0536
FAIRBANKS	AK	61/1-70/12	XXX0537
GULKANA	AK	67/1-71/12	XXX0371
JUNEAU	AK	74/1-74/12	XXX1337
KENAI	AK	66/1-70/12	XXX0373
MIDDLETON ISLAND	AK	59/1-62/12	XXX0626
NENANA	AK	64/1-68/12	XXX1479
SUMMIT	AK	64/1-68/12	XXX1478
ANNISTON	AL	49/1-54/12	ANB0118
BIRMINGHAM	AL	72/1-76/12	BHM1387
CAIRNS FIELD	AL	65/1-69/12	SIR0937
CRAIG	AL	54/1-58/12	SEM0114
HUNTSVILLE	AL	60/1-64/12	HSV0544
MOBILE	AL	66/1-70/12	MOB0144
MONTGOMERY	AL	60/1-64/12	MGM1320
TUSCALOOSA	AL	49/1-54/12	TCL1083
EL DORADO	AR	50/1-54/12	ELD0547
LITTLE ROCK	AR	55/1-64/12	LIT0516
TEXARKANA	AR	63/1-67/12	TXK1043
DOUGLAS	AZ	50/1-54/12	DUG0376
PHOENIX	AZ	55/1-64/12	PNX0309
PRESCOTT	AZ	67/1-71/12	PRC0311
TUCSON	AZ	59/1-63/12	TUS0296
WINSLOW	AZ	49/1-54/12	INW0314
YUMA	AZ	67/1-71/12	YUM0315
ALAMEDA	CA	60/1-64/12	NGZ0322
ARCATA	CA	68/1-72/12	ACV1443
BAKERSFIELD	CA	67/1-71/12	BFL0292
BISHOP	CA	60/1-64/12	BIH0894
BLYTHE	CA	69/9-74/8	BLH0810
CHINA LAKE INYOKE	CA	54/1-63/12	NID0840

DAGGET/SAN BERNA	CA	55/1-64/12	DAG0300
EDWARDS	CA	66/1-70/12	EDW0852
EL CENTRO	CA	55/1-58/12	IPL1455
FRESNO	CA	60/1-64/12	FAT1213
HOLLYWOOD-BURBANK	CA	60/1-64/12	BUR1051
LONG BEACH	CA	60/1-64/12	LGB1052
LOS ALAMITOS	CA	65/1-69/12	SLI1053
LOS ANGELES	CA	64/5-69/4	LAX0304
LOS ANGELES	CA	55/1-64/12	LAX0587
MARCH	CA	66/1-70/12	RIV0930
MOFFET FIELD	CA	60/1-64/12	NUQ1056
MONTEREY	CA	59/1-63/12	MRY1456
NEEDLES	CA	69/9-74/8	EED0811
NORTON	CA	66/1-70/12	SBD1344
OAKLAND	CA	60/1-64/12	OAK0319
OXNARD	CA	60/1-64/12	OXR0704
POINT ARGUELLO	CA	60/1-64/6	PSU0938
POINT MUGU	CA	60/1-64/12	NTD0705
RED BLUFF	CA	72/1-76/12	RBL1415
SACRAMENTO	CA	66/1-70/12	SAC0320
SAN DIEGO	CA	67/1-71/12	NZY0380
SAN FRANCISCO	CA	69/1-73/12	SFO1122
SAN RAFAEL/HAMILT	CA	66/1-70/12	SRF0318
SANTA BARBARA	CA	60/1-64/12	SBA0313
SANTA MARIA	CA	49/1-53/12	SMX0750
STOCKTON	CA	72/1-76/12	SCK1465
TRAVIS	CA	60/1-64/12	SUU0316
TUSTIN	CA	72/1-76/12	SNA1467
UKIAH	CA	55/1-64/12	UKI0568
VANDENBERG	CA	61/1-70/12	VBE0660
VICTORVILLE/GEORG	CA	58/1-67/12	VCV0289
AKRON	CO	50/1-54/12	AKD0667
ALAMOSA	CO	72/1-76/12	ALS1462
COLORADO SPRINGS	CO	69/1-73/12	COS0573
DENVER	CO	60/1-64/12	DEN0618
DENVER	CO	70/1-74/12	DEN0952
GRAND JUNCTION	CO	60/1-64/12	GJT0476
PUEBLO	CO	66/1-70/12	PUB0564
BRIDGEPORT	CT	65/1-69/12	BDR0558
HARTFORD	CT	55/1-64/12	BDL1262
WILMINGTON	DE	60/1-64/12	ILG1058
CAPE CANAVERAL	FL	65/1-69/12	XMR1173
DAYTONA BEACH	FL	67/1-71/12	DAB0541
FORT MYERS	FL	69/1-73/12	FMY0744
JACKSONVILLE	FL	70/1-74/12	JAX1037
MIAMI	FL	70/1-74/12	MIA0979
ORLANDO	FL	60/1-64/12	XXX0615
PENSACOLA	FL	67/1-71/12	XXX0018
TALLAHASSEE	FL	60/1-64/12	TLH0663
TAMPA	FL	65/1-69/12	TAMPA
TAMPA	FL	60/1-64/12	TPA0662
TAMPA	FL	69/1-73/12	TPA0915
TYNDALL	FL	66/1-70/12	PAM0113
WEST PALM BEACH	FL	70/1-70/12	PBI0054
WHITING	FL	62/1-71/12	XXX0491
ALBANY	GA	69/1-74/4	ABY0721

ALMA	GA	54/1-58/12	AMB0771
ATHENS	GA	69/1-73/12	AHN0763
ATLANTA	GA	67/1-71/12	ATL0121
AUGUSTA	GA	70/1-74/12	AGS1018
BRUNSWICK	GA	67/1-71/12	SSI0417
COLUMBUS	GA	69/1-73/12	CSG0767
MACON	GA	69/1-73/12	MCN0768
SAVANNAH	GA	66/1-70/12	SAV0012
BARBERS POINT	HI	72/1-76/12	XXX1416
HILO	HI	62/8-67/7	XXX0273
HONOLULU	HI	72/1-76/12	XXX1417
KAHULUI	HI	66/1-70/12	XXX0275
PUUNENE	HI	53/1-57/12	XXX0276
DES MOINES	IA	72/1-72/12	DSM0753
MASON CITY	IA	70/1-74/12	MCW1049
SIOUX CITY	IA	70/1-74/12	SUX1050
WATERLOO	IA	60/1-64/12	ALO0729
BOISE	ID	60/1-64/12	BOI0653
IDAHO FALLS	ID	55/1-64/12	IDH0910
MALAD CITY	ID	48/1-54/12	MLD0909
MOUNTAIN HOME	ID	65/1-69/12	MUO0654
MULLAN PASS	ID	50/1-54/12	MLP1448
POCATELLO	ID	58/1-62/12	PIH0359
BELLEVILLE	IL	61/1-70/12	BLV0826
CHICAGO	IL	60/1-64/12	ORD1120
CHICAGO	IL	70/1-74/12	ORD1247
CHICAGO/MIDWAY	IL	73/1-73/12	MDW0675
CHICAGO/OHARE	IL	65/1-69/12	ORD0452
GLENVIEW	IL	60/1-64/12	XXX0584
L SPRINGFIELD	IL	67/1-71/12	SPI0415
MOLINE	IL	67/1-71/12	MLI0269
PEORIA	IL	73/1-73/12	PIA0644
PEORIA	IL	65/1-69/12	PIA0716
QUINCY	IL	50/1-54/12	UIN0422
RANTOUL/CHANUTE AF	IL	63/1-67/12	RAN0234
ROCKFORD	IL	70/1-74/12	RFD0866
EVANSVILLE	IN	60/1-64/12	EVV0406
EVANSVILLE	IN	70/1-74/12	EVV1009
FORT WAYNE	IN	60/1-64/12	FWA1156
INDIANAPOLIS	IN	55/1-74/12	IND1080
SOUTH BEND	IN	67/1-71/12	SBN0257
TERRE HAUTE	IN	48/1-54/12	HUF1241
FORT LEAVENWORTH	KS	62/1-70/12	FLV0561
GARDEN CITY	KS	50/1-54/12	GCK0818
GOODLAND	KS	69/1-73/12	GLD0760
TOPEKA	KS	63/1-72/12	TOP0534
WICHITA	KS	63/1-72/12	ICT0604
BOWLING GREEN	KY	50/1-54/12	BWE0402
CORBIN	KY	49/10-54/0	LOZ0005
COVINGTON	KY	58/1-62/12	CVG0403
COVINGTON	KY	70/1-74/12	CVG1916
FORT CAMPBELL	KY	58/1-62/12	XRW0109
FORT KNOX	KY	64/1-68/12	FTK0110
LEXINGTON	KY	55/1-64/12	LEX1327
LOUISVILLE	KY	66/1-70/12	SDF0411
PADUCAH	KY	50/1-54/12	PAH0006

PADUCAH	KY	60/1-64/12	PAH0479
ALEXANDRIA	LA	70/1-73/12	ESF0657
BATON ROUGE	LA	55/1-64/12	BTR0166
LAFAYETTE	LA	54/1-58/12	LFT0755
LAKE CHARLES	LA	66/1-70/12	LCH0025
MONROE	LA	54/1-58/12	MLU0684
NEW ORLEANS	LA	67/1-71/12	NBG1379
SHREVEPORT	LA	67/1-71/12	SHV0157
U BATON ROUGE	LA	72/1-72/12	BTR0169
BEDFORD	MA	63/1-67/12	BED0181
BOSTON	MA	67/1-71/12	BOS0211
BOSTON	MA	74/5-75/4	BOS1072
BOSTON	MA	66/1-70/12	BOS1123
CHICOPEE FALLS	MA	60/1-64/12	CEF0182
FALMOUTH	MA	60/1-64/12	FMH0642
PITTSFIELD	MA	48/1-53/12	PSF0219
SOUTH WEYMOUTH	MA	70/1-74/12	NZW1144
ABERDEEN	MD	55/1-57/12	APG0072
BALTIMORE	MD	69/1-73/12	BAL1059
FORT MEADE	MD	60/1-64/12	FME1207
FREDERICK	MD	49/1-52/12	MD30756
HAGERSTOWN	MD	74/1-74/12	HER0858
PATUXENT RIVER	MD	75/1-75/12	NHK1306
SALISBURY	MD	49/1-58/12	SBY0590
AUGUSTA/STATE	ME	50/1-54/12	AUG0795
BRUNSWICK	ME	60/1-69/12	NHZ0180
CARIBOU	ME	53/1-62/12	CAR0179
OLD TOWN/DEWITT 1	ME	60/1-64/12	OLD0809
PORTLAND	ME	55/1-64/12	PWM0220
ALPENA	MI	72/1-76/12	APN1413
BATTLE CREEK	MI	50/1-54/12	BTL1460
BENTON HARBOR	MI	74/1-74/12	BEH0853
DETROIT	MI	69/1-73/12	DET0672
DETROIT	MI	63/10-68/9	YIP1061
FLINT	MI	67/3-77/2	FNT1395
GWINN	MI	63/1-67/12	SAW0738
LANSING/CAPITAL C	MI	69/1-73/12	LAN0673
MOUNT CLEMENS	MI	65/1-69/12	MTC1425
MUSKEGON	MI	67/1-71/12	MKG0251
SAGINAW	MI	49/1-54/12	MBS0254
TRAVERSE CI	MI	74/1-74/12	TVC0844
ALEXANDRIA	MN	52/1-54/12	AXN0262
DULUTH	MN	67/1-71/12	DLH0263
INTERNATIONAL FALLS	MN	70/1-74/12	INL1264
MINNEAPOLIS	MN	67/1-71/12	MSP0267
ST CLOUD/WHITNEY	MN	67/1-71/12	STC0995
COLUMBIA	MO	64/1-68/12	COU0170
KANSAS CITY	MO	67/1-71/12	MKC1323
KIRKSVILLE	MO	50/1-54/12	IRK1081
O SPRINGFIELD	MO	66/1-70/12	SGF0178
BILOXI	MS	60/1-64/12	BIX0538
COLUMBUS	MS	66/1-70/12	CGM0670
GREENVILLE	MS	55/11-60/1	GLH0153
JACKSON	MS	55/1-64/12	JAN1169
MCCOMB	MS	49/1-54/12	MCB0830
MERIDIAN	MS	66/1-70/12	MEI0115

BUTTE	MT	56/1-60/12	BTM0357
CUSTER	MT	48/1-50/5	CUS0512
CUT BANK	MT	49/1-58/12	CTB0616
GLASGOW	MT	70/1-74/12	GGW0974
GREAT FALLS	MT	71/1-75/12	GTF1322
HAVRE	MT	67/1-71/12	HVR0507
HELENA	MT	65/1-74/10	HLN0806
KALISPELL	MT	68/1-72/12	FCA0543
LEWISTOWN	MT	67/1-71/12	LWT0508
MILES CITY	MT	67/1-71/12	MLS0333
MISSOULA	MT	67/1-71/12	MSO0522
ASHEVILLE	NC	66/1-70/12	AVL0001
CAPE HATTERAS	NC	66/1-70/12	HAT0392
CHARLOTTE	NC	69/1-73/12	CLT0682
ELIZABETH CITY	NC	64/1-68/12	ECG1461
FAYETTEVILLE	NC	66/1-70/12	FBG0075
GOLDSBORO	NC	66/1-70/12	GSB0074
GREENSBORO,HIGH POINT	NC	68/1-72/12	GSO0529
RALEIGH	NC	66/1-70/12	RDU0083
T CHERRY PT	NC	67/1-71/12	NKT0106
WILMINGTON	NC	66/1-70/12	ILM0104
WINSTON SALEM	NC	60/1-64/12	INT0531
BISMARCK	ND	67/1-71/12	BIS0324
DICKINSON	ND	60/1-64/12	DIK0509
FARGO	ND	67/1-71/12	FAR0994
MINOT	ND	67/1-71/12	MOT0510
WILLISTON	ND	67/1-71/12	ISN0511
GRAND ISLAND	NE	64/1-64/12	GRI1243
LINCOLN	NE	59/1-63/12	LNK1142
NORTH PLATTE	NE	69/1-73/12	LBF0761
OMAHA	NE	55/1-64/12	OMA0991
SCOTTSBLUFF	NE	68/1-72/12	BFF0599
CONCORD	NH	60/1-64/12	CON0787
PORTSMOUTH	NH	69/1-69/12	PSM0034
ATLANTIC CITY	NJ	70/1-74/12	ALY1139
BELMAR	NJ	55/1-59/12	BLM0033
LAKEHURST	NJ	68/1-72/12	NEL0505
MILLVILLE	NJ	50/1-54/12	MIV1000
NEWARK	NJ	55/1-64/12	EWR0195
TETERBORO	NJ	52/1-56/12	TEB0428
WRIGHTSTOWN/MCGUI	NJ	66/1-70/12	WRI0709
ALBUQUERQUE	NM	60/1-64/12	ABQ0282
ALBUQUERQUE	NM	75/1-75/12	ABQ1171
CARLSBAD	NM	50/1-54/12	CNM1741
FARMINGTON	NM	63/5-68/4	FMN0285
FARMINGTON	NM	54/1-59/12	FMN0928
FARMINGTON	NM	54/1-64/12	FMN1282
GALLUP	NM	73/1-75/12	GUP1167
GRANTS	NM	54/1-54/12	GNT1246
HOBBS	NM	49/1-54/12	HOB1199
HOLLOMAN	NM	49/1-70/12	HMN1039
LAS CRUCES/WHITE	NM	51/1-55/12	LRU1183
RATON	NM	49/1-51/12	RTN1481
ROSWELL	NM	49/1-54/12	ROW1291
SANTA FE	NM	50/1-54/12	SAF1184
ZUNI	NM	67/1-71/12	ZUN0378

ELKO	NV	69/1-73/12	EKO0833
ELY	NV	67/1-71/12	ELY0291
FALLON	NV	66/1-70/12	FLX0999
LAS VEGAS	NV	60/1-64/12	LAS1077
LAS VEGAS	NV	58/1-67/12	LSV0658
LOVELOCK	NV	69/1-73/12	LOL0832
RENO	NV	60/1-64/12	RNO1180
WINNEMUCCA	NV	69/1-73/12	WMC0831
YUCCA FLATS	NV	61/12-64/1	UCC1026
ALBANY	NY	60/1-64/12	ALB0523
ALBANY	NY	60/1-64/12	ALB1305
BINGHAMTON	NY	60/1-64/12	BGM0525
BUFFALO	NY	73/1-73/12	BUF0741
DUNKIRK	NY	49/1-53/12	DKK1011
ELMIRA	NY	50/1-54/12	ELM0906
GLENS FALLS	NY	50/1-54/12	GFL0907
GRIFFISS	NY	66/1-70/12	RME0789
HEMPSTEAD	NY	59/1-60/12	XXX1368
MASSENA	NY	67/1-76/12	MSS1524
NY/FT TOTTE	NY	65/1-69/12	LEA0435
PLATTSBURG	NY	66/1-70/12	PBG1012
POUGHKEEPSIE	NY	50/1-54/12	POU0217
ROCHESTER	NY	55/1-64/12	ROC0598
STEWART	NY	65/1-69/12	SWF0185
SYRACUSE	NY	55/1-64/12	SYR0878
UTICA	NY	50/1-54/12	UCA0908
WATERTOWN	NY	60/1-64/12	ART0790
WHITE PLAINS	NY	49/1-53/12	HPN0429
AKRON/AKRON CANTO	OH	70/1-74/12	CAK0934
CLEVELAND	OH	69/1-73/12	CLE0816
CLEVELAND	OH	70/1-74/12	CLE1140
COLUMBUS	OH	60/1-64/12	CMH0243
COLUMBUS	OH	70/1-74/12	CMH1041
COLUMBUS	OH	70/1-74/12	CMH1090
DAYTON	OH	65/1-69/12	DAY0404
DAYTON	OH	69/1-73/12	DAY0813
DAYTON	OH	76/1-76/12	DAY1502
FINDLAY	OH	50/1-54/12	FDY0244
MANSFIELD	OH	70/1-74/12	MFD1092
PERRY	OH	49/1-49/12	IBG0745
TOLEDO	OH	60/1-64/12	TOL0990
YOUNGSTOWN	OH	67/1-71/12	YNG0260
ZANESVILLE	OH	50/1-54/12	ZZV1036
ENID/VANE	OK	65/1-69/12	END0151
FORT SILL	OK	66/1-70/12	FSI1326
MCALESTER	OK	54/1-54/12	MLC1076
OKLAHOMA CITY/TIN	OK	65/7-70/6	TIK0152
PONCA CITY	OK	49/1-54/12	PNC0888
TULSA	OK	62/1-71/12	TUL0473
ASTORIA	OR	60/1-64/12	AST0423
BAKER	OR	60/1-64/12	BKE1364
EUGENE	OR	67/1-71/12	EUS0470
KLAMATH FALLS	OR	61/1-65/12	LMT0424
MEDFORD	OR	70/1-74/12	MFR1163
NORTH BEND	OR	66/1-75/12	OTH1376
ONTARIO	OR	48/1-54/12	ONO1377

PENDLETON	OR	55/1-64/12	PTD0585
PORTLAND	OR	67/1-71/12	PDX0364
REDMOND	OR	55/1-64/12	RDM0586
SALEM	OR	67/1-71/12	SLE0471
ALLENTOWN	PA	65/1-69/12	ABE0209
ALTOONA	PA	49/10-54/9	AOO0207
BRADFORD/REGIONAL	PA	60/1-64/12	BDF0035
ERIE	PA	64/1-73/12	ERI0610
HARRISBURG	PA	65/1-69/12	HAR0214
HARRISBURG	PA	64/1-64/12	HAR0631
MARTINS CREEK	PA	36/1-38/03	MC10432
PHILADELPHIA	PA	71/1-75/12	PHL1263
PHILIPSBURG	PA	50/1-54/12	PSB0218
PITTSBURGH	PA	74/1-75/12	AGC1210
PITTSBURGH	PA	64/1-73/12	PIT0880
READING	PA	49/1-49/12	RDG0184
WILKES-BARRE	PA	60/1-64/12	AVP0499
WILLOW GROVE	PA	68/1-71/12	NXX0951
SAN JUAN	PR	65/1-73/12	XXX0757
PROVIDENCE	RI	68/1-72/12	PVD0560
PROVIDENCE	RI	64/1-73/12	PVD0611
ANDERSON	SC	54/1-58/12	AND0421
CHARLESTON	SC	68/1-72/12	CHS0129
COLUMBIA	SC	56/1-75/12	CAE1371
FLORENCE	SC	60/1-64/12	FLO0600
GREER	SC	68/1-72/12	GSP0528
MYRTLE BEACH	SC	66/1-70/12	MYR1027
SPARTANBURG	SC	57/1-61/12	SPA0530
PIERRE	SD	67/1-71/12	PIR0327
RAPID CITY	SD	67/1-71/12	RAP0336
SIOUX FALLS	SD	68/1-72/12	FSD0527
BRISTOL	TN	74/1-74/12	TRI1191
CHATTANOOGA	TN	68/1-73/12	CHA0711
KNOXVILLE	TN	55/1-64/12	TYS1328
MEMPHIS	TN	67/1-71/12	MEM0143
MEMPHIS	TN	74/1-78/12	MEM1824
NASHVILLE	TN	66/1-70/12	BNA0149
NASHVILLE	TN	71/1-75/12	BNA1232
NASHVILLE	TN	74/1-78/12	BNA1825
SMITHVILLE	TN	49/1-53/12	SA31482
ABILENE	TX	67/1-71/12	ABI0524
AMARILLO	TX	55/1-64/12	AMA0621
AUSTIN	TX	69/1-73/12	AUS0869
BEEVILLE	TX	66/1-70/12	NIR0067
CORPUS CHRISTI	TX	73/7-77/6	CRP1459
COTULLA	TX	50/1-54/12	COT0699
DALLAS	TX	67/1-71/12	DAL0161
DALLAS/FORT WORTH	TX	72/5-76/4	DFW1269
DEL RIO/LAUGHLIN	TX	65/1-69/12	DLF0274
EL PASO	TX	60/1-64/12	ELP0489
GALVESTON	TX	58/1-62/12	GLS0066
HOUSTON	TX	64/1-68/12	HOU0062
HOUSTON	TX	70/01-70/1	HOUSTON
KINGSVILLE	TX	72/1-76/12	NQI1470
LAREDO	TX	65/4-70/3	LOI0056
LUBBOCK	TX	69/1-73/12	LBB0970

LUFKIN	TX	67/1-71/12	IFK0469
MIDLAND	TX	60/1-64/12	MAF0278
PORT ARTHUR	TX	64/1-64/12	YXS1310
SAN ANGELO	TX	60/1-64/12	SJT0280
SAN ANTONIO	TX	60/1-64/12	SAT0064
SHERMAN	TX	66/1-76/12	SWI1414
TYLER	TX	50/1-54/12	TYR0922
VICTORIA	TX	73/7-77/6	VCT1458
WACO	TX	69/1-73/12	ACT0862
BRYCE CANYON	UT	49/1-54/12	BCE0294
DELTA	UT	50/1-54/12	XXX0301
HANKSVILLE	UT	49/1-54/12	HV40302
MILFORD	UT	48/7-51/12	MLF0849
OGDEN	UT	65/1-69/12	HIF0337
SALT LAKE CITY	UT	72/1-76/12	SLC1411
DANVILLE	VA	50/1-54/12	DAN0825
GORDONSVILLE	VA	56/1-60/12	GVE0824
LANGLEY	VA	66/1-70/12	LFI1412
LYNCHBURG	VA	69/1-73/12	LYH0645
NORFOLK	VA	62/1-71/12	NGU1374
QUANTICO	VA	65/1-69/12	XXX0107
RICHMOND	VA	64/1-73/12	RIC0706
ROANOKE	VA	68/1-72/12	ROA0526
WALLOPS ISLAND	VA	69/1-73/12	WAL0687
WASHINGTON DC	VA	68/1-73/12	DCA1047
WASHINGTON DC	VA	66/1-70/12	IAD0398
BURLINGTON	VT	70/1-74/12	BTV0867
BELLINGHAM	WA	48/1-58/12	BLI1503
DALLESPORT	WA	64/1-64/12	XXX1196
ELLENSBURG	WA	50/1-54/12	ELN0518
EPHRATA	WA	50/1-54/12	EPH0521
EVERETT	WA	63/1-67/12	PAE1506
HOQUIAM	WA	54/1-58/12	HQM0487
KELSO	WA	48/1-49/12	KLS1378
MOSES LAKE	WA	61/1-65/12	MWH0486
OLYMPIA	WA	60/1-64/12	OLM0520
PORT ANGELES	WA	48/1-53/12	CLM0363
QUILLAYUTE	WA	74/1-74/12	UIL1505
SEATTLE/TACOMA	WA	67/1-71/12	SEA0366
SPOKANE	WA	67/1-71/12	GEG0360
SPOKANE	WA	68/1-77/12	GEG1806
TACOMA	WA	66/1-70/12	TCM0361
TOLEDO	WA	50/1-54/12	TDO0488
WALLA WALLA	WA	50/1-54/12	ALW0485
WHIDBEY ISLAND	WA	67/1-71/12	NUW0925
YAKIMA	WA	60/1-64/12	YKM0484
EAU CLAIRE	WI	69/1-73/12	EAU0715
GREEN BAY	WI	64/1-73/12	ERB0776
LA CROSSE	WI	67/1-71/12	LSE0266
MADISON	WI	64/1-73/12	MSN0773
MILWAUKEE	WI	64/1-73/12	MKE0774
BECKLEY	WV	71/1-75/12	BKW1346
ELKINS	WV	63/1-67/12	EKN1497
HUNTINGTON	WV	67/1-71/12	HTS0019
MARTINSBURG	WV	60/1-64/12	MRB1067
MORGANTOWN	WV	50/1-54/12	MGW0797

PARKERSBURG	WV	50/1-54/12	PKB0117
CASPER	WY	67/1-71/12	CPR0335
CASPER	WY	70/1-74/12	CPR1564
CHEYENNE	WY	67/1-71/12	CYS0325
FORT BRIDGER	WY	50/1-54/12	FBR1311
LANDER	WY	70/1-74/12	LND1100
LARAMIE	WY	50/1-54/12	LAR1454
MOORCROFT	WY	50/1-52/07	MC40334
RAWLINS	WY	55/1-64/12	RWL1261
S ROCK SPRINGS	WY	71/1-75/12	RKS1588
SHERIDAN	WY	49/1-53/12	SHR0330