DETERMINATION OF DERIVED CONCENTRATION GUIDELINE LEVEL (DCGL) FOR BUILDING 1103A AREA 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 Building 1103A Area. Both the Transonic Range and the Building 1103A Area 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 Building 1103A Area. Thus, the DCGL value of 230 pCi/g will be used as the soil action level for remediation and final status survey of the Building 1103A Area.

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,

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
0.138, 0.023, and 0.839, 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 Building 1103A
Area 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 Building 1103A Area.

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 Building 1103A 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 Building 1103A Area. 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	1.00E+06	1.00E+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 Building 1103A Area. 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 individual uranium isotopes 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). However, when considering the mix of uranium isotopes in DU, the maximum dose due to all occurs at year zero.

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

U Isotopes	DSR (mrem/yr)/(pCi/g)	DCGL (pCi/g)
[234]U	4.03E-02	620
[235]U	3.71E-01	67
[238]U	1.01E-01	249

To determine the DCGL for a mixture of radionuclides (or isotopes) as in DU, the following equation is used:

$$\text{DU Mixture DCGL} = \frac{1}{\left(\dfrac{f_{U-234}}{DCGL_{U-234}}\right) + \left(\dfrac{f_{U-235}}{DCGL_{U-235}}\right) + \left(\dfrac{f_{U-238}}{DCGL_{U-238}}\right)}$$

Where:
f = activity fraction for the uranium isotope
DCGL = DCGL for the uranium isotope

Using the Building 1103A uranium isotope activity fractions in DU, the individual uranium isotope DCGL values in Table 4-1 (which are rounded to the nearest whole number) and the above equation, the DCGL for the mixture is 253 pCi/g (rounded down to the nearest whole number).

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 Building 1103A Area. Thus, as a conservative approach, a DCGL of 230 pCi/g will be used for DU at the Building 1103A Area.

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) <u>Uncertainty in the scenario</u>: 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) <u>Uncertainty in the parameters</u>: 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 Building 1103A Area 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 50th 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 Building 1103A Area 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 253 pCi/g, which is higher 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 Building 1103A Area. Thus, the DCGL value of 230 pCi/g will be used as the soil action level for remediation at the Building 1103A Area, and as the concentration limit for evaluating the final status survey results with respect to the NRC criteria for unrestricted release.

8.0   REFERENCES

ANL, 1993. *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil*, ANL/EAIS-8. Argonne National Laboratory, Environmental Assessment Division, Argonne, IL. April 1993.

ANL, 1999. *Derived Uranium Guidelines for the Depleted Uranium Study Area of the Transonic Range, Aberdeen Proving Ground, Maryland.* M. Picel and S. Kamboj, Argonne National Laboratory, Argonne, IL. April 1999.

ANL, 2005. Yu, C., et. al., *RESRAD for Windows, Version 6.3, Computer Modeling Code.* Developed by Argonne National Laboratory, Environmental Assessment Division, Argonne, IL under joint sponsorship by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission. September 2005.

ATG, 2000. *Transonic Range Depleted Uranium Study Area Decommissioning Plan, Rev. 1*.
    Allied Technology Group, Oak Ridge, TN. March 1, 2000.

Bonano, E.J., P.A. Davis, and R.M. Cranwell, 1988. *A review of Uncertainties Relevant in
    Performance Assessment of High Level Radioactive Waste Repositories*, NUREG/CR-5211,
    U.S. Nuclear Regulatory Commission, Washington, D.C., September 1988.

CABRERA, 2003. *U.S. Army Garrison, Aberdeen Proving Ground Derived Uranium Guidelines
    For Depleted Uranium at the BTD Soil Sample Area.* Cabrera Services, Inc., East Hartford,
    CT. 2003.

EPA, 1989. *Human Health Evaluation Manual*, *Volume I, Risk Assessment Guidance for
    Superfund*. EPA/540/1–89/002. U.S. Environmental Protection Agency, Office of
    Emergency and Remedial Response, Washington, DC. December 1989.

EPA, 1991a. *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation
    Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*. U.S.
    Environmental Protection Agency, Office of Emergency and Remedial Response,
    Washington, D.C. December 1991.

EPA, 1991b. *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation
    Model*. OSWER Directive 9285.6-03. U.S. Environmental Protection Agency, Office of
    Emergency and Remedial Response, Washington, D.C. March 1991.

EPA, 1997a. *Exposure Factors Handbook, Volumes I, II, and III*. EPA/600/P-95/002Fa-c. U.S.
    Environmental Protection Agency, Office of Research and Development, Washington, DC,
    August 1997.

EPA, 1997b. *Establishment of Cleanup Levels for CERCLA Sites with Radioactive
    Contamination*. OSWER 9200.4-18. U.S. Environmental Protection Agency, Office of
    Emergency and Remedial Response, Washington, D.C. August 1997.

EPA, 2000. *Soil Screening Guidance for Radionuclides: User's Guide.* EPA/540-R-00-007.
    U.S. Environmental Protection Agency, Office of Radiation and Indoor Air/Office of Solid
    Waste and Emergency Response, Washington, DC. October 2000.

NRC, 1994. Federal Register Notice, Volume 59, Number 161, *Comments from Workshops:
    Radon.* U.S. Nuclear Regulatory Commission. August 22 1994.

NRC, 1999a. *Residual Radioactive Contamination From Decommissioning - Parameter
    Analysis,* Draft Report for Comments. NUREG/CR-5512, Vol. 3, SAND99-2148. U.S.
    Nuclear Regulatory Commission. August 1999.

NRC, 1999b. *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,
    SAND99-2147). U.S. Nuclear Regulatory Commission. August 1999.

NRC, 2000. *Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes*. NUREG/CR-6697, ANL/EAD/TM-98. U.S. Nuclear Regulatory Commission. November 2000.

ATTACHMENT 1

OUTPUT DOSE ASSESSMENT SUMMARY REPORT
FOR RESIDENT FARMER

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RESRAD, Version 6.3     T« Limit = 180 days        01/29/2008  16:12  Page   1
 Summary : Determination of DU DCGL based on Resident Farmer Scenario
 File    : BLDG 1103A Resident Farmer.RAD


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     Part I: Mixture Sums and Single Radionuclide Guidelines
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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page   2
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103ABLDG 1103A Resident Farmer.RAD


                    Dose Conversion Factor (and Related) Parameter Summary
                              File: FGR 13 MORBIDITY
                                                    Current     Base      Parameter
Menu                         Parameter               Value     Case*        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)
```

```
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
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                    Dose Conversion Factor (and Related) Parameter Summary (continued)
                                    File: FGR 13 MORBIDITY
                                                  Current     Base       Parameter
Menu                       Parameter              Value       Case*        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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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page   4
Summary : Determination of DU DCGL based on Resident Farmer Scenario
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                          Site-Specific Parameter Summary
                                      User                    Used by RESRAD          Parameter
Menu                Parameter         Input     Default   (If different from user input)  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
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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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Summary : Determination of DU DCGL based on Resident Farmer Scenario
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                           Site-Specific Parameter Summary (continued)
                                   User                   Used by RESRAD          Parameter
Menu              Parameter        Input     Default  (If different from user input)   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)
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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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Summary : Determination of DU DCGL based on Resident Farmer Scenario
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                         Site-Specific Parameter Summary (continued)
                                        User                  Used by RESRAD           Parameter
Menu                 Parameter          Input    Default  (If different from user input)   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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Summary : Determination of DU DCGL based on Resident Farmer Scenario
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                           Site-Specific Parameter Summary (continued)
                                         User                 Used by RESRAD           Parameter
Menu                  Parameter          Input     Default    (If different from user input)    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
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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)
                                      User                  Used by RESRAD         Parameter
Menu                 Parameter        Input    Default  (If different from user input)   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)
                                          User                  Used by RESRAD            Parameter
Menu              Parameter               Input    Default  (If different from user input)  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
-----Ï------------------------------------------------Ï----------Ï----------Ï----------------------------------Ï--------------
```

```
                  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
        ------------------------------Ï--------------------
```

```
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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)
           Ground            Inhalation           Radon             Plant             Meat              Milk              Soil
Radio-  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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
            Water             Fish              Radon             Plant             Meat              Milk           All Pathways*
Radio-  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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)
          Ground              Inhalation            Radon               Plant               Meat                Milk                Soil
Radio-   ----------------    ----------------    ----------------    ----------------    ----------------    ----------------    ----------------
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
          Water               Fish                Radon               Plant               Meat                Milk              All Pathways*
Radio-   ----------------    ----------------    ----------------    ----------------    ----------------    ----------------    ----------------
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)
           Ground            Inhalation            Radon              Plant               Meat               Milk                Soil
Radio-  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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
           Water              Fish              Radon              Plant               Meat               Milk             All Pathways*
Radio-  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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)
            Ground            Inhalation          Radon            Plant             Meat             Milk             Soil
Radio-  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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
            Water              Fish             Radon            Plant             Meat             Milk         All Pathways*
Radio-  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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)
          Ground            Inhalation           Radon              Plant              Meat               Milk                Soil
Radio-   ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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
          Water             Fish              Radon              Plant              Meat               Milk              All Pathways*
Radio-   ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page  16
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103A Resident Farmer.RAD
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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)
            Ground            Inhalation           Radon             Plant             Meat              Milk              Soil
Radio-   ----------------   ----------------   ----------------   ----------------   ----------------   ----------------   ----------------
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
            Water             Fish              Radon             Plant             Meat              Milk            All Pathways*
Radio-   ----------------   ----------------   ----------------   ----------------   ----------------   ----------------   ----------------
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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RESRAD, Version 6.3     T« Limit = 180 days         01/29/2008  16:12  Page  17
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103A 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 = 3.000E+02 years
                                Water Independent Pathways (Inhalation excludes radon)
            Ground              Inhalation             Radon                 Plant                 Meat                  Milk                  Soil
Radio-  ----------------    ----------------    ----------------    ----------------    ----------------    ----------------    ----------------
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
            Water               Fish                Radon                 Plant                 Meat                  Milk              All Pathways*
Radio-  ----------------    ----------------    ----------------    ----------------    ----------------    ----------------    ----------------
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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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page  18
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103A Resident Farmer.RAD
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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+03 years
                                Water Independent Pathways (Inhalation excludes radon)
           Ground            Inhalation          Radon             Plant             Meat              Milk              Soil
Radio-   ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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
           Water             Fish              Radon             Plant             Meat              Milk            All Pathways*
Radio-   ----------------  ----------------  ----------------  ----------------  ----------------  ----------------  ----------------
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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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page  19
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103A Resident Farmer.RAD


                      Dose/Source Ratios Summed Over All Pathways
                  Parent and Progeny Principal Radionuclide Contributions Indicated
   Parent      Product     Thread              DSR(j,t) At Time in Years   (mrem/yr)/(pCi/g)
    (i)          (j)       Fraction  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  Initial       tmin       DSR(i,tmin) G(i,tmin) DSR(i,tmax) G(i,tmax)
   (i)    (pCi/g)      (years)                  (pCi/g)              (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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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page  20
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103A Resident Farmer.RAD


                    Individual Nuclide Dose Summed Over All Pathways
                      Parent Nuclide and Branch Fraction Indicated
0Nuclide Parent   THF(i)                         DOSE(j,t), mrem/yr
  (j)     (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    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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RESRAD, Version 6.3      T« Limit = 180 days        01/29/2008  16:12  Page  21
Summary : Determination of DU DCGL based on Resident Farmer Scenario
File    : BLDG 1103A Resident Farmer.RAD


                          Individual Nuclide Soil Concentration
                          Parent Nuclide and Branch Fraction Indicated
Nuclide Parent   THF(i)                                  S(j,t), pCi/g
  (j)     (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
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THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time =    4.29 seconds
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