

**PCSA TOOL VERSION 2.0  
USER GUIDE**

*Prepared for*

**U.S. Nuclear Regulatory Commission  
Contract NRC-02-02-012**

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## PREVIOUS REPORT IN SERIES

<u>Name</u>	<u>Date</u>
Development of a Tool and Review Methodology for Assessment of Preclosure Safety Analysis—Progress Report	September 2000
PCSA Tool Development—Progress Report	September 2001
PCSA Tool Development—Progress Report II	September 2002

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## QUALITY OF DATA, ANALYSES, AND COMPUTER CODES

**DATA:** No CNWRA-generated original data are contained in the PCSA Tool. Data used in the PCSA Tool are primarily equipment failure rate actuarial data from several sources. Each data source is cited in the PCSA Tool database.

**ANALYSES AND CODES:** The PCSA Tool Version 2.0 has been developed following CNWRA Technical Operating Procedure-018, which implements the requirements of the CNWRA Quality Assurance Manual. The PCSA Tool uses Microsoft® products and was developed to run on a personal computer using the Windows® NT operating system. Hereafter, the terms Microsoft and Windows will be used without the registered trademark symbol. The PCSA Tool Version 2.0 has been developed using Visual Basic 6.0, Microsoft Access 97 SR-2, SAPHIRE Version 6.70 (Idaho National Engineering and Environmental Laboratory, 1998), RSAC Version 5.2 (Wenzel, 1994), MELCOR Version 1.8.5 (Gauntt, et al., 2000), InstallShield Professional-Windows Installer Edition 2.0, and a suite of utility codes. No other versions of the listed previous codes were used in this document. SAPHIRE is developed, supported, and distributed by Idaho National Engineering and Environmental Laboratory. RSAC is distributed by Radiation Safety Information Computational Center, Oak Ridge National Laboratory. MELCOR is developed, supported, and distributed by Sandia National Laboratories. InstallShield Professional-Windows Installer Edition 2.0 is distributed by InstallShield Software Corporation. The suite of utility codes consists of PCSA\_LHS Version 1.0, PCSA\_LHSINP Version 1.0, PCSA\_PROB Version 1.0, PCSA\_COMBAN Version 1.0, PCSA\_RSACRD Version 1.0, PCSA\_IETCCDF Version 1.0, and PCSA\_RISKCCDF Version 1.0. These utility codes were developed at CNWRA using the Lahey LF90 FORTRAN Compiler. Visual Basic 6.0, Microsoft Access 97 and InstallShield packages do not conduct any computations and, hence, do not need to be put under CNWRA Configuration Control. The acquired computer codes SAPHIRE, RSAC, and MELCOR, which will not be modified, are under CNWRA Configuration Control.

InstallShield Professional-Windows Installer Edition 2.0 is used to create a PCSA Tool installation setup for Windows NT for distribution to the NRC and CNWRA staff. The setup distribution will install SAPHIRE, RSAC, and MELCOR codes and the CNWRA developed applications. Microsoft Access software will not be required to be installed on the user's computer.

## REFERENCES

Gauntt, R.O., R.K. Cole, C.M. Erickson, R.G. Gido, R.D. Gasser, S.B. Rodriguez, M.F. Young, S. Ashbaugh, M. Leonard, and A. Hill. NUREG/CR-6119, "MELCOR Computer Code Manuals." Rev. 2. Washington, DC: NRC. October 2000.

Idaho National Engineering and Environmental Laboratory. "Systems Analysis Programs for Hands-On Integrated Reliability Evaluations (SAPHIRE) Version 6.0, Saphire Reference Manual." Idaho Falls, Idaho: Idaho National Engineering and Environmental Laboratory. 1998.

Wenzel, D.R. "The Radiological Safety Analysis Computer Program (RSAC-5) User's Manual." WINCO-1123. Rev. 1. Idaho Falls, Idaho: Westinghouse Idaho Nuclear Company, Inc. Idaho National Engineering Laboratory. 1994.

# 1 INTRODUCTION

## 1.1 Purpose

The preclosure safety analysis (PCSA) Tool has been developed to provide a capability to the U.S. Nuclear Regulatory Commission and the Center for Nuclear Waste Regulatory Analyses (CNWRA) staffs to conduct an independent analysis and review of the U.S. Department of Energy (DOE) preclosure safety analysis for a proposed repository at Yucca Mountain, Nevada. As part of any license application for construction authorization and a subsequent license amendment to receive and possess waste at the proposed repository, 10 CFR Part 63 (Code of Federal Regulations, 2001) requires DOE to demonstrate, through a preclosure safety analysis, the facility would comply with the preclosure performance objectives for the period until permanent closure. The PCSA Tool, through confirmatory analyses, will be used to identify potential gaps in the DOE safety analysis, assess the DOE calculation of radiological consequences to workers and the public, evaluate identification of structures, systems, and components important to safety, and gain risk insight. The PCSA Tool is a Windows-based software that features a graphical user interface between the databases, software packages, and utility tools. This user guide contains information on operations of the PCSA Tool Version 2.0 for conducting independent preclosure safety analyses.

## 1.2 Background

The proposed geologic repository at Yucca Mountain will be designed for the permanent disposal of approximately 70,000 metric tons of spent nuclear fuel and high-level waste. During the preclosure period, the proposed facility will receive and handle casks containing the waste in sealed disposal canisters or in the form of spent nuclear fuel assemblies. Using a combination of manual and remote operations, the waste will be transferred into disposal waste packages and transported underground for emplacement into drifts. The risk-informed, performance-based regulation 10 CFR Part 63 provides the general scope, requirements, and objectives of the preclosure safety analysis. To ensure safety of the public and workers during the operational phase of the repository until permanent closure, 10 CFR Part 63 requires demonstration of compliance with the regulatory dose limits through a preclosure safety analysis. The requirements for preclosure safety analysis are specified in 10 CFR 63.112 and for performance objectives in 10 CFR 63.111(a, b). An important purpose of the preclosure safety analysis is to identify structures, systems, and components important to safety.

The Yucca Mountain Review Plan (NRC, 2003) will be used by the staff to review any license application for construction authorization and, if a construction authorization is granted, any license to receive and possess nuclear waste. The NRC (2003) implements the requirements of 10 CFR Part 63 and outlines a risk-informed, performance-based review philosophy that requires DOE to demonstrate, through its preclosure safety analysis, the repository will be designed, constructed, and operated to meet the specified performance objectives throughout the preclosure period. Review of the preclosure safety analysis is addressed in Section 2.1.1 (NRC, 2003), which has eight subsections. Each subsection provides guidance (review methods and acceptance criteria) on what information staff is to review, the review basis, how review is accomplished, what demonstrates compliance with regulations, and examples of potential conclusions regarding the applicable sections in 10 CFR Part 63. For reviewing the

## **Introduction**

preclosure safety analysis, NRC (2003) follows a sequence of evaluations that involves assessment of the (i) site description; (ii) description and design of structures, systems, components, equipment, and operational process activities; (iii) identification of hazards and initiating events; (iv) identification of event sequences; and (v) consequence analysis for evaluation of

- Compliance demonstration for Category 1 and Category 2 event sequences
- Identification of structures, systems, and components important to safety
- Design of structures, systems, and components important to safety
- Satisfaction of the as low as is reasonably achievable (ALARA) requirements

The PCSA Tool, which implements the review methodology of NRC (2003), provides risk-informed review capabilities to facilitate staff identification of safety-related structures, systems, and components for detailed review, and staff determination of whether the DOE preclosure safety analysis demonstrates compliance with the performance objectives in 10 CFR Part 63. The sequence of evaluation is depicted in Figure 1.2-1 where associated preclosure safety analysis (NRC, 2003) sections and areas of the PCSA Tool activities in the overall review process are indicated. The preclosure review methodology and function of the PCSA Tool are discussed in detail in Dasgupta, et al. (2000, 2001a,b, 2002, 2003) and in Benke, et al. (2002). This user guide steps through the preclosure safety analysis process and describes the functions of the tool to enable the user to operate the PCSA Tool Version 2.0.

### **1.3 Scope and Content**

The PCSA Tool Version 2.0 User Guide gives procedures for input, operation, and reporting of output. The guide also provides a general description of the process to review and conduct confirmatory analysis in determining compliance with the regulatory requirements for preclosure safety analysis outlined in NRC (2003).

The user guide is intended to give both first-time and experienced users immediate access to the tool while providing brief explanations of the options inherent in the PCSA Tool. The broad spectrum of the analytical capabilities of the tool is described in Dasgupta, et al. (2002, 2003). This user guide consists of the following sections:

- Chapter 1: Introduction, states the purpose and background of the PCSA Tool development including necessary information on system requirements, software used, installation, and user assistance.
- Chapter 2: Overview of the PCSA Tool Design and Operations, contains a general description of the computational approach and the tool menu structure and modules. This chapter also describes the data flow and operations in the PCSA Tool.

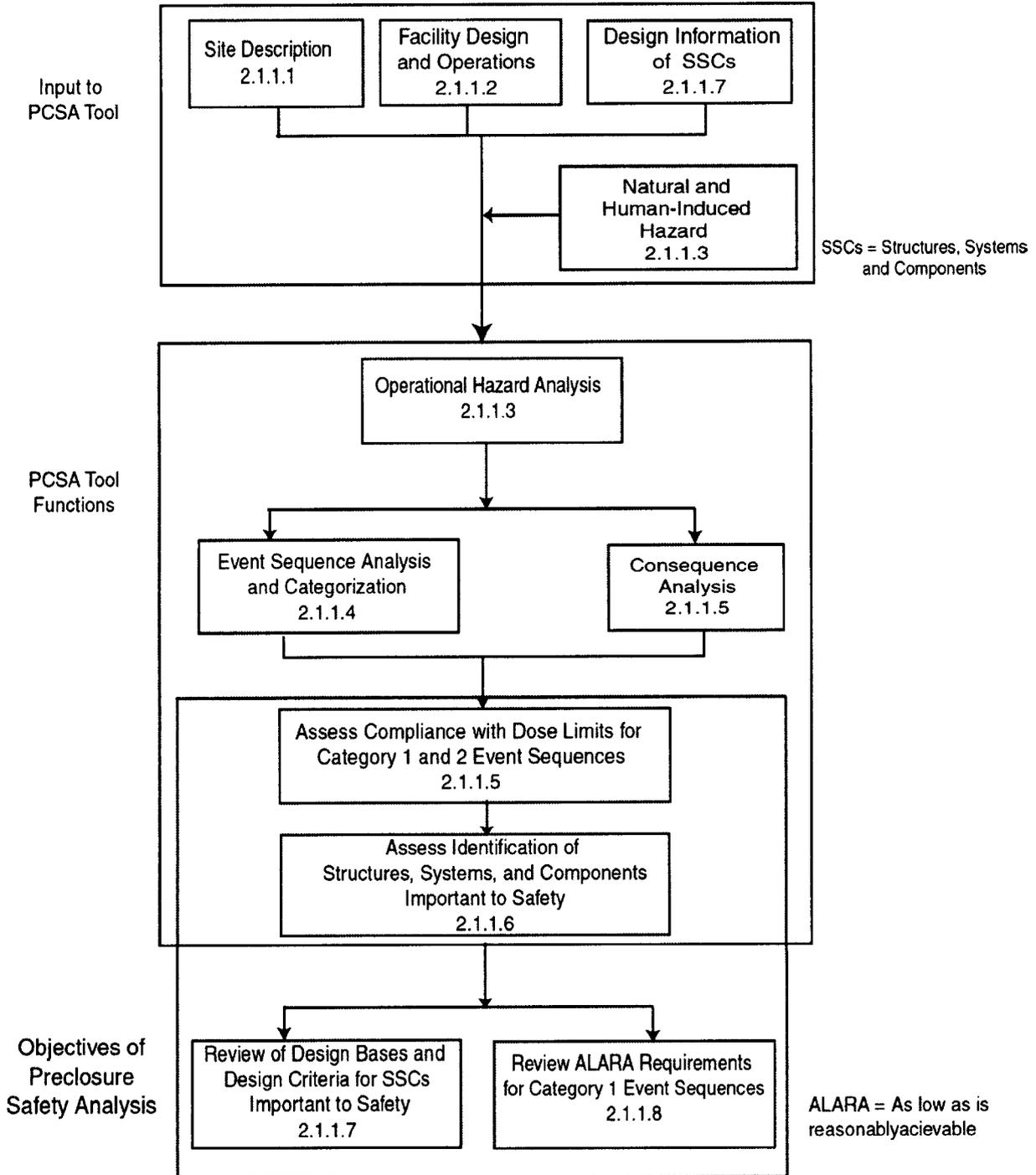


Figure 1.2-1. Preclosure Review Methodology Using Yucca Mountain Review Plan and PCSA Tool Activities

## **Introduction**

- Chapter 3: Reference for Menu Functions, describes the functions of each menu, submenu, and the buttons to store and retrieve data from the database and to conduct analyses. The subsections in this chapter is organized by the menus in the main menu bar.
- Chapter 4: References, provides a list of the references used in preparing this user guide.

### **1.4 System Requirements**

The PCSA Tool has been developed to operate on an IBM-compatible personal computer with a Pentium II-266 MHz. The operating system must be Windows NT 4.0/Windows 2000/Windows XP. The estimated disk space required is 250 MB maximum. The program is currently developed on a Pentium II-266 megahertz computer with 256 MB of Random Access Memory. The final size and memory requirements will be determined at the completion of the tool development. Visual Basic is the chosen programming language for the tool. Visual Basic does not need to be installed on the computer for the executable to run.

### **1.5 Software and Graphics Devices**

The PCSA Tool Version 2.0 has been developed using the following software: Visual Basic 6.0, Microsoft Access 97 SR-2, SAPHIRE Version 6.70, RSAC Version 5.2, MELCOR Version 1.8.5, InstallShield Professional-Windows Installer Edition 2.03, and a suite of utility codes. SAPHIRE is developed, supported, and distributed by Idaho National Engineering and Environmental Laboratory and RSAC codes is distributed by Radiation Safety Information Computational Center, Oak Ridge National Laboratory. MELCOR is developed, supported, and distributed by Sandia National Laboratories. InstallShield Professional-Windows Installer Edition 2.03 is distributed by InstallShield Software Corporation. The suite of utility codes, consisting of PCSA\_LHS Version 1.0, PCSA\_LHSINP Version 1.0, PCSA\_PROB Version 1.0, PCSA\_RSACRD Version 1.0, PCSA\_COMBAN Version 1.0, PCSA\_IETCCDF Version 1.0, and PCSA\_RISKCCDF Version 1.0 have been developed at CNWRA using the Lahey LF90 FORTRAN Compiler.

The tool currently provides graphics and reporting capabilities using the Visual Basic 6.0 chart and report modules. Additionally, fault tree and event tree models are graphically displayed using features in the SAPHIRE code.

### **1.6 Installation Guidelines**

A setup package, InstallShield Professional—Windows Installer Edition 2.03, was used to create a PCSA Tool installation setup for Windows NT/Windows 2000/Windows XP in a compact disk for distribution to prospective users. The setup distribution will also install the application packages SAPHIRE, RSAC, and MELCOR codes, and the CNWRA-developed applications. Microsoft Access database software is not required to be resident in the user's computer. The user may read through the detailed instructions for installation in Readme.txt provided on the installation disk.

## 1.7 Installation Test

After installation is completed, the user can run the PCSA Tool from the desktop by clicking the PCSA Tool icon. The tool installation can be tested by opening two project files PCSAdemo.mdb and Risktest.mdb. Detailed instructions for testing the installation will be provided in a later version of this user guide.

## 1.8 Software Validation

In compliance with the requirements of CNWRA Technical Operating Procedure-018, the PCSA Tool Version 3.0 will be validated. Completion of validation testing of the PCSA Tool for Version 3.0 is scheduled for May 15, 2004. The analyses software SAPHIRE, RASC, and MELCOR will be validated independently; however, validation tests on these software would be a part of the PCSA Tool validation package. The validation test plans for RSAC Version 5.2 and MELCOR Version 1.8.5 have been completed. The SAPHIRE Version 6.7 validation test plan will be delivered by June 30, 2003.

## 1.9 Assistance for PCSA Tool Users

### Typographical Conventions

The following typographical conventions have been adopted in this user guide:

- Menu: Bold, Italic, "hot-key" Underlined
- Submenu: Italic, "hot-key" Underlined
- Action Commands: Bold
- Data Entry Fields: Underlined
- Window Title: Bold MS Serif
- Notes: Denoted by Arrow, Italic

Training: Periodic training for new NRC and CNWRA staff and retraining for any other NRC and CNWRA staff can be provided on request.

Assistance: Telephone assistance and email response can be obtained from

B. Dasgupta	<a href="mailto:bdasgupta@swri.edu">bdasgupta@swri.edu</a>	210-522-6815
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## 2 OVERVIEW OF PCSA TOOL DESIGN AND OPERATIONS

### 2.1 Computational Approach

The PCSA Tool computer code combines the useful components of the integrated safety analysis methodologies used in the chemical industry and the probabilistic risk assessment capabilities and tools used in the safety assessment of nuclear power reactors. The PCSA Tool has been designed to (i) enter and retrieve data and information in a database, (ii) perform calculations using off-the-shelf and specially designed software, and (iii) document the review results. The executive module of the PCSA Tool interfaces with the databases and analytical tools.

The structure of the PCSA Tool is schematically illustrated in Figure 2.1-1. The figure shows that the graphical user interface, developed using Visual Basic 6.0, controls the functions of the tool by independently linking to databases and other software packages. The project database and fixed database were created using Microsoft Access database software. The failure rate, human error and failure mode checklist databases are considered fixed because these databases can only be viewed through the graphical user interface and cannot be modified by the user. The project database is the workbench for the tool, and it has been designed to perform specific data management tasks that allow safety analyses to be conducted in a systematic manner. The input data and output data to and from other software packages are also managed by this database. As seen in Figure 2.1-1, the project data are handled through several tables in the Microsoft Access database for (i) entering or gaining access to data, (ii) sorting and filtering data, and (iii) creating reports.

The model analysis in the PCSA Tool is conducted using the SAPHIRE, RSAC, and MELCOR codes, which are based on mathematical models described in Russel, et al. (1993), Wenzel (1994), and (Gauntt, et al., 2000), respectively. The SAPHIRE software conducts fault tree and event tree analyses, and the RSAC software performs dose calculations from the atmospheric release of radiological material. MELCOR is used to estimate the building discharge fraction (i.e., the fraction of radionuclides released into the building air that is transported through the building ventilation and discharged into the atmosphere).

### 2.2 PCSA Tool Modules

The PCSA Tool structure is modeled after the preclosure safety analysis review methodology as shown in Figure 1.2-1. Activity for each section is divided into several modules, and the PCSA Tool functions through these modules. The main modules parallel the review methodology, and each module has submodules, as shown in Figure 2.2-1(a, b). The modules in the tool allow the staff to perform independent review analysis and to store data and results of the review in a structured and systematic manner. Results of the review are abstracted, as appropriate, for use in other modules of the tool. The PCSA Tool modules and data flow processes are described below. Further details on each of the modules can be obtained from Dasgupta, et al. (2002).

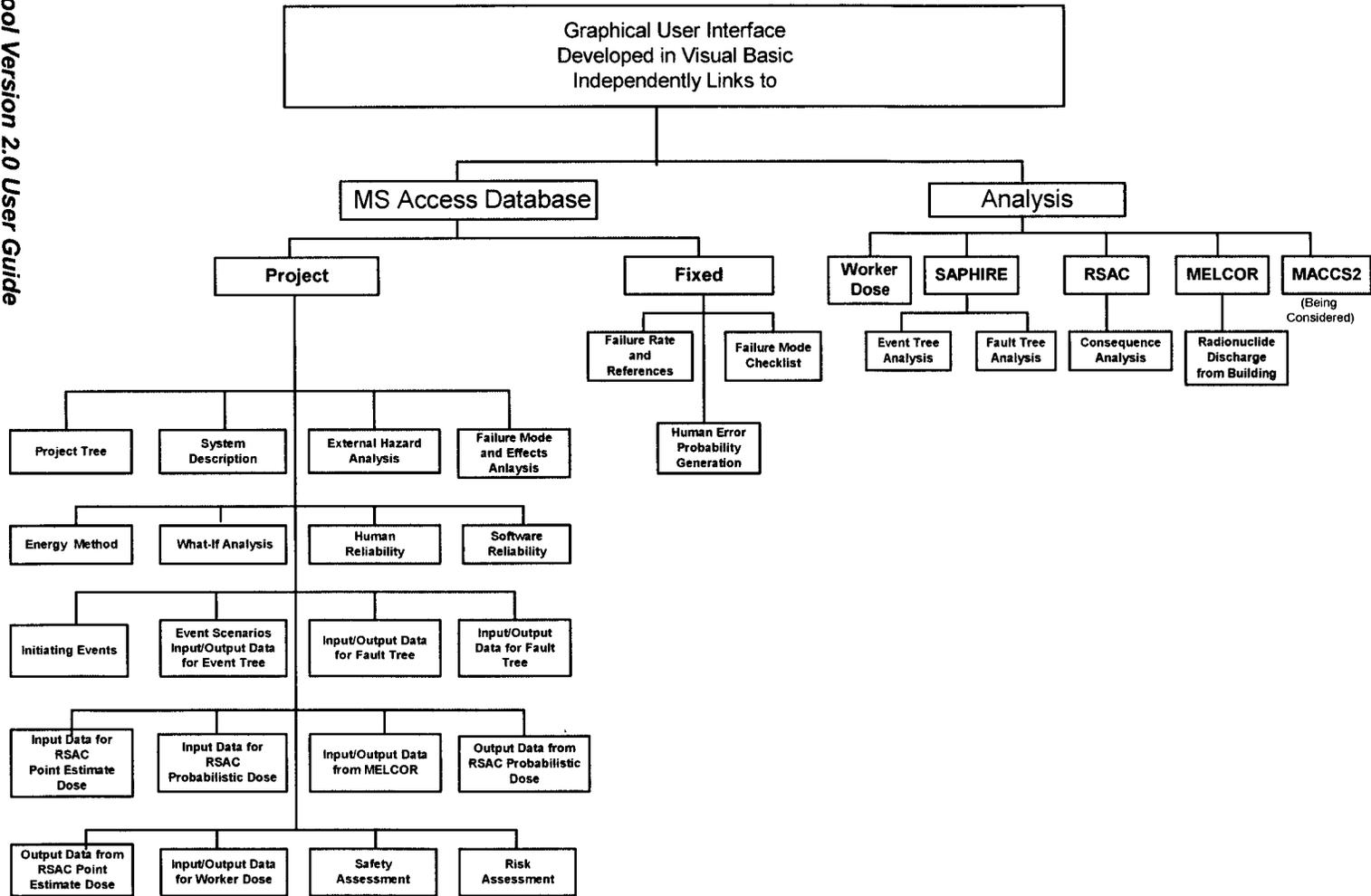


Figure 2.1-1. PCSA Tool Structure

# Overview of PCSA Tool Design and Operations

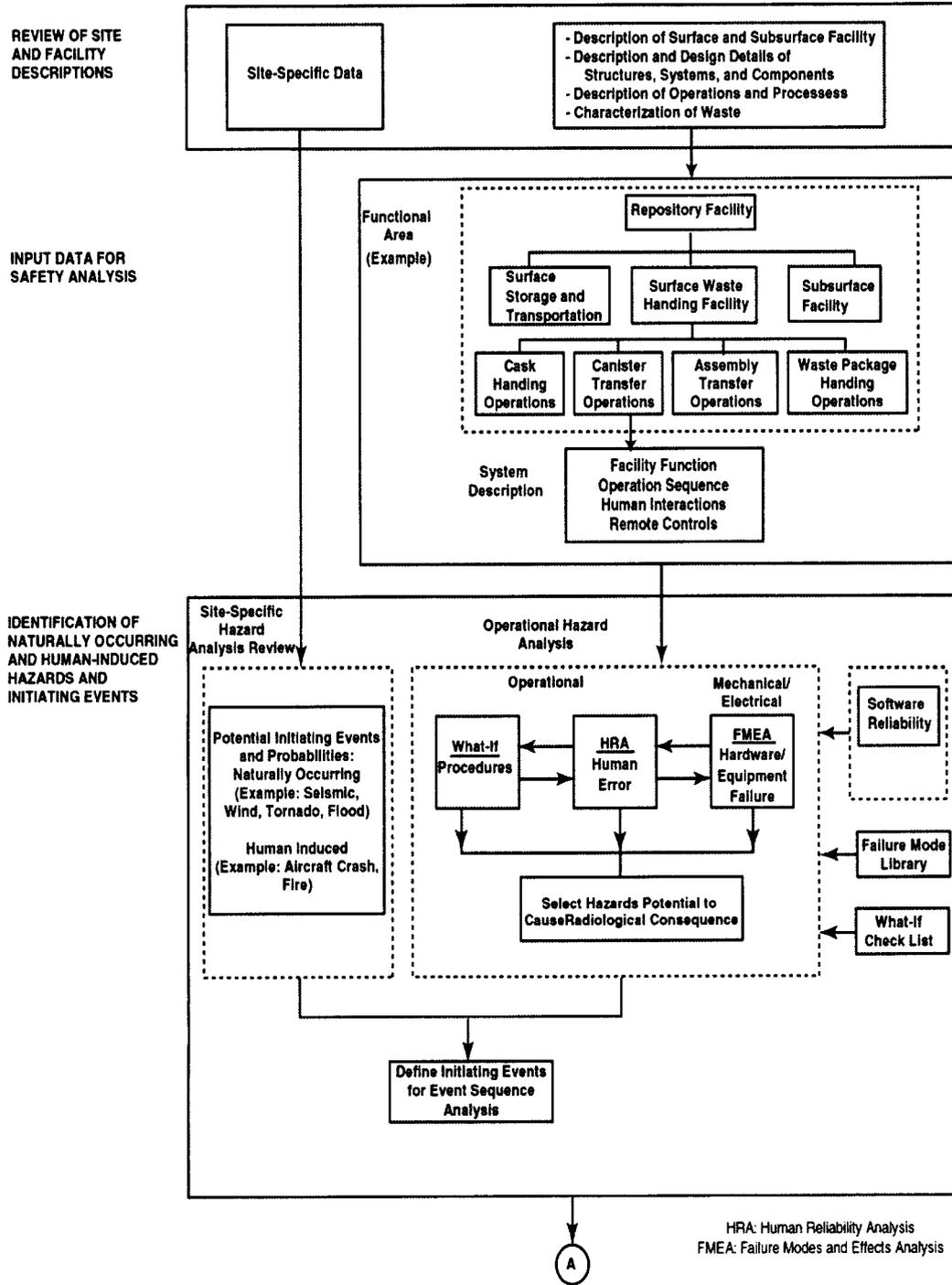


Figure 2.2-1(a). PCSA Tool Modules and Data Flow Diagram

# Overview of PCSA Tool Design and Operations

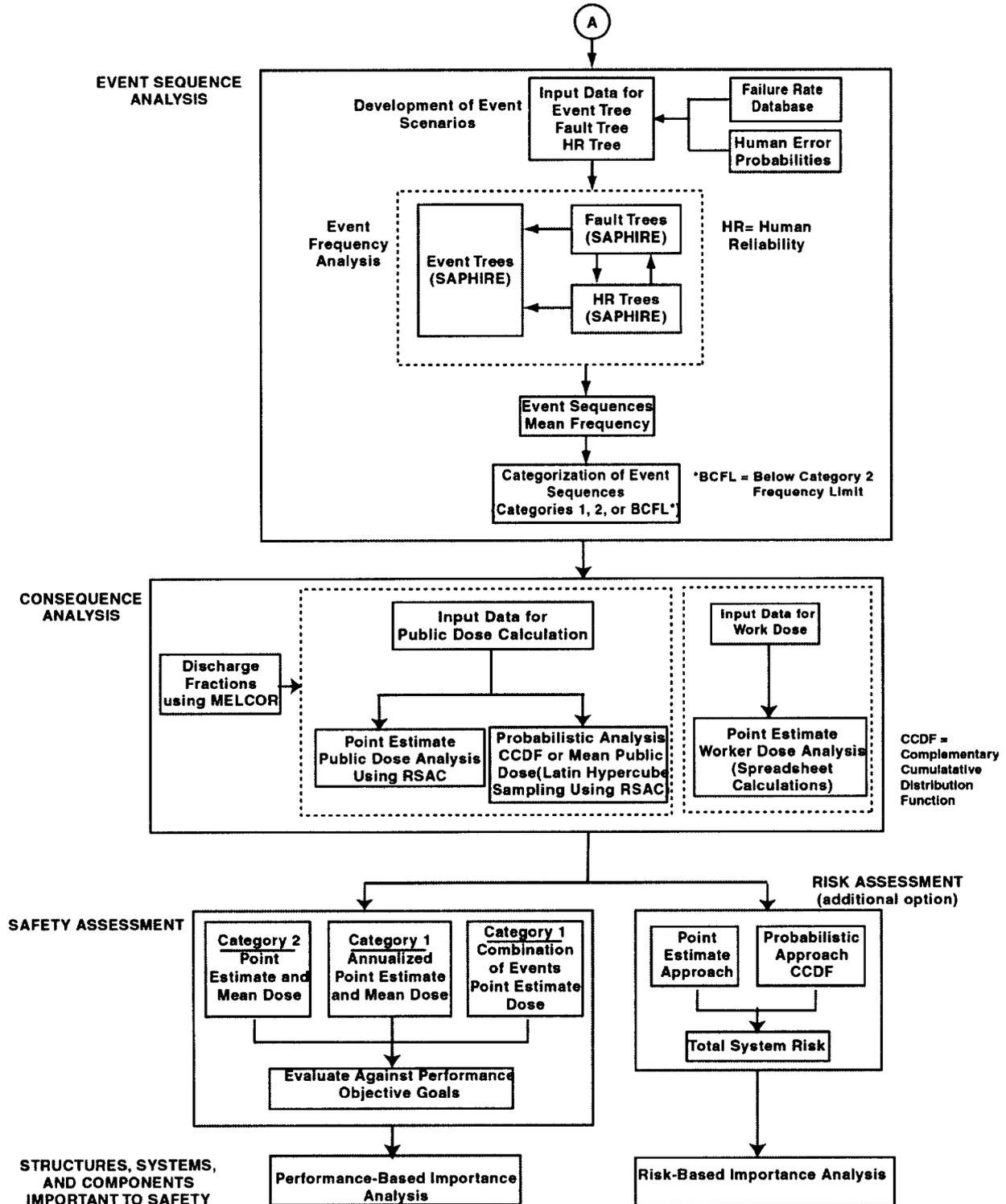


Figure 2.2-1(b). PCSA Tool Modules and Data Flow Diagram

### 2.2.1 Review of Site and Facility Description

This section, which addresses the first three boxes in Figure 1.2-1, does not have a corresponding module in the tool. Staff will identify and verify that sufficient information is available to review and perform independent preclosure safety analysis. Site-specific data refer primarily to meteorology, geology, and human activities. The facility data include description and design details of structures, systems, and components; characterization of waste and source terms; and description of geologic repository operations area operational processes and procedures with an adequate understanding of the component and facility functions and sequence of operations.

### 2.2.2 Input Data for Safety Analysis

#### 2.2.2.1 Functional Area

The facility and operations in the geologic repository operations area can be divided into functional areas by specific function or physical area of the facility or by process. In this module, the functional area is identified to define the physical boundary of the safety analysis. The tool has been designed to develop a project tree by dividing the facility into major functional areas, then dividing the functional areas into several subareas, if required. For example, as shown in Figure 2.2-1(a), the canister transfer operation is a subfunctional area to a top level functional area Surface Waste Handling Facility. The canister transfer can be further subdivided into three subfunctional areas [not shown in Figure 2.2-1 (a)], such as air lock, cask preparation and decontamination, and transfer cell. Functional areas must be planned before using the tool. The tool allows dividing a facility into 26 (A–Z) top level functional areas. Each functional area can be divided into three further sublevels and each sublevel can be divided into nine functional areas. The tool has the potential to create 18,954 functional areas. The tool assigns an identification number to a functional area to help in systematizing the data entry and data retrieval in the project database.

#### 2.2.2.2 System Description

Information required for safety analysis in a functional area is compiled in this submodule. A systematic analysis of operational hazard analysis requires description of the surface and subsurface facility; description of the systems and repository operations; and design information on structures, systems, and components and their functions, human actions, remote system and controls, and software systems used. In addition, nuclear material (e.g., inventories of casks and canisters) handled in the functional area of the operations is also identified and documented.

### 2.2.3 Naturally Occurring and Human-Induced Hazards and Initiating Events

This section addresses two code submodules: (i) site-specific, naturally occurring, and human-induced hazard analysis; and (ii) operational hazard analysis, as shown in Figure 2.2-1(a). The end result of the module is to identify the initiating events that may lead to a potential radiological dose to the public or workers.

## **Overview of PCSA Tool Design and Operations**

### **2.2.3.1 Site-Specific Hazard Analysis Review**

The naturally occurring events and human-induced events common to all functional areas in the facility are identified in this submodule. The naturally occurring events consist of seismic, tornado, wind, flood, and others. Site-specific, human-induced events include aircraft crash, fire, and others. The U.S. Department of Energy (DOE) justification and analyses to include or exclude hazards from a generic list of hazards will be reviewed, and, if required, independent analyses will be made outside the tool. The module in the tool will record the outcome of the staff review and identify the site-specific events, including frequency of occurrence, that may initiate event sequences in the facility.

### **2.2.3.2 Operational Hazard Analysis**

Events resulting from the facility operations are analyzed for each functional area in this submodule. In addition, the failure checklist database is a submodule that provides input to this module.

Hazard analysis techniques are usually qualitative. The tool offers four hazard analysis methods to identify operational hazards that may result in radiological dose to the public and workers: what-if analysis, failure modes and effects analysis, energy method, and human reliability analysis. The what-if analysis technique can be used for identification of process hazards, the failure modes and effects analysis addresses hardware and equipment failures, the energy method seeks to find possible release of energy (e.g., kinetic, chemical, or thermal) from the system that may result in radiological consequences, and human reliability analysis determines the possible human errors from human activities and human interaction with other systems. Details on each of these methodologies can be found in Dasgupta, et al. (2002).

### **2.2.3.3 Initiating Events**

In this submodule, initiating events that have the potential for radiological consequences are identified. The initiating events are selected from naturally occurring or human-induced hazard analysis or operational hazard analysis. The tool further allows documentation of estimation of frequencies for the initiating events and consideration of uncertainties associated with the estimated frequencies. The database on failure rate from actuarial data can be used to evaluate frequencies associated with failure of components. In addition, fault tree analysis and human reliability analysis using the SAPHIRE software can be used to evaluate frequencies for events initiated from failure of a system or human action. To consider events identified by DOE, the tool allows such events to carry forward (flag) the information for subsequent analyses in the tool. All initiating events are assigned a unique identification number to track the event in subsequent modules.

### **2.2.4 Event Sequence Analysis**

This section addresses code submodules: development of an event scenario and event frequency analysis as shown in Figure 2.2-1(b).

### 2.2.4.1 Event Scenarios

In this submodule, the event scenarios are developed by first identifying an initiating event from the site-specific and operational hazards analyses, then propagating its consequences through a series of safety-related systems or operations failures. Each event scenario is analyzed using the event tree method (NRC, 1994) to estimate the event sequence frequencies. Although the event tree analysis technique is exhaustively thorough, the success of this technique is based on three basic presumptions: (i) all system events have been anticipated, (ii) all consequences of these events have been explored, and (iii) the probabilities of failure for all events have been correctly estimated, including consideration of uncertainties. The tool allows the user to systematically record each event scenario and the associated data.

If the system represents a single component or piece of equipment whose failure is modeled in the event tree, the component failure rate can be estimated directly from actuarial data, if available. For multicomponent or complex systems, fault trees are used to find failure probabilities for each node in the event tree. A fault tree is a graphical tool used to depict possible ways that an undesired system state (top event) could occur. Depending on the nature of the subsystem, the fault tree may model failure of electrical systems, mechanical systems, human actions, or combination of these. Basic data for each fault tree top event can be recorded in the tool database.

Every event scenario should have a unique identification. There is no limit to the number of event scenarios that can be developed in a functional area. The user may postulate alternate event scenarios for a given initiating event, however, can flag an event scenario to be used for subsequent analyses (e.g., safety assessment/risk assessment). The flag can be changed at any time to provide the user with the capability to study the effects on safety assessment using alternate event scenarios.

Information generated from this module would be used to model event trees and fault trees in SAPHIRE software, however, that data cannot be directly used as SAPHIRE input.

### 2.2.4.2 Failure Rate Database and HEP Generator

The tool contains a comprehensive library of failure rates of equipment from actuarial data. The data have been organized and categorized in an industry standard taxonomical structure. The data on a particular component can be searched with the help of a taxonomic tree structure or a built-in search capability. Each failure rate datum lists the unit associated with it (e.g., per demand or per hour). The primary and secondary references for the data source and any statistical information available on the data are also provided. The tool provides a generator to estimate human error probability by traversing a logic tree to select the appropriate human error probability and performance-shaping factor. The Technique for Human Error Rate Prediction methodology developed by Swain and Guttman (1983) for evaluating human error probability has been implemented in the tool.

### 2.2.4.3 Event Frequency Analysis

Event trees and fault trees are analyzed using the stand-alone software, SAPHIRE Version 6.70 (Idaho National Engineering and Environmental Laboratory, 1998). The SAPHIRE software is a

## **Overview of PCSA Tool Design and Operations**

collection of programs that allows the user to model event trees and fault trees; define event sequences and basic event failure data; solve system fault trees and event sequences; quantify cutsets; and perform uncertainty, sensitivity, and importance analyses. The system failure response is analyzed by a fault tree-linking technique whereby the fault tree logic is combined with the event tree logic resulting in a logic expression for each sequence in the event tree. The event tree and fault trees are modeled using a graphic editor. The code requires failure probabilities of the basic events as input to the model. The user can specify a point estimate or distribution of basic event probabilities as input. The SAPHIRE program generates reports and graphics. Relevant information can be abstracted and stored in the PCSA Tool project database. The user must be familiar with the operations of the SAPHIRE software package to model and analyze Event Trees and Fault Trees.

### **2.2.4.4 Event Sequences and Categorization**

Results from the event tree analysis from the SAPHIRE runs are stored in this submodule. All event sequences are given unique identification numbers. The frequency and end state (i.e., qualitative assessment of consequence) for each event sequence are entered.

Based on the frequency of occurrences, event sequences are categorized as Category 1 or Category 2. Based on the definitions from 10 CFR 63.2, Category 1 event sequences are those natural and human-induced event sequences expected to occur one or more times before permanent closure. Category 2 event sequences are other natural and human-induced event sequences that have at least 1 chance in 10,000 of occurring before permanent closure. In this submodule, the event sequence frequencies are automatically categorized as Category 1, Category 2, or below category frequency limit based on the preclosure period assigned to the initiating events. Below Category frequency limit (BCFL) are those with frequencies of occurrence less than the Category 2 frequency limit.

### **2.2.5 Analysis of Consequence**

The consequence analysis module calculates the radiological dose to the members of the public and workers. This section addresses the two main code submodules: public dose and worker dose. These modules are supplied information through an input data module. Point estimate or probabilistic calculations can be performed for the public dose determination. Point estimate calculations of the worker dose are also available.

#### **2.2.5.1 Input Data**

This module prepares data required for public dose calculations by deterministic and probabilistic approaches. Dose calculation requires the inventory of radionuclides, meteorological data, and other parameters. For probabilistic analysis, the distributions of sampled parameters are provided in this module.

#### **2.2.5.2 Public Dose**

The point estimate calculations of public dose are performed using RSAC software. The probabilistic calculations are based on Latin Hypercube Sampling of RSAC input parameters. RSAC is executed once for each sampled set of input parameters to determine the dose from

that realization. The results from the simulations and dose calculations are processed and displayed in this module. The tool provides a separate module for generating input data to calculate building discharge fractions using the MELCOR software. The building discharge fraction serves as input data in the public dose calculation using RSAC.

### **2.2.5.3 Worker Dose**

The worker dose option performs a spreadsheet calculation to estimate dose to the facility workers. This calculation is limited to underwater-handling events, with workers present above the pool. A single screen provides the user interface for the input and output of the worker dose calculations.

### **2.2.6 Safety Assessment**

The safety assessment module integrates and analyzes the results obtained in the various tasks for safety assessment. This integration includes, among other things, tabulation of frequencies for event sequences and consequences. The results are analyzed to assess safety by comparing the dose with performance objectives for the Categories 1 and 2 event sequences stipulated in 10 CFR 63.111. For Category 1 event sequences, the two approaches for safety assessment used in this module are annualized dose and combination of events. For Category 2 event sequences, each event sequence is compared with Category 2 dose limits.

### **2.2.7 Risk Assessment**

The risk assessment module evaluates aggregate risk from a potential repository during the preclosure period. Estimation of aggregate risk is not required by the U.S. Nuclear Regulatory Commission (NRC) regulation in 10 CFR Part 63 and will not be used directly in compliance determination. However, estimation of aggregate risk is incorporated in the PCSA Tool for gaining risk insights. Additionally, the risk assessment can be used also to evaluate the reliance on structures, systems, and components important to safety.

### **2.2.8 Structures, Systems, and Components Important to Safety**

The structures, systems, and components important to safety will be identified using a performance-based importance analysis. This module is not yet fully developed. The approach and current state of development are discussed in Dasgupta, et al. (2002, Chapter 9).

## **2.3 PCSA Tool Menu Structure**

The structure of the menus in the context of the PCSA Tool functions is described in this section. When the program is first executed, a startup title form is displayed to the user with an artistic rendering of the proposed Yucca Mountain repository (CRWMS M&O, 1996). The user can open or create projects from the startup page. The tool creates and opens project database files with the extension .mdb. Project files must be stored in an already established directory Project. In the PCSA Tool, the term Project represents a single specific database. The project files for SAPHIRE analysis are managed by the SAPHIRE software. It is, however, recommended these files be saved in an established directory, Saphire Projects.

## **Overview of PCSA Tool Design and Operations**

After selecting a file or creating a new file, the PCSA Tool opens the main tool window with a menu bar at the top the window. The menu bar lists various functions and categories into which the tool allows entry of data or further actions. The overall menu and submenu structure is shown in Figure 2.3-1. By clicking on the various options, the user is able to navigate through various programs, forms, tables, and reports. The user can then enter data into the selected table or form and recall the data at a later time. The forms and tables provide further actions through button controls. A typical example of the structure of action buttons is shown in Figure 2.3-2.

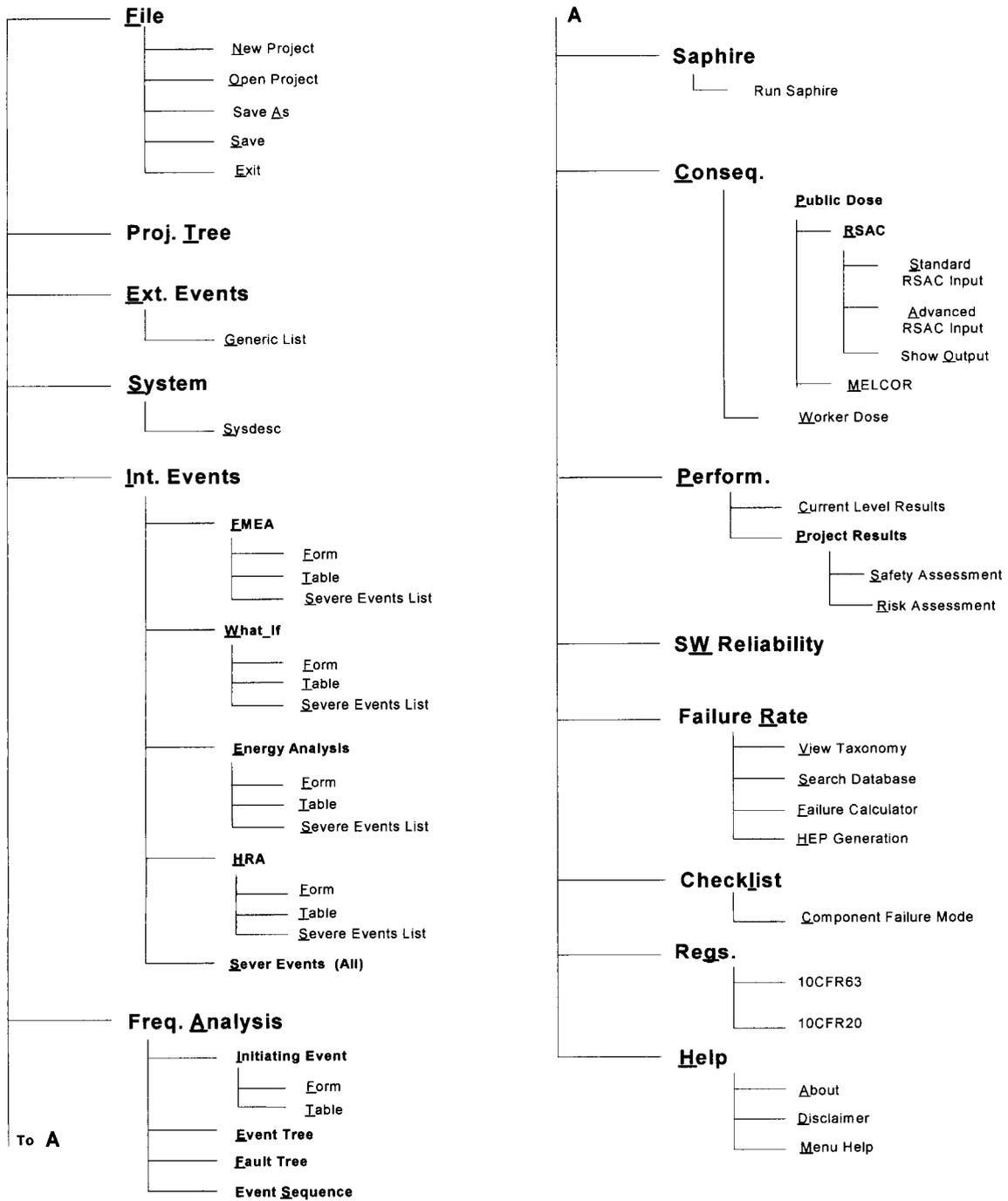
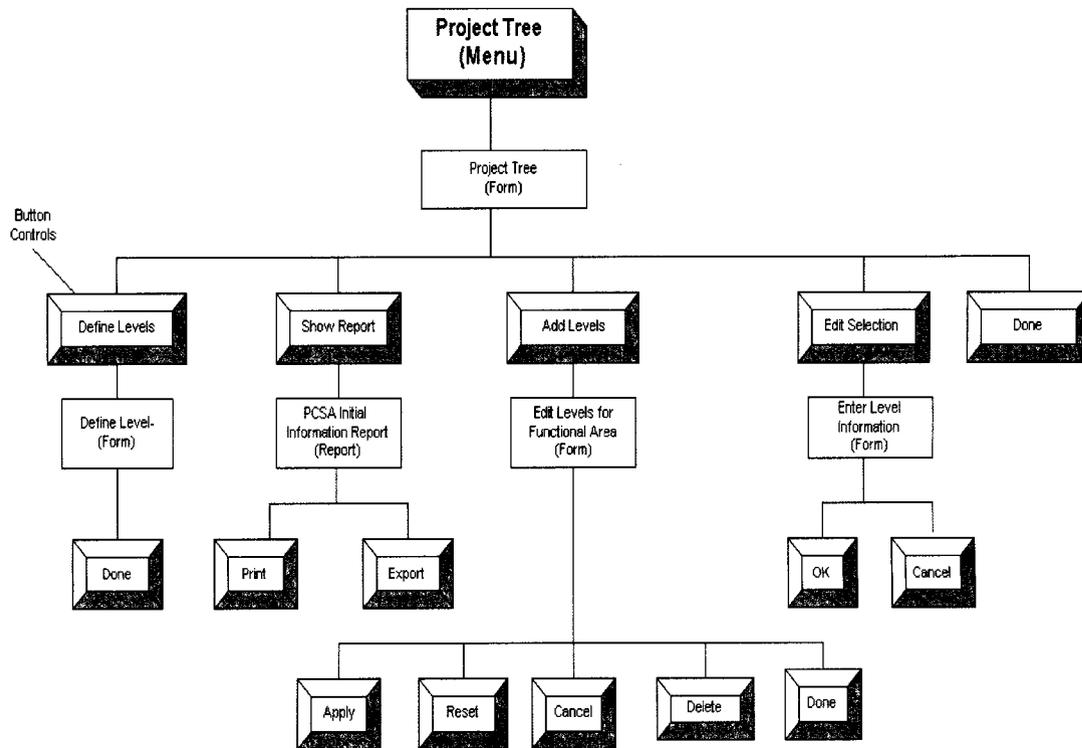


Figure 2.3-1. Tree Diagram Showing Layout of Menus and Submenus



**Figure 2.3-2. Example of Typical Action Buttons for Each Menu**

### 3 REFERENCE FOR MENU FUNCTIONS

#### 3.1 Getting Started

When the program is first executed, a startup title page is displayed to the user (Figure 3.1-1). The startup page displays five buttons: **About PCSA**, **Disclaimer**, **Open Project**, **Create Project**, and **Exit**. **About PCSA** button describes the tool and the project. The **Open Project** button will open an existing project, and the **Create Project** button will enable the user to create a new project. Both buttons open a dialog box as shown in Figure 3.1-2. The dialog box has features similar to other standard Windows application packages (e.g., the Browse Control button enables searching a project file, or storing a project file in the directory structure). The PCSA Tool will create and open database files with the extension .mdb.

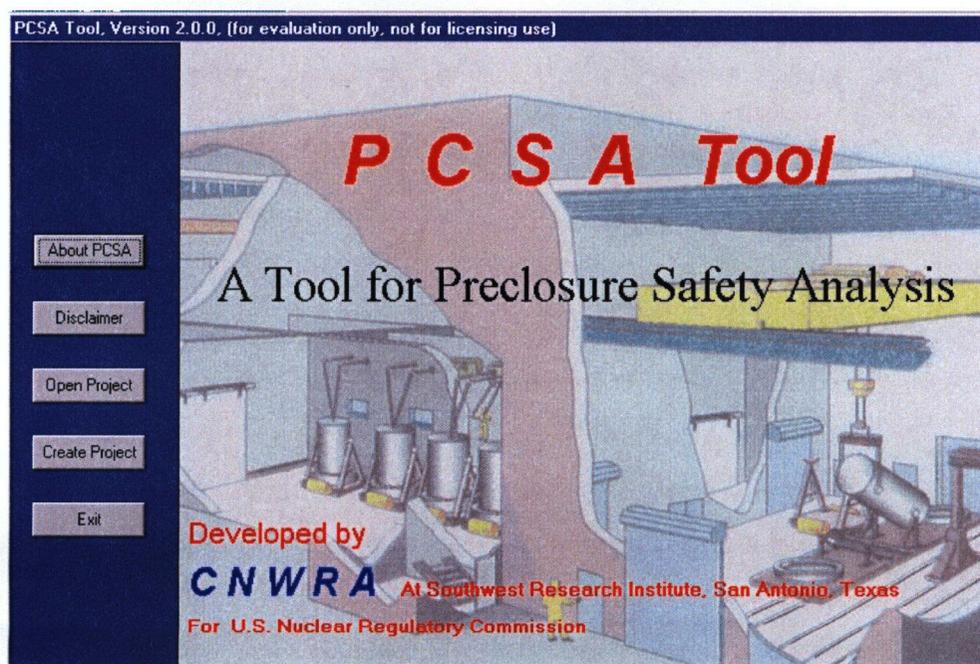


Figure 3.1-1. Display of Startup Screen Window PCSA Tool

## Reference For Menu Functions

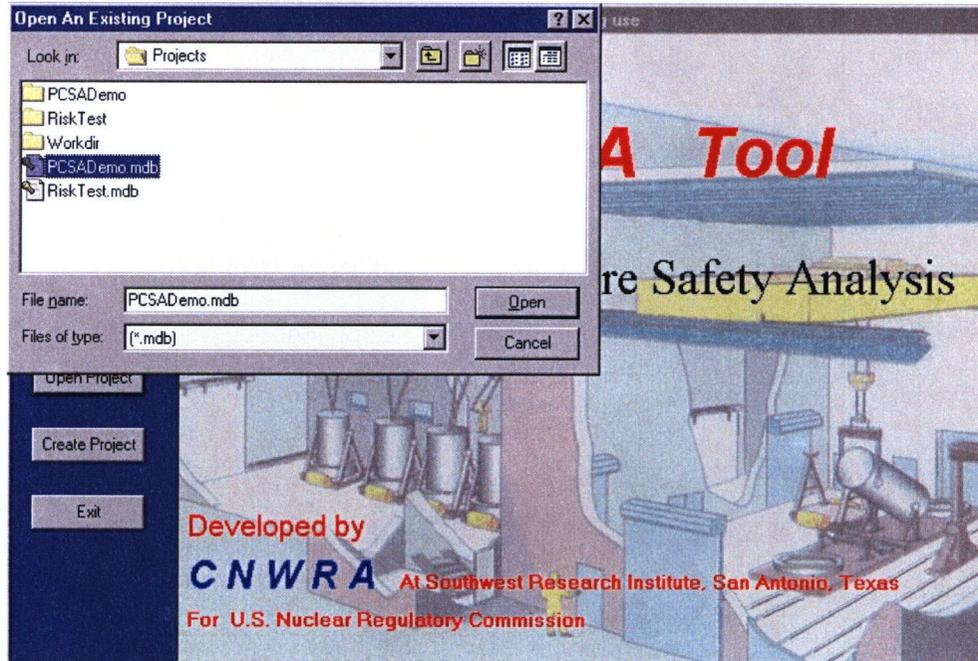


Figure 3.1-2. Open Project Dialog Box to Open an Existing Project

### Action Commands

---

- About PCSA:** Displays pertinent information about PCSA Tool.
- Disclaimer:** Displays PCSA Tool disclaimer statement.
- Open Project:** Opens a dialog box showing existing database files in the Project directory. The user can select and open a database.
- Create Project:** Opens a dialog box showing existing database files in the Projects directory. The user can create a new database file with the extension .mdb.
- Exit:** Allows the user to exit the PCSA Tool.
- 

⇒ **Note:** *Create Project also creates a directory under the same name as the database file. The newly created directory will have three subdirectories RASCRuns, ScRiskRuns and Total Risk. Users sharing the project database must have corresponding subdirectory structure and the associated files in their computers.*

## 3.2 File

Once the database has been selected, the PCSA Tool displays the main form as shown in Figure 3.2-1 with the main menu bar at the top of the screen. The first menu is the File menu. The submenus under the File menu are described below.

Open Project: The program will default back to the opening title screen as illustrated in Figure 3.1-1. The **Open Project** button will allow the user to select an existing file.

New Project: The program will default back to the opening title screen as illustrated in Figure 3.1-1. The **Create Project** button will allow the user to type in the name of a new file.

Save: Saves the information in the current project database. The user must be aware that any entered information resides in a temporary database until saved.

Save As: Saves the information as a new project database.

Exit: The tool will prompt the user to save any information entered in the current session before quitting the program.

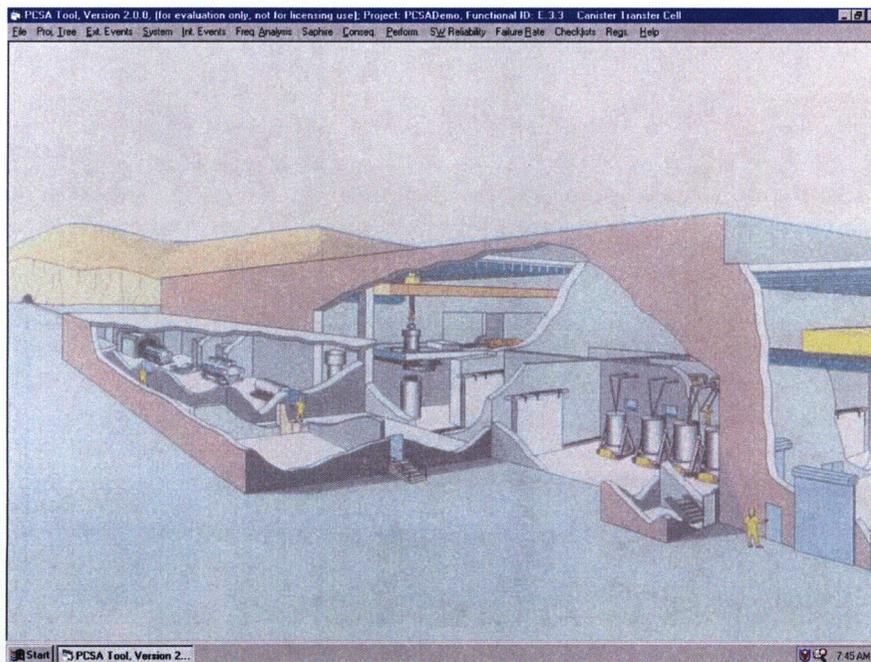


Figure 3.2-1. PCSA Tool Showing Menu Bar

### **3.3 Proj. Tree**

There are two Project Tree (*Proj. Tree*) phases. The first is creating a project tree, while the second is modifying a project tree, which will be discussed in Section 3.3.3.

#### **3.3.1 Creating a Project Tree (Proj. Tree)**

When starting a new project, the **Create Levels for Functional Area** window illustrated in Figure 3.3.1-1, will be displayed with four columns to select the level that will identify a functional area with a Functional ID. The Project Tree assigns an alpha-numeric identification to a functional area that helps systematize data entry and data retrieval in the project database.

The levels are constructed by clicking on the appropriate letter and the sublevel numbers. The tree structure may be viewed using the **View Tree** button. The first column provides options A through Z, and each of the remaining three columns provide options 1 through 9. The Functional ID selection is oriented so the alpha-numeric combination is selected in a set order. With the selection of a level the user builds a Functional ID, which is displayed in the current selection window. The user can either add the Functional ID to the table on the right using **Apply** or clear the selection with **Reset**. To delete a Functional ID, the user must highlight the Functional ID in the table and select **Delete**. The Functional IDs will be placed in order automatically even if an ID is not entered in the correct sequence. For example, if A.1 is inserted after A.2, then A.1 will still be placed before A.2. When the desired number of Functional IDs have been created, select **Done** to advance to the main project screen.

The following list includes basic Project Tree steps:

- (1) **Plan:** Know how many levels the functional area requires and how many sublevels are needed for each level. It is important to plan the project tree structure in advance, because the tool allows limited capability to delete a Functional ID. See the following note.
- (2) **Input the Levels:** Input the alpha-numeric Functional ID using the columns provided, as shown in Figure 3.3.1-1, and select **Apply**.
- (3) **Generate the Project Tree:** When the entries are complete, select **Done** to advance to the main project screen. An entry may be deleted after **Apply** has been selected using the **Delete** command.
- (4) **Describe the Functional Areas:** Provide a description of each functional area at each level and sublevel, by selecting **Proj. Tree** from the top tool bar (see Section 3.3.2).

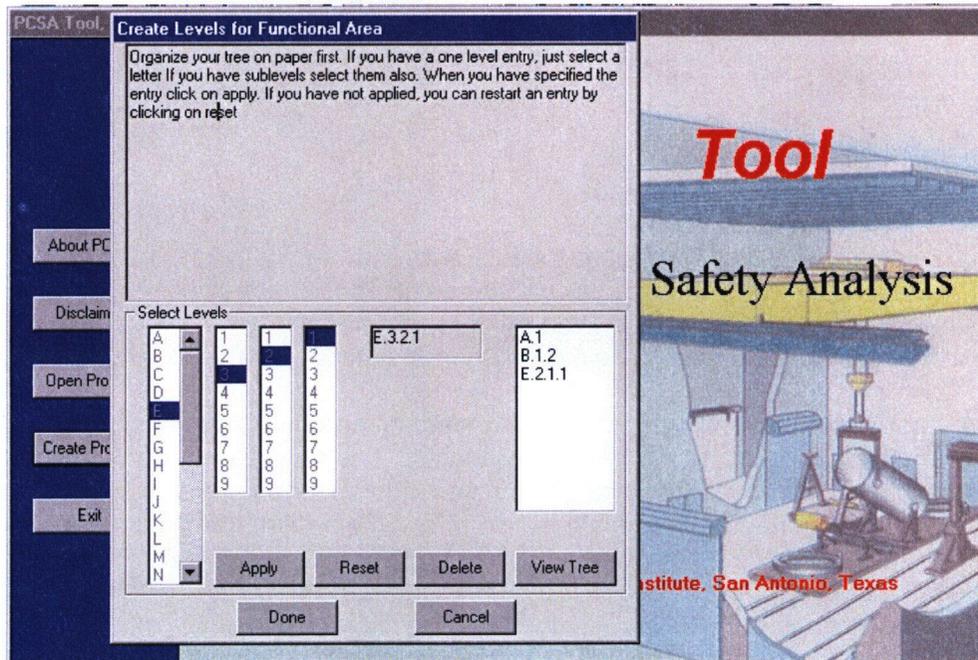


Figure 3.3.1-1. Create Levels for Functional Area Window

### Action Commands

- Apply:** Adds the chosen Functional ID into the Functional Area ID tables.
- Reset:** Clears the Functional ID in the current selection window (Note, **Reset** does not erase the functional ID in the Functional ID table).
- Delete:** Erases a selected Functional ID entry from the Functional ID table.
- View Tree:** Allows the user to see the project tree as it would appear in the project.
- Done:** Allows the user to proceed into project with a created project tree.
- Cancel:** Sends the user back to the opening screen without saving the project tree. The user will be warned with the message "This action will destroy your tree. Do you wish to continue?" before canceling.

⇒ **Note:** ***Delete** is allowed in the Project Tree as long as no data have been entered in another form or table.*

## **Proj. Tree**

⇒ **Note:** *The user is advised to use caution while creating the Project Tree because the tool offers limited flexibility in deleting a Functional ID that has been incorrectly or inadvertently applied. The user must note that a Functional ID already selected (using **Apply** button) cannot be further subdivided. To subdivide the functional area, the user must delete the Functional ID and recreate with the desired sublevels. Another note of caution, the Functional ID can only be deleted if there is no data entered in the database under this Functional ID. It is recommended that the user make several trials to become familiar with building a project tree and understand the limitations before embarking on developing a bigger tree for a project.*

### 3.3.2 Functional Area Descriptions

After the **Project Tree** has been created, selecting a base level will display the **Functional Area Descriptions** window shown in Figure 3.3.2-1, which allows the user to input descriptions of each area. At the bottom of the window, Remarks and Saphire Project Location data may be input without any character limitations.

The screenshot shows a dialog box titled "Functional Area Descriptions". Inside, there is a section "Enter Level Information". It contains four rows, each with a "Level" label and a "Description (40 characters Max.)" label. The 1st Level has a "Functional ID" field with "E.3.3" and a description field with "Surface Waste Handling Facility". The 2nd Level has a description field with "Canister Transfer System". The 3rd Level has a description field with "Canister Transfer Cell". The 4th Level has an empty description field. Below these are two text areas: "Remarks (Optional)" and "Saphire Project Location (Optional)". At the bottom are "OK" and "Cancel" buttons.

Figure 3.3.2-1. Functional Area Descriptions Menu

#### Action Commands

- 
- OK:** Accepts any additions or changes made by the user and closes the Functional Area Descriptions window.
- Cancel:** Closes the Functional Area Descriptions window without retaining any input made by the user.
-

### **3.3.3 Modifying a Project Tree**

The project tree can be modified at any time. The **Proj. Tree** menu can be selected from the top menu bar to display the **Project Tree** window. The **Project Tree** window opens with the first level shown, while the sublevels are displayed by expanding on each node, as shown in Figure 3.3.3-1.

To add a functional area, the **Add Level** button can be used. The **Add Level** button displays a **Edit Levels for Functional Area** window, shown in Figure 3.3.3-2, and the functions of the buttons in that dialog box are given on page 3-5.

The user can delete the functional area at the end of a branch if there is no data associated with the functional area.

### **3.3.4 Selecting a Functional Area**

The **Proj. Tree** menu prompts a **Project Tree** window that displays an expandable and collapsible tree view of the functional area, as shown in Figure 3.3.3-1. The **Project Tree** is used to show and develop the organization of functional areas as a tree structure. This window helps to manage data from the facility hazard analysis in a systematic manner. The data for each node of the tree can be expanded to three levels, allowing three levels of subsections for each functional area. When the lowest level of a functional area is selected and the **Done** button is clicked, a graphical user interface activates the **System**, **Int. Event**, and **Freq. Analysis** menus (see Figure 3.2-1), and the **Current Level Results** submenu under the **Perform.** menu.

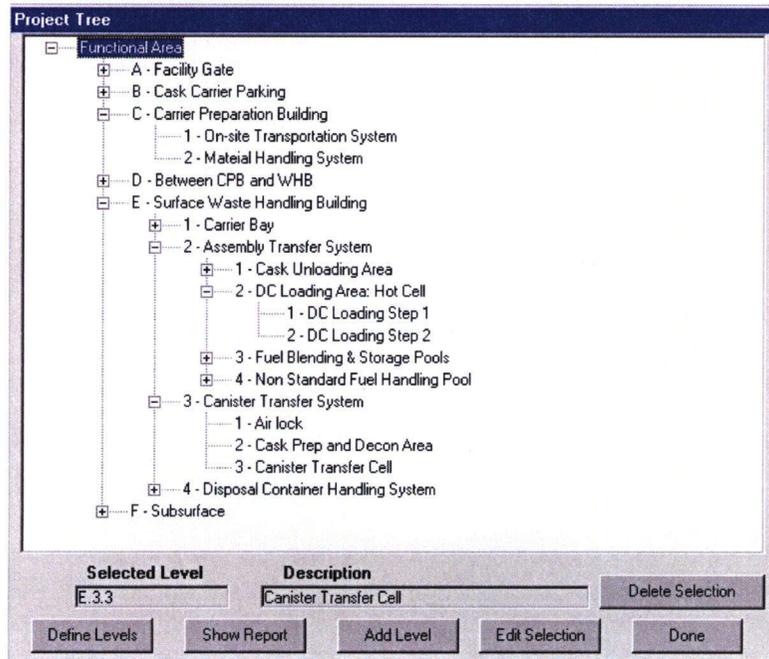


Figure 3.3.3-1. Project Tree Functional Areas Expanded to Fourth Level

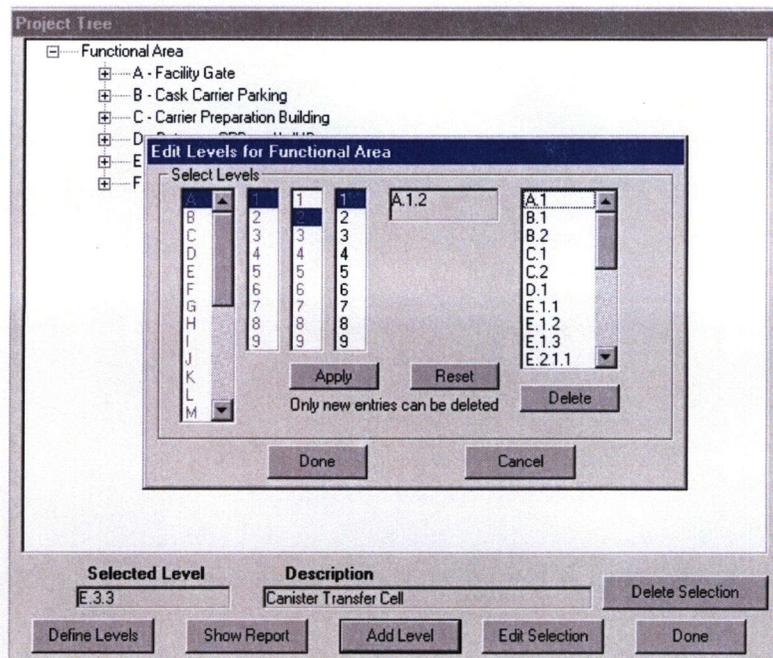


Figure 3.3.3-2. Edits Levels for Functional Area Window

### Action Commands

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- Delete Selection:** Allows the user to delete a base level of Functional Area ID. Deletion is allowed only if no data exist in the database corresponding to the Functional ID.
- Define Levels:** Allows the user to define levels to each functional area. The drop-down list can be used to define the label. The user can type in the desired label.
- Show Report:** Displays the Project Tree in report format.
- Add Level:** Allows the user to add a level to the Project Tree. Selecting **Add Level** will display a dialog box similar to that shown in Figure 3.1-1.
- Edit Selection:** Allows the user to modify a functional area.
- Done:** Exits the **Project Tree** window retaining any changes made by **Add Level** and **Edit Selection**. If a functional area is selected the **Done** button activates **S**ystem, **I**nt. Event, **F**req. Analysis menus and **C**urrent Level Results submenu under **P**erform. menu.
- 

⇒ *Note: If a Functional ID has not been selected, other project options will not be available.*

### 3.4 **Ext. Events**

The **Ext. Events** menu contains a submenu, *Generic List*, that leads to a database with tables containing a generic list of naturally occurring and human-induced external events. The event screening process is based on an in-depth review of U.S. Department of Energy (DOE) reports or an independent analysis. The outcome of the review for each category can be stored in the database.

#### 3.4.1 **Generic List**

The Naturally Occurring and Human-Induced Events window as shown in Figure 3.4.1-1 is accessed by selecting **Ext. Events** from the main menu and opening the *Generic List* submenu. The table shows the four screening criteria: Potential exists for event to be applicable; Rate of process high enough to affect facility; Consequence of an event significantly high to affect facility; and Event Frequency (per year). To consider an event applicable to the repository site, the outcome for the first three screening categories should be Y (yes), and the frequency of occurrence of the event should be greater than the Category 2 frequency limit. A potential initiating event is indicated by Y in the Applicability of the Events to the Site column while N indicates a negative outcome. Based on the four screening criteria listed on the left-hand side in Figure 3.4.1-1, the Applicability of the Event to the Site is automatically determined by the program for an event being evaluated.

Naturally Occurring and Human-Induced Events						
Generic List of Events	Ext Hazard ID	Potential exists for event to be applicable	Rate of process high enough to affect facility	Consequence of event significantly high to affect facility	Event Frequency (per yr)	Applicability of the Event to the site
Debris avalanching	EXHZ_DBR_AVLN	Y	Y	Y	1.00E-06	Y
Denudation	EXHZ_DENUATION	Y	N	N	N/A	N
Dissolution	EXHZ_DISSSOLUT	Y	Y	Y	1.00E-06	Y
Eperogenic displacement	EXHZ_EPER_DISP	Y	N	N	N/A	N
Erosion	EXHZ_EROSION	Y	N	N	N/A	N
Extreme weather fluctuations	EXHZ_EXTR_WTHR	N	N	N	N/A	N
Extreme wind	EXHZ_EXTR_WIND	Y	Y	Y	1.00E-06	Y
Fire (facility)						
Fire (range)	EXHZ_FIRE_RANGE	Y	Y	Y	1.00E-06	Y
Flooding (storm, river diversion)	EXHZ_FLOOD	Y	Y	Y	1.00E-06	Y
Fungus, bacteria, and algae	EXHZ_FUNGUS	Y	Y	N	N/A	N
Glacial erosion	EXHZ_GLAC_EROS	N	N	N	N/A	N

Double click on a heading to edit

**Figure 3.4.1-1. A Site-Specific Hazard Analysis Database**

## **Ext. Events**

### **Action Commands**

---

- Only Applicable:** Displays the list of potential initiating events. To return to the main list, select **Show All**.
- Add Event:** Adds another event to the Generic List of Events. The Tool will prompt the user with a text box titled **Add Event**.
- Delete Event:** Erases the event selected by the user.
- Show Report:** Displays the information in report format.
- Close:** Closes the menu and returns the user to the main project screen.
- 

### **3.4.2 Editing and Creating Event**

The event screening process will be based on an indepth review of DOE reports. The outcome of the review for each screening criterion can be stored in the database by double-clicking on an event in the Generic List of Events column which will launch an **Events** window similar to that in Figure 3.4.2-1. The fields provided in the form allow the reviewer to provide comments about the DOE Definition of events, Required Condition for the events, and brief discussions about corresponding screening criteria. In general, decisions about screening criteria will be made based on DOE document reviews, and the review finding may be provided in the corresponding text fields to support the decision made. The tool provides text field to record the review outcome of DOE documents for four screening criteria: Potential exists for event to be applicable; Rate of process high enough to affect facility; Consequence of an event significantly high to affect facility; and Event Frequency (per year). Acceptance of a screening criterion is indicated by clicking the **Yes** button which automatically updates the corresponding criterion in the Generic List of Events in Figure 3.4.2-1. Furthermore, the events form has Additional Discussion and DOE References text fields for storing more information. If there is an independent report generated from the review, the report file can also be linked to the database by providing the name and path of the directory structure.

**Fire (range)**

**Definition:**  
The combustion of natural vegetation external to the repository that propagates to combustible materials within the MGR operations area.

**Ext. Hazard ID:** EXHZ\_FIRE\_RAN

**Required Condition:** Combustible materials must exist on the site.

**Evaluation**

Potential exists for the event to be applicable to the site  
 Yes  No Potential exists and is applicable to the Yucca Mountain site. Since vegetation is present and at least one source of range fires then range fires are possible.

Rate of process high enough to affect the facility during preclosure period  
 Yes  No The rate of the process is sufficient to affect the 100-year operational period.

Consequence of process significantly high to affect the facility during preclosure period  
 Yes  No The consequence of the process is significant enough to affect the 100-year operational period. Since this statement is indeterminate then the statement is treated as equivalent to true.

**Event Frequency**  
 (per yr) 1.00E-06  
 Justification for Frequency: The event frequency is greater than or equal to 10<sup>-6</sup>.

**Additional Discussion:**  
 This event will be included in the Fire Hazards Analysis. This event includes fires that occur externally to the repository system, such as a range fire. Fires can be man-made or initiated by other external events such as lightning. For the purpose of this evaluation, if fire-initiating events occur

**DOE References:**

**NRC Review Report File Name:** [Text Field] DOE References View Report File

OK Apply Cancel Show Report

**Figure 3.4.2-1. Form to Store Staff Review Results for a Site-Specific Hazard**

## Action Commands

- OK:** Accepts the information input by the user and returns the user to the *Generic List* submenu.
- Apply:** Accepts the information input by the user without returning to the main project screen.
- Cancel:** Does not accept the information input by the user and returns the user to the main project screen.
- Show Report:** Displays the information in report format.
- View Report File:** Displays the referenced report in NRC Review Report FileName text field, provided it exists in the specified location in the **/Documents** subdirectory and the computer has an appropriate viewer compatible with the report file format.

⇒ **Note:** The report file's extension (.wpd, .doc, and such) must be registered on the computer in order for the **View Report File** feature to work.

## **System**

### **3.5 System**

Information required for operational hazard analysis is compiled in this menu.

#### **3.5.1 Sysdesc**

The **System Description** window, is opened in the PCSA Tool by clicking on the SysDesc submenu item under the **System** menu. The **System Description** window, shown in Figure 3.5.1-1, can be used only when a functional area is selected from the **Proj. Tree** menu. The **System Description** window provides fields to document a detailed description of the functions of the system, a detailed operation sequence, a list of equipment used, source terms in the functional area being analyzed, and human actions. Each box may contain an unlimited number of characters. The descriptions of individual data entry fields shown in Figure 3.5.1-1 are presented next.

**Functional ID:** Displays Functional Area ID chosen in the **Project Tree** window along with the level descriptions to the right. All information input into the **System Description** window will correspond to this Functional ID. The Functional ID may not be modified in this window.

**Functions:** Provide a brief description of the functions of the system or process being analyzed.

**Detailed Operations Sequence:** Enter step-by-step sequence of operations in the functional area.

**Equipment Used:** List equipment used in the handling operation of radioactive waste (e.g., overhead bridge crane, manipulator, and such).

**Nuclear Material Handled:** List radioactive waste material handled in this functional area (e.g., 4-BWR, 2-PWR).

**Software Systems:** Enter software systems, if any, used in operating equipment that handle radioactive waste.

**Human Actions:** (a) **Maintenance and Standby:** Describe briefly human actions for maintenance and standby if available. (b) **Operational:** Describe briefly human operations interaction with devices such as software, remote system, and such.

**Additional information:** Enter any additional information.

**DOE References:** Enter information about DOE references.

System Description			
<b>Functional ID</b>	Surface Waste Handling Building Canister Transfer System Canister Transfer Cell		
<b>Functions</b>	The CTS receives transportation casks, without impact limiters, containing large and small disposable canisters, unloads canisters from the cask, and loads them into Disposal Containers (DC). Large canisters are stored directly from transportation canisters into a DC. Small canisters are loaded either		
<b>Detailed Operations Sequence</b>	Ensure Airlock exit door is closed Open Airlock entrance door Transport Cask and Cart to airlock		
<b>Equipment Used</b>	(i) Remotely operated transfer carts (ii) Remotely operated cask reparation manipulators equipment sampling	<b>Nuclear Material Handled</b>	(1) Defense High-Level Waste (DHLW) vitrified glass requires two lifts per canister
<b>Software Systems</b>	Not known at present time		
<b>Human Actions A) Maintenance and Standby</b>	Not known at present time	<b>Human Actions B) Operational</b>	Not known at present time
<b>Additional Information</b>	Test Additional Information, Line 1 Line 2 Line 3		
<b>DOE References</b>	DOE. "Preliminary Preclosure Safety Assessment for Monitored Geologic Repository Site Recommendation." TDR/MGR/ISE/000009. Rev. 00/ICN 03. Las Vegas, Nevada: DOE. 2001. DOE. "Yucca Mountain Science and Engineering Report Technical Information Site		
<input type="button" value="Apply"/> <input type="button" value="Show Report"/> <input type="button" value="OK"/> <input type="button" value="Cancel"/>			

Figure 3.5.1-1. Example of System Description Window

## Action Commands

- 
- Apply:** Transfers data entered in the form to the working copy of the project database without closing the screen. Data can be permanently saved in the project database only by selecting the *File* → *Save* from the main menu.
- Show Report:** Displays the information input into the **System Description** form in a report format. The **Show Report** option becomes inactive when inputting new information into a description field. Clicking **Apply** reactivates this option.
- OK:** Applies the information input in the window and closes the form.
- Cancel:** Closes the **System Description** window. If **Apply** was not clicked, the information input will be lost. If **Apply** was clicked, the information is retained after clicking **Cancel**.
-

### **3.6 *Int. Events***

The Internal Events (*Int. Events*) menu is located in the main menu bar of the PCSA Tool (see Figure 3.2-1). *FMEA*, *What If*, *Energy Method*, *HRA*, and *Severe Events (All)* are submenus of the *Int. Events* menu.

#### **3.6.1 *FMEA***

Under the *Int. Events* menu, the Failure Modes and Effects Analysis (*FMEA*) is a submenu that leads to the *Form*, *Table*, and *Severe Events* submenus. Upon selecting the *Form* or *Table* submenu, the tool launches an *FMEA Form* or *FMEA Table* window. Text fields for data entry and the buttons for Action Commands in *FMEA Form* are shown in Figure 3.6.1-1. At the top, the form also displays information related to the functional area being analyzed. The *FMEA Form* fills only one row of a record in an *FMEA Table*. There is no restriction on the amount of information that can be stored in each text field.

The *FMEA Table* displays data in tabular format. Rows can be inserted between records by incrementing item numbers in decimals. For example, to insert a row between row 3 and 4, the item number may be specified as 3.6. Additional edit features (Copy, Edit, Paste) can be accessed by right clicking on the mouse. The *FMEA Table* is displayed in Figure 3.6.1-2. The *FMEA Table* submenu launches the *FMEA Table*, that shows the same information arranged in a tabular fashion. The data can be entered in the *FMEA Form* or *Table*, and the user can use both forms interchangeably. The descriptions of individual data entry fields shown in Figure 3.6.1-1 are presented next.

**Functional ID:** Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

**Item Number:** A serial number is automatically assigned to the current record.

**Component Description:** Enter the components of the system or process being analyzed.

**Failure Mode:** Describe briefly the type of failure associated with the component. A list of failure modes for limited number of components can be obtained from the **Checklist** menu.

**Cause of Failure:** Describe the reason for failure.

**Effect of Failure:** Describe the effect of the failure.

**DOE Safeguards and Controls:** Describe safeguards and controls, if any, against the type of failure.

**Additional Information:** Enter additional information.

**Severe Events:** Select **Yes** or **No** and enter justification for selection. Each potential failure that may result in a radioactive dose to the public or workers is judged according to severity, on a qualitative basis, and entered as **Yes** or **No** in the **Severe Event** field.

**Justification:** Enter the rationale for selecting the **Yes** or the **No** button. If the decision is based on certain calculations, the user can record this in the Justification box.

FMEA Form, Project: PCSADemo

Functional ID: Surface Waste Handling Building  
Canister Transfer System  
Canister Transfer Cell  
E.3.3

Item No.: 0001.00 Component Description: Shield Door

Failure Mode: Fail Open

Cause of Failure: Power Failure, Mechanical Failure, Human Error

Effect of Failure: Possible spread of contamination

DOE Safeguards and Controls: Adequate design to prevent failure of the door

Additional Information:

Severe Events:  Yes  No

Justification:

Add Record Delete Record Edit Record Record: 1 Show Report FMEA Table Close

Figure 3.6.1-1. Example of Failure Modes and Effects Method (FMEA) Form

FMEA Table, Project: PCSADemo

Functional ID: Surface Waste Handling Building  
Canister Transfer System  
E.3.3 (This field cannot be changed)

Item No	Component Description	Failure Mode	Cause of Failure	Effect of Failure	DOE Safeguards & Controls	Severe Events	Justification	Additional Info
0001.00	Shield Door	Fail Open	Power Failure,	Possible spread of	Adequate design to	N	Proper safe guard in	
0002.00	Shield Door	Fail Close	Power failure,	Disruption of	Administrative control.	N	Proper safe guard in	
0003.00	Shield Door	Fail Drop on Cask	Power Failure,	Damage to cask	Administrative control.	N	Proper safe guard in	Shield door re
0004.00	Trolley	Incorrect position	Sensor fail.	Lid handling	Design of over-travel	N		
0005.00	Trolley	No Braking,	Brake Failure.	Collision with	Administrative control.	N		
0006.00	Bridge crane	Crane Yoke	Structural failure.	Possible drop of	Administrative control.	Y		
0007.00	Bridge Crane	Lid Falls to	Lid jammed on to	Possible tipover of	Proper visibility with	N	Energy not sufficient	
0008.00	Bridge Crane	Crane Failure	No Power	Canister Drop on	Equipment designed	Y		
0009.00	Bridge Crane	Crane Failure	No Power	Canister drop on	Crane designed to fail	Y		
0010.00	Bridge Crane	Crane Failure	No power	Canister drop on	Crane designed to fail	Y	Normal Height 22 ft.	
0011.00	Bridge Crane	Crane Yoke	Structural failure	Possible drop of	Proper visibility with	N	Proper safe guard in	No damage to
0012.00	Bridge Crane	Lid fails to detach	Lid jammed onto	Possible tip over	Proper visibility with	N	Proper safe guard in	Energy not su
0013.00	Bridge Crane	Crane Failure	Failure of	Canister Drop on		Y	Possible Breach of	Number of ca
0014.00	Bridge Crane	Crane Failure	Structural Failure	DC tipover and	Crane designed to fail	Y		Possible brea
0015.00	Bridge Crane	Crane Failure	Structural Failure	Canister drop on	Crane designed to fail	Y		Normal Avg. I

FMEA Form Add Record Edit Record Copy Record Delete Record Show Report Close

Figure 3.6.1-2. Example of Failure Modes and Effects Method Table

### **Action Commands (Figures 3.6.1-1 and 3.6.1-2)**

---

<b>Add Record:</b>	Activates the text box and allows the user to add a record.
<b>Delete Record:</b>	Deletes the record currently displayed in the form window. The user will be prompted "Are you sure you want to delete record?" after <b>Delete Record</b> is selected.
<b>Edit Record:</b>	Allows the user to modify any data entry fields.
<b>Show Report:</b>	Displays the information in the form and table in a report format.
<b>FMEA Form/ FMEA Table:</b>	Allows the user to toggle between FMEA Form and FMEA Table windows.
<b>Close:</b>	Returns to the main project screen after saving changes made in the form or table, however, does not save changes to the project database. To save changes in the database, the user must save the information from <b><u>F</u>ile</b> menu → <b><u>S</u>ave</b> submenu.
<b>Cancel:</b>	The <b>Cancel</b> option is displayed only after <b>Add Record</b> or <b>Edit Record</b> is selected. <b>Cancel</b> returns the user to the default form display screen without saving the information.
<b>Update Record:</b>	The Update Record option appears only after <b>Add Record</b> or <b>Edit Record</b> is selected. <b>Update Record</b> applies and saves any new information or changes made with the <b>Add Record</b> and <b>Edit Record</b> commands.
<b>Copy Record:</b>	Available only in FMEA Table window, copies the information of the entire row into another row.

---

#### **3.6.1.1            Severe Events**

When the Severe Events submenu is selected from the FMEA submenu, **Severe Events List for FMEA** window is displayed containing the events filtered by **Yes** in the Severe Events field in the FMEA Table window. As shown in Figure 3.6.1-3, the table also displays Failure Mode, Cause of Failure, Effects of Failure, Justification from the **FMEA Table** window, and Remarks. The user can enter any additional information in the Remarks column. It is recommended that the user note whether this hazard was included or excluded based on further action taken in this analysis. The tool also generates a report from the severe events list.

Severe Events List for 'FMEA', Project: PCSADemo

Functional ID: E.3.3  
Surface Waste Handling Building  
Canister Transfer System  
Canister Transfer Cell

Item No.	Component Description	Failure Mode	Cause of Failure	Effect of Failure	Justification	Remarks
0006.00	Bridge crane (Lifting)	Crane Yoke	Structural failure,	Possible drop of cask lid on		
0008.00	Bridge Crane (Lifting)	Crane Failure (Normal	No Power	Canister Drop on Cask		
0009.00	Bridge Crane (Lifting)	Crane Failure (Normal	No Power	Canister drop on DC		
0010.00	Bridge Crane (Lifting)	Crane Failure (Normal	No power	Canister drop on floor	Normal Height 22 ft,	
0013.00	Bridge Crane	Crane Failure During	Failure of Mechanical	Canister Drop on Staging	Possible Breach of	FMEA test remark
0014.00	Bridge Crane	Crane Failure (Normal	Structural Failure	DC tipover and multicanister		FMEA test remark
0015.00	Bridge Crane	Crane Failure (Normal	Structural Failure	Canister drop on floor		FMEA test remark

Edit Record Show Report Close

Figure 3.6.1-3. Severe Events List Window

### Action Commands

- Edit Record:** Allows the user to edit only the Remarks field.
- Show Report:** Generates a report on **Severe Events** for display and printing.
- Close:** Closes the window, accepting any changes made to the Remarks field.

### 3.6.2 What-If

The tool functions for a What-If analysis are similar to the FMEA. The analysis is performed by entering data into the database through a Form or Table submenus. A What-If analysis would identify potential initiating events from human interactions. A similar process What-If is used to filter the severe events. An example of What-If analysis applied to the offsite transportation system in Functional Area B.1 is presented in Figure 3.6.2-1. The descriptions of individual data entry fields shown in Figure 3.6.2-1 are presented next.

**Functional ID:** Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

**Item No.:** A serial number is automatically assigned to that current record.

## Int. Events

**What If:** Identify possible event by posing questions with regard to each operation sequence (e.g., What if a specific component failure or process upset, or human error occurs?)

**Causes:** Identify the cause(s) of such an event.

**Consequences:** Speculate on potential consequence to the event.

**DOE Safeguards:** Identify any DOE safeguard(s) to mitigate the event.

**Additional Information:** Store additional information.

**Severe Events:** Select **Yes** or **No** with justification for selection. Each potential failure that may result in a radioactive dose to the public or workers is judged according to severity, on a qualitative basis, and entered as **Yes** or **No** in the Severe Event field.

**Justification:** Enter the rationale for selecting the **Yes** or the **No** button. If the decision is based on certain calculations, the user can record this in the **Justification** box.

What If Form, Project: PCSADemo

Functional ID	Cask Carrier Parking Off-site Transportation System
Item No.	0001.00
What If	(1) Driver forgot to chock the trailer (2) Improper chocking
Causes	Human Error
Consequences	1. Damage to cask due to truck roll and crash into CPB gate 2. Truck rolls back and crashes into other vehicle
DOE Safeguards	(a) Level parking area (b) Use of guard posts to prevent damage to gate (c) Proper training of operators
Additional Information	If recommended safeguards are in place then further action is not necessary
Severe Events	<input checked="" type="radio"/> Yes <input type="radio"/> No
Justification	

Add Record Delete Record Edit Record Record 1 Show Report What If Table Close

Figure 3.6.2-1. Example of a What-If Analysis Form Window

**Action Commands**

---

<b>Add Record:</b>	Activates the text box and allows the user to add a record.
<b>Delete Record:</b>	Deletes the record currently displayed in the form window. The user will be prompted "Are you sure you want to delete record?" after <b>Delete Record</b> is selected.
<b>Edit Record:</b>	Allows the user to modify anything in the form.
<b>Show Report:</b>	Displays information in report format.
<b><u>What-If Table/</u> <u>What-If Form:</u></b>	Allows the user to toggle between <u>What-If Form</u> and <u>What-If Table</u> windows.
<b>Close:</b>	Returns to the main project screen temporarily saving any changes.
<b>Update Record:</b>	The <b>Update Record</b> option appears only after <b>Add Record</b> or <b>Edit Record</b> is selected. <b>Update Record</b> applies and saves any changes made with <b>Add Record</b> and <b>Edit Record</b> commands.
<b>Cancel:</b>	The <b>Cancel</b> option appears only after <b>Add Record</b> or <b>Edit Record</b> is selected. <b>Cancel</b> returns the user to the default display screen.
<b>Copy Record:</b>	Available only in <u>What-If Table</u> window; copies the information in the entire row into another row.

---

**3.6.2.1            Severe Events**

When the Severe Events submenu is selected from the What-If submenu, a table screen is displayed that contains the events filtered by **Yes** in the Severe Events field in the What-If Table.

### **3.6.3 Energy Method**

Located under the **Int. Events** menu from the main menu bar, the **Energy Method** (Figure 3.6.3-1) is initiated by selecting either the **Form** or **Table** submenus. The **Energy Analysis Form** allows using the checklists to identify the hazards in the system. Adopting the DOE approach (CRWMS M&O, 1999), the events have been categorized as collision/crushing, chemical contamination/flooding, explosion/implosion, fire, radiation/magnetic/electrical/fissile, and thermal. Upon selecting a category from the drop-down list in the form, the checklist and the applicability guidelines appear. The checklist helps to identify the energy in the system that can potentially interact with the wastefrom. The checklists developed by DOE contain a series of questions for each generic hazard. The descriptions of individual data entry fields shown in Figure 3.6.3-1 are presented next.

**Functional ID:** Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

**Generic Event and Applicability Guidelines:** Displays checklist to identify potential hazards applicable to the event category. This text field cannot be edited.

**Item No.:** A serial number is automatically assigned to the current record.

**Event Category:** Choose an event category from the drop-down list.

**Event Name:** Provide brief description of the event.

**Cause of Event:** Described cause of the event.

**Severe Events:** Select **Yes** or **No** with justification for selection. Each potential failure that may result in a radioactive dose to the public or workers is judged according to severity, on a qualitative basis, and entered as **Yes** or **No** in the **Severe Events** field.

**Justification:** Enter the rationale for selecting the **Yes** or the **No** button. If the decision is based on certain calculations, the user can record this in the **Justification** box.

**Additional Information:** Enter additional information.

**Energy Analysis Form, Project: PCSADemo**

**Functional ID:** Waste Handling Building  
E.3.3 Canister Transfer System  
Canister Transfer Cell

**Event Category:** < Previous Collision/Crushing Next >

**Generic Event and Applicability Guidelines**

**CATEGORIES:**

1. Uncontrolled Mass/Force -- Examples include:  
Excessive velocity or acceleration of mass, inadvertent operation of appendage, failure of primary/secondary structure, tumbling (or tipped-over) mass, uncontrolled robot or uncontrolled fixed rotating equipment falls, drops.
2. Protrusions into pathways -- Examples include:  
Extended appendages, protruding structural elements, or improperly placed equipment.

**APPLICABILITY TO FUNCTIONAL AREA OF DESIGN:**

1. Is kinetic or potential energy present?
2. Can the kinetic or potential energy be released in an unplanned way?
3. Can the release of kinetic or potential energy interact with the waste form?

**Item No.:** 0008.00

**Event Name:** Canister Drop onto Another Canister

**Cause of Event:** Overhead crane failure

**Severe Events:**  
 Yes  
 No  
Canister with weld defect has potential to breach radiological material.

**Justification:**

**Additional Information:**  
This event has been identified by DOE in CRWMS M&O, "Monitored Geologic Repository Internal Hazard Analysis", ANL-MGR-SE-000003 REV 00

Buttons: Add Record, Delete Record, Edit Record, Record: 8, Show Report, Energy Anal. Table, Close

Figure 3.6.3-1. Example of an Energy Method Window

### Action Commands

- 
- Add Record:** Activates the text box and allows the user to add a record.
- Delete Record:** Deletes the record currently displayed in the form window. The user will be prompted "Are you sure you want to delete record?" after **Delete Record** is selected.
- Edit Record:** Allows the user to modify anything in the form.
- Show Report:** Displays information in report format.
- Energy Anal. Form  
Energy Anal. Table:** Toggles between Energy Analysis Form and Energy Analysis Table windows.
- Close:** Returns to the main project screen temporarily saving any changes.
- Update Record:** **Update Record** option is displayed only after **Add Record** or **Edit Record** is selected. **Update Record** applies and saves any changes made with the **Add Record** and **Edit Record** commands.

## ***Int. Events***

- Cancel:** The **Cancel** option is displayed only after **Add Record** or **Edit Record** is selected. **Cancel** returns the user to the default form display screen.
- Copy Record:** Available only in **Energy Anal. Table** window, copies the information in the entire row into another row.
- 

### **3.6.3.1            Severe Events**

When the Severe Events submenu is selected from the Energy Method submenu, a window is displayed containing the events filtered by **Yes** in the Severe Events field in the Energy Method Table.

### 3.6.4 HRA

The Human Reliability Analysis (HRA) feature can only be used when a functional area is selected from the **Proj. Tree** menu. The HRA submenu is selected from the **Int. Events** menu in the main menu bar of the PCSA Tool. Form, Table, and Severe Events are submenus of the HRA submenu.

The Form submenu launches the **Human Reliability Analysis Form** window (Figure 3.6.4-1). The Table submenu brings up the **Human Reliability Analysis Table**, which shows the same information arranged in a tabular fashion. The data can be entered using Form or Table, and the user can use both forms interchangeably. The descriptions of individual data entry fields shown in Figure 3.6.4-1 are presented next. Further information on the data entry fields can be obtained from Dasgupta, et al. (2002).

Functional ID: Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

Item No.: Serial number is automatically assigned to the current record.

Category: The appropriate human action category is indicated. The main categories are: Type A—Maintenance and Standby Human Events; Type B—Operational Human Events (two subcategories); Type C—Responsive Human Events (three subcategories).

Human Action: This would be one of the Human Actions now listed in the System Description template. It is a description of the human action that may lead to error.

Human Failure Event: There may be several types of errors possible for a single human action. For example, a task might be omitted, a valve might be turned in the wrong direction, or a valve might be turned too far in the correct direction.

Performance Shaping Factors: In this field, the analyst would indicate any performance shaping factors that would influence the human error probability (e.g., training, stress level, use/no use of checklist, repetitiveness of action).

Recovery Action: In this field, the analyst would indicate what actions could be taken to recover from the error. For example, a supervisor checking after maintenance might discover and correct an inappropriately closed valve.

Effect of Failure: For Type A Human Actions, the effect of failures is always enabling of some other initiating event; for Type B Human Actions, the effect of failures could be enabling, but is more likely to produce an initiating event itself. For example, actions during maintenance could close a valve that permits makeup water to be pumped into the assembly storage pool; in the event that a leak from the pool develops because of a mechanical failure, makeup water would not be available and the assemblies could become uncovered in time.

DOE Safeguards and Controls: Safeguards and controls could be either human action oriented (e.g., use a checklist or provide written instructions) or hardware oriented (e.g., use interlocks or stops to prevent incorrect assembly or excessive travel, respectively).

## Int. Events

Additional Information: Enter additional information.

Severe Events: Yes or No.

Justification: The analyst must provide a justification for either choice.

Human Reliability Analysis Form, Project: PCSADemo

Functional ID: E.3.3  
Waste Handling Building  
Canister Transfer System  
Canister Transfer Cell

Item No.: D001.00  
Human Action: Perform maintenance operations on crane

Category: A

Human Failure Event:  
1. Crane control system disabled during maintenance is not reactivated.  
2. Critical maintenance operations are not performed, so control system has higher probability of failure

Performance Shaping Factors:  
1. Is a checklist used?  
2. Have maintenance personnel received training?

Recovery Action:  
1. Is maintenance activity checked? Is any checking performed by the same personnel performing the maintenance, by another crew, or by a supervisor?

Effect Of Failure:  
The crane control system may be or is disabled; therefore, a backup system has been removed.

DOE Safeguards and Controls:  
None specified (test entry).

Additional Information:  
None (the crane is clearly the hardware in use).

Severe Events:  
 Yes  
 No  
Justification: This could lead to an initiating event that crushes the spent fuel - drop of a cask lid onto a cask.

Buttons: Add Record, Delete Record, Edit Record, Record: 1, Show Report, HRA Table, Close

Figure 3.6.4-1. Example of a Human Reliability Analysis Form Window

### Action Commands

- 
- Add Record:** Activates the text box and allows the user to add a record.
- Delete Record:** Deletes the record currently displayed in the window. The user will be prompted "Are you sure you want to delete record?" after **Delete Record** is selected.
- Edit Record:** Allows the user to modify any data entry field.
- Show Report:** Displays information in report format.
- HRA Form**  
**HRA Table:** Allows a toggle between the HRA Form or HRA Table windows.

- Close:** Returns to the main project screen, temporarily saving any changes. To save changes in the database, the user must save the information from the **File**→**Save** menu.
- Update Record:** **Update Record** option is available only after **Add Record** or **Edit Record** is selected. **Update Record** applies and saves any new information or changes made through the **Add Record** and **Edit Record** commands.
- Cancel:** The **Cancel** option is displayed only after **Add Record** or **Edit Record** is selected. **Cancel** returns the user to the default display screen without saving the information.
- Copy Record:** Available only in the **Human Reliability Analysis Table Form**, copies the information in the entire row into another row.
- 

#### **3.6.4.1            Severe Events**

When the Severe Events submenu is selected from the HRA submenu, a table form window is displayed containing the events filtered by **Yes** in the Severe Events field in the **Human Reliability Analysis Form** or **Human Reliability Analysis Table** window. The window displays Category, Human action, Performance shaping factors, recovery Actions, Effects of Failure, DOE Safeguards and Controls, Justification from the **Human Reliability Analysis Form** or **Table**, and Remarks. There is an **Edit Record** button that allows editing only in the Remark column to record additional information. The tool also generates a report on the severe events list using **Show Report** button.

### **3.7 Freq. Analysis**

This menu has four submenus *Initiating Event*, *Event Tree*, *Fault Tree*, and *Event Sequence*.

#### **3.7.1 Initiating Event**

The *Initiating Event* submenu is located in the **Freq. Analysis** menu in the main menu bar. The *Initiating Event* submenu has two submenus, *Form* and *Table*, to enter data into the database and can be used only when a functional area has been selected from the **Proj. Tree** menu. The information can be input into the data entry fields using the **Action Commands**. The **Initiating Event Form** window is shown in Figure 3.7.1-1. The description of individual data entry fields shown in Figure 3.7.1-1 are presented next.

**Functional ID:** Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

**Item No.:** Serial number automatically assigned to the current record.

**Event ID:** Enter an identification number for each initiating event. The tool will not allow entry of additional data in this window without an identification number. The identification number provides a link to event scenarios and sequences and all other subsequent analyses conducted in the tool.

**Hazard ID:** Enter identification number of the hazards, postulated as initiating events, obtained by selecting **Int. Events**→**Severe Events (all)** or **Ext. Events**→**Only Applicable** from the main menu.

**DOE Event:** Select a checkbox if the information pertains to an event identified by DOE. An event is considered to be a DOE event if the user retains all the DOE-calculated data (initiating event frequency, event sequence frequency, and dose estimate). If, however, any DOE-calculated data are reevaluated using the tool, the event is no longer considered to be a DOE event. If such a reevaluation occurs, the information should be recorded in the **Additional Information** field.

**Description:** Provide short description and nature of initiating event, whether operational or natural, or human induced.

**Preclosure Period:** Assign preclosure period associated with each initiating event. User can use the drop-down list to select the preclosure period or type it in.

**Frequency:** Enter frequency of the initiating event.

**Category:** The tool will automatically input the frequency category of the initiating event based on the frequency category limits defined in 10 CFR Part 63 once frequency is provided.

**Uncertainty:** Enter information on uncertainty in estimating the frequency of initiating event if the **Yes** button is selected.

**Frequency Calculation Details:** Record detailed information on the frequency estimation, including all calculations, in this field. When the frequency calculator is used, the numbers used in calculating frequency are automatically transferred into this field.

**Event Included for Sequence Analysis:** Enter the decision to exclude or include initiating events from the hazards list in preclosure safety analysis for determining event sequences using the **Yes** or **No** button.

**Justification:** Record the reason for inclusion or exclusion of initiating events for further preclosure safety analysis.

**Additional Information:** Provide comments, remarks, references to reports, and literature citations.

**Initiating Event Form, Project: PCSADemo**

**Functional ID:** Waste Handling Building  
E.3.3 Canister Transfer System  
Canister Transfer Cell

**Item No.:** 0001.00    **Event ID:** CTS-IE-01    **Hazard ID:** HazardID1     DOE Event

**Description:** Bridge crane failure during transfer of canisters from transportation cask to Disposal containers

**Preclosure Period:** 100        **Frequency:** 2.72E-02    **Category:** 1

**Uncertainty:**  
 Yes  
 No

**Information:**

**Event Included for Sequence Analysis:**  
 Yes  
 No

**Justification:** Initiating event frequency > 10E-6  
A defective canister can breach upon fall

**Frequency Calculation Details:**  
 (Failure Rate: 0.000017) \* (Number of Hours or Demands: 1602) = (Number of Failures: 0.027234)  
 Demand calculations: Number of canisters handled per year is 801. Each canister is

**Additional Information:**  
 Probability of Bridge crane failure per demand is 1.7E-5. The failure probability bridge crane system is analyzed by fault tree, using SAPHIRE. The fault tree details can be found in event is BDCF the

           Record: 1           

**Figure 3.7.1-1. Initiating Event Form**

## **Freq. Analysis**

### **Action Commands**

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- Add Record:** Activates the data entry fields and the **Freq. Calculator** button and allows the user to add a record to the form.
- Delete Record:** Deletes the record currently displayed in the form. The user will be prompted "Are you sure you want to delete record?" after **Delete Record** is selected.
- Edit Record:** Allows the user to modify anything in the form.
- Show Report:** Displays information in report format.
- Init Event Table:** Displays the form in tabular format. While in tabular format, the user may return to the **Init Event Form** window by selecting **Init. Event Form**.
- Close:** Returns to the main project screen, automatically saving any changes.
- Update Record:** Applies and saves any changes made in the **Add Record** and **Edit Record** commands.
- Freq. Calculator:** Displays the **Frequency Calculation** window to calculate expected frequency of failure when failure rate and number of operating hours or demands are entered. The information gets automatically recorded in this Frequency Calculation Details field.
-

### 3.7.2 Event Tree

Event scenarios are created in the PCSA Tool to serve as inputs for the event tree diagrams to be modeled and analyzed using the SAPHIRE Version 6.70 code. To develop an event scenario, the user selects the **Freq. Analysis** menu in the main menu bar and the Event Tree submenu. The event scenarios are developed using the **Event Tree Form** shown in Figure 3.7.2-1. The user develops an event scenario based on the initiating event and postulated sequence of events. The user assigns a unique alphanumeric identification for the scenario in the Scenario ID field and provides the appropriate data entry information. In addition, the **Event Tree Form** includes a **Yes** or **No** radio buttons for the user to select if the postulated event scenario will be used for the safety assessment and risk assessment analysis later. By default, all event scenarios are included in the analysis, while event scenarios not required to safety assessment can be deselected. The user, however, can make the choice at any time and is not required to decide while developing the event scenario. The descriptions of individual data entry fields shown in Figure 3.7.2-1 are presented next.

Functional ID: Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

- **Event Scenario Section**: To access the text fields in the Event Scenario section, the user must select one of the buttons **Add Scenario**, **Delete Scenario**, or **Edit Record** at the bottom of the form.

Item No.: A serial number of the record in the database pertaining to the current form is automatically assigned.

Scenario ID: Provide alphanumeric identification to the scenario. The tool will not allow entry of additional data without a scenario identification number. The identification number provides a link to initiating events and event sequences and all other subsequent analyses conducted in the tool.

Include for Perform. Analysis: Select or deselect an event scenario for performance analysis (e.g., safety assessment or risk assessment).

Event Scenario Description: Provide short description and nature of scenario.

Additional Information: Provide Comments, remarks, references to reports. Literature citations may be recorded here.

Saphire Data Path: Provide location of the SAPHIRE data for the Event Tree Analysis.

- **Initiating Event Section**: To access the text fields in the Initiating Event section, the user must select one of the buttons **Add Scenario**, **Delete Scenario**, or **Edit Record** at the bottom of the form.

Event ID: Select the initiating event from the drop-down list as shown in Figure 3.7.2-1. The data fields Frequency, Uncertainty, DOE Event, Description in the Initiating Event section of the **Event Tree Form** window are displayed from previous input

## **Freq. Analysis**

(see Section 3.7.1) and may not be changed on the current screen. To change any data entry fields in the Initiating Event section, the user must exit the **Event Tree Form** window and make the changes in the **Int. Event** menus discussed in Section 3.7.1.

- **Subsequent System/Operation Failures Section:** To access the text field, the user must click one of the three buttons listed: **Add Subseq. Event**, **Edit Subseq. Event**, or **Delete Subseq. Event**. Clicking **Add Subseq. Event** will allow the user to enter information to the data entry fields in the Subsequent System/Operational Failures section as shown in Figure 3.7.2-2. To edit or delete a subsequent event, the user must highlight an event in the window as illustrated in Figure 3.7.2-3 and then select **Edit Subseq. Event** or **Delete Subseq. Event**.

**Item No:** Serial number to a subsequent event is automatically assigned.

**Event ID:** Assign a alphanumeric subsequent event identification. Same Event IDs should be used in SAPHIRE event tree models.

**Probability:** Assign the probability of system/operations failure. The rationale for probability can be entered in the Additional Information field.

**Uncertainty:** The user may select **Yes** or **No**. If **Yes** is selected, the user can input information concerning the uncertainty of the event.

**Linking:** Indicate if the probability of failure of systems in operations is linked to a **Fault Tree** or **HR Tree** in SAPHIRE analysis. If **Fault Tree** or **HRA** is selected, the user is required to input information for the selection.

**Subsequent Event Description:** Provide short description and nature of Subsequent Event.

Event Tree Form, Project: PCSADemo

Functional ID: Waste Handling Building  
E.3.3  
Canister Transfer System  
Canister Transfer Cell

Event Scenario Item No: 0001.00 Scenario ID: CTS-ES-01 Include for Perform. Analysis:  Yes  No

Event Scenario Description: Vertical drop of canister from bridge crane on to another canister in staging rack. Canister with weld defect may or may not breach and HVAC may or may not be available.

Additional Information: Probability of defective canister is assumed as 1.06E-3 and that of HVAC unavailability 4.80E-4, "Preliminary Preclosure Design Basis Event Calculations for the Monitored Geologic Repository."

Sapphire Data Path: \\SapphireProjects\Ymp1\_ATS1

Initiating Event Event ID: CTS-IE-01 Frequency: 2.72E-02 Uncertainty:  Yes  No  DOE Event

Description: Bridge crane failure during transfer of canisters from transportation cask to Disposal containers

Subsequent System/Operation Failures

Item No: Probability: 0.00E+00

Event ID: Subsequent Event Description

Add Subseq. Event

Edit Subseq. Event

Delete Subseq. Event

Uncertainty:  Yes  No

Linking:  None  Fault Tree  HRA

Event No	Probability	Uncertainty	Linking	Event ID	Event Description
01.0	1.06E-03	N	N	BC	Breach of defective canister
02.0	4.80E-04	N	N	HVAC	HVAC availability

Record 1 Add Scenario Delete Scenario Edit Record Show Report Close

Figure 3.7.2-1. Event Tree Form

Event Tree Form, Project: PCSADemo

Functional ID: Waste Handling Building  
E.3.3  
Canister Transfer System  
Canister Transfer Cell

Event Scenario Item No: 0001.00 Scenario ID: CTS-ES-01 Include for Perform. Analysis:  Yes  No

Event Scenario Description: Vertical drop of canister from bridge crane on to another canister in staging rack. Canister with weld defect may or may not breach and HVAC may or may not be available.

Additional Information: Probability of defective canister is assumed as 1.06E-3 and that of HVAC unavailability 4.80E-4, "Preliminary Preclosure Design Basis Event Calculations for the Monitored Geologic Repository."

Sapphire Data Path: \\SapphireProjects\Ymp1\_ATS1

Initiating Event Event ID: CTS-IE-01 Frequency: 2.72E-02 Uncertainty:  Yes  No  DOE Event

Description: Bridge crane failure during transfer of canisters from transportation cask to Disposal containers

Subsequent System/Operation Failures

Item No: 03.0 Probability: 0.00E+00

Event ID: Subsequent Event Description

Update Record

Edit Subseq. Event

Cancel

Uncertainty:  Yes  No

Linking:  None  Fault Tree  HRA

Event No	Probability	Uncertainty	Linking	Event ID	Event Description
01.0	1.06E-03	N	N	BC	Breach of defective canister
02.0	4.80E-04	N	N	HVAC	HVAC availability

Record 1 Add Scenario Delete Scenario Edit Record Show Report Close

Figure 3.7.2-2. Event Tree Form with Fields in Subsequent System/Operational Failures Section Opened with Add. Subseq. Event Button

Event Tree Form, Project: PCSADemo

Functional ID: Waste Handling Building  
Canister Transfer System  
Canister Transfer Cell

Event Scenario Item No: 0001.00 Scenario ID: CTS-ES-01 Include for Perform. Analysis:  Yes  No

Event Scenario Description: Vertical drop of canister from bridge crane on to another canister in staging rack. Canister with weld defect may or may not breach and HVAC may or may not be available.

Additional Information: Probability of defective canister is assumed as 1.06E-3 and that of HVAC unavailability 4.80E-4, "Preliminary Preclosure Design Basis Event Calculations for the Monitored Geologic Repository."

Saphire Data Path: \SaphireProjects\Ymp1\_ATS1

Initiating Event Event ID: CTS-IE-01 Frequency: 2.72E-02 Uncertainty:  Yes  No  DOE Event

Description: Bridge crane failure during transfer of canisters from transportation cask to Disposal containers

Subsequent System/Operational Failures

Item No: 02.0 Probability: 4.80E-04

Event ID: HVAC Subsequent Event Description: HVAC availability

Uncertainty:  Yes  No

Linking:  None  Fault Tree  HRA

Event No	Probability	Uncertainty	Linking	Event ID	Event Description
01.0	1.06E-03	N	N	BC	Breach of defective canister
02.0	4.80E-04	N	N	HVAC	HVAC availability

Record 1

Buttons: Add Scenario, Delete Scenario, Edit Record, Show Report, Close

**Figure 3.7.2-3. Event Tree Form with Fields Subsequent System/Operational Failures Section Opened with Edit Subseq. Event Button**

### Action Commands

- Add Scenario:** Activates the text boxes in the Event Scenario section and allows the user to add a scenario.
- Delete Scenario:** Deletes the scenario currently displayed in the form. The user will be prompted "Are you sure you want to delete scenario and all subsequent associated events?" after **Delete Scenario** is selected.
- Edit Record:** Allows the user to modify previous information input into the Event Scenario section .
- Show Report:** Displays information in report format.
- Close:** Returns to the main project screen automatically saving any changes.
- Update Record:** The **Update Record** command is displayed only after **Add Scenario** or **Edit Record** is selected. Applies and saves any changes made in the **Add Scenario** and **Edit Record** commands.

- Cancel:** The **Cancel** command is displayed only after **Add Scenario** or **Edit Record** is selected. **Cancel** returns the user to the **Event Tree Form** without saving any new input information.
- Add Subseq. Event:** Allows the user to add a subsequent event and activates text boxes in **Subsequent System/Operation Failure** section.
- Edit Subseq. Event:** Allows the user to edit an existing subsequent event. User must select a subsequent event from the list before selecting the button.
- Delete Subseq. Event:** Allows the user to delete an existing subsequent event. User must select a subsequent event from the list before selecting the button.
-

## ***Freq. Analysis***

### **3.7.3 *Fault Tree***

The *Fault Tree* submenu can be accessed through the ***Freq. Analysis*** menu located in the main menu bar. The *Fault Tree* submenu leads to the **Fault Tree Form** dialog box to allow users to generate data for fault tree analysis. The **Fault Tree Form**, as shown in Figure 3.7.3-1, allows data entry using the Action Commands. Within the **Fault Tree Form**, the user can view the fault tree data in tabular format as shown in Figure 3.7.3-2 by clicking on the **Event Table** button. The descriptions of individual data entry fields shown in Figure 3.7.3-1 are presented next.

**Functional ID:** Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

**Item No.:** Shows the serial number of the record in the database pertaining to the current form.

**Probabilities:** Enter the **Probabilities** or **Frequencies** of the top event derived by SAPHIRE analysis. The mean, median, and 5<sup>th</sup>- and 95<sup>th</sup>-percentile values of the top event from the uncertainty analysis can be entered; in addition, the point estimate value is stored at the **Point Estimate** field.

**Top Event Name:** Provide Top event name.

**Top Event Description:** Provided a brief description of the event.

**Additional Information:** Provide comments, remarks, references to reports. Literature citations should be recorded here.

**Saphire Data Location:** Enter the location of the SAPHIRE Data for the fault tree analysis for the current form.

**Fault Tree Form, Project: PCSADemo**

Functional ID: E.3.3  
 Waste Handling Building  
 Canister Transfer System  
 Canister Transfer Cell

Item No.: 0001.00  
 Top Event Name: BDFC  
 Top Event Description: Bridge Crane Failure

Probabilities:  Probabilities Point Estimate Mean 5%  
 Frequencies 1.7E-5 Median 95%

Additional Information: Failure of bridge crane system failure is modeled after Duke, A.J. "Reliability Techniques Used in the Assessment of Cranes." NCSR/GR/64. Warrington, United Kingdom: National Center of Systems Reliability, United Kingdom Atomic Energy Authority. 1985.

Saphire Data Location: \SaphireProjects\Ymp1

Buttons: Add Record, Delete Record, Edit Record, Record: 1, Show Report, Event Table, Close

Figure 3.7.3-1. Fault Tree Form

**Fault Tree Event Table, Project: PCSADemo**

Functional ID: E.3.3  
 Waste Handling Building  
 Canister Transfer System  
 Canister Transfer Cell

Top Event Name: BDFC      Top Event Description: Bridge Crane Failure

Item No	Event Name	Type of Event	Description	Probability	Uncertainty	Additional Info
0001.00	BMFC	Basic	Brake Motor Coupling	8.00E-07	Point Estimate	Under gate EL-G11
0002.00	BMSF	Basic	Brake Motor Shaft	2.00E-07	Point Estimate	Under gate EL-G11
0003.00	HMF	Basic	Hoist Motor Failure	6.00E-05	Point Estimate	Under gate EL-G11
0004.00	ESF	Basic	Emergency Stop Push	2.50E-04	Point Estimate	Under gate EL-G12
0005.00	DMHF	Basic	Dead Man's Handle	2.54E-04	Point Estimate	Under gate EL-G12
0006.00	HKF	Basic	Hook Failure	2.00E-09	Point Estimate	Under gate MECHF
0007.00	RDF	Basic	Rope Drum Failure	4.00E-08	Point Estimate	Under gate MECHF
0008.00	RDPF	Basic	Rope Drum Pedestal	4.00E-08	Point Estimate	Under gate MECHF
0009.00	DGSF	Basic	Drum/Gearbox Shaft	2.00E-07	Point Estimate	Under gate MECHF
0010.00	DGCF	Basic	Drum/Gearbox Coupling	8.00E-07	Point Estimate	Under gate MECHF
0011.00	BKF	Basic	Brake Failure	1.00E-05	Point Estimate	Under gate MECHF
0012.00	RSF	Basic	Rope System Failure	4.00E-06	Point Estimate	Under gate MECHF
0013.00	GBF	Basic	Gearbox Failure	1.00E-06	Point Estimate	Under gate MECHF
0014.00	GBSF	Basic	Gearbox Brake Failure	2.00E-07	Point Estimate	Under gate MECHF
0015.00	GBCF	Basic	Gearbox/Brake Shaft	8.00E-07	Point Estimate	Under gate MECHF

Buttons: Add Record, Edit Record, Copy Record, Delete Record, Show Report, Close

Figure 3.7.3-2. Fault Tree Event Table

### Action Commands

---

- Add Record:** Activates the text box and allows the user to add a form or table record.
- Delete Record:** Deletes the record currently displayed in the form. The user will be prompted "Are you sure you want to delete scenario and all subsequent associated events?" after **Delete Scenario** is selected.
- Edit Record:** Allows the user to modify previous information input into the form.
- Show Report:** Displays information in the **Fault Tree Form** in report format.
- Event Table:** Displays the **Fault Tree Event Table** window. (Figure 3.7.3-2). The table is used to store information on basic events used in fault tree modeling associated with the top event. The **Fault Tree Event Table** window has a separate set of **Add Record**, **Delete Record**, **Edit Record**, **Show Report** and **Close** buttons. In addition, this window has **Copy Record** button.
- Close:** Returns to the main project screen automatically saving any changes.
- Cancel:** The **Cancel** option is displayed only after **Add Record** or **Edit Record** is selected. **Cancel** returns the user to the default form display screen, not saving any new input information.
- Update Record:** Applies and saves any changes made in the **Add Record** and **Edit Record** commands.
-

### 3.7.4 Event Sequence

The Event Sequence submenu can be accessed from the **Freq. Analysis** menu located in the main toolbar. As shown in Figure 3.7.4-1, the *Form* submenu displays the **Event Sequence Form**, which guides the user input about event sequences into the database. The user first selects the Scenario ID from the drop-down list, which shows a list of all the scenario ID, in the functional area. Upon selecting an event scenario, the details about an associated initiating event are displayed. The user can enter data in the data entry fields with the Action Commands. A unique event sequence identification should be provided using any combination of alphanumeric characters. The descriptions of individual data entry fields shown in Figure 3.7.4-1 are presented next.

Functional ID: Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

Scenario ID: Select Scenario ID from drop-down list.

Preclosure Period: Displays the preclosure period associated with the initiating event selecting.

Init. Event ID: Displays Initiating Event ID associated with the Scenario ID. Everything listed in the Event Scenario and Initiating Event Information section in the **Event Sequence Form** window is displayed from previous input and may not be changed in the current screen.

DOE Event: Displays if the information pertains to an event identified by DOE.

I.E. Frequency: Displays initiating event frequency from previous input.

Event Seq. Frequency: Enter event sequence frequency from the event tree analysis either based on a point estimate or uncertainty analysis (conducted using the SAPHIRE Version 6.70 code). If the SAPHIRE analysis is based on uncertainty analysis, mean frequency should be entered.

Category: Displays Category (1,2 or BCFL) of the event sequence.

Item No.: Displays the serial number of the record in the database of the current form.

Event Sequence ID: Enter identification number of the current event sequence. Tool will not allow the user to save information in this window without Event Sequence ID.

Description: Provide a brief description of the current event sequence.

End State: Define the possible radioactive release scenarios qualitatively, for example, low, high, and moderate.

Additional Information: Provide Comments, remarks, references to reports, Literature citations should be recorded here.

**Event Sequence Form, Project: PCSADemo**

**Functional ID:** E.3.3  
 Waste Handling Building  
 Canister Transfer System  
 Canister Transfer Cell

**Event Scenario and Initiating Event Information**

Scenario ID: CTS-ES-01    Preclosure Period: 100  
 Init. Event ID: CTS-IE-01     DOE Event    I.E. Frequency: 2.72E-02  
 Sapphire Data Path: \SapphireProjects\Ymp1\_ATS1

**Frequency And Category**

Event Seq. Frequency: 2.69E-02  
 Category: 1

Item No.: 0001.00    Event Sequence ID: CTS-1-01

Description: Canister drop, canister intact no breach

End State: No-release

Additional Information:

Buttons: Add Record, Delete Record, Edit Record, Record: 1, Show Report, Event Seq. Table, Close

**Figure 3.7.4-1. Event Sequence Form**

**Action Commands**

---

- Add Record:**            Activates the text box and allows the user to add a record.
  - Delete Record:**        Deletes the scenario currently displayed in the form. The user will be prompted "Are you sure you want to delete scenario and all subsequent associated events?" after **Delete Scenario** is selected.
  - Edit Record:**            Allows the user to modify previous information input into the form.
  - Show Report:**            Displays information in report format.
  - Event Seq. Table:**        Displays the form in tabular format.
  - Close:**                    Returns to the main project screen automatically saving any changes.
  - Cancel:**                    The **Cancel** option is displayed only after **Add Record** or **Edit Record** is selected. **Cancel** returns the user to the default form display screen, not saving any new input information.
  - Update Record:**         Applies and saves any changes made using the **Add Record** and **Edit Record** buttons.
-

### 3.8 SAPHIRE

In the PCSA Tool is a menu containing **SAPHIRE** to run the SAPHIRE Version 6.70 code (Idaho National Engineering and Environmental Laboratory, 1998). Clicking on this submenu item launches the application for the user. Currently, there is no exchange of data between the tool and the SAPHIRE Version 6.70 code. Consequently, data required to run SAPHIRE Version 6.70 code must be separately entered, and the user must be familiar with the software package. SAPHIRE Version 6.70 code is used for event tree and fault tree analyses.

#### 3.8.1 Run SAPHIRE

Selecting the Run SAPHIRE option opens the SAPHIRE for Windows screen illustrated in Figure 3.8.1-1.

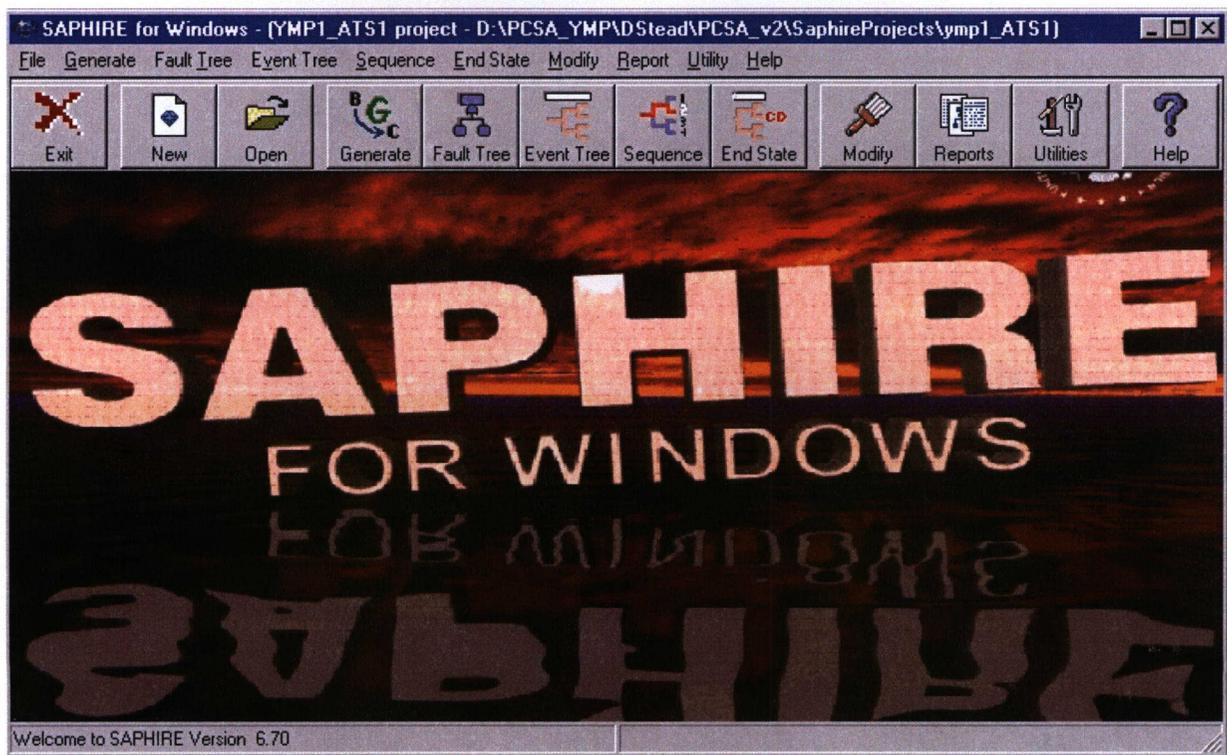


Figure 3.8.1-1. SAPHIRE for Windows Screen

## **Conseq.**

### **3.9**                    **Conseq.**

The Conseq. menu contains two consequence calculation submenus: Public Dose and Worker Dose.

#### **3.9.1**                    **Public Dose**

The Public Dose option performs a calculation of the radiological consequences to an offsite member of the public from an atmospheric release of radioactive material using deterministic and probabilistic approaches. The receptor is assumed to be an adult located directly downwind from the point where the radioactive material is released. Mitigative credit is taken neither for evacuation of the public nor for remediation of radioactive contamination.

As depicted by the Public Dose submenus in Figure 3.9.1-1, the RSAC Version 5.2 code (hereafter referred to as RSAC) and MELCOR Version 1.8.5 code (hereafter referred to as MELCOR) can be used for the Public Dose calculation. RSAC calculates internal and external doses to the receptor. Internal doses are calculated for the inhalation and ingestion pathways, and the external doses are computed for the pathways of ground surface exposure and submersion in the passing airborne plume. The consequence module calculates public doses for the ingestion pathway based on the consumption of food produced locally at the receptor location. Thus, caution should be used when calculating doses from the ingestion pathway for a residential receptor, whose location differs significantly from the location where the receptor's food is produced (see additional discussion in Section 3.9.1.1.1). MELCOR is used to estimate the building discharge fractions, which serve as input parameters for the public dose calculation. Presented in Section 3.9.1.2, execution of MELCOR is not required for calculation of the public dose, but can be used to determine a realistic source term.

##### **3.9.1.1**                    **RSAC**

RSAC is used to calculate radiological consequences to an offsite member of the public from an atmospheric release of radioactive material using deterministic and probabilistic approaches. Shown in Figure 3.9.1-1, selecting RSAC from the drop-down list provides three options: Standard RSAC Input, Advanced RSAC Input, and Show Output.

###### **3.9.1.1.1**                    **Standard RSAC Input**

The Standard RSAC Input submenu allows access to the input data for the dose calculation, organized in nine RSAC input folders. Default values are provided for each parameter. Where possible, site-specific data for the Yucca Mountain site or best-estimate values are assigned as the defaults. Dasgupta, et al. (2002) provide rationale for the selection of the default values.

All parameters used for creating an RSAC input file and for performing a dose calculation are displayed in the nine input folders. Several parameters, however, are fixed for the Standard RSAC Input submenu and are displayed for reference only. The following discussion provides the rationale for fixing the value of one example parameter. The first parameter listed for the Ingestion Dose Input is the Type of dose calculation. This parameter has been fixed at a value of 3 to command RSAC to perform an ingestion dose calculation that allows user-supplied

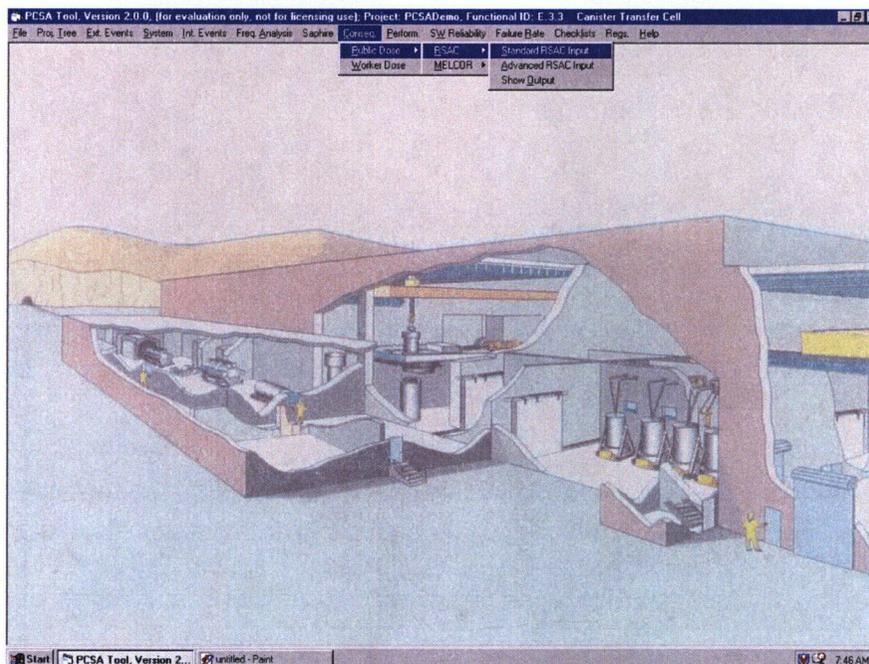


Figure 3.9.1-1. Conseq. Menu

data for ingestion parameters (such as the receptor's annual consumption of contaminated vegetables, meat, and milk). RSAC allows one other option for an ingestion dose calculation in which generic ingestion parameters are used for a chronic (i.e., long-term) release of radioactive material and the diet of the generic receptor consists entirely of contaminated food. This other ingestion option is so restrictive it only allows the user to enter input data for two parameters—Decay time for exponential decay function (s) and TB—Plant midpoint of operating life (y). Other options exist for the Type of dose calculation, however, they correspond to dose calculations for pathways other than ingestion. The dose calculation inputs for pathways other than ingestion are addressed separately by the other input folders (**Inhalation Dose**, **Ground Surface Dose**, and **Submersion Dose**).

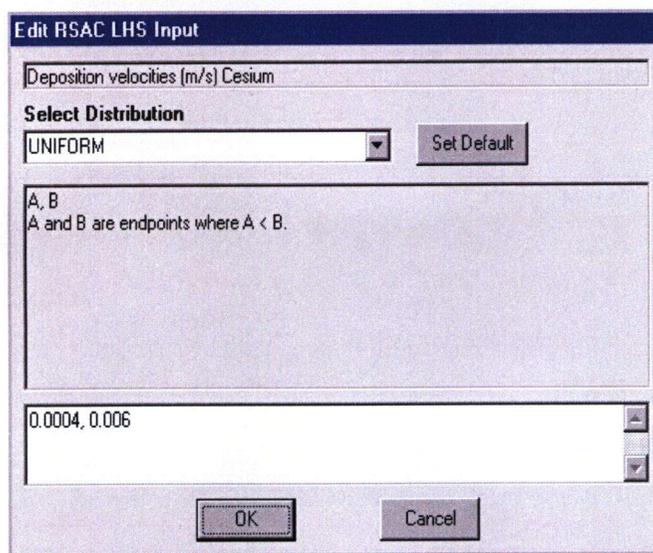
At the bottom of each folder, the **Refresh Point Estimates to Defaults** option is displayed. This option allows the user to reset those input parameters that have not been assigned distributions for Latin Hypercube Sampling (LHS) to their default values. The **Refresh Point Estimates to Defaults** option only affects the input in the current folder. To reset all inputs (point estimates and distributions), the **Set All Defaults** should be used (refer to the discussion in the **Action Commands** section).

For a probabilistic dose calculation, certain parameters throughout the RSAC Input window display **\*\*LHS\*\*** in the Input Value column. Double-clicking the **\*\*LHS\*\*** will display the LHS Input window shown in Figure 3.9.1-2. The user may select the desired type of distribution from the drop-down list provided or select the **Set Default** button to reset to the default distribution and values. Near the bottom of the window, the user can input the numerical values for that distribution. As shown in Figure 3.9.1-2, the constant A corresponds to a 0.33

## Conseq.

numerical value for the parameter, Fraction of annual fresh vegetables that are contaminated by acute release. For a more indepth description of the LHS Input window, the user should read Dasgupta, et al. (2002, Section 7.1.3).

The **Type of Run** (Deterministic or Probabilistic) can be selected at the bottom of any of the nine input folders. It is strongly recommended that the user select the **Type of Run** (Deterministic or Probabilistic) before proceeding to modify the input data. Input data can be lost by toggling between the **Type of Run** (specifically, point estimate values are reset to their default values for those parameters with distributions for probabilistic sampling). The following sections present the nine input folders followed by a section of the execution of the RSAC dose calculation.



**Figure 3.9.1-2. RSAC LHS Input Window for Specifying Input Distributions and Values for a Probabilistic Dose Calculation**

## 3.9.1.1.1 Fuel Selection/Assemblies Breached

This section presents the input parameters for the **Fuel Selection/Assemblies Breached** folder shown in Figure 3.9.1-3. The following **Action Commands** correspond to Figures 3.9.1-3 through 3.9.1-11.

The screenshot shows a software dialog box titled "RSAC Input - BWR Fuel - 1 Assembly Breached". It features several tabs: "Ingestion Dose", "Submersion Dose", "Ground Surface Dose", "View Source Term", "Meteorological Data", and "Inhalation Dose". The "View Source Term" tab is selected, and within it, the "Fuel Selection / Assemblies Breached" sub-tab is active. This sub-tab contains the following fields and controls:

- Fuel Type:** A group box with radio buttons for BWR (selected), PWR, DHLW, NavyFuel, and User Specified.
- Fuel Characteristics:** A group box containing four text input fields: Type (BWR), Burnup (MWd/MTU) (40000.0), Enrichment (%) (3.5), and Decay Time (Y) (25.0).
- Co-60 Crud Activity (Ci/Assembly):** A text input field containing the value 18.4.
- Number of Assemblies Breached:** A dropdown menu currently set to 1.
- Buttons:** "Set All Defaults", "Refresh Point Estimates to Defaults", "Cancel", and "Done/Run".
- Type of Run:** A group box with radio buttons for Deterministic (selected) and Probabilistic.

**Figure 3.9.1-3. Fuel Selection/Assemblies Breach RSAC Input Folder**

### Action Commands

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- Set All Defaults:** Erases any changes made by the user and returns all values to their default settings.
- Cancel:** Prompts the user "You did not create RSAC input file" and exits the menu.
- Done/Run:** Executes RSAC run with the data in the RSAC Input form.
- Type of Run:** The user can choose either a **Deterministic** or **Probabilistic** type of run. The user is advised to choose the type of run before entering any data because alternating between deterministic and probabilistic during data entry could erase previously entered data.
-

## **Conseq.**

**Fuel Type:** The user may choose between **BWR**, **PWR**, and **User Specified**. **BWR** (Boiling Water Reactor) and **PWR** (Pressurized Water Reactor) options have default values, while the **User Specified** option enables the user to alter the Inventory (Ci/Assembly) column in the **View Source Term Folder**.

**Fuel Characteristics:** The fuel characteristics for Fuel Types **BWR** and **PWR** are displayed for reference purposes only and may not be changed by the user.

**Co-60 Crud Activity (Ci/Assembly):** Value must be greater than or equal to zero.

**Number of Assemblies Breached:** The user can input any desired integer or use the drop-down list for selecting the number of assemblies breached. All of the fuel rods are assumed to be breached in each breached assembly. If user wants to specify that some fraction of the rods breach for each assembly, the release fractions should be multiplied by that fraction in the **Release Fraction by Group** input folder.

3.9.1.1.1.2 Bldg. Discharge, HEPA, Probabilistic

This section presents the input parameters for the **Bldg. Discharge, HEPA, Probabilistic** folder shown in Figure 3.9.1-4.

**Fraction Discharged from Building Ventilation:** The user may input any value between zero and one (inclusive) for Vapors and Noble Gases, Crud (Co-60), and Particulates. These values can be estimated by executing the MELCOR code (see Section 3.10.1.2).

**Probabilistic:** The feature may only be changed when Probabilistic is selected for **Type of Run**. As a rule of thumb, the computation speed is approximated at 10 realizations per minute (6 seconds per realization) for a personal computer with a 500-MHz processor.

**HEPA Filtration:** The user can select from **Operative** or **Inoperative** (high-efficiency particulate air (HEPA) filtration). Any value between zero and one (inclusive) may be input for the **HEPA Mitigation Factor**. A zero value represents 100 percent mitigation (i.e., filtration). A value of one represents zero percent mitigation (i.e., no filtration). Defaults are provided for both the **Operative** or **Inoperative** options.

Figure 3.9.1-4. Bldg. Discharge, HEPA, Probabilistic RSAC Input Folder

3.9.1.1.1.3 Release Fraction by Group

This section presents the input parameters for the **Release Fraction by Group** folder shown in Figure 3.9.1-5. For each Group ID, the corresponding KeyNumber, Group Name, Release Fraction, Radionuclides in Group, Default Value, MinValue, and MaxValue are displayed. The Key Number column was included for development purposes but should be ignored by the user.

The user should select Air or Pool under the Release In option located near the bottom of the folder, and then edit the release fractions. Toggling between the Air and Pool releases resets the point-estimate release fractions to their default values.

The Release Fraction column is the only column that can be edited by the user. The Default Value displays the default setting for the Release Fraction value. The Minimum and Maximum columns display the minimum and maximum values for each respective group for checking the input data.

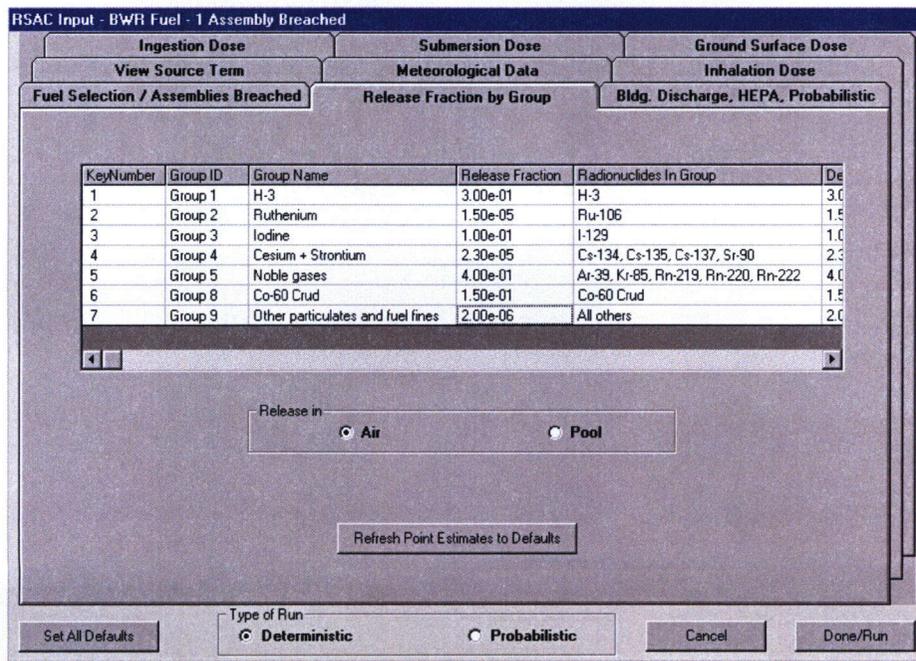


Figure 3.9.1-5. Release Fraction by Group RSAC Input Folder

### 3.9.1.1.1.4 Meteorological Data

This section presents the input parameters for the **Meteorological Data** folder shown in Figure 3.9.1-6. For each Input Parameter, the corresponding Input Value, Remarks, Default Value, LHS, MinValue, and MaxValue are displayed. The Input Value column is the only column that may be edited by the user. The Default Value column displays the default values for the inputs. The MinValue and MaxValue columns display the physical minimum and maximum values for checking the input data. The individual entries are presented next.

Average wind velocity (m/s): Value must be greater than zero. LHS allowed.

Stack release height (m): Value must be greater than or equal to zero.

Mixing layer height (m): Value must be greater than zero. LHS allowed.

Air density (g/m<sup>3</sup>): Value must be greater than zero.

Wet deposition scavenging coefficient (1/s): Value must be greater than or equal to zero.

Plume depletion by dry deposition: Input 0 for No or 1 for Yes.

Deposition velocities to be entered: This parameter has a set value of Yes. The parameter may not be changed and is displayed for information purposes only.

Deposition velocities (m/s) Solids: Value must be greater than or equal to zero. LHS allowed.

Deposition velocities (m/s) Halogens: Value must be greater than or equal to zero. Halogens are nonmetallic elements (F, Cl, Br, I, and At). LHS allowed.

Deposition velocities (m/s) Noble gases: Value must be greater than or equal to zero. Noble gases are inert elements (He, Ne, Ar, Kr, Xe, and Rn). LHS allowed.

Deposition velocities (m/s) Cesium: Value must be greater than or equal to zero. LHS allowed.

Deposition velocities (m/s) Ruthenium: Value must be greater than or equal to zero. LHS allowed.

Downwind distance (m): Value must be greater than or equal to zero.

Linear constant in decay function (1/s): Value must be greater than or equal to zero. A value of 1 corresponds to an instantaneous release.

Exponential constant in decay function (1/s): Value must be greater than or equal to zero. A value of zero corresponds to an instantaneous release.

Crosswind distances to be entered: This parameter has a set value of No. The parameter may not be changed and is listed for information purposes only.

Input Parameter	Input Value	Remarks
Average wind velocity (m/s)	3.0	float - Most-probable velocity (site-specific estimate)
Stack release height (m)	40.0	float - Estimation of stack height
Mixing layer height (m)	1420.0	float - Average mixing height based data from Desert Rock, NV
Air density (g/m <sup>3</sup> )	1.29e+03	float - Site-specific mean value (Mohanty et al., 2000)
Wet deposition scavenging coefficient (1/s)	0.0	float - No plume depletion by wet deposition
Plume depletion by dry deposition	1	integer Yes
Deposition velocities to be entered	Yes	
Deposition velocities (m/s) Solids	0.001	float - RSAC-5 default value
Deposition velocities (m/s) Halogens	0.01	float - RSAC-5 default value
Deposition velocities (m/s) Noble gases	0.0	float - RSAC-5 default value
Deposition velocities (m/s) Cesium	0.001	float - RSAC-5 default value
Deposition velocities (m/s) Ruthenium	0.001	float - RSAC-5 default value
Downwind distance (m)	11000.0	float - Site-specific approximation (U.S. Department of Energy, 1998c)
Linear constant in decay function (1/s)	1.0	float - RSAC default value for instantaneous release
Exponential constant in decay function (1/s)	0.0	float - RSAC default value for instantaneous release
Crosswind distances to be entered	No	text - Assuming critical group is directly downwind
Diffusion definition	2	integer - Program calculates standard deviations
Type of sigma (standard deviation) set	1	integer - Hilsmeier-Gifford for < 15 min releases at desert sites

**Figure 3.9.1-6. Meteorological Data RSAC Input Folder**

**Diffusion definition:** This input parameter is fixed to a value of 2, so that the RSAC code calculates atmospheric diffusion. The parameter may not be changed and is listed for information purposes only.

**Type of sigma (standard deviation) set:** This input parameter takes a value of 1, 2, or 3.

Value	Diffusion Model	Comments
1	Hilsmeier-Gifford	Should be used for desert terrains for releases of a few minutes to 15 minutes in duration (Wenzel, 1994, pp. 4–18)
2	Markee	Should be used for desert terrains for releases of 15 to 60 minutes in duration (Wenzel, 1994, pp. 4–18)
3	Pasquill-Gifford	Should be used for prairie grass terrains for releases of 10 to 60 minutes in duration (Wenzel, 1994, pp. 4–18)

**Building width (m):** Value must be greater than or equal to zero. Stack release height must equal zero for building wake effects to be calculated.

**Building height (m):** Value must be greater than or equal to zero. Stack release height must equal zero for building wake effects to be calculated.

**Building weight coefficient:** Value must be between 0.5 and 2 (unitless). Stack release height must equal zero for building wake effects to be calculated.

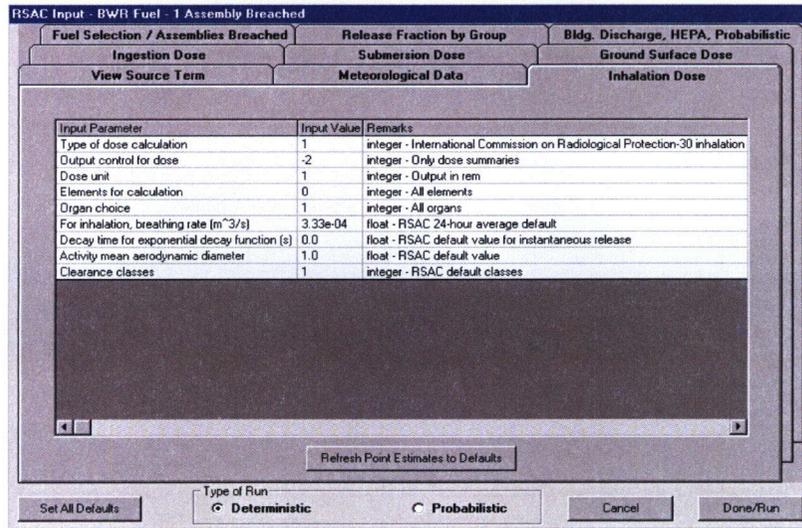
**Weather class:** This input parameter must be an integer between 1 and 8 with the following definitions. LHS allowed.

**Plume rise indicator:** This input parameter is assigned a fixed value of zero, which indicates no plume rise. In general, plume rise corresponds to higher effective stack heights, more diffusion, lower radionuclide concentrations in the air at the ground surface, less deposition of radionuclides on the ground, and lower doses.

Value	Weather Class	Comments
1	A	Most unstable; implies greatest dispersion
2	B	—
3	C	—
4	D	—
5	E	—
6	F	Most stable; implies least dispersion
7	Fumigation	Special case; requires a stack release height greater than zero but less than or equal to the mixing layer height
8	G	Only for Pasquill-Gifford model; most stable; implies least dispersion

3.9.1.1.1.5 Inhalation Dose

This section presents the input parameters for the **Inhalation Dose** folder shown in Figure 3.9.1-7. For each Input Parameter, the corresponding Input Value, Remarks, Default Value, LHS Abbreviations (Probabilistic Only), MinValue, and MaxValue are displayed. The Minimum and Maximum columns display the physical minimum and maximum values for checking the input data. The Default Value displays the default setting for the Input Value column, which is the only column that may be edited by the user. The individual entries are presented below.



**Figure 3.9.1-7. Inhalation Dose RSAC Input Folder**

Type of dose calculation: Fixed for an inhalation dose calculation and may not be edited.

Output control for dose: Fixed for dose summary output and may not be edited.

Dose unit: Fixed for units of rem and may not be edited.

Elements for calculation: Fixed for a dose calculation for all elements and may not be edited.

Organ choice: Fixed for a dose calculation for all organs and may not be edited.

For inhalation, breathing rate (m<sup>3</sup>/s): Value must be greater than zero. LHS allowed.

Decay time for exponential decay fraction (s): Value must be greater than or equal to zero. Value of zero corresponds to an instantaneous release. LHS allowed.

Activity mean aerodynamic diameter (micrometer): Value must be greater than zero. LHS allowed.

Clearance classes: This value is a fixed parameter and may not be edited.

3.9.1.1.1.6 Ingestion Dose

This section presents the input parameters for the **Ingestion Dose** folder shown in Figure 3.9.1-8. For each Input Parameter, the corresponding Input Value, Remarks, Default Value, LHS Abbreviations (Probabilistic Only), MinValue, and MaxValue are displayed. The Minimum and Maximum columns display the physical minimum and maximum values for checking the input data. The Default Value displays the default setting for the Input Value column, which is the only column that may be edited by the user. The individual entries are presented below.

Currently, the consequence module calculates public doses for the ingestion pathway based on the consumption of food produced locally at the receptor location. Thus, caution should be used when calculating doses from the ingestion pathway for a residential receptor, whose location differs significantly from the location where the receptor's food is produced. To account for residential receptors who eat significant amounts of the contaminated, locally produced food, ingestion doses for the residential receptor should be calculated based on the distance from the source to the farm where the food is produced.

Input Parameter	Input Value	Remarks
Type of dose calculation	3	integer - Ingestion with user-specific
Output control for dose	-2	integer - Only dose summaries
Dose unit	1	integer - Output in rem
Elements for calculation	0	integer - All elements
Organ choice	1	integer - All organs
Decay time for exponential decay function (s)	0.0	float - RSAC default value for instant
TB - Plant midpoint of operating life (y)	1.0	float - Dose during the year of intake
Ingestion transfer parameter control	0	integer - RSAC default transfer paran
Ingestion parameter control	2	integer - User-specified ingestion par
Time crops are exposed to contamination during the growing season (d)	7.0	float - Times < 60 d are interpreted a
Harvest duration following acute release (d)	7.0	float - RSAC default value
Stored (other) vegetable consumption rate (wet kg/yr) includes fruits and grains	23.8	float - Mean consumption of locally p
Fresh (leafy) vegetable consumption rate (wet kg/yr)	15.0	float - Mean consumption of locally p
Meat consumption rate (kg/yr) includes beef and poultry	3.7	float - Mean consumption of locally p
Milk consumption rate (L/yr)	4.1	float - Mean consumption of locally p
Fraction of stored vegetables from garden	0.76	float - RSAC default value
Fraction of fresh vegetables from garden	1.0	float - RSAC default value
Retention factor for activity on forams	0.57	float - RSAC default value

Figure 3.9.1-8. Ingestion Dose RSAC Input Folder

Type of dose calculation: Fixed for an ingestion dose calculation and may not be edited.

Output control for dose: Fixed for dose summary output and may not be edited.

Dose unit: Fixed for units of rem and may not be edited.

Elements for calculation: Fixed for a dose calculation for all elements and may not be edited.

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Organ choice: Fixed for a dose calculation for all organs and may not be edited.

Decay time for exponential decay function (s): Value must be greater than or equal to zero. Value of zero corresponds to an instantaneous release. LHS allowed.

TB-Plant mid point of operating life (y): Value must be greater than or equal to zero. If a value of zero is specified, the RSAC code defaults to a value of 1 year. LHS allowed.

Ingestion transfer parameter control: Fixed for default transfer parameters and may not be edited.

Ingestion parameter control: Fixed to allow user-specified ingestion parameters and may not be edited.

Time crops are exposed to contamination during the growing season (d): Value must be between 0.04167 and 60 days. If values of 0 days or greater than 60 days are specified, the RSAC code defaults to a value of 60 days. LHS allowed. The RSAC code will not calculate an ingestion dose for values less than 0.04167 days.

Harvest duration following acute release (d): Value must be greater than or equal to zero. LHS allowed.

Stored (other) vegetable consumption rate (wet kg/yr) includes fruits and grains: Value must be greater than or equal to zero. LHS allowed.

Fresh (leafy) vegetable consumption rate (wet kg/yr): Value must be greater than or equal to zero. LHS allowed.

Meat consumption rate (kg/yr) includes beef and poultry: Value must be greater than or equal to zero. LHS allowed.

Milk consumption rate (L/yr): Value must be greater than or equal to zero. LHS allowed.

Fraction of stored vegetables from garden: Unitless value must be between zero and one (inclusive). LHS allowed.

Fraction of fresh vegetables from garden: Unitless value must be between zero and one (inclusive). LHS allowed.

Retention factor for activity on forage: Unitless value must be between zero and one (inclusive). LHS allowed.

Retention factor for activity on vegetables: Unitless value must be between zero and one (inclusive). LHS allowed.

Retention factor for iodines on forage: Unitless value must be between zero and one (inclusive). LHS allowed.

Removal rate constant for crops (1/h): Value must be greater than or equal to zero. LHS allowed.

Vegetable exposure time for chronic releases (d): Value must be greater than or equal to zero. LHS allowed.

Forage exposure time for chronic releases (d): Value must be greater than or equal to zero. LHS allowed.

HTO removal half-time (d): HTO refers to tritiated water (where at least one of the hydrogen atoms in H<sub>2</sub>O is tritium, <sup>3</sup>H). Value must be greater than or equal to zero. LHS allowed.

Effective surface density for soil (kg/m<sup>3</sup>): Value must be greater than zero. LHS allowed.

Stored vegetable holdup time after harvest (d): Value must be greater than or equal to zero. LHS allowed.

Fresh vegetable holdup time after harvest (d): Value must be greater than or equal to zero. LHS allowed.

Animals daily forage feed (dry kg/d): Value must be greater than or equal to zero. LHS allowed.

Feed-milk receptor transfer time (d): Value must be greater than or equal to zero. LHS allowed.

Slaughter to consumption time (d): Value must be greater than or equal to zero. LHS allowed.

Fraction of year that animals graze: Unitless value must be between zero and one (inclusive). LHS allowed.

Fraction of feed that is pasture when grazing: Unitless value must be between zero and one (inclusive). LHS allowed.

Stored feed holdup time (d): Value must be greater than or equal to zero. LHS allowed.

Vegetable vegetation yield (wet kg/m<sup>2</sup>): Value must be greater than or equal to zero. LHS allowed.

Forage vegetation yield (dry kg/m<sup>2</sup>): Value must be greater than zero. LHS allowed.

Absolute humidity (kg/m<sup>3</sup>): Value must be greater than zero. LHS allowed.

Fraction of annual stored vegetables that are contaminated by acute release: Unitless value must be between zero and one (inclusive). LHS allowed.

Fraction of annual fresh vegetables that are contaminated by acute release: Unitless value must be between zero and one (inclusive). LHS allowed.

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Fraction of annual stored forage that is contaminated by acute release: Unitless value must be between zero and one (inclusive). LHS allowed.

Fraction of annual fresh forage that is contaminated by acute release: Unitless value must be between zero and one (inclusive). LHS allowed.

3.9.1.1.1.7 Ground Surface Dose

This section presents the input parameters for the **Ground Surface Dose** folder shown in Figure 3.9.1-9. For each Input Parameter, the corresponding Input Value, Remarks, Default Value, LHS Abbreviations (Probabilistic Only), MinValue, and MaxValue are displayed. The Minimum and Maximum columns display the minimum and maximum values for checking the input data. The Default Value displays the default setting for the Input Value column, which is the only column that may be edited by the user. The individual entries are presented below.  
Type of dose calculation: Fixed for a ground surface dose calculation and may not be edited.  
Output control for dose: Fixed for dose summary output and may not be edited.

Dose unit: Fixed for units of rem and may not be edited.

Elements for calculation: Fixed for a dose calculation for all elements and may not be edited.

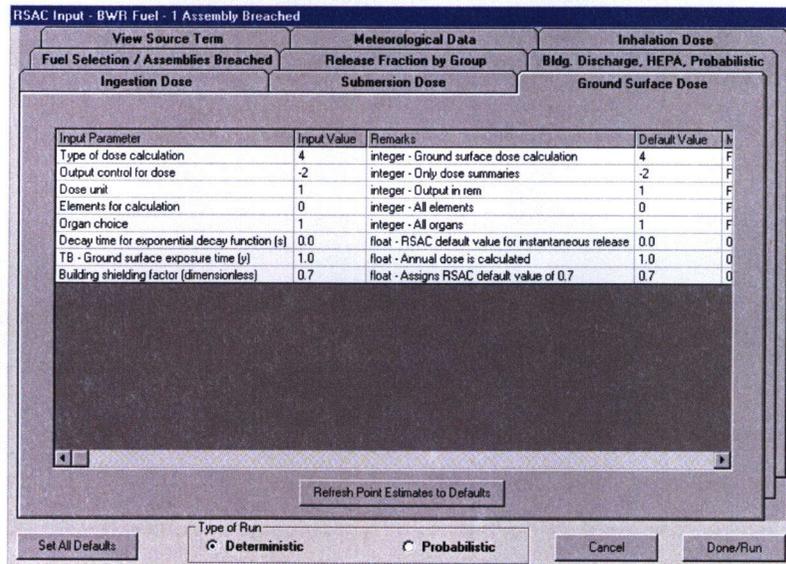


Figure 3.9.1-9. Ground Surface Dose Input Folder

Organ choice: Fixed for a dose calculation for all organs and may not be edited.

Decay time for exponential decay function(s): Value must be greater than or equal to zero. Value of zero corresponds to an instantaneous release. LHS allowed.

TB–Ground surface exposure time (y): Value must be greater than or equal to zero. If a value of zero is specified, the RSAC code defaults to a value of 1 year. LHS allowed.

Building shielding factor (dimensionless): Value must be between zero and one (inclusive). If a value of zero is specified, the RSAC code defaults to a value of 0.7.

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### 3.9.1.1.1.8 Submersion Dose

This section presents the input parameters for the **Submersion Dose** folder shown in Figure 3.9.1-10. For each Input Parameter, the corresponding Input Value, Remarks, Default Value, MinValue, and MaxValue are displayed. The Minimum and Maximum columns display the physical minimum and maximum values for checking the input data. The Default Value displays the default setting for the Input Value column, which is the only column that may be edited by the user. The individual entries are presented below.

Input Parameter	Input Value	Remarks	Default Value
Gamma cloud model selection	0	integer - All calculations are made using a finite model	0
Decay time for exponential decay function (s)	0.0	float - RSAC default value for instantaneous release	0.0
Type of dose calculation	2	integer - Calculate external effective dose equivalent	2

Figure 3.9.1-10. Submersion Dose RSAC Input Folder

Gamma cloud model selection: Fixed for a finite plume calculation and may not be edited.

Decay time for exponential decay function (s): Value must be greater than or equal to zero. Value of zero corresponds to an instantaneous release. LHS allowed.

Type of dose calculation: Fixed for an external effective dose equivalent calculation and may not be edited.

3.9.1.1.1.9 View Source Term

This section presents the **View Source Term** folder shown in Figure 3.9.1-11. This folder displays the parameter values for the source term calculation. The column Released Activity (Ci), located on the far right, presents the radionuclide activities released from the stack into the atmosphere. These activities are calculated by the PCSA Tool (as the product of the other numerical columns) and are transferred directly to the RSAC input file as the source term for the atmospheric transport and dose calculations. The user can only edit the Inventory (Ci/Assembly) column if User Specified was selected for Fuel Type in the **Fuel Selection/Assemblies Breached** folder.

Radionuclide	Inventory (Ci/Assembly)	Release Fraction	LHS	Bldg Discharge	HEPA Mitigation	Assemblies	Released Activity (Ci)
H 3	4.25E+01	3.00E-01	No	1.00E+00	1.00E+00	1	1.28E+01
C 14	3.32E-01	2.00E-06	No	2.00E-03	3.00E-04	1	3.98E-13
CL 36	2.34E-03	2.00E-06	No	2.00E-03	3.00E-04	1	2.81E-15
AR 39	1.44E-05	4.00E-01	No	1.00E+00	1.00E+00	1	5.76E-06
FE 55	5.42E-01	2.00E-06	No	2.00E-03	3.00E-04	1	6.50E-13
NI 59	3.76E-01	2.00E-06	No	2.00E-03	3.00E-04	1	4.51E-13
CO 60	5.39E+01	2.00E-06	No	2.00E-03	3.00E-04	1	6.47E-11
NI 63	4.94E+01	2.00E-06	No	2.00E-03	3.00E-04	1	5.93E-11
SE 79	9.51E-02	2.00E-06	No	2.00E-03	3.00E-04	1	1.14E-13
KR 85	3.83E+02	4.00E-01	No	1.00E+00	1.00E+00	1	1.53E+02
Y 90	8.61E+03	2.00E-06	No	2.00E-03	3.00E-04	1	1.03E-08
SR 90	8.60E+03	2.30E-05	No	2.00E-03	3.00E-04	1	1.19E-07
ZR 93	5.74E-01	2.00E-06	No	2.00E-03	3.00E-04	1	6.89E-13
MD 93	1.70E-04	2.00E-06	No	2.00E-03	3.00E-04	1	2.04E-16
NB 94	2.39E-02	2.00E-06	No	2.00E-03	3.00E-04	1	2.87E-14
TC 99	2.95E+00	2.00E-06	No	2.00E-03	3.00E-04	1	3.54E-12
RI 1106	3.38E-03	1.50E-05	No	2.00E-03	3.00E-04	1	3.04E-14

Figure 3.9.1-11. View Source Term RSAC Input Folder

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### 3.9.1.1.2 *Execution of the RSAC Dose Calculation*

For public dose calculations, RSAC is executed by clicking on the **Done/Run** button from the **RSAC Input** window discussed in Section 3.9.1.1.1. The results from the RSAC run are seen under the *Show Output* submenu. The total effective dose equivalent from each pathway (inhalation, ingestion, ground surface, and submersion) is displayed along with the sum of the four pathways. Organ dose equivalents from the inhalation, ingestion, and ground surface pathways are also tabulated.

### 3.9.1.1.3 *Advanced RSAC Input*

The additional menu, Advanced RSAC Input, enables a deterministic dose calculation and is intended for advanced users familiar with the RSAC code and input file. This menu was added to provide maximum flexibility to the user. As a result, the advanced RSAC calculations are isolated from the rest of the PCSA Tool and are not tracked by PCSA Tool. The results of the advanced RSAC calculations cannot be retrieved. The most recent advanced RSAC input file can be restored and rerun.

For those instances when the *Standard RSAC Input* does not contain the radionuclides desired for the dose calculation, it is recommended the user select the Advanced RSAC Input menu and add appropriate radionuclides into the input file from the full list of radionuclides allowed by the standard RSAC code.

To perform advanced RSAC calculations, users edit the RSAC input file directly. As shown in Figure 3.9.1-12, the user has two options for selecting the advanced RSAC input file: (i) the RSAC input file can be generated from the current consequence input of the PCSA Tool or (ii) the existing advanced RSAC input file can be retrieved.

For option (a), select **Get RSAC input file from PCSA Tool** (see Figure 3.9.1-12) and click **OK** on the following window stating, **RSAC Input File copied to RSAC directory**. The Advanced RSAC input file will open in the Microsoft Windows notepad editor as shown in Figure 3.9.1-13.

For option (b), select **Edit existing Advanced RSAC Input File** (see Figure 3.9.1-12). The Advanced RSAC input file will open in notepad.exe as shown in Figure 3.9.1-13.

**Edit, Save, and Close** the Advanced RSAC Input file and then press the **Run Advanced** button (see Figure 3.9.1-12).

When the calculation is complete, the RSAC output file will automatically open in notepad.exe. In the RSAC output files, the results of the dose calculation are listed after the RSAC inputs. Close the output file when the inspection of the results is finished. Press the **Exit Run Advanced** button (see Figure 3.9.1-12) when no further advanced RSAC calculations are needed.

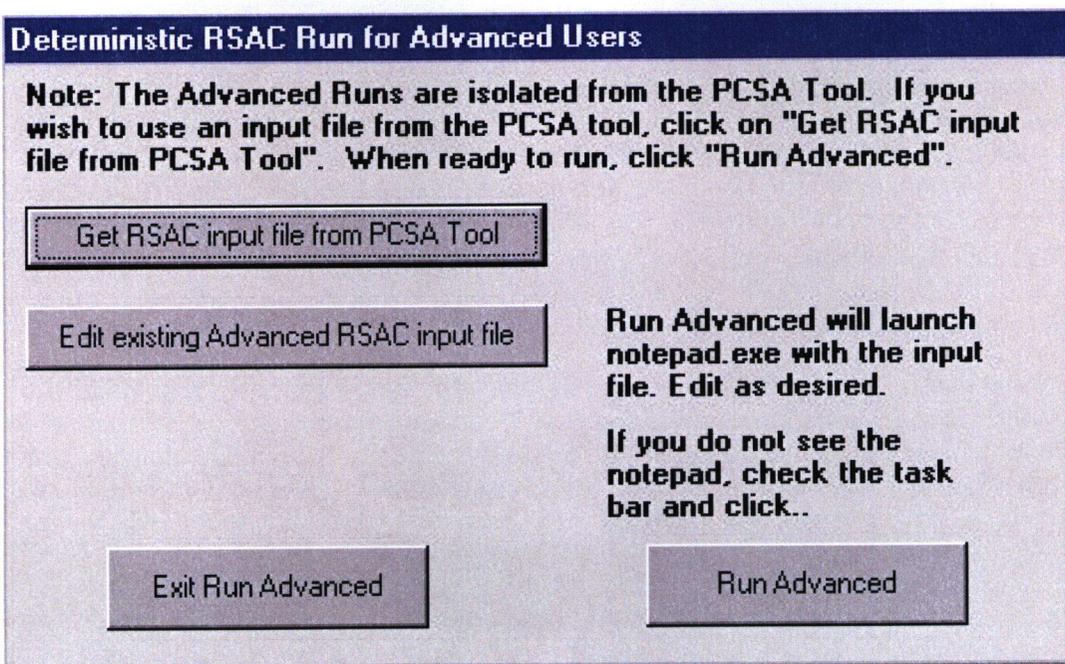


Figure 3.9.1-12. Advanced Input for RSAC

```

rsac5 in - Notepad
File Edit Search Help
* Dose Calcs for inhalation, ingestion, ground surface, & submersion
# Released Activities (Ci) for PWR, BWR, or User Specified SNF
2000, 1
RH106, 1.34E-12
PD107, 1.06E-11
SB125, 2.42E-09
SM126, 7.10E-11
SB126, 9.95E-12
I129, 4.49E-05
CS134, 4.13E-09
CS135, 4.38E-11
CS137, 5.33E-06
PM147, 1.04E-08
SM147, 3.23E-16
SM151, 2.74E-08
EU152, 1.76E-10
EU154, 1.41E-07
EU155, 2.15E-08
TL200, 1.42E-12
PB212, 3.95E-12
BI212, 3.95E-12
PO216, 3.95E-12
RN219, 4.12E-06
RN220, 1.37E-02
RN222, 4.14E-07
RA224, 3.95E-12
TH228, 3.95E-12
PA233, 3.93E-11
U234, 9.35E-11
TH234, 1.92E-11
U235, 8.81E-13

```

Figure 3.9.1-13. Advanced RSAC Input File

## **Conseq.**

### 3.9.1.1.4 *Show Output*

Outputs are automatically displayed after a public dose calculation is performed. Selecting *Show Output* will display the results from the most recent RSAC run in tabular and graphical format, as shown in Figure 3.9.1-14.

The RSAC Output window contains five result folders:

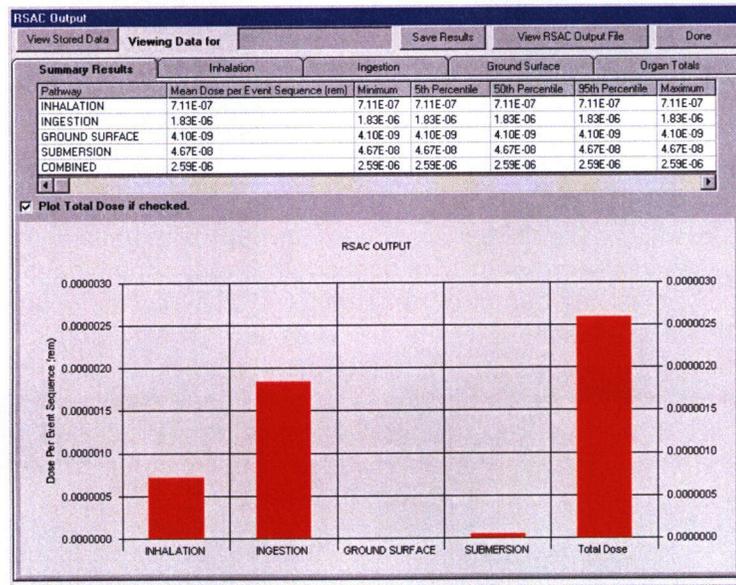
- (1) **Summary Results**—This folder lists the effective dose equivalents (i.e., whole body doses) from the four pathways. The doses from the four pathways are summed, and the results displayed in the bottom row labeled COMBINED, which corresponds to the Total Effective Dose Equivalent (TEDE).
- (2) **Inhalation**—This folder lists the organ committed dose equivalents from the inhalation pathway. CEDE refers to the committed effective dose equivalent for inhalation, which corresponds to the effective whole body dose from inhalation shown in the **Summary Results** folder.
- (3) **Ingestion**—This folder lists the organ committed dose equivalents from the ingestion pathway. CEDE refers to the committed effective dose equivalent for ingestion, which corresponds to the effective whole body dose from ingestion shown in the **Summary Results** folder.
- (4) **Ground Surface**—This folder lists the organ committed dose equivalents from the ground surface pathway. EXTEDE refers to the external effective dose equivalent from the ground surface pathway, which corresponds to the effective whole body dose from deposition on the ground surface shown in the **Summary Results** folder.
- (5) **Organ Totals**—This folder lists the total doses summed for the four pathways for each organ. The bottom row labeled Total lists the effective whole body doses (i.e., TEDEs) for reference.

The RSAC code does not calculate organ doses for the submersion pathway. The effective dose equivalent from the submersion pathway is calculated and included in the **Summary Results** folder for the whole body and in the **Organ Totals** folder for individual organs.

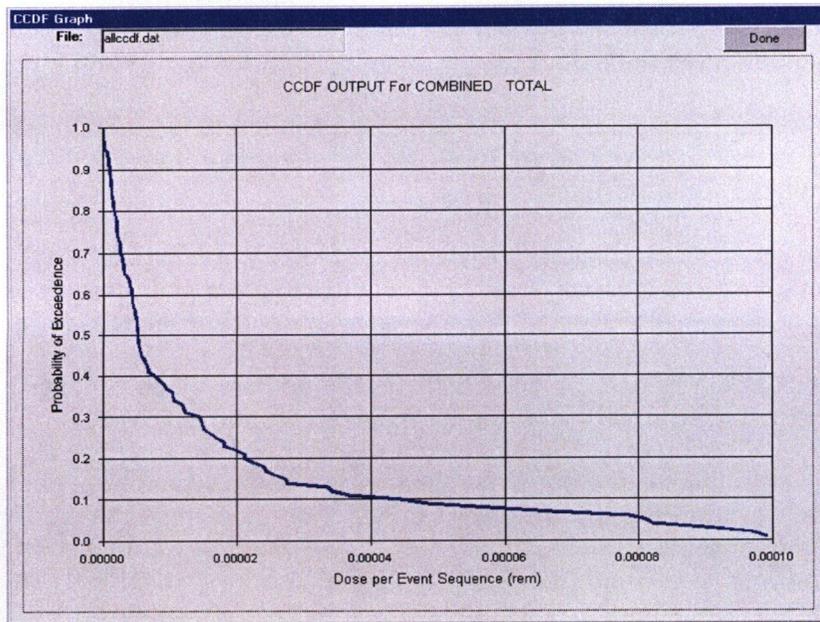
For deterministic calculations, a bar chart displays the pathways doses corresponding to the tabulated values in the **Summary Results** folder [see Figure 3.9.1-14(a)].

For probabilistic calculations, the bar chart displays the pathway contributions to the mean dose to the whole body. In the **Summary Results** folder, the user can double-click on any pathway dose to display a plot of the complementary cumulative distribution function of the whole body dose for that pathway [see Figure 3.9.1-14(b)]. In the other results folders, the user can double-click on any organ dose to display a plot of the complementary cumulative distribution function for that organ and pathway.

Results can be saved (see the **Save Results** Action Command), and results from a previously saved RSAC run can be retrieved (see the **View Stored Data** Action Command).



(a)



(b)

Figure 3.9.1-14. RSAC Output for (a) Deterministic Calculation and (b) Probabilistic Calculation

**Action Commands**

---

**View Stored Data:** Allows the user to view the results from a previous dose calculation. The results file can be selected from the following steps:

- Select and open the project listed in the /PCSATool/Projects directory
- Select and open the /RSACRuns directory
- Select and open the /Det directory for a deterministic run or the /Prb directory for a probabilistic run
- Select and open the results folder (folder name was specified by the user when the results were saved)
- Select and open the file pcsastat.out

**Save Results:** Prompts the user for a subdirectory name to save the current results. The name can be used for viewing previously stored data and should be sufficiently descriptive of the dose calculation. A dose calculation typically corresponds to some event sequence that can be described by the file name.

**View RSAC Output File:** [for deterministic runs, as shown in Figure 3.9.1-14(b)] Opens the pcsastat.txt results file in Notepad.exe. Shows all the results of the five results folders.

**View RSAC Statistics File:** [for probabilistic runs, as shown in Figure 3.9.1-14(b)] Opens the pcsastat.txt results file in Notepad.exe. Shows all the results of the five results folders.

**Done:** Closes the RSAC Output window.

---

### 3.9.1.2 MELCOR

The MELCOR code is used to estimate building discharge fractions, which serve as input parameters for the public dose calculation (see Fraction discharged from building ventilation for Vapors and Noble Gases, Crud (Co-60), and particulates in Figure 3.9.1-4), for a cladding breach (in air) during transfer and handling bare assemblies of spent nuclear fuel.

#### 3.9.1.2.1 Input

The MELCOR Input window consists of three folders providing the input data and their default value as shown in Figures 3.9.1-15 through 3.9.1-17. The parameter names and units for ventilation and volumetric flow rate are consistent with their presentation in the MELCOR code manual (NRC, 2000). The user may make any changes to the input data located in the value column—data in the default column cannot be changed. Note, selecting the **Defaults** button in the folder only resets those data in that folder.

Parameter Name	Defaults	Value	Default
Room length (m)		10	10
Room width (m)		13.4	13.4
Room height (m)		15.24	15.24
Indoor atmospheric pressure (Pa)		101300	101300
Indoor relative humidity		0.5	0.5
Indoor temperature (K)		300	300
Height of lower/middle layer interface (m)		0.5	0.5
Height of middle/upper layer interface (m)		15	15
Outdoor atmospheric pressure (Pa)		101300	101300
Outdoor temperature (K)		300	300
Outdoor dew point temperature (K)		280	280
Height of ventilation inlet (m)		4	4
Stack height, ventilation outlet (m)		40	40
Ventilation inlet area (m <sup>2</sup> )		1	1
Ventilation volumetric flow rate (m <sup>3</sup> /s)		14.16	14.16
Ventilation maximum pressure head (Pa)		312.7	312.7
Volumetric flow rate at zero pressure head (m <sup>3</sup> /s)		14.16	14.16
Volumetric flow rate at maximum pressure head (m <sup>3</sup> /s)		5	5
Minimum particle size (m)		1E-08	1E-08
Maximum particle size (m)		0.01	0.01
Nominal particle density (kg/m <sup>3</sup> )		1000	1000
Initial time step (s)		0.1	0.1
Run time (s)		9000	9000

Buttons: PWR, BWR, DHLW, Navy, User Spec, Defaults, Cancel, Run MELCOR

Figure 3.9.1-15. MELCOR Input Window, General

MELCOR Input

General		Particle Size / Decay Heat		Radionuclide Inventory	
Particle Size Distribution					
		Mean Mass Diameter (m)		Geometric Standard Deviation	
Particle Type		Value	Default	Value	Default
Released spent nuclear fuel		1.8000E-02	1.8000E-02	8.18	8.18
Released crud		9.7000E-06	9.7000E-06	1.87	1.87
Remaining assembly debris		5.0000E-02	5.0000E-02	0.1	0.1
Decay Heat					
Radionuclide Group		Major Decay Heat contributors in 25-year aged SNF		Decay Heat, power per unit group mass (W/kg)	
				Value	Default
Noble gases		Kr		4.5300E-01	4.5300E-01
Alkali Metals		Cs		2.5600E01	2.5600E01
Alkaline Earths		Sr, Ba		9.4000E01	9.4000E01
Early Transition Elements		Co		1.4400E-01	1.4400E-01
Tetravalents		Pu		8.1000E-01	8.1000E-01
Trivalents		Y, Eu, Am, Cm		4.3700E01	4.3700E01
More Volatile Main Group		Sb		4.2700E-01	4.2700E-01
Remaining assembly debris		sum of all groups		8.7800E-01	8.7800E-01

PWR  
 BWR  
 DHLW  
 Navy  
 User Spec  
  
  

Figure 3.9.1-16. MELCOR Input Window, Particle Size/Decay Heat

MELCOR Input

General		Particle Size / Decay Heat		Radionuclide Inventory	
Fuel Assemblies Breached: 8					
Released Radionuclides (into the room air from the spent nuclear fuel or cladding)					
MELCOR Radionuclide Group	Group Mass Released (kg / assembly)	Default	Elements in Group		
Noble gases	1.4100E00	1.4100E00	H, He, N, Ne, Ar, Kr, Xe, Rn		
Alkali metals	3.5500E-05	3.5500E-05	Li, Na, K, Cu, Rb, Cs, Fr		
Alkaline Earths	3.9000E-05	3.9000E-05	Be, Mg, Ca, Sr, Ba, Ra		
Halogens	1.6400E-02	1.6400E-02	F, Cl, Br, I, At		
Chalcogens	5.8100E00	5.8100E00	O, S, Se, Te, Po		
Platinoids	1.0900E-04	1.0900E-04	Ru, Rh, Pd, Re, Os, Ir, Pt, Ni		
Early Transition Elements	2.3500E-04	2.3500E-04	V, Cr, Mn, Fe, Co, Nb, Mo, Tc, Ta, W		
Tetravalents	2.3400E-04	2.3400E-04	C, Ti, Cr, Zr, Hf, Th, Pa, Np, Pu		
Trivalents	1.1100E-05	1.1100E-05	Al, Sc, Y, La, Pr, Nd, Pm, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Ac, Am, Cm, Bk, Cf		
Uranium	8.0400E-04	8.0400E-04	U		
More Volatile Main Group	2.4600E-07	2.4600E-07	Zn, As, Cd, Sb, Tl, Pb, Bi		
Less Volatile Main Group	3.7300E-06	3.7300E-06	Ga, Ge, Ag, In, Sn		
Boron group	4.8400E-07	4.8400E-07	B, Si, P		
Remaining Radionuclides (not released into the room air)					
Mass not Released		Default			
Remaining assembly debris	6.1800E02	6.1800E02	all elements retained in the breached assembly debris		

PWR  
 BWR  
 DHLW  
 Navy  
 User Spec  
  
  

Figure 3.9.1-17. MELCOR Input Window, Radionuclide Inventory

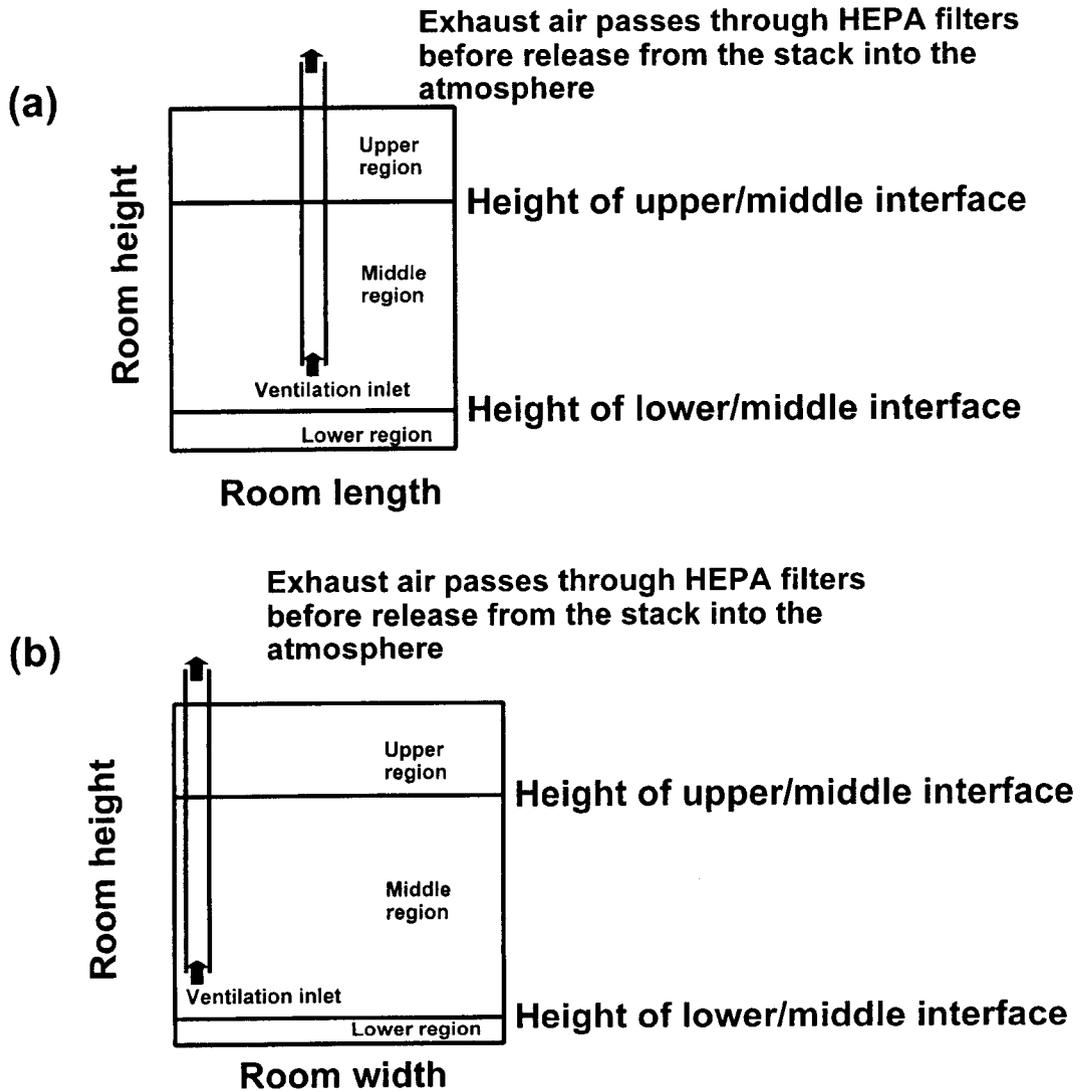
**Action Commands**

---

<b><u>PWR/BWR:</u></b>	The user may select <b>PWR</b> or <b>BWR</b> for fuel type.
<b>Defaults:</b>	Resets all <b>MELCOR</b> Input window data to the default values.
<b>Cancel:</b>	Closes the <b>MELCOR</b> Input window erasing any changes.
<b>Run MELCOR:</b>	Executes a <b>MELCOR</b> run with the data in the <b>MELCOR</b> Input window.

---

Figure 3.9.1-18 displays the room geometry for the MELCOR calculation. The air volume of the room is divided into three vertical regions (upper, middle, and lower). The heights of the region interfaces are specified as input parameters in Figure 3.9.1-15. Airborne radionuclide concentrations are uniformly distributed within a region. The Radionuclide Group Masses Released are released into the middle region, while the remaining mass (not released) occupies the lower region as assembly debris and serves as a heat source. The ventilation inlet height is listed as an input parameter in Figure 3.9.1-15. The ventilation inlet should be located in the middle or upper region of the room. Figure 3.9.1-18 shows the ventilation inlet located in the middle region of the room. Air flows into the ventilation inlet and passes through HEPA filters before being exhausted out a stack into the environment.



**Figure 3.9.1-18. Room Geometries for the MELCOR Calculation (a) Side View Looking Along Room Width and (b) Side View Looking Along Room Length**

3.9.1.2.2 Output

The Output submenu will be displayed only when a MELCOR run has been executed from the MELCOR Input window. As shown in Figure 3.9.1-19, execution of the MELCOR code is computationally demanding and time consuming (typically requires more than 1 hour). The time required to complete a MELCOR simulation is quite sensitive to the values of the last two input parameters in the **General** tab in the MELCOR Input window, Initial timestep(s) and Run time(s). In general, shorter computation times can be achieved for larger initial timesteps or shorter run times. Figure 3.9.1-20 displays the MELCOR output for the fractions discharged from building ventilation of Vapors and Noble Gases, Crud (Co-60), and particulates. These three MELCOR output can serve as input for the public dose calculation (see Section 3.9.1.1.1.2).

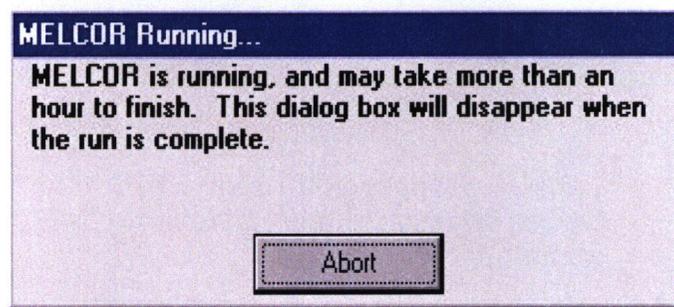


Figure 3.9.1-19. MELCOR Running Window

MELCOR Results	
Radionuclide Type	Building Discharge Fraction (unitless)
Vapors and Noble Gases	1.673E-01
Co-60 Crud	1.319E-02
Particulates	1.506E-03

Close

Figure 3.9.1-20. MELCOR Output Window

**3.9.2 Worker Dose**

As shown in Figure 3.9.2-1, the worker dose calculation is accessed by the *Worker Dose* option under the **Conseq.** header on the toolbar of the PCSA Tool (see Figure 3.9.1-1). This stylized worker dose calculation estimates the doses from gaseous radionuclides released into the air following an underwater breach of fuel cladding. The worker, who is not wearing respiratory protection, is assumed to be located within the transfer room above an open pool. The input parameters and output for the Worker Dose calculation are consolidated on a single screen. The user may make changes to the white boxes located under Input Data at the top left of the menu, which includes the option for Fuel Type, and Intermediate Results at the bottom left of the menu. The gray boxes are for reference and may not be edited. When the desired input is complete, select **Calculate Dose**, and the results are displayed in the yellow boxes at the bottom right of the menu.

**Worker Dose**

**Input Data**

Fuel Assemblies Breached: 8  
 Gaseous Release Fraction: 0.40  
 Inhalation Rate (m<sup>3</sup>/s): 3.33E-04  
 Air Mixing Volume (m<sup>3</sup>): 1059.1  
 Time spent in Mixing Volume after Release (min): 2  
 Fuel Type:  PWR  BWR

**Dose Conversion Factors**  
 DCFs from Federal Guidance Report 11 (EPA 1988)

Radionuclide	Inhalation (Sv/Bq)	Submersion (Sv/h per Bq/m <sup>3</sup> )	Skin (Sv/h per Bq/m <sup>3</sup> )
H3	1.73E-11	1.19E-15	N/A
Ar39	N/A	5.54E-14	3.75E-11
Kr85	N/A	4.70E-13	4.66E-11
I129	4.69E-08	N/A	N/A
Rn219	(t1/2 = 4s, assumed too short for gaseous release from pool)		
Pb212 (Rn220)	4.56E-08	N/A	N/A
Pb214 (Rn222)	2.11E-09	N/A	N/A

**Intermediate Results**

Radionuclide	Ci/Assembly	Air Conc. (Bq/m <sup>3</sup> )	Inhalation (Bq/s)
H3	1.10E+02	1.23E+10	4.10E+06
Ar39	3.39E-05	3.78E+03	1.26E+00
Kr85	1.06E+03	1.19E+11	3.96E+07
I129	1.95E-02	2.18E+06	7.26E+02
Rn220*	2.74E-02	3.07E+06	1.02E+03
Rn222**	8.29E-07	9.26E+01	3.08E-02

**Dose Results**

	Inhalation (rem)	Submersion (rem)	Skin (rem)
H3	8.50E-01	4.98E-05	
Ar39		6.99E-10	4.73E-07
Kr85		1.86E-01	1.85E+01
I129	4.08E-01		
Rn220*	5.59E-01		
Rn222**	7.80E-07		
<b>Totals:</b>	<b>1.82E+00</b>	<b>1.86E-01</b>	<b>1.85E+01</b>

\* Air conc for decay progeny Pb212 was set equal to the air conc of Rn220 (deposition of Pb212 was not considered).  
 \*\* Air conc for decay progeny Pb214 was set equal to the air conc of Rn222 (deposition of Pb214 was not considered).

**Figure 3.9.2-1. Worker Dose Input Window**

**Action Commands**

- Fuel Type :** Allows selection of **PWR** or **BWR** and loads the default radionuclide inventories (shown with the intermediate results under Ci/Assembly) for that fuel type.
- Reload Defaults:** Resets input data for the worker dose calculation to the default values.
- Calculate Dose:** Performs a worker dose calculation with the current input data and updates the intermediate results and dose results.

**Defaults:** Becomes active when changes are made to the default radionuclide inventories. Resets the radionuclide inventories to the default values.

**Close:** Closes the worker dose calculation interface.

---

## Perform.

### 3.10 Perform.

The Perform. menu has two submenus: Current Level Results and Project Results.

#### 3.10.1 Current Level Results

Selecting the Current Level Results submenu opens the **Results Table** window (see Figure 3.10.1-1) that shows the integrated results from event frequency analysis and dose consequence analysis in tabular form. The frequency data for event sequences for the functional area entered in the **Event Sequence Form** are automatically brought into this window. The dose consequence results for point estimate (deterministic) and probabilistic cases for each event sequence are populated in this window. The individual data entry fields are presented next.

Item No: Displays serial number of event sequences

EvScen ID: Displays event Scenario ID

EvSeq ID: Displays event Sequence ID

EvSeq Freq: Displays Event Sequence Frequency entered in the **Event Sequence Form** (Figure 3.8.4-1)

Category: Tool assigns a frequency Category 1, 2, or Below Category 2 frequency (BCFL) to the event sequence based on definitions in 10 CFR Part 63 and the preclosure period.

Description: Corresponds to the Description input in the **Event Sequence Form**

Det Conseq Path: Displays file name and path for point estimate or deterministic dose evaluated using the Conseq. menu. Double clicking in any of the Det Conseq Path cells will display a directory menu (see Figure 3.10.1-2) that allows the user to select a file from any deterministic runs that have been saved. The user has the option to **Accept** a selected file, choose **No Release**, or **Cancel**. For DOE-analyzed Events, the Det Conseq Path cell will be inactive.

Dose PtEst: Displays point estimate (deterministic) dose from the selected consequence analysis file. For DOE-analyzed events, an edit box appears by double clicking on the cell as shown in Figure 3.10.1-3. The user manually enters the dose evaluated by DOE.

Prob Conseq Path: Displays file name and path for probabilistic dose evaluated using Conseq. menu.

Dose, Mean: Value displayed automatically when Prob Conseq Path is selected.

Results Table - Functional ID: E.3.3									
Item No	EvScen ID	EvSeq ID	EvSeq Freq	Category	Description	Det Conseq Path	Dose, PtEst	Prob Conseq Path	Dose, Mean
0001.00	CTS-ES-01	CTS-1-01	2.69E-02	1	Canister drop, canis	21PwRwithHEPA	1.62E-03		
0002.00	CTS-ES-01	CTS-1-02	2.86E-05	2	Canister drop, canis	1PwRPoolWithHE	7.72E-05		
0003.00	CTS-ES-01	CTS-1-03	1.37E-08	BCFL	Canister drop, canis	2PwRwithHEPA	1.54E-04		

Units: Doses: Rem  
Frequency: 1/Year

Refresh    Category Search    Edit Record    Show Report    Close

Figure 3.10.1-1. Current Level Results Table Window

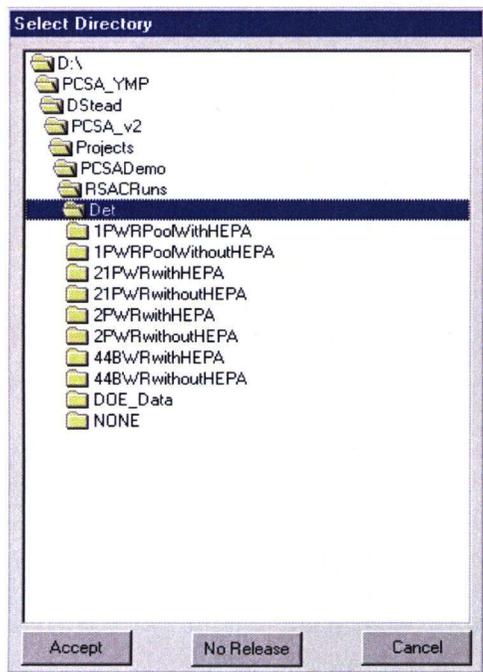
### Action Commands

---

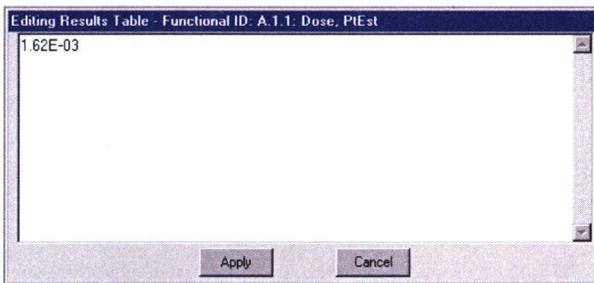
- Refresh:** Displays all categories in the Results Table window.
- Category Search:** Prompts the user to enter a Category of 1, 2, or Below Category 2 frequency and displays list of event sequences sorted by frequency category.
- Edit Record:** Allows the user to edit the Dose, PtEst field for DOE-analyzed events.
- Show Report:** Displays information in report format.
- Close:** Returns to main project screen retaining any changes made in the window.
- 

*Note: The Results Table window displays only data from the Event Sequence Form that corresponds to the selected Functional ID from the Project Tree.*

**Perform.**



**Figure 3.10.1-2. Directory Window**



**Figure 3.10.1-3. Dose Input Window**

### **3.10.2                    *Project Results***

The *Project Results* submenu has further submenus, *Safety Assessment* and *Risk Assessment*.

#### **3.10.2.1                *Safety Assessment***

The *Safety Assessment* submenu under the *Project Results* submenu displays a **Result Table—Project View Base Case** form (see Figure 3.10.2-1) showing results (i.e., frequencies and consequences) from all Functional ID areas. Data cannot be entered or edited in this form. Clicking the **Compliance Assessment** button prompts the user to enter a Category of 1, 2, or below Category 2 frequency.

Selecting Category 1 will sort all Category 1 event sequences in Result Table and display the **Safety Assessment—Category 1 Event Sequences** window as shown in Figure 3.10.2-2. The user must select a Dose Type and input a numerical value for the annual dose caused by Normal Releases from all surface and subsurface operations. The dose in the Normal Release field does not correspond to any event sequence and is estimated outside the tool. Clicking the **Calculate** button in the Frequency-Weighted Annualized Dose group will provide the user with the Total Dose. The Total Dose is compared in the regulatory dose limit given next. If the Total Dose value is greater than the Regulatory Limit, the Total Dose box will be highlighted in red. Clicking the **Calculate** button in the combination of Events group (on the right side of the window) will display Figure 3.10.2-3. The tool provides the capability to evaluate combination Category 1 event sequences that could occur in the same year. The **Calculate** button would display the results on a **Windows Notepad**, which shows a separate list of combinations of events sequences if the annual frequency equals or exceeds the cutoff frequency, and the corresponding dose. The combination dose should not exceed the regulatory dose limit for Category 1 event sequences. Further details on combination of event sequences can be found in Dasgupta, et al. (2002).

Choosing Category 2, in response to Compliance Assessment button, will sort all Category 2 event sequences and user must look for Compliance in each event sequences.

**Perform.**

Results Table - Project View Base Case							
FunctionalID	EvScen ID	EvSeq ID	EvSeq Freq	Category	Description	Dose, PEst	Dose, Mean
E.2.1.2	ATS-CPP-ES-01	ATS_CPP_01	8.68E-03	2	Shipping Cask Drop Into Preparation Pit	2.36E-02	
E.2.1.3	ATS-PUL-ES-01	ATS_PUL_01	8.68E-03	2	Unsealed Shipping Cask Drop Into Cask Unloading Pool	2.39E-03	
E.2.1.4	ATS_PL_ES_1	ATS_PL_01	2.30E-01	1	SFA Drop onto Another SFA in Cask	1.76E-07	
E.2.1.4	ATS_PL_ES_10	ATS_PL_10	6.83E-03	2	ATS Basket Collision During Transfer	3.74E-01	
E.2.1.4	ATS_PL_ES_11	ATS_PL_11	6.83E-03	2	Uncontrolled Descent of Incline Transfer Cart	3.74E-01	
E.2.1.4	ATS_PL_ES_12	ATS_PL_12	1.74E-03	2	Handling Equip Drop Onto SFA Basket in Pool	3.74E-01	
E.2.1.4	ATS_PL_ES_13	ATS_PL_13	2.38E-03	2	Handling Equip Drop Onto SFA in Pool	9.36E-02	
E.2.1.4	ATS_PL_ES_14	ATS_PL_14	6.83E-02	1	SFA Basket Collision During Transfer to Incline Transfer	3.74E-02	
E.2.1.4	ATS_PL_ES_2	ATS_PL_02	3.90E-02	1	SFA Collision	8.81E-08	
E.2.1.4	ATS_PL_ES_3	ATS_PL_03	4.22E-02	1	SFA Drop on Empty Basket	8.81E-08	
E.2.1.4	ATS_PL_ES_4	ATS_PL_04	1.92E-01	1	SFA Drop Onto Another SFA in Basket	1.41E-06	
E.2.1.4	ATS_PL_ES_5	ATS_PL_05	4.10E-02	1	SFA Drop Onto Another Basket in Basket Staging Rack	1.41E-06	
E.2.1.4	ATS_PL_ES_6	ATS_PL_06	4.10E-02	1	Basket Drop Onto Another Basket in Pool	1.41E-06	
E.2.1.4	ATS_PL_ES_7	ATS_PL_07	4.10E-02	1	Basket Drop Onto Another Basket in Pool	1.41E-06	
E.2.1.4	ATS_PL_ES_8	ATS_PL_08	4.10E-02	1	Basket Drop Onto Transfer Cart	7.05E-07	
E.2.1.4	ATS_PL_ES_9	ATS_PL_09	4.10E-02	1	Basket Drop Back to Pool	7.05E-07	
E.2.2.1	ATS_DC_ES-1	ATS_DC_01	4.10E-02	1	Basket Drop Onto ATS Hot Cell Floor	2.17E-04	
E.2.2.1	ATS_DC_ES-2	ATS_DC_02	4.10E-02	1	Basket Drop Onto Another Basket in Dryer	4.34E-04	
E.2.2.1	ATS_DC_ES-3	ATS_DC_03	2.34E-01	1	SFA Drop Onto Another SFA in Dryer	5.42E-05	
E.2.2.1	ATS_DC_ES-4	ATS_DC_04	2.34E-01	1	SFA Drop Onto ATS Hot Cell Floor	2.71E-05	
E.2.2.1	ATS_DC_ES-5	ATS_DC_05	2.34E-01	1	SFA Drop Onto Another SFA in DC	5.47E-05	
E.2.2.1	ATS_DC_ES-6	ATS_DC_06	6.95E-05	2	Handling Equip Drop Onto SFA in Hot Cell	2.78E-03	
E.2.2.1	ATS_DC_ES-7	ATS_DC_07	2.38E-03	2	Handling Equip Drop Onto SFA Basket in Hot Cell	7.46E-04	
E.3.3	CTS-ES-01	CTS-1-01	2.69E-02	1	Canister drop, canister intact no breach	1.62E-03	
E.3.3	CTS-ES-01	CTS-1-02	2.86E-05	2	Canister drop, canister breach, HEPA available	7.72E-05	
E.3.3	CTS-ES-01	CTS-1-03	1.37E-08	BCFL	Canister drop, canister breach HEPA unavailable	1.54E-04	
E.4.1	DHS_CL_ES_1	DHS_CL_01	2.00E-03	2	Unsealed DC collision	1.53E-02	
E.4.1	DHS_CL_ES_2	DHS_CL_01	8.00E-03	2	Unsealed DC Drop and Standdown	1.53E-02	

Units: Doses: Rem  
Frequency: 1/Year

SSCIS Refresh Compliance Assessment Edit Record Show Report Close

Figure 3.10.2-1. Safety Assessment Results Table

Safety Assessment - Category 1 Event Sequences

Frequency-Weighted Annualized Dose		Combination of Events	
Dose <input checked="" type="radio"/> Point Estimate	Dose	Cutoff Frequency	1.00E-02
Type <input type="radio"/> Probabilistic, Mean	Rem / Year		
Frequency Weighted Sum:	0.002657062	Calculate	Run Status
Normal Release:	0.00273		
Total Dose:	0.005387062		
Regulatory Limit: [10CFR Part 63.111(a)(2)]	0.015		
	Calculate	Done	

Figure 3.10.2-2. Category 1 Event Sequences

```

comban.txt - Notepad
File Edit Search Help

PCSA tool event listing for combinations of 1 events that have a composite frequency
that is greater than 0.010

Frequency      Dose      Event-name
(1/yr)        (rem)
2.30E-01  1.76E-07  E.2.1.4-0001.00
6.83E-02  3.74E-02  E.2.1.4-0014.00
3.90E-02  8.81E-08  E.2.1.4-0002.00
4.22E-02  8.81E-08  E.2.1.4-0003.00
1.92E-01  1.41E-06  E.2.1.4-0004.00
4.10E-02  1.41E-06  E.2.1.4-0005.00
4.10E-02  1.41E-06  E.2.1.4-0006.00
4.10E-02  1.41E-06  E.2.1.4-0007.00
4.10E-02  7.05E-07  E.2.1.4-0008.00
4.10E-02  7.05E-07  E.2.1.4-0009.00
4.10E-02  2.17E-04  E.2.2.1-0001.00
4.10E-02  4.34E-04  E.2.2.1-0002.00
2.34E-01  5.42E-05  E.2.2.1-0003.00
2.34E-01  2.71E-05  E.2.2.1-0004.00
2.34E-01  5.47E-05  E.2.2.1-0005.00
2.69E-02  1.62E-03  E.3.3-0001.00

PCSA tool event listing for combinations of 2 events that have a composite frequency
that is greater than 0.010

Frequency      Dose      Event-name      Event-name
(1/yr)        (rem)
5.29E-02  3.52E-07  E.2.1.4-0001.00  E.2.1.4-0001.00
1.57E-02  3.74E-02  E.2.1.4-0014.00  E.2.1.4-0001.00
4.42E-02  1.59E-06  E.2.1.4-0004.00  E.2.1.4-0001.00

```

Figure 3.10.2-3. Output for the Calculation of Combination of Events

### Action Commands

---

- SSCIS:** Allows the user to identify structure, systems, and components important to safety. Users interested in using this feature are advised to consult Dasgupta, et al. (2002, Chapter 9).
- Refresh:** Displays all categories in the **Results Table** window if **Safety Assessment** has been activated.
- Compliance Assessment:** Prompts the user to enter a Category of 1, 2, or below Category 2 frequency and displays only that Category in the **Results Table** window. Selecting Category 1 prompts the user with Figure 3.10.2-2.
- Show Report:** Displays information in report format.
- Close:** Returns to the main project screen retaining any changes made in the window.
-

## **Perform.**

### **3.10.2.2 Risk Assessment**

The *Risk Assessment* submenu allows evaluation of total aggregate risk based on the frequencies and consequences of event scenarios from all functional areas. Details of the risk assessment methodology have been previously described (Benke, et al., 2002). This calculation is not required by the regulation; it is an additional option for generating risk insights. The Risk Analysis (see Figure 3.10.2-4) form displays a table of data for every event scenario from all functional areas. All event scenarios are selected for risk assessment by default. Scenarios excluded from this analysis should be deselected from the **Event Tree Form**. For this analysis, an event scenario relates a single initiating event to its corresponding event sequences. The data fields of the **Risk Analysis** form are described next. Only the first two fields (Time for Risk Analysis Calculation (Yr.) and "Input Cutoff Limit" for Combination of Probability of Events) allow the user to input data directly. The other fields display previously entered or calculated data. The individual data entry fields are presented next.

Time for Risk Analysis Calculation (Yr.): Results of the risk assessment, risk (rem within the specified time period), and the probability of occurrence for combinations of event scenarios within the specified time period are based on this time period. The default value for time of duration for risk evaluation is 1 year. The user may enter a different value by double clicking on the time.

"Input Cutoff Limit" for Combination of Probability of Events: The user can assign a probability cutoff limit for combinations of probability in risk calculations. Event scenario combinations with probabilities of occurrence (within the specified time period) less than the cutoff limit are not included in the calculation of total aggregate risk.

Functional ID: Displays identification number of the functional area along with the description of the functional area selected from the Project Tree.

EvScen ID: Displays event scenario identification.

IE ID: Displays initiating event identification.

DOE: Displays Y if a DOE-analyzed event, otherwise, N.

IE Freq: Displays initiating event frequency (in units of 1 year). Data are transferred into this field automatically for previously specified initiating events.

IE Prob: Displays initiating event probability. This field is populated separately for each event scenario by calculations performed in the **Event Scenario Risk** form (see Figure 3.10.2-5).

Event Scenario: Displays descriptions of the event scenarios.

Time for Calculation: Displays time for risk calculation (in units of 1 year).

Dose, Pt.Est: The point estimate or deterministic dose for each event scenario is evaluated through a separate set of calculations, initiated by double clicking on each cell to display the **Event Scenario Risk** form, shown in Figure 3.10.2-5. Steps to calculate a point estimate (deterministic) dose for the event scenarios are discussed for **Deterministic Dose** at the end of this section with the other **Action Commands**.

**Dose, Mean:** The mean dose for each event scenario is evaluated through a separate set of probabilistic calculations, initiated by double clicking on each cell to display the **Event Scenario Risk** form, shown in Figure 3.10.2-5. Steps to calculate a probabilistic scenario dose for the event scenarios are discussed for **Probabilistic Dose** at the end of this section with the other **Action Commands**.

**Num Realiz:** Shows the number of realizations for probabilistic scenario dose calculation. The tool requires the same number of realizations for all event sequences used in the scenario dose calculation. The number of realizations is displayed once the probabilistic dose path has been selected for an event sequence in the **Event Scenario Risk** form (see Figure 3.10.2-5).

**Dose, Min:** Displays minimum dose from the probabilistic scenario dose calculation.

**Dose, 5%:** Displays 5<sup>th</sup> percentile dose from the probabilistic scenario dose calculation.

**Dose, 50%:** Displays 50<sup>th</sup> percentile dose from the probabilistic scenario dose calculation.

**Dose, 95%:** Displays 95<sup>th</sup> percentile dose from the probabilistic scenario dose calculation.

**Dose, Max:** Displays maximum dose from the probabilistic scenario dose calculation.

**NonFilesOnly:** Indicates if the event scenario dose has been calculated from previously saved consequence runs as specified by the user in the **Event Scenario Risk** form. Y denotes consequence paths have not been specified. N denotes previous consequence paths were used to calculate the event dose. The tool uses this column to determine if sufficient information has been specified by the user to perform the risk analysis.

Calculation of **Dose, PtEst** and **Dose, Mean** for Each Event Scenario: Double clicking in any cell of the **Dose, PtEst** or **Dose, Mean** column will open the **Event Scenario Risk** form, shown in Figure 3.10.2-5, corresponding to that event scenario. The **Event Scenario Risk** form displays existing data on the event scenario: Functional ID, Type of Run, Event Scenario ID, (Ti) Time for [risk] Calculation (yr), and (Fi) Initiating Event Freq (/yr). The fields for (Ei) Event Probability and (Ci) Event Deterministic Dose (rem) (Event Mean Dose for probabilistic calculations) are initially empty. The **Event Dose** button calculates deterministic (or probabilistic) event dose and populates the **Event Probability** and **Event Deterministic Dose** (or Event Mean Dose) fields. The window also displays a table of previously specified data associated with the event sequences of the event scenario: EvSeq ID (Event Sequence ID), EvSeq Freq (Event Sequence frequency), Coefficient, and Det Conseq Path (Deterministic Consequence Path) (or Probabilistic Consequence Path). The Det Conseq Path column displays the directory paths for previously saved consequence analysis (either point estimate or probabilistic) results. The tool also creates a file containing data from deterministic and probabilistic dose calculations and assigns a path for data storage in the (Ci) Event Dose Path field. The user may not specify the Deterministic Consequence Path or Probabilistic Consequence Path in the table provided in the **Event Scenario Risk** form (Figure 3.10.2-5). Using the **Results Table** window (see Figure 3.10.1-1), the user must double click in the empty cells under the Det Conseq Path (or Prob Conseq Path) columns and select the directory, in which the consequence results are saved, to assign a consequence path to an event sequence.

**Perform.**

Risk Analysis, Project: RiskTest

Time for Risk Analysis Calculation (Yr.)  Double click on time to change. 'Input Cutoff Limit' for Combination of Probability of Events

Double click on Dose to perform deterministic scenario calculation.  
 Double click on Mean Dose to perform probabilistic scenario calculation.

FunctionalID	EvScen ID	IE ID	DOE	IE Freq	IE Prob	Event Scenario	Time for	Dose, PtEst	Dose, Mean	Num Realiz	Dose, Min	Dose, 5%	Dose, 1%
A.1	Scenario 1	Event 1	N	2.72E-02	2.683E-02	Risk Scenario 1	1.0	1.739E-06	9.498E-06	50	3.654E-09	1.718E-07	2.71E-07
A.1	Scenario 2	Event 2	N	4.10E-02	4.017E-02	Risk Scenario 2	1.0	7.879E-05	0.000E+00	50	0.000E+00	0.000E+00	0.000E+00
A.1	Scenario 3	Event 3	N	2.34E-01	2.086E-01	Risk Scenario 3	1.0	1.732E-04	9.448E-04	50	3.642E-07	1.713E-05	2.71E-05
A.1	Scenario 4	Event 4	N	8.30E-03	8.266E-03	Risk Scenario 4	1.0	1.331E-03	7.272E-03	50	2.798E-06	1.298E-04	2.10E-04

Deterministic Risk      Probabilistic Risk      Done

Figure 3.10.2-4. Output Screen Showing Risk Analysis Form

Event Scenario Risk, Project: RiskTest

Functional ID  Event Scenario ID

Type of Run

(T) Time for Calculation (yr)

(Fi) Initiating Event Freq. (/yr)

(Ei) Event Probability

(Ci) Event Mean Dose (rem)

(Ci) Event Dose Path

EvSeq ID	EvSeq Freq	Coefficient	Num Realizations	Prob Conseq Path
Sc1_Seq1	2.72E-02	1.014E00	50	NONE
Sc1_Seq2	2.88E-05	1.073E-03	50	Demo21PWRwithHEPA
Sc1_Seq3	4.96E-12	1.849E-10	50	Demo21PWRwithoutHEPA

Event Dose      Done

Figure 3.10.2-5. Output Screen Showing Event Scenario Risk Form

**Deterministic Results**

Calculation Complete

Outcome State	Probability	Consequence (rem)	Risk (rem in time period)
....	7.331E-01	0.000E+00	0.000E+00
+++	2.021E-02	1.739E-06	3.515E-08
++	3.068E-02	7.882E-05	2.418E-06
+-	1.932E-01	1.733E-04	3.348E-05
...	6.110E-03	1.331E-03	8.132E-06
++	8.459E-04	8.056E-05	6.814E-08
+-	5.328E-03	1.750E-04	9.323E-07
...	1.685E-04	1.333E-03	2.245E-07
++	8.087E-03	2.521E-04	2.039E-06
+-	2.557E-04	1.410E-03	3.605E-07
...	1.611E-03	1.504E-03	2.422E-06
++	2.230E-04	2.538E-04	5.659E-08
+-	7.050E-06	1.411E-03	9.950E-09
...	4.440E-05	1.506E-03	6.686E-08
++	6.741E-05	1.583E-03	1.067E-07
+-	1.858E-06	1.585E-03	2.945E-09
Total Risk			5.035E-05

Done

Figure 3.10.2-6. Output Showing Deterministic Results Form

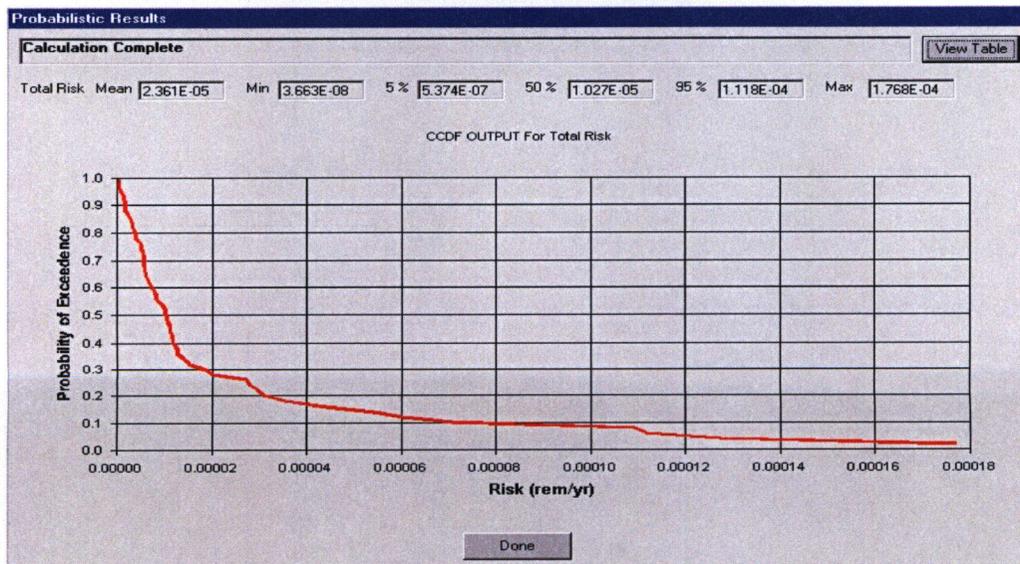


Figure 3.10.2-7. Output Screen Showing Probabilistic Results Form. The View Table Button Displays the Filenames Containing the Probabilistic Results (Consequences and Risk) from Each Combination of Event Scenarios. Instead of the Presented Unit of rem/yr, The Correct Unit for Risk is Rem in Time Period.

## **Perform.**

### **Action Commands**

---

**Deterministic Risk:** Calculates system risk using point estimates for the scenario doses. The deterministic risk will be evaluated only when the IE Prob and Dose PtEst columns are populated for all event scenarios. The results from the risk analysis are displayed in Figure 3.10.2-6, which shows Outcome State (in symbolic notation), Probability (within the specified time period), Consequence (rem), Risk (rem in timer period), and Total Risk (rem i time period). The Outcome State field shows results of outcome analysis with each column representing an event. A + sign indicates the event scenario occurred at least once within the specified time period, and a - sign indicates the event scenario did not occur. For example, +-+- denotes at least one occurrence of the first and third event scenarios and no occurrences of the second and fourth event scenarios. The probability, consequence, and risk for each combination of event scenarios (outcome) are tabulated in Figure 3.10.2-6, followed by a row presenting the total risk.

**Probabilistic Risk:** The probabilistic risk calculations are conducted by clicking on this button. Probabilistic risk is evaluated only when the IE Prob column and columns associated with probabilistic dose columns are populated for all event scenarios. The Probabilistic Results window (Figure 3.10.2-7) displays a complementary cumulative distribution function plot of total risk; it also shows the mean, minimum, 5<sup>th</sup>-, 50<sup>th</sup>-, 95<sup>th</sup>-percent, and maximum risk values at the top of the form.

**Done:** Closes the Risk Analysis window.

---

### 3.11 SW Reliability

Information required for the qualitative analysis of software reliability is compiled using this menu. The feature may be selected from the main menu bar of the PCSA Tool. Because a software system may have application to a limited part of preclosure repository operations or may be applied to all operations, the extent of applicability is defined for each software system described. The SW Reliability menu prompts **Software Systems** window, shown in Figure 3.11-1, which has no submenus, but allows access to various fields by selecting one of five tabs: **Characterization, Items 1–4**; **Characterization, Items 5–7**; **Use in Repository, Items 1–5**; **Use in Repository, Items 6–8**; **Potential Failures**.

The user needs to enter initial information using **Add New Software System** button (see page 3-88 for details). Data entry fields in the folders (tabs) in **Software Systems** window can be accessed by selecting the **Edit** button. The individual data entry fields shown in Figure 3.11-1 to 3.11-5 are presented below. The data entry fields that are self explanatory will not be described further.

Select Software System: Displays a drop-down menu of the software system included in the database using the **Add Software System** button (see page 3-91). Selecting a software system allows the user to view information already stored or enter data on the software.

Functional Areas Where this system is used: List all the functional areas, taken from the system description, in which this software system is used.

Tabs:

- Characterization, Items 1–4 (see Figure 3.11-1)
- 1. Any extant failure data on the software system: Provide any extant failure data on the software system recorded during the development phase or operation of the software system; frequently, failures experienced in developing the software are not reported.
- 2. Characteristics of the software development process: Describe what methods and actions were used to manage the process for developing this software.
- 3. Characteristics (especially Maturity Level) of the software development organization: This characterization is keyed to the Capability Maturity Model developed by the Software Engineering Institute of Carnegie-Mellon University (Paulk, et al., 1993).
- 4. Analysis of the requirements specification for the software: How were the operational requirements for the software stated and to what depth?

The screenshot shows a software application window titled "Software Systems". At the top, there is a dropdown menu labeled "Select the Software System" with a "Change Name" button to its right and an "Add Software System" button further right. Below this are input fields for "ID:" and "Company:", with a "Functional Areas Where this system is used" dropdown menu to the right of the ID field. A horizontal tab bar contains five tabs: "Characterization, Items 1 - 4" (which is selected), "Characterization, Items 5 - 7", "Use in Repository, Items 1 - 5", "Use in Repository, Items 6 - 8", and "Potential Failures". The main content area is titled "Categorization of the Software System and its development process." and includes the instruction "Use a combination of factors to evaluate qualitatively software reliability and its impact on preclosure safety." Below this are four numbered items, each with a text area and a dropdown arrow on the right: 1. Any extant failure data on the software system; 2. Characteristics of the software development process; 3. Characteristics (especially Maturity Level) of the software development organization; 4. Analysis of the requirements specification for the software. At the bottom of the window are "Edit" and "Close" buttons.

**Figure 3.11-1. Software Systems Window and Characterization, Items 1–4**

- Characterization, Items 5–7 (see Figure 3.11-2)
- 5. Identification and evaluation of the software standards used in developing and applying the software, if any: Describe standards used, if any, and how applicable they are to the particular application.
- 6. Determination of the degree to which the software has been previously used and corrected or the degree to which software components (subsystems and reused software) might be employed:
- 7. Other: Provide any other information characterizing the software or its development.

**Software Systems**

Select the Software System

Change Name Add Software System

ID: Functional Areas Where this system is used

Company:

Characterization, Items 1 - 4    **Characterization, Items 5 - 7**    Use in Repository, Items 1 - 5    Use in Repository, Items 6 - 8    Potential Failures

**Categorization of the Software System and its development process.**  
Use a combination of factors to evaluate qualitatively software reliability and its impact on preclosure safety.

5. Identification and evaluation of the software standards used in developing and applying the software, if any

6. Determination of the degree to which the software has been previously used and corrected or the degree to which software components (subsystems and reused software) might be employed

7. Other

Edit Close

**Figure 3.11-2. Software Systems Window and Characterization, Items 5–7**

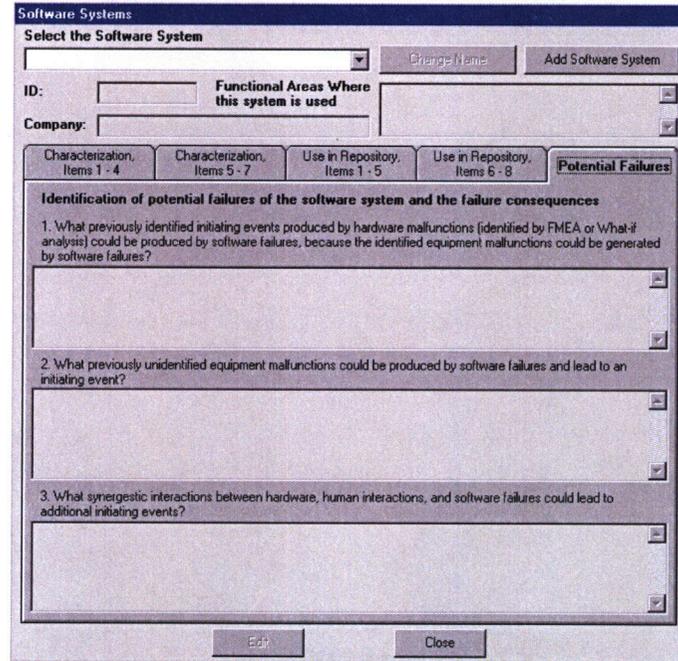
- Use in Repository, Items 1–5 (see Figure 3.11-3)
1. Functions Performed by this System:
  2. Hardware Components Controlled:
  3. Sensors and other Input Devices (including keyboard etc.):
  4. Description of how humans interact with the software system under routine operations and how humans can decide to take action through the software system:
  5. Is the Software System involved in actively controlling the process, in providing standby interaction and/or notification during an upset condition, or both?

**Figure 3.11-3. Software Systems Window and Use in Repository, Items 1–5**

- Use in Repository, Items 6–8 (see Figure 3.11-4)
- 6. Is the Software System applied to specific types of hardware individually or multiple times, or does it control several types of hardware simultaneously (local versus global system)? For example does the software control a single air lock, all the air locks, or all the air locks and all the radiation sensors at entry ports?
- 7. Identification of whether and to what degree fail-safe design approaches have been used in developing or specifying its requirements.
- 8. Determination of the degree to which software failures will be mitigated by other safety systems. These devices include automatic devices or human intervention.

**Figure 3.11-4. Software Systems Window and Use in Repository, Items 6–8**

- Potential Failures
1. What previously identified initiating events produced by hardware malfunctions (identified by FMEA or What-if analysis) could be produced by software failures, because the identified equipment malfunctions could be generated by software failures?
  2. What previously unidentified equipment malfunctions could be produced by software failures and lead to an initiating event?
  3. What synergistic interactions between hardware, human actions, and software failures could lead to additional initiating events?



**Figure 3.11.1-5. Software Systems Window and Potential Failures**

The following Action Commands correspond to Figures 3.11.1-1 through 3.11.1-6:

**Action Commands**

- 
- Select the Software System:** Allows selection, by name, of a previously entered software system.
  
  - Change Name:** Permits revision of the name and description of the software system, while retaining the entries in all other fields. This button is activated by **Edit** button.
  
  - Add New Software System:** Permits addition of a new software system name, with all fields blank; this selection brings up a **Add New Software System** window with three fields to be filled in: ID, Description, and Company (Figure 3.11-6). Every software system is given a unique identification in ID text field. Once entered, the ID cannot be edited. Name of the software system and description is provided next in Description text field. The Description may be edited by selecting **Change Name** and **Edit**. Name of the developer of the software system is provided in the Company text field. The Company name can be edited by selecting **Edit** button.

**Edit/Update:** Allows the user to modify all fields in folder (tab) and some fields in **Add New Software System** window.

**Close/Cancel:** Close returns to the main project screen, automatically saving any changes; Cancel returns to the Software Reliability screen, without changing any edited fields.

<b>Tabs to Access Fields:</b>	Tab 1	Characterization, Items 1–4
	Tab 2	Characterization, Items 5–7
	Tab 3	Use in Repository, Items 1–5
	Tab 4	Use in Repository, Items 6–8
	Tab 5	Potential Failures

---

The image shows a dialog box titled "Add new Software System". It has a dark blue header bar with the title in white. Below the header, there are three input fields: "ID:" with a small rectangular text box, "Description" with a larger rectangular text box, and "Company:" with another rectangular text box. At the bottom of the dialog, there are two buttons: "OK" and "Cancel". The "OK" button is highlighted with a dashed border.

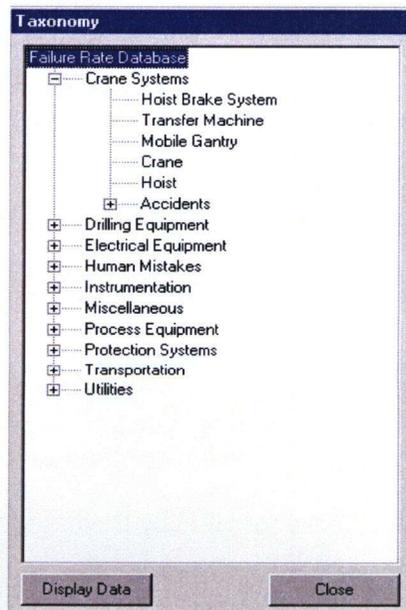
**Figure 3.11.1-6. Software System Input Form**

### 3.12 **Failure Rate**

The **Failure Rate** menu contains View Taxonomy, Search Database, and HEP Generator submenus. A database has been developed that contains failure rates of several components based on the actuarial data. A user can search for the data using either the View Taxonomy or Search Database submenus. These data have been categorized in an industry standard taxonomical structure.

#### 3.12.1 **View Taxonomy**

The View Taxonomy submenu opens a **Taxonomy** window that contains a tree view that shows a listing of all current components and categories (Figure 3.12.1-1). After expanding the nodes of the tree, the user can search for the component. Double clicking on a component or selecting a component and clicking **Display Data** will bring forward a dialog box that contains the failure rate for that component, the references from where the data were acquired, and a brief description of the available statistical basis. In the **Search Results** window (Figure 3.12.1-2), the user can input the Letter ID or the Number ID from the reference column to retrieve and display the primary and secondary references, and the corresponding data will be displayed in the bottom part of the **Search Results** window as shown in Figure 3.12.1-2. To start a new search, click **New Search** and enter up to three keywords. Clicking on **Close** will close the **Search Results** window and return to the **Taxonomy** window.



**Figure 3.12.1-1. Taxonomy Window**

Search results for: crane yielded 67 results

Equipment Description	Field 2	Field3	Field4	Field 5	Field1	Reference	Units of Rate	Failure Rate	High Value	Low Value	Remarks	20%
OVERHEAD CRANES						E2	/HR	0.00005				
OVERHEAD BRIDGE CRANES	10 TON					E3	/HR	0.00011				
BRIDGE CRANES	BASE RANGE OF FAILURE					M1	/YR	0.000054	0.00015	0.00001		
BRIDGE CRANES	CRANE FAILURE	FRACT OF LOAD	1990'S	NAVY		M1	N/A	0.14	0.14	0.14		

Reference Search: Type in the letter ID or number ID from the Reference Column. >>>>>>>

Letter ID: E  
Number ID: 2

Letter ID	Primary Reference: Data source	Number ID	Secondary Reference: Source of data cited by Primary Reference
E	C.W. Ma, R.C. Sit, S.J. Zavoshy, L.J. Jardine. Preclosure Radiologica Analysis for Accident Conditions of the Potential Yucca Mountain Rep Underground Facilities. Bechtel National, Inc. San Francisco for Sand 1 abstraction (1997)		NRC (US Nuclear Regulatory Commission), 1975. Reactor Safety St 2 Accident Risks in U.S. Commercial Nuclear Power Plants. WASH-1: U.S. Nuclear Regulatory Commission, Washington, DC (NNA.90113

Letter ID	Additional Information on Primary Reference
E	

**Notes**  
 Unit Column: /DM means per demand  
 Unit Column: /HR means per calendar hour, unless specified  
 Unit Column: /OP-HR means per operating hour  
 Unit Column: "" signifies that failure rate is the recommended rate for specified entry

Figure 3.12.1-2. Search Results Window

3.12.2 Search Database

The Search Database submenu brings up a dialog box in which the user can type the component name and field to perform a search. The result of the search will display the same window as in Figure 3.12.1-2.

3.12.3 HEP Generator

The Human Error Probability (HEP) is estimated using HEP Generator.

The HEP Generator is opened in the PCSA Tool by selecting HEP Generator in the Failure Rate menu.

There are three main functions of the HEP Generator that are accomplished in three steps:

- (1) Selection of the appropriate Table for HEP by traversing a logic tree (Figure 3.12.4-1).
- (2) Selection of the appropriate entry in a given Table of HEP (Figure 3.12.4-2).
- (3) Application of the appropriate performance shaping factors, if the analyst chooses to apply them (Figure 3.12.4-3).

Step 1. The logic tree is that suggested by Swain and Guttman (1983), but simplified somewhat, as shown in Figure 3.12.4-4, Parts A and B. The initial part of this module steps the analyst through the logic tree by asking a series of questions (four questions for primary

## ***Failure Rate***

operational activities, three questions for maintenance, and checking activities). By selecting the answers appropriate to the human error being analyzed, the code will lead the analyst to the appropriate Table. For the convenience of the analyst, the previously answered questions and the analyst's responses are shown at each step.

Step 2. Once the appropriate Table of HEPs is selected, the analyst is led through a second sequence of questions to select the Table entry appropriate to the human error being analyzed. The number of questions varies, depending on the Table and previous answers. The end result of this process is the selection of a HEP from the Table.

Step 3. Once the HEP value is selected, the analyst may use it or apply performance shaping factors (PSF). If the analyst chooses to use performance shaping factors, another sequence of three questions is asked to select the appropriate performance shaping factor.

**Human Error Probability Generator**

Click the appropriate button to answer each question, then enter your reasons at right. When finished entering your reasons, click 'Next' to continue to the next question.

Reasons for answers to each question:

Abnormal Event?  
 No       Yes

Primary Operational Actions?  
 No       Yes

Type of Error?  
 Omissions       Commissions

Written Materials?  
 No       Yes

<< Previous    Next >>    Accept    Cancel    HEP     EF

Figure 3.12.4-1. Human Error Probability Generator, Step 1

Select HEP from Table 20-7: Estimated probabilities of errors of omission per item of instruction when use of written procedures is specified.

Answer the questions and enter the reasons for your choices in the box below each question. Click 'Next' to go to the next question. The suggested choice from the table will be highlighted when all questions have been answered. Click 'Accept' to accept your choice.

Which of these conditions apply?  
 Written procedures exist and are used.  
 Written procedures are available and should be used, but are not.

Which of these conditions apply?  
 Written procedures with checkoff provisions are used correctly.  
 Written procedures do not have checkoff provisions or such provisions are incorrectly implemented.

Is the procedure list:  
 short, <= 10 items?  
 long, > 10 items?

Item	Omission of Item	HEP	EF
1	When procedures with checkoff provisions are correctly used; short list, <= 10 items	0.001	3
2	When procedures with checkoff provisions are correctly used; long list, > 10 items	0.003	3
3	When procedures without checkoff provisions are used, or when checkoff provisions are incorrectly used; short list, <= 10 items	0.003	3
4	When procedures without checkoff provisions are used, or when checkoff provisions are incorrectly used; long list, > 10 items	0.01	3
5	When written procedures are available and should be used, but are not used††	0.05	5

Table 20-7 from A. D. Swain, H. E. Guttman, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, Final Report, NUREG/CR-1278, August 1983.

\* The estimates for each item (or perceptual unit) presume zero dependence among the items (or units) an must be modified by using the dependence model when a nonzero level of dependence is assumed.

\*\* The term "item" for this column is the usual designator for tabled entries and does NOT refer to an item of instruction in a procedure.

† Correct use of checkoff provisions is assumed for items in which written entries such as

<< Previous    Next >>    Accept    Cancel    Report Info.

Figure 3.12.4-2. Human Error Probability Generator, Step 2

## Failure Rate

Select PSF from Table 20-16: Modifications of estimated HEPs for the effects of stress and experience levels

Answer the questions and enter the reasons for your choices in the box below each question. Click 'Next' to go to the next question. The suggested choice from the table will be highlighted when all questions have been answered. Click 'Accept' to accept your choice.

What is the stress level of the task, as reflected by the task load or threat status?

Very low (very low task load)  
 Optimum (optimum task load)  
 Moderately high (heavy task load)  
 Extremely high (threat stress)

Item	Stress Level	Modifier Skilled	Modifier Novice
1	Very Low (very low task load)	x2	x2
2	Optimum Task Load: Step-by-Step†	x1	x1
3	Optimum Task Load: Dynamic†	x1	x2
4	Moderately High (heavy task load): Step-by-Step†	x2	x4
5	Moderately High (heavy task load):	x5	x10
6	Extremely High (threat stress): Step-by-Step†	x5	x10
7	Extremely High (threat stress): Dynamic† or Diagnosis‡	HEP=0.25, EF=5	HEP=0.50, EF=5

Table 20-16 from A. D. Swain, H. E. Guttman, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, Final Report, NUREG/CR-1278, August 1983.

\* The nominal HEPs are those in the data tables in part III and in Chapter 20. Error factors (EFs) are listed in Table 20-20.

\*\* A skilled person is one with 6 months or more experience in the tasks being assessed. A novice is one with less than 6 months experience. Both levels have the required licensing or certificates.

† Step-by-step tasks are routine, procedurally guided tasks, such as carrying out written calibration procedures. Dynamic tasks require a higher degree of man-machine interaction, such as

Figure 3.12.4-3. Human Error Probability Generator, Step 3

### Action Commands

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- Previous:** Deselects the current choice (if made) and returns to the previous choice in the sequence of questions.
- Next:** Moves to the next question or to the next screen, using the current selection.
- Accept:** Confirms numerical choice of HEP or performance shaping factor from Table. Also confirms numerical choice of HEP with performance shaping factor applied.
- Cancel:** Allows the user to return to a previous screen, when the **Previous** command is not available; if a previous screen is not available, the user is returned to the main menu.
- Report Info.:** Displays the bibliographic information on NUREG/CR-1278, the source of the methodology, Table entries, and evaluations.
-

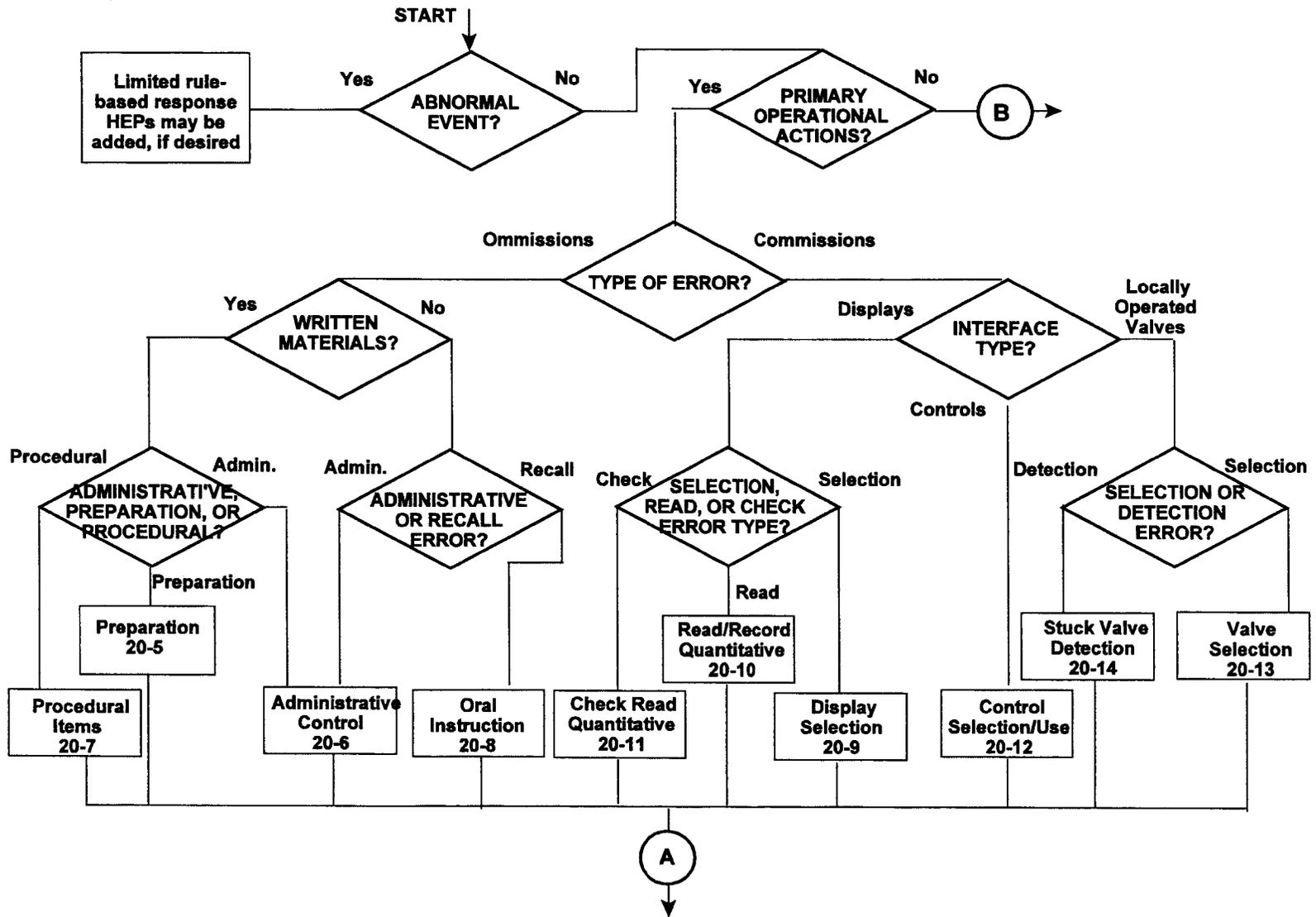


Figure 3.12.4-4. Part A: Selection of Primary HEP Tables Using NUREG/CR-1278 Methodology

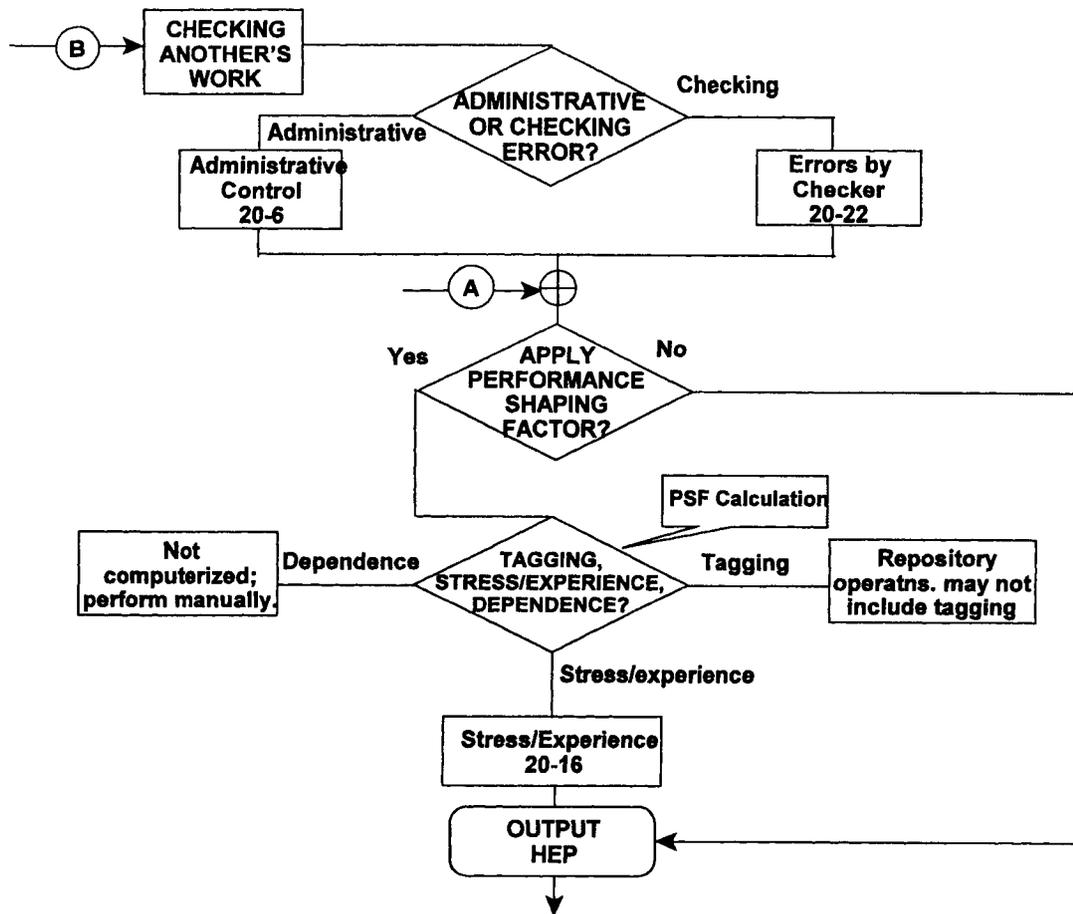


Figure 3.12.4-5. Part B: Selection of Primary HEP Tables and Application of Performance Shaping Factors

### 3.13 Checklist

The Component Failure Mode Checklist submenu in **Checklist** menu displays Component Failure Mode Checklist window containing a checklist of component failure modes.

#### 3.13.1 Component Failure Mode Checklist

The checklist may be used during failure modes and effects analysis. The user can browse through the entire database or use the search option for a component. Figure 3.13.1-1 illustrates the default setting for the Component Failure Mode Checklist, while Figure 3.13.1-2 is an example of a crane component search.

Component	Failure Mode
Agitator/Mixer	<ul style="list-style-type: none"> <li>Fails to start</li> <li>Fails off while running</li> <li>Starts prematurely</li> <li>Starts too late</li> <li>Operates too long</li> <li>Operates too fast</li> <li>Operates too slow</li> <li>Blade damaged or missing</li> </ul>
Annunciator	<ul style="list-style-type: none"> <li>Fails off</li> <li>Fails on</li> <li>Activates at a lower setpoint</li> <li>Activates at a higher setpoint</li> </ul>
Centrifuge	<ul style="list-style-type: none"> <li>External leak</li> <li>External rupture</li> <li>Outlet plugged</li> <li>Fails to start</li> <li>Fails off while running</li> <li>Starts prematurely</li> <li>Operates too long</li> <li>Operates too fast</li> <li>Operates too slow</li> </ul>
Circuit board	<ul style="list-style-type: none"> <li>Fails opened</li> <li>Shorts line to ground</li> <li>Shorts line to line</li> <li>Spurious output signal</li> </ul>

**Figure 3.13.1-1. Component Failure Mode Checklist Default Setting**

## Checklist

Component	Failure Mode
Cranes	Component Failure
	-Hook
	-Rope System
	-Rope drum
	-Drum bearing and pedestal
	-Drum/gearbox shaft and coupling
	-Gearbox
	-Gearbox/brake shaft and coupling
	-Brake (thruuster type)
	-Brake/motor shaft and coupling
	-Motor
	-Contactor L
	-Contactor MC
	-Emergency stop PB
	-Dead man's handle
	-Controller Contact 2

Figure 3.13.1-2. Component Failure Mode Checklist Example

### Action Commands

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**Search:** Searches the database for the component input by the user. If the user input is not found in the database, the window will return blank.

**Close:** Exits the **Component Failure Mode Checklist** window and returns the user to the main project screen.

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### **3.14**                    **Regs.**

The **Regulation** (Regs.) menu displays two submenus, *10 CFR Part 63* and *10 CFR Part 20*. Both regulations have been stored as hypertext markup language files, and the respective menus display the regulations through the default web browser in the user's computer. An html file allows the user to browse through the document using the hypertext links. Both 10 CFR Part 20 and 10 CFR Part 63 were downloaded from the NRC website ([www.nrc.gov](http://www.nrc.gov)).

#### **3.14.1**                    **10CFR63**

The *10 CFR Part 63* submenu displays the text in 10 CFR Part 63: Disposal of High-Level Wastes in a Geologic Repository at Yucca Mountain, Nevada.

#### **3.14.2**                    **10CFR20**

The *10 CFR Part 20* submenu displays the text in 10 CFR Part 20: Standards for Protection Against Radiation.

**3.15**

**Help**

The **Help** menu displays About, Disclaimer, and Menu Help submenus. The Menu Help submenu is not currently active.

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