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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
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EXECUTIVE SUMMARY

The purpose of this report is to document the process leading to, and the results of scoping calculation of receptor-, radionuclide-, scenario-, and ash thickness-specific biosphere dose conversion factors (BDCFs) for the postulated volcanic eruption and for the assumed human exposure conditions. Two receptors are of concern in this report: an average member of the critical group and the reasonably maximally exposed individual. Radionuclides selected for calculation include those of importance for up to 1 million years after the potential repository's closure. Scenarios considered in this report supplement those used previously. Specifically, the approach documented in this report takes into account human exposure during three different phases at the time of, and after, volcanic eruption. Also, it is assumed that the amount of contaminated ash deposition is greater than previously considered.

BDCFs for volcanic eruption, when combined with the concentration of activity deposited by volcanic eruption on the soil surface, allow calculation of radiation doses to the receptor of interest. Calculation of activity deposition is outside the scope of this report and so is the transport of contaminated ash from the volcano to the location of the receptor.

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ACRONYMS AND ABBREVIATIONS

Acronyms

AMAD	Activity Median Aerodynamic Diameter
AMCG	Average Member of the Critical Group
AMR	Analysis Model Report
AQI	Air Quality Index
BDCF	Biosphere Dose Conversion Factor
CRWMS M&O	Civilian Radioactive Waste Management System Management and Operating Contractor
DF	Dose Factors
LHS	Latin Hypercube Sampling
MC	Monte Carlo (Sampling)
PA	Performance Assessment
RMEI	Reasonably Maximally Exposed Individual
SR	Site Recommendation
STD	Standard Deviation
TBV	To Be Verified
TEDE	Total Effective Dose Equivalent
TSPA	Total System Performance Assessment

Abbreviations

Ac	Actinium
Am	Americium
Bq	becquerel

Ci	curie
Cs	Cesium
Fr	Francium
Np	Neptunium
Pa	Protactinium
pCi	picocurie
Pu	Plutonium
Ra	Radium
rem	historically derived from Roentgen Equivalent Man, unit of dose
Rn	Radon
Sr	Strontium
Sv	Sievert
Th	Thorium
U	Uranium
Y	Yttrium

1. PURPOSE

Biosphere is one of the component process models supporting the Total System Performance Assessment (TSPA). The biosphere model considers the movement of radionuclides in the accessible environment and human exposure to these radionuclides. The outcome of biosphere model are biosphere dose conversion factors (BDCFs). BDCFs are included, among other parameters, in the set of input parameters for TSPA computer code, which allows dose assessment from the postulated radionuclide releases from the potential repository.

Human exposure to radionuclides present in environmental media, such as water, soil, air, and food may be of internal or external origin. Internal exposure pathways under consideration in the biosphere model include ingestion and inhalation of radionuclides; external exposure pathway considers external irradiation from contaminated soil.

Discussions regarding the volcanic eruption scenario are ongoing. The previously developed set of BDCFs for volcanic eruption (CRWMS M&O 2000a) concerned different environmental conditions following volcanic eruption than what is currently considered. Despite the lack of the final decisions there was a need to conduct scoping calculation to support performance assessment (PA) efforts. Since results of TSPA modeling that might provide specific information about environmental conditions potentially relevant to the biosphere were not available at the time, the Input Transmittal was generated (CRWMS M&O 2000b). The Input Transmittal contained tentative information regarding environmental conditions following a hypothetical volcanic eruption at Yucca Mountain. However, only limited guidance was provided to the Biosphere group regarding a range of conditions that should or might be considered for calculation of BDCFs for volcanic eruption.

The purpose of the effort documented in this calculation report was to support the Biosphere component of TSPA-SR by developing volcanic eruption BDCFs for:

- Two human receptors.
- Seventeen radionuclides considered important for both assessing repository performance during the regulatory compliance period from 100 years to 10,000 years after the potential repository is closed, and for the Environmental Impact Statement (up to 1 million years).
- Three exposure scenarios based on three phases during and after volcanic eruption.
- Two thicknesses of contaminated volcanic ash.

Activities described in this report were conducted in accordance with the *Development Plan for Volcanic Eruption Biosphere Dose Conversion Factor Scoping Calculations* (CRWMS M&O 2000c).

2. METHOD

Calculation of volcanic eruption BDCFs was carried out by the computer code GENII-S (Leigh et al. 1993). GENII-S has been selected for its capabilities to support modeling of environmental transport and to consider multiple exposure pathways. GENII-S uses a comprehensive set of environmental pathway models and associated computer programs to estimate potential radiation doses to humans from radionuclides in the environment.

The calculation was conducted within the applicable limits of the GENII-S code for the TSPA application, as described in the software qualification report (CRWMS M&O 1998a). The conclusions in this report only apply to radionuclides listed in Section 5.4, and not the full suite of radionuclides considered in GENII-S.

Volcanic eruption BDCFs were calculated in a series of probabilistic runs to propagate uncertainties of input parameters into the output. BDCFs were developed for:

- Two human receptors: an average member of the critical group (AMCG) and the reasonably maximally exposed individual (RMEI).
- Seventeen radionuclides: Strontium-90, Cesium-137, Lead-210, Radium-226, Actinium-227, Thorium-229, Thorium-230, Protactinium-231, Uranium-232, Uranium-233, Uranium-234, Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-242, Americium-241, and Americium-243.
- Three exposure scenarios corresponding to three phases during and following volcanic eruption: eruption phase, transition phase and steady-state phase.
- Two thicknesses of volcanic ash deposited on the ground: 1 cm and 15 cm.

Input for the computer code was either developed earlier in a series of analyses identified in Section 5 or documented in form of assumptions for the purpose of this report. The latter category includes parameters related to increased dustiness after a volcanic eruption. These are described in Section 3.

Evaluation of electronic data management process control was performed in accordance with AP-SV.1Q, *Control of the Electronic Management of Data* (CRWMS M&O 2000d). The computer code produces output that was, for the duration of document development, stored on the same computer hard drive. Access to the data contained on the personal computer used to perform this work was controlled (password protected). The results were transferred into tables in the calculation report by reading the values from the computer screen. The report was saved daily to the server drive, which was periodically backed up (H drive). The work did not depend on electronic data transfer, neither for the input nor the output, to the degree of generating the technical product (calculation report).

The work, however, involved conducting model runs. Upon completion of model runs, the files generated by the computer code were transferred to one of the modeling databases, such as the System Performance Assessment Database, of the Technical Data Management System. To

accomplish the transfer, the files were zipped, using Winzip utility to maintain data security and integrity. The list of the transferred files, including filename, file size, and date the file was generated is included in Attachment I.

The calculation was developed in accordance with AP-3.12Q, *Calculations.*

3. ASSUMPTIONS

The volcanic eruption can be divided into three phases: eruption phase which continues through the duration of the event, the transition phase characterized by increased dustiness caused by resuspension of volcanic ash, and the steady-state phase characterized by the return of particulate concentration in air to the pre-eruption level. Also, two thicknesses of volcanic ash deposits were selected: 1 cm and 15 cm, to represent conditions of thin ash deposition as well as conditions of thicker volcanic ash deposits. Some parameters have values that are phase-specific or ash thickness-specific.

The assumptions were made regarding the values of input parameters, which were unavailable from the previous analyses. The assumptions were as follows.

3.1 THICKNESS OF ASH DEPOSIT

Considering the wide range of ash thicknesses (see Table 1), BDCFs were developed for two different thicknesses of ash. As indicated in Table 5, containing information obtained from the Performance Assessment Department regarding the characteristics of the possible outcomes of the volcanic eruption, ash layers are likely to be one centimeter or less in thickness, however greater thickness are possible, although with smaller probability. Therefore, BDCFs were calculated for two thicknesses of ash: 1 cm, representing the more likely conditions, and 15 cm to referring to thicker ash deposits. The thicker ash layer was chosen to be 15 cm because this thickness corresponds to the depth of plant growing zone, which is one of the input parameters in the GENII-S. Greater thicknesses have no effect on the calculation outcome because it is assumed that plants' roots don't extend past 15 cm in depth. The selection of ash thicknesses is considered a criterion and does not require a TBV.

3.2 ASH DENSITY

Bulk in-situ density of ash is estimated to be 1000 kg/m^3 (CRWMS M&O 2000e). However, this number concerns the recent fallout rather than the ash that has been compacted by water, such as could be expected on an irrigated field. Therefore, for the steady-state phase, it is assumed that the ash density is the same as the density of soil, i.e., 1500 kg/m^3 (CRWMS M&O 1999a). This assumption requires a TBV (TBV-4719). This assumption was used in GENII-S menu-driven input described in Section 5.6 (Table 8). Ash density of 1000 kg/m^3 was used for the transition phase.

3.3 MASS LOADING

Mass loading, *S*, representing annual average value of respirable fraction (PM_{10}) of suspended particulates in air, is used in the GENII-S code to calculate inhalation exposure of a receptor. The value of this parameter for the transition phase was developed using Mount St. Helens volcano eruption as an analog. It was assumed that PM_{10} concentration in air decreases exponentially with time. Based on the results of air quality measurements following volcanic eruption at Mount St. Helens, in the first year after the eruption, annual average PM_{10} concentration was assumed to be 1000 μg/m^3. This value is significantly higher than the EPA's PM_{10} breakpoint of 604 μg/m^3, for the highest Air Quality Index (AQI) of 500 (40 CFR 58,

Appendix G, Table 2). The breakpoints in this case represent 24-hour averages. AQI of 500 corresponds to the significant harm level, at which serious and widespread health effects occur to the general population. In addition, it needs to be noted again, that this parameter in GENII-S is used as an annual average. It is extremely conservative to assume that an annual average concentration could be as high as 1000 $\mu g/m^3$. This implies that the initial instantaneous PM_{10} values were much greater. Such values do not seem to be realistic. People could not spend a year under such conditions without serious health effects unrelated to radiation.

The final annual average PM_{10} concentration, corresponding to the return of the biosphere to the pre-event conditions, was assumed to be 30 $\mu g/m^3$, which is an annual average current value for the state of Nevada. The reduction of airborne particulate concentration was assumed to occur exponentially. The probability distribution for mass loading is therefore loguniform with a minimum of 30 $\mu g/m^3$ and a maximum of 1000 $\mu g/m^3$. For the steady-state phase it was assumed that the mass loading has reached a steady-state value of 30 $\mu g/m^3$ and that the ash became uniformly mixed into the surface soil layer of 15 cm. This assumption and was used in GENII-S menu-driven input described in Section 5.6 (Table 8). It has been given a TBV-4718.

3.4 CROP RESUSPENSION FACTOR

Crop resuspension factor, or resuspension factor, M, is a measure of the amount of particulate matter that becomes resuspended and is available for deposition on plant's surfaces. Crop resuspension factor can be developed using the amount of total suspended particulate (TSP) in air. It was assumed that concentration of TSP is 3 times that of PM_{10} used to develop mass loading (see Section 3.3).

This assumption is based on the results of dust measurements after Mount St Helens eruption, which indicate that at dusty locations the ratio of respirable dust to total dust is no higher than 0.3 (Buist et al. 1986).

Resuspension factor is calculated using total suspended particulate, TSP, and the surface soil density, ρ_s, using the following formula (CRWMS M&O 1999a):

$$M = \frac{TSP}{\rho_s} = \frac{3S}{\rho_s} \qquad \text{(Eq. 1)}$$

Surface soil density is equal to the mass of the unit area of soil of predetermined thickness, d_s. It is calculated using the following equation:

$$\rho_s = \rho \times d_s \qquad \text{(Eq. 2)}$$

where:

ρ - bulk soil density

Crop resuspension factors for the transition phase and the steady-state phase were calculated using PM_{10} values (mass loading, S, is expressed in terms of PM_{10}) and the surface density of top

layer of ash or soil using Equation 1. The results of calculations are summarized in Table 1. Ash density and the thickness of ash deposit used in calculation of the resuspension factor were discussed in Sections 3.2 and 3.1, respectively. The probability distribution of the resuspension factor for the transition phase, follows the distribution of the mass loading, and is, therefore, loguniform. Listed in Table 1, are minimum and maximum of the distribution.

Table 1. Crop resuspension factor and parameters used for its calculation.

Ash deposition thickness, cm	Phase	Thickness and type of medium[a], d_s cm	Bulk Density, ρ g/cm^3	Surface Density, ρ_s kg/m^2	Mass loading, S μg/m^3	Resuspension factor, M 1/m
1	Transition, Maximum	1 (ash)	1	10	1000	3E-7
	Transition, Minimum	1 (ash)	1	10	30	9E-9
	Steady state	15 (soil)	1.5	225	30	4E-10
15	Transition, Maximum	15 (ash)	1	150	1000	2E-8
	Transition, Minimum	15 (ash)	1	150	30	6E-10
	Steady state	15 (ash)	1.5[b]	225	30	4E-10

[a] Thickness of medium considered in calculation of resuspension factor.
[b] See Section 3.5.

Assumption regarding the values and distribution crop resuspension factor was used in GENII-S menu-driven input described in Section 5.6 (Table 8). It has been assigned the TBV-4716.

3.5 INADVERTENT SOIL INGESTION

With a high concentration of mass loading, the inhalation of large particles (>10 μm) can not be ignored, and is treated as additional soil ingestion which is combined with inadvertent soil ingestion for nominal performance. This assumption is based on the dosimetric model of the respiratory system (ICRP 1979), and specifically, on the pattern of dust deposition in the respiratory system (ICRP 1979, Figure 5.1).

The values of additional inadvertent soil ingestion, *ISI*, were calculated based on the breathing rate of 23 m^3/day, and the inhalation exposure time of 3918.5 hours per year (CRWMS M&O 2000f). At mass loading (PM_{10}) of 1000 μg/m^3, and TSP equal to three times the mass loading, the concentration of particles larger than 10μm is 2000 μg/m^3. Therefore, the additional inadvertent soil ingestion due to the increased dustiness can be calculated as follows:

$$ISI = \frac{2000\frac{\mu g}{m^3}}{1000\frac{\mu g}{m^3}} \times 23\frac{m^3}{d} \times \frac{3918.5\frac{h}{y}}{8760\frac{h}{y}} = 21\frac{mg}{d} \qquad \text{(Eq. 3)}$$

This amount, rounded to 20 mg/d was added to the inadvertent soil ingestion for the nominal performance of 50 mg/d (CRWMS M&O 1999a). Following the distribution of mass loading, the probability distribution for inadvertent soil ingestion was assumed to be loguniform with a minimum of 50 mg/day and maximum of 70 mg/day. The assumption regarding the values and probability distribution of inadvertent soil ingestion was used in menu-driven GENII-S input described in Section 5.6 (Table 8). TBV-4717 is associated with this assumption.

3.6 DOSE COEFFICIENTS

For thin ash deposits (1 cm or less), a new set of dose coefficients (DC) for external exposure was developed to represent a radionuclide distribution profile different from that previously used (15-cm layer of contaminated soil was used in previous calculations (CRWMS M&O 2000a)). In addition, the previously developed set of DCs for 15-cm layer of contaminated soil needed an amendment because the radionuclides considered important for up to 1 million years were not included. For most radionuclides, their decay products must be included in BDCF calculations. Decay products should match those considered in GENII-S for a given radionuclide. Following computational methods of GENII-S, DCs for some radionuclides include contributions from their own chains of short-lived radionuclides.

DCs were developed using the same method as that described in (CRWMS M&O 1999b), using the accepted data from Federal Guidance Report No. 12 (FGR-12) (Eckerman and Ryman 1993) (MO9912SPASUB02.001) as the source of data. DCs in the FGR-12 are listed in units of Sv/s per Bq/m^3. GENII-S input should be in Sv/y per Bq/m^3. DC were therefore converted to the units used in GENII-S input file by multiplying FGR-12 DCs by 3.15×10^7 s/y. In addition, for three radionuclides (Radon-222, Actinium-225, and Radium-223) contributions from their short-lived decay products were added to the DC of a parent, in a process such as that described in (CRWMS M&O 1999b). The FGR-12 DCs apply to contaminated soil, rather than ash. Because data for ash are not available, DCs for soil were used instead. DCs for 1cm and for 15 cm for radionuclides of interest and their decay products are summarized in Table 2.

Table 2. Dose Coefficients for 1-cm and 15-cm layer of contaminated soil for radionuclides of interest (shown in bold type) and their decay products.

Radionuclide	Dose Coefficient for contaminated soil			
	1 cm		15 cm	
	Sv/s per Bq/m^3	Sv/y per Bq/m^3	Sv/s per Bq/m^3	Sv/y per Bq/m^3
Strontium-90	1.31E-21	4.13E-14	3.72E-21	1.17E-13
Yttrium-90	3.10E-20	9.77E-13	1.20E-19	3.78E-12
Cesium-137 + Barium-137m	3.77E-18	1.12E-10	1.71E-17	5.39E-10
Lead-210	8.27E-21	2.61E-13	1.31E-20	4.13E-13
Bismuth-210	5.54E-21	1.75E-13	1.86E-20	5.87E-13
Polonium-210	5.32E-23	1.68E-15	2.45E-22	7.73E-15
Radium-226	4.15E-20	1.31E-12	1.65E-19	5.20E-12
Radon-222 + decay products [a]	(2.54E-21)		(1.14E-20)	
Polonium-218	(5.70E-23)		(2.63E-22)	
Lead-214	(1.57E-18)	3.40E-10	(6.70E-18)	1.59E-09
Bismuth-214	(9.15E-18)		(4.36E-17)	
Polonium-214	(5.22E-22)		(2.40E-21)	
Lead-210 [b]				
Actinium-227	7.70E-22	2.43E-14	2.62E-21	8.26E-14
Thorium-229	5.09E-19	1.60E-11	1.70E-18	5.36E-11
Radium-225	4.24E-20	1.34E-12	5.90E-20	1.86E-12
Actinium-225 + decay products[a]	(9.56E-20)		(3.34E-19)	
Francium-221	(1.93E-19)		(7.90E-19)	
Astatine-217	(1.95E-21)		(8.61E-21)	
Bismuth-213	(8.52E-19)	4.44E-11	(3.75E-18)	1.94E-10
Polonium-213 at 97.84%	(0)		(0)	
Thallium-209 at 2.16%	(2.66E-19)		(1.25E-18)	
Lead-209	(1.40E-21)		(4.08E-21)	
Thorium-230	2.33E-21	7.34E-14	6.39E-21	2.02E-13
Radium-226 [b]				
Protactinium-231	2.30E-19	7.25E-12	9.62E-19	3.03E-11
Thorium-227	6.49E-19	2.04E-11	2.65E-18	8.36E-11
Francium-223	3.10E-19	9.77E-12	1.01E-18	3.19E-11
Radium-223 + decay products [a]	(8.10E-19)		(3.10E-18)	
Radon-219	(3.56E-19)		(1.54E-18)	
Polonium-215	(1.13E-21)	5.70E-11	(4.98E-21)	2.36E-10
Lead-211	(3.25E-19)		(1.46E-18)	
Bismuth-211	(2.96E-19)		(1.28E-18)	
Thallium-207	(2.26E-20)		(9.48E-20)	
Uranium-232	1.88E-21	5.92E-14	4.77E-21	1.50E-13
Uranium-233	2.16E-21	6.80E-14	7.24E-21	2.28E-13
Thorium-229 [b]				
Uranium-234	1.01E-21	3.18E-14	2.14E-21	6.75E-14
Plutonium-238	6.34E-22	2.00E-14	8.07E-22	2.54E-14
Uranium-234 [b]				
Plutonium-239	5.61E-22	1.77E-14	1.52E-21	4.79E-14
Plutonium-240	6.20E-22	1.95E-14	7.84E-22	2.47E-14
Uranium-236	6.53E-22	2.06E-14	1.14E-21	3.60E-14
Plutonium-242	5.23E-22	1.65E-14	6.85E-22	2.16E-14
Americium-241	1.15E-19	3.62E-12	2.34E-19	7.38E-12
Neptunium-237	1.38E-19	4.35E-12	4.16E-19	1.31E-11
Americium-243	2.96E-19	9.32E-12	7.60E-19	2.40E-11
Neptunium-239	1.02E-18	3.21E-11	3.90E-18	1.23E-10
Plutonium-239 [b]				

[a] Contribution from decay products listed below is added to the DC for this radionuclide
[b] The DCs for this radionuclide and its decay product(s), if applicable, have been listed earlier in the Table.

3.7 FOOD TRANSFER COEFFICIENTS

Soil-to-plant transfer coefficients and transfer coefficients for animal products for lead were not included in the previously developed set (CRWMS M&O 2000g). Therefore GENII-S default values for this element were used (TBV-4720). They are listed in Table 3. The assumption was used for input file shown in Section 5.6 (Figure 2).

Table 3. Food products transfer coefficients for lead.

Category	Food Product	Value
Soil-to-plant Transfer Coefficient, dimensionless	Leafy Vegetables	1.0E-1
	Root Vegetables	1.0E-1
	Fruit	1.0E-1
	Grain	1.0E-2
Animal Feed-to-animal Transfer Coefficient, day/kg or day/L	Beef	4.0E-4
	Poultry	9.9E-4
	Milk	3.0E-5
	Eggs	9.9E-4

Food transfer coefficients, both developed, as well as the original GENII-S ones, apply to soil, rather than ash. Since transfer coefficients for ash were not available, coefficients for soil were used instead.

3.8 LOCALLY GROWN FOOD CONSUMPTION RATES FOR THE RMEI

Food consumption rates for the RMEI were based on the results of the regional food survey (DOE 1997). The average weighted for gender of the survey respondents consumption rates (CRWMS M&O 1998b, Table 9-18) (DOE 1998) obtained in that survey were used as input for the BDCF calculation for the RMEI. The consumption rates for the food groups under consideration and for milk are summarized in Table 4. Consumption rate of drinking water for the RMEI is equal to 2 L/d (730 L/y) (64 FR 46976, Section 197.21(c)).

Table 4. Average Amount of Locally Produced Food Consumed Annually by Amargosa Valley Population

Food Product	Average Annual Consumption kg/y for food, L/y for milk and water
Leafy Vegetable	8.01
Other Vegetable	4.20
Fruit	8.53
Grains	0.17
Meat	2.75
Milk	4.42
Poultry	0.49
Eggs	4.03
Drinking water	730

3.9 ROOTS IN UPPER AND DEEP SOIL

For thin ash deposits (1 cm and less) and the transition phase, fraction of roots in upper soil was assumed to be $1/15^{th}$ of the root length of 15 cm, for consistency with the assumption that for the transition phase volcanic ash remains on the soil surface for the entire crop growing season. The assumption of undisturbed layer of ash continuously present on the soil surface maximizes the inhalation of resuspended particles, and the ingestion from particle deposition on plant surfaces. For the remaining phase/ash-thickness combinations, fraction of roots in upper soil was assumed to be equal to 1.0 (CRWMS M&O 1999a). Fraction of roots in deep soil complements the fraction of roots in upper soil (their sum is equal to one).

4. USE OF COMPUTER SOFTWARE AND MODELS

The computer code GENII-S V1.4.8.5 was used to calculate volcanic eruption BDCFs. GENII-S is a computer program used to calculate statistical and deterministic values of radiation doses to humans from exposure to radionuclides in the environment. GENII-S is acquired software, which was qualified for use on the Yucca Mountain Project (CRWMS M&O 1998a). Justification for the selection of this software to perform calculation of radionuclide transport in the biosphere and uptake by human receptor is documented in (Harris 1997). The biosphere model used by GENII-S was validated in accordance with AP-3.10Q (CRWMS M&O 2000h) and was used within the range of validation.

The GENII-S computer code consists of executable program and auxiliary files, all of which are maintained under Configuration Management (CM) (CSCI: 30034 V1.4.8.5). The software was obtained from CM, it is appropriate for this application, and was used within the range of validation in accordance with AP-SI.1Q, *Software Management*, as described in the software qualification report (CRWMS M&O 1998a). The analysis was performed using a Gateway 2000 Personal Computer, CPU# 111161. The computer was located in Building 2, Summerlin, initially in cubicle No. 227J and later in 327D.

Documentation for the biosphere model used in calculation of volcanic eruption BDCFs is contained in (Leigh et al. 1993) as well as in Model Warehouse database, DTN MO0002SPADVE03.001, *Disruptive Volcanic Event BDCFs*.

5. CALCULATION

Biosphere Dose Conversion Factors for volcanic eruption account for radionuclide transport and uptake following the deposition of contaminated volcanic ash. The biosphere processes that are considered after the ash is deposited include ash resuspension, radionuclide uptake in plants and animals and human uptake with inhalation of contaminated air, ingestion of contaminated food, as well as external exposure to radionuclides present in the immediate vicinity of a person. BDCFs are used in the TSPA-SR model to calculate doses from volcanic eruption.

5.1 BASES FOR CALCULATION

Volcanic eruption BDCFs calculation was based on information provided to the biosphere group (CRWMS M&O 2000b), regarding a range of conditions that should or might be considered. The TSPA guidance, and how it was addressed, is outlined in Table 5. The input from the Performance Assessment in form of TSPA guidance was necessary to ensure integration and coupling of the biosphere model and BDCF calculation with the Disruptive Events model in the TSPA-SR process.

Table 5. Draft Memo Information and Biosphere Interpretation

Information Provided in the Draft Memo	Biosphere Interpretation
Ash layer thickness: At 20 kilometers from the repository, volcanic ash layers are likely to be one cm or less in thickness. However, there is a significant possibility that a relatively large eruption could produce an ash layer several tens of cm thick, and the TSPA must include such events. The biosphere analysis should therefore include the consideration of ash layers ranging in thickness from less than 1 mm up to 50 cm.	It was not feasible to calculate "one-size-fits-all" BDCFs that could be applied to such a wide range of ash thicknesses. Scenario- and receptor-specific sets of BDCFs were calculated for the two, narrower, ranges of ash thickness, represented by a single value of ash thickness: 1 cm for thin deposits and 15 cm for thick deposits.
Ash particle size: The mean ash particle size for YM-type eruptions may be assumed to have a log-triangular distribution that ranges 0.01 mm to 1.0 mm, with a mode of 0.1 mm. The standard deviation about this mean should be assumed to have a uniform distribution between 1 and 3 phi units ($-\log_2$). This distribution describes the unaltered ash particles at the time they are deposited.	The specified particle size range refers to the unaltered ash particles at the time of deposition. Human activities and weathering may affect in particle size reduction resulting in undetermined size distribution, which however, may include higher fraction of fine particles (less than 10μm), which are important from the perspective of inhalation pathway and resuspension. Per correspondence with Peter Swift, the proposed distribution was not used to derive BDCFs. Instead, assumptions were made regarding the fractions of particles in the PM_{10} range and in the TSP range, with PM_{10} particles contributing one-third of the TSP concentration in air.
Distribution of radionuclides in the ash: Radionuclides should be assumed to be attached to ash particles and uniformly distributed vertically through the ash layer.	Used in calculation.
Duration of eruption: Eruptions should be assumed to occur over a period ranging from several days to several months.	BDCFs for the eruption phase were not developed. Therefore the information on the eruption duration was not used. Instead, dose factors were developed for the conditions during the volcanic eruption, while inhalation of volcanic ash, prior to its resuspension, is a dominant exposure pathway. Dose factors are applied on a per day basis, and are, therefore, independent of the event duration.
Total areal extent of ash layer: Volcanic ash should be assumed to be deposited over an area of many hundreds of square kilometers. Distribution of ash within this area is not uniform, with thicker deposits likely to occur closer to the point of eruption. Radionuclide concentrations within ash should be assumed to be constant, and total mass of radionuclides at any point is therefore correlated with the total amount of ash.	Not considered in biosphere calculations. Total areal extent of ash layer does not affect BDCF calculations.
Bulk density of ash deposits: Ash deposited on the ground should be assumed to have a bulk density of 1.0 g/cm^3.	Used in calculation.
Grain density of ash particles: The grain density of newly erupted ash particles should be assumed to be 2.08 g/cm^3 for particles 0.01 mm and smaller in diameter. Particles larger than 10 mm in diameter should be assumed to have a density of 1.04 g/cm^3. Density should be assumed to decrease linearly with increasing particle diameter between these values.	The assumption of grain density of ash particles was not used to develop BDCFs. This quantity is important from the perspective of aerodynamic properties of particles. However, the specific aerodynamic properties of ash particles are not going to be considered to calculate BDCFs because the proposed size distribution of ash particles will not be used. Instead, the assumption of the PM_{10} fraction of TSP is made, as previously noted, and, it is also conservatively assumed that all PM_{10} particles have AMAD of 1 μm (and the density of 1 g/cm^3).

5.2 SOURCES OF INPUTS

Most of the input parameters were developed in a series of analyses and documented in the analysis and model reports (AMRs). Some input parameters were developed and documented in this calculation report as assumptions (see Section 3). The data sets used in calculation are listed in Table 6. Selection of the values, ranges, and distributions of input parameters as well as justification of the applicability of the selected data to the specific exposure scenarios considered for the proposed Yucca Mountain repository is described in the corresponding AMRs.

Table 6. Input Data.

No.	DTN/TBV No.	Title	Q Status	Comments
1	MO9911RIB00064.000	Environmental Transport Parameter Values for Dose Assessment	Qualified	Crop resuspension factor and soil ingestion rate included in this set of parameters were not used. Instead these parameter was developed as described in Section 3.2.
2	MO0001RIB00065.001	Parameter Values for Transfer Coefficients	Unqualified	Transfer coefficients for lead were not included in this set. Therefore GENII-S default values were used, as described in Section 3.6.
3	MO0003RIB00061.001	Input Parameter Values for External and Inhalation Radiation Exposure	Qualified	Mass loading included in this set of parameters was not used. Instead this parameter was developed as described in Section 3.1.
4	MO0002RIB00068.000	Ingestion Exposure Parameter Values	Unqualified	
5	MO0002RIB00062.000	Parameter Values for Consumption of Locally Produced Food and Tap Water	Unqualified	This set was used only for an average member of the critical group. Consumption rates for the RMEI were developed separately, as described in Section 3.8.
6	MO9912RIB00066.000	Parameter Values for Internal and External Dose Conversion Factors	Qualified	External dose conversion factors for 1-cm layer of contaminated soil have been developed in addition to coefficients included in this data set as described in Section 3.4
7	MO0004RIB00085.000	Soil and Radionuclide Removal by Erosion and Leaching	Unqualified	
8	MO9912SPASUB02.001	Dose Coefficients for Air Submersion and Exposure to Contaminated Soil	Accepted	The source of the data is Federal Guidance Report No. 12 (Eckerman and Ryman 1993).
9	MO0007SPAEDC20.002	Exposure-to-Dose Conversion Factors for Inhalation and Ingestion of Radionuclides	Accepted	The source of the data is Federal Guidance Report No. 11 (Eckerman et al. 1988).
10	TBV-4716	Assumption of the value and distribution of crop resuspension factor following volcanic eruption and for the steady state conditions	Unqualified	The value/distribution of this input parameter will be developed and documented in the AMR.
11	TBV-4717	Assumption of the value and distribution of inadvertent soil ingestion following volcanic eruption	Unqualified	The value/distribution of this input parameter will be developed and documented in the AMR.
12	TBV-4718	Assumption of the value and distribution of mass loading following volcanic eruption and for the steady state conditions	Unqualified	The value/distribution of this input parameter will be developed and documented in the AMR.
13	TBV-4719	Assumption of the value of ash density for the steady state conditions	Unqualified	The value/distribution of this input parameter will be developed and documented in the AMR.
14	TBV-4720	Assumption of the value of food transfer coefficients for lead	Unqualified	The value/distribution of this input parameter will be developed and documented in the AMR.

5.3 RECEPTOR OF INTEREST

Two receptors of interest were considered in the calculation: an average member of the critical group (AMCG) and the RMEI. Both receptors were developed based on characteristics of Amargosa Valley population, and both represent those individuals expected to receive the highest doses from radionuclides released from a potential Yucca Mountain repository. An AMCG is a receptor identified in the proposed Nuclear Regulatory Commission rule 10 CFR 63 (64 FR 8640, Section 63.115). The RMEI is a hypothetical person defined in the Environmental Protection Agency's proposed rule 40 CFR 197 (64 FR 46976, Section 197.21).

5.4 RADIONUCLIDES OF INTEREST

BDCFs were calculated for seventeen radionuclides identified as important for disruptive volcanic eruptions that may occur during any time after the potential repository closure up to one million years (CRWMS M&O 2000i). These radionuclides were as follows: Strontium-90, Cesium-137, Lead-210, Radium-226, Actinium-227, Thorium-229, Thorium-230, Protactinium-231, Uranium-232, Uranium-233, Uranium-234, Plutonium-238, Plutonium-239, Plutonium-240, Plutonium-242, Americium-241, and Americium-243.

5.5 EXPOSURE SCENARIOS

Calculations of BDCFs were performed for a GENII-S scenario in which interest is focused on the exposure of an individual at a particular location as a result of initial contamination with the volcanic ash deposition. Radionuclide release and transport from a volcano to the location of interest was modeled in the *Igneous Consequence Modeling for the TSPA–SR* (CRWMS M&O 2000j).

From the perspective of BDCF calculation for volcanic eruption, three different human exposure scenarios were specified for different phases during and following volcanic eruption: (1) eruption, (2) transition, and (3) steady-state. Eruption phase refers to the conditions during the volcanic eruption, before ash deposition on the ground occurs. Because of the expected high concentration of particulates in air during this phase, inhalation of airborne contaminated ash particles is the only primary pathway considered in calculation. Inhalation of larger, non-respirable particles may result in a subsequent ingestion by swallowing particles deposited in the upper part of respiratory system (nasal passages and pharynx). Therefore, this process is also included in calculation.

Transition phase is characterized by resuspension of volcanic ash deposited on the ground during volcanic event. The contaminated ash is thus available for inhalation, followed by swallowing of the larger particles. Resuspended ash, if deposited on plant's surfaces, may cause contamination on edible crops, as well as animal feed. Contaminated animal feed results in contamination of animal products, such as milk, meat and eggs. It is postulated that contaminated ash is not mixed into the soil below the ash layer for the duration of the entire transition phase. This is a conservative approach that maximizes inhalation of resuspended particles, but does not affect other pathways, such as root uptake. The following exposure pathways were considered in calculation of the transition phase BDCFs:

- Consumption of locally produced leafy vegetables

- Consumption of other (root) locally produced vegetables
- Consumption of locally produced fruit
- Consumption of locally produced grain
- Consumption of locally produced meat (beef and pork)
- Consumption of locally produced poultry
- Consumption of locally produced milk
- Consumption of locally produced eggs
- Inadvertent soil ingestion
- Inhalation of resuspended particulate matter
- External exposure to contaminated soil

Drinking water ingestion and aquatic food ingestion, usually considered for the undisturbed performance, were not included because of the assumption that groundwater was not contaminated.

The third phase is characterized by the steady-state conditions. For the case of thin ash deposits, volcanic ash is assumed to be uniformly mixed into the soil to a depth of 15 cm, whereas for the thick deposits, ash is assumed to be consolidated by the ongoing irrigation practices taking place during the transition phase. Such ash exhibits characteristics that resemble those of soil. Specifically, the ash density is expected to be the same as the soil density. Exposure pathways considered for the steady-state phase match the transition phase pathways.

5.6 DETAILS OF CALCULATION

5.6.1 Eruption Phase

As noted previously, air transport of volcanic ash from the volcano to the location of a receptor was excluded from the biosphere consideration of eruption phase. Radionuclide activity concentration in air at the location of the receptor was consider the source of contamination for the eruption phase.

For the eruption phase dose factors (DFs) were developed, rather than BDCFs. DFs represent doses resulting from one-day intake of radionuclides by inhalation of air containing unit activity concentration of a radionuclide under consideration (1 pCi/m^3). It is assumed that inhalation exposure time is equal to 3918.5 hours per year (CRWMS M&O 2000f) which results in inhalation exposure factor of 0.447, calculated by dividing 3918.5 hours of inhalation exposure time per year by 8760 hours per year. Inhalation exposure time and, subsequently, inhalation exposure factor do not reflect actual time spent outdoors. Rather, they are scaling factors that include inhalation exposure both outdoors and indoors. In addition it is assumed that suspended activity consists of the respirable fraction contributing one-third, and larger particles which become swallowed following inhalation, contributing two-thirds of suspended activity. DFs, for the eruption were calculated using the following formula including contributions from inhalation and ingestion pathway:

$$DF\left(\frac{rem}{pCi\ d}\right) = 1\frac{pCi}{m^3} \times 23\frac{m^3}{d} \times 0.447 \times \left[DCF_{inh}\left(\frac{Sv}{Bq}\right) + 2\,DCF_{ing}\left(\frac{Sv}{Bq}\right)\right] \times 0.037\frac{Bq}{pCi} \times 100\frac{rem}{Sv}$$

(Eq. 4)

where:

$23\ \frac{m^3}{d}$ – breathing rate

DCF_{inh} – dose conversion factor for inhalation, $\frac{Sv}{Bq}$

DCF_{ing} – dose conversion factor for ingestion, $\frac{Sv}{Bq}$

$0.037\ \frac{Bq}{pCi}$ – conversion factor from picocuries to becquerels

$100\ \frac{rem}{Sv}$ – conversion factor from sieverts to rems.

DCFs for inhalation and ingestion used in Equation 4 are listed in Table 7. Federal Guidance Report No. 11 (Eckerman et al. 1988) (MO0007SPAEDC20.002) was used as the source of DCFs.

Table 7. Dose Conversion Factors used in Equation 4.

Radionuclide	DCF for Inhalation Sv/Bq	DCF for Ingestion Sv/Bq
Strontium-90	6.47E-8	3.85E-8
Cesium-137	8.63E-9	1.35E-8
Lead-210	3.67E-6	1.45E-6
Radium-226	2.32E-6	3.58E-7
Actinium-227	1.81E-3	3.80E-6
Thorium-229	5.80E-4	9.54E-7
Thorium-230	8.80E-5	1.48E-7
Protactinium-231	3.47E-4	2.86E-6
Uranium-232	1.78E-4	3.54E-7
Uranium-233	3.66E-5	7.81E-8
Uranium-234	3.58E-5	7.66E-8
Plutonium-238	1.06E-4	8.65E-7
Plutonium-239	1.16E-4	9.56E-7
Plutonium-240	1.16E-4	9.56E-7
Plutonium-242	1.11E-4	9.08E-7
Americium-241	1.20E-4	9.84E-7
Americium-243	1.19E-4	9.79E-7

5.6.2 Transition and Steady-state Phases

BDCF calculation for the transition phase does not consider effects of redistribution of radionuclides in soil due to deposition of volcanic ash blanket or application of contaminated

water on the soil. Deposition of contaminated ash will create a layer of contamination on the surface soil. To maximize the predictions of potential doses, radionuclides are assumed to remain on the surface soil for the duration of the transition phase.

BDCFs for the transition phase and the steady-state phase were calculated using GENII-S computer code. In the statistical process, input parameters were sampled from their distributions, where applicable, using Latin Hypercube sampling method with random seed equal to 0.333 and the number of trials equal to 160. Most of the input parameters were developed in a series of AMRs while the remaining ones constitute assumptions listed in Section 3. GENII input consists of input files and menu-driven interface. The content of input files is shown, as file images, in Figures 1, 2, 3, and 4. Figure 1 shows the image of the file containing default parameters of GENII-S. Parameters used in calculation, included in this file, were developed in the AMR (CRWMS M&O 1999a) (MO9911RIB00064.000) except for the chronic breathing rate (MO0003RIB00061.001). The remaining parameters, which were not used, were left unchanged from the GENII-S original default file.

The image of file containing food transfer factors developed in (CRWMS M&O 2000g) (MO0001RIB00065.001) for most radionuclides except lead (see Section 3.7 for lead transfer coefficients) is shown in Figure 2. This file also contains leaching factors developed in a separate report (CRWMS M&O 2000k) (MO0004RIB00085.000). Figures 3 and 4 show the images of the files containing dose coefficients for external exposure for 1-cm and 15-cm layer of contaminated soil, respectively. The majority of dose coefficients for 15 cm were derived previously (CRWMS M&O 1999b) (MO9912RIB00066.000). The remaining ones and the coefficients for 1 cm were developed and documented in this report (Section 3.6) based on accepted data (MO9912SPASUB02.001).

The example of the set of input values, entered using GENII-S menu-driven interface, is shown in Table 8. The input concerns an AMCG, transition phase and thin ash deposit. Inputs for the other receptor (RMEI) use consumption rates listed in Table 4 (MO9806MWDGENII.000), where indicated in Table 8. Inputs for other phase/ash thickness combinations differ by the values of mass loading, ash resuspension factor and inadvertent soil ingestion, as shown in Table 1. The values/selections in the tables are listed in the way they are entered in GENII-S. Parameters related to water, such as water consumption, irrigation rate, and irrigation time, although listed as input, were not used by GENII-S because water-related pathways were not selected from the pathway menu (see Table 8). The reason is that doses from the separate sources of contamination, such as groundwater or volcanic eruption, are calculated separately. This calculation report documents only development of BDCFs for volcanic eruption.

```
GENII Default Parameters for Reasonable Representation Cases (25-Jul-00)

INVENTORY PARAMETERS-------------------------------------------------------
0.037, 3.7E4, 3.7E7, 3.7E10, 1.0          NVU     Source input conversion
1.0, 0.15, 225.0                          SVU     Soil source conversion
ENVIRONMENTAL PARAMETERS---------------------------------------------------
0.008                                     ABSHUM  Absolute humidity (kg/m3)
2                                         PRCNTI  Air dispersion conserv. flag
0.1                                       DPVRES  Deposition vel./resuspension
8.3E-11                                   LEAFRS  Leaf resuspension factor
2.0,2.0,3.0,0.8,0.8,0.8,1.0,0.8,1.0,1.5   BIOMAS  BIOMA2 Biomass (kg/m2)
0.259                                     DEPFR2  Interception frac./irrigate
15.0                                      SURCM   Depth of surface soil (cm)
225.0                                     SLDN    Surface soil density (kg/m2)
1.5E3                                     SSLDN   Soil density (kg/m3)
False                                     HARVST  Harvest removal considered?
50.0                                      SOLING  Soil ingested (mg/da)
14.0                                      WTIM    Weathering time (da)
1.0, 0.1, 0.1, 0.1                        TRANS   Translocation, plants
0.1, 0.1, 0.1, 0.1, 1.0, 1.0              TRANSA  Translocation, animal food
68.0, 0.12, 55.0, 0.12, 68.0, 55.0        CONSUM  Animal Consumption (kg/da)
50.0, 0.3, 60.0, 0.3                      DWATER  Animal drinking water (L/da)
0.0, 0.8, 1.0, 0.8                        FRACUT  Acute fresh forage by season
0.2, 0.3, 0.5, 1.0                        SHORWI  Shore width factors
0.02                                      INGWAT  Swim water ingested (L/hr)
25295.0                                   TCWS    H2O/sed. transfer (L/m2/yr)
0.4,  5.0, 4.0                            YELDBT  BIOT: Veg. prod. (kg/m2/yr)
9.41E-4, 2*7.48E-4                        TOTEXC  BIOT: Excavation (m2/m3-yr)
1.0, 0.81, 0.19, 0.02, 0.008, 0.002,      EXCAV   BIOT: Frac. soil brought to
1.0, 0.9, 0.096, 0.006, 0.0005, 0.0005,           surface from within the
1.0, 0.9, 0.096, 0.006, 0.0005, 0.0005            waste by animal excavation
266.2                                     RINH    Chronic breathing (cm3/sec)
330.0                                     RINHA   Acute breathing (cm3/sec)
10                                        NDIST   Number of distances
805.0, 2414.0, 4023.0, 5632.0, 7241.0,
12068.0, 24135.0, 40255.0, 56315.0,
72405.0                                   X       JF/chi/Q/pop grid dist. (m)
0.1, 0.25, 0.18, 0.91, 0.18, 0.91, 0.18,
0.91, 2*0.20                              DRYFAC, DRYFA2 dry/wet ratio
METABOLIC PARAMETERS-------------------------------------------------------
0.5, 50.0, 500.0                                  XDIV
0.5,  0.5,  0.95, 0.05,  0.8, 0.0, 0.0,   0.2, 0.0,     ADJ
0.1,  0.9,  0.5,  0.5,  0.15, 0.4, 0.4,  0.05, 0.0,
0.01, 0.99, 0.01, 0.99, 0.05, 0.4, 0.4, 0.135, 0.015

DOSE PARAMETERS------------------------------------------------------------
0.25, 0.15, 0.12, 0.12, 0.03, 0.03, 5*0.06        WT   Weighting factors
2.0                                               SI2I Semi-infinite/inf
==============================================================================
```

Figure 1. The Image of the GENII-S Default File

Food Transfer Factors for Reasonable Representation (8/30/99)

Ele-men	Dep Vel m/sec	Leafy Veg	Root Veg	Fruit --	Grain --	Beef day/kg	Poulty day/kg	Milk day/L	Egg day/kg	Leaching Factor
AC	1.0E-3	3.5E-3	3.5E-4	3.5E-4	3.5E-4	2.5E-5	4.0E-3	2.0E-5	2.0E-3	1.5E-03
AM	1.0E-3	2.0E-3	4.7E-4	4.1E-4	9.0E-5	2.0E-5	6.0E-3	2.0E-6	4.0E-3	3.6E-04
C	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	0.0E+0	1.3E-01
CS	1.0E-3	1.3E-1	4.9E-2	2.2E-1	2.6E-2	5.0E-2	4.4E+0	8.0E-3	4.0E-1	2.4E-03
FR	1.0E-3	2.0E-2	2.0E-2	2.0E-2	1.0E-2	3.0E-2	4.4E+0	7.0E-3	4.9E-1	0.0E-04
I	1.0E-2	3.4E-3	5.0E-2	5.0E-2	5.0E-2	7.0E-3	1.8E-2	1.0E-2	3.0E+0	5.9E-01
MO	1.0E-3	2.5E-1	6.0E-2	6.0E-2	6.0E-2	1.0E-3	1.9E-1	1.5E-3	9.0E-1	6.7E-02
NI	1.0E-3	1.8E-1	6.0E-2	6.0E-2	3.0E-2	5.0E-3	1.0E-3	2.0E-2	1.0E-1	1.7E-03
NP	1.0E-3	3.7E-2	1.7E-2	1.7E-2	2.7E-3	1.0E-3	4.0E-3	5.0E-6	2.0E-3	1.3E-01
PA	1.0E-3	2.5E-3	2.5E-4	2.5E-4	2.5E-4	1.0E-5	4.0E-3	5.0E-6	2.0E-3	1.2E-03
PB	1.0E-3	1.0E-1	1.0E-1	1.0E-1	1.0E-2	4.0E-4	9.9E-4	3.0E-5	9.9E-4	2.5E-03
PO	1.0E-3	1.0E-2	1.0E-2	1.0E-2	1.0E-3	4.5E-3	9.9E-4	1.2E-4	9.9E-4	4.5E-03
PU	1.0E-3	3.9E-4	2.0E-4	1.9E-4	2.6E-5	1.0E-5	4.0E-3	1.1E-6	8.0E-3	1.2E-03
RA	1.0E-3	8.0E-2	1.3E-2	6.1E-3	1.2E-3	9.0E-4	3.0E-2	1.3E-3	2.0E-5	1.4E-03
SR	1.0E-3	2.0E+0	1.2E+0	2.0E-1	2.0E-1	8.0E-3	3.5E-2	1.5E-3	3.0E-1	4.5E-02
TC	1.0E-3	4.0E+1	6.6E+0	1.5E+0	7.3E-1	1.0E-4	3.0E-2	9.9E-3	3.0E+0	2.8E+00
TH	1.0E-3	4.0E-3	3.0E-4	2.1E-4	3.4E-5	6.0E-6	4.0E-3	5.0E-6	2.0E-3	2.1E-04
U	1.0E-3	8.5E-3	1.4E-2	4.0E-3	1.3E-3	3.0E-4	1.2E+0	6.0E-4	1.0E+0	1.9E-02
Y	1.0E-3	1.5E-2	6.0E-3	6.0E-3	6.0E-3	1.0E-3	1.0E-2	2.0E-5	2.0E-3	4.0E-03

Figure 2. The Image of the GENII-S File Containing Food Transfer Coefficients and Leaching Factors.

FGR12 air,water,soil(1 CM) DCFs (Sv/yr per Bq/n) (7 Apr 00 MAW)

n	Air Submersion m3	Water Surface L	Soil 1 cm "m3"	Buried 0.15 m m3	Buried 0.5 m m3	Buried 1.0m m3
C 14	0.00E+00	0.00E+00	1.35E-15	0.00E+00	0.00E+00	0.00E+00
NI63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR90	0.00E+00	0.00E+00	4.13E-14	0.00E+00	0.00E+00	0.00E+00
Y 90	0.00E+00	0.00E+00	9.77E-13	0.00E+00	0.00E+00	0.00E+00
MO93	0.00E+00	0.00E+00	1.00E-13	0.00E+00	0.00E+00	0.00E+00
NB93M	0.00E+00	0.00E+00	1.76E-14	0.00E+00	0.00E+00	0.00E+00
TC99	0.00E+00	0.00E+00	9.20E-15	0.00E+00	0.00E+00	0.00E+00
I 129	0.00E+00	0.00E+00	1.87E-12	0.00E+00	0.00E+00	0.00E+00
CS137	0.00E+00	0.00E+00	1.12E-10	0.00E+00	0.00E+00	0.00E+00
U 232	0.00E+00	0.00E+00	5.92E-14	0.00E+00	0.00E+00	0.00E+00
TH228	0.00E+00	0.00E+00	3.84E-13	0.00E+00	0.00E+00	0.00E+00
RA224	0.00E+00	0.00E+00	2.04E-12	0.00E+00	0.00E+00	0.00E+00
PB212	0.00E+00	0.00E+00	2.87E-11	0.00E+00	0.00E+00	0.00E+00
BI212	0.00E+00	0.00E+00	2.58E-10	0.00E+00	0.00E+00	0.00E+00
PU242	0.00E+00	0.00E+00	1.65E-14	0.00E+00	0.00E+00	0.00E+00
U 234	0.00E+00	0.00E+00	3.18E-14	0.00E+00	0.00E+00	0.00E+00
U 236	0.00E+00	0.00E+00	2.06E-14	0.00E+00	0.00E+00	0.00E+00
TH230	0.00E+00	0.00E+00	7.34E-14	0.00E+00	0.00E+00	0.00E+00
RA226	0.00E+00	0.00E+00	1.31E-12	0.00E+00	0.00E+00	0.00E+00
RN222	0.00E+00	0.00E+00	3.40E-10	0.00E+00	0.00E+00	0.00E+00
PB210	0.00E+00	0.00E+00	2.61E-13	0.00E+00	0.00E+00	0.00E+00
BI210	0.00E+00	0.00E+00	1.75E-13	0.00E+00	0.00E+00	0.00E+00
PO210	0.00E+00	0.00E+00	1.68E-15	0.00E+00	0.00E+00	0.00E+00
PA231	0.00E+00	0.00E+00	7.25E-12	0.00E+00	0.00E+00	0.00E+00
AC227	0.00E+00	0.00E+00	2.43E-14	0.00E+00	0.00E+00	0.00E+00
TH227	0.00E+00	0.00E+00	2.04E-11	0.00E+00	0.00E+00	0.00E+00
FR223	0.00E+00	0.00E+00	9.77E-12	0.00E+00	0.00E+00	0.00E+00
RA223	0.00E+00	0.00E+00	5.70E-11	0.00E+00	0.00E+00	0.00E+00
NP237	0.00E+00	0.00E+00	4.35E-12	0.00E+00	0.00E+00	0.00E+00
PA233	0.00E+00	0.00E+00	3.91E-11	0.00E+00	0.00E+00	0.00E+00
U 233	0.00E+00	0.00E+00	6.80E-14	0.00E+00	0.00E+00	0.00E+00
TH229	0.00E+00	0.00E+00	1.60E-11	0.00E+00	0.00E+00	0.00E+00
RA225	0.00E+00	0.00E+00	1.34E-12	0.00E+00	0.00E+00	0.00E+00
AC225	0.00E+00	0.00E+00	4.44E-11	0.00E+00	0.00E+00	0.00E+00
U 238	0.00E+00	0.00E+00	1.39E-14	0.00E+00	0.00E+00	0.00E+00
TH234	0.00E+00	0.00E+00	4.44E-12	0.00E+00	0.00E+00	0.00E+00
PA234	0.00E+00	0.00E+00	3.72E-10	0.00E+00	0.00E+00	0.00E+00
PU238	0.00E+00	0.00E+00	2.00E-14	0.00E+00	0.00E+00	0.00E+00
PU240	0.00E+00	0.00E+00	1.95E-14	0.00E+00	0.00E+00	0.00E+00
AM241	0.00E+00	0.00E+00	3.62E-12	0.00E+00	0.00E+00	0.00E+00
AM243	0.00E+00	0.00E+00	9.32E-12	0.00E+00	0.00E+00	0.00E+00
NP239	0.00E+00	0.00E+00	3.21E-11	0.00E+00	0.00E+00	0.00E+00
PU239	0.00E+00	0.00E+00	1.77E-14	0.00E+00	0.00E+00	0.00E+00

Figure 3. Image of the File with Dose Coefficients for Soil Contaminated to 1 cm

FGR12 air,water,soil(15 CM) DCFs (Sv/yr per Bq/n) (25 Jul 99 MAW)

n	Air Submersion m3	Water Surface L	Soil 15 cm "m3"	Buried 0.15 m m3	Buried 0.5 m m3	Buried 1.0m m3
C 14	7.06E-12	0.00E+00	2.27E-15	0.00E+00	0.00E+00	0.00E+00
NI63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SR90	2.37E-10	0.00E+00	1.17E-13	0.00E+00	0.00E+00	0.00E+00
Y 90	5.99E-09	0.00E+00	3.78E-12	0.00E+00	0.00E+00	0.00E+00
MO93	7.95E-10	0.00E+00	9.97E-14	0.00E+00	0.00E+00	0.00E+00
NB93M	1.40E-10	0.00E+00	1.76E-14	0.00E+00	0.00E+00	0.00E+00
TC99	5.11E-11	0.00E+00	2.11E-14	0.00E+00	0.00E+00	0.00E+00
I 129	1.20E-08	0.00E+00	2.19E-12	0.00E+00	0.00E+00	0.00E+00
CS137	9.08E-07	0.00E+00	5.39E-10	0.00E+00	0.00E+00	0.00E+00
TH230	5.49E-10	0.00E+00	2.02E-13	0.00E+00	0.00E+00	0.00E+00
RA226	9.93E-09	0.00E+00	5.20E-12	0.00E+00	0.00E+00	0.00E+00
RN222	2.79E-06	0.00E+00	1.59E-09	0.00E+00	0.00E+00	0.00E+00
PB210	1.78E-09	0.00E+00	4.13E-13	0.00E+00	0.00E+00	0.00E+00
BI210	1.04E-09	0.00E+00	5.87E-13	0.00E+00	0.00E+00	0.00E+00
PO210	1.31E-11	0.00E+00	7.73E-15	0.00E+00	0.00E+00	0.00E+00
U 232	4.48E-10	0.00E+00	1.50E-13	0.00E+00	0.00E+00	0.00E+00
TH228	2.90E-09	0.00E+00	1.32E-12	0.00E+00	0.00E+00	0.00E+00
RA224	1.55E-08	0.00E+00	8.62E-12	0.00E+00	0.00E+00	0.00E+00
PB212	2.17E-07	0.00E+00	1.14E-10	0.00E+00	0.00E+00	0.00E+00
BI212	2.30E-06	0.00E+00	1.27E-09	0.00E+00	0.00E+00	0.00E+00
PU242	1.26E-10	0.00E+00	2.16E-14	0.00E+00	0.00E+00	0.00E+00
U 234	2.41E-10	0.00E+00	6.75E-14	0.00E+00	0.00E+00	0.00E+00
U 236	1.58E-10	0.00E+00	3.60E-14	0.00E+00	0.00E+00	0.00E+00
PA231	5.42E-08	0.00E+00	3.03E-11	0.00E+00	0.00E+00	0.00E+00
AC227	1.84E-10	0.00E+00	8.26E-14	0.00E+00	0.00E+00	0.00E+00
TH227	1.54E-07	0.00E+00	8.36E-11	0.00E+00	0.00E+00	0.00E+00
FR223	7.22E-08	0.00E+00	3.19E-11	0.00E+00	0.00E+00	0.00E+00
RA223	4.30E-07	0.00E+00	2.36E-10	0.00E+00	0.00E+00	0.00E+00
NP237	3.25E-08	0.00E+00	1.31E-11	0.00E+00	0.00E+00	0.00E+00
PA233	2.95E-07	0.00E+00	1.63E-10	0.00E+00	0.00E+00	0.00E+00
U 233	5.14E-10	0.00E+00	2.28E-13	0.00E+00	0.00E+00	0.00E+00
TH229	1.21E-07	0.00E+00	5.36E-11	0.00E+00	0.00E+00	0.00E+00
RA225	8.80E-09	0.00E+00	1.86E-12	0.00E+00	0.00E+00	0.00E+00
AC225	3.40E-07	0.00E+00	1.94E-10	0.00E+00	0.00E+00	0.00E+00
U 238	1.08E-10	0.00E+00	1.74E-14	0.00E+00	0.00E+00	0.00E+00
TH234	3.33E-08	0.00E+00	1.73E-11	0.00E+00	0.00E+00	0.00E+00
PA234	2.95E-06	0.00E+00	1.70E-09	0.00E+00	0.00E+00	0.00E+00
PU238	1.54E-10	0.00E+00	2.54E-14	0.00E+00	0.00E+00	0.00E+00
PU240	1.50E-10	0.00E+00	2.47E-14	0.00E+00	0.00E+00	0.00E+00
AM241	2.58E-08	0.00E+00	7.38E-12	0.00E+00	0.00E+00	0.00E+00
AM243	6.87E-08	0.00E+00	2.40E-11	0.00E+00	0.00E+00	0.00E+00
NP239	2.43E-07	0.00E+00	1.23E-10	0.00E+00	0.00E+00	0.00E+00
PU239	1.34E-10	0.00E+00	4.79E-14	0.00E+00	0.00E+00	0.00E+00

Figure 4. Image of the File with Dose Coefficients for Soil Contaminated to 15 cm

Table 8. GENII-S Menu-Accessible Input Parameters for Average Member of Critical Group, Transition Phase and Thin Ash Deposit

Menu(s)	Option/ - Parameter, Unit	Selection	Values			Distribution	Reference[a]/ Comments
			Minimum	Best Estimate	Maximum		
PRE-GENII							
Edit Flags and Options	Scenario Options						
	- Near-Field Scenario	Y	NA [b]	NA	NA	NA	Near-Field Scenario
	- Population Dose	N	NA	NA	NA	NA	
	- Acute Release	N	NA	NA	NA	NA	
	Transport Options						
	- Air Transport	N	NA	NA	NA	NA	No radionuclide transport
	- Surface Water Transport	N	NA	NA	NA	NA	
	- Biotic Transport	N	NA	NA	NA	NA	
	- Waste From Degradation	N	NA	NA	NA	NA	
	Exposure Pathway Options						
	- External Finite Plume	N	NA	NA	NA	NA	Pathway Selection
	- External Infinite Plume	N	NA	NA	NA	NA	
	- External Ground Exposure	Y	NA	NA	NA	NA	
	- External Recreational Exposure	N	NA	NA	NA	NA	
	- Inhalation Uptake	Y	NA	NA	NA	NA	
	- Drinking Water Ingestion	N	NA	NA	NA	NA	
	- Aquatic Food Ingestion	N	NA	NA	NA	NA	
	- Terrestrial Food Ingestion	Y	NA	NA	NA	NA	
	- Animal Product Ingestion	Y	NA	NA	NA	NA	
	- Inadvertent Soil Ingestion	Y	NA	NA	NA	NA	
	Deterministic Output Options						
	- Both Committed and Cumulative	N	NA	NA	NA	NA	Output Selection
	- EDE by Nuclide	N	NA	NA	NA	NA	
	- EDE by Pathway	N	NA	NA	NA	NA	
	Run Options						
	- Inventory Unit Index (1-5)	1, pCi	NA	NA	NA	NA	Unit selection, Run Selection, Intake Duration
	- Soil Inventory Unit Index (1-3)	1, per m^2	NA	NA	NA	NA	
	- Inventory Input Option (1-3)	2	NA	NA	NA	NA	
	- Det Run/Stat Run/Both (1/2/3)	2	NA	NA	NA	NA	
	- Nuclide Intake Duration, yr	1	NA	NA	NA	NA	
Select Nuclides	Radionuclide selection	Y/N	-	-	-	-	Section 5.4

Table 8. Continued

Menu(s)	Option/ - Parameter, Unit	Selection	Values Minimum	Values Best Estimate	Values Maximum	Distribution	Reference[a]/ Comments
PRE-GENII (continued)							
Select Statistical Output	- Statistical Committed Dose Summary	Y	NA	NA	NA	NA	Output Selection
	- Statistical Committed Nuclide Dose	N	NA	NA	NA	NA	
	- Statistical Committed Pathway Dose	N	NA	NA	NA	NA	
	- Statistical Committed Organ Dose	N	NA	NA	NA	NA	
	- Statistical Cumulative Pathway Dose	N	NA	NA	NA	NA	
	- Statistical Cumulative Organ Dose	N	NA	NA	NA	NA	
	- Statistical External Dose Summary	N	NA	NA	NA	NA	
MAIN EDITING MENU							
Titles And Run Controls	- Model Name		NA	NA	NA	NA	
	- Title (2 lines)		NA	NA	NA	NA	
	- Latin Hypercube (LHS) or Monte Carlo (MC) Sampling	LHS	NA	NA	NA	NA	
	- The Number of Trials (<=500)	160	NA	NA	NA	NA	
	- A Random Seed (0.0<=Seed<=1.0)	0.333	NA	NA	NA	NA	
Fixed Data Input Variable Distribution	Population/Soil/Scenario Data						
	- Total Population	1	NA	NA	NA	—	Not used
	- Population Scale Factor	NA	--	1	--	Fixed	Not used
	- Soil/Plant Transfer Scale Factor, (-)	NA	0.0275	--	36.4	Lognormal	Input #2
	- Animal Uptake Scale Factor, (-)	NA	0.117	--	8.51	Lognormal	Input #2
	- Human Dose Factor Scale Factor, (-)	NA	--	1	--	Fixed	Input #6
	- Dose Commitment Period, yr	NA	NA	50	NA	NA	
	- Surface Soil Depth, cm	NA	--	1 [c]	--	Fixed	Section 3.1 & 3.4
	- Surface Soil Density, kg/m^2	NA	--	10 [c]	--	Fixed	Sec. 3.2, Input#13
	- Deep Soil Density, kg/m^3	NA	--	1500	--	Fixed	Input source #1
	- Roots in Upper Soil, fraction	NA	--	0.067 [d]	--	Fixed	Section 3.9
	- Roots in Deep Soil, fraction	NA	--	0.933 [d]	--	Fixed	Section 3.9
	- Air Release Time Before Intake, yr	NA	NA	0	NA	NA	Input source #1
	- H2O Release Time Before Intake, yr	NA	NA	0	NA	NA	Not used
							Not used
	Biotic Trans./Near Field Data Not used	—	—	—	—	—	—

Table 8. Continued.

Menu(s)	Option/ - Parameter, Unit	Selection	Values Minimum	Values Best Estimate	Values Maximum	Distribution	Reference[a]/ Comments
	MAIN EDITING MENU (continued)						
Fixed Data Input Variable Distribution	External/Inhalation Exposure (cont.)						
	- Chronic Plume Exposure Time, hr	NA	--	0	--	Fixed	Not used
	- Acute Plume Exposure Time, hr/phr	NA	--	0	--	Fixed	Not used
	- Inhalation Exposure Time, hr/yr	NA	---	3,918.5	---	Fixed	Input source #3
	- Resuspension Model Flag (0-2)	1	NA	NA	NA	NA	Mass loading
	- Mass Loading, g/m^3	NA	3×10^{-5} [c]	--	1×10^{-3} [c]	Loguniform	Input source #12
	- Transit Time to Rec. Site, hr	NA	--	0	--	Fixed	|
	- Swimming Exposure Time, hr	NA	--	0	--	Fixed	|
	- Boating Exposure Time, hr	NA	--	0	--	Fixed	| Parameters
	- Shoreline Exposure Time, hr	NA	--	0	--	Fixed	| not used
	- Type of Shoreline Index (1-4)	0	NA	NA	NA	NA	|
	- H2O/Sediment Transfer1/m^2/yr	NA	--	0	--	Fixed	|
	- Soil Exposure Time, hr	NA	---	827	---	Fixed	Input source #3
	- Home Irrigation Flag (0/1 = N/Y)	0	NA	NA	NA	NA	|
	- Irrigation Water Index (1-2)	1	NA	NA	NA	NA	| Water not
	- Home Irrigation Rate, in/yr	NA	52	74.5	97	Uniform	| contaminated
	- Home Irrigation Duration, mo/yr	NA	--	12	--	Fixed	|
	Ingestion Exposure						
	- Food Production Option	0	NA	NA	NA	NA	Not used
	- Food-Weighted Chi/Q, kg-s/m^3	0	--	0	--	Fixed	Not used
	- Crop Resuspension Factor, 1/m	NA	9×10^{-9} [c]	--	3×10^{-7} [c]	Loguniform	Input source #10
	- Crop Deposition Velocity, m/s	NA	--	0.001	--	Fixed	Input source #1
	- Crop Interception Fraction	NA	0.044	0.259	0.474	Normal	Input source #4
	- Exported Food Dose (0/1 = N/Y)	0	NA	NA	NA	NA	Not used
	- Soil Ingestion Rate, mg/day	NA	50	--	70	Loguniform	Input source #11
	- Swim H2O Ingestion Rate, l/h	NA	--	0	--	Fixed	Not used
	- Population Ingesting Aquatic Food	0	NA	NA	NA	NA	Not used
	- Bioaccumulation Flag (0/1 = N/Y)	0	NA	NA	NA	NA	Not used
	- Population Drinking Contaminated Water	0	NA	NA	NA	NA	|
	- Drink Water Source Index (0-3)	0	NA	NA	NA	NA	| Drinking water not
	- Drink Water Treated (0/1 = N/Y)	0	NA	NA	NA	NA	| contaminated
	- Drink Water Holdup Time, days	NA	--	0	--	Fixed	|
	- Drink Water Consumption, l/y	NA	--	752.85 [e]	--	Fixed	|

Table 8. Continued.

Menu(s)	Option/ - Parameter, Unit	Selection	Values			Distribution	Reference[a]/ Comments
			Minimum	Best Estimate	Maximum		
MAIN EDITING MENU (continued)							
Array Data Input (cont.) Variable Distribution	Aquatic Food Ingestion Not used	—	—	—	—	—	—
	Terrestrial Food Ingestion						
	- Use (0/1 = F/T)						
	Leafy Vegetables	1	NA	NA	NA	NA	Input source #5
	Root Vegetables	1	NA	NA	NA	NA	Input source #5
	Fruit	1	NA	NA	NA	NA	Input source #5
	Grain	1	NA	NA	NA	NA	Input source #5
	- Growing Time, days						
	Leafy Vegetables	NA	45	64.5	75	Triangular	Input source #4
	Root Vegetables	NA	70	(84) [f]	98	Uniform	Input source #4
	Fruit	NA	88	(136)	184	Uniform	Input source #4
	Grain	NA	75	(159)	244	Uniform	Input source #4
	- Water Source Flag (0-2)						
	Leafy Vegetables	0	NA	NA	NA	NA	|
	Root Vegetables	0	NA	NA	NA	NA	| Water not
	Fruit	0	NA	NA	NA	NA	| contaminated
	Grain	0	NA	NA	NA	NA	|
	- Irrigation Rate, in/yr						
	Leafy Vegetables	NA	28.17	42.11	80.37	Triangular	| Input source #4
	Root Vegetables	NA	47.34	(49.46)	51.58	Uniform	|
	Fruit	NA	30.00	(37.69)	45.37	Uniform	| Water not
	Grain	NA	55.85	(68.11)	80.37	Uniform	| contaminated
	- Irrigation Time, mo/yr						
	Leafy Vegetables	NA	2.0	3.2	4.9	Triangular	| Input source #4
	Root Vegetables	NA	3.2	(3.9)	4.6	Uniform	|
	Fruit	NA	2.9	(4.5)	6.0	Uniform	| Water not
	Grain	NA	4.9	(6.5)	8.0	Uniform	| contaminated
	- Crop Yield, kg/m^2						
	Leafy Vegetables	NA	0.59	1.82	4.11	Triangular	Input source #4
	Root Vegetables	NA	1.73	4.33	5.87	Triangular	Input source #4
	Fruit	NA	1.57	(1.91)	2.25	Uniform	Input source #4
	Grain	NA	0.33	(0.56)	0.78	Uniform	Input source #4

Table 8. Continued.

Menu(s)	Option/ - Parameter, Unit	Selection	Values			Distribution	Reference[a]/ Comments
			Minimum	Best Estimate	Maximum		
MAIN EDITING MENU (continued)							
Array Data Input (cont.) Variable Distribution	Terrestrial Food Ingestion (cont.)						
	- Production, kg/yr						
	Leafy Vegetables	NA	--	0	--	Fixed	|
	Root Vegetables	NA	--	0	--	Fixed	| Parameter
	Fruit	NA	--	0	--	Fixed	| not used
	Grain	NA	--	0	--	Fixed	|
	- Holdup, days						
	Leafy Vegetables	NA	--	1	--	Fixed	Input source #4
	Root Vegetables	NA	--	14	--	Fixed	Input source #4
	Fruit	NA	--	14	--	Fixed	Input source #4
	Grain	NA	--	14	--	Fixed	Input source #4
	- Consumption Rate, kg/yr						
	Leafy Vegetables	NA	--	15.14 [e]	--	Fixed	Input source #5
	Root Vegetables	NA	--	7.81 [e]	--	Fixed	Input source #5
	Fruit	NA	--	15.57 [e]	--	Fixed	Input source #5
	Grain	NA	--	0.48 [e]	--	Fixed	Input source #5
	Animal Product Consumption						
	- Use (0/1 = F/T)						
	Beef	1	NA	NA	NA	NA	Input source #5
	Poultry	1	NA	NA	NA	NA	Input source #5
	Milk	1	NA	NA	NA	NA	Input source #5
	Eggs	1	NA	NA	NA	NA	Input source #5
	• Consumption Rate, kg/yr						
	Beef	NA	--	2.93 [e]	--	Fixed	Input source #5
	Poultry	NA	--	0.80 [e]	--	Fixed	Input source #5
	Milk	NA	--	4.14 [e]	--	Fixed	Input source #5
	Eggs	NA	--	6.68 [e]	--	Fixed	Input source #5
	• Holdup, days						
	Beef	NA	--	20	--	Fixed	Input source #4
	Poultry	NA	--	1	--	Fixed	Input source #4
	Milk	NA	--	1	--	Fixed	Input source #4
	Eggs	NA	--	1	--	Fixed	Input source #4

Table 8. Continued.

Menu(s)	Option/ - Parameter, Unit	Selection	Values			Distribution	Reference[a]/ Comments
			Minimum	Best Estimate	Maximum		
MAIN EDITING MENU (continued)							
Array Data Input (cont.) Variable Distribution	Animal Product Consumption						
	- Production, kg/yr						
	Beef	NA	--	0	--	Fixed	|
	Poultry	NA	--	0	--	Fixed	| Parameter
	Milk	NA	--	0	--	Fixed	| not used
	Eggs	NA	--	0	--	Fixed	|
	- Contaminated Water Fraction						
	Beef	NA	--	0	--	Fixed	|
	Poultry (corn)	NA	--	0	--	Fixed	| Water not
	Milk	NA	--	0	--	Fixed	| contaminated
	Eggs (corn)	NA	--	0	--	Fixed	|
	Animal Products (Stored Feed Data)						
	- Dietary Fraction						
	Beef	NA	--	0	--	Fixed	Input source #4
	Poultry (corn)	NA	--	1	--	Fixed	Input source #4
	Milk	NA	--	0	--	Fixed	Input source #4
	Eggs (corn)	NA	--	1	--	Fixed	Input source #4
	- Growing Time, days						
	Beef	NA	--	0	--	Fixed	Input source #4
	Poultry (corn)	NA	--	75	--	Fixed	Input source #4
	Milk	NA	--	0	--	Fixed	Input source #4
	Eggs (corn)	NA	--	75	--	Fixed	Input source #4
	- Water Source Flag						
	Beef	0	NA	NA	NA	NA	|
	Poultry (corn)	0	NA	NA	NA	NA	| Water not
	Milk	0	NA	NA	NA	NA	| contaminated
	Eggs (corn)	0	NA	NA	NA	NA	|
	- Irrigation Rate, in/yr						
	Beef	NA	--	0	--	Fixed	| Input source #4
	Poultry (corn)	NA	--	80.37	--	Fixed	|
	Milk	NA	--	0	--	Fixed	| Water not
	Eggs (corn)	NA	--	80.37	--	Fixed	| contaminated
	- Irrigation Time, mo/yr						
	Beef	NA	--	0	--	Fixed	| Input source #4
	Poultry (corn)	NA	--	4.9	--	Fixed	|
	Milk	NA	--	0	--	Fixed	| Water not
	Eggs (corn)	NA	--	4.9	--	Fixed	| contaminated

Table 8. Continued.

Menu(s)	Option/ - Parameter, Unit	Selection	Values			Distribution	Reference[a]/ Comments
			Minimum	Best Estimate	Maximum		
MAIN EDITING MENU (continued)							
Array Data Input (cont.) Variable Distribution	Animal Products (Stored Feed Data) cont.						
	- Feed Yield, kg/m^2						
	Beef	NA	--	0	--	Fixed	Input source #4
	Poultry (corn)	NA	0.59	(0.69)	0.78	Uniform	Input source #4
	Milk	NA	--	0	--	Fixed	Input source #4
	Eggs (corn)	NA	0.59	(0.69)	0.78	Uniform	Input source #4
	- Storage, days						
	Beef	NA	--	0	--	Fixed	Input source #4
	Poultry (corn)	NA	--	14	--	Fixed	Input source #4
	Milk	NA	--	0	--	Fixed	Input source #4
	Eggs (corn)	NA	--	14	--	Fixed	Input source #4
	Animal Products (Fresh Forage Data)						
	- Dietary Fraction						
	Beef (alfalfa)	NA	--	1	--	Fixed	Input source #4
	Milk (alfalfa)	NA	--	1	--	Fixed	Input source #4
	- Grow Time, days						
	Beef (alfalfa)	NA	46	47	135	Triangular	Input source #4
	Milk (alfalfa)	NA	46	47	135	Triangular	Input source #4
	- H2O Source Flag						
	Beef (alfalfa)	0	NA	NA	NA	NA	| Water not
	Milk (alfalfa)	0	NA	NA	NA	NA	| contaminated
	- Irrigation Rate, in/yr						
	Beef (alfalfa)	NA	--	94.66	--	Fixed	| Water not
	Milk (alfalfa)	NA	--	94.66	--	Fixed	| contaminated
	- Irrigation Time, mo/yr						
	Beef (alfalfa)	NA	--	12	--	Fixed	| Water not
	Milk (alfalfa)	NA	--	12	--	Fixed	| contaminated
	- Feed Yield, kg/m^2						
	Beef (alfalfa)	NA	0.25	(0.7)	1.15	Uniform	Input source #4
	Milk (alfalfa)	NA	0.25	(0.7)	1.15	Uniform	Input source #4
	- Storage, days						
	Beef (alfalfa)	NA	--	0	--	Fixed	Input source #4
	Milk (alfalfa)	NA	--	0	--	Fixed	Input source #4

Table 8. Continued.

Menu(s)	Option/ - Parameter, Unit	Selection	Values			Distribution	Reference[a]/ Comments
			Minimum	Best Estimate	Maximum		
MAIN EDITING MENU (continued)							
Array Data Input (cont.) Variable Distribution	Inventory – Basic Concentrations						
	- Air, pCi/m^3	NA	--	0	--	Fixed	
	- Surface Soil, pCi/m^2	NA	--	1	--	Fixed	
	- Deep Soil, pCi/kg	NA	--	0	--	Fixed	
	- Ground Water, pCi/l	NA	--	0	--	Fxed	
	- Surface Water, pCi/l	NA	--	0	--	Fixed	

[a] Input source numbers identified in Reference/Comment column refer to input numbers in Table 4.

[b] NA as an entry means that a given selection/option/value does not appear in GENII-S.

[c] For the other ash thickness/phase combinations than the one shown in Table 8, the thickness of surface medium as well as values of surface density, mass loading, and resuspension factors are taken from the appropriate rows of Table 1.

[d] For the 15-cm thickness of surface medium, fraction of roots in upper soil is equal to one (fraction of roots in deep soil is equal to zero).

[e] If the RMEI is the receptor of interest, consumption rates from Table 4 are used.

[f] If data for best estimate value of uniform distribution was not provided by the input source, the average value was used (number in parentheses).

6. RESULTS

The objective of this calculation was to construct factors that allow dose assessment for the volcanic direct release. The calculation involved development of DFs for the eruption phase as well as development of BDCFs for the transition and steady-state phases following volcanic eruption. DFs are used in TSPA to compute doses human receptors receive during volcanic eruption. BDCFs, in form of discrete probability distributions, are entered in the TSPA model which calculates doses following an eruption. BDCFs for two human receptors have been calculated for 1 cm and 15 cm ash layers for both the transition and steady-state periods following volcanic eruption. TSPA dose assessment and, therefore, BDCFs are based on doses expressed in terms of total effective dose equivalent (TEDE), which is a sum of the committed effective dose equivalent and deep dose equivalent (10 CFR 20, Section 20.1003). TEDE is expressed in terms of rems or millirems (thousandth parts of a rem).

6.1 DOSE FACTORS

As noted previously, DFs represent doses resulting from one-day intake of radionuclides by inhalation of air containing unit activity concentration of a radionuclide under consideration. DFs, calculated using Equation 4, are listed in Table 9.

Table 9. Dose Factors for Eruption Phase.

Radionuclide	Dose Factor, rem/d per pCi/m^3
Strontium-90	5.39E-06
Cesium-137	1.36E-06
Lead-210	2.07E-04
Radium-226	1.16E-04
Actinium-227	6.92E-02
Thorium-229	2.22E-02
Thorium-230	3.36E-03
Protactinium-231	1.34E-02
Uranium-232	6.80E-03
Uranium-233	1.40E-03
Uranium-234	1.37E-03
Plutonium-238	4.10E-03
Plutonium-239	4.49E-03
Plutonium-240	4.49E-03
Plutonium-242	4.29E-03
Americium-241	4.64E-03
Americium-243	4.60E-03

The use of DFs to calculate dose is as follows:

$$D\left(\frac{rem}{d}\right) = PM_{10}\left(\frac{g}{m^3}\right) \times C_{ash}\left(\frac{pCi}{g}\right) \times DF\left(\frac{rem}{pCi\ d}\right) \qquad \text{(Eq. 5)}$$

where:

PM_{10} – average daily mass concentration of PM_{10} fraction of suspended particulates, $\frac{g}{m^3}$

C_{ash} – activity concentration of radionuclide in ash, $\frac{pCi}{g}$.

Same set of DFs is used for both an AMCG and the RMEI.

6.2 BIOSPHERE DOSE CONVERSION FACTORS

Considering the wide range of ash thicknesses that may results from the eruption modeling (see Table 5), BDCFs were developed for two different thicknesses of ash. In the most probable eruption modeling outcome, volcanic ash layers are one centimeter or less in thickness.

In this report BDCFs are presented in the form of discrete cumulative probability distributions, which is consisted with the format required for the TSPA input. Cumulative probability distributions were obtained directly from the screen readout of GENII-S.

6.2.1 Thin Ash Deposits

Two sets of BDCFs were calculated for thin layers of ash for each receptor: for the transition phase, and for the steady-state phase. BDCFs can be applied to ash thicknesses of about 1 cm or less and are given in units of rem/y per pCi/m^2.

BDCFs for the transition phase are characterized by the exponential decrease of mass loading, resuspension factor and inadvertent soil ingestion. Activity for the transition phase is contained in 1-cm layer of ash at the soil surface. Although, technically, transition phase BDCFs can be applied to a time period of any duration, it would be very conservative to use transition BDCFs for the time periods longer than several years. Transition phase BDCFs should be used for the period of the airborne particle concentration reduction from the initial high values (after a volcanic eruption) to the pre-eruption background values. BDCFs for the transition phase, thin ash deposits are summarized in Table 10 and Table 11, for an AMCG and the RMEI, respectively. The tables include the mean, standard deviation, minimum, and the icosatile values for the BDCF cumulative probability distributions.

BDCFs for the steady-state phase are characterized by the constant values of mass loading, resuspension factor and inadvertent soil ingestion. The values of these parameters are equal to the low-end values of the corresponding ranges considered for the transition phase. Activity is assumed to be uniformly mixed into a 15-cm layer of surface soil. BDCFs for the steady-state phase and thin ash deposits are shown in Table 12 and Table 13, for an AMCG and the RMEI, respectively. The mean, standard deviation, minimum, and the discrete cumulative probability distribution (in icosatiles) are shown in the tables.

6.2.2 Thick ash deposits

In the less probable outcome, volcanic eruption modeling produces thicker ash layers of several tens of centimeters. In this case, ash thicknesses are comparable with the extent of the plant growing zone, which is assumed to encompass the surface soil layer extending to a depth of 15

cm (CRWMS M&O 1999a). BDCFs developed for 15-cm ash thickness are believed to apply to ash layer deposits 15 cm in depth and greater, because radionuclides contained in ash beneath the roots are unavailable for plant uptake. Because the layers of ash below 15 cm do not participate in radionuclide uptake by plants, and, therefore, do not contribute to BDCFs, in this case doses are more closely related to the activity concentration in ash (activity per unit mass of ash) rather than to the surface activity deposition (activity per unit surface area). Consequently, to use 15-cm BDCFs for ash deposits thicker than 15 cm, the user should adjust the surface activity concentration in the actual ash deposit to the 15-cm value. For example, if ash deposit thickness is 30 cm and the surface activity concentration is 10 pCi/m^2, the activity concentration corresponding to 15-cm ash layer would be 5 pCi/m^2 (activity concentration in ash is the same in both cases). Doses would then be calculated by using BDCFs developed for the 15-cm layer of ash.

Similar to the case of thin ash deposits, BDCFs for thick ash layers were calculated for the transition and steady-state phases. BDCFs for the transition phase (Table 14 and Table 15, for an AMCG and the RMEI, respectively) are characterized by exponential decrease of mass loading, resuspension factor and inadvertent soil ingestion. Activity is assumed to be uniformly distributed in a 15-cm layer of ash at the soil surface.

BDCFs for the steady-state phase are characterized by constant values of mass loading, resuspension factor and inadvertent soil ingestion. The values of these parameters are equal to the low-end values of the corresponding ranges considered for the transition phase. Activity is assumed to be uniformly distributed in a 15-cm layer of ash. Additionally, it is assumed that the ash is compacted and its density is the same as the density of soil, i.e., 225 kg/m^2 (CRWMS M&O 1999a). Therefore, BDCFs for the steady-state phase and thick ash deposits are the same as BDCFs for the steady-state, thin ash deposits (Table 12 and Table 13, for an AMCG and the RMEI, respectively).

Table 10. BDCFs for an Average Member of the Critical Group, Thin Ash Deposits (1cm or less), Transition Phase

Radio-nuclide	BDCF, rem/y per pCi/m^2											
	Mean	**STD**	**Min.**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**	**45%**
Sr-90	1.22E-08	1.91E-08	6.33E-10	1.22E-09	1.80E-09	2.26E-09	2.56E-09	3.09E-09	3.61E-09	4.40E-09	4.85E-09	5.37E-09
Cs-137	1.28E-09	1.51E-09	4.09E-10	4.62E-10	5.22E-10	5.47E-10	5.82E-10	6.02E-10	6.80E-10	7.03E-10	7.59E-10	8.13E-10
Pb-210	6.05E-08	6.66E-08	1.44E-08	1.75E-08	2.16E-08	2.40E-08	2.54E-08	2.72E-08	2.84E-08	2.96E-08	3.27E-08	3.71E-08
Ra-226	5.66E-09	3.41E-09	2.30E-09	2.86E-09	3.26E-09	3.43E-09	3.58E-09	3.73E-09	3.92E-09	4.27E-09	4.44E-09	4.57E-09
Ac-227	7.34E-07	6.44E-07	1.07E-07	1.29E-07	1.42E-07	1.65E-07	1.91E-07	2.21E-07	2.56E-07	2.96E-07	3.37E-07	4.06E-07
Th-229	2.31E-07	2.05E-07	3.17E-08	3.86E-08	4.25E-08	5.02E-08	5.72E-08	6.81E-08	7.83E-08	9.15E-08	1.05E-07	1.27E-07
Th-230	3.47E-08	3.08E-08	4.78E-09	5.81E-09	6.38E-09	7.55E-09	8.58E-09	1.02E-08	1.18E-08	1.38E-08	1.58E-08	1.91E-08
Pa-231	1.64E-07	1.24E-07	3.89E-08	4.42E-08	5.07E-08	5.27E-08	5.94E-08	6.40E-08	7.42E-08	8.00E-08	9.14E-08	9.92E-08
U-232	7.39E-08	6.43E-08	1.07E-08	1.37E-08	1.51E-08	1.66E-08	1.91E-08	2.21E-08	2.75E-08	3.05E-08	3.47E-08	4.07E-08
U-233	1.50E-08	1.30E-08	2.23E-09	2.85E-09	3.17E-09	3.44E-09	3.91E-09	4.54E-09	5.62E-09	6.30E-09	7.24E-09	8.27E-09
U-234	1.48E-08	1.28E-08	2.20E-09	2.80E-09	3.12E-09	3.39E-09	3.85E-09	4.46E-09	5.53E-09	6.20E-09	7.12E-09	8.14E-09
Pu-238	4.94E-08	3.77E-08	1.16E-08	1.33E-08	1.52E-08	1.60E-08	1.78E-08	1.92E-08	2.19E-08	2.40E-08	2.74E-08	3.00E-08
Pu-239	5.48E-08	4.18E-08	1.29E-08	1.47E-08	1.69E-08	1.77E-08	1.99E-08	2.13E-08	2.43E-08	2.66E-08	3.04E-08	3.33E-08
Pu-240	5.47E-08	4.17E-08	1.29E-08	1.47E-08	1.68E-08	1.77E-08	1.99E-08	2.13E-08	2.43E-08	2.66E-08	3.04E-08	3.32E-08
Pu-242	5.11E-08	3.89E-08	1.20E-08	1.37E-08	1.57E-08	1.65E-08	1.85E-08	1.98E-08	2.26E-08	2.48E-08	2.83E-08	3.10E-08
Am-241	5.60E-08	4.26E-08	1.33E-08	1.51E-08	1.74E-08	1.80E-08	2.03E-08	2.19E-08	2.54E-08	2.71E-08	3.13E-08	3.40E-08
Am-243	5.59E-08	4.25E-08	1.33E-08	1.51E-08	1.73E-08	1.80E-08	2.03E-08	2.19E-08	2.54E-08	2.71E-08	3.12E-08	3.39E-08
	50%	**55%**	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**	**95%**	**100%**	
Sr-90	6.06E-09	7.19E-09	8.28E-09	9.42E-09	1.14E-08	1.35E-08	1.64E-08	2.02E-08	2.62E-08	3.90E-08	1.84E-07	
Cs-137	8.46E-10	9.38E-10	9.87E-10	1.09E-09	1.17E-09	1.37E-09	1.64E-09	1.77E-09	2.24E-09	2.89E-09	1.59E-08	
Pb-210	3.97E-08	4.30E-08	4.72E-08	5.11E-08	5.64E-08	6.78E-08	7.83E-08	9.07E-08	1.13E-07	1.74E-07	6.13E-07	
Ra-226	4.79E-09	4.96E-09	5.36E-09	5.66E-09	6.05E-09	6.48E-09	6.91E-09	7.45E-09	8.48E-09	1.04E-08	3.44E-08	
Ac-227	4.63E-07	5.64E-07	6.55E-07	7.73E-07	9.06E-07	1.08E-06	1.25E-06	1.50E-06	1.79E-06	2.13E-06	2.53E-06	
Th-229	1.45E-07	1.76E-07	2.06E-07	2.44E-07	2.86E-07	3.50E-07	3.96E-07	4.77E-07	5.67E-07	6.74E-07	8.02E-07	
Th-230	2.18E-08	2.65E-08	3.09E-08	3.66E-08	4.30E-08	5.26E-08	5.95E-08	7.16E-08	8.51E-08	1.01E-07	1.20E-07	
Pa-231	1.12E-07	1.30E-07	1.45E-07	1.69E-07	1.94E-07	2.37E-07	2.65E-07	3.13E-07	3.70E-07	4.35E-07	5.12E-07	
U-232	4.76E-08	5.67E-08	6.64E-08	7.73E-08	9.05E-08	1.12E-07	1.31E-07	1.50E-07	1.79E-07	2.12E-07	2.53E-07	
U-233	9.67E-09	1.15E-08	1.35E-08	1.57E-08	1.83E-08	2.26E-08	2.64E-08	3.04E-08	3.62E-08	4.29E-08	5.11E-08	
U-234	9.52E-09	1.14E-08	1.33E-08	1.54E-08	1.80E-08	2.22E-08	2.60E-08	2.99E-08	3.56E-08	4.22E-08	5.03E-08	
Pu-238	3.38E-08	3.94E-08	4.40E-08	5.11E-08	5.87E-08	7.18E-08	7.93E-08	9.48E-08	1.12E-07	1.32E-07	1.55E-07	
Pu-239	3.75E-08	4.37E-08	4.88E-08	5.66E-08	6.51E-08	7.96E-08	8.80E-08	1.05E-07	1.24E-07	1.46E-07	1.72E-07	
Pu-240	3.74E-08	4.36E-08	4.87E-08	5.65E-08	6.50E-08	7.95E-08	8.78E-08	1.05E-07	1.24E-07	1.46E-07	1.72E-07	
Pu-242	3.49E-08	4.07E-08	4.55E-08	5.27E-08	6.06E-08	7.42E-08	8.19E-08	9.80E-08	1.16E-07	1.36E-07	1.61E-07	
Am-241	3.82E-08	4.46E-08	4.98E-08	5.78E-08	6.64E-08	8.13E-08	9.09E-08	1.07E-07	1.27E-07	1.49E-07	1.76E-07	
Am-243	3.81E-08	4.45E-08	4.97E-08	5.76E-08	6.62E-08	8.10E-08	9.06E-08	1.07E-07	1.27E-07	1.49E-07	1.75E-07	

Table 11. BDCFs for the RMEI Thin Ash Deposits (1cm or less), Transition Phase

Radio-nuclide	BDCF, rem/y per pCi/m^2											
	Mean	STD	Min.	5%	10%	15%	20%	25%	30%	35%	40%	45%
Sr-90	7.42E-09	1.21E-08	4.85E-10	8.49E-10	1.13E-09	1.41E-09	1.61E-09	1.89E-09	2.24E-09	2.71E-09	2.95E-09	3.22E-09
Cs-137	9.90E-10	1.08E-09	3.92E-10	4.23E-10	4.66E-10	4.86E-10	5.08E-10	5.22E-10	5.74E-10	6.05E-10	6.31E-10	6.64E-10
Pb-210	3.87E-08	3.58E-08	1.29E-08	1.51E-08	1.78E-08	1.89E-08	2.02E-08	2.05E-08	2.12E-08	2.20E-08	2.42E-08	2.64E-08
Ra-226	4.47E-09	2.05E-09	2.18E-09	2.65E-09	2.81E-09	2.99E-09	3.06E-09	3.21E-09	3.45E-09	3.52E-09	3.70E-09	3.77E-09
Ac-227	7.30E-07	6.44E-07	1.05E-07	1.27E-07	1.37E-07	1.61E-07	1.78E-07	2.18E-07	2.50E-07	2.92E-07	3.33E-07	4.05E-07
Th-229	2.30E-07	2.05E-07	3.14E-08	3.82E-08	4.15E-08	4.91E-08	5.46E-08	6.68E-08	7.73E-08	9.04E-08	1.04E-07	1.27E-07
Th-230	3.45E-08	3.08E-08	4.72E-09	5.73E-09	6.25E-09	7.39E-09	8.22E-09	1.00E-08	1.16E-08	1.36E-08	1.56E-08	1.90E-08
Pa-231	1.60E-07	1.24E-07	3.71E-08	4.31E-08	4.64E-08	5.06E-08	5.62E-08	6.06E-08	6.97E-08	7.46E-08	8.65E-08	9.83E-08
U-232	7.31E-08	6.47E-08	1.05E-08	1.29E-08	1.41E-08	1.63E-08	1.80E-08	2.16E-08	2.68E-08	2.90E-08	3.36E-08	4.04E-08
U-233	1.48E-08	1.30E-08	2.17E-09	2.68E-09	2.93E-09	3.34E-09	3.68E-09	4.42E-09	5.46E-09	5.92E-09	6.83E-09	8.22E-09
U-234	1.46E-08	1.28E-08	2.13E-09	2.64E-09	2.88E-09	3.28E-09	3.62E-09	4.35E-09	5.38E-09	5.83E-09	6.72E-09	8.09E-09
Pu-238	4.85E-08	3.76E-08	1.11E-08	1.30E-08	1.39E-08	1.53E-08	1.70E-08	1.83E-08	2.10E-08	2.26E-08	2.61E-08	2.98E-08
Pu-239	5.38E-08	4.17E-08	1.23E-08	1.44E-08	1.55E-08	1.69E-08	1.89E-08	2.03E-08	2.32E-08	2.51E-08	2.89E-08	3.30E-08
Pu-240	5.37E-08	4.17E-08	1.23E-08	1.43E-08	1.54E-08	1.69E-08	1.88E-08	2.03E-08	2.32E-08	2.50E-08	2.89E-08	3.30E-08
Pu-242	5.01E-08	3.89E-08	1.14E-08	1.34E-08	1.44E-08	1.58E-08	1.76E-08	1.89E-08	2.16E-08	2.33E-08	2.69E-08	3.08E-08
Am-241	5.49E-08	4.25E-08	1.27E-08	1.47E-08	1.59E-08	1.73E-08	1.92E-08	2.07E-08	2.39E-08	2.56E-08	2.96E-08	3.07E-08
Am-243	5.48E-08	4.24E-08	1.27E-08	1.47E-08	1.59E-08	1.73E-08	1.92E-08	2.07E-08	2.38E-08	2.55E-08	2.96E-08	3.36E-08
	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	
Sr-90	3.57E-09	4.31E-09	5.10E-09	5.53E-09	6.87E-09	8.48E-09	9.67E-09	1.21E-08	1.60E-08	2.20E-08	1.20E-07	
Cs-137	6.97E-10	7.40E-10	7.89E-10	8.37E-10	9.19E-10	1.03E-09	1.16E-09	1.33E-09	1.64E-09	2.17E-09	1.17E-08	
Pb-210	2.78E-08	2.92E-08	3.13E-08	3.35E-08	3.64E-08	4.28E-08	4.88E-08	5.50E-08	6.62E-08	9.97E-08	3.34E-07	
Ra-226	3.94E-09	4.06E-09	4.30E-09	4.61E-09	4.87E-09	5.08E-09	5.44E-09	5.93E-09	6.35E-09	7.53E-09	2.07E-08	
Ac-227	4.62E-07	5.53E-07	6.50E-07	7.70E-07	9.04E-07	1.10E-06	1.25E-06	1.50E-06	1.78E-06	2.12E-06	2.52E-06	
Th-229	1.45E-07	1.73E-07	2.05E-07	2.43E-07	2.86E-07	3.49E-07	3.94E-07	4.77E-07	5.65E-07	6.71E-07	8.00E-07	
Th-230	2.18E-08	2.60E-08	3.07E-08	3.65E-08	4.29E-08	5.25E-08	5.92E-08	7.16E-08	8.48E-08	1.01E-07	1.20E-07	
Pa-231	1.08E-07	1.27E-07	1.43E-07	1.67E-07	1.92E-07	2.31E-07	2.60E-07	3.05E-07	3.64E-07	4.28E-07	5.06E-07	
U-232	4.75E-08	5.53E-08	6.54E-08	7.69E-08	9.04E-08	1.11E-07	1.27E-07	1.50E-07	1.78E-07	2.12E-07	2.52E-07	
U-233	9.63E-09	1.12E-08	1.33E-08	1.56E-08	1.83E-08	2.25E-08	2.58E-08	3.03E-08	3.60E-08	4.27E-08	5.09E-08	
U-234	9.48E-08	1.11E-08	1.30E-08	1.53E-08	1.80E-08	2.21E-08	2.54E-08	2.98E-08	3.54E-08	4.20E-08	5.01E-08	
Pu-238	3.26E-08	3.85E-08	4.23E-08	5.05E-08	5.80E-08	7.00E-08	7.84E-08	9.25E-08	1.10E-07	1.30E-07	1.54E-07	
Pu-239	3.62E-08	4.27E-08	4.80E-08	5.60E-08	6.44E-08	7.76E-08	8.69E-08	1.03E-07	1.22E-07	1.44E-07	1.70E-07	
Pu-240	3.62E-08	4.27E-08	4.79E-08	5.59E-08	6.43E-08	7.74E-08	8.68E-08	1.02E-07	1.22E-07	1.44E-07	1.70E-07	
Pu-242	3.37E-08	3.98E-08	4.47E-08	5.22E-08	6.00E-08	7.22E-08	8.09E-08	9.56E-08	1.14E-07	1.34E-07	1.59E-07	
Am-241	3.69E-08	4.36E-08	4.91E-08	5.71E-08	6.58E-08	7.92E-08	8.92E-08	1.05E-07	1.25E-07	1.47E-07	1.74E-07	
Am-243	3.63E-08	4.35E-08	4.89E-08	5.69E-08	6.56E-08	7.90E-08	8.90E-08	1.04E-07	1.24E-07	1.46E-07	1.73E-07	

Table 12. BDCFs for an Average Member of the Critical Group, Thin Ash Deposits (1cm or less), Steady-state Phase

Radio-nuclide	BDCF, rem/y per pCi/m^2											
	Mean	**STD**	**Min.**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**	**45%**
Sr-90	7.70E-09	1.14E-08	2.38E-10	6.19E-10	8.77E-10	1.22E-09	1.42E-09	1.87E-09	2.17E-09	2.64E-09	3.03E-09	3.38E-09
Cs-137	1.80E-09	8.66E-10	1.27E-09	1.29E-09	1.32E-09	1.34E-09	1.36E-09	1.37E-09	1.41E-09	1.43E-09	1.46E-09	1.48E-09
Pb-210	2.93E-08	4.01E-08	1.30E-09	2.64E-09	3.86E-09	4.98E-09	6.19E-09	7.44E-09	8.78E-09	1.02E-08	1.18E-08	1.38E-08
Ra-226	1.50E-09	2.00E-09	1.38E-10	2.10E-10	2.65E-10	3.16E-10	3.64E-10	4.30E-10	4.91E-10	5.78E-10	6.37E-10	7.23E-10
Ac-227	5.38E-09	1.18E-09	4.56E-09	4.60E-09	4.63E-09	4.67E-09	4.70E-09	4.74E-09	4.78E-09	4.82E-09	4.87E-09	4.91E-09
Th-229	1.70E-09	3.02E-10	1.49E-09	1.50E-09	1.51E-09	1.52E-09	1.53E-09	1.54E-09	1.55E-09	1.56E-09	1.57E-09	1.58E-09
Th-230	2.39E-10	4.57E-11	2.07E-10	2.08E-10	2.10E-10	2.11E-10	2.12E-10	2.14E-10	2.15E-10	2.17E-10	2.19E-10	2.21E-10
Pa-231	2.06E-09	6.33E-10	1.62E-09	1.64E-09	1.66E-09	1.68E-09	1.70E-09	1.72E-09	1.74E-09	1.76E-09	1.79E-09	1.82E-09
U-232	1.04E-09	8.32E-10	4.63E-10	4.93E-10	5.17E-10	5.38E-10	5.62E-10	5.86E-10	6.15E-10	6.47E-10	6.80E-10	7.10E-10
U-233	2.24E-10	1.84E-10	9.63E-11	1.03E-10	1.08E-10	1.13E-10	1.18E-10	1.23E-10	1.30E-10	1.37E-10	1.44E-10	1.51E-10
U-234	2.19E-10	1.80E-10	9.43E-11	1.01E-10	1.06E-10	1.11E-10	1.16E-10	1.21E-10	1.27E-10	1.34E-10	1.41E-10	1.48E-10
Pu-238	5.06E-10	5.72E-11	4.66E-10	4.68E-10	4.70E-10	4.72E-10	4.73E-10	4.75E-10	4.77E-10	4.79E-10	4.81E-10	4.84E-10
Pu-239	5.62E-10	6.35E-11	5.17E-10	5.20E-10	5.21E-10	5.23E-10	5.25E-10	5.27E-10	5.30E-10	5.31E-10	5.34E-10	5.37E-10
Pu-240	5.61E-10	6.34E-11	5.16E-10	5.19E-10	5.21E-10	5.22E-10	5.24E-10	5.26E-10	5.29E-10	5.30E-10	5.33E-10	5.36E-10
Pu-242	5.23E-10	5.91E-11	4.81E-10	4.83E-10	4.85E-10	4.87E-10	4.89E-10	4.90E-10	4.93E-10	4.94E-10	4.97E-10	4.99E-10
Am-241	7.00E-10	2.18E-10	5.47E-10	5.54E-10	5.61E-10	5.67E-10	5.74E-10	5.81E-10	5.88E-10	5.96E-10	6.04E-10	6.15E-10
Am-243	7.36E-10	2.18E-10	5.84E-10	5.92E-10	5.98E-10	6.04E-10	6.11E-10	6.18E-10	6.25E-10	6.33E-10	6.41E-10	6.52E-10
	50%	**55%**	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**	**95%**	**100%**	
Sr-90	3.82E-09	4.64E-09	5.28E-09	6.03E-09	7.45E-09	8.74E-09	1.06E-08	1.30E-08	1.72E-08	2.55E-08	9.53E-08	
Cs-137	1.51E-09	1.57E-09	1.62E-09	1.67E-09	1.76E-09	1.90E-09	1.99E-09	2.14E-09	2.47E-09	2.97E-09	8.96E-09	
Pb-210	1.54E-08	1.77E-08	2.01E-08	2.35E-08	2.84E-08	3.38E-08	4.04E-08	4.97E-08	6.62E-08	1.03E-07	3.03E-07	
Ra-226	8.29E-10	9.51E-10	1.07E-09	1.22E-09	1.53E-09	1.70E-09	2.00E-09	2.41E-09	3.26E-09	5.02E-09	1.60E-08	
Ac-227	4.98E-09	5.04E-09	5.12E-09	5.23E-09	5.35E-09	5.50-09	5.69E-09	5.97E-09	6.40E-09	7.54E-09	1.34E-08	
Th-229	1.60E-09	1.62E-09	1.64E-09	1.67E-09	1.69E-09	1.74E-09	1.78E-09	1.86E-09	1.99E-09	2.25E-09	3.77E-09	
Th-230	2.23E-10	2.26E-10	2.29E-10	2.33E-10	2.37E-10	2.44E-10	2.51E-10	2.62E-10	2.82E-10	3.21E-10	5.52E-10	
Pa-231	1.85E-09	1.88E-09	1.92E-09	1.98E-09	2.05E-09	2.13E-09	2.24E-09	2.39E-09	2.65E-09	3.17E-09	6.43E-09	
U-232	7.53E-10	8.07E-10	8.58E-10	9.26E-10	1.04E-09	1.12E-09	1.26E-09	1.44E-09	1.80E-09	2.57E-09	6.87E-09	
U-233	1.60E-10	1.73E-10	1.83E-10	1.99E-10	2.23E-10	2.41E-10	2.73E-10	3.13E-10	3.91E-10	5.61E-10	1.51E-09	
U-234	1.57E-10	1.69E-10	1.80E-10	1.95E-10	2.19E-10	2.36E-10	2.68E-10	3.07E-10	3.84E-10	5.51E-10	1.48E-09	
Pu-238	4.87E-10	4.90E-10	4.94E-10	4.99E-10	5.05E-10	5.12E-10	5.22E-10	5.36E-10	5.62E-10	6.12E-10	8.96E-10	
Pu-239	5.40E-10	5.44E-10	5.48E-10	5.54E-10	5.60E-10	5.68E-10	5.79E-10	5.95E-10	6.24E-10	6.79E-10	9.95E-10	
Pu-240	5.39E-10	5.43E-10	5.47E-10	5.53E-10	5.59E-10	5.67E-10	5.78E-10	5.94E-10	6.23E-10	6.78E-10	9.93E-10	
Pu-242	5.03E-10	5.06E-10	5.10E-10	5.15E-10	5.21E-10	5.29E-10	5.39E-10	5.54E-10	5.80E-10	6.31E-10	9.25E-10	
Am-241	6.27E-10	6.35E-10	6.52E-10	6.72E-10	6.95E-10	7.20E-10	7.60E-10	8.11E-10	8.99E-10	1.10E-09	2.19E-09	
Am-243	6.64E-10	6.72E-10	6.89E-10	7.08E-10	7.32E-10	7.57E-10	7.96E-10	8.48E-10	9.35E-10	1.13E-09	2.22E-09	

Table 13. BDCFs for the RMEI, Thin Ash Deposits (1cm or less), Steady-state Phase

Radio-nuclide	BDCF, rem/y per pCi/m^2											
	Mean	STD	Min.	5%	10%	15%	20%	25%	30%	35%	40%	45%
Sr-90	4.59E-09	7.00E-09	1.45E-10	3.53E-10	5.41E-10	7.07E-10	8.55E-10	1.05E-09	1.30E-09	1.55E-09	1.75E-09	1.95E-09
Cs-137	1.62E-09	6.21E-10	1.27E-09	1.28E-09	1.3E-09	1.30E-09	1.32E-09	1.33E-09	1.35E-09	1.37E-09	1.39E-09	1.40E-09
Pb-210	1.60E-08	2.16E-08	9.11E-10	1.64E-09	2.27E-09	2.90E-09	3.56E-09	4.16E-09	4.89E-09	5.68E-09	6.64E-09	7.58E-09
Ra-226	8.81E-10	1.13E-09	1.18E-10	1.60E-10	1.85E-10	2.21E-10	2.45E-10	2.90E-10	3.11E-10	3.63E-10	4.00E-10	4.42E-10
Ac-227	4.96E-09	6.22E-10	4.53E-09	4.55E-09	4.57E-09	4.59E-09	4.61E-09	4.62-09	4.65E-09	4.67E-09	4.68E-09	4.72E-09
Th-229	1.60E-09	1.59E-10	1.49E-09	1.49E-09	1.50E-09	1.50E-09	1.51E-09	1.51E-09	1.52E-09	1.52E-09	1.53E-09	1.53E-09
Th-230	2.23E-10	2.42E-11	2.06E-10	2.07E-10	2.07E-10	2.08E-10	2.09E-10	2.09E-10	2.10E-10	2.11E-10	2.12E-10	2.13E-10
Pa-231	1.84E-09	3.38E-10	1.60E-09	1.61E-09	1.62E-09	1.63E-09	1.64E-09	1.65E-09	1.66E-09	1.67E-09	1.69E-09	1.70E-09
U-232	7.66E-10	4.55E-10	4.53E-10	4.70E-10	4.82E-10	4.93E-10	5.07E-10	5.20E-10	5.35E-10	5.54E-10	5.69E-10	5.87E-10
U-233	1.63E-10	1.00E-10	9.41E-11	9.78E-11	1.00E-10	1.03E-10	1.06E-10	1.09E-10	1.12E-10	1.16E-10	1.20E-10	1.24E-10
U-234	1.60E-10	9.86E-11	9.22E-11	9.58E-11	9.84E-11	1.01E-10	1.04E-10	1.07E-10	1.10E-10	1.14E-10	1.17E-10	1.21E-10
Pu-238	4.83E-10	3.08E-11	4.61E-10	4.63E-10	4.64E-10	4.64E-10	4.65E-10	4.66E-10	4.67E-10	4.68E-10	4.69E-10	4.71E-10
Pu-239	5.35E-10	3.42E-11	5.12E-10	5.13E-10	5.14E-10	5.15E-10	5.16E-10	5.17E-10	5.18E-10	5.20E-10	5.21E-10	5.23E-10
Pu-240	5.35E-10	3.41E-11	5.11E-10	5.12E-10	5.13E-10	5.14E-10	5.15E-10	5.16E-10	5.17E-10	5.19E-10	5.20E-10	5.22E-10
Pu-242	4.99E-10	3.18E-11	4.76E-10	4.78E-10	4.79E-10	4.80E-10	4.80E-10	4.81E-10	4.82E-10	4.84E-10	4.85E-10	4.86E-10
Am-241	6.22E-10	1.16E-10	5.41E-10	5.44E-10	5.48E-10	5.51E-10	5.55E-10	5.58E-10	5.62E-10	5.66E-10	5.71E-10	5.76E-10
Am-243	6.58E-10	1.15E-10	5.78E-10	5.82E-10	5.85E-10	5.88E-10	5.92E-10	5.95E-10	5.99E-10	6.03E-10	6.09E-10	6.13E-10
	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	
Sr-90	2.15E-09	2.66E-09	3.17E-09	3.53E-09	4.36E-09	5.49E-09	6.13E-09	7.72E-09	1.01E-08	1.43E-08	6.09E-08	
Cs-137	1.43E-09	1.46E-09	1.48E-09	1.52E-09	1.58E-09	1.68E-09	1.74E-09	1.85E-09	2.06E-09	2.44E-09	6.99E-09	
Pb-210	8.69E-09	9.86E-09	1.13E-08	1.35E-08	1.56E-08	1.83E-08	2.20E-08	2.72E-08	3.55E-08	5.67E-08	1.62E-07	
Ra-226	4.90E-10	5.76E-10	6.40E-10	7.15E-10	8.96E-10	9.70E-10	1.16E-09	1.46E-09	1.83E-09	2.82E-09	9.29E-09	
Ac-227	4.76E-09	4.78E-09	4.83E-09	4.89E-09	4.95E-09	5.02E-09	5.14E-09	5.27E-09	5.53E-09	6.11E-09	9.23E-09	
Th-229	1.54E-09	1.55E-09	1.56E-09	1.58E-09	1.59E-09	1.61E-09	1.64E-09	1.68E-09	1.75E-09	1.89E-09	2.68E-09	
Th-230	2.14E-10	2.15E-10	2.17E-10	2.19E-10	2.22E-10	2.25E-10	2.29E-10	2.35E-10	2.45E-10	2.67E-10	3.86E-10	
Pa-231	1.72E-09	1.74E-09	1.76E-09	1.79E-09	1.82E-09	1.87E-09	1.92E-09	2.01E-09	2.15E-09	2.46E-09	4.14E-09	
U-232	6.13E-10	6.40E-10	6.65E-10	7.00E-10	7.73E-10	8.03E-10	8.83E-10	9.81E-10	1.17E-09	1.59E-09	3.99E-09	
U-233	1.29E-10	1.35E-10	1.41E-10	1.49E-10	1.65E-10	1.71E-10	1.89E-10	2.11E-10	2.53E-10	3.45E-10	8.76E-10	
U-234	1.27E-10	1.33E-10	1.38E-10	1.46E-10	1.62E-10	1.68E-10	1.85E-10	2.07E-10	2.48E-10	3.38E-10	8.60E-10	
Pu-238	4.73E-10	4.74E-10	4.76E-10	4.79E-10	4.82E-10	4.86E-10	4.91E-10	4.99E-10	5.12E-10	5.38E-10	6.95E-10	
Pu-239	5.25E-10	5.26E-10	5.28E-10	5.32E-10	5.35E-10	5.39E-10	5.45E-10	5.53E-10	5.685-10	5.97E-10	7.72E-10	
Pu-240	5.24E-10	5.25E-10	5.27E-10	5.31E-10	5.34E-10	5.39E-10	5.44E-10	5.53E-10	5.67E-10	5.96E-10	7.70E-10	
Pu-242	4.88E-10	4.90E-10	4.92E-10	4.95E-10	4.98E-10	5.02E-10	5.07E-10	5.15E-10	5.28E-10	5.55E-10	7.18E-10	
Am-241	5.82E-10	5.88E-10	5.98E-10	6.06E-10	6.18E-10	6.35E-10	6.54E-10	6.80E-10	7.29E-10	8.37E-10	1.41E-09	
Am-243	6.19E-10	6.25E-10	6.35E-10	6.43E-10	6.55E-10	6.72E-10	6.91E-10	7.17E-10	7.65E-10	8.73E-10	1.45E-09	

Table 14. BDCFs for an Average Member of the Critical Group, Thick Ash Deposits (15cm), Transition Phase

Radio-nuclide	BDCF, rem/y per pCi/m^2											
	Mean	**STD**	**Min.**	**5%**	**10%**	**15%**	**20%**	**25%**	**30%**	**35%**	**40%**	**45%**
Sr-90	1.18E-08	1.91E-08	3.12E-10	9.35E-10	1.34E-09	1.80E-09	2.11E-09	2.78E-09	3.25E-09	3.94E-09	4.45E-09	5.05E-09
Cs-137	2.10E-09	1.48E-09	1.28E-09	1.32E-09	1.36E-09	1.39E-09	1.41E-09	1.45E-09	1.49E-09	1.54E-09	1.56E-09	1.61E-09
Pb-210	4.51E-08	6.61E-08	2.17E-09	4.41E-09	6.03E-09	7.94E-09	9.59E-09	1.14E-08	1.34E-08	1.59E-08	1.79E-08	2.06E-08
Ra-226	2.40E-09	3.32E-09	2.39E-10	3.77E-10	4.68E-10	5.91E-10	6.62E-10	7.72E-10	8.16E-10	9.92E-10	1.08E-09	1.22E-09
Ac-227	5.02E-08	4.30E-08	7.67E-09	9.65E-09	1.08E-08	1.22E-08	1.29E-08	1.56E-08	1.91E-08	2.14E-08	2.43E-08	2.83E-08
Th-229	1.59E-08	1.37E-08	2.39E-09	2.99E-09	3.33E-09	3.71E-09	3.97E-09	4.82E-09	5.98E-09	6.68E-09	7.64E-09	8.93E-09
Th-230	2.36E-09	2.06E-09	3.42E-10	4.31E-10	4.85E-10	5.40E-10	5.79E-10	7.06E-10	8.80E-10	9.87E-10	1.13E-09	1.32E-09
Pa-231	1.16E-08	8.30E-09	2.86E-09	3.42E-09	3.87E-09	4.13E-09	4.45E-09	5.02E-09	5.38E-09	6.33E-09	6.87E-09	7.26E-09
U-232	5.78E-09	4.45E-09	7.94E-10	1.20E-09	1.40E-09	1.53E-09	1.91E-09	2.12E-09	2.64E-09	2.96E-09	3.21E-09	3.56E-09
U-233	1.19E-09	9.04E-10	1.65E-10	2.49E-10	2.90E-10	3.25E-10	3.96E-10	4.58E-10	5.41E-10	6.19E-10	6.66E-10	7.48E-10
U-234	1.17E-09	8.89E-10	1.62E-10	2.45E-10	2.85E-10	3.19E-10	3.89E-10	4.49E-10	5.32E-10	6.08E-10	6.54E-10	7.35E-10
Pu-238	3.36E-09	2.52E-09	8.08E-10	9.37E-10	1.05E-09	1.13E-09	1.19E-09	1.35E-09	1.53E-09	1.69E-09	1.90E-09	2.07E-09
Pu-239	3.72E-09	2.79E-09	8.97E-10	1.04E-09	1.17E-09	1.25E-09	1.32E-09	1.50E-09	1.70E-09	1.87E-09	2.11E-09	2.30E-09
Pu-240	3.72E-09	2.79E-09	8.95E-10	1.04E-09	1.16E-09	1.25E-09	1.32E-09	1.50E-09	1.69E-09	1.87E-09	2.10E-09	2.29E-09
Pu-242	3.47E-09	2.60E-09	8.34E-10	9.68E-10	1.08E-09	1.16E-09	1.23E-09	1.40E-09	1.58E-09	1.74E-09	1.96E-09	2.14E-09
Am-241	3.98E-09	2.85E-09	9.69E-10	1.16E-09	1.31E-09	1.41E-09	1.52E-09	1.71E-09	1.83E-09	2.15E-09	2.34E-09	2.50E-09
Am-243	4.01E-09	2.84E-09	1.01E-09	1.20E-09	1.35E-09	1.45E-09	1.55E-09	1.75E-09	1.87E-09	2.18E-09	2.37E-09	2.53E-09
	50%	**55%**	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**	**95%**	**100%**	
Sr-90	5.67E-09	6.90E-09	7.96E-09	9.02E-09	1.11E-08	1.32E-08	1.58E-08	1.99E-08	2.58E-08	3.87E-08	1.84E-07	
Cs-137	1.64E-09	1.73E-09	1.81E-09	1.89E-09	2.00E-09	2.23E-09	2.36E-09	2.57E-09	3.08E-09	3.77E-09	1.63E-08	
Pb-210	2.41E-08	2.72E-08	3.15E-08	3.64E-08	4.36E-08	5.03E-08	6.29E-08	7.64E-08	1.02E-07	1.53E-07	5.90E-07	
Ra-226	1.35E-09	1.52E-09	1.70E-09	1.92E-09	2.41E-09	2.66E-09	3.25E-09	3.89E-09	4.98E-09	7.74E-09	3.09E-08	
Ac-227	3.21E-08	3.85E-08	4.54E-08	5.19E-08	6.24E-08	7.50E-08	8.97E-08	1.03E-07	1.18E-07	1.43E-07	1.72E-07	
Th-229	1.02E-08	1.21E-08	1.43E-08	1.62E-08	1.97E-08	2.35E-08	2.85E-08	3.26E-08	3.73E-08	4.56E-08	5.45E-08	
Th-230	1.51E-09	1.80E-09	2.12E-09	2.41E-09	2.94E-09	3.51E-09	4.26E-09	4.88E-09	5.59E-09	6.83E-09	8.17E-09	
Pa-231	8.41E-09	9.54E-09	1.09E-08	1.21E-08	1.40E-08	1.68E-08	1.87E-08	2.23E-08	2.46E-08	2.97E-08	3.52E-08	
U-232	4.04E-09	4.85E-09	5.53E-09	6.05E-09	6.99E-09	8.46E-09	9.72E-09	1.13E-08	1.28E-08	1.48E-08	1.78E-08	
U-233	8.32E-10	9.95E-10	1.14E-09	1.26E-09	1.42E-09	1.72E-09	1.97E-09	2.30E-09	2.59E-09	3.06E-09	3.60E-09	
U-234	8.19E-10	9.78E-10	1.12E-09	1.23E-09	1.40E-09	1.69E-09	1.93E-09	2.27E-09	2.55E-09	3.01E-09	3.54E-09	
Pu-238	2.35E-09	2.67E-09	2.99E-09	3.37E-09	4.01E-09	4.81E-09	5.59E-09	6.37E-09	7.39E-09	8.71E-09	1.05E-08	
Pu-239	2.60E-09	2.96E-09	3.32E-09	3.73E-09	4.44E-09	5.33E-09	6.20E-09	7.06E-09	8.19E-09	9.65E-09	1.17E-08	
Pu-240	2.60E-09	2.96E-09	3.32E-09	3.73E-09	4.44E-09	5.33E-09	6.19E-09	7.05E-09	8.18E-09	9.64E-09	1.17E-08	
Pu-242	2.42E-09	2.76E-09	3.09E-09	3.48E-09	4.14E-09	4.97E-09	5.77E-09	6.58E-09	7.63E-09	8.99E-09	1.09E-08	
Am-241	2.87E-09	3.26E-09	3.70E-09	4.15E-09	4.77E-09	5.74E-09	6.41E-09	7.66E-09	8.42E-09	1.02E-08	1.21E-08	
Am-243	2.91E-09	3.29E-09	3.73E-09	4.18E-09	4.79E-09	5.76E-09	6.43E-09	7.67E-09	8.44E-09	1.02E-08	1.21E-08	

Table 15. BDCFs for the RMEI, Thick Ash Deposits (15 cm), Transition Phase

Radio-nuclide	BDCF, rem/y per pCi/m^2											
	Mean	STD	Min.	5%	10%	15%	20%	25%	30%	35%	40%	45%
Sr-90	7.06E-08	1.20E-08	1.95E-10	5.40E-10	8.14E-09	1.05E-09	1.28E-09	1.56E-09	1.98E-09	2.35E-09	2.65-09	2.94E-09
Cs-137	1.83E-09	1.08E-09	1.27E-09	1.30E-09	1.33E-09	1.34E-09	1.36E-09	1.37E-09	1.41E-09	1.44E-09	1.46E-09	1.48E-09
Pb-210	2.48E-08	3.59E-08	1.59E-09	2.75E-09	3.56E-09	4.76E-09	5.54E-09	6.45E-09	7.70E-09	8.96E-09	9.93E-09	1.15E-08
Ra-226	1.43E-09	1.89E-09	2.00E-10	3.02E-10	3.49E-10	4.16E-10	4.53E-10	5.12E-10	5.58E-10	6.24E-10	6.91E-10	7.57E-10
Ac-227	4.93E-08	4.30E-08	7.36E-09	9.04E-09	9.89E-09	1.11E-08	1.24E-08	1.47E-08	1.83E-08	2.07E-08	2.33E-08	2.69E-08
Th-229	1.59E-08	1.37E-08	2.31E-09	2.83E-09	3.06E-09	3.44E-09	3.91E-09	4.62E-09	5.77E-09	6.42E-09	7.23E-09	8.49E-09
Th-230	2.33E-09	2.06E-09	3.30E-10	4.08E-10	4.43E-10	5.00E-10	5.71E-10	6.77E-10	8.48E-10	9.47E-10	1.07E-09	1.26E-09
Pa-231	1.11E-08	8.28E-09	2.74E-09	3.18E-09	3.48E-09	3.66E-09	4.02E-09	4.36E-09	5.15E-09	5.58E-09	6.37E-09	6.72E-09
U-232	5.34E-09	4.32E-09	7.70E-10	1.07E-09	1.19E-09	1.38E-09	1.60E-09	1.89E-09	2.14E-09	2.51E-09	2.84E-09	3.12E-09
U-233	1.09E-09	8.74E-10	1.60E-10	2.22E-10	2.45E-10	2.87E-10	3.34E-10	3.87E-10	4.60E-10	5.17E-10	5.81E-10	6.45E-10
U-234	1.07E-09	8.60E-10	1.57E-10	2.18E-10	2.40E-10	2.81E-10	3.28E-10	3.81E-10	4.52E-10	5.08E-10	5.72E-10	6.34E-10
Pu-238	3.27E-09	2.52E-09	7.79E-10	8.89E-10	9.78E-10	1.02E-09	1.10E-09	1.25E-09	1.45E-09	1.56E-09	1.76E-09	1.97E-09
Pu-239	3.63E-09	2.79E-09	8.64E-10	9.86E-10	1.09E-09	1.14E-09	1.22E-09	1.39E-09	1.61E-09	1.73E-09	1.95E-09	2.18E-09
Pu-240	3.62E-09	2.78E-09	8.62E-10	9.84E-10	1.08E-09	1.13E-09	1.22E-09	1.39E-09	1.61E-09	1.73E-09	1.95E-09	2.18E-09
Pu-242	3.38E-09	2.60E-09	8.04E-10	9.18E-10	1.01E-09	1.06E-09	1.14E-09	1.30E-09	1.50E-09	1.61E-09	1.82E-09	2.03E-09
Am-241	3.80E-09	2.84E-09	9.30E-10	1.08E-09	1.18E-09	1.25E-09	1.38E-09	1.49E-09	1.75E-09	1.91E-09	2.17E-09	2.29E-09
Am-243	3.83E-09	2.83E-09	9.66E-10	1.12E-09	1.22E-09	1.28E-09	1.41E-09	1.52E-09	1.78E-09	1.94E-09	2.21E-09	2.33E-09
	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	
Sr-90	3.22E-09	3.98E-09	4.69E-09	5.24E-09	6.59E-09	8.19E-09	9.20E-09	1.16E-08	1.56E-08	2.18E-08	1.19E-07	
Cs-137	1.52E-09	1.57E-09	1.60E-09	1.66E-09	1.75E-09	1.90E-09	2.00E-09	2.19E-09	2.45E-09	3.05E-09	1.25E-08	
Pb-210	1.33E-08	1.53E-08	1.77E-08	2.02E-08	2.38E-08	2.79E-08	3.44E-08	4.19E-08	5.54E-08	8.52E-08	3.21E-07	
Ra-226	8.65E-10	9.38E-10	1.04E-09	1.14E-09	1.44E-09	1.61E-09	1.88E-09	2.31E-09	2.91E-09	4.27E-09	1.80E-08	
Ac-227	3.20E-08	3.74E-08	4.41E-08	5.06E-08	6.12E-08	7.22E-08	8.76E-08	1.02E-07	1.17E-07	1.43E-07	1.71E-07	
Th-229	1.01E-08	1.18E-08	1.40E-08	1.61E-08	1.94E-08	2.28E-08	2.76E-08	3.26E-08	3.71E-08	4.55E-08	5.43E-08	
Th-230	1.51E-09	1.76E-09	2.08E-09	2.40E-09	2.89E-09	3.40E-09	4.12E-09	4.88E-09	5.56E-09	6.82E-09	8.13E-09	
Pa-231	7.88E-09	8.99E-09	9.94E-08	1.13E-08	1.34E-08	1.60E-08	1.85E-08	2.08E-08	2.41E-08	2.89E-08	3.45E-08	
U-232	3.69E-09	4.26E-09	5.04E-09	5.72E-09	6.51E-09	7.89E-09	9.04E-09	1.08E-08	1.18E-08	1.45E-08	1.74E-08	
U-233	7.65E-10	8.99E-10	1.03E-09	1.17E-09	1.32E-09	1.61E-09	1.86E-09	2.20E-09	2.41E-09	2.93E-09	3.52E-09	
U-234	7.51E-10	8.83E-10	1.01E-09	1.15E-09	1.30E-09	1.58E-09	1.83E-09	2.17E-09	2.37E-09	2.88E-09	3.46E-09	
Pu-238	2.26E-09	2.58E-09	2.93E-09	3.32E-09	3.97E-09	4.64E-09	5.45E-09	6.28E-09	7.29E-09	8.68E-09	1.04E-08	
Pu-239	2.51E-09	2.86E-09	3.25E-09	3.69E-09	4.41E-09	5.15E-09	6.04E-09	6.96E-09	8.08E-09	9.62E-09	1.15E-08	
Pu-240	2.34E-09	2.67E-09	3.03E-09	3.43E-09	4.11E-09	4.79E-09	5.63E-09	6.48E-09	7.53E-09	8.96E-09	1.07E-08	
Pu-242	2.42E-09	2.76E-09	3.11E-09	3.49E-09	4.15E-09	4.98E-09	5.78E-09	6.61E-09	7.65E-09	9.00E-09	1.09E-08	
Am-241	2.70E-09	3.08E-09	3.40E-09	3.87E-09	4.58E-09	5.48E-09	6.34E-09	7.11E-09	8.27E-09	9.92E-09	1.18E-08	
Am-243	2.73E-09	3.11E-09	3.43E-09	3.89E-09	4.60E-09	5.50E-09	6.36E-09	7.13E-09	8.28E-09	9.93E-09	1.19E-08	

6.2.3 Intermediate Ash Thicknesses

For intermediate ash thicknesses, a decision needs to be made, to select one of the two sets of BDCFs to better represent the BDCFs for the predicted ash thickness conditions. The major difference between the sets is that doses calculated using BDCFs for thin ash layers are a function of surface activity deposition, while it is recommended that doses calculated using thick ash layer are independent of the ash layer thickness. This is achieved by normalizing them to 15-cm ash layer thickness. Both sets are derived based on an assumed concentration of TSP and PM_{10} fraction. In other words, it is assumed that the level of "dustiness" in the air is the same, regardless of whether the ash thickness is 1 cm or 15 cm. Therefore, for consistency, the same assumption should be used for the intermediate ash thicknesses. Since in both cases the contributions from inhalation and resuspension are the same, the difference in the BDCF values results from the contribution of root uptake. More conservative values will be obtained if BDCFs for 15-cm thickness of ash are used. The scaling, or normalizing, procedure described previously for thick ash deposits can be applied. For example, if the calculations indicate that the ash deposit thickness is 10 cm and the surface activity concentration is 8 pCi/m^2, the corresponding activity concentration for 15-cm ash layer would be equal to 12 pCi/m^2 (activity concentration in ash is the same in both cases). Doses could then be calculated by using BDCFs developed for the 15-cm layer of ash.

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7.3 ASSUMPTIONS

Initial Use - Assumption of the value and distribution of crop resuspension factor following volcanic eruption and for the steady state conditions. TBV-4716.

Initial Use - Assumption of the value and distribution of inadvertent soil ingestion following volcanic eruption. TBV-4717.

Initial Use - Assumption of the value and distribution of mass loading following volcanic eruption and for the steady state conditions. TBV-4718.

Initial Use - Assumption of the value of ash density for the steady state conditions. TBV-4719.

Initial Use - Assumption of the value of food transfer coefficients for lead. TBV-4720.

7.4 CORRESPONDENCE CITED

Harris, M.W. 1997. "Recommendation of Models to be Used in the Biosphere Modeling Effort." Letter from M.W. Harris (CRWMS M&O) to W.R. Dixon (DOE/YMSCO), July 8, 1997, LV.ESR.CHT.07/97-125, with attachment. ACC: MOL.19971124.0033 MOL.19971124.0034.

7.5 CODES, STANDARDS, AND REGULATIONS

10 CFR 20. Energy: Standards for Protection Against Radiation. Readily Available.

40 CFR 58. Protection of Environment: Ambient Air Quality Surveillance.

64 FR 46976. Environmental Radiation Protection Standards for Yucca Mountain, Nevada; Proposed rule 40 CFR 197. Readily Available.

64 FR 8640. Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada. Proposed rule 10 CFR 63. Readily Available.

7.6 PROCEDURES

AP-2.1Q, Rev. 0, ICN 0. *Indoctrination and Training of Personnel.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19990702.0318.

AP-2.2Q, Rev. 0, ICN 0. *Establishment and Verification of Required Education and Experience of Personnel.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19990701.0618.

AP-2.13Q, Rev. 0, ICN 3. *Technical Product Development Planning.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000504.0305.

AP-2.16Q, Rev. 0, ICN 0. *Activity Evaluation.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000207.0716.

AP-3.12Q, Rev. 0, ICN 2. *Calculations.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL. MOL.20000620.0068.

AP-3.14Q, Rev. 0 ICN 1. *Transmittal of Input.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL. MOL.20000427.0419.

AP-3.15Q, Rev. 1 ICN 2. *Managing Technical Product Inputs.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000713.0363.

AP-6.1Q, Rev. 5, ICN 0. *Controlled Documents.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL. MOL.20000608.0009.

AP-17.1Q, Rev. 1, ICN 2. *Record Source Responsibilities for Inclusionary Records.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19991217.0505.

AP-SI.1Q, Rev.2 ICN 4 *Software Management.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.20000223.0508.

AP-SIII.2Q. Rev. 0, ICN 2. *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL.19991214.0625.

AP-SIII.3Q. Rev. 0, ICN 3. *Submittal and Incorporation of Data to the Technical Data Management System.* Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: MOL. MOL.20000418.0808.

AP-SV.1Q. Rev. 0, ICN 1. *Control of the Electronic Management of Data.* Las Vegas, Nevada: CRWMS M&O. ACC: MOL. MOL.20000512.0068.

8. ATTACHMENTS

Attachment	Title
I	Files Generated by GENII-S

ATTACHMENT I

FILES GENERATED BY GENII-S

(12 pages)

BDCFs for an average member of the critical group, thin ash layer, transition phase.

VC1AC227	FLG	712	05-05-00	1:35p
VC1AC227	INP	14,200	05-05-00	1:35p
VC1AC227	OUT	1,292	05-05-00	1:33p
VC1AC227	PTI	7,397	05-05-00	1:33p
VC1AC227	VEC	45,800	05-05-00	1:33p
VC1AM241	FLG	712	05-07-00	10:03a
VC1AM241	INP	14,200	05-07-00	10:04a
VC1AM241	OUT	1,348	05-07-00	10:04a
VC1AM241	PTI	7,397	05-07-00	10:04a
VC1AM241	VEC	45,800	05-07-00	10:04a
VC1AM243	FLG	712	05-07-00	10:05a
VC1AM243	INP	14,200	05-07-00	10:06a
VC1AM243	OUT	1,292	05-07-00	10:06a
VC1AM243	PTI	7,397	05-07-00	10:06a
VC1AM243	VEC	45,800	05-07-00	10:06a
VC1CS137	FLG	712	05-05-00	1:38p
VC1CS137	INP	14,200	05-05-00	1:39p
VC1CS137	OUT	1,292	05-05-00	1:39p
VC1CS137	PTI	7,397	05-05-00	1:39p
VC1CS137	VEC	45,800	05-05-00	1:39p
VC1PA231	FLG	712	05-07-00	9:43a
VC1PA231	INP	14,200	05-07-00	9:44a
VC1PA231	OUT	1,292	05-07-00	9:44a
VC1PA231	PTI	7,397	05-07-00	9:44a
VC1PA231	VEC	45,800	05-07-00	9:44a
VC1PB210	FLG	712	05-07-00	9:29a
VC1PB210	INP	14,200	05-07-00	9:31a
VC1PB210	OUT	1,292	05-07-00	9:32a
VC1PB210	PTI	7,397	05-07-00	9:32a
VC1PB210	VEC	45,800	05-07-00	9:32a
VC1PU238	FLG	712	05-07-00	9:54a
VC1PU238	INP	14,200	05-07-00	9:54a
VC1PU238	OUT	1,292	05-07-00	9:55a
VC1PU238	PTI	7,397	05-07-00	9:55a
VC1PU238	VEC	45,800	05-07-00	9:55a
VC1PU239	FLG	712	05-07-00	9:56a
VC1PU239	INP	14,200	05-07-00	9:56a
VC1PU239	OUT	1,292	05-07-00	9:57a
VC1PU239	PTI	7,397	05-07-00	9:57a
VC1PU239	VEC	45,800	05-07-00	9:57a
VC1PU240	FLG	712	05-07-00	9:58a
VC1PU240	INP	14,200	05-07-00	9:59a
VC1PU240	OUT	1,292	05-07-00	9:59a
VC1PU240	PTI	7,397	05-07-00	9:59a
VC1PU240	VEC	45,800	05-07-00	9:59a
VC1PU242	FLG	712	05-07-00	10:00a
VC1PU242	INP	14,200	05-07-00	10:01a
VC1PU242	OUT	1,348	05-07-00	10:01a
VC1PU242	PTI	7,397	05-07-00	10:01a

VC1PU242	VEC	45,800	05-07-00	10:01a
VC1RA226	FLG	712	05-07-00	9:35a
VC1RA226	INP	14,200	05-07-00	9:36a
VC1RA226	OUT	1,292	05-07-00	9:36a
VC1RA226	PTI	7,397	05-07-00	9:36a
VC1RA226	VEC	45,800	05-07-00	9:36a
VC1SR90	FLG	711	05-05-00	1:36p
VC1SR90	INP	14,200	05-05-00	1:36p
VC1SR90	OUT	1,292	05-05-00	10:54a
VC1SR90	PTI	7,397	05-05-00	10:54a
VC1SR90	VEC	45,800	05-05-00	10:54a
VC1TH229	FLG	712	05-07-00	9:38a
VC1TH229	INP	14,200	05-07-00	9:38a
VC1TH229	OUT	1,292	05-07-00	9:39a
VC1TH229	PTI	7,397	05-07-00	9:39a
VC1TH229	VEC	45,800	05-07-00	9:39a
VC1TH230	FLG	712	05-07-00	9:41a
VC1TH230	INP	14,200	05-07-00	9:41a
VC1TH230	OUT	1,292	05-07-00	9:42a
VC1TH230	PTI	7,397	05-07-00	9:42a
VC1TH230	VEC	45,800	05-07-00	9:42a
VC1U232	FLG	712	05-07-00	9:46a
VC1U232	INP	14,200	05-07-00	9:46a
VC1U232	OUT	1,460	05-07-00	9:47a
VC1U232	PTI	7,397	05-07-00	9:47a
VC1U232	VEC	45,800	05-07-00	9:47a
VC1U233	FLG	712	05-07-00	9:48a
VC1U233	INP	14,200	05-07-00	9:49a
VC1U233	OUT	1,292	05-07-00	9:49a
VC1U233	PTI	7,397	05-07-00	9:49a
VC1U233	VEC	45,800	05-07-00	9:49a
VC1U234	FLG	712	05-07-00	9:51a
VC1U234	INP	14,200	05-07-00	9:52a
VC1U234	OUT	1,292	05-07-00	9:52a
VC1U234	PTI	7,397	05-07-00	9:52a
VC1U234	VEC	45,800	05-07-00	9:52a

BDCFs for an average member of the critical group, thin and thick ash layers, steady state phase.

VC2AC227	FLG	712	05-07-00	10:18a
VC2AC227	INP	14,180	05-07-00	10:18a
VC2AC227	OUT	1,292	05-07-00	10:18a
VC2AC227	PTI	7,397	05-07-00	10:18a
VC2AC227	VEC	42,560	05-07-00	10:18a
VC2AM241	FLG	712	05-07-00	10:59a
VC2AM241	INP	14,180	05-07-00	10:59a
VC2AM241	OUT	1,348	05-07-00	10:59a
VC2AM241	PTI	7,397	05-07-00	10:59a
VC2AM241	VEC	42,560	05-07-00	10:59a
VC2AM243	FLG	712	05-07-00	11:01a

VC2AM243	INP	14,180	05-07-00	11:01a
VC2AM243	OUT	1,292	05-07-00	11:01a
VC2AM243	PTI	7,397	05-07-00	11:01a
VC2AM243	VEC	42,560	05-07-00	11:01a
VC2CS137	FLG	712	05-07-00	10:29a
VC2CS137	INP	14,180	05-07-00	10:29a
VC2CS137	OUT	1,292	05-07-00	10:29a
VC2CS137	PTI	7,397	05-07-00	10:29a
VC2CS137	VEC	42,560	05-07-00	10:29a
VC2PA231	FLG	712	05-07-00	10:42a
VC2PA231	INP	14,180	05-07-00	10:42a
VC2PA231	OUT	1,292	05-07-00	10:42a
VC2PA231	PTI	7,397	05-07-00	10:42a
VC2PA231	VEC	42,560	05-07-00	10:42a
VC2PB210	FLG	712	05-07-00	10:31a
VC2PB210	INP	14,180	05-07-00	10:31a
VC2PB210	OUT	1,292	05-07-00	10:32a
VC2PB210	PTI	7,397	05-07-00	10:32a
VC2PB210	VEC	42,560	05-07-00	10:32a
VC2PU238	FLG	712	05-07-00	10:51a
VC2PU238	INP	14,180	05-07-00	10:51a
VC2PU238	OUT	1,292	05-07-00	10:51a
VC2PU238	PTI	7,397	05-07-00	10:51a
VC2PU238	VEC	42,560	05-07-00	10:51a
VC2PU239	FLG	712	05-07-00	10:53a
VC2PU239	INP	14,180	05-07-00	10:53a
VC2PU239	OUT	1,292	05-07-00	10:53a
VC2PU239	PTI	7,397	05-07-00	10:53a
VC2PU239	VEC	42,560	05-07-00	10:53a
VC2PU240	FLG	712	05-07-00	10:55a
VC2PU240	INP	14,180	05-07-00	10:55a
VC2PU240	OUT	1,292	05-07-00	10:55a
VC2PU240	PTI	7,397	05-07-00	10:55a
VC2PU240	VEC	42,560	05-07-00	10:55a
VC2PU242	FLG	712	05-07-00	10:56a
VC2PU242	INP	14,180	05-07-00	10:57a
VC2PU242	OUT	1,348	05-07-00	10:57a
VC2PU242	PTI	7,397	05-07-00	10:57a
VC2PU242	VEC	42,560	05-07-00	10:57a
VC2RA226	FLG	712	05-07-00	10:33a
VC2RA226	INP	14,180	05-07-00	10:33a
VC2RA226	OUT	1,292	05-07-00	10:34a
VC2RA226	PTI	7,397	05-07-00	10:34a
VC2RA226	VEC	42,560	05-07-00	10:34a
VC2SR90	FLG	711	05-07-00	10:22a
VC2SR90	INP	14,180	05-07-00	10:22a
VC2SR90	OUT	1,292	05-07-00	10:23a
VC2SR90	PTI	7,397	05-07-00	10:23a
VC2SR90	VEC	42,560	05-07-00	10:23a
VC2TH229	FLG	712	05-07-00	10:35a
VC2TH229	INP	14,180	05-07-00	10:36a
VC2TH229	OUT	1,292	05-07-00	10:36a

VC2TH229	PTI	7,397	05-07-00	10:36a
VC2TH229	VEC	42,560	05-07-00	10:36a
VC2TH230	FLG	712	05-07-00	10:40a
VC2TH230	INP	14,180	05-07-00	10:40a
VC2TH230	OUT	1,292	05-07-00	10:40a
VC2TH230	PTI	7,397	05-07-00	10:40a
VC2TH230	VEC	42,560	05-07-00	10:40a
VC2U232	FLG	712	05-07-00	10:44a
VC2U232	INP	14,180	05-07-00	10:44a
VC2U232	OUT	1,460	05-07-00	10:45a
VC2U232	PTI	7,397	05-07-00	10:45a
VC2U232	VEC	42,560	05-07-00	10:45a
VC2U233	FLG	712	05-07-00	10:46a
VC2U233	INP	14,180	05-07-00	10:46a
VC2U233	OUT	1,292	05-07-00	10:47a
VC2U233	PTI	7,397	05-07-00	10:47a
VC2U233	VEC	42,560	05-07-00	10:47a
VC2U234	FLG	712	05-07-00	10:49a
VC2U234	INP	14,180	05-07-00	10:49a
VC2U234	OUT	1,292	05-07-00	10:49a
VC2U234	PTI	7,397	05-07-00	10:49a
VC2U234	VEC	42,560	05-07-00	10:49a

BDCFs for an average member of the critical group, thick ash layer, transition phase

VC3AC227	FLG	712	05-07-00	11:05a
VC3AC227	INP	14,188	05-07-00	11:07a
VC3AC227	OUT	1,292	05-07-00	11:08a
VC3AC227	PTI	7,397	05-07-00	11:08a
VC3AC227	VEC	45,800	05-07-00	11:08a
VC3AM241	FLG	712	05-07-00	11:54a
VC3AM241	INP	14,188	05-07-00	11:54a
VC3AM241	OUT	1,348	05-07-00	11:55a
VC3AM241	PTI	7,397	05-07-00	11:55a
VC3AM241	VEC	45,800	05-07-00	11:55a
VC3AM243	FLG	712	05-07-00	11:56a
VC3AM243	INP	14,188	05-07-00	11:56a
VC3AM243	OUT	1,292	05-07-00	11:57a
VC3AM243	PTI	7,397	05-07-00	11:57a
VC3AM243	VEC	45,800	05-07-00	11:57a
VC3CS137	FLG	712	05-07-00	11:24a
VC3CS137	INP	14,188	05-07-00	11:25a
VC3CS137	OUT	1,292	05-07-00	11:25a
VC3CS137	PTI	7,397	05-07-00	11:25a
VC3CS137	VEC	45,800	05-07-00	11:25a
VC3PA231	FLG	712	05-07-00	11:36a
VC3PA231	INP	14,188	05-07-00	11:36a
VC3PA231	OUT	1,292	05-07-00	11:37a
VC3PA231	PTI	7,397	05-07-00	11:37a
VC3PA231	VEC	45,800	05-07-00	11:37a
VC3PB210	FLG	712	05-07-00	11:27a

VC3PB210	INP	14,188	05-07-00	11:27a
VC3PB210	OUT	1,292	05-07-00	11:28a
VC3PB210	PTI	7,397	05-07-00	11:28a
VC3PB210	VEC	45,800	05-07-00	11:28a
VC3PU238	FLG	712	05-07-00	11:46a
VC3PU238	INP	14,188	05-07-00	11:47a
VC3PU238	OUT	1,292	05-07-00	11:47a
VC3PU238	PTI	7,397	05-07-00	11:47a
VC3PU238	VEC	45,800	05-07-00	11:47a
VC3PU239	FLG	712	05-07-00	11:48a
VC3PU239	INP	14,188	05-07-00	11:48a
VC3PU239	OUT	1,292	05-07-00	11:49a
VC3PU239	PTI	7,397	05-07-00	11:49a
VC3PU239	VEC	45,800	05-07-00	11:49a
VC3PU240	FLG	712	05-07-00	11:50a
VC3PU240	INP	14,188	05-07-00	11:50a
VC3PU240	OUT	1,292	05-07-00	11:51a
VC3PU240	PTI	7,397	05-07-00	11:51a
VC3PU240	VEC	45,800	05-07-00	11:51a
VC3PU242	FLG	712	05-07-00	11:52a
VC3PU242	INP	14,188	05-07-00	11:52a
VC3PU242	OUT	1,348	05-07-00	11:53a
VC3PU242	PTI	7,397	05-07-00	11:53a
VC3PU242	VEC	45,800	05-07-00	11:53a
VC3RA226	FLG	712	05-07-00	11:29a
VC3RA226	INP	14,188	05-07-00	11:30a
VC3RA226	OUT	1,292	05-07-00	11:30a
VC3RA226	PTI	7,397	05-07-00	11:30a
VC3RA226	VEC	45,800	05-07-00	11:30a
VC3SR90	FLG	711	05-07-00	11:14a
VC3SR90	INP	14,188	05-07-00	11:14a
VC3SR90	OUT	1,292	05-07-00	11:14a
VC3SR90	PTI	7,397	05-07-00	11:14a
VC3SR90	VEC	45,800	05-07-00	11:14a
VC3TH229	FLG	712	05-07-00	11:32a
VC3TH229	INP	14,188	05-07-00	11:32a
VC3TH229	OUT	1,292	05-07-00	11:33a
VC3TH229	PTI	7,397	05-07-00	11:33a
VC3TH229	VEC	45,800	05-07-00	11:33a
VC3TH230	FLG	712	05-07-00	11:34a
VC3TH230	INP	14,188	05-07-00	11:34a
VC3TH230	OUT	1,292	05-07-00	11:35a
VC3TH230	PTI	7,397	05-07-00	11:35a
VC3TH230	VEC	45,800	05-07-00	11:35a
VC3U232	FLG	712	05-07-00	11:39a
VC3U232	INP	14,188	05-07-00	11:39a
VC3U232	OUT	1,460	05-07-00	11:40a
VC3U232	PTI	7,397	05-07-00	11:40a
VC3U232	VEC	45,800	05-07-00	11:40a
VC3U233	FLG	712	05-07-00	11:41a
VC3U233	INP	14,188	05-07-00	11:41a
VC3U233	OUT	1,292	05-07-00	11:42a

VC3U233	PTI	7,397	05-07-00	11:42a
VC3U233	VEC	45,800	05-07-00	11:42a
VC3U234	FLG	712	05-07-00	11:44a
VC3U234	INP	14,188	05-07-00	11:44a
VC3U234	OUT	1,292	05-07-00	11:44a
VC3U234	PTI	7,397	05-07-00	11:44a
VC3U234	VEC	45,800	05-07-00	11:44a

BDCFs for the RMEI, thin ash layer, transition phase

VR1AC227	FLG	712	07-19-00	12:01p
VR1AC227	INP	14,190	07-19-00	12:01p
VR1AC227	OUT	1,292	07-19-00	7:08a
VR1AC227	PTI	7,397	07-19-00	7:08a
VR1AC227	VEC	45,800	07-19-00	7:08a
VR1AM241	FLG	712	07-19-00	12:02p
VR1AM241	INP	14,190	07-19-00	12:02p
VR1AM241	OUT	1,348	07-19-00	7:09a
VR1AM241	PTI	7,397	07-19-00	7:09a
VR1AM241	VEC	45,800	07-19-00	7:09a
VR1AM243	FLG	712	07-19-00	12:03p
VR1AM243	INP	14,190	07-19-00	12:03p
VR1AM243	OUT	1,292	07-19-00	7:11a
VR1AM243	PTI	7,397	07-19-00	7:11a
VR1AM243	VEC	45,800	07-19-00	7:11a
VR1CS137	FLG	712	07-19-00	12:04p
VR1CS137	INP	14,190	07-19-00	12:04p
VR1CS137	OUT	1,292	07-19-00	7:12a
VR1CS137	PTI	7,397	07-19-00	7:12a
VR1CS137	VEC	45,800	07-19-00	7:12a
VR1PA231	FLG	712	07-19-00	12:04p
VR1PA231	INP	14,190	07-19-00	12:04p
VR1PA231	OUT	1,292	07-19-00	7:14a
VR1PA231	PTI	7,397	07-19-00	7:14a
VR1PA231	VEC	45,800	07-19-00	7:14a
VR1PB210	FLG	712	07-19-00	12:05p
VR1PB210	INP	14,190	07-19-00	12:05p
VR1PB210	OUT	1,292	07-19-00	7:15a
VR1PB210	PTI	7,397	07-19-00	7:15a
VR1PB210	VEC	45,800	07-19-00	7:15a
VR1PU238	FLG	712	07-19-00	12:05p
VR1PU238	INP	14,190	07-19-00	12:05p
VR1PU238	OUT	1,292	07-19-00	7:17a
VR1PU238	PTI	7,397	07-19-00	7:17a
VR1PU238	VEC	45,800	07-19-00	7:17a
VR1PU239	FLG	712	07-19-00	12:06p
VR1PU239	INP	14,190	07-19-00	12:06p
VR1PU239	OUT	1,292	07-19-00	7:18a
VR1PU239	PTI	7,397	07-19-00	7:18a
VR1PU239	VEC	45,800	07-19-00	7:18a
VR1PU240	FLG	712	07-19-00	12:07p

VR1PU240	INP	14,190	07-19-00	12:07p
VR1PU240	OUT	1,292	07-19-00	7:19a
VR1PU240	PTI	7,397	07-19-00	7:19a
VR1PU240	VEC	45,800	07-19-00	7:19a
VR1PU242	FLG	712	07-19-00	12:07p
VR1PU242	INP	14,190	07-19-00	12:07p
VR1PU242	OUT	1,348	07-19-00	7:20a
VR1PU242	PTI	7,397	07-19-00	7:20a
VR1PU242	VEC	45,800	07-19-00	7:20a
VR1RA226	FLG	712	07-19-00	12:08p
VR1RA226	INP	14,190	07-19-00	12:08p
VR1RA226	OUT	1,292	07-19-00	7:21a
VR1RA226	PTI	7,397	07-19-00	7:21a
VR1RA226	VEC	45,800	07-19-00	7:21a
VR1SR90	FLG	711	07-19-00	12:09p
VR1SR90	INP	14,190	07-19-00	12:09p
VR1SR90	OUT	1,292	07-19-00	7:23a
VR1SR90	PTI	7,397	07-19-00	7:23a
VR1SR90	VEC	45,800	07-19-00	7:23a
VR1TH229	FLG	712	07-19-00	12:09p
VR1TH229	INP	14,190	07-19-00	12:09p
VR1TH229	OUT	1,292	07-19-00	7:24a
VR1TH229	PTI	7,397	07-19-00	7:24a
VR1TH229	VEC	45,800	07-19-00	7:24a
VR1TH230	FLG	712	07-19-00	12:10p
VR1TH230	INP	14,190	07-19-00	12:10p
VR1TH230	OUT	1,292	07-19-00	7:25a
VR1TH230	PTI	7,397	07-19-00	7:25a
VR1TH230	VEC	45,800	07-19-00	7:25a
VR1U232	FLG	712	07-19-00	12:10p
VR1U232	INP	14,190	07-19-00	12:10p
VR1U232	OUT	1,460	07-19-00	7:26a
VR1U232	PTI	7,397	07-19-00	7:26a
VR1U232	VEC	45,800	07-19-00	7:26a
VR1U233	FLG	712	07-19-00	12:11p
VR1U233	INP	14,190	07-19-00	12:11p
VR1U233	OUT	1,292	07-19-00	7:27a
VR1U233	PTI	7,397	07-19-00	7:27a
VR1U233	VEC	45,800	07-19-00	7:27a
VR1U234	FLG	712	07-19-00	12:11p
VR1U234	INP	14,190	07-19-00	12:11p
VR1U234	OUT	1,292	07-19-00	7:28a
VR1U234	PTI	7,397	07-19-00	7:28a
VR1U234	VEC	45,800	07-19-00	7:28a

BDCFs for the RMEI, thin ash layer and thick ash layer, steady state

VR2AC227	FLG	712	07-14-00	12:51p
VR2AC227	INP	14,175	07-14-00	12:51p
VR2AC227	OUT	1,292	07-13-00	3:36p
VR2AC227	PTI	7,397	07-13-00	3:36p

VR2AC227	VEC	42,560	07-13-00	3:36p
VR2AM241	FLG	712	07-14-00	12:52p
VR2AM241	INP	14,175	07-14-00	12:52p
VR2AM241	OUT	1,348	07-13-00	3:37p
VR2AM241	PTI	7,397	07-13-00	3:37p
VR2AM241	VEC	42,560	07-13-00	3:37p
VR2AM243	FLG	712	07-14-00	12:53p
VR2AM243	INP	14,175	07-14-00	12:53p
VR2AM243	OUT	1,292	07-13-00	3:38p
VR2AM243	PTI	7,397	07-13-00	3:38p
VR2AM243	VEC	42,560	07-13-00	3:38p
VR2CS137	FLG	712	07-14-00	12:54p
VR2CS137	INP	14,175	07-14-00	12:54p
VR2CS137	OUT	1,292	07-13-00	3:39p
VR2CS137	PTI	7,397	07-13-00	3:39p
VR2CS137	VEC	42,560	07-13-00	3:39p
VR2PA231	FLG	712	07-14-00	12:54p
VR2PA231	INP	14,175	07-14-00	12:54p
VR2PA231	OUT	1,292	07-13-00	3:40p
VR2PA231	PTI	7,397	07-13-00	3:40p
VR2PA231	VEC	42,560	07-13-00	3:40p
VR2PB210	FLG	712	07-14-00	12:55p
VR2PB210	INP	14,175	07-14-00	12:55p
VR2PB210	OUT	1,292	07-13-00	3:42p
VR2PB210	PTI	7,397	07-13-00	3:42p
VR2PB210	VEC	42,560	07-13-00	3:42p
VR2PU238	FLG	712	07-14-00	12:56p
VR2PU238	INP	14,175	07-14-00	12:56p
VR2PU238	OUT	1,292	07-13-00	3:42p
VR2PU238	PTI	7,397	07-13-00	3:42p
VR2PU238	VEC	42,560	07-13-00	3:42p
VR2PU239	FLG	712	07-14-00	12:56p
VR2PU239	INP	14,175	07-14-00	12:56p
VR2PU239	OUT	1,292	07-13-00	3:43p
VR2PU239	PTI	7,397	07-13-00	3:43p
VR2PU239	VEC	42,560	07-13-00	3:43p
VR2PU240	FLG	712	07-14-00	12:57p
VR2PU240	INP	14,175	07-14-00	12:57p
VR2PU240	OUT	1,292	07-13-00	3:44p
VR2PU240	PTI	7,397	07-13-00	3:44p
VR2PU240	VEC	42,560	07-13-00	3:44p
VR2PU242	FLG	712	07-14-00	12:57p
VR2PU242	INP	14,175	07-14-00	12:57p
VR2PU242	OUT	1,348	07-13-00	3:45p
VR2PU242	PTI	7,397	07-13-00	3:45p
VR2PU242	VEC	42,560	07-13-00	3:45p
VR2RA226	FLG	712	07-14-00	4:31p
VR2RA226	INP	14,175	07-14-00	4:31p
VR2RA226	OUT	1,292	07-13-00	3:46p
VR2RA226	PTI	7,397	07-13-00	3:46p
VR2RA226	VEC	42,560	07-13-00	3:46p
VR2SR90	FLG	711	07-14-00	4:31p

VR2SR90	INP	14,175	07-14-00	4:31p
VR2SR90	OUT	1,292	07-13-00	3:47p
VR2SR90	PTI	7,397	07-13-00	3:47p
VR2SR90	VEC	42,560	07-13-00	3:47p
VR2TH229	FLG	712	07-14-00	4:32p
VR2TH229	INP	14,175	07-14-00	4:32p
VR2TH229	OUT	1,292	07-13-00	3:49p
VR2TH229	PTI	7,397	07-13-00	3:49p
VR2TH229	VEC	42,560	07-13-00	3:49p
VR2TH230	FLG	712	07-14-00	4:33p
VR2TH230	INP	14,175	07-14-00	4:33p
VR2TH230	OUT	1,292	07-13-00	3:50p
VR2TH230	PTI	7,397	07-13-00	3:50p
VR2TH230	VEC	42,560	07-13-00	3:50p
VR2U232	FLG	712	07-14-00	4:34p
VR2U232	INP	14,175	07-14-00	4:34p
VR2U232	OUT	1,460	07-13-00	3:51p
VR2U232	PTI	7,397	07-13-00	3:51p
VR2U232	VEC	42,560	07-13-00	3:51p
VR2U233	FLG	712	07-14-00	4:35p
VR2U233	INP	14,175	07-14-00	4:35p
VR2U233	OUT	1,292	07-13-00	3:52p
VR2U233	PTI	7,397	07-13-00	3:52p
VR2U233	VEC	42,560	07-13-00	3:52p
VR2U234	FLG	712	07-14-00	4:35p
VR2U234	INP	14,175	07-14-00	4:35p
VR2U234	OUT	1,292	07-13-00	3:53p
VR2U234	PTI	7,397	07-13-00	3:53p
VR2U234	VEC	42,560	07-13-00	3:53p

BDCFs for the RMEI, thick ash layer, transition phase

VR3AC227	FLG	712	07-14-00	4:36p
VR3AC227	INP	14,183	07-14-00	4:36p
VR3AC227	OUT	1,292	07-13-00	3:54p
VR3AC227	PTI	7,397	07-13-00	3:54p
VR3AC227	VEC	45,800	07-13-00	3:54p
VR3AM241	FLG	712	07-14-00	4:37p
VR3AM241	INP	14,183	07-14-00	4:37p
VR3AM241	OUT	1,348	07-14-00	8:09a
VR3AM241	PTI	7,397	07-14-00	8:09a
VR3AM241	VEC	45,800	07-14-00	8:09a
VR3AM243	FLG	712	07-14-00	4:38p
VR3AM243	INP	14,182	07-14-00	4:38p
VR3AM243	OUT	1,292	07-14-00	8:11a
VR3AM243	PTI	7,397	07-14-00	8:11a
VR3AM243	VEC	45,800	07-14-00	8:11a
VR3CS137	FLG	712	07-14-00	4:38p
VR3CS137	INP	14,183	07-14-00	4:38p
VR3CS137	OUT	1,292	07-14-00	8:13a
VR3CS137	PTI	7,397	07-14-00	8:13a

VR3CS137	VEC	45,800	07-14-00	8:13a
VR3PA231	FLG	712	07-14-00	4:39p
VR3PA231	INP	14,183	07-14-00	4:39p
VR3PA231	OUT	1,292	07-14-00	8:16a
VR3PA231	PTI	7,397	07-14-00	8:16a
VR3PA231	VEC	45,800	07-14-00	8:16a
VR3PB210	FLG	712	07-17-00	8:49a
VR3PB210	INP	14,183	07-17-00	8:49a
VR3PB210	OUT	1,292	07-14-00	8:19a
VR3PB210	PTI	7,397	07-14-00	8:19a
VR3PB210	VEC	45,800	07-14-00	8:19a
VR3PU238	FLG	712	07-14-00	4:40p
VR3PU238	INP	14,183	07-14-00	4:40p
VR3PU238	OUT	1,292	07-14-00	8:20a
VR3PU238	PTI	7,397	07-14-00	8:20a
VR3PU238	VEC	45,800	07-14-00	8:20a
VR3PU239	FLG	712	07-14-00	4:40p
VR3PU239	INP	14,183	07-14-00	4:40p
VR3PU239	OUT	1,292	07-14-00	8:22a
VR3PU239	PTI	7,397	07-14-00	8:22a
VR3PU239	VEC	45,800	07-14-00	8:22a
VR3PU240	FLG	712	07-14-00	4:41p
VR3PU240	INP	14,183	07-14-00	4:41p
VR3PU240	OUT	1,292	07-14-00	8:24a
VR3PU240	PTI	7,397	07-14-00	8:24a
VR3PU240	VEC	45,800	07-14-00	8:24a
VR3PU242	FLG	712	07-14-00	4:42p
VR3PU242	INP	14,183	07-14-00	4:42p
VR3PU242	OUT	1,348	07-14-00	8:25a
VR3PU242	PTI	7,397	07-14-00	8:25a
VR3PU242	VEC	45,800	07-14-00	8:25a
VR3RA226	FLG	712	07-14-00	4:43p
VR3RA226	INP	14,183	07-14-00	4:43p
VR3RA226	OUT	1,292	07-14-00	8:27a
VR3RA226	PTI	7,397	07-14-00	8:27a
VR3RA226	VEC	45,800	07-14-00	8:27a
VR3SR90	FLG	711	07-14-00	4:43p
VR3SR90	INP	14,183	07-14-00	4:43p
VR3SR90	OUT	1,292	07-14-00	8:29a
VR3SR90	PTI	7,397	07-14-00	8:29a
VR3SR90	VEC	45,800	07-14-00	8:29a
VR3TH229	FLG	712	07-14-00	4:44p
VR3TH229	INP	14,183	07-14-00	4:44p
VR3TH229	OUT	1,292	07-14-00	8:31a
VR3TH229	PTI	7,397	07-14-00	8:31a
VR3TH229	VEC	45,800	07-14-00	8:31a
VR3TH230	FLG	712	07-14-00	4:44p
VR3TH230	INP	14,183	07-14-00	4:44p
VR3TH230	OUT	1,292	07-14-00	8:33a
VR3TH230	PTI	7,397	07-14-00	8:33a
VR3TH230	VEC	45,800	07-14-00	8:33a
VR3U232	FLG	712	07-14-00	4:45p

VR3U232	INP	14,183	07-14-00	4:45p
VR3U232	OUT	1,460	07-14-00	8:39a
VR3U232	PTI	7,397	07-14-00	8:39a
VR3U232	VEC	45,800	07-14-00	8:39a
VR3U233	FLG	712	07-14-00	4:45p
VR3U233	INP	14,183	07-14-00	4:45p
VR3U233	OUT	1,292	07-14-00	8:40a
VR3U233	PTI	7,397	07-14-00	8:40a
VR3U233	VEC	45,800	07-14-00	8:40a
VR3U234	FLG	712	07-14-00	4:46p
VR3U234	INP	14,183	07-14-00	4:46p
VR3U234	OUT	1,292	07-14-00	8:42a
VR3U234	PTI	7,397	07-14-00	8:42a
VR3U234	VEC	45,800	07-14-00	8:42a