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December 16, 2003
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U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Reference: (a) License No. DPR-3 (Docket No. 50-29)

Subject: RESRAD Calculation for License Termination Plan (LTP)

This letter provides a copy of a calculation in support of the LTP for the Yankee Nuclear Power Station (YNPS). A hardcopy of the calculation is enclosed as well as an electronic copy of the input files via CD. The specific calculation provided is as follows:

(1) YA-CALC-01-001-03, "RESRAD 6.21 Sensitivity Analysis for Resident Farmer Scenario - Soil"

This calculation is provided for your review. If you have any questions, please contact us.

Sincerely,

YANKEE ATOMIC ELECTRIC COMPANY

James A. Kay
Principal Licensing Engineer

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CALCULATION TITLE PAGE

RESRAD 6.21 Sensitivity Analysis for Resident Farmer Scenario-Soil

Title

YA-CALC-01-001-03

Calculation Number

COPY

Executive Summary:
Nuclide-specific sensitivity analyses were performed using RESRAD Version 6.21 to assess the sensitivity of the dose from residual radioactivity in soil to key input parameters. This calculation presents the methodology used to prioritize parameters and the results of the sensitivity analysis.

Approvals	(Print & Sign Name)		
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Preparer: Estella Keefer			Date:
Preparer: Joe Bisson			Date:
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ELLEN M. HEATH

FOR SIGNATURES

CALCULATION TITLE PAGE

RESRAD 6.21 Sensitivity Analysis for Resident Farmer Scenario-Soil

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YA-CALC-01-001-03

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Approvals (Print & Sign Name)		
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Reviewer:	Section:	Date:
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Approvals	(Print & Sign Name)		
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Approvals (Print & Sign Name)		
Preparer: Ron Cardarelli		Date:
Preparer: Estella Keefer		Date:
Preparer: Joe Bisson		Date:
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A. 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 identification of the sensitive parameters is accomplished through the use of the probabilistic modules in the RESRAD version 6.21 computer code. A flow-charted process is used to identify parameters as behavioral, metabolic or physical. Metabolic and behavioral parameters are assigned site-specific values or values from NUREG/CR -5512 Vol. 3, or NUREG/CR-6697. Physical parameters are assigned site-specific values or are treated stochastically and assigned a distribution from NUREG/CR-6697. The distribution statistics are used as the input to the probabilistic module of RESRAD. The Partial Rank Correlation Coefficient (PRCC) is used as the measure of the sensitivity of the dose to variations in the input parameter.

B. SUMMARY OF RESULTS:

A summary of results of the sensitivity analysis for the nuclides in Table 2 is presented below. 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. Parameters are listed in order of PRCC rank.

Table 1
Sensitive Parameters Based on RESRAD Sensitivity Analysis

Nuclide	Rank 1 parameter	Rank 2 parameter	Rank 3 parameter	Rank 4 parameter	Rank 5 parameter
H-3	Depth of roots	Kd of H-3 in contaminated zone	Thickness of contaminated zone		
C-14	Depth of roots	Thickness of contaminated zone	Thickness of evasion layer of C-14		
Fe-55	Meat transfer factor for Fe	Plant transfer factor for Fe			
Co-60	External gamma shielding factor	Plant transfer factor for Co	Meat transfer factor for Co		
Ni-63	Plant transfer factor for Ni	Milk transfer factor for Ni	Depth of roots		
Sr-90	Plant transfer factor for Sr	Depth of roots			
Nb-94	External gamma shielding factor	Kd of Nb in contaminated zone			
Tc-99	Plant transfer factor for Tc	Depth of roots	Kd of Tc in contaminated zone		
Ag-108m	External gamma shielding factor				
Sb-125	External gamma shielding factor	Kd of Sb in contaminated zone			
Cs-134	External gamma shielding factor	Plant transfer factor for Cs	Depth of roots	Milk transfer factor for Cs	Meat transfer factor for Cs
Cs-137	Plant transfer factor for Cs	External gamma shielding factor	Depth of roots	Milk transfer factor for Cs	Meat transfer factor for Cs
Eu-152	External gamma shielding factor				
Eu-154	External gamma shielding factor				

Table 1
Sensitive Parameters Based on RESRAD Sensitivity Analysis

Nuclide	Rank 1 parameter	Rank 2 parameter	Rank 3 parameter	Rank 4 parameter	Rank 5 parameter
Eu-155	External gamma shielding factor	Plant transfer factor for Eu			
Pu-238	Plant transfer factor for Pu	Depth of roots			
Pu-239	Plant transfer factor for Pu	Depth of roots			
Pu-241	Plant transfer factor for Am	Depth of roots	Kd of Am-241 in contaminated zone		
Am-241	Plant transfer factor for Am	Depth of roots			
Cm-243	Plant transfer factor for Cm	External gamma shielding factor	Depth of roots		

C. REFERENCES:

1. YA-REPT-00-001-03, "Radionuclide Selection for DCGL Determination," October 2003.

2. 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.

3. CFR Title 10, Section 20.1402, "Radiological Criteria for Unrestricted Uses."

4. NUREG-1727. "NMSS Decommissioning Standard Review Plan," September 2000.

5. ANL/EAD-4, "Users Manual for RESRAD Version 6.0," Yu, C. et al., July 2001.

6. 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.

7. 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.

8. 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.

9. YA-REPT-00-002-03, "Hydrogeological Parameter Estimates for Radiation Dose Modeling," April 2003.

10. YA-REPT-00-008-03, "Evaluation of GeoTesting Express Soil Testing and Determination of Depth to Groundwater," December 2003.

11. Yu, C., et al, Argonne National Laboratory, April 1993, Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil.

D. ASSUMPTIONS:

1. Radionuclide List

The sensitivity analysis runs of the RESRAD Resident Farmer scenario were performed for the radionuclides listed in Table 2. This list of radionuclides was developed by consideration of historical site data, waste stream analyses and source terms in NUREG guidance to encompass the radionuclides that may present a significant dose impact (Ref. 1).

Table 2
YNPS Radionuclide List

H-3	Tc-99	Eu-155
C-14	Ag-108m	Pu-238
Fe-55	Sb-125	Pu-239
Co-60	Cs-134	Pu-241
Ni-63	Cs-137	Am-241
Sr-90	Eu-152	Cm-243
Nb-94	Eu-154	

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

The dose model used to perform the sensitivity analyses and to calculate subsequent soil DCGLs is based upon the Resident Farmer Scenario defined in NUREG/CR-5512 Volumes 1, 2 and 3 (Ref. 2). 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 postulated 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. 3, Ref. 4). 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., 1993 (Ref. 5).

E. 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. 6, Ref. 7, Ref. 8). 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 NUREG/CR-6697 approach to prioritizing parameters was applied in this calculation. The priority of a particular parameter is based upon:

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

Input parameters are treated as either "deterministic" -assigned a single value, or "stochastic" -assigned a probability distribution. The treatment depends on parameter type, priority, availability of site-specific data and the relevance of the parameter in dose calculations.

- Behavioral and metabolic parameters are treated as deterministic and are assigned values from NUREG/CR-5512, Volume 3, NUREG/CR-6697, or the RESRAD default library.
- Physical parameters for which site-specific data is available are treated as deterministic based on information in Attachment 1, YA-REPT-00-002-003 (Ref. 9) and YA-REPT-00-004-003 (Ref. 10).
- The remaining physical parameters, for which no site-specific data is available, are assigned values based on priority. Priority 1 and 2 parameters were treated as stochastic and are assigned a probability distribution from NUREG/CR-6697. The priority 3 physical parameters were treated as deterministic and are assigned values from NUREG/CR-5512, Volume 3, NUREG/CR-6697, or the RESRAD default library.

Parameter values and the basis for the assignment are summarized in Attachment 2, Table 1.

2. RESRAD Resident Farmer Sensitivity Analysis Runs

The probabilistic module of the RESRAD code was used to perform the analyses to identify stochastic parameters having the greatest influence on the resultant dose and the associated DCGLs. The data in Attachment 2, Table 1 were used as inputs to the RESRAD code and, where appropriate, the probability distribution statistical parameters were entered into the probabilistic modules of the code. The code is run individually for the nuclides listed in Table 2 at a concentration of 1 pCi per gram. Prior to use, the operability of the RESRAD Version 6.21 code was verified in accordance with YNPS Procedures.

Sample Specifications

The analyses were run using 2000 observations and 1 repetition. 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

Input correlations were assigned between correlated parameters based on guidance provided in NUREG/CR-6676 and NUREG/CR-6697.

Output Specifications

All of the output options were specified.

The 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.

Uncertainty Report

The RESRAD Uncertainty Report provides regression and correlation coefficients for the peak of the mean dose. The PRCC correlation coefficient has been used to identify sensitive parameters with the limit set at 0.25. Parameter values are further identified as being positively or negatively correlated to dose by assessing whether the PRCC value is greater than zero or less than zero.

NUREG/CR-6692 and 6697 recommend the use of the PRCC or SRRC for cases where a non-linear relationship and widely disparate scales exists between the inputs and outputs. The NUREG/CR

guidance further recommends the use of the PRCC if the strong correlation exists between input parameters.

Table 3 identifies for each radionuclide the sensitive parameters in order of rank, the PRCC values and the R-Squared value. R-Squared, the coefficient of determination presents a measure of the variation in the peak dose explained by the regression on the input parameters involved in the analysis and varies between 0 and 1.

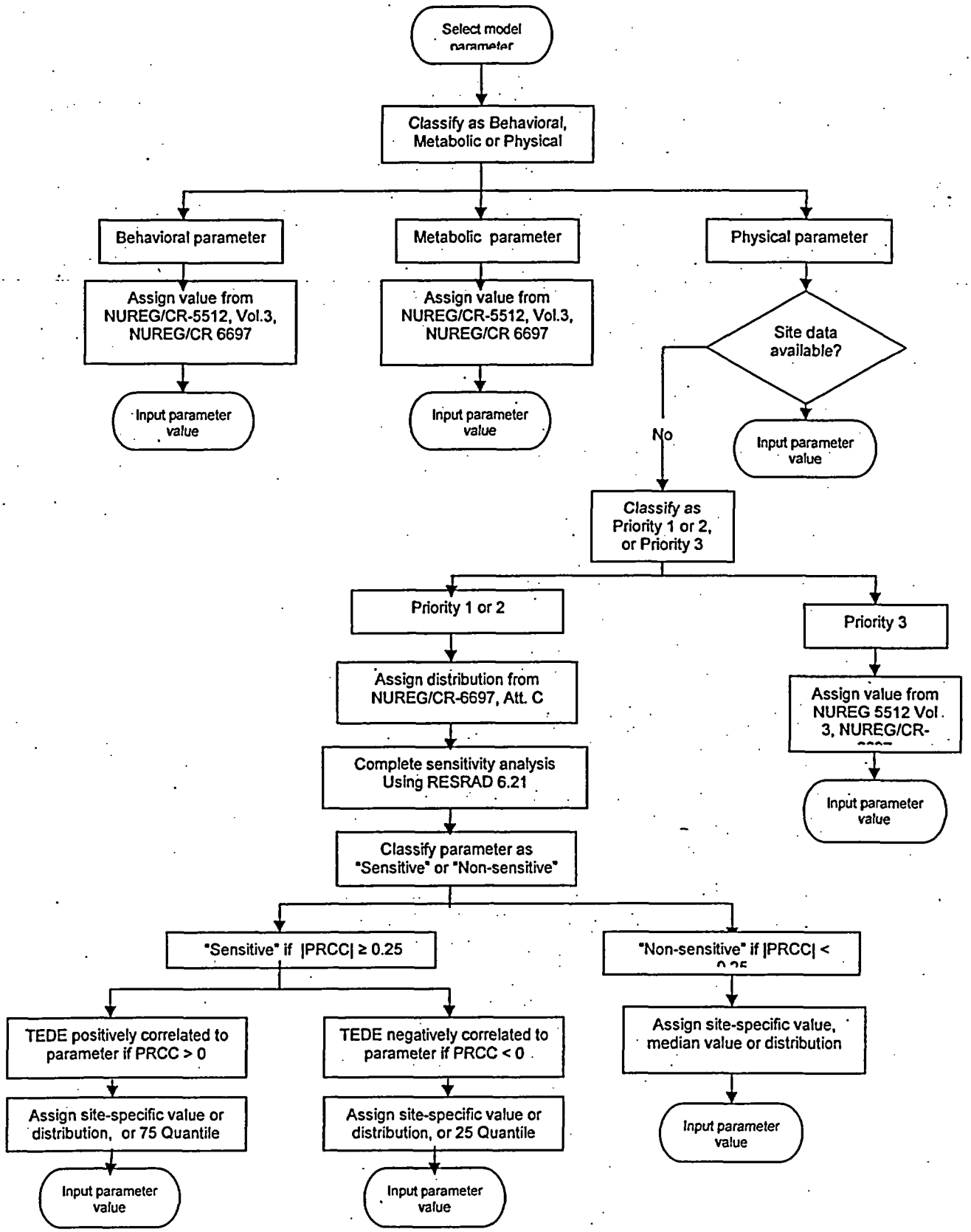
Table 3
Sensitivity Analysis Results Based on the Partial Rank Correlation Coefficient

Radionuclide	Sensitive Parameter	Units	PRCC [R Squared]
H-3	Depth of roots	m	-0.59
	Kd of H-3 in contaminated zone	cm^3/g	-0.54
	Thickness of contaminated zone	m	0.45
			[0.93]
C-14	Depth of roots	m	-0.59
	Thickness of contaminated zone	m	0.48
	Thickness of evasion layer of C-14	m	0.35
			[0.94]
Fe-55	Meat transfer factor for Fe	pCi/kg per pCi/d	0.92
	Plant transfer factor for Fe	pCi/g plant per pCi/g soil	0.68
			[0.88]
Ni-63	Plant transfer factor for Ni	pCi/g plant per pCi/g soil	0.90
	Milk transfer factor for Ni	pCi/l per pCi/d	0.80
	Depth of roots	m	-0.49
			[0.88]
Co-60	External gamma shielding factor	Unit-less	0.95
	Plant transfer factor for Co	pCi/g plant per pCi/g soil	0.67
	Meat transfer factor for Co	pCi/kg per pCi/d	0.36
			[0.91]
Sr-90	Plant transfer factor for Sr	pCi/g plant per pCi/g soil	0.93
	Depth of roots	m	-0.53
			[0.89]
Nb-94	External gamma shielding factor	Unit-less	0.99
	Kd of Nb-94 in contaminated zone	cm^3/g	0.30
			[0.97]
Tc-99	Plant transfer factor for Tc	pCi/g plant per pCi/g soil	0.88
	Depth of roots	m	-0.44
	Kd of Tc-99 in contaminated zone	cm^3/g	0.49
			[0.85]
Ag-108m	External gamma shielding factor	Unit-less	1.00
			[0.99]
Sb-125	External gamma shielding factor	Unit-less	0.99
	Kd of Sb in contaminated zone	cm^3/g	0.29
			[0.97]
Cs-134	External gamma shielding factor	Unit-less	0.84
	Plant transfer factor for Cs	pCi/g plant per pCi/g soil	0.84
	Depth of roots	m	-0.33
	Milk transfer factor for Cs	pCi/l per pCi/d	0.32
	Meat transfer factor for Cs	pCi/kg per pCi/d	0.25

Table 3
Sensitivity Analysis Results Based on the Partial Rank Correlation Coefficient

Radionuclide	Sensitive Parameter	Units	PRCC [R Squared]
			[0.84]
Cs-137	Plant transfer factor for Cs	pCi/g plant per pCi/g soil	0.88
	External gamma shielding factor	Unit-less	0.75
	Depth of roots	m	-0.39
	Milk transfer factor for Cs	pCi/l per pCi/d	0.39
	Meat transfer factor for Cs	pCi/kg per pCi/d	0.31
			[0.85]
Eu-152	External gamma shielding factor	Unit-less	0.99
			[0.98]
Eu-154	External gamma shielding factor	Unit-less	0.99
			[0.99]
Eu-155	External gamma shielding factor	Unit-less	0.99
	Plant transfer factor for Eu	pCi/g plant per pCi/g soil	0.29
			[0.99]
Pu-238	Plant transfer factor for Pu	pCi/g plant per pCi/g soil	0.92
	Depth of roots	m	-0.54
			[0.88]
Pu-239	Plant transfer factor for Pu	pCi/g plant per pCi/g soil	0.92
	Depth of roots	m	-0.53
			[0.88]
Pu-241	Plant transfer factor for Am	pCi/g plant per pCi/g soil	0.85
	Depth of roots	m	-0.44
	Kd of Am-241 in contaminated zone	cm^3/g	0.28
			[0.79]
Am-241	Plant transfer factor for Am	pCi/g plant per pCi/g soil	0.92
	Depth of roots	m	-0.54
			[0.88]
Cm-243	Plant transfer factor for Cm	pCi/g plant per pCi/g soil	0.91
	External gamma shielding factor	Unit-less	0.58
	Depth of roots	m	-0.50
			[0.87]

Figure 1
Parameter Selection Process



ATTACHMENT 1

Supporting Documentation for Site-Specific Physical Parameter Values

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3. Humidity in Air	6
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5. Precipitation	8
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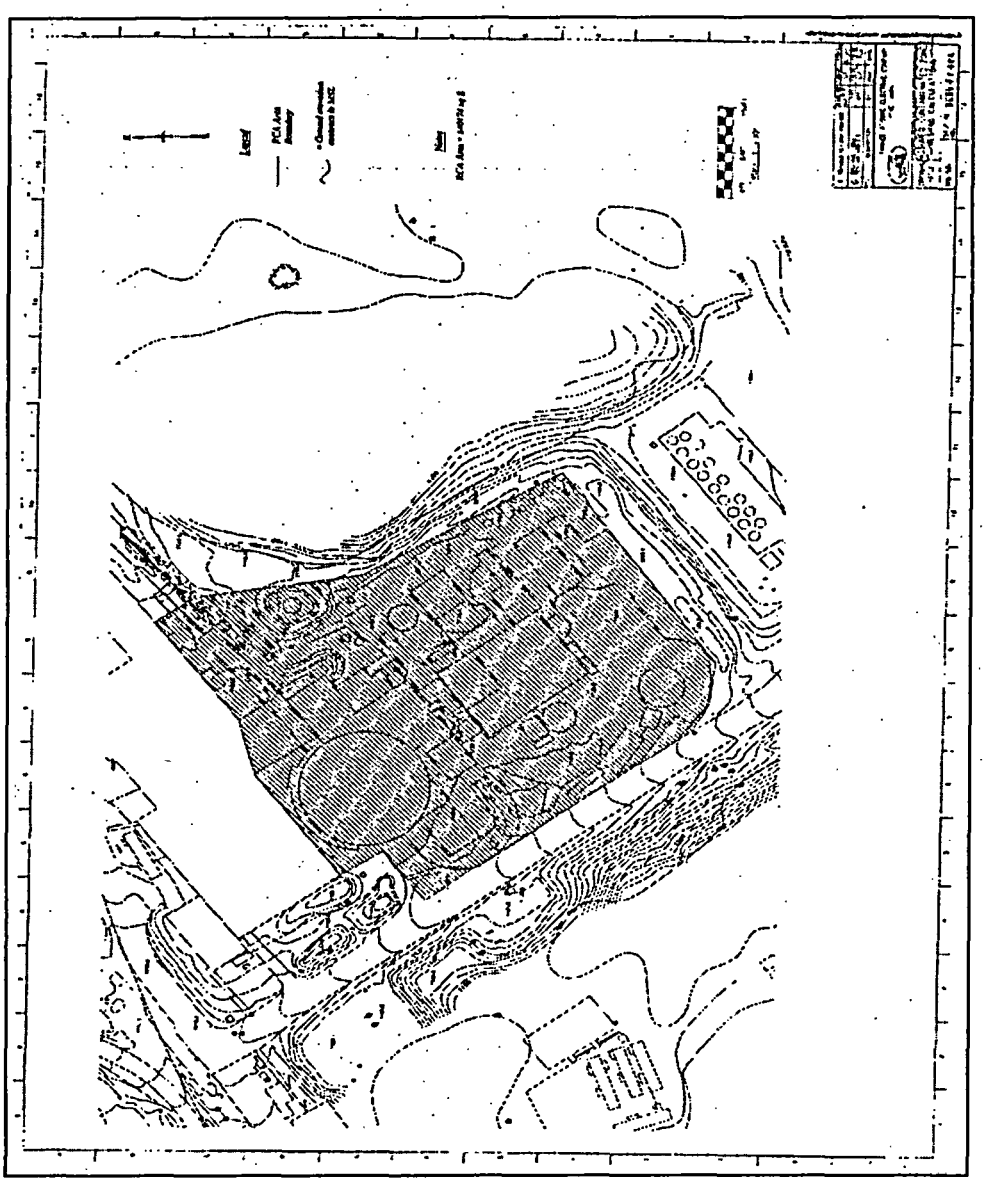
1. Area of the Contaminated Zone

Figure 1-1, (YR Drawing: 9699-FY-6BA Original) 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 ft^2) * (9.29E-02 m^2 per ft^2) = 13022m^2. The area of the contaminated zone was assigned a value of 13022m^2. Attachment 4 contains a larger version of Figure 1-1.

Figure 1- 1 Area of the Contaminated Zone

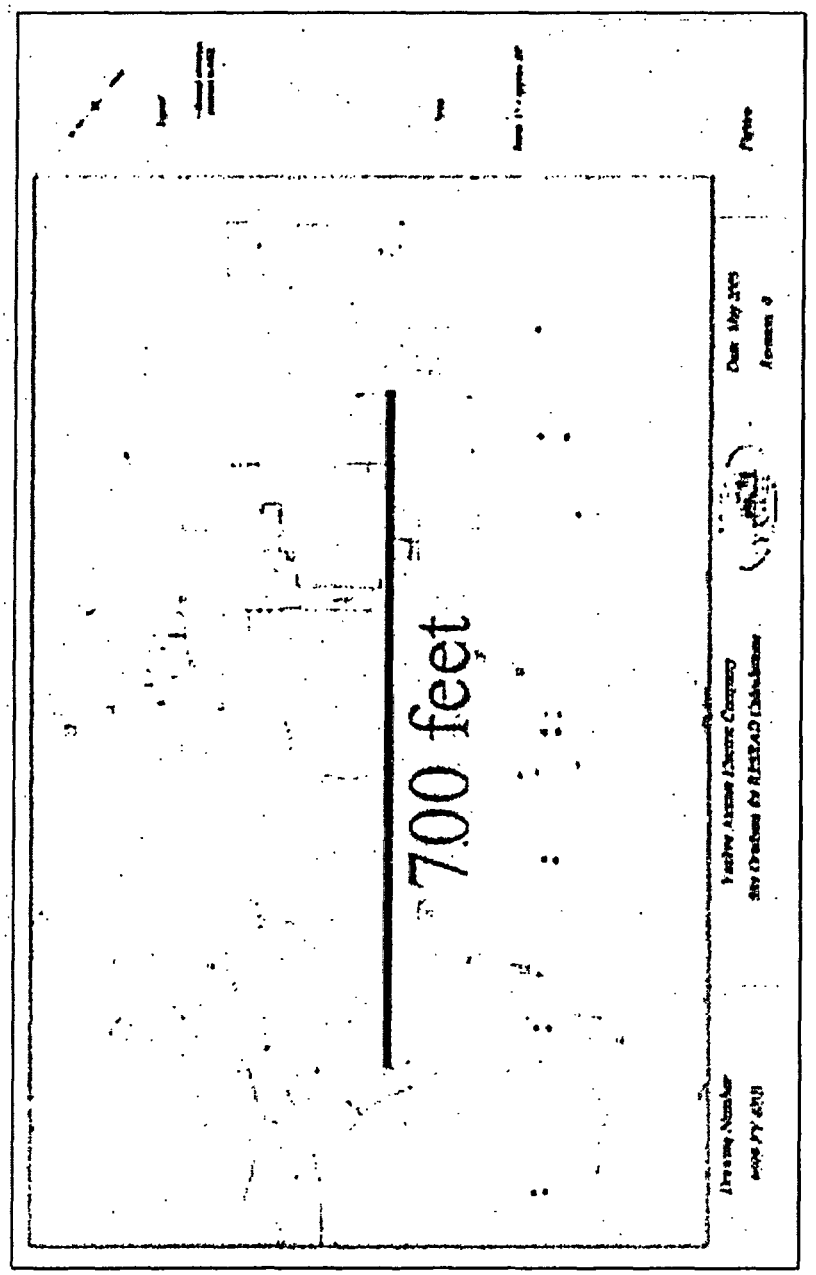


2. Contaminated Zone Erosion Rate

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 contour line near CB-2 to the contour line in near 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. Attachment 4 contains a larger version of Figure 2-1.

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, 2nd 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%.

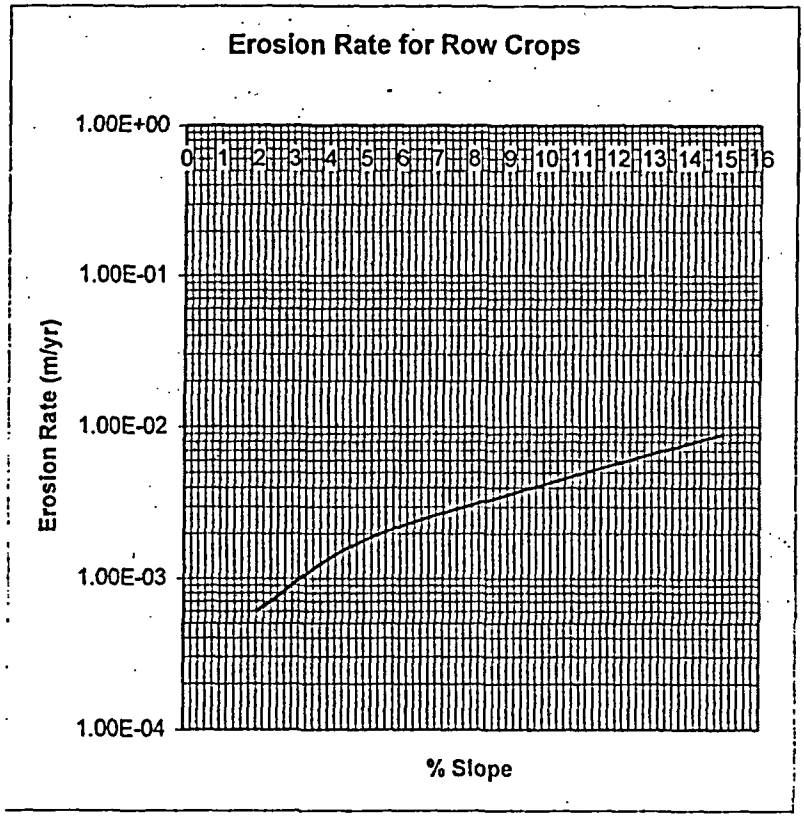
The data in Table 2-1 below was generated using NUREG/CR-6697's row-crop Erosion Rate of 6.0 E-4 for a 2 % slope. Erosion Rates where then calculated for 5, 10 and 15 percent slopes using their rate increase factors as specified in the Discussion of Section 3.8 referenced above. As recommended in this section of NUREG/CR-6697, the Erosion Rate of 6.0 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/y)
2	6.0E-4
5	1.8E-3
10	4.2E-3
15	9.0E-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 E-4 m/y 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^3 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 wind speed. The mid-range value was calculated for each of the ranges for which data was available. An average wind speed 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 the 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/h 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

YNPS 35-Foot
Wind Speed and Direction Joint Frequency Distributions
1988-1992

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
(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
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 inches/year x 2.54 cm/inch x meter/100 cm = 1.2 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:

$$Ce = \frac{ETr}{(1-Cr)(Pr) + IRr}$$

Where: ETr = the Evapotransporation Rate (m/y)
Pr = the Precipitation Rate (m/y)
IRr = the Irrigation Rate (m/y) and
Cr = the Runoff Coefficient.

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

$$IRr = \frac{ETr}{Ce} - (1-Cr)(Pr)$$

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

1. YA-REPT-00-002-03, (Ref. 9), cites a value for the average annual Evapotranspiration Rate, ETr, in the upper Housatonic River basin of 21.6 in/yr or 0.549 m/yr from 1931 to 1960.

2. The Precipitation Rate, Pr, 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.

$$Cr = 1 - 0.1 - 0.2 - 0.1 = 0.6$$

4. NUREG/CR-6697, Attachment C, Section 4.3-Evapotranspiration Coefficient, Ce, 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/CR 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 Ce 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/y
Pr	1.2	1.2	m/y
Cr	0.6	0.6	–
Ce	0.5	0.75	–
IRr	0.252	0.618	m/y

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/CR-6697 and NUREG/CR-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. 11) 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. 11 relates Total and Effective Porosity to Field Capacity as follows:

Effective Porosity = Total Porosity - Field Capacity

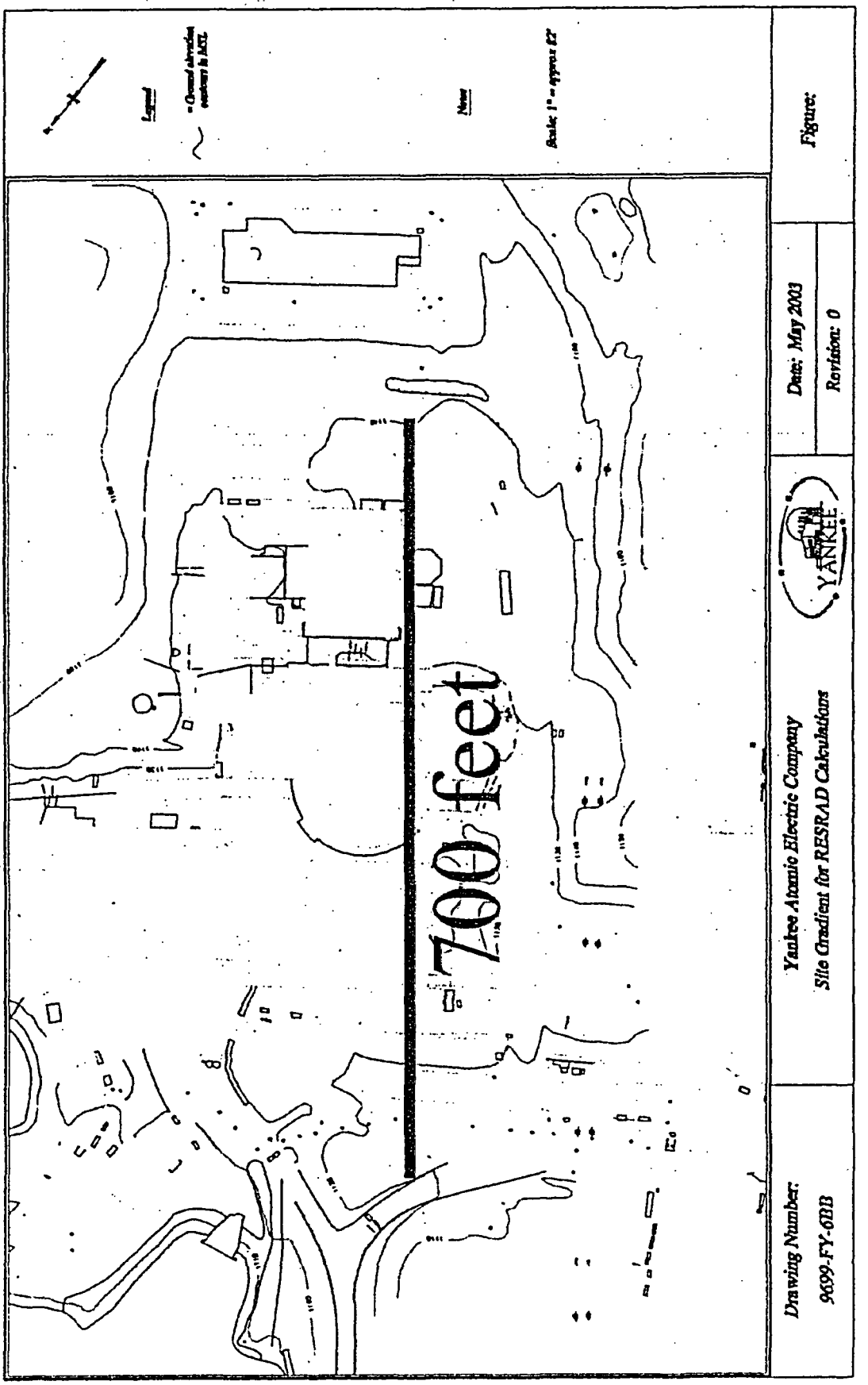
Rearranging this equation:

Field Capacity = Total Porosity - Effective Porosity

The total and effective porosity values for the various zones are the mean values of the NUREG/CR-6697 distributions for sand.

Table 7- 1 Field Capacity

Zone / Soil Type	Total Porosity	Effective Porosity	Field Capacity
Contaminated/ sand	0.43	0.383	0.047
Unsaturated/ sand	0.43	0.383	0.047
Saturated/ sand	0.43	0.383	0.047


Legend
Scale: 1" = approx 67'
Figure:
Date: May 2003
Revision: 0
YANKEE
Yankee Atomic Electric Company
Site Gradient for RESRAD Calculations
Drawing Number:
9699-FY-003
700 feet

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:

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

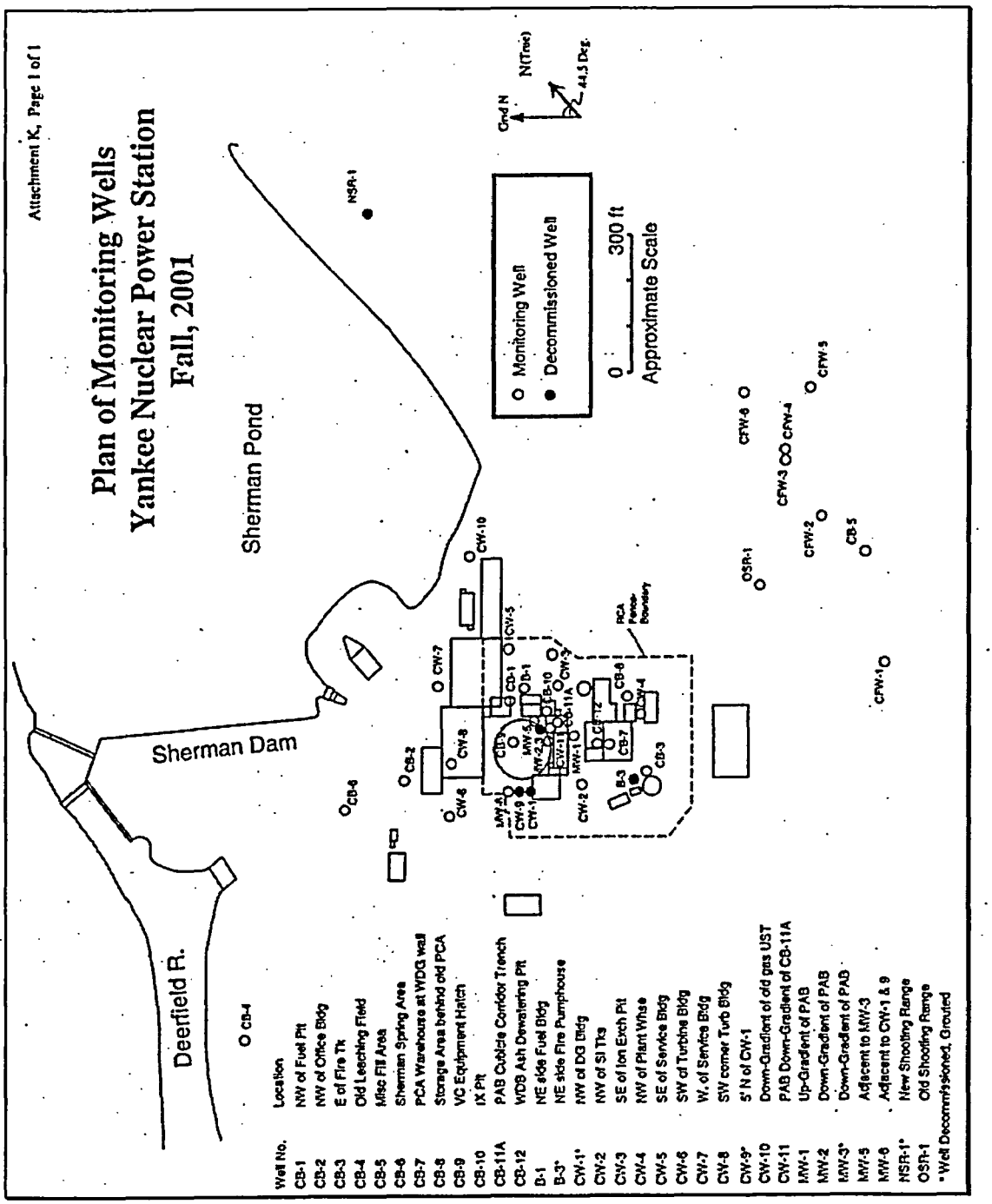
Where h_1 and h_2 represent the hydraulic heads or the water level elevations at location 1 and 2, and Δ_x is the distance between the two locations. The water level elevations are referenced to mean sea level, msl. This methodology was followed in YA -REPT-00-002-03, Hydrogeological Parameter Estimates for Radiation Dose Modeling, (Ref. 9) 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 calculated from the Domestic Water Use discussed in YA-REPT-00-002-03, Ref. 9. 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 Components for a Family of Four		Median	Minimum	Maximum	
Household*		**374**	**374**	**374**	m^3/y
Livestock		**76.7**	**76.7**	**76.7**	m^3/y
Irrigation of vegetable plot					
Contaminated fraction	f_p = min (Area/2000, 0.5)	1	1	1	
Irrigation rate	I_r (m/y)	0.435	0.252	0.618	
Irrigation water	$f_p \times I_r \times 2000$	**870**	**504**	**1236**	m^3/y
Irrigation of pasture (Not a New England practice.)					
Contaminated fraction	f_m = Area/20,000 <= 1.	1	1	1	
Irrigation rate	I_r (m/y)	0	0	0	m/y
Irrigation water	$f_m \times I_r \times 20{,}000$	**0**	**0**	**0**	m^3/y
Drinking water **		**1.91**	**1.91**	**1.91**	m^3/y
TOTAL FOR A FAMILY OF FOUR					
(sum of water components in **Bold** type)		**1323**	**957**	**1689**	m^3/y

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

* Household Use: Domestic Water Use for family of 4 of 272 gallons per day (Ref. 9) minus the drinking water component of 1.91m3/y)

** 478 L/y per individual adjusted to family of 4 and converted to m^3/y.

conversion: 478 L/y-Ind * 4 Ind * $1m^3/1000L$ = 1.91 m^3/y

272 gal/day * 3.79E-3 gal/m^3 * 365.25day/y = 376 m^3/y

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. 9.

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

Figure 10- 1 Local Site Drainage Area

Attachment J, Page 2 of 4

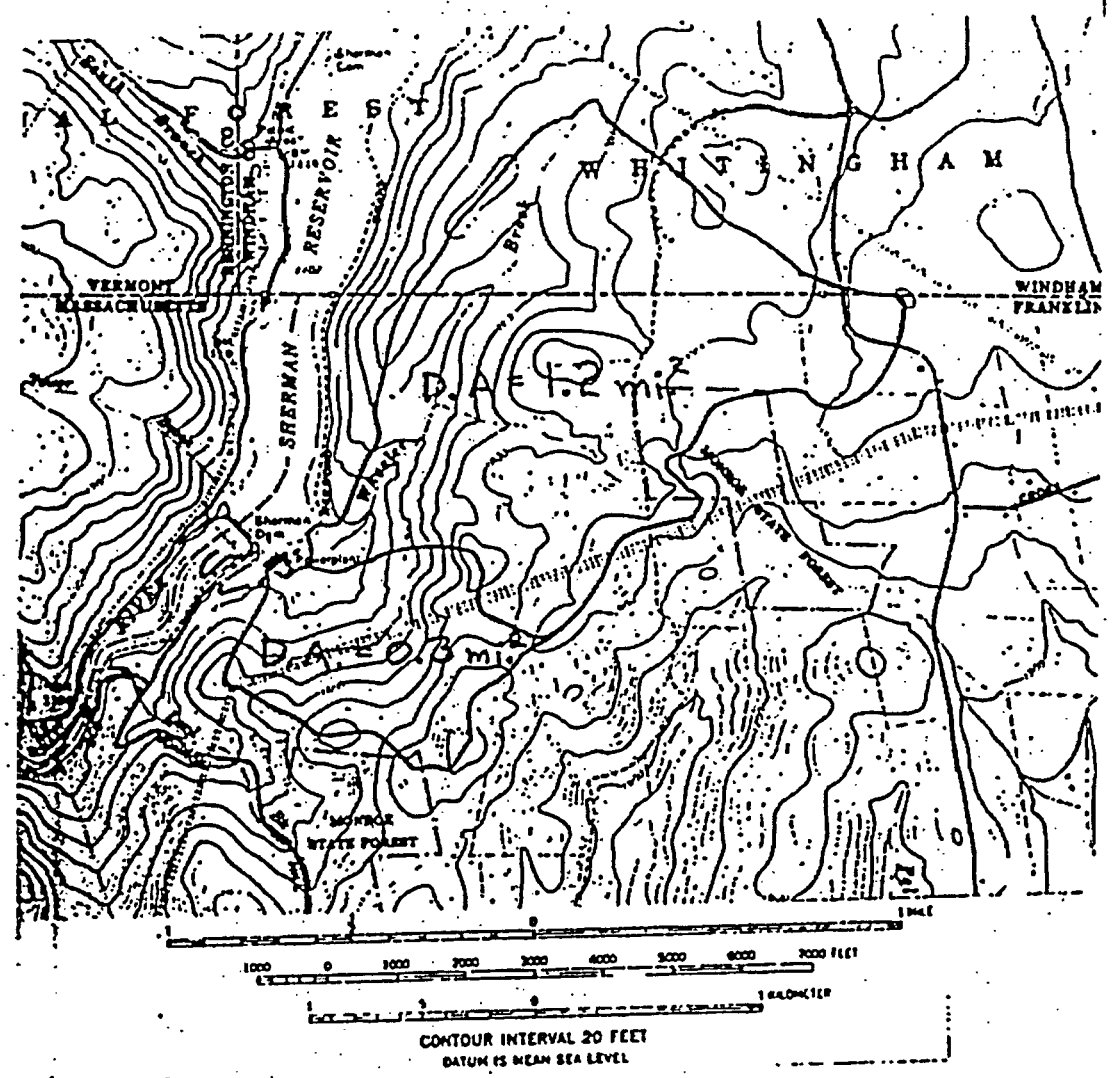


FIGURE 1

LOCAL SITE DRAINAGE AREAS

Attachment 2

RESRA D 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[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
Soil Concentrations										
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	
Distribution coefficients (contam., unsat. and sat. zones) (cm**3/g)										
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	6761
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[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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-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
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
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	
Calculation Times										
Time since placement of material (yr)	P	3	D	0		NR	NR	NR	NR	

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
Time for calculations (yr)	P	3	D	0, 1, 3, 10, 30, 100, 300, 1000	RESRAD Default	NR	NR	NR	NR	
Contaminated Zone										
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 (3.8m) (Ref. 6)	0.15	3.8			1.975
Length parallel to aquifer flow (m)	P	2	D	129	Site-specific - diameter of circle with an area of 13022 m^2 (Att. I)	NR	NR	NR	NR	
Cover and Contaminated Zone Hydrological Data										
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	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	1.5105	0.159	1.019	2.002	1.5105
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	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	0.43	0.06	0.2446	0.6154	0.43
Contaminated zone field capacity	P	3	D	0.05	Site-specific value calculated using Equation 4.4 from Ref. 1 (Att. I)	NR	NR	NR	NR	0.05
Contaminated zone hydraulic conductivity (m/yr)	P	2	S	Beta	NUREG 6697 dist for site soil type -sand (Ref. 6)	110	5870	1.398	1.842	2506
Contaminated zone b parameter	P	2	S	Bounded Log Normal n	NUREG 6697 dist for site soil type -sand (Ref. 6)	- 0.0253	0.216	0.501	1.90	0.975
Humidity in air (g/m**3)	P	3	D	6.1	Regional value. (Att. I).	NR	NR	NR	NR	
Evapotranspiration coefficient	P	2	S	Uniform	NUREG/CR-6697 Att. C, Ref. 4	0.5	0.75	NR	NR	0.625
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	

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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. L)	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	
Saturated Zone Hydrological Data										
Density of saturated zone (g/cm**3)	P	1	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	1.5105	0.159	1.019	2.002	1.5105
Saturated zone total porosity	P	1	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	0.43	0.06	0.2446	0.6154	0.43
Saturated zone effective porosity	P	1	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	0.383	0.0610	0.195	0.572	0.383
Saturated zone field capacity	P	3	D	0.05	Site-specific value calculated using Equation 4.4 from Ref. 1 (Att. I)	NR	NR	NR	NR	0.05
Saturated zone hydraulic conductivity (m/yr)	P	1	S	Beta	NUREG 6697 dist for site soil type -sand (Ref. 6)	110	5870	1.398	1.842	2506
Saturated zone hydraulic gradient	P	2	D	0.1	Site gradient (Att. I)	NR	NR	NR	NR	
Saturated zone b parameter	P	2	S	Bounded Log Normal n	NUREG 6697 dist for site soil type -sand (Ref. 6)	- 0.0253	0.216	0.501	1.90	0.975
Water table drop rate (m/yr)	P	3	D	1.00E-03	RESRAD Default	NR	NR	NR	NR	
Well pump intake depth (m below water table)	P	2	S	Triangular	NUREG/CR-6697, Att. C (Ref. 4)	6	10	30		14.51

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
Model: Nondispersion (ND) or Mass-Balance (MB)	P	3	D	ND	ND model recommended for contaminant areas > 1,000 m^2 (Ref. 1)	NR	NR	NR	NR	
Well pumping rate (m**3/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
Unsaturated Zone Hydrological Data										
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 3.8 m contaminated zone thickness and 3.8 m depth to water table (Ref. 6)	0.01	3.65			1.82
Unsat. zone 1, soil density (g/cm**3)	P	2	S	Bounded Normal	NUREG 6697 dist for6site soil type -sand (Ref. 6)	1.5105	0.159	1.019	2.002	1.5105
Unsat. zone 1, total porosity	P	2	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	0.43	0.06	0.2446	0.6154	0.43
Unsat. zone 1, effective porosity	P	2	S	Bounded Normal	NUREG 6697 dist for site soil type -sand (Ref. 6)	0.383	0.0610	0.195	0.572	0.383
Unsat. zone 1, field capacity	P	3	D	0.05	Site-specific value calculated using Equation 4.4 from Ref. 1 (Att. I)	NR	NR	NR	NR	0.05
Unsat. zone 1, hydraulic conductivity (m/yr)	P	2	S	Beta	NUREG 6697 dist for site soil type -sand (Ref. 6)	110	5870	1.398	1.842	2506
Unsat. zone 1, soil-specific b parameter	P	2	S	Bounded Log Normal n	NUREG 6697 dist for site soil type -sand (Ref. 6)	- 0.0253	0.216	0.501	1.90	0.975
Occupancy										
Inhalation rate (m**3/yr)	B	3	D	8400	NUREG/CR-6697, Att C (Ref. 4)	NR	NR	NR	NR	
Mass loading for inhalation (g/m**3)	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[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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	
Ingestion, Dietary										
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/CR5512, 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[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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	
Ingestion, Non-Dietary										
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	Min. from NUREG/CR-6697, Att. C (Ref. 4) Max. is site specific depth to water table (Ref. 6)	0.3	3.8			2.05
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[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						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**2)	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**2)	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**2)	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[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
Dry Foliar Interception Fraction for Fodder	P	3	D	0.35	NUREG/CR-5512, Vol. 3 (Ref. 2)	NR	NR	NR	NR	
Storage times of contaminated foodstuffs (days):										
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	
Special Radionuclides (C-14)										
C-12 concentration in water (g/cm**3)	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		0.3
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	

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
Fraction of grain in milk cow feed	B	3	D	0.1000	NUREG/CR-6697, Att. B (Ref. 4)	NR	NR	NR	NR	
Dose Conversion Factors (Inhalation mrem/pCi)										
Ac-227+D	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	
Nb-94	M	3	D	4.14E-04	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	
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	
Tc-99	M	3	D	8.33E-06	FGR11	NR	NR	NR	NR	

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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	
Dose Conversion Factors (Ingestion mrem/pCi)										
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	
Nb-94	M	3	D	7.14E-06	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	
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	

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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	
Plant Transfer Factors (pCi/g plant)/(pCi/g soil)										
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
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

Table 1
Input Parameters for Sensitivity Analysis; Soil
Resident Farmer Scenario

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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
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-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
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
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

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
Meat Transfer Factors (pCi/kg)/(pCi/d)										
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
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
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-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

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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
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
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
Milk Transfer Factors (pCi/L)/(pCi/d)										
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

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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
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-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

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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
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
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
Bioaccumulation Factors for Fish ((pCi/kg)/(pCi/L))										
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

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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
Nb-94	P	2	S	Lognormal-n	NUREG/CR-6697, Att. C (Ref. 4)	5.7	1.1			3.0E+02
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
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

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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
Bioaccumulation Factors for Crustacea/ Mollusks ((pCi/kg)/(pCi/L))										
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	
Nb-94	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	

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

Parameter (unit)	Type[a]	Priority[b]	Treatment[c]	Value/Distribution	Basis	Distribution's Statistical Parameters[d]				
						1	2	3	4	Median
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	
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	
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	
Graphics Parameters										
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 =2000
Number of repetitions = 1

Input Rank Correlation Coefficients:

Thickness of contaminated zone and unsaturated zone = - 0.99
Total porosity and bulk density = - 0.99 (contaminated zone, unsaturated and saturated zones)
Total porosity and effective porosity = 0.96 (unsaturated and saturated zones)
Effective porosity and bulk density = -0.99 (unsaturated and saturated zones)
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, Title10, 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.
6. YA-REPT-00-008-03, "Evaluation of GeoTesting Express Soil Testing and Determination of Depth to Groundwater," December 2003

Attachment 3

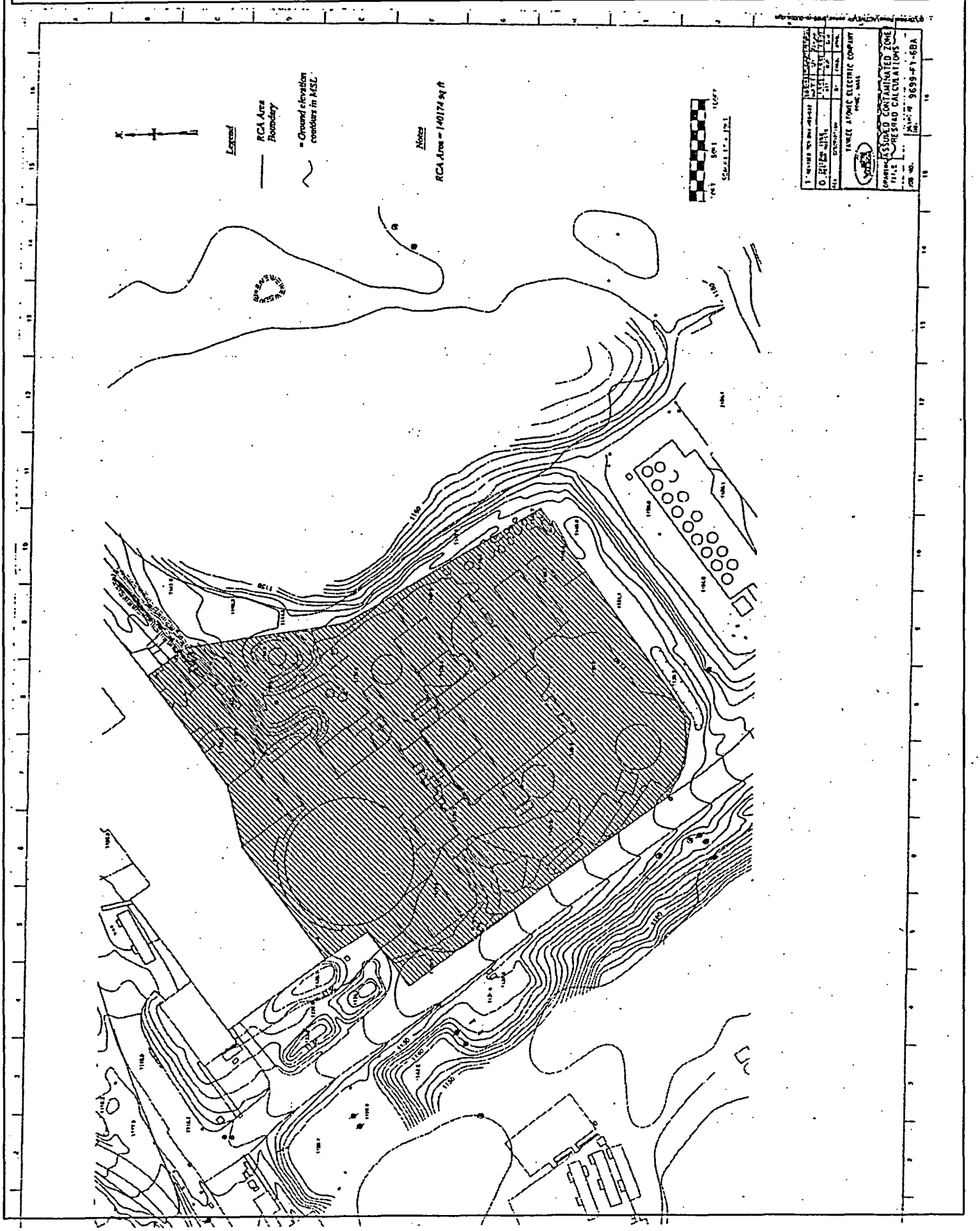
CD Table of Contents - RESRAD Input/0utput Files

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. The files can be used to verify deterministic and probabilistic input values and the sensitivity analysis results.

CD Name: YACALC-01-001-03
File: RESRAD Appendix.Deterministic.pdf
RESRAD Appendix.Probabilistic.pdf

Attachment 4

Site Maps
Figure 1-1 and Figure 2-1


Legend
RCA Area Boundary
= Ground elevation contours in MSL
Notes
RCA Area = 140174 sq ft
YANKEE ATOMIC ELECTRIC COMPANY
ASSUMED CONTAMINATED ZONE
RESRAD CALCULATIONS
9699-FY-16BA