

## CALCULATION TITLE PAGE

RESRAD 6.21 Sensitivity Analysis for Soil-Resident Farmer Scenario

Title

YA-CALC-00-001-03

Calculation Number

### Executive Summary:

RESRAD version 6.21 was used to identify the parameters in the resident farmer model that are correlated to the dose. This calculation presents the methodology used to prioritize parameters and provides the results of the sensitivity analysis. RESRAD also calculates the peak of the mean dose per unit radionuclide concentration that will be used in subsequent calculation of the Derived Concentration Guideline Levels (DCGL) for YNPS site soil.

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## PURPOSE:

The purpose of this calculation is to identify the stochastic parameters used in the RESRAD Resident Farmer Scenario that have the greatest influence on the peak of the mean dose. The RESRAD code, Version 6.21 includes probabilistic modules that perform "sensitivity analyses". Each parameter identified as stochastic is assigned a distribution based on NUREG/CR-6697 guidance. The distribution statistics are used as the input to the probabilistic module of RESRAD. The results of the sensitivity analysis include the peak of the mean dose and information that can be used to determine conservative values for "sensitive" parameters for use in subsequent RESRAD runs to determine nuclide Derived Concentration Guideline Levels (DCGL) for soil.

## SUMMARY OF RESULTS:

The RESRAD results of the sensitivity analyses provide a Partial Rank Correlation Coefficient (PRCC) for each of the stochastic parameters. The PRCC is a measure of correlation of the resultant dose with the input parameters. Parameters were identified as sensitive if the absolute value of the PRCC was greater than or equal to 0.25 and non-sensitive if the absolute value of the PRCC was less than 0.25. The sensitivity runs were performed for a suite of 23 nuclides listed in Table 1.

Table 2 summarizes the results of the sensitivity analyses as follows:

1. R-squared, the coefficient of determination, presents a measure of the variation in the peak dose,
2. The peak of the mean dose for each radionuclide of interest is based on the time that the dose, averaged over all samples, is the maximum.
3. The PRCC value for each sensitive parameter in order of rank, by nuclide. The parameter with the highest PRCC value (rank =1) has the strongest relationship with the total dose.

Table 1 YNPS Suite of Radionuclides	
H-3	Ru-106
C-14	Ag-108m
Mn-54	Sb-125
Fe-55	Cs-134, Cs-137
Co-60	Eu-152, Eu-154, Eu-155
Ni-59, Ni-63	Pu-238, Pu-239, Pu-241
Sr-90	Am-241
Nb-94	Cm-243
Tc-99	

**Table 2**  
**Results of the Sensitivity Analysis**

Radionuclide	Sensitive Parameters	Units	PRCC <sup>1</sup> [R Squared] <sup>2</sup> Peak of the Mean Dose ( mRem/yr) <sup>3</sup>		
			Repetition 1	Repetition 2	Repetition 3
H-3	Depth of roots	m	-0.79	-0.82	-0.84
	Kd of H-3 in contaminated zone	cm <sup>3</sup> /g	-0.52	-0.45	-0.55
	Thickness of contaminated zone	m	0.44	0.51	0.56
			[0.94]	[0.94]	[0.95]
			2.932E-02	2.913E-02	2.947E-02
C-14	Depth of roots	m	-0.86	-0.89	-0.88
	Thickness of contaminated zone	m	0.63	0.65	0.68
	Thickness of evasion layer of C-14	m	0.37	0.36	0.40
			[0.97]	[0.97]	[0.97]
			2.229E+00	2.219E+00	2.227E+00
Mn-54	External gamma shielding factor	Unit-less	0.97	0.98	0.98
	Plant transfer factor for Mn	pCi/g plant per pCi/g soil	0.64	0.70	0.68
	Depth of roots	m	-0.26	-0.33	
			[0.95]	[0.97]	[0.96]
			1.153E+00	1.154E+00	1.156E+00
Fe-55	Meat transfer factor for Fe	pCi/kg per pCi/d	0.94	0.93	0.94
	Plant transfer factor for Fe	pCi/g plant per pCi/g soil	0.67	0.68	0.70
	Depth of roots	m	-0.31	-0.27	-0.31
			[0.90]	[0.89]	[0.90]
			6.907E-04	6.923E-04	6.904E-04
Ni-59	Plant transfer factor for Ni	pCi/g plant per pCi/g soil	0.90	0.90	0.91
	Milk transfer factor for Ni	pCi/l per pCi/d	0.83	0.81	0.81
	Depth of roots	m	-0.61	-0.61	-0.64
			[0.90]	[0.89]	[0.90]
			6.010E-03	6.023E-03	6.550E-03
Ni-63	Plant transfer factor for Ni	pCi/g plant per pCi/g soil	0.90	0.90	0.91
	Milk transfer factor for Ni	pCi/l per pCi/d	0.83	0.81	0.81
	Depth of roots	m	-0.61	-0.61	-0.64

**Table 2**  
**Results of the Sensitivity Analysis**

Radionuclide	Sensitive Parameters	Units	PRCC <sup>1</sup> [R Squared] <sup>2</sup> Peak of the Mean Dose ( mRem/yr) <sup>3</sup>		
			Repetition 1	Repetition 2	Repetition 3
			[0.90] 1.645E-02	[0.89] 1.649E-02	[0.90] 1.793E-02
Co-60	External gamma shielding factor	Unit-less	0.96	0.97	0.96
	Plant transfer factor for Co	pCi/g plant per pCi/g soil	0.61	0.66	0.67
	Meat transfer factor for Co	pCi/kg per pCi/d	0.33	0.30	0.39
	Depth of roots	m	-0.30	-0.37	-0.29
			[0.93]	[0.94]	[0.92]
			5.172E+00	5.154E+00	5.167E+00
Sr-90	Plant transfer factor for Sr	pCi/g plant per pCi/g soil	0.93	0.94	0.94
	Depth of roots	m	-0.64	-0.65	-0.70
	Milk transfer factor for Sr	pCi/l per pCi/d			0.27
			[0.90] 9.270E+00	[0.91] 9.330E+00	[0.92] 9.653E+00
Nb-94	External gamma shielding factor	Unit-less	1.00	1.00	0.99
	Kd of Nb-94 in contaminated zone	cm <sup>3</sup> /g	0.25	0.33	0.29
			[0.99]	[0.99]	[0.99]
			2.927E+00	2.931E+00	2.930E+00
Tc-99	Plant transfer factor for Tc	pCi/g plant per pCi/g soil	0.89	0.91	0.92
	Depth of roots	m	-0.58	-0.61	-0.66
	Kd of Tc-99 in contaminated zone	cm <sup>3</sup> /g	0.25	0.30	0.32
			[0.87] 9.883E-01	[0.88] 9.891E-01	[0.89] 1.027E+00
Ru-106	External gamma shielding factor	Unit-less	0.89	0.91	0.92
	Plant transfer factor for Ru	pCi/g plant per pCi/g soil	0.79	0.77	0.82
	Depth of Roots	m	-0.38	-0.42	-0.47
			[0.86] 3.665E-01	[0.87] 3.668E-01	[0.90] 3.655E-01
Ag-108m	External gamma shielding factor	Unit-less	1.00	1.00	1.00
	Kd of Ag-108m in contaminated zone	cm <sup>3</sup> /g	0.30		0.36

<p><b>Table 2</b>  <b>Results of the Sensitivity Analysis</b></p>					
Radionuclide	Sensitive Parameters	Units	PRCC <sup>1</sup> [R Squared] <sup>2</sup> Peak of the Mean Dose ( mRem/yr) <sup>3</sup>		
			Repetition 1	Repetition 2	Repetition 3
	Plant transfer factor for Ag	pCi/g plant per pCi/g soil			0.37
	Milk transfer factor for Ag	pCi/l per pCi/d			0.31
			[1.00] 2.934E+00	[1.00] 2.932E+00	[1.00] 2.934E+00
<b>Sb-125</b>	External gamma shielding factor	Unit-less	1.0	1.0	0.99
	Plant transfer factor for Sb	pCi/g plant per pCi/g soil	0.29		0.31
	Kd of Sb in contaminated zone	cm <sup>3</sup> /g	[0.99] 6.619E-01	[0.99] 6.627E-01	[0.99] 6.626E-01
<b>Cs-134</b>	External gamma shielding factor	Unit-less	0.88	0.87	0.88
	Plant transfer factor for Cs	pCi/g plant per pCi/g soil	0.79	0.81	0.84
	Depth of roots	m	-0.38	-0.44	-0.46
	Milk transfer factor for Cs	pCi/l per pCi/d	0.32		0.41
	Meat transfer factor for Cs	pCi/kg per pCi/d			0.34
			[0.85] 3.751E+00	[0.86] 3.688E+00	[0.88] 3.728E+00
<b>Cs-137</b>	Plant transfer factor for Cs	pCi/g plant per pCi/g soil	0.86	0.85	0.87
	External gamma shielding factor	Unit-less	0.81	0.78	0.81
	Depth of roots	m	-0.45	-0.51	-0.54
	Milk transfer factor for Cs	pCi/l per pCi/d	0.47	0.46	0.44
	Meat transfer factor for Cs	pCi/kg per pCi/d	0.29	0.36	
			[0.86] 2.042E+00	[0.85] 2.037E+00	[0.87] 2.052E+00
<b>Eu-152</b>	External gamma shielding factor	Unit-less	1.00	1.00	1.00
	Kd of Eu-152 in Contaminated Zone	cm <sup>3</sup> /g	0.25	0.31	0.25
			[0.99] 2.073E+00	[0.99] 2.074E+00	[0.99] 2.073E+00
<b>Eu-154</b>	External gamma shielding factor	Unit-less	1.0	1.0	1.0
	Kd of Eu-154 in Contaminated Zone	cm <sup>3</sup> /g		0.29	0.28
			[1.00]	[1.00]	[1.00]

<p><b>Table 2</b>  <b>Results of the Sensitivity Analysis</b></p>					
Radionuclide	Sensitive Parameters	Units	PRCC <sup>1</sup> [R Squared] <sup>2</sup> Peak of the Mean Dose ( mRem/yr) <sup>3</sup>		
			Repetition 1	Repetition 2	Repetition 3
			2.246E+00	2.247E+00	2.248E+00
Eu-155	External gamma shielding factor Plant transfer factor for Eu Kd of Eu-155 in Contaminated Zone	Unit-less pCi/g plant per pCi/g soil cm <sup>3</sup> /g	1.0	1.0	1.0
			0.38	0.41	0.32
			[0.99]	[1.00]	[1.00]
			5.348E-02	5.353E-02	5.354E-02
Pu-238	Plant transfer factor for Pu  Depth of roots Thickness of the contaminated zone	pCi/g plant per pCi/g soil m m	0.93	0.92	0.94
			-0.65	-0.68	-0.76
			[0.91]	[0.90]	[0.92]
			4.714E-01	4.952E-01	4.839E-01
Pu-239	Plant transfer factor for Pu  Depth of roots Thickness of the contaminated zone	pCi/g plant per pCi/g soil m C	0.93	0.94	0.93
			-0.71	-0.69	-0.69
			[0.90]	[0.91]	[0.91]
			5.462E-01	5.445E-01	5.275E-01
Pu-241	Plant transfer factor for Am  Depth of roots Kd of Am-241 in contaminated zone Plant transfer factor for Pu	pCi/g plant per pCi/g soil m cm <sup>3</sup> /g pCi/g plant per pCi/g soil	0.86	0.89	0.89
			-0.52	-0.61	-0.63
			[0.84]	[0.86]	[0.87]
			1.578E-02	1.581E-02	1.624E-02
Am-241	Plant transfer factor for Am  Depth of roots	pCi/g plant per pCi/g soil m	0.93	0.93	0.93
			-0.70	-0.66	-0.69
			[0.91]	[0.90]	[0.91]
Cm-243	Plant transfer factor for Cm  External gamma shielding factor	pCi/g plant per pCi/g soil Unit-less	0.91	0.91	0.91
			0.66	0.66	0.65

<b>Table 2</b> <b>Results of the Sensitivity Analysis</b>					
Radionuclide	Sensitive Parameters	Units	PRCC <sup>1</sup> [R Squared] <sup>2</sup> Peak of the Mean Dose ( mRem/yr) <sup>3</sup>		
			Repetition 1	Repetition 2	Repetition 3
	Depth of roots	m	-0.56 [0.89] 5.493E-01	-0.62 [0.88] 5.445E-01	-0.63 [0.89] 5.582E-01

Footnotes:

1. Partial Rank Correlation Coefficient from RESRAD sensitivity analyses.
2. R-Square value from RESRAD sensitivity analyses.
3. Dose is the Peak Mean Dose from the RESRAD sensitivity analyses for a soil concentration of 1 pCi/g.

## REFERENCES:

1. NUREG/CR-5512, "Residual Radioactive Contamination From Decommissioning,"  
Volume 1: "Technical Basis for Translating Contamination Levels to Annual TEDE," October 1992  
Volume 2: "User's Manual DandD Version 2.1," April 2001  
Volume 3: "Parameter Analysis, Draft Report for Comment," October 1999.
2. Code of Federal Regulations, Title 10, Section 20.1402, "Radiological Criteria for Unrestricted Uses."
3. NUREG-1727. "NMSS Decommissioning Standard Review Plan," September 2000.
4. ANL/EAD-4, "Users Manual for RESRAD Version 6.0," Yu, C. et al., July 2001.
5. NUREG/CR-6676, "Probabilistic Dose Analysis Using Parameter Distributions Developed for RESRAD and RESRAD-BUILD Codes", Kamboj S., et al. US Department of Energy- Argonne National Laboratory, May 2000.
6. NUREG/CR-6692, "Probabilistic Modules for the RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes", LePoire, D., et al., US Department of Energy- Argonne National Laboratory, November 2000.
7. NUREG/CR-6697, "Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes", Yu, C. et al., US Department of Energy- Argonne National Laboratory, November 2000.
8. YA-REPT-00-002-03, "Hydrogeological Parameter Estimates for Radiation Dose Modeling," April 2003.
9. Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil, Yu, C., et al, Argonne National Laboratory, April 1993.

## ASSUMPTIONS:

### 1. Radionuclide Suite

Sensitivity Analyses were performed for the radionuclides listed in Table 1. This suite of radionuclides was developed by the License Termination team to encompass the significant radionuclides that may exist at the site at the time of the final status survey.

### 2. Dose Model: The Resident Farmer Scenario of RESRAD 6.21

The dose model used to perform the sensitivity analyses (and to calculate the corresponding soil DCGLs) is based upon the Resident Farmer Scenario defined in NUREG/CR Volumes 1, 2 and 3, (Ref. 1). The dose model translates residual soil radioactivity into potential radiation dose and is defined by the scenario, exposure pathways and the critical group. The resident farmer scenario is a reasonably conservative bounding scenario, which generally overestimates (rather than underestimates) potential dose.

The residual radioactivity in this scenario is assumed to be contained in a soil layer on the property that can be used for residential and light farming activities. The residential farming family is expected to live onsite, raise crops and livestock for consumption and drink water from a ground water source onsite. The dose from residual radionuclides in the soil is evaluated for the average member of the critical group as required by 10CFR Part 20, Subpart E and described in NUREG-1727, Appendix C (Ref. 2, Ref. 3). The critical group represents the group reasonably expected to receive the greatest exposure, given the scenario, to residual radioactivity

The potential exposure pathways that define the residential farmer scenario are:

1. Direct exposure to external radiation from radionuclides in the soil
2. Internal dose from inhalation of airborne radionuclides, and
3. Internal dose from ingestion of radionuclides in
  - a. Crops grown on the property and irrigated with water obtained onsite,
  - b. Meat and milk obtained from livestock fed fodder and water produced onsite,
  - c. Drinking water from an onsite well,
  - d. Fish from an onsite pond and
  - e. Soil.

### 3. Conceptual Model underlying the dose model

The conceptual model used in the code was based on the site characteristics expected at the time of release of the site. The model is comprised of a contaminated zone underlain by an unsaturated zone underlain by a saturated zone. The contaminated zone is assumed to be at the ground surface with no cover material and the ground water is initially uncontaminated. The model as described is consistent with that described by Yu et al. (Ref. 4).

## METHOD / BODY OF CALCULATION:

### 1. Parameter Selection Process

The dose and conceptual models are quantified by a set of input parameters that are listed in Attachment 2, Table 1 under the following categories

- Soil Concentration
- Distribution Coefficients
- Calculation Time
- Contaminated Zone
- Cover and Hydrological Data
- Saturated Zone Hydrological Data
- Unsaturated Zone Hydrological Data
- Occupancy
- Ingestion, Dietary
- Ingestion, Non-dietary
- Storage Times
- Special Radionuclides (C-14)
- Dose Conversion Factors
- Transfer Factors

Incorporated within RESRAD Version 6.21 are Probabilistic Modules that allow the evaluation of dose as a function of parameter distributions. The code output provides a measure of the sensitivity of the dose to variations in parameter values as defined by the statistical parameters of an assigned probability distribution. To aid in selecting which parameter sensitivities to evaluate, a process was followed in this calculation that was developed in accordance with guidance from NUREG/CR-6676, -6692, and -6697 (Ref. 5, Ref. 6, & Ref. 7). A schematic flow diagram of the parameter selection process is provided in Figure 1. Each step of the selection process is discussed below.

#### Classification (Type):

The parameters were classified as behavioral, metabolic or physical consistent with NUREG/CR-6697. Behavioral parameters depend on the behavior of the receptor and the scenario definition. Metabolic parameters represent the metabolic characteristics of the receptor and are independent of the scenario definition. Physical parameters are the parameters that would not change if a different group of receptors were considered.

#### Prioritization

The parameters were prioritized in order of importance consistent with NUREG/CR-6697. Prioritization was based on

1. The relevance of the parameter in dose calculations,
2. The variability of the dose as a result of changes in the parameter value,
3. The parameter type and
4. The availability of parameter-specific data.

Priority 1 parameters are considered to be high priority; priority 2 parameters are considered to be medium priority; and priority 3 parameters are considered to be low priority.

### Treatment

The parameters were treated as either "deterministic" or "stochastic" depending on parameter type, priority, availability of site-specific data and the relevance of the parameter in dose calculations. The "Deterministic" modules of the code use a single value for input parameters and generate a single value for dose. The "Probabilistic" modules of the code use probability distributions for input parameters and generate a range of doses. The "Stochastic" parameters are parameters that are defined by a probabilistic distribution. The bases for the values assigned to the input parameters are outlined in Attachment 2, Table 1.

- The behavioral and metabolic parameters were treated as deterministic and were assigned values from NUREG/CR-5512, Volume 3, NUREG/CR-6697, or the RESRAD default library.
- The physical parameters for which site-specific data were available were also treated as deterministic. The basis for calculated physical parameter values is provided in Attachment 1 and YA-REPT-00-002-003 (Ref. 8).
- The remaining physical parameters, for which no site-specific data were available to quantify, were classified as either priority 1, 2, or 3. Priority 1 and 2 parameters were treated as stochastic and were assigned a probability distribution from NUREG/CR-6697. The priority 3 physical parameters were treated as deterministic and were assigned values from NUREG/CR-5512, Volume 3, NUREG/CR-6697, or the RESRAD default library.

## 2. Sensitivity Analyses

The probabilistic module of the RESRAD code was used to perform the analyses to determine which stochastic parameters have the greatest influence on the resultant dose and the associated DCGLs. The code performs regression analyses to determine the correlation of the dose with the input parameter distributions and the Partial Rank Correlation Coefficient (PRCC) is provided for each parameter. The PRCC is ranked and can be used to determine the relative importance of each input parameter in influencing the dose. To perform the sensitivity analyses, the following input information is entered into the code. A detailed summary of this information is provided in Attachment 2, Table 1.

### Sample Specifications

The analyses were run using 300 observations and 3 repetitions. The Latin Hypercube Sampling (LHS) technique was used to sample the probability distributions for each of the stochastic input parameters. The correlated or uncorrelated grouping option was used to preserve the prescribed correlations, and a random seed of 1000 was used to preserve the prescribed sampling technique.

### Input Rank Correlations

Correlation coefficients were assigned between correlated parameters. The values of the input correlations between parameters are based on guidance provided in NUREG-6676 and NUREG-6697 (Ref. 5, Ref. 7).

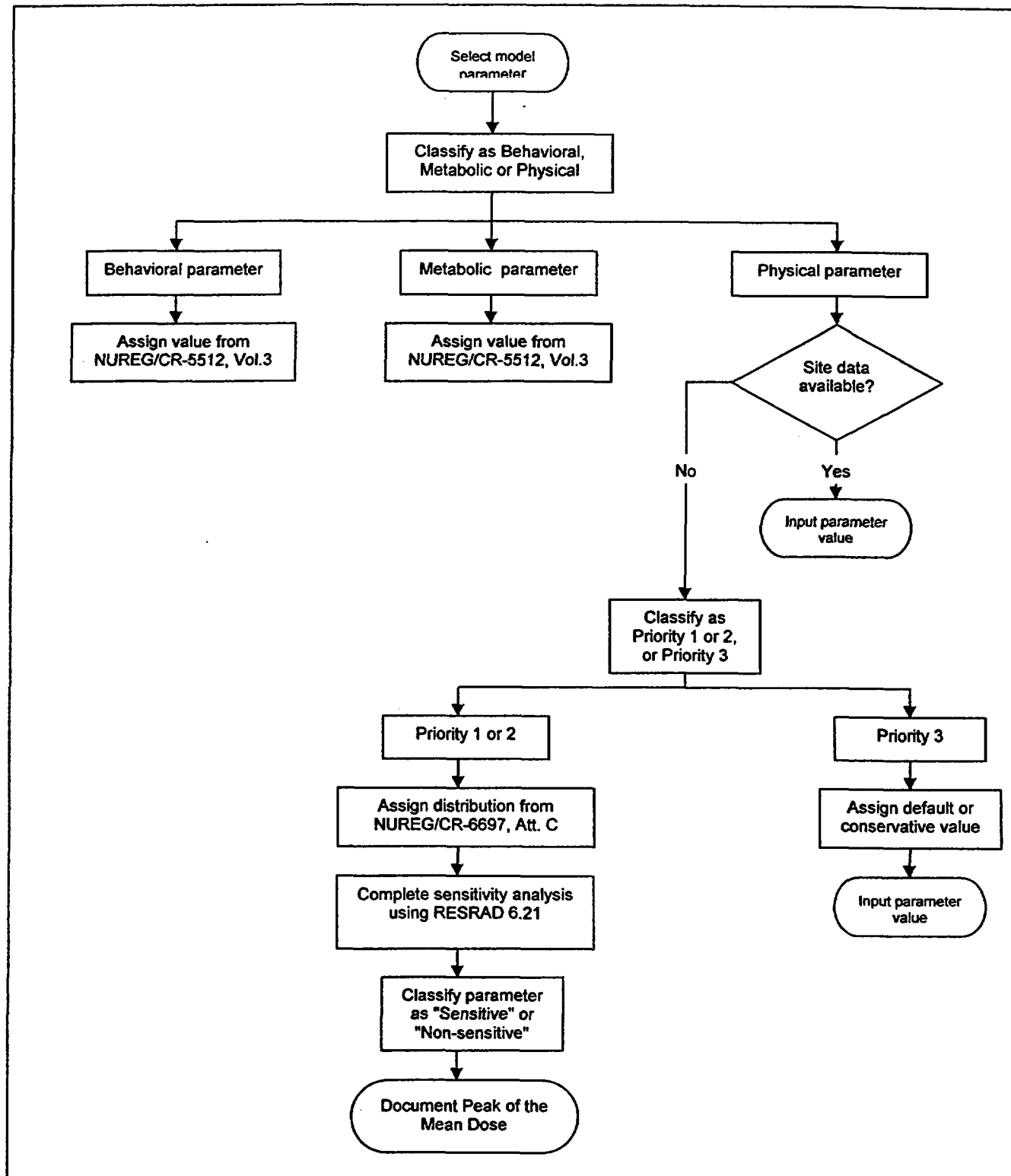
### Output Specifications

All of the output options were specified.

A sensitivity analysis was performed for each radionuclide. The Partial Rank Correlation Coefficient (PRCC) for the peak of the mean dose was used as the measure of the sensitivity of each parameter to the peak of the mean dose.

For the resident farmer scenario, a parameter was identified as sensitive if the absolute value of its PRCC (|PRCC|) was greater than or equal to 0.25 and non-sensitive if the |PRCC| value was less than 0.25. These thresholds were selected based on the guidance included in NUREG/CR-6676.

**Figure 1**  
**Parameter Selection Process**



**Project: Yankee Rowe License Termination Plan**  
**Subject: RESRAD 6.21 Sensitivity Analysis for Soil**

**Calculation No. YA-CALC-00-001-03**  
**Sheet No. Attachment 1-1**

## **ATTACHMENT 1**

### **Supporting Documentation for Site-Specific Physical Parameter Values**

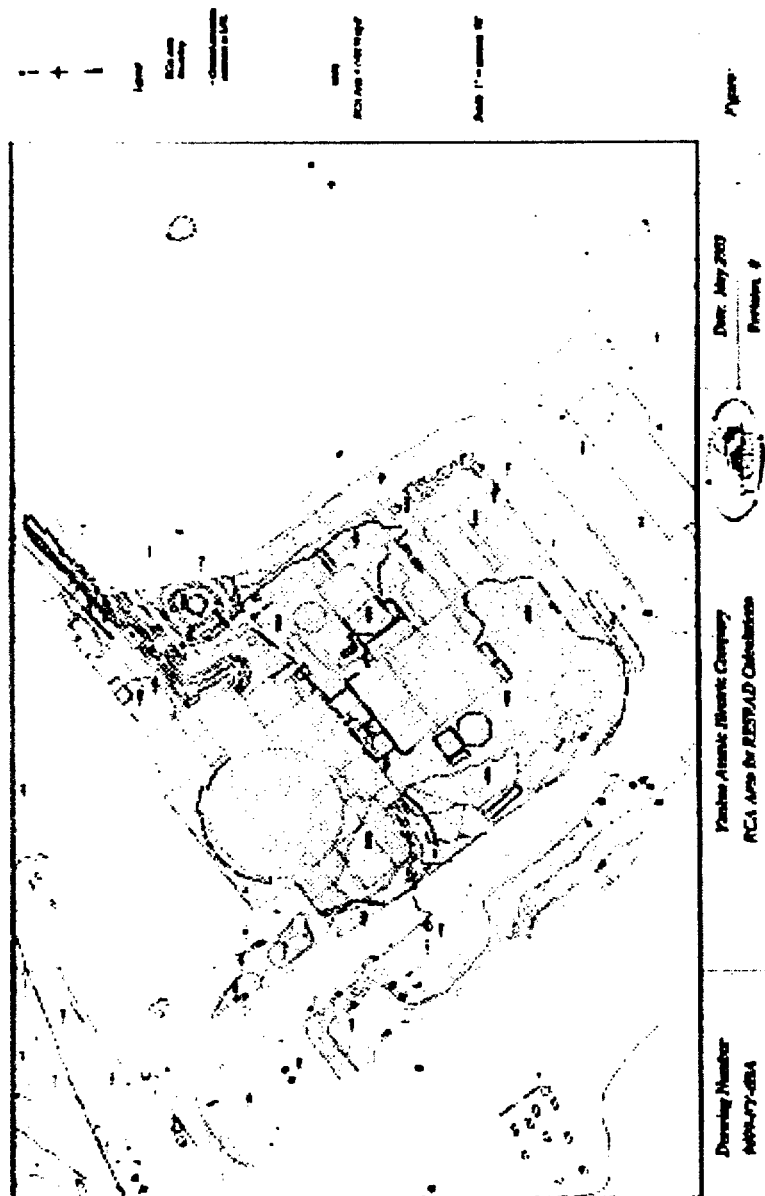
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## 1. Area of the Contaminated Zone

Figure 1-1, (YR Drawing: 9699-FY-6BA Original) Rowe Site Closure Base Map was generated with AutoCAD Version 6. The area of the contaminated zone was drawn and calculated by the AutoCAD software. Converting to  $m^2$ :  $(140174 \text{ ft}^2) * (9.29E-02 \text{ m}^2) = 13022m^2$ . The Area of the contaminated zone was assigned a value of  $13022m^2$ .

Figure 1- 1 Area of the RCA



## 2. Contaminated Zone Erosion Rate

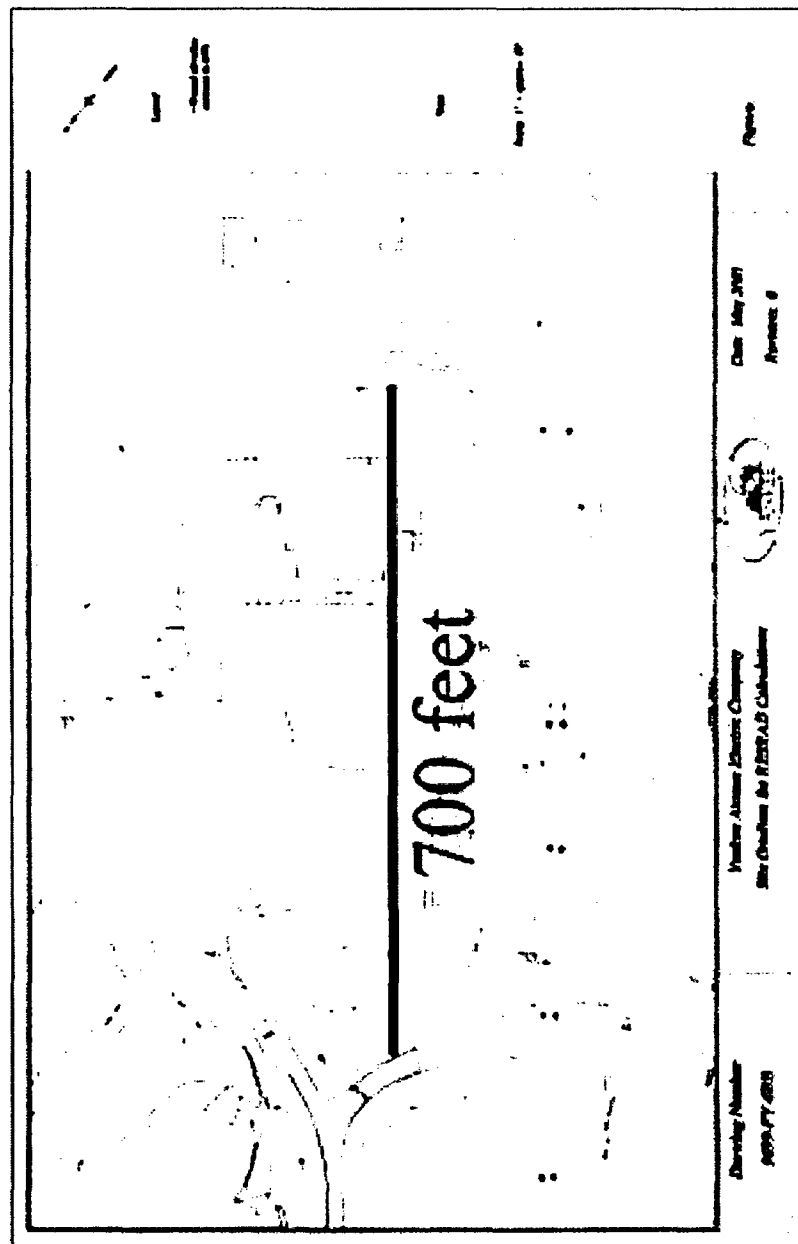
The slope of the contaminated zone was determined from the Rowe Site Closure Base map (YR Drawing: 9699-FY-6BB Original) generated by AutoCAD Map Version 6. The line extending from the vicinity of CB-2 to the vicinity of CB-3 is a run of 700 feet with a decreasing change in elevation from 1140 to 1120 feet. The slope at the Rowe site is 20' per 700', which corresponds to a 2.86% slope.

The following YR site drawing provides a transferable scale to the Vapor Containment

Reference: VC Site Drawing Number 9699-FV-1a

Scale: Outer Diameter of VC sphere = 125'

Figure 2-1 Rowe Site Closure Base Map



Data from NUREG/CR-6697, Attachment C, Section 3.8, 2<sup>nd</sup> paragraph of the Discussion Section on pages 3-25 & 3-26, was used to select the appropriate Erosion Rate that corresponds to the Rowe Site slope of 2.86%.

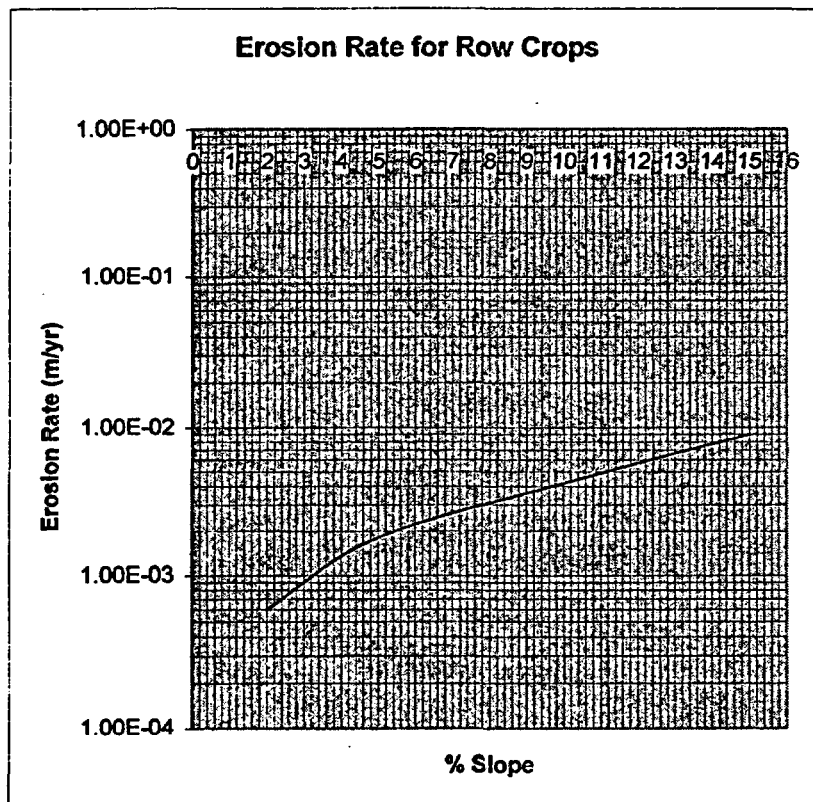
The data in Table 2-1 below was generated using NUREG/CR-6697's row-crop Erosion Rate of  $6.0 \text{ E-}4$  for a 2 % slope. Erosion Rates were then calculated for 5, 10 and 15 percent slopes using their rate increase factors as specified in the Discussion of Section 3.8 referenced above. As recommended in this section of NUREG/CR-6697, the Erosion Rate of  $6.0 \text{ E-}4$  for a 2% slope was assumed based on a farm-garden scenario where the dose contribution from the food ingestion pathway is expected to be significant.

Table 2-1 Erosion Rate

Percent Slope	Erosion Rate (m/yr)
2	$6.0\text{E-}4$
5	$1.8\text{E-}3$
10	$4.2\text{E-}3$
15	$9.0\text{E-}3$

Plotting the above Erosion Rate/Slope data and then selecting a value which corresponds to the Rowe site slope of ~ 2.9 %, yields an  $8.5 \text{ E-}4 \text{ m/yr}$  Erosion Rate.

Figure 2-2 Erosion Rate vs. Slope



### 3. Humidity in Air

The reference, "Regional and Site-Specific Absolute Humidity Data for Use in Tritium Dose Calculations", Health Physics, Vol.39, pp318-320, 1980 provides a table of absolute humidity for selected locations in the US. These values were calculated from data from the National Oceanic and Atmospheric Administration, 1977, Climatological Data, Annual Summary, volume 28(13), US Dept. of Commerce.

The value of 6.1 g/m<sup>3</sup> was chosen for the RESRAD humidity parameter corresponding to the Northeast region in the vicinity of Albany, NY.

### 4. Average Annual Wind Speed

The wind speed and direction, joint frequency distributions from Table 3.3-2 of the YNPS Environmental Decommissioning were used to calculate the average annual windspeed. The mid-range value was calculated for each of the ranges for which data was available. An average windspeed was calculated by summing the product of the mid-range value for each range and the percentage of time the wind was recorded to be within that range. A value of 2.03 m/s was assigned to this parameter.

Table 4- 1 Wind Speed

Min. Wind Speed (mph)	Max. Wind Speed (mph)	Mid-Range Wind Speed (mph)	Percent of Time in Range	Mid-Range (weighted by percentage of time)
0.00	0.95	0.48	0.00	0.00
0.95	3.00	1.98	47.11	0.93
4.00	7.00	5.50	38.98	2.14
8.00	12.00	10.00	12.72	1.27
13.00	18.00	15.50	1.16	0.18
19.00	24.00	21.50	0.02	0.00
			Average:	4.53 mph

Converting to meters/second: 4.53 mi/hr x 1 meter/6.214-04 mi x 1h/3600 sec = 2.03 meters/sec

Figure 4-1  
Joint Frequency Distribution Table Produced by YAEC METROSE Computer Code Using Meteorological  
Data Collected at Yankee Nuclear Power Station Met Tower

<p align="center"><u>YNPS 35-Foot</u>  <u>Wind Speed and Direction Joint Frequency Distributions</u>  <u>1988-1992</u></p>																			
WIND DIRECTION FROM																			
SPEED(MPH)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	VRBL	TOTAL	
CALM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(1)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
(2)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
C-3	570	1010	1351	1672	2941	3952	2556	1741	1284	942	763	385	283	221	169	297	0	20137	
(1)	1.33	2.36	3.16	3.91	6.88	9.25	5.98	4.07	3.00	2.20	1.78	.90	.66	.52	.40	.69	.00	47.11	
(2)	1.33	2.36	3.16	3.91	6.88	9.25	5.98	4.07	3.00	2.20	1.78	.90	.66	.52	.40	.69	.00	47.11	
4-7	1468	1363	975	727	761	374	455	773	1230	2046	2570	1176	773	565	625	783	0	16664	
(1)	3.43	3.19	2.28	1.70	1.78	.87	1.06	1.81	2.88	4.79	6.01	2.75	1.81	1.32	1.46	1.83	.00	38.98	
(2)	3.43	3.19	2.28	1.70	1.78	.87	1.06	1.81	2.88	4.79	6.01	2.75	1.81	1.32	1.46	1.83	.00	38.98	
8-12	1137	952	263	35	4	2	2	13	96	483	1159	481	179	137	188	308	0	5439	
(1)	2.66	2.23	.62	.08	.01	.00	.00	.03	.22	1.13	2.71	1.13	.42	.32	.44	.72	.00	12.72	
(2)	2.66	2.23	.62	.08	.01	.00	.00	.03	.22	1.13	2.71	1.13	.42	.32	.44	.72	.00	12.72	
13-18	141	195	12	1	0	0	0	0	1	12	116	9	1	1	0	7	0	496	
(1)	.33	.46	.03	.00	.00	.00	.00	.00	.00	.03	.27	.02	.00	.00	.00	.02	.00	1.16	
(2)	.33	.46	.03	.00	.00	.00	.00	.00	.00	.03	.27	.02	.00	.00	.00	.02	.00	1.16	
19-24	2	5	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	10	
(1)	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	
(2)	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.02	
GT 24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
(1)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
(2)	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
ALL SPEEDS	3318	3525	2602	2435	3706	4328	3013	2527	2611	3483	4610	2051	1236	924	982	1395	0	42746	
(1)	7.76	8.25	6.09	5.70	8.67	10.12	7.05	5.91	6.11	8.15	10.78	4.80	2.89	2.16	2.30	3.26	.00	100.00	
(2)	7.76	8.25	6.09	5.70	8.67	10.12	7.05	5.91	6.11	8.15	10.78	4.80	2.89	2.16	2.30	3.26	.00	100.00	

(1)=PERCENT OF ALL GOOD OBSERVATIONS FOR THIS PAGE  
(2)=PERCENT OF ALL GOOD OBSERVATIONS FOR THIS PERIOD

C= CALM (WIND SPEED LESS THAN OR EQUAL TO .95 MPH)

## 5. Precipitation

Table 3.3-4 of the YNPS Environmental Decommissioning Report provides monthly mean precipitation totals for Readsboro, Vt. (located within 5 miles of the YNPS). This information is based on data from the National Oceanic and Atmospheric Administration.

Figure 5- 1 Precipitation Rate

Readsboro Monthly Mean Precipitation Totals (inches of water)	
Period: 1961-1990	
Month	Precipitation (inches)
Jan	3.49
Feb	3.43
Mar	3.86
April	4.32
May	4.59
Jun	4.54
Jul	4.08
Aug	4.29
Sept	3.79
Oct	3.8
Nov	4.61
Dec	4.28
Year Total	49.08

Converting to meters/year:  $49.08 \text{ inches/year} \times 2.54 \text{ cm/inch} \times \text{meter}/100 \text{ cm} = 1.2 \text{ meters/year}$ . The precipitation rate was assigned a value of 1.2 meters/year

## 6. Irrigation Rate (Evapotranspiration and Runoff Coefficients)

NUREG/CR-6697 Attachment C, Section 4.3 discusses the Irrigation Rate in terms of the Evapotranspiration Coefficient. Equation 4.3-1 expresses the Evapotranspiration Coefficient as:

$$C_e = \frac{ET_r}{(1-C_r)(P_r) + I R_r}$$

Where:  $ET_r$  = the Evapotranspiration Rate (m/y)  
 $P_r$  = the Precipitation Rate (m/y)  
 $I R_r$  = the Irrigation Rate (m/y) and  
 $C_r$  = the Runoff Coefficient.

Rearranging this equation, the Irrigation Rate can be expressed as:

$$I R_r = \frac{ET_r - (1-C_r)(P_r)}{C_e}$$

The input values for the variables in the equation above follow:

1. YA-REPT-00-002-03, (Ref. 8), cites a value for the average annual Evapotranspiration Rate,  $ET_r$ , in the upper Housatonic River basin of 21.6 in/yr or 0.549 m/yr from 1931 to 1960.
2. The Precipitation Rate,  $P_r$ , has been assigned a site-specific value of 1.2 m/yr as discussed in Section 5 of this Attachment.
3. Appendix E, Table E.1 of Ref. 4 provides the equation below to calculate the Runoff Coefficient,  $C_r$ , for an agricultural environment. Table E.1, Runoff Coefficient Values, also lists values for  $c_1$ ,  $c_2$  and  $c_3$  for various environments:

$$C_r = 1 - c_1 - c_2 - c_3$$

$c_1 = 0.1$  for hilly land with an average slopes of 46 m/mi (Refer to section 2 of this Attachment for the site slope determination- 20' drop per 700' run or 46 m/mi).

$c_2 = 0.2$  for intermediate combinations of clay and loam as identified at the site in Ref. 8.

$c_3 = 0.1$  for cultivated lands which also fits the scenario for the site.

$$C_r = 1 - 0.1 - 0.2 - 0.1 = 0.6$$

4. NUREG/CR-6697, Attachment C, Section 4.3-Evapotranspiration Coefficient,  $C_e$ , defines this parameter as the ratio of the total volume of water (a combination of evaporation from soil surfaces and transpiration from vegetation) transferred to the atmosphere to the total volume of water available within the root zone of the soil. The NUREG recommends the use of a uniform distribution with minimum and maximum values of 0.5 and 0.75, respectively and with 0.625 as median. Any selected value for the irrigation rate should satisfy the  $C_e$  minimum to maximum range

Making the appropriate substitution of minimum and maximum values of Ce into the rearranged Equation 4.3-1 results in the following range for the Irrigation Rate, IRr.

Table 6- 1 Irrigation Rate

Variable	"min" value	"max" value	units
ETr	0.549	0.549	m/yr
Pr	1.2	1.2	m/yr
Cr	0.6	0.6	—
Ce	0.5	0.75	—
IRr	0.252	0.618	m/yr

Based on the calculated minimum and maximum IRr values, the median value is 0.435 m/y. A uniform distribution was assigned to this parameter and a positive input correlation to the Well Pumping Rate was assigned based on guidance in NUREG-6697 and NUREG- 6676.

## 7. Field Capacity: Contaminated Zone, Unsaturated zone 1 and Saturated zone

The "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil," (Ref. 9) defines the relationship of field capacity (residual water content) to effective porosity. The field capacity is the ratio of the volume of water retained in the soil sample, after all drainage has ceased, to the total volume of the soil sample. Equation 4.4 of Ref. 9 relates Total and Effective Porosity to Field Capacity as follows:

$$\text{Effective Porosity} = \text{Total Porosity} - \text{Field Capacity}$$

Rearranging this equation:

$$\text{Field Capacity} = \text{Total Porosity} - \text{Effective Porosity}$$

Reference 8 provides site-specific values for the total and effective porosity for the soil types found at the site. These values are listed below along with the calculated Field Capacity.

Table 7- 1 Field Capacity

Zone / Soil Type	Total Porosity	Effective Porosity	Field Capacity
Contaminated/ loamy sand	0.35	0.25	0.10
Unsaturated/loamy sand	0.35	0.25	0.10
Saturated/sandy loam	0.30	0.21	0.09

## 8. Saturated Zone Hydraulic Gradient

NUREG/CR-6697, Attachment C, Section 3.6 -Hydraulic Gradient, discusses this parameter's use in the determination of the groundwater flow rate, which effects the rise time and the dilution of radionuclides in the well water. The method for calculating the hydraulic gradient is given in NUREG/CR-6697, Attachment C, Equation 3.6-1:

$$J_x = \frac{h_1 - h_2}{\Delta_x}$$

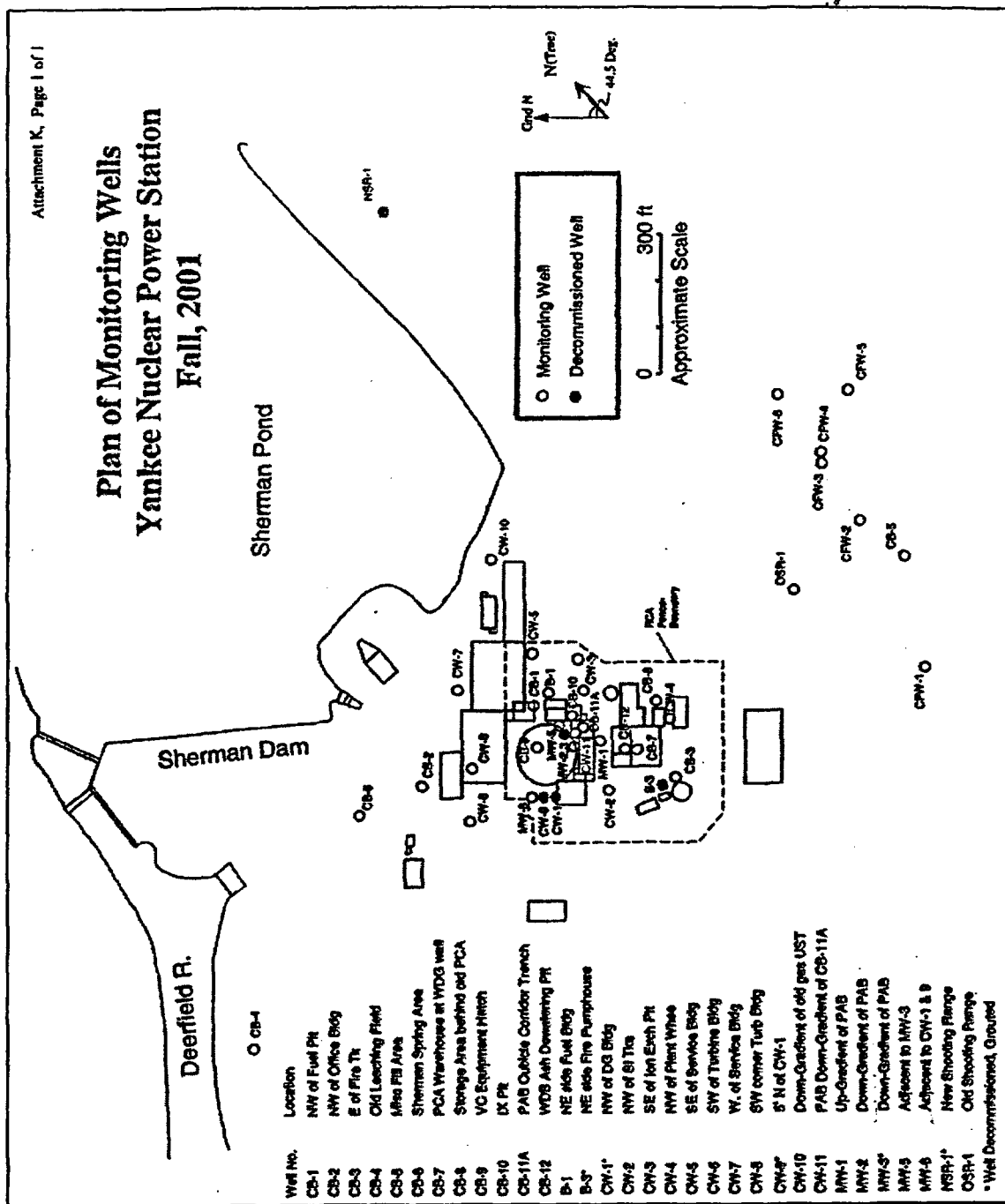
Where  $h_1$  and  $h_2$  represent the hydraulic heads or the water level elevations at location 1 and 2, and  $\Delta_x$  is the distance between the two locations. The water level elevations are referenced to mean sea level, msl. This methodology was followed in YA -REPT-00-002-03, Hydrogeological Parameter Estimates for Radiation Dose Modeling, (Ref. 8) to determine the average hydraulic gradient across the site. An average value for the site was calculated from three separate hydraulic gradient determinations as follows in Table 8.1. Figure 8.1 shows the well locations.

Table 8- 1 Hydraulic Gradient

Well / Location Designation	Water Level Elevation (msl), ft	Distance Between Wells, ft	Hydraulic Gradient, ft/ft
CB-3	1135		
Deerfield River below Sherman Dam	1020	1000	(1135-1020)/1000 = 0.115
CB-3	1135		
CB-2	1105	533	(1135-1105)/533 = 0.056
CW-3	1132		
CB-1	1114	118	(1132-1114)/118 = 0.152
			Average = 0.1

The hydraulic gradient was assigned a value of 0.1 feet/foot.

Figure 8- 1 Monitoring Well Locations



## 9. Well Pumping Rate

NUREG/CR-6697, Attachment C, Section 3.10 states that "A site-specific input distribution for well pumping rate can be determined as the sum of individual water needs." The household use component is taken from YA-REPT-00-002-03, Ref. 8. To support the assumption that irrigation of pasture is not a common practice in New England, the USDA 1992 Census of Agriculture, State Data, was reviewed and showed that in 1992 in all of Massachusetts 19622 total acres of cropland was irrigated and 287 total acres of pastureland was irrigated. In 1997 only one farm, in Franklin County, claimed irrigation of pasture.

Water Use Component	Median	Minimum	Maximum	
<b>Household</b>	<b>374</b>	<b>374</b>	<b>374</b>	m <sup>3</sup> /y
<b>Livestock</b>	<b>76.7</b>	<b>76.7</b>	<b>76.7</b>	m <sup>3</sup> /y
Irrigation of vegetable plot				
Contaminated fraction $f_p = \min(\text{Area}/2000, 0.5)$	1	1	1	
Irrigation rate $I_r$ (m/y)	0.435	0.252	0.618	
<b>Irrigation water</b> $f_p \times I_r \times 2000$	<b>870</b>	<b>504</b>	<b>1236</b>	m <sup>3</sup> /y
Irrigation of pasture (Not a New England practice.)				
Contaminated fraction $f_m = \text{Area}/20,000 \leq 1$	1	1	1	
Irrigation rate $I_r$ (m/y)	0	0	0	m/y
<b>Irrigation water</b> $f_m \times I_r \times 20,000$	<b>0</b>	<b>0</b>	<b>0</b>	m <sup>3</sup> /y
<b>Drinking water</b>	<b>1.91</b>	<b>1.91</b>	<b>1.91</b>	m <sup>3</sup> /y
<b>TOTAL FOR A FAMILY OF FOUR</b>				
(sum of water components in Bold type)	<b>1323</b>	<b>957</b>	<b>1689</b>	m <sup>3</sup> /y

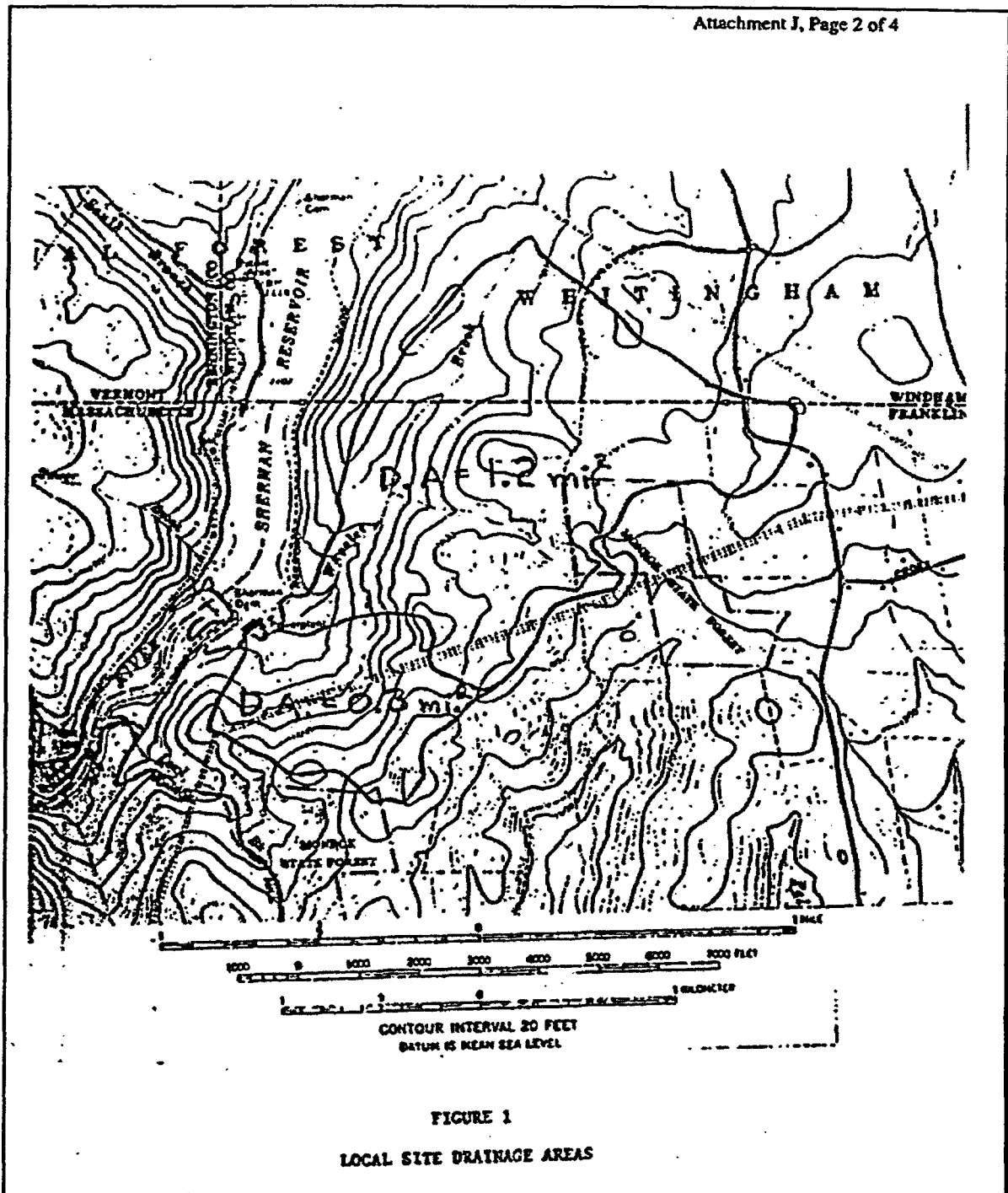
A uniform distribution was assigned to this parameter with a positive correlation to the Irrigation Rate.

#### 10. Watershed for Nearby Stream or Pond

The figure below is taken from a letter to the USNRC from Yankee Atomic Electric Co., FYR 82-59, 6/16/82 that delineates the watersheds to Wheeler Brook and to the site. An evaluation of this topographic map and the drainage areas is also included in Ref. 8.

The watershed area to the site is 0.3 square miles. Converting to square meters yields a total watershed area of  $0.3 \text{ mi}^2 \times (1609.3 \text{ m/mi})^2 = 7.77\text{E}+05 \text{ m}^2$ . This parameter was assigned a value of  $7.77\text{E}+05 \text{ m}^2$ .

Figure 10- 1 Local Site Drainage Area



## **Attachment 2**

### **RESRAD 6.21- Input Parameters to Sensitivity Analysis for Soil Scenario: Resident Farmer**

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				
						1	2	3	4	Median
<b>Soil Concentrations</b>										
Basic radiation dose limit (mrem/yr)		3	D	25	10 CFR 20.1402 (Ref. 3)	NR	NR	NR	NR	
Initial principal radionuclide (pCi/g)	P	2	D	1	Unit Value	NR	NR	NR	NR	
<b>Distribution coefficients (contam., unsat. and sat. zones) (cm<sup>3</sup>/g)</b>										
Ac-227+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.72	3.22	0.001	0.999	825
Ag-108m	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.38	2.1	0.001	0.999	216
Am-241	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	7.28	3.15	0.001	0.999	1445
Am-243+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	7.28	3.15	0.001	0.999	1445
C-14	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.4	3.22	0.001	0.999	11
Cm-243	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	8.82	1.82	0.001	0.999	6781
Co-60	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.46	2.53	0.001	0.999	235
Cs-134	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.1	2.33	0.001	0.999	446
Cs-137+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.1	2.33	0.001	0.999	446
Eu-152	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.72	3.22	0.001	0.999	825
Eu-154	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.72	3.22	0.001	0.999	825
Eu-155	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.72	3.22	0.001	0.999	825
Fe-55	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.34	2.67	0.001	0.999	209
Gd-152	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.72	3.22	0.001	0.999	825
H-3	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-2.81	0.5	0.001	0.999	0.06

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Mn-54	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.06	2.29	0.001	0.999	158
Nb-94	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.94	3.22	0.001	0.999	380
Ni-59	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.05	1.46	0.001	0.999	424
Ni-63	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.05	1.46	0.001	0.999	424
Np-237+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.84	2.25	0.001	0.999	17
Pa-231	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.94	3.22	0.001	0.999	380
Pb-210+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	7.78	2.76	0.001	0.999	2392
Pu-238	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.86	1.89	0.001	0.999	953
Pu-239	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.86	1.89	0.001	0.999	953
Pu-241+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6.86	1.89	0.001	0.999	953
Ra-226+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	8.17	1.7	0.001	0.999	3533
Ru-106	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	7.37	3.13	0.001	0.999	1588
Sb-125	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.94	3.22	0.001	0.999	380
Sr-90+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.45	2.12	0.001	0.999	32
Tc-99	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-0.67	3.16	0.001	0.999	0.51
Th-229+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	8.68	3.62	0.001	0.999	5884
Th-230	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	8.68	3.62	0.001	0.999	5884
U-233	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.84	3.13	0.001	0.999	126
U-234	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.84	3.13	0.001	0.999	126

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				
						1	2	3	4	Median
U-235+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.84	3.13	0.001	0.999	126
Initial concentration of radionuclides present in groundwater (pCi/l)	P	3	D	0	Ground water uncontaminated	NR	NR	NR	NR	
<b>Calculation Times</b>										
Time since placement of material (yr)	P	3	D	0		NR	NR	NR	NR	
Time for calculations (yr)	P	3	D	0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR	NR	NR	NR	
<b>Contaminated Zone</b>										
Area of contaminated zone (m**2)	P	2	D	13022	Site-specific- radiation control area (Att. I)	NR	NR	NR	NR	
Thickness of contaminated zone (m)	P	2	S	Uniform	Minimum equal depth of soil mixing layer (0.15m); maximum equal depth to water table (3m)	0.15	3			1.575
Length parallel to aquifer flow (m)	P	2	D	129	Site-specific - diameter of circle with an area of 13022 m <sup>2</sup> (Att. I)	NR	NR	NR	NR	
<b>Cover and Contaminated Zone Hydrological Data</b>										
Cover depth (m)	P	2	D	0	Site-specific - no cover assumed	NR	NR	NR	NR	
Density of contaminated zone (g/cm**3)	P	1	D	1.86	Site-specific loamy sand soil type (Ref. 5)					
Contaminated zone erosion rate (m/yr)	P	2	D	8.5E-04	Calculated value based on site-specific slope of 2.9% (Att. I)	NR	NR	NR	NR	
Contaminated zone total porosity	P	2	D	0.35	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Contaminated zone field capacity	P	3	D	0.10	Site-specific value calculated using Equation 4.4 from Ref. 1 (Att. I)	NR	NR	NR	NR	
Contaminated zone hydraulic conductivity (m/yr)	P	2	D	555	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Contaminated zone b parameter	P	2	D	4.38	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Humidity in air (g/m**3)	P	3	D	6.1	Regional value. (Att. I).	NR	NR	NR	NR	

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Evapotranspiration coefficient	P	2	D	0.75	NUREG/CR-6697 Att. C, distribution (Ref. 4, Att. I)	NR	NR	NR	NR	
Average annual wind speed (m/sec)	P	2	D	2.03	Site-specific value calc. from site meteorological data (Att. I)	NR	NR	NR	NR	
Precipitation (m/yr)	P	2	D	1.2	Site-specific value calculated from site geographical area ppt. (Att. I)	NR	NR	NR	NR	
Irrigation (m/yr)	B	3	S	Uniform	NUREG/CR-6697, Att C methodology, Ref. 4, Att. I	0.252	0.618	NR	NR	0.435
Irrigation mode	B	3	D	Overhead	Site-specific - overhead vs. ditch irrigation is standard practice in Eastern U. S.	NR	NR	NR	NR	
Runoff coefficient	P	2	D	0.6	NUREG/CR-6697, Att. C section 4.2 methodology (Ref. 4, Att. I)	NR	NR	NR	NR	
Watershed area for nearby stream or pond (m**2)	P	3	D	7.77E+05	Site-specific- drainage area (Att. I, Ref. 5)	NR	NR	NR	NR	
Accuracy for water/soil computations	-	3	D	1.00E-03	RESRAD Default	NR	NR	NR	NR	
<b>Saturated Zone Hydrological Data</b>										
Density of saturated zone (g/cm**3)	P	1	D	2.12	Site-specific Sandy Loam soil type (Ref. 5)	NR	NR	NR	NR	
Saturated zone total porosity	P	1	D	0.30	Site-specific Sandy Loam soil type (Ref. 5)	NR	NR	NR	NR	
Saturated zone effective porosity	P	1	D	0.21	Site-specific Sandy Loam soil type (Ref. 5)	NR	NR	NR	NR	
Saturated zone field capacity	P	3	D	0.09	Site-specific value calculated using Equation 4.4 from Ref. 1 (Att. I)	NR	NR	NR	NR	
Saturated zone hydraulic conductivity (m/yr)	P	1	D	0.1	Site-specific Sandy Loam soil type (Ref. 5)	NR	NR	NR	NR	
Saturated zone hydraulic gradient	P	2	D	0.1	Site gradient (Att. I)	NR	NR	NR	NR	
Saturated zone b parameter	P	2	D	4.90	Site-specific Sandy Loam soil type (Ref. 5)	NR	NR	NR	NR	
Water table drop rate (m/yr)	P	3	D	1.00E-03	RESRAD Default	NR	NR	NR	NR	

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Well pump intake depth (m below water table)	P	2	S	Triangular	NUREG/CR-6697, Att. C (Ref. 4)	6	10	30		14.51
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3	D	ND	ND model recommended for contaminant areas > 1,000 m <sup>2</sup> (Ref. 1)	NR	NR	NR	NR	
Well pumping rate (m <sup>3</sup> /yr)	P	2	S	Uniform	Min, Max, median value based on site irrigation and area and calculated according to NUREG/CR-6697, Att. C section 3.10 method. (Ref. 4, Att. I)	957	1689			1323
<b>Unsaturated Zone Hydrological Data</b>										
Number of unsaturated zone strata	P	3	D	1	Site-specific value	NR	NR	NR	NR	
Unsat. zone 1, thickness (m)	P	1	S	Uniform	Assumes 0.15 to 3 m contaminated zone thickness and 3 m depth to water table	0.01	2.85			1.430
Unsat. zone 1, soil density (g/cm <sup>3</sup> )	P	2	D	1.86	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Unsat. zone 1, total porosity	P	2	D	0.35	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Unsat. zone 1, effective porosity	P	2	D	0.25	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Unsat. zone 1, field capacity	P	3	D	0.10	Site-specific value calculated using Equation 4.4 (Ref. 1, Att. I)	NR	NR	NR	NR	
Unsat. zone 1, hydraulic conductivity (m/yr)	P	2	D	555	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
Unsat. zone 1, soil-specific b parameter	P	2	D	4.38	Site-specific loamy sand soil type (Ref. 5)	NR	NR	NR	NR	
<b>Occupancy</b>										
Inhalation rate (m <sup>3</sup> /yr)	B	3	D	8400	NUREG/CR-6697, Att C (Ref. 4)	NR	NR	NR	NR	
Mass loading for inhalation (g/m <sup>3</sup> )	P	2	S	Continuous linear	NUREG/CR-6697, Att. C (Ref. 4)					2.33E-05
Exposure duration	B	3	D	30	RESRAD Default	NR	NR	NR	NR	
Indoor dust filtration factor	P	2	S	Uniform	NUREG/CR-6697, Att. C (Ref. 4)	0.15	0.95			0.55

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Shielding factor, external gamma	P	2	S	Bounded lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-1.3	0.59	0.044	1	0.2725
Fraction of time spent indoors	B	3	D	0.6571	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Fraction of time spent outdoors (on site)	B	3	D	0.1181	NUREG/CR-5512, Vol. 3 Table 6.87 (outdoors + gardening) (Ref. 2)	NR	NR	NR	NR	
Shape factor flag, external gamma	P	3	D	Circular	RESRAD Default - Circular contaminated zone assumed	NR	NR	NR	NR	
<b>Ingestion, Dietary</b>										
Fruits, vegetables, grain consumption (kg/yr)	B	2	D	112	NUREG/CR-5512, Vol. 3 (other vegetables + fruits + grain) (Ref. 2)	NR	NR	NR	NR	
Leafy vegetable consumption (kg/yr)	B	3	D	21.4	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Milk consumption (L/yr)	B	2	D	233	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Meat and poultry consumption (kg/yr)	B	3	D	65.1	NUREG/CR-5512, Vol. 3 (beef + poultry) (Ref. 2)	NR	NR	NR	NR	
Fish consumption (kg/yr)	B	3	D	20.6	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Other seafood consumption (kg/yr)	B	3	D	0.9	RESRAD Default	NR	NR	NR	NR	
Soil ingestion rate (g/yr)	B	2	D	18.26	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Drinking water intake (L/yr)	B	2	D	478.5	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Contamination fraction of drinking water	P	3	D	1	RESRAD Default - all water assumed contaminated	NR	NR	NR	NR	
Contamination fraction of household water (if used)	P	3		NA						
Contamination fraction of livestock water	P	3	D	1	RESRAD Default - all water assumed contaminated	NR	NR	NR	NR	
Contamination fraction of irrigation water	P	3	D	1	RESRAD Default - all water assumed contaminate	NR	NR	NR	NR	

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Contamination fraction of aquatic food	P	2	D	1	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Contamination fraction of plant food	P	3	D	1	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Contamination fraction of meat	P	3	D	1	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Contamination fraction of milk	P	3	D	1	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
<b>Ingestion, Non-Dietary</b>										
Livestock fodder intake for meat (kg/day)	M	3	D	27.1	NUREG/CR5512, Vol. 3 Table 6.87, beef cattle + poultry + layer hen (Ref. 2)	NR	NR	NR	NR	
Livestock fodder intake for milk (kg/day)	M	3	D	63.2	NUREG/CR5512, Vol. 3 Table 6.87, forage + grain + hay (Ref. 2)	NR	NR	NR	NR	
Livestock water intake for meat (L/day)	M	3	D	50.6	NUREG/CR5512, Vol. 3 Table 6.87, beef cattle + poultry + layer hen (Ref. 2)	NR	NR	NR	NR	
Livestock water intake for milk (L/day)	M	3	D	60	NUREG/CR5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Livestock soil intake (kg/day)	M	3	D	0.5	RESRAD Default	NR	NR	NR	NR	
Mass loading for foliar deposition (g/m**3)	P	3	D	4.00E-04	NUREG/CR-5512, Vol. 3 Table 6.87, gardening (Ref. 2)	NR	NR	NR	NR	
Depth of soil mixing layer (m)	P	2	S	Triangular	NUREG/CR-6697, Att. C (Ref. 4)	0	0.15	0.6		0.23
Depth of roots (m)	P	1	S	Uniform	NUREG/CR-6697, Att. C (Ref. 4)	0.3	4			2.15
Drinking water fraction from ground water	P	3	D	1	RESRAD Default - all water assumed to be supplied from groundwater	NR	NR	NR	NR	
Household water fraction from ground water (if used)	P	3		NA						

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				
						1	2	3	4	Median
Livestock water fraction from ground water	P	3	D	1	RESRAD Default - all water assumed to be supplied from groundwater	NR	NR	NR	NR	
Irrigation fraction from ground water	P	3	D	1	RESRAD Default - all water assumed to be supplied from groundwater	NR	NR	NR	NR	
Wet weight crop yield for Non-Leafy (kg/m <sup>2</sup> )	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	0.56	0.48	0.001	0.999	1.75
Wet weight crop yield for Leafy (kg/m <sup>2</sup> )	P	3	D	2.88921	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Wet weight crop yield for Fodder (kg/m <sup>2</sup> )	P	3	D	1.8868	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Growing Season for Non-Leafy (years)	P	3	D	0.246	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Growing Season for Leafy (years)	P	3	D	0.123	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Growing Season for Fodder (years)	P	3	D	0.082	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Translocation Factor for Non-Leafy	P	3	D	0.1	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Translocation Factor for Leafy	P	3	D	1	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Translocation Factor for Fodder	P	3	D	1	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Weathering Removal Constant for Vegetation (1/yr)	P	2	S	Triangular	NUREG/CR-6697, Att. C (Ref. 4)	5.1	18	84		33
Wet Foliar Interception Fraction for Non-Leafy	P	3	D	0.35	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Wet Foliar Interception Fraction for Leafy	P	2	S	Triangular	NUREG/CR-6697, Att. C (Ref. 4)	0.06	0.67	0.95		0.58
Wet Foliar Interception Fraction for Fodder	P	3	D	0.35	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Non-Leafy	P	3	D	0.35	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Dry Foliar Interception Fraction for Leafy	P	3	D	0.35	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Dry Foliar Interception Fraction for Fodder	P	3	D	0.35	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
<b>Storage times of contaminated foodstuffs (days):</b>										
Fruits, non-leafy vegetables, and grain	B	3	D	14	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Leafy vegetables	B	3	D	1	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Milk	B	3	D	1	NUREG/CR-5512, Vol. 3 Table 6.87 (Ref. 2)	NR	NR	NR	NR	
Meat and poultry	B	3	D	20	NUREG/CR-5512, Vol. 3 Table 6.87 (holdup period for beef) (Ref. 2)	NR	NR	NR	NR	
Fish	B	3	D	7	RESRAD Default	NR	NR	NR	NR	
Crustacea and mollusks	B	3	D	7	RESRAD Default	NR	NR	NR	NR	
Well water	B	3	D	1	RESRAD Default	NR	NR	NR	NR	
Surface water	B	3	D	1	RESRAD Default	NR	NR	NR	NR	
Livestock fodder	B	3	D	45	RESRAD Default	NR	NR	NR	NR	
<b>Special Radionuclides (C-14)</b>										
C-12 concentration in water (g/cm <sup>3</sup> )	P	3	D	2.00E-05	RESRAD Default	NR	NR	NR	NR	
C-12 concentration in contaminated soil (g/g)	P	3	D	3.00E-02	RESRAD Default	NR	NR	NR	NR	
Fraction of vegetation carbon from soil	P	3	D	2.00E-02	RESRAD Default	NR	NR	NR	NR	
Fraction of vegetation carbon from air	P	3	D	9.80E-01	RESRAD Default	NR	NR	NR	NR	
C-14 evasion layer thickness in soil (m)	P	2	S	Triangular	NUREG/CR-6697, Att. C (Ref. 4)	0.2	0.3	0.6		0.36
C-14 evasion flux rate from soil (1/sec)	P	3	D	7.00E-07	RESRAD Default	NR	NR	NR	NR	
C-12 evasion flux rate from soil (1/sec)	P	3	D	1.00E-10	RESRAD Default	NR	NR	NR	NR	
Fraction of grain in beef cattle feed	B	3	D	0.2500	NUREG/CR-6697, Att. B (Ref. 4)	NR	NR	NR	NR	
Fraction of grain in milk cow feed	B	3	D	0.1000	NUREG/CR-6697, Att. B (Ref. 4)	NR	NR	NR	NR	

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						1	2	3	4	
<b>Dose Conversion Factors (Inhalation mrem/pCi)</b>										
Ac-227+D <sup>2</sup>	M	3	D	6.72E+00	FGR11 (RESRAD Dose Conversion Library)	NR	NR	NR	NR	
Ag-108m	M	3	D	2.83E-04	FGR11	NR	NR	NR	NR	
Am-241	M	3	D	4.44E-01	FGR11	NR	NR	NR	NR	
Am-243+D	M	3	D	4.40E-01	FGR11	NR	NR	NR	NR	
C-14	M	3	D	2.09E-06	FGR11	NR	NR	NR	NR	
Cm-243	M	3	D	3.07E-01	FGR11	NR	NR	NR	NR	
Co-60	M	3	D	2.19E-04	FGR11	NR	NR	NR	NR	
Cs-134	M	3	D	4.63E-05	FGR11	NR	NR	NR	NR	
Cs-137+D	M	3	D	3.19E-05	FGR11	NR	NR	NR	NR	
Eu-152	M	3	D	2.21E-04	FGR11	NR	NR	NR	NR	
Eu-154	M	3	D	2.86E-04	FGR11	NR	NR	NR	NR	
Eu-155	M	3	D	4.14E-05	FGR11	NR	NR	NR	NR	
Fe-55	M	3	D	2.69E-06	FGR11	NR	NR	NR	NR	
Gd-152	M	3	D	2.43E-01	FGR11	NR	NR	NR	NR	
H-3	M	3	D	6.40E-08	FGR11	NR	NR	NR	NR	
Mn-54	M	3	D	6.70E-06	FGR11	NR	NR	NR	NR	
Nb-94	M	3	D	4.14E-04	FGR11	NR	NR	NR	NR	
Ni-59	M	3	D	2.70E-06	FGR11	NR	NR	NR	NR	
Ni-63	M	3	D	6.29E-06	FGR11	NR	NR	NR	NR	
Np-237+D	M	3	D	5.40E-01	FGR11	NR	NR	NR	NR	
Pa-231	M	3	D	1.28E+00	FGR11	NR	NR	NR	NR	
Pb-210+D	M	3	D	1.38E-02	FGR11	NR	NR	NR	NR	
Pu-238	M	3	D	3.92E-01	FGR11	NR	NR	NR	NR	
Pu-239	M	3	D	4.29E-01	FGR11	NR	NR	NR	NR	
Pu-241+D	M	3	D	8.25E-03	FGR11	NR	NR	NR	NR	
Ra-226+D	M	3	D	8.60E-03	FGR11	NR	NR	NR	NR	
Ru-106	M	3	D	4.77E-04	FGR11	NR	NR	NR	NR	
Sb-125	M	3	D	1.22E-05	FGR11	NR	NR	NR	NR	
Sr-90+D	M	3	D	1.31E-03	FGR11	NR	NR	NR	NR	

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						1	2	3	4	
Tc-99	M	3	D	8.33E-06	FGR11	NR	NR	NR	NR	
Th-229+D	M	3	D	2.16E+00	FGR11	NR	NR	NR	NR	
Th-230	M	3	D	3.26E-01	FGR11	NR	NR	NR	NR	
U-233	M	3	D	1.35E-01	FGR11	NR	NR	NR	NR	
U-234	M	3	D	1.32E-01	FGR11	NR	NR	NR	NR	
U-235+D	M	3	D	1.23E-01	FGR11	NR	NR	NR	NR	
<b>Dose Conversion Factors (Ingestion mrem/pCi)</b>										
Ac-227+D	M	3	D	1.48E-02	FGR11 (RESRAD Dose Conversion Library)	NR	NR	NR	NR	
Ag-108m	M	3	D	7.62E-06	FGR11	NR	NR	NR	NR	
Am-241	M	3	D	3.64E-03	FGR11	NR	NR	NR	NR	
Am-243+D	M	3	D	3.63E-03	FGR11	NR	NR	NR	NR	
C-14	M	3	D	2.09E-06	FGR11	NR	NR	NR	NR	
Cm-243	M	3	D	2.51E-03	FGR11	NR	NR	NR	NR	
Co-60	M	3	D	2.69E-05	FGR11	NR	NR	NR	NR	
Cs-134	M	3	D	7.33E-05	FGR11	NR	NR	NR	NR	
Cs-137+D	M	3	D	5.00E-05	FGR11	NR	NR	NR	NR	
Eu-152	M	3	D	6.48E-06	FGR11	NR	NR	NR	NR	
Eu-154	M	3	D	9.55E-06	FGR11	NR	NR	NR	NR	
Eu-155	M	3	D	1.53E-06	FGR11	NR	NR	NR	NR	
Fe-55	M	3	D	6.07E-07	FGR11	NR	NR	NR	NR	
Gd-152	M	3	D	1.61E-04	FGR11	NR	NR	NR	NR	
H-3	M	3	D	6.40E-08	FGR11	NR	NR	NR	NR	
Mn-54	M	3	D	2.77E-06	FGR11	NR	NR	NR	NR	
Nb-94	M	3	D	7.14E-06	FGR11	NR	NR	NR	NR	
Ni-59	M	3	D	2.10E-07	FGR11	NR	NR	NR	NR	
Ni-63	M	3	D	5.77E-07	FGR11	NR	NR	NR	NR	
Np-237+D	M	3	D	4.44E-03	FGR11	NR	NR	NR	NR	
Pa-231	M	3	D	1.06E-02	FGR11	NR	NR	NR	NR	
Pb-210+D	M	3	D	5.37E-03	FGR11	NR	NR	NR	NR	
Pu-238	M	3	D	3.20E-03	FGR11	NR	NR	NR	NR	

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Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Pu-239	M	3	D	3.54E-03	FGR11	NR	NR	NR	NR	
Pu-241+D	M	3	D	6.85E-05	FGR11	NR	NR	NR	NR	
Ra-226+D	M	3	D	1.33E-03	FGR11	NR	NR	NR	NR	
Ru-106	M	3	D	2.74E-05	FGR11	NR	NR	NR	NR	
Sb-125	M	3	D	2.81E-06	FGR11	NR	NR	NR	NR	
Sr-90+D	M	3	D	1.53E-04	FGR11	NR	NR	NR	NR	
Tc-99	M	3	D	1.46E-06	FGR11	NR	NR	NR	NR	
Th-229+D	M	3	D	4.03E-03	FGR11	NR	NR	NR	NR	
Th-230	M	3	D	5.48E-04	FGR11	NR	NR	NR	NR	
U-233	M	3	D	2.89E-04	FGR11	NR	NR	NR	NR	
U-234	M	3	D	2.83E-04	FGR11	NR	NR	NR	NR	
U-235+D	M	3	D	2.67E-04	FGR11	NR	NR	NR	NR	
<b>Plant Transfer Factors (pCi/g plant)/(pCi/g soil)</b>										
Ac-227+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	1.1	0.001	0.999	1.0E-03
Ag-108m	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-5.52	0.9	0.001	0.999	4.0E-03
Am-241	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Am-243+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
C-14	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-0.36	0.9	0.001	0.999	7.0E-01
Cm-243	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Co-60	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-2.53	0.9	0.001	0.999	8.0E-02
Cs-134	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.22	1.0	0.001	0.999	4.0E-02
Cs-137+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.22	1.0	0.001	0.999	4.0E-02
Eu-152	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.1	0.001	0.999	2.0E-03
Eu-154	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.1	0.001	0.999	2.0E-03

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Eu-155	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.1	0.001	0.999	2.0E-03
Fe-55	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Gd-152	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.1	0.001	0.999	2.0E-03
H-3	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	1.57	1.1	0.001	0.999	4.8E+00
Mn-54	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-1.20	0.9	0.001	0.999	3.0E-01
Nb-94	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.61	1.1	0.001	0.999	1.0E-02
Ni-59	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.0	0.9	0.001	0.999	5.0E-02
Ni-63	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.0	0.9	0.001	0.999	5.0E-02
Np-237+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.91	0.9	0.001	0.999	2.0E-02
Pa-231	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.61	1.1	0.001	0.999	1.0E-02
Pb-210+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-5.52	0.9	0.001	0.999	4.0E-03
Pu-238	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Pu-239	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Pu-241+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Ra-226+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.22	0.9	0.001	0.999	4.0E-02
Ru-106	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.51	0.9	0.001	0.999	3.0E-02
Sb-125	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.61	1.0	0.001	0.999	1.0E-02
Sr-90+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-1.20	1.0	0.001	0.999	3.0E-01
Tc-99	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	1.61	0.9	0.001	0.999	5.0E+00

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Th-229+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Th-230	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
U-233	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.9	0.001	0.999	2.0E-03
U-234	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.9	0.001	0.999	2.0E-03
U-235+D	P	1	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.9	0.001	0.999	2.0E-03
<b>Meat Transfer Factors (pCi/kg)/(pCi/d)</b>										
Ac-227+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-10.82	1.0	0.001	0.999	2.0E-05
Ag-108m	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.7	0.001	0.999	2.0E-03
Am-241	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.90	0.2	0.001	0.999	5.0E-05
Am-243+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.90	0.2	0.001	0.999	5.0E-05
C-14	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.47	1.0	0.001	0.999	3.1E-02
Cm-243	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-10.82	1.0	0.001	0.999	2.0E-05
Co-60	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.51	1.0	0.001	0.999	3.0E-02
Cs-134	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.00	0.4	0.001	0.999	5.0E-02
Cs-137+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.00	0.4	0.001	0.999	5.0E-02
Eu-152	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.0	0.001	0.999	2.0E-03
Eu-154	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.0	0.001	0.999	2.0E-03
Eu-155	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.0	0.001	0.999	2.0E-03
Fe-55	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.51	0.4	0.001	0.999	3.0E-02

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Gd-152	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	1.0	0.001	0.999	2.0E-03
H-3	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.42	1.0	0.001	0.999	1.2E-02
Mn-54	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.7	0.001	0.999	1.0E-03
Nb-94	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.82	0.9	0.001	0.999	1.0E-06
Ni-59	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-5.30	0.9	0.001	0.999	5.0E-03
Ni-63	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-5.30	0.9	0.001	0.999	5.0E-03
Np-237+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.7	0.001	0.999	1.0E-03
Pa-231	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-12.21	1.0	0.001	0.999	5.0E-06
Pb-210+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.13	0.7	0.001	0.999	8.0E-04
Pu-238	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.21	0.2	0.001	0.999	1.0E-04
Pu-239	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.21	0.2	0.001	0.999	1.0E-04
Pu-241+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.21	0.2	0.001	0.999	1.0E-04
Ra-226+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.7	0.001	0.999	1.0E-03
Ru-106	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.9	0.001	0.999	2.0E-03
Sb-125	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.9	0.001	0.999	1.0E-03
Sr-90+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.61	0.4	0.001	0.999	1.0E-02
Tc-99	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.21	0.7	0.001	0.999	1.0E-04
Th-229+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.21	1.0	0.001	0.999	1.0E-04
Th-230	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.21	1.0	0.001	0.999	1.0E-04

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
U-233	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.13	0.7	0.001	0.999	8.0E-04
U-234	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.13	0.7	0.001	0.999	8.0E-04
U-235+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.13	0.7	0.001	0.999	8.0E-04
<b>Milk Transfer Factors (pCi/L)/(pCi/d)</b>										
Ac-227+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.12	0.9	0.001	0.999	2.0E-06
Ag-108m	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-5.12	0.7	0.001	0.999	6.0E-03
Am-241	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.12	0.7	0.001	0.999	2.0E-06
Am-243+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.12	0.7	0.001	0.999	2.0E-06
C-14	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.4	0.9	0.001	0.999	1.2E-02
Cm-243	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.12	0.9	0.001	0.999	2.0E-06
Co-60	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.7	0.001	0.999	2.0E-03
Cs-134	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.61	0.5	0.001	0.999	1.0E-02
Cs-137+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.61	0.5	0.001	0.999	1.0E-02
Eu-152	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.72	0.9	0.001	0.999	6.0E-05
Eu-154	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.72	0.9	0.001	0.999	6.0E-05
Eu-155	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.72	0.9	0.001	0.999	6.0E-05
Fe-55	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-8.11	0.7	0.001	0.999	3.0E-04
Gd-152	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.72	0.9	0.001	0.999	6.0E-05
H-3	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-4.6	0.9	0.001	0.999	1.0E-02

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				
						1	2	3	4	Median
Mn-54	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-8.11	0.7	0.001	0.999	3.0E-04
Nb-94	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.12	0.7	0.001	0.999	2.0E-06
Ni-59	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.91	0.7	0.001	0.999	2.0E-02
Ni-63	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-3.91	0.7	0.001	0.999	2.0E-02
Np-237+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-11.51	0.7	0.001	0.999	1.0E-05
Pa-231	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-12.21	0.9	0.001	0.999	5.0E-06
Pb-210+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-8.11	0.9	0.001	0.999	3.0E-04
Pu-238	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.82	0.5	0.001	0.999	1.0E-06
Pu-239	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.82	0.5	0.001	0.999	1.0E-06
Pu-241+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-13.82	0.5	0.001	0.999	1.0E-06
Ra-226+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.5	0.001	0.999	1.0E-03
Ru-106	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-10.82	0.6	0.001	0.999	2.0E-05
Sb-125	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-9.72	0.9	0.001	0.999	6.0E-05
Sr-90+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.21	0.5	0.001	0.999	2.0E-03
Tc-99	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-6.91	0.7	0.001	0.999	1.0E-03
Th-229+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-12.21	0.9	0.001	0.999	5.0E-06
Th-230	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-12.21	0.9	0.001	0.999	5.0E-06
U-233	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.82	0.6	0.001	0.999	4.0E-04
U-234	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.82	0.6	0.001	0.999	4.0E-04

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				
						1	2	3	4	Median
U-235+D	P	2	S	Truncated lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	-7.82	0.6	0.001	0.999	4.0E-04
<b>Bioaccumulation Factors for Fish ((pCi/kg)/(pCi/L))</b>										
Ac-227+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.7	1.1			1.5E+01
Ag-108m	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	1.6	1.1			5.0E+00
Am-241	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
Am-243+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
C-14	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	10.8	1.1			4.9E+04
Cm-243	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
Co-60	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.7	1.1			3.0E+02
Cs-134	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	7.6	0.7			2.0E+03
Cs-137+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	7.6	0.7			2.0E+03
Eu-152	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.9	1.1			4.9E+01
Eu-154	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.9	1.1			4.9E+01
Eu-155	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.9	1.1			4.9E+01
Fe-55	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.3	1.1			2.0E+02
Gd-152	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.2	1.1			2.5E+01
H-3	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	0	0.1			1.0E+00
Mn-54	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	6	1.1			4.0E+02

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
Nb-94	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.7	1.1			3.0E+02
Ni-59	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.6	1.1			9.9E+01
Ni-63	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.6	1.1			9.9E+01
Np-237+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
Pa-231	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.3	1.1			1.0E+01
Pb-210+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.7	1.1			3.0E+02
Pu-238	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
Pu-239	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
Pu-241+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.4	1.1			3.0E+01
Ra-226+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.9	1.1			4.9E+01
Ru-106	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3.0	1.1			2.0E+01
Sb-125	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.6	1.1			9.9E+01
Sr-90+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.1	1.1			6.0E+01
Tc-99	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	3	1.1			2.0E+01
Th-229+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.6	1.1			9.9E+01
Th-230	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	4.6	1.1			9.9E+01
U-233	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.3	1.1			1.0E+01
U-234	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.3	1.1			1.0E+01
U-235+D	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	2.3	1.1			1.0E+01

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				Median
						1	2	3	4	
<b>Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))</b>										
Ac-227+D	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
Ag-108m	P	3	D	7.70E+02	RESRAD Default	NR	NR	NR	NR	
Am-241	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
Am-243+D	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
C-14	P	3	D	9.10E+03	RESRAD Default	NR	NR	NR	NR	
Cm-243	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
Co-60	P	3	D	2.00E+02	RESRAD Default	NR	NR	NR	NR	
Cs-134	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Cs-137+D	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Eu-152	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
Eu-154	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
Eu-155	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
Fe-55	P	3	D	3.20E+03	RESRAD Default	NR	NR	NR	NR	
Gd-152	P	3	D	1.00E+03	RESRAD Default	NR	NR	NR	NR	
H-3	P	3	D	1.00E+00	RESRAD Default	NR	NR	NR	NR	
Mn-54	P	3	D	9.00E+04	RESRAD Default	NR	NR	NR	NR	
Nb-94	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Ni-59	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Ni-63	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Np-237+D	P	3	D	4.00E+02	RESRAD Default	NR	NR	NR	NR	
Pa-231	P	3	D	1.10E+02	RESRAD Default	NR	NR	NR	NR	
Pb-210+D	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Pu-238	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Pu-239	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Pu-241+D	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Ra-226+D	P	3	D	2.50E+02	RESRAD Default	NR	NR	NR	NR	
Ru-106	P	3	D	3.00E+02	RESRAD Default	NR	NR	NR	NR	
Sr-90+D	P	3	D	1.00E+02	RESRAD Default	NR	NR	NR	NR	
Sb-125	P	3	D	1.00E+01	RESRAD Default	NR	NR	NR	NR	

**Table 1**  
**Input Parameters for Sensitivity Analysis, Soil**  
**Resident Farmer Scenario**

Parameter (unit)	Type <sup>a</sup>	Priority <sup>b</sup>	Treatment <sup>c</sup>	Value/Distribution	Basis	Distribution's Statistical Parameters <sup>d</sup>				
						1	2	3	4	Median
Tc-99	P	3	D	5.00E+00	RESRAD Default	NR	NR	NR	NR	
Th-229+D	P	3	D	5.00E+02	RESRAD Default	NR	NR	NR	NR	
Th-230	P	3	D	5.00E+02	RESRAD Default	NR	NR	NR	NR	
U-233	P	3	D	6.00E+01	RESRAD Default	NR	NR	NR	NR	
U-234	P	3	D	6.00E+01	RESRAD Default	NR	NR	NR	NR	
U-235+D	P	3	D	6.00E+01	RESRAD Default	NR	NR	NR	NR	
<b>Graphics Parameters</b>										
Number of points				32	RESRAD Default	NR	NR	NR	NR	
Spacing				log	RESRAD Default	NR	NR	NR	NR	
Time integration parameters										
Maximum number of points for dose				17	RESRAD Default	NR	NR	NR	NR	

**Notes:**

a P = physical, B = behavioral, M = metabolic; (see NUREG/CR-6697, Attachment B, Table 4.)

b 1 = high-priority parameter, 2 = medium-priority parameter, 3 = low-priority parameter (see NUREG/CR-6697, Attachment B, Table 4.1)

c D = deterministic, S = stochastic

d Distributions Statistical Parameters:

Lognormal-n: 1 = mean, 2 = standard deviation

Bounded lognormal-n: 1 = mean, 2 = standard deviation, 3 = minimum, 4 = maximum

Truncated lognormal-n: 1 = mean, 2 = standard deviation, 3 = lower quantile, 4 = upper quantile

Bounded normal: 1 = mean, 2 = standard deviation, 3 = minimum, 4 = maximum

Beta: 1 = minimum, 2 = maximum, 3 = P-value, 4 = Q-value

Triangular: 1 = minimum, 2 = mode, 3 = maximum

Uniform: 1 = minimum, 2 = maximum

**Additional Sensitivity Analysis Data:**

Sampling technique = Latin Hypercube

Number of observations = 300

Number of repetitions = 3

**Input Rank Correlation Coefficients:**

Thickness of contaminated zone and unsaturated zone = - 0.99

Well Pumping Rate and Irrigation Rate = 0.96

**References:**

1. Yu, C. et al., "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil"; US Department of Energy – Argonne National Laboratory, April 1993.
2. NUREG/CR-5512, Volume 3, "Residual Radioactive Contamination From Decommissioning: Parameter Analysis, Draft Report for Comment," October 1999.
3. Code of Federal Regulations, Title 10, Section 20.1402, "Radiological Criteria for Unrestricted Use".

4. NUREG/CR-6697, "Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes", December 2000.
5. YA-REPT-00-002-03, Hydrogeological Parameter Estimates for Radiation Dose Modeling, April 2003.

**Attachment 3**

**YA-CALC-00-001-03 CD**

**Stored pdf files:   Sensitivity Analysis.pdf  
                          Deterministic Analysis.pdf**

The enclosed CD holds the pdf files containing the Resident Farmer Scenario sensitivity analyses input and output pages from the RESRAD mcsummar.rep and summary.rep reports.

CD Name: YACALC-00-001-03

File: Sensitivity Analysis.pdf  
Deterministic Analysis.pdf

## CALCULATION TITLE PAGE

Derived Concentration Guideline Levels for Soil at YNPS Site

Title

YA-CALC-00-002-03

Calculation Number

### Executive Summary:

The resident farmer scenario of the probabilistic computer code RESRAD version 6.21 was used to determine the peak of the mean dose for radionuclides of interest at the Yankee Rowe site. The peak of the mean dose per unit radionuclide concentration was used to calculate the nuclide specific Derived Concentration Guideline Levels for residual radioactivity in soil to meet the regulatory annual dose limit of 25 mrem/yr.

### Approvals

(Print & Sign Name)

Preparer: Estella Keefer	<i>Estella Keefer</i>	Date: 6/4/03
Alice Carson	<i>Alice C. Carson</i>	6/4/03
Reviewer: Ben Caronault	<i>Ben Caronault</i>	Date: 6/18/03
Approver (Cognizant Manager): Gm Babineau	<i>Gm Babineau</i>	Date: 6/18/03

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## ATTACHMENTS

	<u>No. of Pages</u>
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## PURPOSE:

The purpose of this calculation is to calculate nuclide specific Derived Concentration Guideline Level (DCGL) values using the peak of the mean dose determined in YR-CALC-00-001-03, "RESRAD 6.21 Sensitivity Analysis for Soil-Resident Farmer Scenario," (Ref. 1). This method is in accordance with the NRC guidance provided in NUREG-1727 and the draft NUREG-1757 (Ref. 2, Ref. 3). Compliance with dose guidelines is demonstrated by running RESRAD V 6.21 using the calculated values of the DCGL as the radionuclide soil concentration.

## SUMMARY OF RESULTS:

NUREG-1727 and Draft NUREG-1757 both discuss the application of the peak of the mean dose to derive a nuclide specific DCGL value. The Sensitivity Analysis discussed in Ref. 1 used the probabilistic module in the RESRAD code to determine the mean dose distribution. The Sensitivity Analysis output also provides a summary of the peak of the mean dose and the time this peak occurs as determined from this dose distribution. The peak of the mean dose from a RESRAD run using a unit concentration for a particular nuclide is the Dose Conversion Factor (DCF) used for determining the DCGL. In the specific runs performed for this calculation, three repetitions were specified and the median of the three DCF results was used in the DCGL calculation.

Table 1 summarizes the DCF values documented in YR-CALC-00-001-03 (Ref.1), with the exception of the nickel values, which were obtained following the protocol discussed in the "Method/Body of Calculation" section below. The calculated DCGL values are based on the regulatory dose limit of 25 mrem/yr (Ref 4).

Table 1 - Radionuclide Specific DCGL Values for Soil

Nuclide	Median DCF mrem/yr per pCi/gm	DCGL pCi/gm	Nuclide	Median DCF mrem/yr per pCi/gm	DCGL pCi/gm
H-3	2.932E-02	8.527E+02	Sb-125	6.626E-01	3.773E+01
C-14	2.227E+00	1.123E+01	Cs-134	3.728E+00	6.706E+00
Mn-54	1.154E+00	2.166E+01	Cs-137	2.042E+00	1.224E+01
Fe-55	6.907E-04	3.620E+04	Eu-152	2.073E+00	1.206E+01
Ni-59	6.239E-03	4.007E+03	Eu-154	2.247E+00	1.113E+01
Ni-63	1.708E-02	1.464E+03	Eu-155	5.353E-02	4.670E+02
Co-60	5.167E+00	4.838E+00	Pu-238	4.839E-01	5.166E+01
Sr-90	9.330E+00	2.680E+00	Pu-239	5.445E-01	4.591E+01
Nb-94	2.930E+00	8.532E+00	Pu-241	1.581E-02	1.581E+03
Tc-99	9.891E-01	2.528E+01	Am-241	5.637E-01	4.435E+01
Ru-106	3.665E-01	6.821E+01	Cm-243	5.493E-01	4.551E+01
Ag-108m	2.934E+00	8.521E+00			

#### REFERENCES:

1. YA-CALC-00-001-03, "RESRAD 6.21 Sensitivity Analysis for Soil-Resident Farmer Scenario," May 2003.
2. NUREG-1727. "NMSS Decommissioning Standard Review Plan," September 2000.
3. NUREG-1757. "Consolidated NMSS Decommissioning Guidance," Volume 2: Characterization, Survey and Determination of Radiological Criteria," Draft Report for Comment, dated September 2002.
4. Code of Federal Regulations, Title 10, Section 20.1402, "Radiological Criteria for Unrestricted Uses."

## ASSUMPTIONS:

The resident farmer scenario was chosen for the YR site as the conservative bounding scenario for establishing DCGL values for residual radioactivity in soil in compliance with the regulatory limits of 10CFR 20 (Ref. 4). A probabilistic analysis of the impact of parameter changes on the resultant dose is documented in Reference 1, "RESRAD 6.21 Sensitivity Analysis for Soil-Resident Farmer Scenario". Running the RESRAD code in conjunction with a unit radionuclide concentration, results in a dose conversion factor in mrem/yr per pCi/gm. This dose conversion factor can be used to derive DCGL values that satisfy the dose limit for the average member of the critical group as required by 10CFR Part 20, Subpart E and described in NUREG-1727, Appendix C (Ref. 2). Inherent in the use of the peak of the mean dose are the assumptions that the true value of a parameter falls within the specified range and that the peak of the mean dose is the maximum value of the mean dose over the evaluation time. In the specific case at YR, deterministic values were determined for 26 site-specific parameters, including 20 hydro-geologic parameters and 6 site-area parameters that minimize the uncertainty in the results that are associated with the use of parameter distributions.

## METHOD / BODY OF CALCULATION:

The nuclide specific sensitivity analysis documented in Ref. 1 was performed using the following sampling specifications in the uncertainty analysis: Random Seed = 1000, No. of Observations = 300 and No. of Repetitions = 3. An average or mean dose distribution is determined over time based on 300 samplings of each parameter distribution. A peak search routine identifies the peak of the mean dose for each repetition of the RESRAD run as well as the time that the peak dose occurs. The peak of the mean dose, obtained with a 1 pCi/gm radionuclide concentration, is used as a dose conversion factor (DCF) to derive the DCGL value.

RESRAD determines the peak of the mean dose for each of the 3 repetitions. A criterion for an acceptable variation among the results was established for the runs using 300 observations and 3 repetitions. This acceptance criterion for the precision in the repetitions, set at 3%, was used to trigger an additional probabilistic analysis using 1000 observations (and 3 repetitions) to minimize the variation among the resultant dose distributions (or optimize the convergence of the dose curves). Results falling outside this criterion were re-run with 1000 observations.

The nuclide DCGL was calculated using the median value of the three results. The median, which provides a measure of the middle of the data is, in the case of 3 reps, the middle value. The DCF was used to calculate the nuclide DCGL value according to the following equation.

$$\text{DCGL (pCi/gm)} = \frac{25 \text{ mrem/yr}}{\text{DCF (mrem/yr / pCi/gm)}}$$

Table 2 lists the DCF for each repetition of the run and the precision among the repetitions. For the nuclides with results falling outside the 3% criteria listed above, the results of the runs performed for 1000 observations are presented as well.

Table 3 lists the median DCF value from Table 2 and the corresponding DCGL based on the equation above. The dose verification in column 4 of Table 3, as recommended in NUREG-1727, demonstrates that the median dose value resulting from exposure to a soil concentration at the DCGL value derived in this manner does not exceed the regulatory dose criterion of 25 mrem/yr. The verification runs used all the same input parameters as the sensitivity analysis documented in Ref. 1. The three doses listed for each

nuclide in column 4 represent the results of the probabilistic code run with three repetitions and 300 observations as used in Ref. 1.

Table 2 - Peak of the Mean Dose per unit pCi/gm as Determined by Probabilistic Analysis for the Resident Farmer Scenario-soil

Radionuclide	Peak of the Mean Dose* Repetition 1	Peak of the Mean Dose* Repetition 2	Peak of the Mean Dose* Repetition 3	% precision among Repetitions
H-3	2.932E-02	2.913E-02	2.947E-02	0.58
C-14	2.229E+00	2.219E+00	2.227E+00	0.24
Mn-54	1.153E+00	1.154E+00	1.156E+00	0.13
Fe-55	6.907E-04	6.923E-04	6.904E-04	0.15
Ni-59	6.010E-03	6.023E-03	6.550E-03	4.97
1000 obs.	6.222E-03	6.239E-03	6.267E-03	0.36
Ni-63	1.645E-02	1.649E-02	1.793E-02	4.95
1000 obs.	1.703E-02	1.708E-02	1.716E-02	0.38
Co-60	5.172E+00	5.154E+00	5.167E+00	0.18
Sr-90	9.270E+00	9.330E+00	9.653E+00	2.19
Nb-94	2.927E+00	2.931E+00	2.930E+00	0.07
Tc-99	9.883E-01	9.891E-01	1.027E+00	2.21
Ru-106	3.665E-01	3.668E-01	3.655E-01	0.19
Ag-108m	2.934E+00	2.932E+00	2.934E+00	0.04
Sb-125	6.619E-01	6.627E-01	6.626E-01	0.07
Cs-134	3.751E+00	3.688E+00	3.728E+00	0.86
Cs-137	2.042E+00	2.037E+00	2.052E+00	0.37
Eu-152	2.073E+00	2.074E+00	2.073E+00	0.03
Eu-154	2.246E+00	2.247E+00	2.248E+00	0.04
Eu-155	5.348E-02	5.353E-02	5.354E-02	0.06
Pu-238	4.714E-01	4.952E-01	4.839E-01	2.46
Pu-239	5.462E-01	5.445E-01	5.275E-01	1.92
Pu-241	1.578E-02	1.581E-02	1.624E-02	1.61
Am-241	5.637E-01	5.639E-01	5.496E-01	1.47
Cm-243	5.493E-01	5.445E-01	5.582E-01	1.26

\* Unit in mrem/yr per pCi/gm

Table 3 - Soil DCGL values and DCGL Dose Results

Nuclide	Median DCF mrem/yr per pCi/gm	DCGL pCi/gm	DCGL Dose Calculation, mrem/yr
H-3	2.932E-02	8.527E+02	25.00
			24.84
			25.13
C-14	2.227E+00	1.123E+01	25.03
			24.91
			25.01
Mn-54	1.154E+00	2.166E+01	24.97
			24.99
			25.03
Fe-55	6.907E-04	3.620E+04	25.00
			25.06
			24.99
Ni-59	6.239E03	4.007E+03	24.93
			25.00
			25.11
Ni-63	1.708E-02	1.464E+03	24.94
			25.01
			25.12
Co-60	5.167E+00	4.838E+00	25.02
			24.94
			25.00
Sr-90	9.330E+00	2.680E+00	24.84
			25.01
			25.87
Nb-94	2.930E+00	8.532E+00	24.97
			25.01
			25.00
Tc-99	9.891E-01	2.528E+01	24.98
			25.00
			25.96
Ru-106	3.665E-01	6.821E+01	25.00
			25.02
			24.93
Ag-108m	2.934E+00	8.521E+00	25.00
			24.98
			25.00
Sb-125	6.626E-01	3.773E+01	24.97
			25.01
			25.00

Table 3 - Soil DCGL values and DCGL Dose Results, con't

Nuclide	Median DCF mrem/yr per pCi/gm	DCGL pCi/gm	DCGL Dose Calculation mrem/yr
Cs-134	3.728E+00	6.706E+00	25.16
			24.73
			25.00
Cs-137	2.042E+00	1.224E+01	25.00
			24.94
			25.12
Eu-152	2.073E+00	1.206E+01	25.00
			25.01
			25.00
Eu-154	2.247E+00	1.113E+01	25.00
			25.01
			25.02
Eu-155	5.353E-02	4.670E+02	24.98
			25.00
			25.00
Pu-238	4.839E-01	5.166E+01	24.35
			25.58
			25.00
Pu-239	5.445E-01	4.591E+01	25.08
			25.00
			24.22
Pu-241	1.581E-02	1.581E+03	24.95
			25.00
			25.68
Am-241	5.637E-01	4.435E+01	25.00
			25.01
			24.38
Cm-243	5.493E-01	4.551E+01	25.00
			24.78
			25.40

**Attachment 1**

**YA-CALC-00-002-03 CD**

The enclosed CD contains the electronic image files containing the Resident Farmer Scenario DCGL Dose Verification output pages from the RESRAD V6.21 mcsummar.rep and summary.rep reports.

The DCGL Deterministic Input.pdf is included to demonstrate that the calculated DCGL value was used as the initial radionuclide concentration. The DCGL Dose Verification.pdf is included to show the annual dose corresponding to a radionuclide concentration equal to the calculated DCGL values. The Sensitivity Analysis.pdf is provided to show the DCF values determined in the probabilistic runs discussed in Ref. 1. Two Files are also provided containing the Nickel runs with 1000 observations.

CD Name: YA-CALC-00-002-03

File: DCGL Deterministic Input.pdf  
Deterministic Input\_Ni\_1000.pdf  
DCGL Dose Verification.pdf  
DCGL Dose Verification\_Ni\_1000.pdf  
Sensitivity Analysis.pdf