DEPARTMENT OF THE ARMY
US ARMY RESEARCH, DEVELOPMENT AND ENGINEERING COMMAND
ARMY RESEARCH LABORATORY
ABERDEEN PROVING GROUND MD 21005-5066

REPLY TO
ATTENTION OF

20 February 2008

Experimentation Support Group

Ms 16
Q-5

Ms. Elizabeth Ullrich
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Region I
King of Prussia, Pennsylvania 19406

Reference: Docket No. 040-06394
Control No. 141302

Dear Ms. Ullrich,

On December 28, 2007 you requested additional information in support of a request for approval of a Decommissioning Plan (DP) Range 14 (R-14) licensed under SMB-141.

The additional information is attached as three enclosures:

1. R14 Range DP - Responses to NRC Comments 021407.pdf
2. R14 Range FSSP Rev 0 - App A - Figures (bldg SUs) 021408.pdf
3. R14 Range DP Rev 0 - App C - DCGLs 021408.pdf

The responses were prepared by Cabrera Services, Inc. Cabrera has agreed to meet with you to discuss further details or supply additional information.

Point of Contact for this action is Richard Markland, (410) 278-6354, markland@arl.army.mil.

Sincerely,

Pamela E. Fry
Experimentation Support Manager

Enclosures

141302

Responses to Comments from U.S. Nuclear Regulatory Commission on
R-14 Range Decommissioning Plan, Rev. 0 (CABRERA, November 2007)

Comment No.	pp/§/¶	Comment	Response
Request for Additional Information from B. Ullrich, NRC, dated 12/28/07			
1	Section 1.0	"Executive Summary" states that non-contaminated debris may be disposed of, and decontaminated materials may be re-used. However, the release criteria was not specified. Please specify the criteria that you intend to use to determine if debris and other materials may be released for unrestricted use. See also items 4, 6, 7, 14 and 16.a. below.	Radiological surface activity limits for unrestricted release of material and equipment, etc. are discussed in Sections 6.1.1, 6.1.3, 6.1.4, 8.1.8, and 12.1 of the *R-14 Range Decommissioning Plan (DP)*. These sections refer to limits in Army Engineer Manual (EM) 385-1-80, *Radiation Protection Manual*, and the CABRERA *Radiation Safety Program*. The tables in EM 385-1-80 (Table 6-4) and the CABRERA RSP (Table I) reflect the average, maximum, and removable surface activity limits in NRC Regulatory Guide 1.86, Table 1.
2	Section 4.1.2 Page 4-3	"Hot line", on page 4-3 refers compares the contaminated water concentration of 3,500 micrograms per liter (ug/L) to the EPA drinking water limit of 30 ug/L. However, the NRC limits for natural uranium in water released to the environment is 3 E-7 microcuries per milliliter (uCi/ml) and to the sewer is 3 E-6 uCi/ml. Using the specific activity for natural uranium of 6.77 E-7 curies per gram, the concentration of 3,500 ug/L is equivalent to 2.4 E-6 mCi/ml, in excess of limits for release to the environment. Other sections of this DP also discuss uranium concentrations in water located in the other tanks, etc. Confirm that you will compare water concentrations to applicable NRC limits, and that any discharges will meet NRC regulations as well as other applicable requirements.	Radiological effluent controls and limits are discussed in Sections 9.0 and 10.2 of the *DP*. Specifically, these sections state that air and liquid effluents during decommissioning activities shall not exceed the applicable limits in 10 CFR 20, Appendix B, Table 2, for releases to the environment. Additionally, Section 9.0 commits to an air effluent ALARA goal of 20% of the applicable Appendix B, Table 2 limit. For uranium, this equates to an ALARA air effluent goal of 5.9E-14 µCi/cc. This assumes Class Y uranium with individual isotopic activity fractions in DU of 0.904 for ^{238}U, 0.012 for ^{235}U, and 0.084 for ^{234}U.
3	Section 4.3	"Surface Soil Contamination" states that the thorium-234 concentration in soil of 511 picocuries per gram (pCi/g) based on gamma spectroscopy, is equivalent to 565 pCi/g depleted uranium (DU). Provide the conversion, including any assumptions needed.	Thorium-234 (^{234}Th) is in secular equilibrium with uranium-238 (^{238}U) approximately 150 days after processing to a metallic form. Therefore, this radionuclide (^{234}Th) is used as a surrogate nuclide for identifying and quantifying ^{238}U based on gamma spectroscopy results. Since the ^{238}U activity fraction in DU at APG is 0.904 (Barg, 1995), the total DU activity determined via gamma

ENCLOSURE 1

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3 (cont'd)			spectroscopy is equivalent to the ^{234}Th activity divided by the ^{238}U fraction. Actual application of this relationship is shown in the *R-14 Range Characterization Survey Report*, Section 2.5, which provides the following equation: $$DU = \frac{^{234}Th}{0.904}$$ where: DU = Activity concentration of DU (pCi/g) ^{234}Th = Activity concentration of surrogate ^{234}Th (pCi/g) And, for the example in question: $$DU = \frac{^{234}Th}{0.904} = \frac{511\,\text{pCi/g}}{0.904} = 565\,\text{pCi/g}$$
4	Section 5.1	"Unrestricted Release of Structures Using NRC Screening Criteria" used NRC screening values for building surfaces to determine a Derived Concentration Guideline level (DCGL) for the DU of 100 disintegrations per minute (dpm) per 100 square centimeters of surface area ($cm^{2)}$. This is acceptable for building surfaces. However, the NRC screening values have not been approved for items of equipment to be released for unrestricted use. If you have release criteria for equipment approved already in your current license, you may use that release criteria for equipment. Specify the criteria you will use for equipment and items to be released for unrestricted use (re-use or disposal – see also Item 1 above) from any area at Range 14 included in this DP.	See response to Comment No. 1.

Responses to Comments from U.S. Nuclear Regulatory Commission on
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5	Section 5.2	"Unrestricted Release of Surface Soils Using Site-Specific Information" proposes to use a site-specific DCGL of 230 pCi/g, a value originally developed for use at the Transonic Range. Calculations for this value, and changes made in the dose modeling for the R-14 Range, were provided in Appendix C. However, the following information was not provided. Please submit a. the input and output files from the computer code used to determine the site-specific DCGL, with the modeling changes; and b. a discussion of the effect of uncertainty on the results, and the results of any sensitivity analysis performed.	A revised Appendix C, which includes the requested items, is attached.
6	Section 6.1.1	Refers to release limits for steel specified in the Army's EM 385-1-80: Radiation Protection Manual. Section 6.1.4 also refers to release limits in this document. Please submit the criteria; if this criteria has been reviewed and approved for use by the NRC prior to this action, please provide the documentation for that.	*See response to Comment No. 1.*
7	Section 6.2	"Contaminated Systems and Equipment" discusses scanning to be performed to determine if material is contaminated or not contaminated. Scan surveys are usually not sensitive enough to determine if equipment meets unrestricted release criteria. Describe your scan survey criteria in more detail, including the release criteria based on scans, the scan sensitivity, the instrumentation to be used, and the method of scanning.	Throughout Section 6.2, the term "scanned" is synonymous with "surveyed." All radiological surveys for unrestricted release of materials and equipment will be conducted in accordance with procedure requirements, which include measurements of total and removable activity sufficient to assess surface activity with respect to compliance with the unrestricted release criteria discussed in response to Comment No. 1.

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8	Section 6.3	"Surface Soil", states that the soil is assumed to be contaminated to a depth of six inches. Describe your criteria for deciding when additional actions will be taken to determine if soil contamination extends to a greater depth, and what those actions would be.	Section 3.8.2 of the *DP Appendix D* (Final Status Survey Plan) states that surface and subsurface soil samples will be collected at each sample location within Class 1 land area survey units. This section further states that the surface soil samples will be submitted for analysis and, following review, if any surface soil sample analytical result is greater than the $DCGL_w$, the corresponding subsurface soil sample will then be submitted for analysis to evaluate the potential for soil contamination below the surface soil layer, i.e., below 6 inches. Inherent to this sampling and analysis strategy is the assumption that the only potential source of subsurface contamination is the vertical migration of surface contaminants via storm water infiltration. Historical usage of the R-14 grounds did not include any excavation activities or ground disturbances that would have provided other contaminant pathways to the subsurface soils. Thus, if the surface soils are not contaminated, there is no reason to suspect any impacts to deeper soils.
9	Section 6.3	"Surface Soil", states that the average DU activity in soil to be removed is in the range of 175 to 200 picocuries per gram (pCi/g). Confirm that waste soils will be sampled to verify the concentration to ensure appropriate disposal.	A waste profile will be developed for each R-14 Range decommissioning waste stream intended for off-site disposal. The waste stream profile, including anticipated volumes of waste, will be submitted to the receiving disposal facility for approval prior to shipment of the waste. An appropriate number of samples will be collected and analyzed to facilitate the accurate development of the waste profile and to ensure that the waste conforms to the receiving facility's waste acceptance criteria (WAC).
10	Section 6.3	"Surface Soil", does not describe the methods you plan to use for removal of surface soils during remediation or the radiation protection methods to be used during soil remediation. In addition, it does not specify which	Large area soil removal will be accomplished using industry standard earth moving equipment (e.g., excavator, bobcat, etc.). Small areas of soil contamination (i.e., spot remediation) may be performed manually using shovels or similar tools. All

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10 (cont'd)		methods are currently authorized under your license, and if any new methods are requested for approval. Please provide this information.	decommissioning tasks, including soil removal, will be performed in accordance with the radiation protection requirements specified in the *DP*, which addresses appropriate radiation protection requirements for occupational workers, members of the public, and the environment.
11	Section 7.3	"Decommissioning Task Management", does not address the use of radiation Work Permits (RWP) or equivalent procedures to manage tasks. Please describe: a. how tasks will be managed through the use of the RWP or other procedures; b. how decommissioning tasks are evaluated and the RWP or other procedures developed for the tasks; c. how the RWP or other procedures are issued, maintained, revised, and terminated throughout the decommissioning process; and d. how individuals performing tasks will be informed and/or trained in the use of the applicable RWP or other procedures.	Section 8.0 of the *DP* commits to the use of the decommissioning contractor's NRC-approved radiation safety program. This section further specifies procedures required to implement the radiation safety program for the R-14 Range decommissioning, which includes a standard operating procedure for radiation work permits (RWPs). This procedure describes the RWP life-cycle, from initial generation and any required revisions through RWP termination. Section 7.5 of the *DP* discusses training requirements for visitors to the site and occupational radiation workers. The content of the radiation worker training includes discussion of the radiation safety program, including applicable implementing procedures. Section 7.5.4 also discusses initial site training to include further discussion of applicable decommissioning processes and procedures. In addition to initial briefing of workers on the work area hazards, hazard controls (including administrative and engineering controls), PPE, etc. upon initial RWP use and following any required RWP revision, Section 7.5.6 requires tailgate meetings to be conducted prior to the start of work each day. Topics to be discussed in this meeting include at, a minimum, the work plan for the day, work area hazards, hazard controls, etc.

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12	Section 8.3	"Health Physics Audits, Inspections, and Recordkeeping Program", states that audits will be performed periodically. Specify a minimum frequency for audits to be performed during implementation of your Decommissioning Plan.	Section 11.6 of the *DP* states that audits will be performed quarterly, at a minimum, while decommissioning activities are underway, and that a comprehensive audit of the radiation safety program will be conducted annually. Based on the anticipated duration of decommissioning activities, one quarterly audit will be performed during field work. Quarterly audits collectively address all aspects of decommissioning activities, including the adequacy of the various elements of the radiation safety program and implementation of these requirements.
13	Section 8.0	Confirm that, if assessment of internal dose is required to support Section 8.0, "Health and Safety Program During Decommissioning", you will follow procedures already approved under your license, or will submit new procedures for review and approval.	Occupational exposures due to intakes of radioactive material are not expected to exceed the threshold for internal exposure monitoring as specified in 10 CFR 20.1502(b). To verify that actual conditions support this assumption throughout decommissioning activities that have the potential for personnel exposure to airborne radioactivity, individual and work area air sampling will be performed. Derived air concentration (DAC) - hour tracking will be initiated for each worker with the potential for exposure to 12 DAC-hours in one week or greater, as determined through air sampling. Bioassay (in-vitro or in-vivo) and assessment of internal exposure based on bioassay results will not be required for routine decommissioning activities. If it becomes necessary to use bioassays to assess potential internal exposure due to accidental exposures (inhalation, ingestion or injection) that occur during abnormal events, the bioassay type, frequency, and analysis requirements will be specified by a professional health physicist, with assessment of potential internal exposures in accordance with the specifications of NRC Regulatory Guide 8.9, *Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program*, or other similar accepted guidance.

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14	Section 10.1	"Solid Radioactive Waste", states that, if waste is generated that meets the unrestricted release criteria specified in the Cabrera RSP and qualifies for disposal as non-hazardous waste, it will be disposed of in a local landfill. Provide this criteria, describe the surveys that will be done to verify if materials meet this criteria, and explain any assumptions used in determining this criteria. Also, confirm the Army Research Laboratory agrees to use of this criteria.	See response to Comment No. 1.
15	Section 10.1	"Solid Radioactive Waste", does not address management of mixed wastes that may be generated. However, Section 4.0, " Radiological Status of the "Facility", states that some buildings contain asbestos and that other hazardous substances may be present. Please provide the information requested in NUREG-1757, Volume 1, Revision 2, Section 17.5.3, "Mixed Waste".	Asbestos and polychorinated biphenyls (PCBs) are subject to the Toxic Substances Control Act (TSCA) regulations, but are not necessarily regulated as EPA hazardous wastes. Therefore, asbestos and PCB wastes that also contain radioactive contamination are typically accepted at LLRW disposal facilities without classification as "mixed waste," as defined by EPA. Off-site disposal facilities identified in the *DP* for receipt and disposal of decommissioning wastes are permitted to dispose of asbestos and PCB waste under RCRA permits in their chemical landfill facilities, depending on contaminant concentrations. Specific disposal site requirements for waste containing these materials are specified in the applicable WAC. Although hazardous materials may be present within the R-14 facility, they are not collocated with radioactive contamination that is intended for remediation. Decommissioning activities will be planned and executed in a manner that ensures that hazardous chemicals are not introduced into radioactive waste streams, which would require disposal of the waste as mixed waste.

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16	App. B Section 3.4 and 3.5.4	In the Appendix B," R-14 Range Characterization Survey Report" a. Section 3.4, other Structures", states that Building 1150D, the wash rack shed, and housings for the Cartridge and HEPA filter components were expected to be re-used and were not included in the characterization activities or decommissioning activities. If they will be re-used for activities with DU, this is acceptable but if they will be released for unrestricted use, then surveys would be required. Confirm if these structures will be released for unrestricted use, and if necessary, revise the Final Status Surveys to include these structures.	a. Building 1150D, the Wash Rack Shed, and the Cartridge and HEPA Filter housings were excluded from the Characterization Survey but are addressed in the DP to facilitate their reuse and/or unrestricted release. The R-14 Range decommissioning activities discussed in Section 6.1 indicate that equipment and/or material (such as the Cartridge and HEPA Filter housings) may be removed from the range and transported to other locations at APG that are authorized by the Army's NRC license for use or handling of radioactive material, where further processing and radiological surveys may be performed. The Army has the option of re-using the contaminated equipment in other "licensed" areas, decontaminating each item to achieve the unrestricted release criteria for use at any location at the APG, decontaminating equipment and/or material to meet the unrestricted release criteria for disposal, or declaring the material radioactive waste subject to appropriate disposal requirements. As discussed in the *DP Appendix D* (Final Status Survey Plan), the only remaining intact R-14 Range structures following decommissioning will be the Wash Rack Shed and Building 1150D. Both are identified in the Final Status Survey Plan, Sections 3.4 and 3.8, as Class 3 structure survey units due to the low potential for surface contamination. These survey units are also listed in Table 3-4. The justification for the MARSSIM classification of these structures is also provided in Section 3.4. The attached figures showing these survey units and their systematic sampling locations were inadvertently omitted from the November 2007 submittal, and should be inserted at the end of the FSSP Figures section.
		b. Section 3.5.4 discusses pavement areas at Range 14. Confirm if the pavement was in place prior to any use of	b. The majority of the pavement within the boundaries of the R-14 Range (as defined in the *DP*) was installed prior to the

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16 (cont'd)		DU; if pavement was installed after use of DU began at Range 14, state if soil underlying the pavement may have been contaminated from previous activities and whether or not an assessment will be performed to determine soil containment levels under the pavement.	commencement of DU activities and, therefore, does not overlie contaminated soils. The only exception to this is a small area of pavement on the south side of the Laydown Yard, which is identified in the Final Status Survey Plan as part of Survey Unit 4a-2. To evaluate the potential for soil contamination in this area, a soil sample will be collected from beneath the asphalt at each designated measurement location within the area that may have been impacted prior to asphalt placement.
17	App. D Section 3.7	In the Appendix D, "R-14 Range Decommissioning Final Status Survey Plan," a. Section 3.7, "Survey Design" uses MARSSIM assumptions for the values of factors such as the LBGR and coefficient of variation, instead of actual data from the characterization surveys. The MARSSIM states that these factors are site-specific values that should be estimated from actual data where available. Explain why the MARSSIM assumptions were used instead of actual data.	a. While MARSSIM does suggest the use of site-specific data when available, this assumes that the data are indicative of conditions likely to be encountered during the Final Status Survey. As indicated in the *DP*, significant remediation will be performed at the R-14 Range, and current conditions, as assessed through site characterization, are not indicative of the final conditions expected during the Final Status Survey. The characterization survey was designed and implemented to assess both soil concentrations and surface activity due to the presence of radionuclides of concern (ROCs) in terms of "nature and extent." Therefore, many of the sampling and survey locations were selected using a biased approach to assess the potential extent of contamination in soil and on structure surfaces, as well as to bound the magnitude of the contamination present. Even though characterization data are available, and estimated standard deviations can be calculated, these standard deviations will be high due to the nature and extent of existing contamination, and will not be representative of expected post-remediation conditions or appropriate use for Final Status Survey design. Thus, MARSSIM assumptions for the LBGR and standard deviation representative of the post-remediation radiological conditions were used in the Final Status Survey design.

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17 (cont'd)	App. D	b. Section 3.7 refers to the alpha DCGL and the beta DCGL. Specify the values for the alpha DCGL and the beta DCGL, and show how these values were determined.	b. The surface activity alpha $DCGL_w$ is discussed in *DP Appendix D* (Final Status Survey Plan), Section 3.2.2. This includes the methodology for determining the single alpha $DCGL_w$ for the mixture of uranium isotopes present in DU. As indicated, the alpha $DCGL_w$ is based on the NRC surface activity screening values provided in NUREG/CR-5512, Volume 3, Table 5.19. A surface activity beta $DCGL_w$ is presented in *DP Appendix D* for performance of surface activity scan measurements only. Given the inherent difficulties in performance of surface alpha activity scans, scans for surface beta activity are more reliable (fewer false positives and more surveyor "friendly"). Additionally, scan surveys are used to assess the potential for elevated areas of activity that may not be identified through systematic sampling. Once an area of potential elevated activity is identified via beta scans, a static or fixed alpha measurement will be performed. It is the static alpha measurement that will be used to determine whether the initial indication of elevated activity is true (i.e., contamination is actually present) and to assess the magnitude of this contamination. Taking into account the total number of beta particles emitted in the two uranium decay chains associated with DU (3 in the ^{238}U decay chain [1 from ^{234}Th, 1 from ^{234m}Pa, and 1 from ^{234}Pa] and 1 in the ^{235}U decay chain from ^{231}Th), the effective gross beta $DCGL_w$ is determined to be 295 dpm/100 cm^2. However, the beta $DCGL_w$ selected for use during scanning is equal to the alpha $DCGL_w$, or 100 dpm/100 cm^2, as a conservative measure. Again, the bases for these values are the NRC screening values in NUREG/CR-5512, Volume 3, Table 5.19.

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17 (cont'd)	App. D	c. Section 3.7 refers to use of area factors. The MARSSIM Tables 5.6 and 5.7 are provided as examples of area factors, based on the assumed concentration and specified dose models and are not intended to be used directly in situations that are different than the assumptions described in MARSSIM. Explain your use of the area factors from these tables. (Please note that Table 8.2, referenced in your plan, is a summary of statistical tests.) You may request alternate area factors if appropriate.	c. Area factors were developed for the Transonic Range (attached), but were limited to areas of 1 to 25 square meters. Area factors were also calculated using the input parameters provided in the *DP Appendix C* (Determination of DCGL for Soil). This was accomplished by changing the area of the contaminated zone to be consistent with each of the areas specified in the table. Additionally, the "length parallel to aquifer flow" was adjusted for each area and assumed to be equal to the square root of the contaminated zone area. These results were very similar to the Transonic Range area factors in the 1 to 25 square meter range. The calculated area factors, with additional area factors in the 300 to 3,000 square meter range, are also attached. This full range of calculated area factors are proposed for use at the R-14 Range in lieu of the MARSSIM land area default area factors previously presented in *DP Appendix D*, Table 6-1. Since there are no changes to the exposure scenario or model input parameters for structure area factors, and the predominant nuclide contributing to surface activity on structures is ^{238}U, the MARSSIM default area factors for structures in Table 5.7 (*DP Appendix D, Table 6-2*) are appropriate for use at the R-14 Range.
		d. Section 3.7 describes surveys to be performed of two Class 3 structures, the Wash Rack Shed and Building 1150D. If these structures were not included in the characterization survey (see also item 11.a above), explain the basis for performing surveys only of certain parts of the interior of these structures.	d. See response to Comment No. 16a.

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17 (cont'd)	App. D	e. Section 6.2.2, "Elevated Measurement Comparison Criteria", uses values from the MARSSIM Tables 5.7 and 5.7. As stated in item 12.c above, these values are based on a specific assumed concentration and certain dose models. Explain why the assumptions in MARRSIM are applicable to your facility, or request different area factors for development of your elevated measurement comparison criteria.	e. See response to Comment No. 17c.

MARSSIM Table 5.6 Default Land Area Factors

Area (m^2)	1	3	10	30	100	300	1,000	3,000	10,000
^{238}U Area Factor	30.6	18.3	11.1	8.4	6.7	4.4	1.3	1.0	1.0

Transonic Range Land Area Factors (Derived using RESRAD Version 5.8.3)

Area (m^2)	1	3	10	30	100	300	1,000	3,000	10,000
Area Factor	10	6	3	2	--	--	--	--	1.0

R-14 Range Calculated Land Area Factors (Derived using RESRAD Version 6.3)

Area (m^2)	1	3	10	30	100	300	1,000	3,000	10,000
Area Factor	10.6	5.4	2.8	2.0	1.5	1.3	1.1	1.1	1.0

DETERMINATION OF DERIVED CONCENTRATION GUIDELINE LEVEL (DCGL) FOR R-14 RANGE SOILS

1.0 INTRODUCTION

This appendix presents an evaluation of the Transonic Range derived concentration guideline level (DCGL) calculation for depleted uranium (DU) in soils with respect to its applicability to the R-14 Range. Both ranges are part of the U.S. Army Research Laboratory (ARL) located at Aberdeen Proving Ground (APG) in Aberdeen, Maryland. This DCGL evaluation was performed based on the resident farmer receptor scenario, which is the limiting dose scenario at both sites.

The DCGLs presented in this document are based on the *Radiological Criteria for Unrestricted Use* requirements set forth by the U.S. Nuclear Regulatory Commission (NRC) in 10 CFR Part 20.1402. In accordance with these requirements, a site is considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a Total Effective Dose Equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year (mrem/yr), and the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA).

The results of this evaluation verify that the soils DCGL used previously at the Transonic Range is applicable and protective for use at the R-14 Range Site. Thus, the DCGL value of 230 pCi/g will be used as the soil action level for remediation and final status survey of the R-14 Range Site.

2.0 BACKGROUND INFORMATION

The *Transonic Range Decommissioning Plan* (DP; ATG, 2000) utilized the DCGL report developed by Argonne National Laboratory (ANL) for DU-contaminated soils at the Transonic Range of APG (ANL, 1999). The DP was approved by NRC, and the site was remediated and released in accordance with the specified DCGLs. The DCGLs for the DU Study Area of the Transonic Range were based on site-specific uranium guidelines derived for a 50-year TEDE to a hypothetical individual not exceeding 25 mrem in any one year, and evaluated over a 1,000 year time interval. The *Residual Radioactivity* (RESRAD) computer code, Version 5.82, was used to develop DCGLs for the Transonic Range (ANL, 1999). The RESRAD code parameters and pathways used in the Transonic Range evaluation were set up to consider nine exposure pathways:

1) Direct exposure from contaminated soil,
2) Internal dose from inhalation of contaminated dust,
3) Internal radiation from the inhalation of emanating radon-222,
4) Internal radiation from the ingestion of plant foodstuffs grown in contaminated soil and irrigated with groundwater drawn from a well located within the decontaminated area,
5) Internal radiation from the ingestion of meat from livestock fed fodder grown in the decontaminated area and irrigated with groundwater from the decontaminated area,

ENCLOSURE 2

6) Ingestion of milk from milk animals raised with fodder and irrigation groundwater drawn from the decontaminated area,
7) Internal radiation from ingestion of fish from a pond drawing water from the decontaminated area,
8) Internal dose from the ingestion of onsite soil, and
9) Internal radiation from drinking water drawn from an onsite well.

Two potential exposure scenarios - the industrial worker scenario and the resident farmer scenario - were considered for the Transonic Range using combinations of the above pathways. Based on uranium-234 (^{234}U), uranium-235 (^{235}U), and uranium-238 (^{238}U) activity fractions of 0.190, 0.021, and 0.790, a DCGL of 230 picocuries per gram (pCi/g) was determined for DU in soils under the more restrictive resident farmer scenario.

A similar evaluation was performed to develop the DCGL for DU in soils at the Aberdeen Test Center (ATC) Bomb Throwing Device (BTD) Site by utilizing the same procedure as that for the Transonic Site (CABRERA, 2003). The results of the BTD evaluation showed that:

> *"The DCGL developed at the Transonic Range is considered applicable to and adequately protective for the BTD Site on the basis of comparable site-specific RESRAD parameter/pathways, the similarity of both locations, and the equivalence of the radiological isotopic DU mixes. Use of the approved Transonic DCGL at the BTD Site will ensure that the potential dose to a hypothetical individual will not exceed 25 mrem in any one year over a 1,000-year period. The DCGL for the BTD Site soil is 230 pCi/g total DU (resident farmer scenario)."*

3.0 METHODOLOGY

The following sections of this evaluation summarize the methodology used for determining the soil DCGL for DU under the standard resident farmer receptor scenario at the R-14 Range Site and compare the result with that obtained for Transonic Range Site. The results of the more conservative DCGL derivation will be utilized as the DCGL for the R-14 Range Site.

3.1 Dose Assessment Model

RESRAD, Version 6.3 (ANL, 2005), was used to derive the DCGL for DU. RESRAD is a computer code developed by ANL for the U.S. Department of Energy (DOE) to determine site-specific residual radiation guidelines and dose to a future hypothetical onsite receptor at sites that are contaminated with residual radioactive materials.

3.2 Source Term

Radionuclides of concern (ROCs) known to be present in the R-14 Range area are limited to DU isotopes (i.e., ^{234}U, ^{235}U, and ^{238}U) and their short-lived decay progeny. The activity fractions are calculated from the weight ratios and specific activities of each uranium isotope. The resulting composition consists of ^{234}U, ^{235}U, and ^{238}U activity fractions of 0.084, 0.012, and 0.904, respectively. These fractional source terms were used as inputs to RESRAD model.

3.3 Receptor

NRC guidance recommends analysis of a residential farmer scenario as the basis for the DCGLs for residual contamination in site-wide surface soil (NUREG/CR-1549). As with the Transonic and BTD sites, the resident farmer scenario was confirmed to be the most restrictive scenario evaluated during the determination of the DU soils DCGL for the R-14 Range Site. Under this scenario, the receptor was assumed to be exposed to radioactive contamination in soil through various pathways.

The residential farmer receptor is assumed to live onsite for 350 days per year for 30 years (EPA, 2000). Under a resident farmer scenario, a family is assumed to move onto the site after it has been released for use without radiological restrictions, builds a home, and raises crops and livestock for family consumption. Based on a 24-hour occupancy scenario, the resident is assumed to spend 240 days/yr indoors, 40.2 days/yr outdoors, and 2.92 days/yr for gardening activities (NUREG/CR-5512).

3.4 Exposure Scenarios

The resident farmer is exposed through various exposure pathways to radioactive contamination present in the site soil. Members of the critical group can incur a radiation dose by:

(1) Direct radiation from radionuclides in the soil,
(2) Inhalation of re-suspended dust (if the contaminated area is exposed at the ground surface),
(3) Ingestion of food from crops grown in contaminated soil,
(4) Ingestion of milk from livestock raised in the contaminated area,
(5) Ingestion of meat from livestock raised in the contaminated area,
(6) Ingestion of fish from a nearby pond contaminated by water that has percolated through the contaminated area,
(7) Ingestion of water from a well contaminated by water that has percolated through the contaminated zone, and
(8) Ingestion of contaminated soil.

Unlike the Transonic Range and BTD Sites, the radon pathway was suppressed during this evaluation due to its inapplicability. As radium-226 is not an ROC for this site, neither is its daughter radon an ROC for the site. In addition, in a Federal Register Notice (NRC, 1994), issued as a result of comments received from a radon workshop, the NRC noted that "radon would not be evaluated when developing release criteria due to: the ubiquitous nature of radon in the general environment, the large uncertainties in the models used to predict radon concentrations; and the inability to distinguish between naturally occurring radon and that which occurs due to licensed activities."

3.5 Recommended Values for RESRAD Parameters

3.5.1 Selection Process for Recommended Values

Site-specific information is the first preference for selection of values to use as RESRAD input parameters. When site-specific data is not available, the default values assigned in NRC documents are used. Between the three NRC documents, Volume 4 of NUREG/CR-5512

defines the residential farmer scenario, hence was given first preference. The remaining documents define the values for residential scenario.

a) *Comparison of the Models and Assumptions used in DandD 1.0, RESRAD 5.61, and RESRAD-Build 1.50 Computer Codes with Respect to the Residual Farmer and Industrial Occupant Scenarios* Provided in NUREG/CR-5512 (NUREG/CR-5512, Vol.4)
b) *Residual Radioactive Contamination From Decommissioning - Parameter Analysis, Draft Report for Comments* (NUREG/CR-5512, Vol. 3)
c) *Residual Radioactive Contamination From Decommissioning: Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent,* Volume 1) PNL-7994 (NUREG/CR-5512)
d) *Development of Probabilistic RESRAD 6.0 and RESRAD-Build 3.0 Computer Codes* (NUREG/CR-6697, 2000)

US EPA guidance documents were given the third preference. The following EPA documents were mainly used for comparison purposes and for selection of conservative values for intake parameters.

a) *Soil Screening Guidance Document for Radionuclides: User's Guide* (EPA, 2000)
b) *Exposure Factors Handbook* (EPA, 1997)

When no site-specific, NRC, and EPA values for the RESRAD parameters is available, *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil,* Environmental Assessment and Information Sciences Division, Argonne National Laboratory (ANL, 1993) was used for selection of RESRAD default values.

However, there is one exception. EPA's assigned value of 36.5 g/yr was selected instead of NUREG/CR-5512 value of 18.3 g/yr for the resident adult soil ingestion rate. This was done due to the fact that NUREG/CR-5512 assigned value is equivalent to the soil ingestion rate for an industrial worker scenario under the EPA's guidance document.

3.5.2 Recommended Values for RESRAD Input Parameters

Table 3-1 presents the default value and the selected recommended value associated with each RESRAD input parameter. The recommended values were used in the derivation of soil DCGLs for the resident farmer scenario.

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Area of contaminated zone	AREA	10,000	10,000	m^2	RESRAD-default value is used. Site-specific area is higher than the default value. However, dose is insensitive to an area greater than 10000 m^2.	ANL, 1993
Thickness of contaminated zone	THICK0	2	0.15	m	No site-specific data is available. NRC assumed surface contamination of 0.15 m;	NUREG/CR 5512
Length parallel to aquifer flow	LCZPAQ	100	100	m	RESRAD default value was assumed.	ANL, 1993
Time since placement of material	TI	0	1,3,10,30, 100, 300, 1000	yr	This is RESRAD model-related parameter. No NRC and EPA value could be located.	ANL, 1993
Cover depth	COVER0	0	0	m	No site-specific data is available. The project assumed no cover as a conservative approach.	NA
Density of cover material	DENSCV	1.5	NA	g/m^3	No value is assigned due to no soil cover.	NA
Cover depth erosion rate	VCV	0.001	NA	m/yr	No value is assigned due to no soil cover.	NA
Density of contaminated zone	DENSCZ	1.5	1.5	g/m^3	RESRAD default value was assumed.	ANL, 1993
Contaminated zone erosion rate	VCZ	0.001	0.0006	m/yr	No site-specific data is available. Assuming 2% slope and significant farming and gardening activities at the site, 0.0006 m/yr was assigned.	ANL, 1993
Contaminated zone total porosity	TPCZ	0.4	0.4	unitless	RESRAD default value was assumed.	ANL, 1993
Contaminated zone field capacity	FCCZ	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Contaminated zone hydraulic conductivity	HCCZ	10	10	m/yr	RESRAD default value was assumed.	ANL, 1993
Contaminated zone b parameter	BCZ	5.3	5.3	unitless	RESRAD default value was assumed.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Average annual wind speed	WIND	2	2	m/sec	RESRAD default value was assumed.	ANL, 1993
Humidity in air	HUMID	8	NA	g/m^3	No value was assigned, as Tritium is not a radionuclide of interest for this site. Humidity input only required if Tritium is present.	NA
Evapotranspiration coefficient	EVAPTR	0.5	0.5	unitless	No site-specific data is available. NRC and EPA value could not be located. Hence, RESRAD default value was assigned for this parameter.	ANL, 1993
Precipitation	PRECIP	1	1	m/yr	RESRAD default value was assumed.	ANL, 1993
Irrigation	RI	0.2	0.2	m/yr	No site-specific data is available. NRC and EPA value could not be located. Hence, RESRAD default value was assigned for this parameter.	ANL, 1993
Irrigation mode	IDITCH	Overhead	Overhead	unitless	RESRAD default value was assumed.	ANL, 1993
Runoff coefficient	RUNOFF	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Watershed area for nearby stream or pond	WAREA	6.00E+06	6.00E+06	m^2	RESRAD default value was assumed.	ANL, 1993
Accuracy for water/soil computations	EPS	0.001	0.001	unitless	This is RESRAD model-related parameter. No NRC and EPA value could be located.	ANL, 1993
Saturated zone density	DENSAQ	1.5	1.5	g/m^3	RESRAD default value was assumed.	ANL, 1993
Saturated zone total porosity	TPSZ	0.4	0.4	unitless	RESRAD default value was assumed.	ANL, 1993
Saturated zone effective porosity	EPSZ	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Saturated zone field capacity	FCSZ	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Saturated zone hydraulic conductivity	HCSZ	100	100	m/yr	RESRAD default value was assumed.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Saturated zone hydraulic gradient	HGWT	0.02	0.02	unitless	This is RESRAD model-related parameter. No NRC and EPA value could be located.	ANL, 1993
Saturated zone b parameter	BSZ	5.3	5.3	unitless	RESRAD default value was assumed.	ANL, 1993
Water table drop rate	VWT	0.001	0.001	m/yr	No site-specific data, NRC and EPA value could be located. Hence, RESRAD default value was assumed.	ANL, 1993
Well pump intake depth (m below water table)	DWIBWT	10	10	m	RESRAD default value was assumed.	ANL, 1993
Model: Nondispersion (ND) or Mass-Balance (MB)	MODEL	ND	ND	unitless	Area of contamination is greater than 1000 m^2, hence non-dispersion model was assumed.	ANL, 1993
Well pumping rate	UW	250	250	m^3/yr	RESRAD default value was assumed.	ANL, 1993
Number of unsaturated zone strata #	NS	1	1	unitless	No site-specific data is available. Both NRC & RESRAD default used the same value.	ANL, 1993 NUREG/CR-5512
Unsaturated zone thickness	H(1)	4	4	m	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone density	DENSUZ(1)	1.5	1.5	g/m^3	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone total porosity	TPUZ(1)	0.4	0.4	unitless	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone effective porosity	EPUZ(1)	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone field capacity	FCUZ(1)	0.2	0.2	unitless	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone hydraulic conductivity	HCUZ(1)	100	100	m/yr	RESRAD default value was assumed.	ANL, 1993
Unsaturated zone b parameter	BUZ(1)	5.3	5.3	unitless	RESRAD default value was assumed.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Distribution coefficients						
Uranium	D-1	50	50	cm^3/g	In absence of soil type, RESRAD default value was assumed.	ANL 1993
Inhalation rate	INHALR	8,400	6650 (footnote)	m^3/yr	Site-specific value for this parameter is not available. Hence, time-weighted inhalation rate was calculated based on NRC defined inhalation rates for different activities, and the time, receptor will spend for each activity. Indoor = 0.9; Outdoor = 1.4 ; Gardening = 1.7 (m^3/hr)	NUREG/CR-5512
Mass loading for inhalation	MLINH	0.0001	4.6E-6 (footnote)	g/m^3	Site-specific value for this parameter is not available. Hence, time-weighted mass loading for inhalation rate was calculated based on NRC defined mass loading factor for different activities, and the time, receptor will spend for each activity. Indoor = 1.4E-6; Outdoor=3.14E-6; Gardening = 4E-4; (g/m^3)	NUREG/CR-5512
Exposure duration	ED	30	30	yr	No site-specific value is available. As conservative approach, EPA's defined value was assigned for this parameter.	EPA, 2000
Indoor Dust Filtration Factor	SHF3	0.4	0.2448	unitless	No site-specific value is available. Hence, NRC value was assigned.	NUREG/CR-5512
External gamma shielding factor	SHF1	0.7	0.5512	unitless	No site-specific value is available. Hence, NRC value was assigned.	NUREG/CR-5512
Fraction of time spent indoors	FIND	0.5	0.658	unitless	NRC value was assigned.	NUREG/CR 5512

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Fraction of time spent outdoors (onsite)	FOTD	0.25	0.118	unitless	NRC value was assigned based on combining outdoor and gardening activities.	ANL, 1993
Shape of the contaminated zone: Circular; Non-Circular	FS	Circular	Circular	unitless	No site-specific, NRC and EPA value for this parameter could be located; hence, RESRAD default was assigned.	ANL, 1993
Fruits, vegetables and grain consumption	DIET(1)	160	166	kg/yr	No site-specific value is available. NUREG/CR-5512 default value was chosen for this parameter. The value is almost equal to the most likely value defined in NUREG/CR-6697. This value is more conservative than EPA value. (Fruits = 51; Grains = 69; Vegetables = 51; kg/yr)	NUREG/CR-5512
Leafy vegetable consumption	DIET(2)	14	11	kg/yr	No site-specific value is available. Hence, NRC value was used for this parameter. This value is more conservative than EPA value.	NUREG/CR-5512
Milk consumption	DIET(3)	92	100	L/yr	No site-specific value is available. NUREG/CR-5512 default value was chosen for this parameter. The value is almost equal to the most likely value defined in NUREG/CR-6697. This value is more conservative than EPA value.	NUREG/CR-5512
Meat and poultry consumption	DIET(4)	63	65.1	kg/yr	No site-specific value is available. NRC value was used. (Beef = 59; Poultry = 6; kg./yr)	NUREG/CR-5512
Fish consumption	DIET(5)	5.4	10	kg/yr	No site-specific value is available. Hence, NRC value was used.	NUREG/CR-5512
Other seafood consumption	DIET(6)	0.9	0.9	kg/yr	No site-specific value, NRC and EPA value could be located. Hence, RESRAD default value was assigned.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Soil ingestion rate	SOIL	36.5	36.5	g/yr	Soil ingestion rate Both RESRAD default and EPA use the same value for this parameter for adult receptor. Adult = 100 mg/day	EPA, 1997
Drinking water intake	DWI	510	478.5	L/yr	No site-specific value is available. Hence, NRC value was used. (1.3 L/d)	NUREG/CR-5512
Contamination fraction of drinking water	FDW	1	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of household water	FHHW	1	NA	unitless	Radon pathway is not selected; hence this parameter is not applicable	NA
Contamination fraction of livestock water	FLW	1	1	unitless	No site-specific value is available. Hence, maximum NRC value was used.	NUREG/CR-6697
Contamination fraction of irrigation water	FIRW	1	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used.	NUREG/CR-6697
Contamination fraction of aquatic food	FR9	0.5	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of plant food	FPLANT	-1 **	1	unitless	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of meat	FMEAT	-1 **	1	unitless	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Contamination fraction of milk	FMILK	-1**	1	unitless	No site-specific value is available. Hence, the maximum NRC value was used for this parameter.	NUREG/CR-6697
Livestock fodder intake for meat	LFI5	68	26.85	kg/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Livestock fodder intake for milk	LFI6	55	63.25	kg/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Livestock water intake for meat	LWI5	50	50	L/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Livestock water intake for milk	LWI6	160	60	L/day	No site-specific value is available. Hence, NRC value was used for this parameter.	NUREG/CR-6697
Livestock soil intake	LSI	0.5	0.5	kg/day	Both NRC and RESRAD values are the same; hence that value was assigned for this parameter.	ANL, 1993 NUREG/CR-5512
Mass loading for foliar deposition	MLFD	0.0001	0.0001	g/m^3	No site-specific value, NRC and EPA value could be located. Hence RESRAD default value is assigned.	ANL, 1993
Depth of soil mixing layer	DM	0.15	0.15	m	No site-specific value, NRC and EPA value could be located. Hence RESRAD default value is assigned for this parameter.	ANL, 1993
Depth of roots	DROOT	0.9	0.9	m	No site-specific value, EPA value could be located. Hence RESRAD default value is assigned.	ANL, 1993
Drinking water fraction from ground water	FGWDW	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Household water fraction from ground water	FGWHH	1	NA	unitless	Radon pathway is not selected; hence this parameter is not applicable	NA
Livestock fraction from ground water	FGWLW	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Irrigation fraction from ground water	FGWIR	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Wet weight crop yield for non-leafy vegetables	YV(1)	0.7	0.7	kg/m2	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Wet weight crop yield for leafy	YV(2)	1.5	1.5	kg/m^2	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Wet weight crop yield for fodder	YV(3)	1.1	1.1	kg/m^2	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Growing season for non-leafy	TE(1)	0.17	0.17	years	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Growing season for leafy	TE(2)	0.25	0.25	years	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Growing season for fodder	TE(3)	0.08	0.08	years	No site-specific, NRC and EPA value could be located. Hence RESRAD default value was assigned.	ANL, 1993
Translocation factor for non-leafy	TIV(1)	0.1	0.1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Translocation factor for leafy	TIV(2)	1	1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Translocation factor for fodder	TIV(3)	0.1	0.1	unitless	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Dry foliar interception fraction for non-leafy vegetables	RDRY(1)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993
Dry foliar interception fraction for leafy vegetables	RDRY(2)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993
Dry foliar interception fraction for fodder	RDRY(3)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Wet foliar interception fraction for non-leafy vegetables	RWET(1)	0.25	0.25	unitless	No site-specific, NRC and EPA value could be located. RESRAD default value was assigned.	ANL, 1993
Wet foliar interception fraction for leafy	RWET(2)	0.25	0.25	unitless	Site-specific value is not available. Most likely value defined in NUREG/CR was assigned.	ANL, 1993
Wet foliar interception fraction for fodder	RWET(3)	0.25	0.25	unitless	Site-specific value is not available. Most likely value defined in NUREG/CR was assigned.	ANL, 1993
Weathering removal constant for vegetation	WLAM	20	18	unitless	Site-specific value is not available. Most likely value defined in NUREG/CR was assigned.	NUREG/CR 6697
Storage time: fruits, non-leafy vegetables, and grain	STOR_T(1)	14	14	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Storage time: leafy vegetables	STOR_T(2)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: milk	STOR_T(3)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: meat and poultry	STOR_T(4)	20	20	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Storage time: fish	STOR_T(5)	7	7	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: crustacea and mollusks	STOR_T(6)	7	7	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned	ANL, 1993 NUREG/CR-5512
Storage time: well water	STOR_T(7)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Storage time: surface water	STOR_T(8)	1	1	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	Code	Default Value	Value	Units	Justification	Reference
Storage time: livestock fodder	STOR_T(9)	45	45	days	Both NRC and RESRAD values for this parameter are the same; hence that value was assigned.	ANL, 1993 NUREG/CR-5512
Thickness of building foundation	FLOOR1	0.15	NA	m	No Radon pathway, hence this parameter is not applicable.	NA
Bulk density of building foundation	DENSFL	2.4	NA	g/cm^3	No Radon pathway, hence this parameter is not applicable.	NA
Total porosity of the cover material	TPCV	0.4	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Total porosity of the building foundation	TPFL	0.1	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Volumetric water constant of the cover material	PH2OCV	0.05	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Volumetric water constant of the foundation	PH2OFL	0.03	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Diffusion coefficient for radon gas in cover material	DIFCV	2.00E+06	NA	m/sec	No Radon pathway, hence this parameter is not applicable.	NA
Diffusion coefficient for radon gas in foundation material	DIFFL	3.00E-07	NA	m/sec	No Radon pathway, hence this parameter is not applicable.	NA
Diffusion coefficient for radon gas in contaminated zone soil	DIFCZ	2.00E-06	NA	m/sec	No Radon pathway, hence this parameter is not applicable.	NA
Radon vertical dimension of mixing	HMIX	2	NA	m	No Radon pathway, hence this parameter is not applicable.	NA
Average building air exchange rate	REXG	0.5	NA	1/hour	No Radon pathway, hence this parameter is not applicable.	NA
Height of the building (room)	HRM	2.5	NA	m	No Radon pathway, hence this parameter is not applicable.	NA

TABLE 3-1: DEFAULT AND RECOMMENDED VALUES FOR RESRAD INPUT PARAMETERS (CONT'D)

RESRAD			Recommendations			
Parameter	**Code**	**Default Value**	**Value**	**Units**	**Justification**	**Reference**
Building interior area factor	FAI	0	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Building depth below ground surface	DMFL	-1	NA	m	No Radon pathway, hence this parameter is not applicable.	NA
Emanating power of Rn-222 gas	EMANA(1)	0.25	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Emanating power of Rn-220 gas	EMANA(2)	0.15	NA	unitless	No Radon pathway, hence this parameter is not applicable.	NA
Pathway – external gamma	NA	active	active	unitless	NA	NA
Pathway – inhalation (w/o radon)	NA	active	active	unitless	NA	NA
Pathway – plant ingestion	NA	active	active	unitless	NA	NA
Pathway – meat ingestion	NA	active	active	unitless	NA	NA
Pathway – milk ingestion	NA	active	active	unitless	NA	NA
Pathway – aquatic foods	NA	active	active	unitless	NA	NA
Pathway – drinking water	NA	active	active	unitless	NA	NA
Pathway – soil ingestion	NA	active	active	unitless	NA	NA
Pathway – radon	NA	active	inactive	unitless	NA	NA

NA = Not Applicable
N/A = Not Available
** specifies that the contaminated fraction will be calculated from the appropriate area factor in RESRAD.
Inhalation Rate = ((0.9 m^3/hr x 15.77 hrs/day) + (1.4 m^3/hr x 2.64 hrs/day) + (1.7 m^3/hr x 0.20 hrs/day)) x 8760 hrs/yr / (24 hrs/day) = 6650 m^3/yr, where 15.77, 2.64, and 0.2 hrs/day are indoor, outdoor, and gardening activities for the receptor
Mass loading for inhalation = ((1.4 E-6 g/m^3 x 15.77 hrs/day) + (3.14E-06 g/m^3 x 2.64 hrs/day) + (4E-04 g/m^3 x 0.20 hrs/day)) /24 hrs/day = 4.6E-06 g/m^3

4.0 SOIL DCGL RESULTS FOR DU

RESRAD, Version 6.3 (ANL, 2005), was used to perform the dose assessments for contaminated soil present at the R-14 Range Site. The concentrations for DU isotopes presented in Section 4-2 were inputted into the model along with the RESRAD input parameters presented in Table 3-1 during the dose assessments. The dose resulting from a unit concentration for a given radionuclide is defined as the dose-to-source ratio (DSR). The maximum DSR (in units mrem/yr per pCi/g) over the 1,000-year evaluation period for each radionuclide of concern was then divided into the 25 mrem/yr primary limit to determine the soil DCGLs. Attachment 1 presents the results of the surface soil RESRAD "run" for depleted uranium isotopes. Table 4-1 lists the surface soil DCGL results for individual radionuclides. All radionuclides except ^{234}U produce a maximum dose at year zero. ^{234}U produces a maximum dose at year 1000 due to the water dependent pathways (drinking water and plant ingestion).

TABLE 4-1: DETERMINATION OF DCGLS FOR INDIVIDUAL URANIUM ISOTOPES AND DU

U Isotopes	Year at Maximum Dose	DSR (mrem/yr)/(pCi/g)	DCGL (pCi/g)
^{234}U	1000	8.87E-02	282
^{235}U	0	3.71E-01	67
^{238}U	0	1.01E-01	249
		DCGL for DU[1]	**249**

[1] DCGL for DU = DCGL of ^{234}U x 0.084 + DCGL of ^{235}U x 0.012 + DCGL of ^{238}U x 0.904

Based on the resident farmer scenario, the DCGL for DU at R-14 Range Site is 249 pCi/g. The same resident farmer scenario was used for both the Transonic Range and BTD Sites, and the DCGL for DU was determined to be 230 pCi/g. The DCGL results for the other two sites at APG are more conservative than that for R-14 Range Site. Thus, as a conservative approach, a DCGL of 230 pCi/g will be used for DU at the R-14 Range Site.

Page 10 of Attachment 1 presents the maximum dose resulting from the three uranium isotopes. The results showed that the maximum dose occurs at year 0. Table 4-2 presents the contribution of doses to total dose for year 0 by different exposure pathways. According to the table, the external gamma pathways is the most significant dose contributor for the site, followed by plant ingestion, milk ingestion, soil ingestion, and meat ingestion. The table also showed that the contribution of doses by inhalation and fish ingestion pathways are negligible.

TABLE 4-2: CONTRIBUTION OF TOTAL DOSE BY EACH EXPOSURE PATHWAY

DU Isotopes	External Gamma	Inhalation	Plant	Meat	Milk	Soil	All Pathways
^{234}U	1.5E-05	1.6E-05	1.7E-03	2.6E-04	7.3E-04	6.4E-04	3.4E-03
^{235}U	4.0E-03	2.1E-06	2.3E-04	3.6E-05	9.9E-05	8.7E-05	4.5E-03
^{238}U	5.6E-02	1.5E-04	1.8E-02	2.7E-03	7.5E-03	6.6E-03	9.1E-02
Total	6.0E-02	1.7E-04	2.0E-02	3.0E-03	8.3E-03	7.3E-03	9.9E-02
% Contribution	61%	0.2%	20%	3%	8%	7%	

5.0 SENSITIVITY ANALYSIS

Sensitivity analyses were performed for the site using the RESRAD sensitivity graphic utility on input parameters related to intake assumptions for the receptors. Based on the results presented in Table 4-2, pathways that contributed more than 15% of total dose are considered significant dose contributors. The following intake parameters related to significant dose contributors were selected for the sensitivity analyses. Those include:

(1) External Gamma Shielding Factor

(2) Fraction of Time Spent Indoor

(3) Fraction of Time Spent Outdoor

(4) Fruits, Vegetables, and Grains Consumption; and

(5) Leafy Vegetables Consumption

The RESRAD sensitivity utility operates by both reducing and increasing the selected input parameter by a common factor. During the sensitivity analyses, the common factor was selected in such a way that the maximum and minimum values related to the parameter included the uncertainty range associated with the parameter. For parameters for which there was no uncertainty range, a common factor of two was used.

Doses were calculated for each perturbed parameter value. The output, including dose with the parameter unperturbed, dose with parameter reduced, and dose with parameter increased, was graphically displayed, with time as the independent variable.

A sensitivity index (SI) was calculated to determine which parameters have the greatest influence on the calculated DCGLs by using the following formula.

$$SI = 1 - (f(p)_{min} / f(p)_{max}),$$

where the f(p) values are the minimum and maximum doses resulting from the increased and reduced values related to certain intake parameters.

Table 5-1 presents the results of the sensitivity analysis for radionuclide-specific intake parameters. The table presents the average sensitivity index, as determined based on the dose results examined over a 1000-year period. A positive value of the sensitivity index indicates that the DCGL is directly proportional to the parameter of interest, whereas a negative value indicates that the DCGL is inversely proportional to the parameter of interest. The higher the value of SI,

the more sensitive is the intake value. A SI value of greater than 15% was used to identify the most sensitive parameters.

The results of the sensitivity analysis summarized in Table 5-1 shows that the external gamma shielding factor is the most sensitive intake parameter for DU. However, leafy vegetable consumption is the least sensitive intake parameters for all radionuclides. Conservative values were assigned for the intake parameters that are most sensitive to the radionuclides of concern under current site conditions.

TABLE 5-1: SENSITIVITY INDICES FOR RESRAD INTAKE PARAMETERS

RESRAD Input Parameter	Sensitivity Index (unitless)	
	Average	Maximum
External Gamma Shielding Factor	0.33	0.48
Fraction of Time Spent Outdoor	0.16	0.23
Fraction of Time Spent Indoor	0.28	0.39
Fruits, Vegetables, and Grains Consumption	0.19	0.23
Leafy Vegetables Consumption	0.02	0.05

6.0 UNCERTAINTY ANALYSIS

Uncertainty is inherent in all dose and risk assessment calculations and should be considered in determining whether a selected DCGL concentration will satisfy the regulatory decision-making criteria.

6.1 Types of Uncertainty

In general, there are three primary sources of uncertainty in a dose/risk assessment (Bonano et.al., 1988, and Kozak et al., 1991). The following paragraphs explain each of these sources of uncertainty and summarize how this project handled the associated uncertainties.

(1) Uncertainty in the models;
(2) Uncertainty in scenarios; and
(3) Uncertainty in the parameters.

(1) Uncertainty in the models: A number of computer software models are available to characterize the site-specific fate and transport mechanisms of the contaminants in the environment, and to assess dose and risk present at the site. Models are simplifications of reality, and in general, are not able to fully characterize the physical condition of the site. During this project, the RESRAD code is used for estimating the carcinogenic risk to human receptors from exposure to soil contaminated with residual radioactivity. DOE and NRC have approved the use of RESRAD for dose evaluation and waste disposal at licensed nuclear facilities. EPA also used the code in rule making for sites contaminated with radioactivity. Therefore, the uncertainty associated with the RESRAD model is considered to be acceptable.

(2) Uncertainty in the scenario: Uncertainty in scenarios is the result of lack of absolute knowledge about the future uses of the Site. Hence, DCGLs were determined based on the most conservative receptor scenario. Based on NRC regulatory guidance and recommendations, a

residential farmer scenario was chosen for determining the soil DCGLs at the site. However, it is important to recognize that the outlook evaluation time criterion (1000 years) is not intended to predict future scenarios for the next 1000 years. It is intended to evaluate the continued protectiveness of a given DCGL for 1000 years into the future given the reasonable and plausible future uses of the Site in today's social and economic conditions. Since the residential farmer scenario is considered the most conservative scenario, the uncertainty associated with this scenario is considered to be acceptable.

(3) Uncertainty in the parameters: Uncertainty in parameters was limited by using, whenever possible, site-specific values. However, there are no site-specific values for many of the parameters; thus, conservative NRC/EPA reference values were used to ensure that doses would be over- rather than under-estimated. The selection of prudently conservative parameters was conducted based on the hierarchy presented in Section 3.5 and was designed to utilize broadly accepted values. Because of the established hierarchy and the tendency toward prudently conservative parameters values that tend to overestimate doses, the uncertainties associated with parameter selection is considered to be acceptable.

RESRAD allows users to consider parameters as point estimates (deterministic) or as distributions (probabilistic). A sensitivity analysis on point estimate values may be used to determine which parameters have the largest impact on dose results. This analysis was performed as described above. Knowledge of sensitivity analysis results helps modelers limit uncertainty by focusing on the most sensitive parameters, if possible. When the probabilistic module is used, modelers can represent parameters as distributions (e.g., with a mean and standard deviation) to limit the conservatism in using NRC/EPA reference values. In some cases, there is sufficient site-specific data to utilize the probabilistic module, or NRC default definitions can be used. In either case, the selection of probabilistic inputs can limit uncertainty assuming those inputs are representative of site conditions. If a probabilistic module is populated with default distributions the uncertainty may or may not be reduced depending on the overlap of modeled versus actual conditions.

6.2 Selection of Uncertainty Range for RESRAD Input Parameters

DCGLs for the R-14 Range site were calculated using the deterministic and not the probabilistic approach. However, Table 6-1 presents probabilistic parameters along with the selected deterministic values for non-default RESRAD input exposure parameters. NUREG/CR-6697-assigned values were used as uncertainty ranges for most of the RESRAD parameters under a residential scenario. When site-specific values were not available, values defined in NUREG/CR-6697 were used. NUREG/CR-5512-assigned values were used for parameters that are directly proportional to dose.

TABLE 6-1: RECOMMENDED VALUES AND UNCERTAINTY RANGES FOR THE NON-DEFAULT RESRAD EXPOSURE PARAMETERS

RESRAD Parameter	Recommended Value	Units	Uncertainty Range			
			Value	Statistics	Distribution	NUREG/CR-6697
Inhalation rate	6650	m^3/yr	4,380	Minimum	Triangular	Section 5
			13,100	Maximum		
			8,400	Most likely		
Mass loading for inhalation	4.6E-06	g/m^3	2.00E-04	Indoor and outdoor time fraction	Empirical	RESRAD
Indoor Dust Filtration Factor	0.2448	unitless	0.15	Minimum	Uniform	Section 7.1
			0.95	Maximum		
External gamma shielding factor	0.5512	unitless	-1.3	Mean	Bounded lognormal-n	Section 7.10
			0.59	Std. Dev		
			0.044	Lower value		
			1	Upper value		
Fraction of time spent indoors	0.6571	unitless	NA	NA	NA	NA
Fraction of time spent outdoors	0.1181	unitless	NA	NA	NA	NA
Fruits, vegetables and grain consumption	166	kg/yr	135	Minimum	Triangular	Section 5.4
			318	Maximum		
			178	Most likely		
Leafy vegetable consumption	10	kg/yr	NA	NA	NA	NA
Milk consumption	100	L/yr	60	Minimum	Triangular	Section 5.3
			200	Maximum		
			102	Most likely		
Meat and poultry consumption	65.1	kg/yr	NA	NA	NA	NA
Fish consumption	10	kg/yr	NA	NA	NA	NA
Other seafood consumption	0.9	kg/yr	NA	NA	NA	NA
Soil ingestion rate	36.5	g/yr	0	Minimum	Triangular	Section 5.6
			36.5	Maximum		
			18.3	Most likely		
Drinking water intake	478.5	L/yr	510	Mean	Truncated lognormal-n	Table 5.2-2 (Adult) (EPA, 1997)
			478.5	50th Percentile		
			840	90th Percentile		

NA = Not Available

6.3 Selection of Recommended Value Based On Uncertainty

This section summarizes the process regarding the selection of the recommended values based on the uncertainty associated with the RESRAD input parameters.

6.3.1 Inhalation Rate

The time-weighted inhalation rate was determined by multiplying the inhalation rates for each activity (i.e., indoor, outdoor, and gardening) with the fraction of time the resident farmer will spend for each activity. The calculated inhalation rate (6,650 m^3/yr) falls within the minimum and maximum values of 4,380 and 13,100 m^3/yr, respectively, of the uncertainty range. The inhalation pathway is sensitive to this parameter; however, the total annual dose is not, because the inhalation pathway is not a significant contributor to total annual dose.

6.3.2 Mass Loading for Inhalation

The site-specific mass-loading factor for the inhalation was calculated based on time- weighted-average activity-specific mass loading inhalation factor and fraction of the time being spent for each activity (i.e., indoor, outdoor, and gardening). The site-specific mass loading for inhalation factor is 4.6E-06 g/m^3 for the site and is less than the RESRAD default value of 0.0002 g/m^3. The inhalation pathway is sensitive to this parameter; however, total annual dose is not because the inhalation pathway is not a significant contributor to total annual dose.

6.3.3 External Gamma Shielding Factor

The external gamma shielding factor is used to calculate the dose from the external penetrating gamma radiation pathway. The external gamma pathway and the overall dose (particularly the dose from a byproduct source term for which the dominant pathway is external gamma radiation) are sensitive to this parameter. The total annual dose from the external gamma pathway is 63%. This is the most sensitive parameter among all exposure parameters. EPA's *Soil Screening Guidance Document for Radionuclides: User's Guide* (EPA, 2000) assigned a value of 0.4 for this parameter. The recommended value of 0.5512 is higher than that for EPA's recommended value and falls within the upper and lower values of 1 and 0.044 of the uncertainty range.

6.3.4 Indoor Dust Filtration Factor

NUREG/CR-5512 lists the value for the indoor dust filtration factor as 0.2448 (unitless) under the residential farmer scenario. The inhalation pathway is relatively sensitive to this parameter but the overall dose is insensitive to variation in this factor as the inhalation pathway is not a significant contributor to overall dose. The indoor dust filtration factor is represented with a uniform distribution ranging from 0.15 to 0.95, and the recommended value falls within that uncertainty range.

6.3.5 Indoor & Outdoor Time Fractions

Under NUREG/CR-5512, the indoor & outdoor time fractions are 0.658 and 0.1181, respectively. The results of the sensitivity analyses using the NRC values showed that both parameters are sensitive to the total dose.

6.3.6 Fruits, Vegetable, and Grains Consumption

This parameter is relevant for resident farmer scenario. The recommended value of 166 kg/yr is almost equal to the most likely value of 178 kg/yr as defined in NUREG/CR-6697 and falls within the minimum and maximum values of 135 and 318 kg/yr, respectively, of the uncertainty

range. The sensitivity analysis shows that the plant ingestion pathway is sensitive to this parameter. The plant ingestion pathway is a significant contributor of total overall dose.

6.3.7 Milk Consumption

The recommended value of 100 L/yr for milk consumption is equivalent to the most likely value of 102 L/yr, as defined in NUREG/CR-6697, and falls within the minimum and maximum values of 60 and 200 L/yr, respectively, of the uncertainty range. The milk ingestion pathway is not a significant contributor of total overall dose.

6.3.8 Soil Ingestion Rate

The recommended value of 36.5 g/yr for this parameter is based on adult resident farmer and the value is equal to the maximum value of the uncertainty range. The soil ingestion pathway does not contribute significantly to the total dose for the Site.

6.3.9 Drinking Water Intake

The recommended value of 478.5 L/yr for this parameter is equal to the 50^{th} percentile value of the uncertainty range. The results of the soil dose assessment indicated that the drinking water ingestion pathway is not a significant contributor to the total dose.

7.0 CONCLUSION

Surface soil DCGLs were derived for DU present at the R-14 Range Site using the residential farmer exposure scenario. The NRC dose limit of 25 mrem in any year in excess of natural background radiation was used as the basis for each derivation. Table 4-1 presents the DCGL results for individual uranium isotopes and for DU. The resulting DCGL for DU was calculated to be 249 pCi/g, which is higher (i.e., less protective) than the 230-pCi/g value used for the Transonic Range and BTD Sites. This evaluation demonstrates that the DCGL used previously at the Transonic Range and BTD Sites is applicable and protective for use at the R-14 Range Site. Thus, the DCGL value of 230 pCi/g will be used as the soil action level for remediation at the R-14 Range Site, and as the concentration limit for evaluating the final status survey results with respect to the NRC criteria for unrestricted release.

8.0 REFERENCES

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ATTACHMENT 1

OUTPUT DOSE ASSESSMENT SUMMARY REPORT FOR RESIDENT FARMER

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Summary : Determination of DU DCGL based on Resident Farmer Scenario
File : R-14 Resident Farmer.RAD

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Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(3)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238	1.180E-01	1.180E-01	DCF2(8)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(9)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(3)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(7)
D-1	U-238	2.550E-04	2.550E-04	DCF3(8)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(9)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)

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D-34
D-34  U-234     , plant/soil concentration ratio, dimensionless    2.500E-03  2.500E-03  RTF(  6,1)
D-34  U-234     , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    3.400E-04  3.400E-04  RTF(  6,2)
D-34  U-234     , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     6.000E-04  6.000E-04  RTF(  6,3)
D-34
D-34  U-235+D   , plant/soil concentration ratio, dimensionless    2.500E-03  2.500E-03  RTF(  7,1)
D-34  U-235+D   , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)    3.400E-04  3.400E-04  RTF(  7,2)
D-34  U-235+D   , milk/livestock-intake ratio, (pCi/L)/(pCi/d)     6.000E-04  6.000E-04  RTF(  7,3)
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Summary : Determination of DU DCGL based on Resident Farmer Scenario
File : R-14 Resident Farmer.RAD

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

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Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): U-234	8.400E-02	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	1.200E-02	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	9.040E-01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	6.000E-04	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	5.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	2.000E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	1.000E+00	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ

R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	1.000E+02	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	5.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT

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Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	1.000E+01	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.099E-01	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)

R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.426E-02	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)

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Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	2.217E-02	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.165E-02	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.704E-05	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R017	Inhalation rate (m**3/yr)	6.650E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	4.600E-06	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	2.448E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	5.512E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	6.580E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (onsite)	1.180E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

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Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.660E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.100E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	1.000E+02	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.510E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	1.000E+01	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.560E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	4.785E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	5.000E-01	5.000E-01	---	FR9
R018	Contamination fraction of plant food	1.000E+00	-1	---	FPLANT
R018	Contamination fraction of meat	1.000E+00	-1	---	FMEAT
R018	Contamination fraction of milk	1.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	2.685E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	6.325E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	6.000E+01	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR

R19B	Wet weight crop yield for Non-Leafy	(kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy	(kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder	(kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy	(years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy	(years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder	(years)	8.000E-02	8.000E-02	---	TE(3)

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Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ

R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)

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Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	suppressed

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Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	U-234	8.400E-02
Thickness:	0.15 meters	U-235	1.200E-02
Cover Depth:	0.00 meters	U-238	9.040E-01

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	9.875E-02	9.428E-02	8.594E-02	6.210E-02	2.448E-02	8.969E-04	2.918E-04	8.697E-02
M(t):	3.950E-03	3.771E-03	3.437E-03	2.484E-03	9.794E-04	3.588E-05	1.167E-05	3.479E-03

Maximum TDOSE(t): 9.875E-02 mrem/yr at t = 0.000E+00 years

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.534E-05	0.0002	1.565E-05	0.0002	0.000E+00	0.0000	1.719E-03	0.0174	2.633E-04	0.0027	7.336E-04	0.0074	6.411E-04	0.0065
U-235	3.998E-03	0.0405	2.083E-06	0.0000	0.000E+00	0.0000	2.323E-04	0.0024	3.574E-05	0.0004	9.901E-05	0.0010	8.656E-05	0.0009
U-238	5.646E-02	0.5717	1.506E-04	0.0015	0.000E+00	0.0000	1.756E-02	0.1779	2.690E-03	0.0272	7.496E-03	0.0759	6.551E-03	0.0663
Total	6.047E-02	0.6124	1.683E-04	0.0017	0.000E+00	0.0000	1.951E-02	0.1976	2.989E-03	0.0303	8.329E-03	0.0843	7.279E-03	0.0737

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.388E-03	0.0343
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.454E-03	0.0451
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.091E-02	0.9206
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.875E-02	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.468E-05	0.0002	1.491E-05	0.0002	0.000E+00	0.0000	1.638E-03	0.0174	2.510E-04	0.0027	6.991E-04	0.0074	6.109E-04	0.0065
U-235	3.823E-03	0.0405	1.985E-06	0.0000	0.000E+00	0.0000	2.222E-04	0.0024	3.451E-05	0.0004	9.435E-05	0.0010	8.255E-05	0.0009
U-238	5.396E-02	0.5723	1.435E-04	0.0015	0.000E+00	0.0000	1.674E-02	0.1775	2.565E-03	0.0272	7.144E-03	0.0758	6.243E-03	0.0662
Total	5.780E-02	0.6130	1.604E-04	0.0017	0.000E+00	0.0000	1.860E-02	0.1973	2.850E-03	0.0302	7.937E-03	0.0842	6.936E-03	0.0736

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.229E-03	0.0342
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.259E-03	0.0452
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.680E-02	0.9206
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.428E-02	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.344E-05	0.0002	1.354E-05	0.0002	0.000E+00	0.0000	1.487E-03	0.0173	2.279E-04	0.0027	6.347E-04	0.0074	5.547E-04	0.0065
U-235	3.496E-03	0.0407	1.804E-06	0.0000	0.000E+00	0.0000	2.031E-04	0.0024	3.215E-05	0.0004	8.566E-05	0.0010	7.509E-05	0.0009
U-238	4.930E-02	0.5737	1.303E-04	0.0015	0.000E+00	0.0000	1.520E-02	0.1769	2.328E-03	0.0271	6.486E-03	0.0755	5.668E-03	0.0660
Total	5.281E-02	0.6145	1.456E-04	0.0017	0.000E+00	0.0000	1.689E-02	0.1965	2.588E-03	0.0301	7.206E-03	0.0839	6.298E-03	0.0733

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.932E-03	0.0341
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.894E-03	0.0453
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.911E-02	0.9206
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.594E-02	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	9.907E-06	0.0002	9.650E-06	0.0002	0.000E+00	0.0000	1.060E-03	0.0171	1.624E-04	0.0026	4.524E-04	0.0073	3.954E-04	0.0064
U-235	2.556E-03	0.0412	1.289E-06	0.0000	0.000E+00	0.0000	1.483E-04	0.0024	2.494E-05	0.0004	6.107E-05	0.0010	5.390E-05	0.0009
U-238	3.592E-02	0.5784	9.284E-05	0.0015	0.000E+00	0.0000	1.083E-02	0.1744	1.660E-03	0.0267	4.623E-03	0.0744	4.040E-03	0.0650
Total	3.849E-02	0.6197	1.038E-04	0.0017	0.000E+00	0.0000	1.204E-02	0.1939	1.847E-03	0.0297	5.137E-03	0.0827	4.489E-03	0.0723

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.090E-03	0.0337
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.845E-03	0.0458
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.717E-02	0.9205
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.210E-02	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	4.365E-06	0.0002	3.654E-06	0.0001	0.000E+00	0.0000	4.013E-04	0.0164	6.145E-05	0.0025	1.711E-04	0.0070	1.497E-04	0.0061
U-235	1.042E-03	0.0426	4.928E-07	0.0000	0.000E+00	0.0000	6.007E-05	0.0025	1.162E-05	0.0005	2.310E-05	0.0009	2.086E-05	0.0009
U-238	1.450E-02	0.5921	3.512E-05	0.0014	0.000E+00	0.0000	4.098E-03	0.1674	6.278E-04	0.0256	1.749E-03	0.0714	1.528E-03	0.0624
Total	1.554E-02	0.6348	3.926E-05	0.0016	0.000E+00	0.0000	4.559E-03	0.1862	7.008E-04	0.0286	1.943E-03	0.0794	1.699E-03	0.0694

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.915E-04	0.0323
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.158E-03	0.0473
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.253E-02	0.9204
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.448E-02	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	9.176E-07	0.0010	1.169E-07	0.0001	0.000E+00	0.0000	1.282E-05	0.0143	1.927E-06	0.0021	5.285E-06	0.0059	4.766E-06	0.0053
U-235	4.318E-05	0.0481	1.577E-08	0.0000	0.000E+00	0.0000	2.282E-06	0.0025	5.927E-07	0.0007	7.115E-07	0.0008	6.941E-07	0.0008
U-238	5.764E-04	0.6426	1.080E-06	0.0012	0.000E+00	0.0000	1.260E-04	0.1405	1.931E-05	0.0215	5.378E-05	0.0600	4.700E-05	0.0524
Total	6.205E-04	0.6918	1.213E-06	0.0014	0.000E+00	0.0000	1.411E-04	0.1574	2.183E-05	0.0243	5.978E-05	0.0666	5.246E-05	0.0585

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.583E-05	0.0288
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.748E-05	0.0529
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.236E-04	0.9183
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.969E-04	1.0000

*Sum of all water independent and dependent pathways.

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Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	2.495E-04	0.8550	2.735E-06	0.0094	0.000E+00	0.0000	3.933E-05	0.1348	6.655E-08	0.0002	1.813E-07	0.0006	2.918E-04	1.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	2.495E-04	0.8550	2.735E-06	0.0094	0.000E+00	0.0000	3.933E-05	0.1348	6.655E-08	0.0002	1.813E-07	0.0006	2.918E-04	1.0000

*Sum of all water independent and dependent pathways.

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File : R-14 Resident Farmer.RAD

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As *mrem/yr* and Fraction of Total Dose At t = 1.000E+03 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	6.281E-03	0.0722	1.322E-05	0.0002	0.000E+00	0.0000	9.920E-04	0.0114	2.951E-05	0.0003	1.369E-04	0.0016	7.453E-03	0.0857
U-235	3.759E-03	0.0432	2.727E-05	0.0003	0.000E+00	0.0000	5.936E-04	0.0068	5.100E-05	0.0006	2.002E-05	0.0002	4.451E-03	0.0512
U-238	6.330E-02	0.7278	1.019E-04	0.0012	0.000E+00	0.0000	9.996E-03	0.1149	2.890E-04	0.0033	1.387E-03	0.0159	7.507E-02	0.8631
Total	7.334E-02	0.8432	1.424E-04	0.0016	0.000E+00	0.0000	1.158E-02	0.1332	3.695E-04	0.0042	1.544E-03	0.0178	8.697E-02	1.0000

*Sum of all water independent and dependent pathways.

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Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	4.033E-02	3.844E-02	3.490E-02	2.488E-02	9.413E-03	2.900E-04	0.000E+00	8.695E-02
U-234	Th-230	1.000E+00	1.609E-07	4.557E-07	9.981E-07	2.497E-06	4.557E-06	4.158E-06	0.000E+00	7.685E-07
U-234	Ra-226+D	1.000E+00	3.830E-09	2.663E-08	1.345E-07	1.001E-06	5.034E-06	1.129E-05	0.000E+00	3.817E-04
U-234	Pb-210+D	1.000E+00	1.750E-11	2.243E-10	2.258E-09	4.444E-08	5.308E-07	2.031E-06	0.000E+00	1.389E-03
U-234	-DSR(j)		4.033E-02	3.844E-02	3.490E-02	2.488E-02	9.423E-03	3.075E-04	0.000E+00	8.872E-02
U-235+D	U-235+D	1.000E+00	3.711E-01	3.547E-01	3.241E-01	2.363E-01	9.564E-02	3.863E-03	0.000E+00	8.237E-02
U-235+D	Pa-231	1.000E+00	5.191E-05	1.552E-04	3.340E-04	7.200E-04	7.937E-04	8.087E-05	0.000E+00	7.081E-02
U-235+D	Ac-227+D	1.000E+00	3.326E-07	1.914E-06	8.128E-06	4.118E-05	8.347E-05	1.244E-05	2.432E-02	2.177E-01
U-235+D	-DSR(j)		3.711E-01	3.549E-01	3.245E-01	2.371E-01	9.652E-02	3.957E-03	2.432E-02	3.709E-01
U-238	U-238	5.400E-05	1.956E-06	1.864E-06	1.693E-06	1.206E-06	4.564E-07	1.404E-08	0.000E+00	4.243E-06
U-238+D	U-238+D	9.999E-01	1.006E-01	9.601E-02	8.751E-02	6.324E-02	2.493E-02	9.109E-04	0.000E+00	8.279E-02
U-238+D	U-234	9.999E-01	5.671E-08	1.630E-07	3.459E-07	7.402E-07	8.138E-07	8.263E-08	0.000E+00	2.470E-04
U-238+D	Th-230	9.999E-01	1.563E-13	1.011E-12	4.896E-12	3.442E-11	1.541E-10	2.526E-10	0.000E+00	1.533E-09
U-238+D	Ra-226+D	9.999E-01	2.675E-15	3.985E-14	4.418E-13	9.446E-12	1.245E-10	6.159E-10	0.000E+00	4.519E-07
U-238+D	Pb-210+D	9.999E-01	1.034E-17	2.708E-16	5.783E-15	3.254E-13	1.059E-11	1.016E-10	0.000E+00	1.590E-06
U-238+D	-DSR(j)		1.006E-01	9.601E-02	8.751E-02	6.324E-02	2.493E-02	9.110E-04	0.000E+00	8.304E-02

The DSR includes contributions from associated (half-life ó 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

0Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	6.199E+02	6.504E+02	7.163E+02	1.005E+03	2.653E+03	8.130E+04	*6.247E+09	2.818E+02
U-235	6.736E+01	7.045E+01	7.705E+01	1.054E+02	2.590E+02	6.318E+03	1.028E+03	6.741E+01
U-238	2.486E+02	2.604E+02	2.857E+02	3.953E+02	1.003E+03	2.744E+04	*3.361E+05	3.011E+02

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
U-234	8.400E-02	1.000E+03	8.872E-02	2.818E+02	4.033E-02	6.199E+02
U-235	1.200E-02	0.000E+00	3.711E-01	6.736E+01	3.711E-01	6.736E+01
U-238	9.040E-01	0.000E+00	1.006E-01	2.486E+02	1.006E-01	2.486E+02

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Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	3.388E-03	3.229E-03	2.932E-03	2.090E-03	7.907E-04	2.436E-05	0.000E+00	7.304E-03
U-234	U-238	9.999E-01	5.127E-08	1.474E-07	3.127E-07	6.692E-07	7.356E-07	7.470E-08	0.000E+00	2.232E-04
U-234	-DOSE(j)		3.388E-03	3.229E-03	2.932E-03	2.090E-03	7.914E-04	2.444E-05	0.000E+00	7.527E-03
Th-230	U-234	1.000E+00	1.351E-08	3.828E-08	8.384E-08	2.098E-07	3.828E-07	3.493E-07	0.000E+00	6.456E-08
Th-230	U-238	9.999E-01	1.413E-13	9.143E-13	4.426E-12	3.112E-11	1.393E-10	2.283E-10	0.000E+00	1.386E-09
Th-230	-DOSE(j)		1.351E-08	3.828E-08	8.384E-08	2.098E-07	3.829E-07	3.495E-07	0.000E+00	6.594E-08
Ra-226	U-234	1.000E+00	3.217E-10	2.237E-09	1.130E-08	8.409E-08	4.228E-07	9.482E-07	0.000E+00	3.206E-05
Ra-226	U-238	9.999E-01	2.418E-15	3.602E-14	3.994E-13	8.539E-12	1.125E-10	5.567E-10	0.000E+00	4.085E-07
Ra-226	-DOSE(j)		3.217E-10	2.237E-09	1.130E-08	8.410E-08	4.229E-07	9.488E-07	0.000E+00	3.247E-05
Pb-210	U-234	1.000E+00	1.470E-12	1.884E-11	1.897E-10	3.733E-09	4.459E-08	1.706E-07	0.000E+00	1.167E-04
Pb-210	U-238	9.999E-01	9.350E-18	2.448E-16	5.228E-15	2.942E-13	9.571E-12	9.189E-11	0.000E+00	1.438E-06
Pb-210	-DOSE(j)		1.470E-12	1.884E-11	1.897E-10	3.733E-09	4.460E-08	1.707E-07	0.000E+00	1.181E-04
U-235	U-235	1.000E+00	4.453E-03	4.257E-03	3.890E-03	2.836E-03	1.148E-03	4.636E-05	0.000E+00	9.885E-04
Pa-231	U-235	1.000E+00	6.229E-07	1.863E-06	4.008E-06	8.640E-06	9.525E-06	9.704E-07	0.000E+00	8.498E-04
Ac-227	U-235	1.000E+00	3.991E-09	2.297E-08	9.753E-08	4.942E-07	1.002E-06	1.493E-07	2.918E-04	2.612E-03
U-238	U-238	5.400E-05	1.768E-06	1.685E-06	1.530E-06	1.091E-06	4.126E-07	1.270E-08	0.000E+00	3.835E-06
U-238	U-238	9.999E-01	9.091E-02	8.679E-02	7.911E-02	5.717E-02	2.253E-02	8.235E-04	0.000E+00	7.484E-02
U-238	-DOSE(j)		9.091E-02	8.680E-02	7.911E-02	5.717E-02	2.253E-02	8.235E-04	0.000E+00	7.484E-02

THF(i) is the thread fraction of the parent nuclide.

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Summary : Determination of DU DCGL based on Resident Farmer Scenario
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Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated
S(j,t), pCi/g

Nuclide (j)	Parent (i)	THF(i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	8.400E-02	8.036E-02	7.356E-02	5.396E-02	2.227E-02	1.005E-03	1.439E-07	5.050E-21
U-234	U-238	9.999E-01	0.000E+00	2.452E-06	6.732E-06	1.646E-05	2.038E-05	3.067E-06	1.317E-09	1.543E-22
U-234	-S(j):		8.400E-02	8.037E-02	7.356E-02	5.398E-02	2.229E-02	1.008E-03	1.452E-07	5.205E-21
Th-230	U-234	1.000E+00	0.000E+00	7.397E-07	2.124E-06	6.109E-06	1.255E-05	1.682E-05	1.687E-05	1.633E-05
Th-230	U-238	9.999E-01	0.000E+00	1.120E-11	9.506E-11	8.634E-10	4.508E-09	1.098E-08	1.164E-08	1.127E-08
Th-230	-S(j):		0.000E+00	7.397E-07	2.124E-06	6.109E-06	1.255E-05	1.683E-05	1.688E-05	1.634E-05
Ra-226	U-234	1.000E+00	0.000E+00	1.597E-10	1.366E-09	1.275E-08	7.150E-08	2.035E-07	2.281E-07	2.209E-07
Ra-226	U-238	9.999E-01	0.000E+00	1.616E-15	4.109E-14	1.236E-12	1.877E-11	1.193E-10	1.573E-10	1.524E-10
Ra-226	-S(j):		0.000E+00	1.597E-10	1.366E-09	1.275E-08	7.152E-08	2.037E-07	2.282E-07	2.210E-07
Pb-210	U-234	1.000E+00	0.000E+00	1.643E-12	4.159E-11	1.232E-09	1.800E-08	1.049E-07	1.332E-07	1.290E-07
Pb-210	U-238	9.999E-01	0.000E+00	1.250E-17	9.448E-16	9.168E-14	3.796E-12	5.631E-11	9.178E-11	8.903E-11
Pb-210	-S(j):		0.000E+00	1.643E-12	4.159E-11	1.232E-09	1.801E-08	1.050E-07	1.333E-07	1.291E-07
U-235	U-235	1.000E+00	1.200E-02	1.148E-02	1.051E-02	7.709E-03	3.181E-03	1.436E-04	2.057E-08	7.235E-22
Pa-231	U-235	1.000E+00	0.000E+00	2.429E-07	6.670E-07	1.631E-06	2.019E-06	3.035E-07	1.302E-10	1.515E-23
Ac-227	U-235	1.000E+00	0.000E+00	3.744E-09	2.896E-08	1.923E-07	4.459E-07	8.894E-08	4.105E-11	4.895E-24
U-238	U-238	5.400E-05	4.882E-05	4.670E-05	4.275E-05	3.136E-05	1.294E-05	5.842E-07	8.368E-11	2.943E-24
U-238	U-238	9.999E-01	9.040E-01	8.648E-01	7.916E-01	5.807E-01	2.396E-01	1.082E-02	1.550E-06	5.450E-20
U-238	-S(j):		9.040E-01	8.649E-01	7.916E-01	5.807E-01	2.396E-01	1.082E-02	1.550E-06	5.450E-20

THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time = 4.29 seconds