RESRAD Update, *C. Yu, J.-J. Cheng, A.J. Zielen, L.G. Jones, D.J. LePoire, Y.Y. Wang (Argonne National Laboratory, Argonne, Ill.), Y.C. Yuan (Square Y Consultants, Orchard Park, N.Y.), C.O. Loureiro (Escola da Engenharia de UFMG, Brazil), A. Wallo III (DOE Office of Environmental Guidance), W.A. Williams (DOE Office of Environmental Restoration and Waste Management), and H. Peterson (DOE Office of Environmental Guidance)***

INTRODUCTION

A microcomputer program called RESRAD, which implements a pathway analysis method for radiological risk assessment, was developed by Argonne National Laboratory (ANL) in 1989. This program is used to derive allowable residual concentrations of radionuclides in soil and to predict effective dose equivalents and excess cancer incidence risks incurred by an individual exposed to radioactive materials. Since its development, the RESRAD code has been adopted by DOE in Order 5400.5 for the derivation of soil cleanup criteria and dose calculations,[1] and it has been used widely by DOE, other agencies, and their contractors. The original models used by ANL to develop RESRAD were initially developed as part of a DOE effort that began in the early 1980s and involved most of the national laboratories and DOE program offices. The RESRAD code is continuously improved and updated to incorporate comments from users and new features that ease the interaction with users and increase the code's capability and flexibility. The DOE Offices of Environmental Guidance and Environmental Restoration also provide periodic guidance regarding any significant changes to the code. The RESRAD update, Version 5.0, has substantial improvements in many aspects compared with the last version released in 1989.

INCORPORATION OF GRAPHICAL OUTPUT

One of the most substantial improvements to RESRAD has been the addition of graphical output. This option is accessible from inside or outside the RESRAD program and can be used to display calculational results and any sensitivity analyses that have been requested. The graphical function provides an easier way to interpret and compare calculational results within the time frame considered. This option can generate publication-

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quality hard copy output from several devices, including dot-matrix printers, laser printers, and plotters.

INTRODUCTION OF A MENU SYSTEM INTERFACE

The user interface to RESRAD has been expanded and redesigned to simplify management of the user's RESRAD work. This improvement has been accomplished by introducing a menu system from which the user can access the data input screens, run the RESRAD calculations, and view the output. The menu system also provides options for suppressing one or more of the nine exposure pathways calculated by RESRAD. The nine exposure pathways considered in RESRAD are external radiation, dust inhalation, inhalation of radon, and ingestion of plant food, meat, milk, water, aquatic food, and soil. Two of the nine exposure pathways are new with Version 5.0: radon inhalation and soil ingestion. Suppressing pathways not only decreases the calculation time but also decreases the number of input parameters that the user must consider. A feature of RESRAD 5.0 blanks out these nonapplicable parameters to simplify data input for the user.

CAPABILITY OF SENSITIVITY ANALYSIS AND PROVISION OF INPUT OPTIONS

Further improvements to RESRAD include the ability to run sensitivity analyses on most RESRAD parameters, optional input of groundwater radionuclide concentrations, optional user-specified dose factors and transfer factors, an improved groundwater transport model, optional input of solubility constants, calculation of cancer incidence risks, and context-specific help files. Parameters for the sensitivity analyses can be selected directly from the data input forms, and the analyses are performed automatically during RESRAD's calculational phase. The input of groundwater radionuclide concentrations is an option that can be used to derive distribution coefficients for radionuclides on the basis of site-specific data. User-specified dose factors (effective dose conversion, food/soil transfer, and aquatic bioaccumulation) can be used to override the RESRAD defaults, which are always the most conservative if multiple choices exist. An improved groundwater transport model that calculates parent and daughter nuclide concentrations by a transfer function method is developed and incorporated in RESRAD 5.0. An optional input of a solubility constant is added for the calculation of radionuclide leaching from the contaminated zone. In addition

to the calculation of dose, slope factors are used to calculate excess cancer incidence risk. Finally, context-specific help files provide information about every data input parameter accessible to the user. These help files for individual parameters are additional to the expanded general help files that provide useful keystroke and background information to the user at any time.

ADDITION OF NEW RADIONUCLIDES IN DATABASE

The calculational phase of RESRAD 5.0 also reflects many improvements since the 1989 version. These include the addition of 11 new radionuclides in the database: sodium-22, chlorine-36, calcium-41, manganese-54, cobalt-57, ruthenium-106, antimony-125, cesium-134, cerium-144, gadolinium-152, and europium-155. The cutoff half-life for associated radionuclides, which are assumed to be in secular equilibrium with their parent radionuclides, has been reduced to six months. The output reports generated by RESRAD have been redesigned and expanded in Version 5.0.

INSTALLATION IMPROVEMENTS

Other improvements to RESRAD include an interactive installation program to simplify and automate installation of the code. Also, the menu-driven interface library FORMPACK has undergone significant modifications. Among these modifications are the use of a mouse with menus, the ability to display multiple menus on one screen, the ability to read imbedded screen files, the ability to read data in a Namelist format, and the support of far-string memory allocation. This latter modification has resulted in an increase in the number of parameters available for calculations in RESRAD and an increase in the variety of options available to the user. Furthermore, to take advantage of the 32 bit chips in 386 and 486 computers, the RESRAD FORTRAN programs are compiled with the LAHEY F77L/EM32 compiler. The old 16-bit compiler, LAHEY F77L, is still used for 286 and 8088 computers.

RESULTS

The development of the RESRAD code is aimed at providing a user-friendly tool for radiological risk assessment by using simplified models to represent complex processes while

expanding its application and flexibility. To attain this objective, many new features have been incorporated in the code, such as a menu system interface, a graphical output presentation, the capability of doing sensitivity analyses, an expanded radionuclide database, and additional optional input selections. The inclusion of two new pathways, radon inhalation and soil ingestion, reflects user requirements and covers real situations more comprehensively. Suppression of unrelated pathways and input parameters eases user input tasks and shortens calculation time. Accompanying the RESRAD code are the following supplemental documents: *Manual for Implementing Residual Radioactive Material Guidelines*,[2] *Data Collection Handbook for Establishing Residual Radioactive Material Guidelines*,[3] *A Compilation of Transfer Factors for the Plant, Meat, Milk, and Aquatic Food Pathways and the Suggested Default Values for the RESRAD Code*,[4] and *RESRAD Parameter Sensitivity Analysis*.[5] These documents serve to clarify the RESRAD code so that it will be used and applied properly to solve real problems.

Since its development, RESRAD has been used widely among DOE, other agencies, and their contractors. It has received favorable response regarding its easy operation and broad applications. Users of the RESRAD code will find the updated version even more useful and powerful than the 1989 version.

REFERENCES

1. U.S. DEPARTMENT OF ENERGY, "Radiation Protection of the Public and the Environment," Order 5400.5 (Feb. 1990).

2. C. YU ET AL., in preparation (1993).

3. C. YU ET AL., in preparation (1993).

4. Y.-Y. WANG, B.M. BIWER, C. YU, in preparation (1993).

5. J.-J. CHENG, C. YU, A.J. ZIELEN, "RESRAD Parameter Sensitivity Analysis," ANL/EAIS-3, Argonne National Laboratory, Argonne, Ill. (Aug. 1991).

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